

Frontiers of Energy Efficiency: Next Generation Programs Reach for High Energy Savings

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Executive Summary

Energy efficiency programs for utility customers have been in place for over three decades in many areas in the United States. These programs have experienced unprecedented growth over the past decade, in significant part attributable to policies that establish high, specific energy savings targets to be achieved through utility and related non-utility energy efficiency programs. Achieving and sustaining high savings levels present challenges for energy efficiency programs. Increasingly stringent building codes and energy efficiency standards for appliances and other technologies are moving baseline energy efficiency performance higher and achieving high participation rates has been difficult. These developments present challenges for customer energy efficiency programs that must reach increasing targets.

To achieve high savings requires next generation energy efficiency programs—program designs and approaches that can gain higher customer participation and achieve high savings per customer in the near future through innovative technologies, program designs, and marketing. While there are numerous advances in the energy efficiency of individual technologies and devices, an overarching finding of this research is that next generation programs are focusing on system efficiencies in commercial and residential buildings, and optimization of processes in industry. The clear emphasis is the energy performance of systems both in design and operation. For new construction and major renovation of buildings, this requires integrated design and whole building approaches to optimize building performance. Consequently, program designs are increasingly performance-based with incentives and services structured to foster and reward performance of systems. A variety of design tools and standardized designs of common building types are being used by programs to achieve higher performance in greater numbers of new buildings.

Reaching underserved markets is another direction for next generation programs. Improved understanding of more narrowly defined customer segments through better data analytics can enable program administrators to structure and focus incentives and marketing to increase participation. Programs are successfully serving customers in markets that historically have been difficult to reach, such as multifamily housing and manufactured homes.

A clear trend across program portfolios is an emphasis on better understanding customer behavior and motivations. There has been a rapid rise in behavior-based programs in the residential sector. Such programs seek to combine feedback on energy use with contextual information to motivate customers to reduce energy use. Creating better awareness and understanding of energy use is also a trend in commercial building markets. A number of programs seek to make energy use a visible and valued element in commercial building markets through energy disclosure requirements; education and training for owners and occupants; and public recognition of high performance, energy-efficient buildings.

How to achieve high performance across numerous and diverse markets varies by program type. In the next sections we highlight key findings and trends for programs within these targeted markets. In each section we examine the technologies, markets, and program designs that can yield increased energy savings.

The common thread of next generation programs is high performance. By applying advances in technologies, marketing, and program designs, next generation programs are capable of reaching greater numbers of customers and achieving high savings. ACEEE examined 20 next generation energy efficiency program types, plus two additional emerging program areas. Our research focused on identifying how these leading-edge programs are responding to the challenges of achieving greater savings for each participating customer, and also reaching greater numbers of customers. Taken together, these next generation programs offer a pallet of approaches that will allow program administrators to continue to meet energy efficiency savings targets into the future.

RESIDENTIAL PROGRAMS

Next generation residential programs will incorporate advances in technologies and program designs to expand program participation and create new savings opportunities, particularly focusing on underused savings opportunities and reaching out to underserved markets. Such programs will draw upon behavioral science and rapidly expanding data, communication, and control technologies to engage and motivate greater numbers of customers to take actions necessary to reduce their energy use through energy efficiency improvements. Programs will have to diversify their savings opportunities—in most cases, relying proportionately less on lighting than many have done in the past.

Programs will be able to draw upon advances in the energy performance of some residential technologies and appliances, although such savings may be smaller than past gains and be limited to certain types of products. Many of the products within common end-use categories are approaching their technical savings potential for the near-term future. Our research identified the following technologies as promising, although some of these technologies still are at the early stages of their entry and acceptance into markets:

- LED (light emitting diode; solid-state) lighting
- Ductless heat pumps
- Heat pump water heaters
- High-efficiency clothes dryers (especially heat pump units)
- High-efficiency clothes washers
- Advanced power strips
- Home energy displays and smart meters

Some existing technologies still offer significant energy savings for many existing homes markets, such as building shell improvements to reduce heating and cooling loads, and air and duct sealing. Savings opportunities also can be realized by increasing the market saturation of high-efficiency air-source heat pumps, central and room air conditioning units, and electric or natural-gas fired water heaters. While programs will continue to support and incorporate high-efficiency technologies, a key program direction for both new and existing homes programs is to address home mechanical system efficiencies, not simply device efficiency. High system efficiencies are achieved through proper design, installation, and operation—all elements that can be addressed through effective program design.

A large savings potential remains for existing homes. Residential retrofit programs will continue to evolve and strive to improve their services in order to gain higher participation and remain cost-effective. Retrofit programs must ultimately target improvements to the building envelope, mechanical systems, household appliances, and occupant behavior. The focus needs to be achieving and maintaining high overall household energy performance. Programs need to engage customers and build relationships that encourage comprehensive improvements, not just single upgrades. A goal is for customers to value energy efficiency and use it as a key decision criterion across the range of household decisions that affect energy use, from the purchase of a light bulb to major remodeling.

Residential lighting clearly will remain a main focus of present and future programs. New standards in place for lighting products that become effective over the 2012–2014 period may reduce the energy savings attributable to residential lighting programs by more than one-third compared to 2011. However, considerable savings potential still exists in some markets for compact fluorescent lamps (CFLs). LEDs are poised for rapid penetration into residential lighting markets, but cost remains a barrier to widespread adoption. Residential lighting and appliance programs have largely taken mass market approaches by providing rebates for qualified purchases. Next generation programs can be more narrowly focused on eligible products meeting the highest performance standards within a product category. Programs may need to try “upstream” approaches such as “market lift” that provide incentives to retailers to increase sales of energy-efficient products compared to a pre-determined baseline.

A variety of information technologies are rapidly becoming part of residential programs. These include smart meters and home energy displays. While such devices on their own do not save energy or improve energy efficiency, they can change behavior and potentially motivate customers to make investments that do yield energy savings through increased energy efficiency. Behavior change program design has grown rapidly and continues to show great promise. A variety of enhanced billing feedback approaches that track and compare household energy use, along with providing information on ways to reduce use and improve efficiency, have been widely implemented. A better understanding of customer behavior and motivations can also improve all types of energy efficiency programs.

Emerging programs are reaching out to underserved markets. Numerous successful multifamily housing programs are demonstrating approaches that can serve these markets. The most effective multifamily program designs provide integrated packages that address energy use (both electricity and natural gas where applicable) within individual units and the larger building systems and common areas. A key to success for design of multifamily housing programs is to bring together key stakeholders, including utilities, housing authorities, and financial organizations, to collaborate and leverage available resources and work toward common goals.

Opportunities in residential markets vary depending upon the history of programs in the area. In states and regions without a history of programs, overall market saturation of energy efficiency technologies and practices is low, so opportunities exist for deploying program models that have worked in other areas. For more mature markets with longer records of customer programs, capturing greater market share requires more finely tuned and targeted programs that address underserved and otherwise promising markets, such as multifamily housing and manufactured

homes. Our research shows that whatever the program history, there are next residential generation programs capable of achieving high savings.

COMMERCIAL PROGRAMS

Commercial buildings markets will continue to provide large savings opportunities across the spectrum of building types and their owners and occupants. Such markets are highly diverse and dynamic, providing unique opportunities and challenges for program administrators. New commercial buildings can achieve high performance with very low energy use. Existing buildings can achieve dramatic energy reductions through major renovations. Improved operations and more incremental improvements to building components and systems can yield significant cost and energy savings along with superior building performance. Next generation commercial buildings programs are achieving such results for new and existing buildings.

Commercial building technologies show some significant advances in many areas. Lighting is undergoing dramatic changes as in the residential sector. New technologies, especially LED, will spur major changes to lighting markets and customer applications. LED technologies already are cost-effective and well suited for certain applications (including directional lamps, refrigerated cases, and street lights) in contrast with the residential sector. However, LED technologies are not yet capable of effectively replacing linear fluorescent lamps. Next generation lighting programs will emphasize integrated lighting design and effective use of daylighting and control technologies to optimize lighting quality and energy performance.

Building mechanical technologies overall show much more incremental improvements in energy performance. Some technologies that do show promise in the near term include variable refrigerant flow systems, ground-source heat pumps and radiant heating systems, condensing gas boilers, and variable speed, high-efficiency rooftop cooling and heating systems. While improvements to individual building mechanical components remain important in achieving greater energy efficiency, the greatest improvements in mechanical technologies will come from improvements to entire building systems.

Achieving high energy performance in new buildings requires taking whole building, integrated approaches. New commercial construction programs are encouraging developers and design teams to achieve high performance by structuring incentives based on achieving high performance. A clear direction for commercial building energy efficiency programs is to expand the market for building performance services and increase the number of high-performance buildings. For new building programs, the big push is to make high-performance buildings possible across a wide range of building types—not just those types typically served. Design tools and standardized designs of common building types have been developed and are being used to achieve higher performance in greater numbers of new buildings.

Expanding markets for major retrofits and renovations can achieve higher energy savings from commercial buildings programs. The emphasis of major retrofit programs is to make energy use and energy efficiency a valued attribute in commercial buildings markets so that whenever a major renovation occurs, improving energy performance is a priority. Approaches being taken toward this

end include energy disclosure requirements, education and training for owners and occupants, and public recognition of successful projects. Ensuring quality installation also is important to achieve optimal performance. Providing incentives for commissioning has proven beneficial. Major renovation and retrofit programs also should emphasize whole building, integrated design of systems.

Improving performance of existing buildings without doing major renovations also is a direction for commercial building programs, such as retro-commissioning and related operations improvement programs. Retro-commissioning and other programs that target the operations and performance of existing buildings can serve more customers and improve their effectiveness by improving screening of candidates and structuring incentives to reward quicker action and implementation. Another approach to improve building operations is the use of strategic energy management (SEM), which addresses ongoing and improved facility/building management practices.

New approaches for improving operations and associated energy performance are being used to better serve smaller buildings (less than 50,000 square feet), a market segment that generally has not been effectively served through existing programs. Small business programs serve a large and unique market. Such programs will need to expand the types of eligible measures if they wish to achieve high savings. They also will need to gain higher participation, which requires offering favorable incentives and targeted services.

INDUSTRIAL, CHP, AGRICULTURE, AND DISTRIBUTION SYSTEM PROGRAMS

The majority of existing programs have focused on the residential and commercial sectors. With the industrial sector accounting for almost a third of energy use, it will be important for the next generation of customer energy efficiency programs to move beyond their traditional focus markets. Our research looked at emerging program trends focused on the industrial and agricultural sectors, and programs that support expanded use of combined heat and power (CHP) and improvements to utility distribution systems. The combined savings available from these programs are very large.

Most opportunities for industrial-sector energy efficiency exist in improvements and optimization of processes, which is where the majority of the energy is used. Next generation industrial energy efficiency programs must evolve beyond equipment replacement programs toward whole system and customized approaches that also take into consideration the size and unique needs of industrial customers. Several broad categories of program approaches are emerging: (1) custom programs that offer targeted support through financial incentives and engineering expertise tailored to specific industrial processes; (2) SEM programs that focus on integrating energy management practices into a company's culture, standard operating procedures, and profitability; and (3) working with small and medium businesses (SMB) through market channels such as regional trade associations or supplier networks for larger companies.

CHP systems offer significant energy savings and can reduce emissions compared to separate grid-provided power and onsite thermal energy systems. CHP savings are different from other energy efficiency savings because the savings occurs by displacing utility generated fuel consumption. While most utilities in the past have not targeted CHP savings, this needs to change since CHP has the potential to reduce the need for utility investments in generation and transmission, reducing energy

costs for all consumers. Only a handful of states allow CHP to count toward energy efficiency goals. In these states, CHP programs are using innovative designs such as performance-based metrics and real-time electric metering to estimate savings. Other states could consider CHP as an eligible efficiency measure, or states could set a separate target for annual CHP output and emissions reductions. In both cases, targets need to be set with CHP potential in mind and appropriate accounting methods will need to be considered for addressing the impact of expanded CHP on utility bottom-lines.

In recent years, agricultural energy efficiency programs have languished. Agricultural energy efficiency 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. It also is important to market to farmers a variety of different options for increasing energy efficiency that are most applicable to their individual situations. Financing is also a barrier in implementing rural energy efficiency projects, so programs that connect farmers with available state and federal funding plus assist them through the application process are important.

Significant opportunities exist to improve the efficiency of electric utility distribution systems by reducing losses. Two leading opportunities are distribution voltage optimization and amorphous core transformers. Such system improvements complement customer energy efficiency programs by reducing overall system costs.

SAVINGS POTENTIAL

Significant potential savings remain as programs evolve and advance through new program designs and new technologies that reach more customers and achieve high savings despite concerns that customer energy efficiency programs are reaching limits. We made first-order estimates of the energy savings potential from each of the 22 program areas and estimate that a full portfolio of next generation programs in the U.S. could yield savings of about 1162 TWh, or 27% of total forecasted electricity consumption in 2030, and about 1887 TBtu, or 19% of total forecasted natural gas consumption. While the focus of our research is on program designs, technologies, and customer markets, this estimated potential savings is intended to provide the reader with a sense of the ability of these next generation programs to meet energy savings targets. These numbers represent potential savings from programs for electricity and natural gas end-uses through 2030 if the programs were fully deployed across the country at aggressive but reasonable levels of participation. Table ES-1 summarizes our estimates of the savings potential by sector.

Table ES-1. Total Savings Potential for 2030

Savings Estimates by Sector	Electricity (TWh)	% of savings by Sector	Natural Gas (TBtu)	% of savings by Sector
Reference Case Delivered Energy for 2030 (AEO)	4,242		10,030	
Residential Programs	417	36%	997	53%
Commercial Programs	565	48%	770	41%
Industrial Programs	109	9%	119	6%
Distribution System Efficiency	70	6%	n/a	n/a
Total Energy Efficiency Savings	1,162	100%	1,887	100%
Savings as % of Reference Forecast	27%		19%	

CONCLUSIONS AND RECOMMENDATIONS

Next generation customer energy efficiency programs are rising to meet the numerous challenges that are being created by changes in technologies, policies, and markets, and can offer the potential to achieve and sustain high savings. In some cases, new technologies may revolutionize markets and associated customer applications, such as the promise of solid-state lighting (LED). In other cases, programs will need to be redesigned to offer incentives and services that produce much higher savings than traditional approaches. Significant savings can be realized through better building and systems design, high-quality installation practices, and improved operations practices that optimize and maintain system performance. Behavior change represents another key frontier in achieving energy savings, with improved feedback and communications targeted to both inform and motivate customers to action.

To achieve aggressive energy efficiency saving targets, programs will need to serve all types of customers and capture all of the significant, cost-effective energy savings opportunities across the wide spectrum of customer types. This includes industrial and agricultural customers—segments that have not always been well served by programs.

Our research clearly indicates the continued need to better focus and refine programs to meet the unique needs of the many customer markets that comprise the full expanse of electric and natural gas utility customers. Recognizing the dynamic relationship among energy efficiency program goals, appliance standards, and buildings codes will be important.

Based on our research, we offer these overall strategic recommendations:

- Foster the development and deployment of new, high efficiency technologies across the spectrum of customer types and end-uses.

- Promote systems approaches to realize the greatest energy efficiency potential.
- Promote the development and advancement of best practices among building designers, contractors and operators to achieve improved energy performance.
- Use market research and data analytics to improve market characterization to better design and target customer energy efficiency programs.
- Target behavioral change of all customer types as a key part of overall program portfolios.

Customer energy efficiency programs have grown and matured over the past few decades. They have become common features of the services available to utility customers. Some skeptics have raised questions and concerns about the ability of these programs to achieve and sustain high energy savings. Our research finds significant progress being made with technologies and program designs to create a next generation of programs that are capable of realizing the high energy savings needed to prove these skeptics wrong, in spite of the finding that some program types are approaching savings limits. These next generation customer energy efficiency programs will save large amounts of energy while creating customer value, lowering customer energy costs, and reducing environmental impacts, all while promoting future economic health of our communities and country.

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PART I

Background: Pushing the Frontier of Energy Efficiency

Energy efficiency programs for utility customers¹ have been in place for over three decades in many areas in the United States and Canada. Borne of the energy crises and environmentalism of the 1970s, such programs have become commonplace and have clear records of successfully helping electric and natural gas customers lower their energy costs through increased energy efficiency of homes, businesses, institutions, and factories. Such programs yield energy savings that comprise significant energy resources for meeting customer needs and system demands. Saving energy through improved customer efficiency is by far the cheapest energy resource available. Customer programs achieve energy savings at about one-third the cost of new generation resources for electricity (Friedrich et al. 2009). These programs also deliver significant environmental benefits by reducing emissions from fossil fuel generation plus they provide positive economic benefits by lowering utility system costs and boosting economic development and jobs.

These programs have experienced unprecedented growth over the past decade (York et al. 2012a, 2012b). This growth is in significant part attributable to enactment of policies that establish high, specific energy savings targets to be achieved through utility and related non-utility energy efficiency programs. Such energy efficiency resource standards (EERS) are now in place in 24 states. Many other states without such specific policies also have greatly increased their commitments to energy efficiency programs. The common driver of this rapid growth is the objective of achieving high levels of cost-effective energy efficiency and thereby reaping the substantial economic and environmental benefits that result. Research completed by ACEEE (Sciortino et al. 2011) on state progress in meeting these targets showed that almost all states were largely meeting the early targets, many of which were part of a “ramping up” of savings to achieve higher targets. EERS are proving to be a strong policy tool to advance energy efficiency technologies and approaches.

Codes and standards are additional policy tools that strongly influence technologies and approaches for achieving greater customer end-use energy efficiency. There is a dynamic relationship among EERS, codes, standards, and other program goals. EERS help to drive the leading edge of program achievements. Codes and standards lock in advancements, meaning that certain energy efficiency measures may no longer meet program criteria for cost-effectiveness. The result is that programs need to innovate in order to stay ahead of the curve and to continue to push for new technologies and approaches to meet overall goals as established by EERS or similar policies. This dynamic interplay is evident across the range of customer products and markets as appliance standards and building codes have continued to advance and become more stringent. The net impact of these policies is that they

¹ By “energy efficiency programs for utility customers,” we mean those programs funded by utility customers via customer rates or special purpose “public benefits fees.” Such programs may be administered by utilities or non-utility organizations. As a shorthand, throughout this report we often refer to these as “utility-sector” programs in recognition of both utility and non-utility administration.

are successfully moving affected customer markets toward greater and greater energy efficiency. Such policies spur innovations in technology and programs (Neme and Wasserman 2012).

Scope and Objectives

This report examines how energy efficiency programs are responding to the numerous challenges they are facing in achieving and sustaining high energy savings. Experience with these programs and markets suggest that just expanding existing programs will be insufficient in meeting these challenges. Rather, the programs' designs themselves may need to change in addition to expanding the scale of programs to reach and engage more customers. Programs will need to achieve higher savings through some combination of going "deeper" and "broader." "Deeper" means gaining more savings per participating customer or project, while "broader" means gaining higher participation rates.

The fundamental research question addressed by this report is: What are the next generation energy efficiency program designs and approaches? By "next generation" we mean programs that are capable of being implemented at full scale within the next 1–3 years. This means that the technologies to be employed need to be commercially viable today or within this near-term horizon. It also means that the program approaches and services to be provided can be implemented in this same near-term period. In practical terms, it means that the types of programs we include in this research are likely already being offered at a pilot stage or are otherwise close to being put into the field at either the pilot or full-scale stage.

Next generation programs also can mean continuation of and refinements to successful existing programs. In our research we also examined existing approaches and programs that will continue to hold promise for the future. In many of these cases, a basic program structure may remain in place, but there should be enhancements made to improve program results.

The scope of this project includes the full array of program areas (defined by customer type and targeted energy-end uses and applications) typically included in energy efficiency program portfolios. We identified a total of 20 program types for full characterization plus two additional emerging concepts; these are listed below:

Residential Programs

- Residential Lighting
- Residential Appliances
- Residential Plug Loads and Consumer Electronics
- Residential Mechanical Systems
- Residential Low-Income Weatherization
- Residential Home Retrofit Programs
- Residential New Construction
- Manufactured Housing
- Multifamily Housing

- Behavior-Based Energy Efficiency Programs: Enhanced Billing, Real-Time Feedback, and Social Marketing

Commercial Programs

- Commercial Lighting
- Commercial Building Operations and Performance Programs Commercial Major Retrofit and Renovation
- Commercial HVAC
- Commercial New Construction
- Small Business

Industrial, Agriculture, CHP, and Distribution Systems Programs

- Industrial
- Agriculture
- Combined Heat and Power
- Distribution System Efficiency Improvements

Additional Program Concepts

- Miscellaneous Energy Use in Commercial Buildings
- Commercial Sector Behavior Programs

We believe the above set of programs captures the vast majority of program types and associated program savings and budgets. However, there clearly are other types of programs not included in this set—programs that target narrower customer segments and end-uses, such as food service programs or data center programs. Such “niche” programs can be important components of program portfolios and may well grow in size and importance within portfolios as the targeted markets grow or as new technologies emerge that greatly increase energy-saving opportunities within these markets.

While we used these characterizations for the purposes of focusing our research, there are numerous programs where such sharp boundaries are not defined. Many program administrators are working to integrate services offered by programs so that customers can access a full array of applicable services and technologies with a single program contact. The goal is a seamless “one-stop shop” for services available to help manage customer energy use and associated costs. From a program perspective, this helps break down some existing “silos” that can make it difficult and confusing to customers as to what programs and services are available and how they can participate and benefit from them. A leading program practice is to take such an integrated approach in program design. This also can help develop more of a long-term relationship with interested customers who may implement certain energy efficiency measures in the near term and plan for other steps farther ahead, participating again in available programs as opportunities arise.

Within each program area we sought to identify trends and developments in key elements of the programs, including:

- Technologies
- Markets
- Program approaches

Our overall objective is to create a resource for energy efficiency program developers, managers, and evaluators. This report presents design principles and innovative practices for next generation customer energy efficiency programs across a broad array of customer energy efficiency program areas. It is by nature broad in scope, providing relatively short, concise reviews of key trends and developments in these areas.

METHOD

We relied on existing leading-edge customer energy efficiency programs to guide the research. Our research focused on identifying how these leading-edge programs are responding to the challenges of achieving greater savings for each participating customer and also reaching greater numbers of customers overall. In short, how programs are evolving to go “deep” and “broad.” This work builds on research ACEEE completed in 2011 that examined overall policies and program approaches in states with aggressive energy efficiency resource standards (Sciortino et al. 2011; Nowak et al. 2011). We also took advantage of other recent and ongoing ACEEE research on emerging technologies, behavior programs, industrial programs, and “intelligent efficiency” opportunities.

For this research we relied heavily on interviews with program experts. We talked with numerous experts familiar with overall program and industry trends as well as experts within each specific program area. In addition we reviewed relevant literature. Based on our interviews and literature review, we selected programs in place that illustrate how some of the next-generation program designs or program elements are being implemented or piloted.

Findings

We present our specific findings for the programs within each of the program area profiles. What emerge from these findings are changes in technologies, markets, and program designs that are shaping next-generation programs. The prominence or importance of the specific changes varies widely from one program area to the next. In some cases technological changes are the primary reasons for program changes. In other cases new program designs are the most prominent change underway for next-generation programs. Still in other cases the markets for programs, particularly key target markets within broader customer markets, may be changing or may be underserved by existing programs. We highlight the changes affecting next-generation programs according to the three broad categories below.

RESIDENTIAL PROGRAMS

Technologies

The outlook for new residential technologies capable of significant increases in savings opportunities compared to existing technologies is mixed. Many of the products within common end-use categories have reached or nearly reached their technical savings potential for the near-term future. For many of these product categories and end-use applications, to gain more savings means increasing program participation.

There are a variety of new technologies that do promise significant increases, although some of these technologies still are at the early stages of their entry and acceptance into markets. The primary technologies we identified in our research as most promising are:

- LED (light emitting diode; solid-state) lighting
- Ductless heat pumps
- Heat pump water heaters
- High-efficiency clothes dryers (especially heat pump units)
- High-efficiency clothes washers
- Advanced power strips
- Home energy displays and smart meters

Certain existing technologies that yield significant energy savings need to become more prevalent in residential homes markets, such as air and duct sealing in conjunction with home retrofits and weatherization. There are still considerable savings opportunities to be realized by increasing the market saturation high-efficiency air source heat pumps, central and room air conditioning units, and electric or natural-gas fired water heaters. Addressing home mechanical *system* efficiencies, not simply device efficiency, is another program direction to capture higher savings along with the continued need for building shell improvements to reduce heating and cooling loads. No technological breakthroughs are needed in many of these areas, just expanded application of best building practices.

Residential lighting is clearly a main focus of present and future programs. The Energy Independence and Security Act of 2007 (EISA), which imposes efficiency standards for lighting products beginning in 2012 for general service incandescent lamps, may reduce the energy savings attributable to residential lighting programs by more than one-third compared to 2011. However, there is still considerable savings potential in some markets for compact fluorescent lamps (CFLs). There is clearly room for continued inclusion and promotion of CFLs in programs. More than 70% of the sockets that could have a CFL in them still have an incandescent. There also are additional lighting technologies that can provide additional savings, including “2X halogen lamps” (twice as efficient as present halogen lamps) and a variety of “specialty” CFLs. While light-emitting diodes are poised for rapid penetration into residential lighting markets, cost-competitiveness is still a barrier to widespread adoption as the initial products are much more expensive than the lighting products they replace. However, the prices of LED products are predicted to decline as with most new technologies, just as was experienced with CFLs.

A variety of information technologies is rapidly becoming part of residential programs. These include smart meters and home energy displays. Such devices on their own do not save energy or improve energy efficiency. However, through improved communications and messaging to residential customers such technologies can change behavior and potentially spur customer investments that do yield energy savings and increased energy efficiency.² More timely, meaningful, and understandable customer data helps make energy use visible. Use of comparative customer data as part of home energy use reporting has been shown to yield behavioral changes resulting in 2–4% savings across large customer populations. Further study with the passage of time will reveal whether behavior change will, in turn, be succeeded by related energy efficiency capital improvements (automation or other improvements to energy performance). In some cases customers may avail themselves of other program services and incentives to make such improvements, thus improving the performance of other customer energy efficiency programs.

Markets

Our research shows considerable opportunities in many existing markets targeted by residential energy efficiency programs. In states and regions without long records of programs being available to customers, overall market saturation generally is low. This means there is room for programs to capture savings through increasing participating in existing programs. For more mature markets with longer records of customer programs, capturing greater market share will require more finely tuned and targeted programs that address underserved and otherwise more promising markets. Many existing programs have largely taken a mass market approach across the wide spectrum of residential customer types. For example, many residential appliance programs may have offered the same rebate for all qualified products, whether they were more the “premium” product with numerous features or more “basic” or “entry-level” products without such extra features. Instead, programs may need to focus on those segments of mass markets with the greatest opportunities for increasing the market share of energy-efficient products. Similarly, for lighting products, regions with higher saturation of CFLs will need to diversify to newer lighting technologies earlier than those regions with lower CFL saturation. Some programs also are targeting messages to customers when they are in the market for a product that uses a lot of energy to encourage purchasing models that are among the most energy efficient available.

Another market direction for programs is to move “upstream” and focus more on the supply chain by working with retailers, contractors, and manufacturers so that they are pushing the markets to increase saturation of energy-efficient products.

² New dynamic pricing innovations are being deployed in certain states and introduced through pilot programs in others. These pricing approaches are a complement to the smart metering and home displays. While these innovations present some price volatility to ratepayers, that risk can be managed through energy efficiency investments and automation. This is an area that may hold promise for future programs.

For new home construction markets, only half of the states in the country require compliance with the 2009 International Energy Conservation Code (IECC) (or above) and many of the remaining states have no mandatory statewide codes or require compliance with codes that precede the 2006 IECC. Therefore, there are still significant cost-effective savings to be achieved through new home programs that incorporate ENERGY STAR standards or greater. Utilities and other program operators can also support updating of building codes in a variety of ways and potentially receive credit towards savings goals for such actions. Other areas of potential focus are code compliance strategies or credit toward both meeting and exceeding existing codes.

Residential programs need to reach all types of residential customers, including those living in multifamily housing and in manufactured homes. Such customers often have been underserved due to a variety of barriers facing the development and implementation programs that would meet their unique needs and circumstances. Next-generation program portfolios can ill afford to miss large market segments. There are multiple examples of successful program models that serve these residential market segments.

Program Design

Most existing programs have been developed over many years of experience with residential customers and markets. They have had time to evolve and mature. Next-generation programs clearly need to build on these strong foundations. Many existing program designs may well serve tomorrow's programs. However, it also is clear that some new approaches and new adaptations are necessary to reinvigorate programs and remain successful with the numerous changes that have occurred with relevant technologies, regulations, policies, and markets both for products and energy.

Residential lighting and appliance programs largely have taken mass market approaches by providing rebates for qualified purchases. Such program designs may well work with newer, more efficient technologies that replace past eligible products. For example, programs are already offering rebates for purchase of LED lamps just as they have for CFLs. For other types of products, though, such as ENERGY STAR refrigerators and freezers, such blanket approaches are reaching limits as the penetration of these products in most markets is high and paying customer rebates is pushing at the margins of cost-effectiveness. More focused marketing and product eligibility are two ways that rebate programs for purchases of energy-efficient products may still provide cost-effective program designs. More focused marketing can draw upon market research and data analytics to identify and target market segments where rebates are still very cost-effective, such as entry level, "no frills" kitchen appliances such as refrigerators. Programs also can more narrowly focus eligible products, such as only those that meet such distinctions as Top Ten, ENERGY STAR Most Efficient, or the Consortium for Energy Efficiency's Super-Efficient Home Appliance that distinguish the most efficient products in a given category. Next-generation residential lighting programs are increasing customer education, honing financial incentive levels and delivery methods, and engaging in new marketing approaches with retailers.

Incentives can also be directed to other market actors. Programs may need to try "upstream" approaches such as "market lift," which provide incentives to retailers to increase sales of energy-

efficient products compared to a pre-determined baseline. This also can address free ridership and related program evaluation and attribution issues. Incentives also can be directed to distributors and manufacturers to increase availability of products in markets.

Residential retrofit programs will continue to evolve and strive to improve their services incrementally. The home retrofit market is complex with many barriers, such as seemingly infinite vintage variety and insufficient or conflicting information, and needs to move away from the prevailing idea of “one-size-fits-all.” Retrofit programs must ultimately target comprehensive improvements, understanding that the home is a system and, therefore, a sum of its parts, and that one-off installations of energy-efficient measures will never achieve the full potential that exists. Performance-based programs are preferred, placing obligation on the part of the program administrator, thereby ensuring that retrofits are performed to maximize savings. Offering some type of financial incentives, whether rebates and/or financing, remains an important element of programs to address the cost barriers that exist for comprehensive retrofits. Other efforts to improve program services and increase participation include simplifying the application process for customers and providing quality assurance of contractors, such as through certification requirements. Program tracking and management also can be services provided to customers to ensure successful outcomes. Other strategies light outside the purview of program administrators and require government involvement, such as building labeling programs, realtor participation, and minimum efficiency requirements at time of sale or major renovation.

New homes programs will similarly show continued evolution with more incremental improvements in services and program design. Programs designs are moving to be more performance-based rather than prescriptive; the ENERGY STAR platform remains common and is moving in this direction. Getting higher performance homes—those that exceed code performance—will require a multi-pronged program design that includes: (1) education and training for both homeowners and contractors; (2) distinct performance tiers and associated incentives for packages of building components that yield desired performance above codes; and (3) flexibility in applying performance-based criteria for eligibility and associated services.

There are a number of multifamily housing programs in place that provide models for successfully capturing the energy savings possible in this market and serving both owners and occupants. The program designs serving multifamily housing most effectively are those that provide integrated packages that address energy use within individual units and the larger building systems and common areas. The ability to target both electric and natural gas uses is important, especially in climates with relatively high winter heating loads. Another key to success for program design of multifamily housing programs is to bring together key stakeholders, including utilities, housing authorities, and financial organizations, to collaborate and leverage available resources and work toward common goals.

Behavior change is one area of residential program design that has grown rapidly and continues to show great promise. Specific behavior change programs have been widely implemented, particularly a variety of enhanced billing feedback approaches that track and compare household energy use along

with providing information on ways to reduce use and improve efficiency. Some customers can be motivated to achieve greater energy savings through use of in-home displays; identifying which customers are more likely to respond can improve cost-effectiveness. Other behavioral approaches and insights should be incorporated into other residential customer programs in order to increase participation and achieve greater savings for each participant. Better understanding motivations and behavior can improve all types of customer energy efficiency programs. It also is important that behavior-based programs are part of comprehensive portfolios of customer programs and services that provide the expertise and incentives needed when customers make decisions to improve energy efficiency. Over time, these same technologies that lead to behavioral change may, in turn, spur investments in more energy efficiency devices. Smart meters and most related customer displays generally don't improve energy efficiency directly, but they can be effective tools and important elements to guide and enable customers to reduce household energy use. These same technologies enable new retail price offerings that expose consumers to more volatile rates that may in turn create opportunities for both economic and energy efficiency investments. Innovative pricing and rate design clearly can be tools to facilitate customer improvements in energy efficiency, but these tools are outside the scope of this research.

COMMERCIAL PROGRAMS

Technologies

The outlook for commercial building technologies shows some significant changes underway for certain end-uses while in others the changes are more incremental. Lighting is clearly one end-use undergoing dramatic change as new standards will raise baseline performance while new technologies, LED especially, will be rapidly changing markets and customer applications. LEDs are rapidly entering commercial lighting markets, particularly for certain applications such as for directional lamps, refrigerated cases, and street lights. Along with the introduction of new lighting technologies, next-generation lighting programs will emphasize integrated lighting design and effective use of daylighting and control technologies to optimize lighting quality and energy performance.

As more LED products enter the market, there is a strong need for quality control to ensure customer satisfaction, persistence of savings, and stable market uptake. The Design Lights Consortium (DLC), U.S. Department of Energy (DOE) Lighting Facts, and others play a critical role in vetting LED technologies for life, efficacy, and other critical parameters. The need for this vetting role is clearly apparent with linear LED technologies. Linear LED lamps are being touted as a replacement for general service fluorescent lamps. However, the first linear LED lamp originally listed by DLC was recently delisted from its Qualified Products List when the data supporting its listing was found to be erroneous. The DLC and DOE continue to vet the veracity and reliability of test data, and other issues pertaining to linear LED lamps including light quality, rated life, efficacy, and safety concerns.

Building mechanical technologies overall show much more incremental, smaller improvements in energy performance. A few such technologies, however, do show great promise in the near term and likely will become more widely used. These include variable refrigerant flow systems, ground source heat pumps and radiant heating systems, and condensing gas boilers as well as new variable speed

high IEER rooftop cooling and heating systems. The greatest improvements in mechanical technologies will not come from improvements with individual pieces of equipment, however, but from better and more widespread application of whole building, integrated design. The focus needs to be on the performance of entire systems, driven by clear, aggressive energy performance targets. There are also substantial savings available from better system operation and maintenance efforts, particularly for rooftop systems where such efforts are traditionally very limited.

Other technological advances that can help programs achieve higher savings in both new commercial buildings as well as major renovation are a variety of technologies affecting the building envelope. These include cool roofs, superinsulation, and high-performance windows. These technologies can greatly reduce building heating and cooling loads.

Much of the potential for improving energy efficiency in existing buildings is from improved operation of all building systems. Building retro-commissioning and improved operations can yield significant reductions in energy use. Existing building monitoring, control, and information systems provide important data platforms that can be coupled with advanced software to provide building operators real-time energy use and overall close monitoring of the performance of key components and systems to identify problems and optimize performance. These systems provide operators with strong diagnostic and analytic capabilities, enabling them to fine-tune performance and assure efficient operation. Better data and analytic capabilities also makes screening of energy efficiency measures easier and more accurate, allowing operators and owners to identify the most cost-effective improvements among available options. Better data monitoring, control, and analytic capabilities also are valuable post-installation as means to assess and document actual performance.

Markets

A clear direction for commercial building energy efficiency programs is to expand the markets and increase the number of high-performance buildings. For new buildings programs, the big push is to make high-performance buildings possible across a wide range of building types—not just those types typically served, such as Class A offices and institutional buildings. A lot of work has gone into developing tools, such as design guidelines, that can assist building owners, designers, and contractors to readily incorporate high-performance design, equipment, and materials into new buildings without incurring a lot of additional time and costs. Creating more standardized designs of common building types and packages of building features that yield high performance can expand markets for high-performance buildings. 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.

Expanding markets for major retrofits and renovations is another needed direction to achieve higher energy savings from commercial buildings programs. The emphasis of major retrofit programs is to make energy use and energy efficiency a valued attribute in commercial buildings markets so that whenever a major renovation occurs, improving energy performance is a priority. There is a need to demonstrate this value and create a demand for high-performance buildings. Energy disclosure requirements for commercial real estate can help to make energy use both visible and a criterion for

comparison among competing spaces. Education and training on high-performance buildings targeted to building owners and occupants also can help build awareness and demand for such environments. Public recognition of successful projects also can be helpful toward this objective.

Improving the performance of existing buildings without doing major renovations is also a direction for commercial building programs. Traditionally retro-commissioning and related operations improvement programs have targeted large buildings (50,000 to 100,000 square feet). Some retro-commissioning programs are seeking to serve smaller customer markets, but low cost-effectiveness remains a significant barrier as costs relative to savings can be high. Energy management systems and associated software can help reduce monitoring and tracking costs.

Program Design

An over-arching direction for the design of commercial building energy efficiency programs will be to achieve high savings for each participant, that is, “deep savings.” To achieve such high savings requires taking whole building, integrated approaches as much as possible to achieve optimal system performance. New construction programs for commercial buildings generally include three services available to building owners, design teams, and developers to facilitate such holistic, integrated approaches: (1) design assistance (technical help from designated design professionals); (2) design tools (e.g., energy models or design guidelines); and (3) financial incentives. The trend is to encourage developers and design teams to achieve high performance by structuring incentives based on performance metrics. For smaller projects for which modeling of performance may not be practical, prescriptive incentives (those paid on the basis of eligible equipment) may still be desirable although a variety of whole building tools for small buildings are now becoming available. Prescriptive incentives also can be structured around systems, not single pieces of equipment. Ensuring quality installation also is important to achieve optimal performance; incentive amounts may be increased for qualified measures if they are installed by certified contractors. In the same vein it may be beneficial to provide incentives for commissioning. Major renovation and retrofit programs have a lot in common with new construction. Most of the same program design principles for new construction also can be applied to major retrofit programs, particularly the emphasis on promoting whole building, integrated approaches with specific performance goals driving the design and construction processes.

Retro-commissioning and other programs that target the operations and performance of existing buildings may be able to serve more customers and improve their effectiveness through modest changes in their design. Such changes include: (1) better screening to identify most promising candidates; and (2) incentives structured to reward quicker action and implementation. Another approach to improve building operations is the use of strategic energy management (SEM), which addresses ongoing and improved facility/building management practices. SEM involves obtaining high level support; performing assessments of system-wide policies, practices, and opportunities; and developing strategic goals for improving energy efficiency practices. While SEM is not new to the industrial market in some regions of the country such as the Pacific Northwest, there are now promising pilots to introduce this approach to commercial markets.

Small business programs occupy a unique niche in most commercial building portfolios due to the unique characteristics of this market. Our review of small business programs reveals that the best small business programs are slowly but steadily penetrating the small business market and achieving significant cost-effective savings. To date the vast bulk of savings have been due to lighting improvements and these savings will decline as minimum efficiency standards and building codes improve the efficiency of baseline lighting systems. Consequently, small business programs will need to expand the types of eligible measures if they wish to continue to achieve high savings. To increase overall program savings by increasing participation may require programs to increase budgets for these programs and, as possible within cost-effectiveness guidelines, increase financial incentives, offer free installation of appropriate measures, and offer favorable financing for the larger investments that are recommended. Three possible strategies to remain cost-effective are: (1) integrating demand response options with efficiency for lower administrative cost per kWh saved; (2) targeting marketing and outreach effectively; and (3) optimizing financing terms.

INDUSTRIAL, CHP, AGRICULTURE, AND DISTRIBUTION SYSTEM PROGRAMS

Industrial

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 as 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 challenge is that programs have historically 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. Secondly, strategic energy management programs are a major new program trend that focuses on integrating energy management practices into a company's culture, standard operating procedures, and profitability. Third, while only a handful of program administrators have yet to tap into the savings potential from SEM, these customers represent another promising target for savings. An important approach to working with small and medium businesses (SMB) 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.

Combined Heat and Power (CHP) Systems

CHP systems save energy and reduce emissions compared to most 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 offer insight into best practices for next generation CHP program development, such as the importance 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.

Agriculture Programs

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 situations. Financing is also a barrier for farmers in improving their energy efficiency, so programs that connect farmers with available state and federal funding and assist them through the application process are also important.

Distribution Systems

There are significant opportunities to improve the efficiency of distribution systems. Two leading opportunities are 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. Programs and utility initiatives to improve distribution system efficiency yield savings apart from customer end-use efficiency. Consequently, the ability to count such savings as part of EERS requirements is an issue not yet decided by most states. ACEEE is supportive of allowing these savings to count towards EERS, although there may be some state-specific considerations.

Savings Potential

Each program profile in this report includes a high-level estimate of the potential for electricity and natural gas end-use savings from that program through 2030. Our goal is to provide a first-order approximation of the savings potential if the programs were fully deployed across the country at aggressive but reasonable levels of participation. We generally follow a consistent methodology for each program profile: first we assume a baseline delivered energy use reference case for the applicable market sector, which is based on the *Annual Energy Outlook 2012* (EIA 2012); then we assume an average savings per participant based on a variety of resources and conversations with program managers; and last we estimate a participation rate based on our estimates of aggressive but reasonable levels. Savings estimates are adjusted to account for overlap between savings from some

programs. Tables 1–3 present the summary results of all programs combined. Details for each program assumptions are provided in the program profiles.

Table 1. Residential Program Savings Potential for 2030

Savings Estimates from Efficiency Programs	Electricity (TWh)	Natural Gas (TBtu)
Reference Case Delivered Energy for 2030 (AEO)	1,626	5,550
Residential Lighting	44	n/a
Residential New Construction	5	16
Plug Loads & Consumer Electronics	46	n/a
Low-Income Weatherization	24	68
Home Energy Retrofits	118	279
Residential Appliances	30	39
Residential Mechanical Systems	66	446
Behavior-Based Programs	39	48
Manufactured Housing	32	29
Multi-Family Housing	12	73
Total Energy Efficiency Savings	417	997
Savings as % of Reference Forecast	26%	18%

Table 2. Commercial Program Savings Potential for 2030

Savings Estimates from Efficiency Programs	Electricity (TWh)	Natural Gas (TBtu)
Reference Case Delivered Energy for 2030 (AEO)	1,607	3,600
Commercial Lighting	68	n/a
Building Operations	50	83
Small Business Direct Install	12	n/a
Commercial Major Retrofit and Renovation	116	259
Commercial HVAC	53	176
Commercial New Construction	42	94
Combined Heat & Power (CHP)	9*	n/a*
Miscellaneous Energy Use	176	68
Commercial Behavior	40	90
Total Energy Efficiency Savings	565	770
Savings as % of Reference Forecast	35%	21%

*Note: CHP savings represent displaced grid electricity delivered to consumers. For the purposes of this high-level analysis, we do not estimate increased natural gas usage or other fuels required for CHP systems.

Table 3. Industrial and Other Program Savings Potential for 2030

Savings Estimates from Efficiency Programs	Electricity (TWh)	Natural Gas (TBtu)
Reference Case Delivered Energy for 2030 (AEO)	1,009	1,590
Industrial programs	68	107
Agriculture	6	12
Combined Heat & Power	35	n/a*
Total Energy Efficiency Savings	109	119
Savings as % of Reference Forecast	11%	7%

*Note: CHP savings represent displaced grid electricity delivered to consumers. For the purposes of this high-level analysis, we do not estimate increased natural gas sales or other fuels required for CHP systems.

Table 4 provides an overall summary of the savings potential estimates by sector. In our estimates, the commercial sector accounts for the greatest share of electricity savings potential (49%), followed by residential (36%), industrial (9%), and distribution system efficiency (6%). For natural gas efficiency, the residential sector accounts for the greatest share of savings (53%), followed by the commercial sector (41%), and the industrial sector (6%). Our estimates suggest a large potential for energy efficiency savings, and each of the program profiles suggest ideas for program design and deployment that would be needed to tap into this potential for the next generation of efficiency gains.

Table 4. Total Savings Potential for 2030

Savings Estimates by Sector	Electricity (TWh)	% of savings by Sector	Natural Gas (TBtu)	% of savings by Sector
Reference Case Delivered Energy for 2030 (AEO)	4,242		10,030	
Residential Programs	417	36%	997	53%
Commercial Programs	565	48%	770	41%
Industrial Programs	109	9%	119	6%
Distribution System Efficiency	70	6%	n/a	n/a
Total Energy Efficiency Savings	1,162	100%	1,887	100%
Savings as % of Reference Forecast	27%		19%	

Conclusions and Recommendations

Reaching and sustaining high savings from customer energy efficiency programs will be challenging, especially with the numerous changes affecting these markets and technologies. Codes and standards are raising baseline energy performance. While improved technologies continue to offer energy savings opportunities from higher energy efficiency, for many products and technologies, the additional gains may be significantly less than those achieved from past improvements. There is thus a need to look beyond individual pieces of equipment to how various components can be integrated

into optimized systems. Our research also shows the need to focus and tailor programs to those customer markets that provide the greatest opportunities for improvements through energy efficiency programs. This means in some cases identifying market segments within larger markets that provide such opportunities. It also can mean identifying markets that have been underserved by existing programs.

Programs are rising to meet these many challenges. In some cases, new technologies may revolutionize markets and associated customer applications, such as the advent and likely rapid rise of solid-state lighting (LED). In other cases, programs will need to be redesigned to offer incentives and services that result in much higher savings than traditional approaches. Gaining high savings isn't always just about improving pieces of equipment or building components. Significant savings can be realized through better building and systems design, high-quality installation practices, and operations practices that optimize and maintain optimal system performance. Behavior change is another key frontier in achieving high savings. Improved feedback and communications targeted to both inform and motivate customers to action is rapidly growing.

Programs will need to serve all types of customers where there are significant opportunities to capture energy savings cost-effectively. This includes industrial and agricultural customers, segments that have not always been well served by programs for a variety of reasons. It can be especially challenging to design and deliver programs that effectively meet the unique needs of these types of customers. Much progress has been made in developing such effective programs, but next-generation industrial and agricultural programs will need to build on the successes and lessons learned to capture what is still a large potential. For industrial programs, the emphasis needs to be toward whole-system and customized approaches, while also taking into consideration the size and unique characteristics of different types of industrial customers. For agricultural programs, there is a similar need to develop flexible approaches that can best serve the needs of a diverse market.

There also are opportunities to deploy certain systems improvements that can yield significant energy and cost savings. One such opportunity is to make greater use of combined heat and power systems. Another opportunity is to improve the efficiency of electricity distribution systems through such means as reduced voltage and high efficiency transformers.

We provide specific recommendations within each program profile. Our research clearly indicates the continued need to focus and refine programs to meet the unique needs of the many customer markets that comprise the full expanse of electric and natural gas utility customers. It's also important to recognize the dynamic relationship between energy efficiency program goals and appliance standards and buildings codes. We offer these overall strategic recommendations:

- Foster the development and deployment of new, high-efficiency technologies across the spectrum of customer types and end-uses.
- Promote systems approaches to realize the greatest energy efficiency potential.
- Promote the development and advancement of best practices among building designers, contractors, and building operators to achieve high building performance.

- Use market research and data analytics to improve market characterization for customer energy efficiency programs.
- Target behavioral change of all customer types as a key part of overall program portfolios.
- Capitalize on the rapidly expanding capabilities of improved data, communications, and control technologies as part of customer energy efficiency programs.
- Conduct research to better understand “miscellaneous” energy uses in order to better design and target programs that address these uses, which are growing in both absolute and relative use as lighting and HVAC energy use decreases from improved efficiency.
- Refine and apply cost-effectiveness tests to capture full avoided costs and benefits.
- Reflect changes in codes and standards in developing program energy savings targets.

Customer energy efficiency programs have grown and matured over the past few decades. They have become widespread and are common features of the services available to utility customers, whether provided by the utilities themselves or by third parties. Such programs have made significant advances in capturing the large energy efficiency potential estimated by numerous studies. Recent advances in the policies, markets, and technologies affecting customer energy efficiency programs have raised questions and concerns about the ability of these programs to achieve and sustain high energy savings. Our research confirms that programs are approaching certain limits. However, our research also reveals that significant progress is being made with technologies and program designs to create next-generation programs capable of capturing high energy savings. Such advances will create customer value and lower energy costs.

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PART II

Residential Program Profiles

RESIDENTIAL LIGHTING

Synopsis

The outlook for residential lighting is strong. As one of largest and most cost-effective contributors of energy savings to energy efficiency program portfolios, a powerful combination of forces is spurring innovation for the next generation. More stringent federal lighting efficiency standards as well as increasing energy efficiency resource standards in over half the states are driving programs to seize the opportunities presented by the proliferation of efficient lighting technologies. What may once have been the simplest of energy efficiency programs—rebates for compact fluorescent lamps—is now more complex. Next-generation residential lighting programs are increasing customer education, honing financial incentive levels and delivery methods, and engaging in new marketing approaches with retailers, all in an effort to help consumers purchase the most efficient lamps that meet their lighting needs, to allow them to increase energy savings and minimize costs. As the cost of newer efficient lighting technologies, especially LEDs, continues to drop and quality improves, next-generation lighting programs will gain a growing share of program savings beyond standard CFLs.

Background

A typical residential lighting program today may have been in existence for from a few years to decades. Many are comprised entirely of CFLs. Virtually every residential lighting program includes these. CFL savings are very significant and often comprise more than a quarter and sometimes more than half of the savings of entire energy efficiency portfolios. The majority of CFLs purchased or incentivized through the program will be general purpose rather than three-way, decorative, or dimmable specialty CFLs. Even a small or mid-sized program will likely influence residential consumers to acquire a million lamps per year or more than they otherwise would have purchased in the absence of the program. In the past, incentives were often provided by coupons redeemable at local stores, although many current programs have been moving toward upstream discounts through lamp manufacturers and distributors. Some programs provided an incentive of one to two dollars per CFL or provided free CFLs as a component of other residential programs.

Current marketing channels broadly employed in residential lighting programs include printed materials on shelves in stores, radio spots from program implementation contractors (often in conjunction with the program administrator, and often emphasizing cost savings), utility bill inserts, and information included with online billing. The bare spiral, or twist CFL, has been the icon of utility-sector energy efficiency since they were introduced in the 1990s.

Residential lighting energy efficiency programs have sometimes provided consumer education as a minor component of overall outreach and marketing communication efforts. These include, for example, information booths at fairs and trade shows, or children's events demonstrating the differences between lighting options using hand-cranked or pedal-power displays.

Common buy-down residential lighting programs provide sales data to program administrators only on the incentivized products, rather than the full category, and do not provide historical sales data.

They are also characterized by paying incentives on all sales of the efficient product while the incentive is on, which may distort prices, even to below actual cost.

Drivers for Change

There are numerous factors creating a dynamic market for innovation in residential lighting programs.

One of the most visible, and perhaps one of the predominant, drivers of change for residential lighting programs has been the impending impact of provisions of the Energy Independence and Security Act of 2007 (EISA), which imposed efficiency standards for lighting products beginning in 2012 for general service incandescent lamps. These requirements change the baseline per lamp, and therefore the savings attributable for each lamp, within traditional residential lighting programs. By 2014, when the dominant 60-watt lamp is scheduled to be replaced by lamps (of any technology) that meet the new efficiency standards, energy savings attributable to residential lighting programs may decline by more than one-third compared to 2011, primarily because the baseline lamp is getting more efficient due to the new standards.

CFLs have contributed the most to residential lighting program savings, with lighting programs (both residential and commercial) often making up a significant proportion of overall portfolio savings.

The combination of EISA, with the traditional reliance on residential lighting CFL programs for a large share of portfolio savings, along with increasing and persisting state energy efficiency resource standards requiring programs to demonstrate greater net savings, all together represents a powerful motivation for residential lighting program managers to reach for deeper savings, increase program participation, and seek approaches that can have not only save energy, but give the program credit for these energy savings.

A second, though much less significant, driver for innovation is the trend toward CFL “socket saturation” in some markets, primarily the West Coast and Northeast. California plays an important role, as both the largest state market for energy efficiency programs and products, and the state with perhaps the highest socket saturation in the country. Residential customers inclined to use CFLs in these regions have often put in standard twist CFLs in most appropriate household applications.

In some of these markets, energy efficiency portfolio planners and regulators have concluded that the CFL market has been transformed in their state or service territory. In the Northwest states, most incentive money for CFLs has been ramped down. This leaves any additional savings that could be gained from CFL programs on the table and creates a strong incentive to look to other high efficiency lighting technologies to replace the energy savings and fill that void. California and New York are two other large, market transformation-oriented markets looking beyond CFL incentives. In New England, CFL promotion will remain a major part of the regional strategy, but will be increasingly concentrated in innovative program methodologies and less so in traditional programs .

Increasing free-ridership found in impact evaluations of CFL-based residential lighting programs in mature energy efficiency markets such as a California and Oregon, and the resulting reduced

attribution of savings to programs, has been a related trend furthering the search for next-generation program alternatives to sustain savings and capture deeper energy savings.

Dissatisfaction with older CFLs, and a customer perception of poor quality (“people hate CFLs,” said one program manager), has been another force at work pushing for change in the lighting technologies featured in energy efficiency programs and how they are marketed to residential customers.

Residential lighting programs are also affected by trends in the retail prices of CFL lamps and by the shifts in comparative prices among the various lamp technologies. In the 1990s, retail prices of CFLs declined steadily from over \$15 down to the \$10 range by 2000, and they continued to fall until 2006 to 2008, when prices leveled off at approximately \$3 per lamp.³ Increasing global prices of rare-earth phosphors, a material used in the manufacture of CFLs, has pushed up prices recently, although the future impacts on prices are not certain.

Emerging Trends and Recommendations

Roughly three-fourths of all light sockets in the U.S. continue to have incandescent lamps in them, leaving a vast opportunity to be seized by program administrators with next-generation programs.

Technologies

The next generation of residential lighting programs is characterized by a proliferation and diffusion of multiple lamp and lighting technologies, in stark contrast to the relative simplicity of traditional programs reliance on CFLs. In all but a very few markets, this new diversity of widely available, highly efficient products still includes standard twist CFLs as part of residential energy efficiency programs. They have been such a cost-effective means of saving energy to begin with that even with the erosion of savings per lamp impending due to the higher standards required by EISA, they can still be an attractive option. In addition, other lamp options to promote include “2X” halogen lamps, specialty (or “advanced”) CFLs, and several types of LEDs.

Incandescent

On the lower end of the pricing scale, traditional incandescents sell for about \$0.50 each; halogen incandescents, \$1.50; and CFL prices in multi-packs can be \$2.00 or less. Among incandescents, the most energy efficient are 2X halogen lamps, which are twice as efficient as traditional incandescent lamps. For example, if a 60W incandescent lamp puts out 800 lumens, and an EISA-compliant lamp with the same light output might use 43W, a 2X halogen will use only 30W. This may make them appealing for consumers seeking efficiency gains in what looks more like a familiar light lamp. 2X halogen lamps also have superior dimming capability relative to LEDs at the higher light-output levels. However, 2X lamps are just entering the market and are not yet available in most stores. Some

³ *ENERGY STAR CFL Market Profile*, March 2009. U.S. Department of Energy.

program administrators are opposed to promoting 2X lamps because they have promoted CFLs for so long, which have more efficient and more cost-effective lamp options than 2X lamps.

Bare Spiral CFL

More than 70% of the sockets that could have a CFL in them still have an incandescent, and while costs have remained low relative to other options, CFL market share has been slightly lower than the 2007 peak every year since then. As manufacturers continue to work to improve product quality, customer perceptions and inherent technological characteristics persist, including flicker, lack of full brightness when first turned on, safety concerns about the presence of mercury, and distrust that the lamp will really last for complete product life claimed. Even as other technologies are emphasized and promoted by next-generation programs, the existing established base of CFL programs is so large, and the need for cost-effective savings opportunities so great, that bare spirals are likely to comprise a major part of residential lighting programs during the next three years to five years at least.

Specialty CFL

As product quality and quantity grow and customers become more educated about lighting purchases, the specialty CFL category continues to expand, trending toward making up a greater share of residential lighting programs. Specialty CFLs refer to those that are decorative, with different shapes, sizes, or covers, and also lamps that have special attributes, such as being dimmable, three-way, with a different base, or a combination of these features. Often, the characteristics of specialty CFLs address consumer concerns with the negatives or limitations of general purpose CFLs.

Some decorative lighting applications are exempt from EISA standards, leaving the savings above baseline intact and thereby keeping the program savings undiminished by the higher standards, making these applications potentially more attractive to program managers than they otherwise would have been.

LED

Among the alternatives, light-emitting diodes are getting the most attention. Utilities are starting with lighting applications where “reflector LEDs” may be used. LED lamps are inherently directional, sending the light in one direction. A reflector LED includes reflective material inside the housing, so it can readily replace directional end-uses such as lights used in kitchen ceilings, often called “recessed cans.” There are many models of reflector LEDs on the market, and these can provide a cost-competitive replacement for the more expensive incandescent lamps typically used (prices can be around \$8 per reflector incandescent lamp).

As with specialty CFLs, LED technology represents solutions to some of the problems consumers face with bare spiral CFLs, such as a flicker or delay turning on, not being dimmable, safety issues due to mercury, and shorter lamp life than advertised. As a much more recent entrant into the residential mass market, LEDs do not have the low and declining net-to-gross ratio CFLs do in many markets.

LED replacement lamps for omnidirectional lighting applications are still much more expensive than the incandescent or CFL lamps they would replace, leaving such replacements not cost-effective for many applications—yet. The first ENERGY STAR-qualified LED with 800 lumen output started out

at \$40 retail in 2010. Average prices have dropped from over \$30 in 2011 to \$20–25 in 2012 (EPA 2012).

While LED lighting for residential use may not be the “next CFL” within the next three years, the growing focus on LED technology is part of a changing conversation in residential lighting, moving beyond measuring energy savings and cost-effectiveness to measuring overall lighting system performance. Performance includes the quality of the light, the user’s experience, and characteristics of each light and how it matches with the end-use, including light output, life rating, lumens, color temperature, and directionality. A lamp labeled as “equivalent” to a 40W incandescent may not even be close to the overall performance of a 40W lamp as more accurately captured with additional measures of performance attributes. One possible contributing factor to the difference may be that, because EISA standards are based on ranges of lumen output rather than an exact equivalent, the brightness or total light output observed by the customers at home may not meet their expectations; the actual amount of light could be at the low end of the range of lumens.

LED technology is expected to continue to improve rapidly and prices are expected to continue to drop over the next several years. The number of lumens per watt—light output per unit of energy input—is forecast to continue to improve as well. One development worthy of mention in this area is the U.S. Department of Energy competition, the Bright Tomorrow Lighting Prize, commonly known as the “L Prize.” It was designed to encourage lighting manufacturers to develop high-quality, high-efficiency solid-state lighting products.

Incentives

For LEDs, cost-competitiveness is still a barrier to widespread adoption of the technology for residential uses. Prices are many times higher than those of incandescent and CFL lamps. While their useful life is longer than CFLs, LED prices generally range from \$10 to \$50, depending on the type of lamp and number of lumens, whereas CFLs are typically \$2 to \$5 at retail. This makes setting incentives at the most optimal level important, and several major utilities are studying the options carefully.

There is more upfront market research being conducted now. Southern California Edison is currently doing a price elasticity study, evaluating \$10 to 15 rebates for LEDs. Pacific Gas and Electric also conducted a shorter study of incentive levels, which found that a combination of signage and incentives significantly improve demand for LEDs, and that there are diminishing returns to higher rebate levels. In the past, some manufacturers had been unwilling to endorse incentive levels that they viewed as too high, because it could train consumers to only buy if their price was below the true market price that would be optimum for the manufacturers. At one end of the spectrum, Long Island Power Authority is offering a \$40 rebate for the winning L-Prize lamp, bringing the original \$60 price down to \$20. Other utilities and program administrators are planning on \$5 to \$10 rebates for LED lamps.

Program Design

Over-arching realities discussed above shape the environment for residential lighting program design. In the past, programs promoted CFLs as the efficient alternative. Today, next-generation programs

include or are planning to include LEDs, 2X halogens, specialty CFLs, and bare spiral CFLs, and this has implications for program design, some of which are discussed below.

Market Segmentation

The proliferation of widely available efficient lighting technologies, varying degrees of market transformation across regions (and the policy responses to them), the continued importance of lighting as a highly cost-effective—and far-from tapped—energy savings resource for program portfolios, taken together, point to using market segmentation as an organizing principle in program design. Matching-up customer groups with the right lamp for each end-use, with more extensive consumer education, new marketing strategies, and more sophisticated deployment of financial incentives are emerging characteristics of next-generation programs.

This market segmentation, or portfolio, approach is recommended in *NEXT GENERATION LIGHTING PROGRAMS: U.S. EPA Report on Opportunities to Advance Efficient Lighting* (EPA 2012). The report, managed by EPA with technical support by ECOS (now ECOVA), was reviewed by many of the leading experts on residential lighting programs. Defining elements include:

- Diverse portfolio of technologies
- Inclusion of bare spiral CFLs at first; increasing proportion of support for LEDs in future years
- Allocation of incentive dollars to those lamps that result in greatest savings
- Use of ENERGY STAR as the platform to ensure high efficacy and technology-neutrality
- Encouragement of regions with higher adoption rates of CFLs to diversify earlier to LEDs, 2X halogen, and specialty CFLs
- Recommendation that newer programs strongly promote basic CFLs in the short run

These next-generation residential lighting approaches are demonstrated by many of the leading energy efficiency programs, such as those in California and in the Northeast. See the Examples section.

Emerging Retail Strategies

One new program design that holds some promise is “market lift.” Although it is still at the pilot/experimental stage, it does include potentially important innovations. Market lift starts with existing longitudinal sales data (time series data on sales) from a major retailer to establish a baseline of naturally occurring unit sales per period, such as per month. The program and retailer would agree that this is the baseline to use; the program would then seek to improve sales above that baseline and direct the incentives only for success by the retailer in achieving those increases. The parties establish a target above the baseline, which, if the retailer hits that target, they will get financial incentives from the program.

The California Public Utilities Commission (CPUC), among others, is considering taking a market lift approach for residential programs including lighting and appliances.

Some advantages that have been claimed for the market lift model are:

1. Market lift avoids the difficulties of estimating net-to-gross⁴ associated with conventional approaches of providing incentives to customers rather than retailers. It is a different paradigm, using real sales data, rather than having to estimate free-ridership.
2. Market lift allows the program to concentrate its incentives for the sales increases it seeks. The program does not incentivize all products, only those that would not have been sold in the absence of the program.
3. The energy efficiency program is only paying incentives for those units for which it may claim full savings, reducing the cost per unit of saved energy.
4. It does not cut into the retailers' profit margin as some other programs would. If the programs were to buy down the price of these products with incentives, the retailers' margins would be lowered as a result; they also would then miss out on "margin bonuses" from manufacturers, which are sometimes offered to provide incentives to retailers for reaching certain sales levels.
5. Market lift gives the retailer an incentive for what they do best: selling products. The retailers are good at managing supply chains and stocking, and promoting and marketing products. Market lift does not require the program to figure out how to be a marketer in order to increase the sales volume of products: rather, it leaves this to the retailers who already do this well.

There are disadvantages and risks of market lift to be addressed before it will be ready and scalable for mainstream deployment in the next generation of high-savings program approaches. Implementers need to give retailers sufficient time to plan for merchandizing and inventory; the baseline and "lift target" need to have robust assumptions, which requires careful analysis; the program needs to be adaptable and responsive if performance results are inadequate; and implementers need to learn how to work with large retailers.

Marketing and Consumer Education

One program manager anticipates that for the shift from CFLs to LEDs, a significant increase in customer education communications and events will be required. An example would be a "buy one,

⁴ The net energy savings directly attributable to the activities of a utility-sector energy efficiency program are commonly estimated by independent third-party evaluation contractors, which rely on participant surveys asking respondents questions to determine if they would have purchased the light in the absence of the financial incentive, or a different quantity, or postponed the purchase, in order to estimate a net-to-gross ratio for the program. In the case of market lift, free-riders are not an issue because only incremental sales beyond business-as-usual are being incented.

get one free” at a participating retail store. There are some customers interested in bypassing CFLs completely and state that they are waiting for LEDs to come down in price because they do not like the way CFLs dim and lack the strength of light desired for home use. LEDs are just one efficient option on the market, and educating and assisting retail customers to get the right lamp for the job is now desirable to combat customer confusion at the proliferation of lighting choices.

One tool of the new retail lighting landscape for consumer education is the “Lighting Facts” label. The label is now required by the Federal Trade Commission on packaging for all medium screw-base lamps sold. The labels prominently feature the number of lumens per lamp, in part to reduce consumer reliance on thinking of light output in terms of watts, which is no longer a good indicator of what the consumer is really getting in terms of light output.

Savings

Below we present the potential savings in the residential lighting area that could be generated through 2030 if the high efficiency technologies promoted by next generation programs were to be adopted at the maximum potential levels.

Residential Lighting	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	135	NA	For 2030 from <i>Annual Energy Outlook 2012</i>
Average percent savings	65%	NA	Relative to lamps meeting EISA standards—i.e., $(43W - 15W) / 43W$
Ultimate net participation rate	50%	NA	Programs impact 2/3 of the 75% of residential lighting that remains inefficient
Potential savings 2030	44	NA	

Examples

Pacific Gas & Electric

Pacific Gas and Electric Company (PG&E) is among the largest utilities in the nation and has one of the largest energy efficiency program portfolios, with an overall budget of more than \$400 million per year. PG&E’s residential lighting programs are the epitome of the next generation on almost every level, and they are illustrative of many of the recommendations of the EPA/ECOVA next generation lighting report.

PG&E is:

- Continuing to get as much savings as possible from basic CFLs in the near term. (A very mature market for CFLs, bare spirals will not be incentivized at all by the investor-owned utilities in California after the end of 2013).
- Ramping up specialty CFLs (called Advanced CFLs).

- Expanding promotion of LEDs, beginning with reflector LEDs.
- By the end of the next program cycle in 2014, may be putting more incentive funds into LEDs than any other technology.
- Looking into options that change the program design with respect to how they work with retailers, including market lift and Full Category Sales Model (FCSM). FCSM provides the program with more comprehensive sales data, rather than just shipped lamp data, and more of the incentive money goes to the retailer.⁵ They are also increasing consumer education by improving their website, adding educational videos, and training sales representatives with respect to EISA and Lighting Facts labels.

<http://www.pge.com/myhome/saveenergymoney/rebates/light/products/>

Vermont Energy Investment Corporation (VEIC)

In one of the longest established CFL markets, Efficiency Vermont continues to obtain high energy savings from CFL residential lighting programs by reaching underserved market segments with innovative marketing approaches and consumer education and outreach, and also by increasing their promotion of specialty CFLs in an approach integrated with standard spiral CFLs. Vermont Energy Investment Corporation, which runs Efficiency Vermont, has been distributing standard spiral CFLs and specialty CFLs through food banks to reach low-income individuals since 2005. While not new, VEIC has expanded the number of lamps distributed this way many times over, to 160,000 in 2011. This is a high number for a state with a very small population. The next-generation aspect is the expansion of savings by ramping up program participation in an underserved market segment with a highly cost-effective energy-saving technology.

Since 2010, Efficiency Vermont has increased their program emphasis on specialty CFLs relative to standard spirals. “Choose the right CFL for you” points consumers to educational material on their website directly from the main CFL page, seamlessly guiding them toward higher value-added in efficient lighting for the home.

http://www.encyvermont.com/for_my_home/ways-to-save-and-rebates/residential_lighting/residential_lighting_intro/general_info/overview.aspx

⁵ In traditional consumer products-based energy efficiency programs with an upstream or mid-stream rebate, the efficiency program managers will be provided with sales data on the number of units of the incented product that is shipped for their program tracking database; if rebates are instant, or at point-of-purchase, sales data will be provided to the program by the retailer. In either case, the data is isolated and without key contextual data that is highly relevant for program marketing and management decision-making. For example, if sales of CFLs at a particular retailer do not increase, despite efficiency program rebates, it would be important to know concurrent sales levels for incandescent lamps and other alternatives. In the “full category” approach, retailers provide more data to the program and are compensated financially for this.

D & R International Market Lift Pilot Projects

D & R International is an energy efficiency program designer and implementation contractor, and a leader in market lift. They conducted a pilot market lift program at Lowe's retail stores in Wisconsin, working with administrator Wisconsin Energy Conservation Corporation, as part of the statewide Focus on Energy program. For all the advantages described above, market lift remains an unproven approach and is still at the pilot project stage. Lift objectives were not achieved in the Wisconsin pilot, although sales increased, the retailer supported and participated in the project, and D&R International is planning four more market lift pilot projects in Massachusetts, Vermont, Oregon, and Rhode Island. D&R has been working closely with two of the major retail companies.

<http://www.drintl.com/energy-efficiency.aspx>

Recommendations

As several factors erode the cost-effectiveness, net-to-gross, regulatory support, and depth of savings per lamp from traditional CFL programs, residential lighting program managers have access to a wide repertoire of program and technology options from which to choose to maintain and expand their programs' contribution to portfolio savings.

To obtain higher energy savings, we recommend building next-generation lighting programs around the paradigm shift happening at the customer level. Customer confusion stems from the clash between established expectations at point of purchase, from back when a light bulb was a light bulb and the only choice to make was "How many watts?," to the new realities of multiple technologies, specialty features, product life, government labels, lumens, color temperature, and more.

Some key features of programs that will seize these opportunities include expanded customer education; new program relationships with retailers that leverage the retail companies' expertise in promotions and displays, and their market research data; careful selection of those efficient lighting products with the highest customer perceptions of quality; and use of more upfront research on optimizing incentive levels, especially for LED products.

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RESIDENTIAL APPLIANCES

Synopsis

The energy efficiency of most residential appliances has increased greatly over the past 20 or more years due to a combination of standards, utility customer energy efficiency programs, labeling (ENERGY STAR), and market changes. Market shares for energy-efficient appliances, such as ENERGY STAR, are high for many common appliances, such as dishwashers. Consequently many

utilities no longer offer rebate programs for energy-efficient appliances or otherwise have scaled back such programs or offer limited-term promotions. The remaining potential for improved energy efficiency of many of these appliances is more limited than the large gains that have been made in the past. Some appliance technologies, especially clothes dryers, still have significant potential for improved energy efficiency. New program approaches, such as market lift, may be needed to continue to push the markets for these products by directing incentives to retailers. Market research also suggests improvements could be made with customer rebate programs through greater segmentation, data analytics, and targeted marketing to broaden participation from market segments where high penetration of energy-efficient units has not been achieved and to reach customers in the market for an appliance. Another program approach may be to target only the most efficient units of a given type of appliance.

Background

Programs to promote energy-efficient appliances have existed in some form in many states and service areas for many years, some dating back to the 1980s. The basic form of these programs has been to offer a rebate or other financial incentive for the purchase of energy-efficient appliances, including refrigerators, freezers, clothes washers, dishwashers, and room air conditioners. Similar programs and approaches exist for residential heating, cooling, and ventilating equipment (HVAC), covered in a different section of this report. Energy-efficient appliances generally carry a price premium; incentives are designed to address this first-cost hurdle faced by consumers as they shop around and compare alternatives.

While some form of appliance labeling for energy use comparisons goes far back, it wasn't until the introduction of ENERGY STAR labeling that these programs had a consistent platform and national support structure to gain state, regional, and even national scale. With the introduction of ENERGY STAR in the 1990s, utility-sector energy efficiency programs gained a national brand for energy efficiency. Appliance rebate programs quickly became a primary offering of most residential energy efficiency programs.

Appliance efficiency standards have greatly advanced over this same period. This raises baseline performance of all units of a certain type. Most program administrators have viewed their appliance rebate programs for ENERGY STAR or other high-efficiency appliances as pulling the front edge of these markets to encourage customers to demand and purchase the highest energy-efficient appliances. In concert, the program administrators have viewed increasing appliance efficiency standards as a way to push the market towards higher and higher minimum energy performance. The combination of the pull at the top of the market and the push at the bottom has indeed worked to make today's selection of household appliances much more efficient than those available even ten years ago.

The advancing of these markets, though, and especially the rapid growth of ENERGY STAR products in an ever increasing number of product markets, means that the difference between the highest performing units of a certain type and the baseline units (as required by standards) has often diminished over time. The efficiency of common technologies is reaching limits in some cases; the changes required to make further improvements can become more and more costly and possibly less

practical. Thus the cost-effectiveness of these marginal improvements can decline. As a result, many utilities and non-utility programs have discontinued their rebate programs for energy-efficient appliances. This seems to apply mostly to programs in states with long histories of customer programs for energy efficiency. For states that have only more recently initiated major efforts for customer energy efficiency improvement, such programs are more likely to be included in portfolios since these markets have not previously been targeted by programs.

Energy-efficient appliances also have gained high penetration; ENERGY STAR appliances have achieved market shares of 40–50% in many cases. For certain products, such as dishwashers, this may even be 90% in some areas. Some may argue that the markets for many of these products are “transformed” (or very close to this end). As one expert commented, “There are few inefficient models on the market today, which makes it hard for programs to find, promote, and justify more energy-efficient units.”

Drivers for Change

At a high level, there has not been a lot of evolution in appliance program designs over the years: mail-in rebates for qualified energy-efficient products has been the primary program model. The amount of rebate has been a function of selected performance criteria measured against applicable minimum performance as required by appliance standards and the cost-effectiveness of the incremental savings due to higher energy efficiency.

The markets for certain types of consumer appliances do appear to have reached thresholds in terms of the opportunities for additional significant efficiency improvements. Refrigerators and clothes washers have advanced greatly since the 1970s through a combination of standards and customer energy efficiency programs, along with supporting research and market development.⁶ Appliance efficiency standards have led to dramatic improvements in the energy efficiency of common appliances. For example, refrigerators meeting today’s standards use about one-third the electricity of refrigerators on the market in the 1970s, which was before the advent of standards. ENERGY STAR has also been effective in moving the top tier of energy performance higher and higher. These efforts are making it “harder” for programs to find and justify continuation of typical rebate programs. It’s more difficult to find product performance that distinguishes leading units from those meeting standards. At the same time, units meeting ENERGY STAR criteria have achieved high penetration in many appliance markets.

ENERGY STAR performance criteria continue to advance, not only to continue to raise energy efficiency of qualified units, but also to ensure performance and promote other attributes. DOE is

⁶ An early example of promoting the development of higher efficiency products is the “Golden Carrot” program that provided a significant monetary prize to the manufacturer who developed a super-efficient refrigerator ready for commercialization. Another effort was to introduce and promote horizontal axis (“front loading, tumble action”) clothes washers into the American market, which use significantly less water and energy than top loading, agitator washers.

working on metrics and associated threshold criteria to assure “cleanability”—that is, washing performance of dishwashers and possibly clothes washers. ENERGY STAR also uses “water factors” for water savings criteria for dishwashers and clothes washers.

Emerging Trends and Recommendations

The biggest pending changes in next-generation appliance programs likely will occur in program design. With the exception of clothes dryers and clothes washers, there appear to be relatively few near-term breakthrough opportunities for appliance technologies, as we describe below.

Technologies

There appears to be nothing really transformative in terms of large technological improvements and associated improved energy efficiency for dishwashers and refrigerators—the appliances that have long been the primary targets for appliance efficiency programs. Perhaps the biggest challenge for these types of appliances is reducing the cost of the improvements necessary to achieve higher energy efficiency. Many of these appliances are at levels of performance under existing standards or ENERGY STAR criteria that make it difficult for additional improvements to be cost-effective; customers may not be willing to pay more for increasingly marginal improvements in energy efficiency. Many programs are having difficulty keeping paybacks acceptable (cost-effective).

Residential clothes dryers have made dramatic improvements in their efficiencies for both water and energy use (which are clearly related). Even with such improvements, there still is room for increased energy efficiency. For example, new federal standards are being set for clothes washers to meet a minimum “modified energy factor” of 2.0 effective in 2015. The proposed new ENERGY STAR criterion is to meet a Modified Energy Factor (MEF) of 2.6 (30% higher). DOE notes in its new proposed criteria for ENERGY STAR clothes washers that 23% of clothes washers on the market meet this criterion (along with a water factor less than or equal to 3.7) (DOE 2012). The best clothes washers on the market today have a MEF of about 2.8.

The one residential appliance technology that is poised for a significant breakthrough in terms of energy efficiency is clothes drying. The largest improvement possible is to use a heat pump rather than electric resistance as the heating technology needed for clothes drying. Heat pump technologies for clothes drying are being used in Europe and Australia and are much more energy efficient than electric dryers using resistance heating elements. The Super Efficient Dryer Initiative (SEDI), New Jersey’s Clean Energy Program, Collaborative Labeling and Appliance Standards Program (CLASP), and other key stakeholders have played critical roles in promoting the introduction of advanced clothes dryers in to the North American market. However, introduction of these units into the U.S. market still will need a lot of support as a frontier technology. Experts with appliance efficiency programs believe that heat pump water heaters are now ready for prime time. A few programs are offering rebates for these units. Programs will need to promote these products to get them into and accepted by markets, but they also will need to be careful to ensure proper installation and operation. As one example, the Northeast Energy Efficiency Partnerships (NEEP) is managing a process to develop best practices for heat pump water heaters to get the market to accelerate.

While heat pump dryers are on the cusp of entering the U.S. market and gaining market share, this development will take time. It does not seem to be quite ready for a major push and widespread, rapid increase over the next few years. Furthermore, in some cases, switching from an electric dryer to a natural gas dryer is easier if there is already gas service in a home and particularly if there is gas service in the laundry area. Efforts also are underway to improve the energy efficiency of conventional clothes drying technology, including better controls and moisture sensors. Some efforts may also examine improvements possible through reconfiguration of the drums and retooling heating elements for higher efficiency.

The other area for improvement in the market for energy-efficient clothes dryers will be the introduction of ENERGY STAR labeling for the first time. To date, clothes dryers have not been included in the line of ENERGY STAR-rated products largely due to the lack of acceptable metrics and associated test procedures to determine performance. DOE is working on revised test procedures to test and measure performance in ways that accurately reflect customer use of these products. One aspect of earlier efforts to be improved is the automatic shut-off mode. Earlier testing procedures proposed did not incorporate this important energy-saving feature; the ability to accurately sense the “dryness” of a load and turn off the operation is critical to avoid unnecessary on-time and associated energy use. DOE’s new test procedures and ratings would include criteria for sensors and controls in addition to metrics on energy performance to remove water from dryer loads. Experts interviewed for ACEEE’s research indicated that DOE is close to finalizing the final test procedures and associated ENERGY STAR labeling. DOE’s schedule calls for publication of the Final Version 1.0 Specification to be published in April 2013 (DOE 2012). If this occurs, it may be possible to introduce customer programs for ENERGY STAR clothes dryers in 2014.

Another area of technological advancement in appliance technology is that of “smart appliances”—that is, appliances that incorporate communication and control technologies that would enable them to interact with the grid. In this manner, appliances could respond to price or other signals from grid operators to modify operation accordingly, such as not operating during peak, high price periods and instead operate at off-peak, low price periods. While some appliances, initially room air conditioners and refrigerators, will soon be manufactured and sold with smart technologies, actual program and operational experience is largely lacking. It is unclear what the potential energy savings might be through these mechanisms. Clearly a principal benefit will be the load management (reducing peak power demand). Energy savings might arise more from the improved feedback possible through these smart technologies that could be provided to customers. Over the next 2 to 3 years, appliances enabled with smart technologies will become more prevalent and with it, there likely will be more piloting and testing of various applications within customer energy efficiency programs. ENERGY STAR and related programs are examining this closely in terms of improved energy efficiency and performance of such appliances.

Pool pumps may not always be thought of as residential appliances, but in some utility service areas the energy use from pool pumping may be significant. Utilities in California have long-standing programs serving this market. Other states may achieve significant savings from this market. Pool pumps are not yet ENERGY STAR-rated so existing programs have to rely on maintaining a qualified products list for mail-in rebates that have been the prevalent program design. Typically the energy-

efficient units are either variable speed or two speed. Newer initiatives in these types of programs seek to promote the more efficient pumps, as well as controls, installation, and operation. Some programs are working on training programs for contractors to verify proper installation and efficient operation of pool systems.

Program Design

With fewer technological advances on the horizon for significant increases in the energy efficiency of most residential appliances, programs can focus their efforts in two areas: (1) increasing program participation; and (2) promoting only the most efficient products in a given category. Many utilities have eliminated or greatly scaled back their traditional appliance rebate programs because of reaching high saturation and facing greatly diminished prospects for capturing additional savings cost-effectively. To move ahead with such programs generally will require new approaches and entirely new program designs.

While it's true that high-efficiency products have achieved high penetration in many markets, there remain markets where high market penetration has not been achieved. Identifying and analyzing such under-served markets can reveal unique barriers and associated program strategies. Research on efficient appliance programs in California revealed significant differences in participation and resulting market share in different segments of product markets (Frank et al. 2012). This research showed, for example, that participation in appliance rebate programs was much lower for the lower cost refrigerators with corresponding fewer features and generally smaller sizes. More detailed analysis of markets and programs can reveal segments within larger markets that have been underserved by existing programs and therefore provide greater opportunities for programs if they can effectively address the identified barriers. The wealth of customer data available today also can be used for market research with a focus to better identify and segment markets (Bellino and Harris 2012). With improved market data and better analytics, program marketing and services can be tailored to those customer segments most likely to be responsive to programs. It also allows integration across programs such that a customer who may have just participated in a home performance retrofit program may be a prime candidate for appliance rebate programs. With much richer sets of customer data and analytics applied to the data, marketing will become much more sophisticated and much more highly tailored to specific sub-sets of customers within larger customer segments. In short, "laser-focused" marketing can be developed and applied to increase program participation.

Another direction for appliance efficiency programs would be to base them on an entirely new program model. Traditional programs have targeted customers through program marketing and incentives, which are paid directly to them. An alternative model targets retailers (moving "midstream" in product channels). Such "market lift" programs are being piloted with residential lighting products, another mass market in many ways similar to appliance markets. The premise of market lift is that incentives are paid to retailers for increasing sales of targeted products above baseline sales (those expected without program promotions) (Curtis and Montgomery 2012). In this way, retailers are provided the incentives directly for increasing sales of qualified products. They are only paid incentives for sales above baseline sales (which are agreed upon projections based on

longitudinal market data). Retailers thus are rewarded for what they do best: sell products. In these cases, they are rewarded for being able to increase sales of targeted energy-efficient products.

Traditionally, appliance rebate programs have had extensive sets of eligible products, whether ENERGY STAR qualified or meeting other performance specifications. There have not been incentives structured to differentiate among qualified products; essentially meeting the threshold standard was all that was needed to be eligible for the customer incentive. And these incentive amounts were the same for a broad sweep of products without regard to sizes, prices, and features. For example, a certain program may offer a \$75 rebate for all ENERGY STAR refrigerators, whether a modest sized, entry level model with few features or a large model with many features. A new program approach is to provide incentives only to the most efficient units of any given product type. Basing program eligibility, for example, on the “Topten” most efficient products,⁷ focuses program resources on the leading edge of energy-efficient performance. With the saturation of ENERGY STAR products in many markets along with increased appliance efficiency standards, this approach is a way to distinguish leading products from the rest of the market and promote their purchase. CL&P is one utility moving ahead with an appliance efficiency program taking this approach. CL&P plans to offer \$50 rebates for “Top ten” products, specifically refrigerators, freezers, and clothes washers. While this is a modest rebate level, it is sufficient to justify the rebates based on the incremental savings achieved.

CL&P’s appliance efficiency program has three core elements:

- Providing customer incentives for only Topten products.
- Educating consumers to increase consumer awareness and knowledge about the range of efficiencies with a given type of product.
- Working on bulk procurement in selected markets, notably purchases of Topten appliances for low-income housing and new housing development programs.

Two other efforts take this same approach of promoting only the most efficient products. ENERGY STAR now has the ENERGY STAR Most Efficient designation, an extension of the ENERGY STAR brand designed to identify and advance highly efficient products in the marketplace. Southern California Edison, for example, offers a \$75 rebate for refrigerators with the ENERGY STAR Most Efficient designation compared to the \$35 rebate they offer for the ENERGY STAR models that do not meet the ENERGY STAR Most Efficient designation. Likewise, the Consortium for Energy Efficiency’s (CEE’s) Super-Efficient Home Appliance Initiative (SEHA) directs customers to purchase the super-efficient end of the ENERGY STAR spectrum. Michigan’s Energy Saves Program, for example, recommends that customers purchase appliances on CEE’s SEHA list. Efficiency Vermont is another program that is beginning to use the Topten listing of products to determine eligibility for

⁷ [Topten USA](#) is a nonprofit organization that identifies and publicizes the most energy-efficient products on the market across a wide spectrum of consumer products, from automobiles to refrigerators to consumer electronics.

customer incentives. Other programs are likely to begin using Topten as a way to continue offering a residential appliance incentive program.

Topten and related efforts to promote the most efficient products may be most effective when they leverage retail relationships. More incentives can be targeted to retailers, which can help ensure greater product availability and more effective promotions, especially in-store. It also provides opportunities for program administrators to track sales impacts with messaging and promotions.

One program area emerging and worth following is the development of state appliance standards, such as those established by California where regulators have allowed program administrators to spend program dollars on standards processes. While TVs and consumer electronics are covered in a different section of this report, an example of setting state standards for TVs illustrates what is possible for consumer products and appliances. In 2011, the California utilities collaborated with the California Energy Commission to establish efficiency standards for TVs (there are no federal standards for TVs although DOE has initiated a rulemaking and test procedure development process for them). The California investor-owned utilities provided technical assistance, participated in hearings, collected data, and addressed concerns raised by manufacturers and industry associations. Once established, the utilities also worked with retailers to train their sales staff and to offer rebates for the most efficient models. The efficiency increases projected to be achieved by the California TV standards are from 33 to 49%, which would yield an average annual electric utility bill reduction of \$18 to \$30. For their involvement in establishing this state standard for TV efficiency, the California investor-owned utilities receive credit for the savings attributed to sales of color TVs that meet this standard (Cooper and Wood 2011). Other states could benefit from similar efforts to establish standards for appliances, those either not covered by federal standards or for which a higher statewide standard would be justified, such as for climate variations. Massachusetts is working on a proposal for a pilot state standards program as part of a 2013 through 2025 plan in development by utilities. Another role for utilities in the development of appliance standards is that their programs can help grow the market for advanced technologies, which lays the groundwork for future standards.

Another approach that is worth considering is to offer incentives and other program features to encourage people to purchase more efficient product types (e.g., top mount refrigerator-freezer instead of side-by-side) or even smaller units. For example, incentives could be offered for refrigerator-freezers of 16 cubic feet or more (so as to only include primary and not secondary refrigerators) that use 400 kWh per year or less with perhaps a larger incentive for 350 kWh per year or less. ENERGY STAR lists more than 100 top freezer units that would qualify as well as some bottom freezers. The most efficient side-by-side unit listed by ENERGY STAR uses 438 kWh per year (for a 22 cubic foot model). The concept was suggested in a paper by Harris et al. (2006). We are not aware of any program yet using this approach but are researching this further.

In this section, we have discussed various approaches to push program participation and market penetration of energy-efficient products. A program area designed to eliminate inefficient appliances from markets and take them out of operation entirely is appliance recycling. While these types of programs are well-established and long-running in many areas, such programs will continue to offer opportunities to capture savings cost-effectively. Some program administrators interviewed for this

report noted that while they don't offer such programs on an ongoing basis, they occasionally offer the service to "clean up the market" of older units. Such a limited-term program offering may be done in conjunction with a push for high-efficiency replacements of a particular appliance, ensuring that the units replaced are taken out of the market and out of use.

Target Market

Efficient appliance programs are largely targeted to individual homeowners as they are the customers who purchase, own, and operate appliances in their homes. This clearly is a mass market. There are important additional market segments targeted by some programs, such as owners of multifamily buildings or other bulk purchases. Within the mass markets, there are clear sub-markets that may be targeted, such as small window air conditioners for apartments and condominiums. Also, as noted earlier, the increased richness and availability of customer data creates new opportunities using various analytics to sharply define a customer niche and, in turn, develop specific marketing and services designed to appeal to and serve this niche. Market research and program evaluations, such as performed by Frank et al. (2012), also reveal gaps in how well particular customer sub-segments are being served. In this way, the "mass market" is undergoing finer definition and segmentation. Top-tier and related efforts to identify the most efficient products are being careful so not to only define such products in upper tiers of product features, quality, and cost. In this way, a customer interested in buying a basic, modest-sized, no frills refrigerator will be able to choose among the top performers in this product category the same as a customer shopping for a full-featured, professional grade, large refrigerator.

Marketing

Marketing energy-efficient appliance programs is becoming much more focused on specific customer types. There's also a shift by some programs to focus on establishing relationships with retailers so that marketing is left mostly to the retailers themselves with the programs providing supplementary materials to direct interest to the retailers and provide customer information. More emphasis also is being made on marketing that moves customers from interest to conversion; that is, focusing on decision processes and using messages that elicit desired purchase decisions. Again, improved data and analytic capabilities allow for much more focused, granular messages to specific types of customers. It is clear that messaging to urban condo dwellers needs to be different than messaging to suburban homeowners. With improved data tracking and analysis, it is becoming easier to understand what works and what doesn't. Data analytics can reveal how effective messaging leads to observed actions. This gives program administrators greater ability to develop and use marketing that gets the best results. Better targeting of programs improves cost-effectiveness by focusing resources where they are likely to get the strongest customer response and participation. Customers who have participated in energy efficiency programs are more likely to participate in additional programs. Therefore, data analytics is a powerful tool to be able to track complementary programs and target marketing to those customers who have participated in other programs. Such capabilities also can improve program tracking in order to make more timely adjustments to improve program performance.

Marketing to trade allies is another avenue being pursued to increase program participation. Home remodelers and builders clearly can have a major influence on customer appliance purchase.

Electronic marketing and social media provide new opportunities for program marketing. Programs are combining efforts among multiple communication channels in order to create more successful campaigns and do so most cost-effectively (getting greater results per marketing dollar). “Groupon”-type promotions are being explored by some programs, an example of new wrinkles in program marketing. These can be structured to provide an initial rebate for an individual purchase, which then could yield a second rebate if a targeted community reaches a specified threshold of similar purchases. Appliance marketing also can readily be tied to some behavioral change programs. For example, the types of comparative home energy reports employed by many utilities can easily target and promote energy-efficient appliance purchases.

Potential Savings

Below we present the potential savings that could be generated in 2030 by residential appliance programs.

Residential Appliances	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	417	1620	From AEO 2030; includes water heating for clothes washing and dish washing.
Average percent savings	25%	25%	
Ultimate net participation rate	50%	50%	

Examples

Efficiency Vermont: Appliance Rebate Program

Efficiency Vermont (EVT) offers buying advice and rebates on ENERGY STAR residential clothes washers, dehumidifiers, dishwashers, refrigerators, and room air conditioners. In addition, EVT promotes high-efficiency products that exceed ENERGY STAR standards. For example, EVT is a sponsor of Topten USA, mentioned above.

Efficiency Vermont has created a quality rebate program by establishing and maintaining working relationships with key partners and stakeholders such as supply chain actors (installers, suppliers, distributors, and manufacturers), design professionals, national efficiency organizations, and professional and trade associations. EVT engages with partners by coordinating planning efforts, creating innovative programs, sharing information, training, providing financial incentives, creating cooperative marketing opportunities, and making other efforts that deliver value to partners while also promoting greater participation in efficiency activities.

Efficiency Vermont makes an effort to strengthen and expand partnerships with those that influence Vermonters’ energy-related decisions because it realizes that the strength of these partnerships helps increase customer demand for energy-efficient products, services, and information. Efficiency

Vermont works with manufacturers and suppliers to ensure product availability and to reduce lead times for ordering efficient products, as well as with contractors and installers to encourage adoption of new efficient technologies and approaches.

Efficiency Vermont uses a mix of incentives including efficient equipment buy-downs, promotional incentives, contractor sales incentives, and other mechanisms that lower initial-cost barriers for consumers and engage the marketplace as an ally to promote energy efficiency improvements. Efficiency Vermont partners with retailers and manufacturers to provide incentives at the point of sale as well as upstream markdowns and buy-downs that reduce the retail cost of efficient products.

In addition to marketing the appliance rebate program through trade allies, Efficiency Vermont widely publicizes the program through newspaper and TV ads, its website, and inserts in customers' utility bills.

Efficiency Vermont. *Annual Plan 2012*. Prepared for the Vermont Public Service Board. December 20, 2011.

http://www.encyvermont.org/docs/about_encyvermont/annual_plans/EVT_AnnualPlan2012.pdf

Efficiency Vermont website. http://www.encyvermont.com/for_my_home/ways-to-save-and-rebates/appliances/appliances/general_info/overview.aspx

Connecticut Light and Power, and the United Illuminating Company: Home Energy Solutions and Home Energy Solutions—Home Performance Connecticut Light and Power's (CL&P) and the United Illuminating Company's (UE') appliance rebates are offered through the Home Energy Solutions—Core Services (HES) and Home Energy Solutions—Home Performance (HPwES) programs, supported by the Connecticut Energy Efficiency Fund. Qualifying customers can receive rebates for ENERGY STAR clothes washers, refrigerators, freezers, and dehumidifiers in addition to other measures like insulation and HVAC systems.

In the HES Program, a utility-authorized contractor performs an energy assessment, makes on-the-spot improvements, including caulking and sealing of critical air leaks, and, if the customer is eligible, provides money-saving rebates on appliances, HVAC systems, and insulation. A fee is collected at the time of service.

With the HPwES Program, the authorized contractor performs a more in-depth audit and uses state-of-the-art diagnostic testing equipment to identify sources of energy loss in the home. After the audit, the contractor will provide the customer with a custom proposal for services to reduce energy loss, outlining the energy savings these upgrades will provide. If the customer chooses to move forward with the project (including the purchase of appliances that qualify for a rebate), they complete the HPwES application form and submit the proposal for services, along with the application, to CL&P or UE. The utility then sends the customer a formal letter of agreement outlining the incentives for the upgrades. Upon completion, the project is inspected by the utility and the incentive check is mailed to the customer.

CL&P's website: http://www.cl-p.com/Home/SaveEnergy/Rebates/Home_Energy_Solutions/?MenuID=4294985035

Database of State Incentives for Renewables and Efficiency (DSIRE):
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT74F&re=0&ee=0

Recommendations

Appliances will continue to offer significant opportunities for energy savings through increased energy efficiency. However, the magnitude of potential savings is more varied than in the past due to numerous changes in available products stemming from market and technological changes.

To continue to capture energy savings from more efficient appliances, programs should:

- Explore and develop services for those appliances with significant savings potential, such as clothes dryers and more advanced clothes washers.
- Develop new program approaches that can continue to push the markets for energy-efficient appliances, such as “market lift,” which directs incentives to retailers.
- Use market research to identify underserved segments within larger customer markets and develop programs and services to reach such customer segments.
- Use data analytics to focus marketing to those customers identified as most likely to participate in programs.
- Narrow the field of eligible products to sets of only the most efficient units in a given category.

Past appliance programs generally have taken a broad umbrella approach—offering rebates to broad sets of customers for a broad set of products, such as ENERGY STAR. Future appliance programs will need to narrow their focus in several ways. First, they will need to focus on specific technologies that offer the most savings potential. They also will need to narrow their focus on customer segments underserved and most likely to participate. Finally, they will need to focus the messages and messaging to targeted customer segments in order to get intended program results.

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RESIDENTIAL PLUG LOADS AND CONSUMER ELECTRONICS

Synopsis

Driving energy savings from consumer electronics programs is dependent upon the technologies rebated and participation on the part of retailers, manufacturers, and consumers to increase the saturation of energy-efficient devices. It is important for program administrators to expend funds that increase the availability and prominence of energy-efficient products on retailers' shelves, which, by stimulating demand, in turn encourages manufacturers to produce a higher volume of efficient devices. But consumers rarely include the energy efficiency of a product as a major purchasing consideration, so they are unlikely to purchase an energy-efficient television, for example, unless they are educated about its benefits. On-site training and education of retail sales forces can therefore have a significant impact on customer purchases of energy-efficient products. Well-designed marketing efforts and accessible educational resources, such as social media and program websites, can have a significant impact on consumers' purchasing decisions and drive demand for energy-efficient products. Given that the number of electronic devices in our homes is rising, it is also important for program administrators to educate consumers on how to effectively manage the energy consumption of these devices.

Background

Energy efficiency programs that target plug loads and consumer electronics, hereafter referred to as "consumer electronics" programs, generally try to achieve savings by offering upstream incentives to big box retailers, such as Best Buy and Home Depot, as well as manufacturers in order to increase the sale and production of energy-efficient products. The targeted standard for these products is typically the ENERGY STAR standard, though some manufacturers have developed products that exceed the respective ENERGY STAR standard, a good example of which is televisions.

Consumer electronics programs target retailers and manufacturers rather than providing incentives directly to consumers for a number of reasons. Retailers, for example, are well positioned to influence consumer choice as they already commit a great deal of resources to marketing these types of products through various media advertisements as well as point-of-purchase materials. Incentivizing manufacturers to produce more efficient equipment or buying down the cost of their products helps to increase the saturation of energy-efficient products in the market. Program administrators do occasionally offer rebates directly to consumers, but argue that this is not the most effective use of program funds because the incentives are small and the processing costs are significant.

The types of products that are targeted in consumer electronics programs vary considerably. Energy-efficient lighting is occasionally included, though program administrators generally target lighting through autonomous lighting programs or building retrofit and new construction programs. Typically consumer electronics programs target plug loads that are heavy consumers of energy—such as audio/video products, computer electronics, and, increasingly, televisions—focusing a lot of attention on those products that spend a significant amount of time operating in stand-by mode. For program administrators in warmer climates, it is not uncommon for them to target pool products as well. Retailer incentives for the sale of energy-efficient appliances, such as clothes washers and refrigerators, are also not uncommon, but appliances, like lighting, are also generally targeted through

autonomous programs. For the purposes of this analysis, we are only concerned with consumer electronics, such as televisions, audio/visual equipment, etc.

Drivers for Change

According to the Energy Information Administration's (EIA) *Annual Energy Outlook 2012*, miscellaneous end-uses (consumer electronics) are a growing share of residential energy use—it is the second fastest growing end-use next to cooking, growing at a rate of 1.4% per year, from 10.6% of residential electricity consumption in 2012 to 12% in 2030 (EIA 2012). Consumer products programs are relatively recent additions to program portfolios, so these types of programs have only scratched the surface in terms of their savings potential.

With that in mind, there are essentially two major drivers for change for achieving deep savings from consumer products programs: increasing the saturation of energy-efficient products and increasing the efficiency of new and existing products, such as through the support of federal appliance standards and the ENERGY STAR brand.

Product Saturation

Increasing the saturation of energy-efficient plug loads and consumer electronics in our homes and businesses is the primary driver. While the saturation of ENERGY STAR televisions and other audio/video equipment has been consistently trending upwards since the inception of the ENERGY STAR program, the absolute number of these types of products is also increasing as homes become bigger and income levels rise. The decreasing cost and increasing ubiquity of information technology and communication will only exacerbate this trend. Influencing consumers to choose the more energy-efficient technology when making a purchase will be crucial to generating savings and keeping energy consumption from careening out of control.

Advancing Technology

The second major driver of energy savings is the technological advancements of the products themselves. It is clear that consumer electronics are becoming more and more efficient, in large part due to the standards imposed by federal appliance and equipment standards and the federal ENERGY STAR program. Another facet of the potential impact on savings from a technology perspective is the types of products that are included in these programs. There are many energy-hungry products for which no federal efficiency standard exists and no ENERGY STAR standard has been developed, such as cable set-top boxes,⁸ video game consoles, and new kinds of technologies such as tablets and smart phones. So working with state and federal governments as well as manufacturers to develop standards and encourage the production of energy-efficient technologies will be important.

⁸ The U.S. Department of Energy is working on testing procedures and efficiency standards for cable set-top boxes. Industry and energy efficiency groups are engaging in discussions on a voluntary agreement: http://www1.eere.energy.gov/buildings/appliance_standards/residential/set_top_boxes.html.

Marketing and Education

While retailers can be provided incentives to boost sales of energy-efficient products and, likewise, manufacturers can be provided incentives to produce more of them, energy efficiency is not a primary purchase consideration for consumers. In fact, energy efficiency is often one of the lowest motivating factors of the purchase of consumer electronics. Retailers and manufacturers must therefore do more to increase consumers' awareness of the availability and benefits of purchasing energy-efficient products, as well as educate consumers on the various ways they can manage the energy consumption of their devices.

Managing Power Consumption

Since the saturation of consumer electronics is increasing rapidly, it is becoming more important to be able to manage their power consumption. The vast majority of these products operate in distinct modes: stand-by and active. Consumer electronics spend much their lives operating in stand-by mode, during which they consume a substantial amount of energy: research has found that stand-by electricity consumption of plug-in devices accounts for about 20% of the electricity consumed by these devices, or about 4% of home electricity use (ECW 2010).⁹ Some products also require persistent charging (cell phones, tablets). Therefore, there are large efficiency gains to be realized from decreasing the energy consumption of these products across all modes of operation, especially when users are not present or actively using them. Consumers can achieve this by installing devices to automatically manage plug-load energy consumption, as well as take behavioral measures to manage energy consumption manually.

Emerging Trends and Recommendations

Technologies

Program administrators have identified three ways in which to achieve savings through a focus on technology: (1) increase the number of different energy-efficient products for which retailers are incentivized to sell and manufacturers incentivized to develop; (2) support state and federal efforts to develop and improve energy efficiency standards; and (3) find ways to help consumers manage the increasing number of electronics permeating our homes and businesses.

More Variety = More Savings

Consumer electronics programs generally focus on a core set of products: computers (PCs and monitors), audio/video equipment, and, increasingly, televisions. Televisions have only recently become integrated into these programs since the introduction of the first ENERGY STAR specification for televisions in 1998.¹⁰ The potential for savings from energy-efficient televisions is considerable: LCDs and plasma TVs generally consume more energy than LED TVs, and the saturation of ENERGY STAR televisions is still quite low (in contrast to ENERGY STAR

⁹ This does not include stand-by electricity used by hard-wired devices, such as major appliances.

¹⁰ See http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=TV.

appliances).¹¹ There are also efficient products that go beyond ENERGY STAR standards; there are many manufacturers that have developed products that achieve electricity savings well above the ENERGY STAR specifications. Topten USA has listings of the top ten most efficient products for a variety of consumer electronics, including televisions.¹² However, the fact that the energy efficiency of a television is one of a consumer's last purchase considerations, next to features such as size and clarity, creates a massive barrier despite the proliferation of energy-efficient models on the market.

There has also been a lot of discussion among program administrators about the incorporation of cable set-top boxes, which are currently unregulated by federal standards. ENERGY STAR has developed a specification (currently at Version 3.0¹³), though there are different requirements for set-top boxes manufactured by the myriad cable providers across the nation. Because of the variety of products available within this category, developing one standard applicable to all products is proving to be quite difficult, which, until resolved, will limit scalability. If the market can be successfully penetrated, the savings potential is considerable: ENERGY STAR reports that set-top boxes meeting its current standard will achieve 40% savings compared to conventional models. Eliminating multi-DVR set-top boxes in homes and replacing them with a thin client set-top box is another opportunity with high savings potential.

Finally, to help consumers manage their electronic devices, manufacturers have developed the advanced power strip (APS), which has a similar look to a surge protector and has the ability to regulate energy consumption in products that are connected to it. APSs currently eliminate power being consumed by auxiliary devices in sleep mode, such as speakers or DVD players, when a control device, such as a computer or TV, is not being used. Other APSs (called Tier 2) are able to achieve further savings by shutting off the control device when it has not been operated, often by remote control, for a set time period. Like set-top boxes, there are numerous manufacturers that have developed products with varying functionality and savings, which presents a challenge, so the development of a specification is ongoing. Consumer awareness and interest for this product is practically non-existent, however, and their installation is not particularly intuitive, so APSs either need to become easier for consumers to install or they need to be installed as part of another energy efficiency services (such as a home energy audit, for example).¹⁴

Support Standards

Several regional energy efficiency organizations and leading program administrators (Northwest Energy Efficiency Alliance, Northeast Energy Efficiency Partnerships, Consortium for Energy

¹¹ Integrated occupancy sensing technology, automatic brightness control, and auto-power-down are existing technologies for televisions with very low penetration and high potential.

¹² See <http://www.toptenusa.org/>.

¹³ See http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=ST.

¹⁴ Additional opportunities for energy savings from technological innovation in consumer electronics exist for computers and game consoles. For more information, see Frank et al. (2012).

Efficiency, and the New York State Energy Research and Development Authority) are working cooperatively among themselves and with ENERGY STAR to develop specifications for products that are currently unregulated by federal appliance and equipment standards, such as advanced power strips. Supporting federal minimum efficiency standards is another way to help transform the market for consumer electronics, and program administrators that have established relationships with manufacturers through consumer products programs have the ability to leverage that relationship in support of new and existing standards. Uniform federal standards are ideal in order to limit the variation of product performance while ENERGY STAR specifications establish incentive for manufacturers to push the envelope and expand consumer choice while achieving greater energy savings.

Home Energy Management

With the number of electronic devices on the rise, the management of these devices will be very important and a potential source of huge energy savings, especially in the home. There are examples of utilities incorporating pertinent energy management measures into existing programs (see the Residential Home Retrofit profile) as well as developing autonomous home energy management programs.¹⁵ APSs are one technology that is being developed to address this issue, though their focus is primarily on reducing the energy consumption of connected devices in sleep mode (capturing active mode power waste is a Tier 2 focus). Home energy management systems, on the other hand, allow for a much more interactive and, hence, behavior dependent approach to controlling the energy consumption of electronic devices, including a home's HVAC system and appliances. Using in-home displays allows users to monitor energy consumption in real-time and exercise a greater deal of control over usage patterns, as opposed to assigning control to an electronic device (such as an APS). In concert with a smart meter, home energy monitoring can provide important information on time-of-use and facilitate the installation of efficient products, as well as provide information on market saturation.

Program Design

Consumer electronics programs are fairly new and existing programs generally appear to be working well, though there are aspects that can be augmented. Targeting retailers and manufacturers through incentives or buy-downs has proved to be an effective and preferred method of increasing the saturation of energy-efficient consumer electronics. Some program administrators also offer rebates directly to consumers, but acknowledge that this method is unlikely to influence consumer purchases as much because energy efficiency is not a primary purchase consideration. Consumers research purchases using information from retailers (in-store browsing, website browsing, and advice from

¹⁵ The Public Service Company of Colorado (Xcel Energy) is piloting an In-Home Smart Devices program during the 2012–2013 program years, which is “designed to test how customers respond to various control strategies and energy consumption delivered to their homes through in-home energy management devices.” The pilot provides devices and installation at no cost to participants, which can include utility-controllable programmable thermostats and plug-load or hard-wired appliance modules, and controllers to communicate with those devices (Xcel 2011).

sales associates) and, to a lesser-degree, manufacturers, so it is better to focus program efforts on facilitating these vehicles for influencing consumer purchase decisions.

One of the ways program administrators can help retailers and manufacturers sell more efficient products is to train sales associates on the benefits of energy-efficient products, such as ENERGY STAR-certified televisions. Program administrators can also reward retailers for high sales with cash or non-monetary rewards as further encouragement. Market studies have shown that sales associates rarely mention energy efficiency when describing the features of various products unless they are prompted by the customer (NEEA 2010). This is particularly pertinent for cable set-top boxes and advanced power strips, devices for which the market for and standardization of efficient products is only beginning to develop. Some program administrators and regional energy efficiency organizations are continually working with manufacturers, ENERGY STAR, and the DOE to develop standards for these products, but the onus will be on state and local program administrators to educate consumers on plug loads generally as well as to market these products.

Additionally, given the frequency with which new and updated products are brought to market (annually, if not more frequently), there is a need to consistently reassess the market to address product cycles and train sales associates accordingly. For example, there are already discussions among program administrators on the future integration of cable set-top boxes directly into televisions, which manufacturers predict will begin entering the market in the next 3–5 years. The Consortium for Energy Efficiency regularly holds forums on consumer electronics for program administrators and other interested stakeholders, which is a valuable asset to any program administrator attempting to stay informed on market developments in order to make timely adjustments to program design.¹⁶

Lastly, consumer electronics programs can include design elements that achieve energy savings from a non-technological perspective. In other words, there are more direct, behavioral approaches to generating energy savings that are technically feasible, but are not necessarily convenient for consumers. These opportunities range from manually unplugging or turning off devices to using timers. There are major barriers to the implementation of these approaches, such as a lack of interest and inconvenience, which behooves program administrators to invest in educating consumers on home energy management and devising different approaches to addressing these behavioral barriers. Research shows that consumers respond to well-crafted messaging and access to usage data, though attributing savings to programs from behavioral approaches is a potential barrier for program administrators (ECW 2010).

Marketing

The growth of information technology and communication is creating massive opportunities for new marketing techniques for consumer electronics. Programs have been experimenting with social media

¹⁶ See <http://www.cee1.org/> and <http://www.ceeforum.org/>

as a method of reaching a greater number of consumers, such as providing special offers through Facebook and Twitter or blogging on program and partner websites. Through social media, program administrators can also tie sales promotions to special events, such as back-to-school specials (energy-efficient computers), the Super Bowl (energy-efficient televisions), holidays (energy-efficient audio/video equipment), etc.

Meanwhile, more traditional methods of marketing can still be harnessed to drive consumer purchases of energy-efficient products. Marketing should be concentrated at the retailer level, but for certain products, such as computers, enough purchasing is done through manufacturers (Dell, Apple) and the Internet that messaging should be focused at a variety of channels. A lot more work can be done through point-of-purchase marketing, as well as training retailers' sales associates to extoll the benefits of energy efficiency when discussing products with consumers (see the discussion of the market lift model in our residential lighting profile). There is evidence that consumers are accepting of a modest increase in price for more energy-efficient equipment, especially when it is marketed in terms of its long-term monetary savings. ENERGY STAR has developed resources that program administrators can utilize for retailer/sales outreach as well as developed point-of-purchase marketing strategies.¹⁷ The Consortium for Energy Efficiency, through the CEE Forum, also provides resources on effective marketing and messaging campaigns for program administrators to utilize when coordinating with retailers.¹⁸

Potential Savings

Below we present the potential savings that could be generated in 2030 by consumer electronics programs in the residential sector that integrate the design elements discussed above.

Consumer Electronics	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	205	NA	For 2030 from EIA 2012; includes TVs, set-top boxes, PCs, and related equipment. Does not include small electric devices.
Average percent savings	28%	NA	High-end of range reported by ECW 2010.
Ultimate net participation rate	<u>80%</u>	<u>NA</u>	ENERGY STAR appliances routinely average around 50% of sales. Technological and behavioral approaches should push this number much higher.
Potential long-term savings	46	NA	

¹⁷ See http://www.energystar.gov/index.cfm?c=pt_reps_res_retail.pt_reps_res_retail

¹⁸ See <http://www.ceeforum.org/library/results/taxonomy%3A90.99%2C580>

Examples

Since consumer electronics programs are fairly new, there are only a few utilities or program administrators that have introduced innovative design elements to drive energy savings. Developing and expanding these programs is important to curtailing load growth in the U.S. given that the energy consumption of consumer electronics is the second-fastest growing end-use next to cooking, according to the EIA. In the near future, significant savings can be achieved by expanding the existing model to scale in accordance with the variety of drivers identified above. Still, there are some program administrators and related organizations that are actively engaged in consumer electronic programs. We discuss a few of them below.

Northwest Energy Efficiency Alliance (NEEA)

NEEA's role in the energy efficiency market is unique. It is generally not a program administrator; rather it focuses on market transformation, working with utilities and other program administrators in its region to help them achieve their energy efficiency goals. However, NEEA does run a consumer electronics program targeting televisions, and it is considering adding set-top boxes, gaming consoles, and advanced power strips. NEEA works with regional utilities, retailers and manufacturers to increase the saturation of energy-efficient televisions. NEEA provides per-unit incentives directly to retailers (which vary by size, of \$6-\$20) and works with them to maximize the effectiveness of point-of-purchase materials, as well as providing training on energy efficiency to sales associates. While NEEA does not provide incentives directly to manufacturers (it influences them by stimulating demand at the retailer level), it meets with them during trade shows to discuss pertinent issues. NEEA also provides consumer resources and education through its Energy Forward website. Through its efforts, 26% of all residential TVs sold in the Pacific Northwest Region meet or exceed ENERGY STAR 5.1+20% or 5.1+30%.

<http://neea.org/initiatives/residential/televisions>

<http://energyefficientelectronics.org/>

Pacific Gas & Electric (PG&E)

PG&E's Business and Consumer Electronics Program is fairly new. PG&E provides midstream incentives to retailers, manufacturers, and distributors to encourage increased stocking, promotion, and sales of high-efficient electronic products including computers, computer monitors, and televisions. The program provides incentives to the market actor best positioned to influence purchasing, stocking, and specification decisions and provide field support services to update marketing materials in retail stores and support education to the retail sales force. PG&E uses online systems to help educate customers and enable identification of the most energy-efficient and environmentally friendly products available in the market for multiple categories. In 2011, the program achieved gross savings of almost 50 GWh.

Northeast Energy Efficiency Partnerships (NEEP)

In 2010, NEEP initiated working groups to focus on marketing best practices, product testing, and deemed savings for advanced power strips to help the energy efficiency industry better understand the

savings potential of these products. In 2012, the working group produced an APS deemed savings report, which focuses on generating savings from devices that operate in stand-by mode. NEEP is in the process of developing specifications for APS that target active-mode energy waste (where the product is on but not performing its main function, like a television inadvertently left on) as well as conducting an analysis of direct versus retail installation opportunities.

<http://neep.org/regional-initiatives/3/56/Business-and-Consumer-Electronics/Project/27>

Recommendations

Given that consumer products programs are still in their nascent stages, there is much that can yet be done to augment these programs in order to drive deeper savings. Ultimately their success will be dependent upon a prudent mixture of all the design elements we discussed above.

Providing retailers and manufacturers incentives to develop and promote a variety of energy-efficient products is a primary driver (there is room for rebates aimed directly at consumers, but program administrators argue that this is not the most effective use of program funds). In-store marketing can be accomplished through point-of-purchase materials as well as training retail sales associates on energy efficiency and offering rewards for increased sales of efficient products. Historically, most programs started with PCs and related equipment, but there are a number of additional electronics, both regulated and unregulated by federal standards, for which energy-efficient alternatives exist, such as televisions and cable set-top boxes. Targeting computer equipment and televisions is today common practice for these types of programs. New electronic devices are perpetually being released, so it is important for program administrators to keep informed of market developments and tweak program design accordingly.

Additionally, considering the myriad electronic products that exist, not only overall but within categorical types (televisions, set-top boxes, smart phones), and new products entering the market, the more effort that program administrators can exert to promote uniform and practical standards and work with partners that are engaged in similar activities, the more likely manufacturers will be inclined to develop these products and ensure their availability and affordability. For example, program administrators can work with cable companies to encourage them to purchase set-top boxes to the existing ENERGY STAR specification and to encourage their suppliers to develop more efficient products.

Equally important is ensuring that consumers are aware of the availability of these products and their benefits through various marketing and labeling efforts that include point-of-purchase and web-based methods. For example, the ENERGY STAR brand is well-recognized, something that the Northwest Energy Efficiency Alliance recognized and replicated in developing their Energy Forward program, which utilizes a unique label and a website to educate and raise awareness of the availability of energy-efficient televisions.

Along with marketing consumer electronics programs, program administrators must also educate retailers, manufacturers, and consumers on the benefits of purchasing energy-efficient electronics, as well on how to effectively manage the increasing number of electronic devices in their homes, from

both a technological and behavioral approach. Advanced power strips offer a lot of potential for savings and more program administrators are beginning to include them in programs, but customer awareness is low, so a lot has to be done at the retail level to promote their availability. Point-of-purchase and web-based resources are also effective methods of disseminating educational information to consumers in order to influence their purchasing decisions.

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RESIDENTIAL MECHANICAL SYSTEMS

Synopsis

Mechanical systems programs have long been a staple of energy efficiency program portfolios and will continue to be so, as these programs provide homeowners opportunities to generate meaningful savings without the costly investment of a whole-home retrofit. Still, mechanical systems programs must provide services beyond equipment replacement: improving a forced air heating/cooling system to ensure it delivers conditioned air efficiently is a source of significant savings (complete system replacement), typically around 20% of heating and cooling loads when incorporating quality installation/quality assurance measures. There are a variety of products (air-source versus ductless heat pumps, evaporative coolers) and efficiency levels within product categories (electric versus natural gas water heaters) that allow customers a considerable degree of choice when investing in new equipment. Driving savings for these programs then becomes a matter of educating customers on the benefits of energy efficiency and working with the supply chain—such as retailers, their sales associates, and manufacturers—to increase the availability and sales of energy-efficient products.

Background

Rebate programs for the purchase of energy-efficient mechanical equipment have long been a staple of energy efficiency program portfolios. While home retrofits that involve heating, ventilation, and air conditioning upgrades should ideally be complemented by additional measures that constitute a whole-home, comprehensive retrofit, not all homeowners require whole-home retrofits as many are simply seeking to replace an inefficient unit or one that has come to the end of its life. This is true for homes that heat and cool with gas and electricity, as well as those with hydronic (water) heating systems. Upgrades to water heaters for potable water are most often one-off installations, though measures related to the delivery system (pipe insulation, efficient faucet aerators and showerheads) are relatively inexpensive measures that are easy to install and are therefore sometimes included.

Incentives for upgrades to HVAC and water heating systems are generally targeted to end-users and are structured to address the high up-front and installation costs of mechanical equipment. Rebates

are often tiered as well, focusing on equipment with varying levels of efficiency in order to provide consumers with greater choice so that they are not forced to purchase the most efficient piece of equipment on the market. Programs focus on providing rebates for ENERGY STAR-qualified equipment as well as products that go beyond ENERGY STAR standards for most equipment within these end-use categories. Some programs target retailers, contractors, and manufacturers in order to incent them to sell (or produce) larger volumes of efficient equipment, leveraging the knowledge and relationships that distributors and manufacturers have with their consumers. This can also facilitate stocking practices so that units available for “emergency repairs” are more likely to be relatively efficient units, or at least they are an available option to consumers.

Drivers for Change

There are many ways for program administrators to increase savings from their mechanical systems programs. Programs can focus on improvements to the technologies, either by offering various product types within an end-use category (air-source or ductless heat pumps, electric resistance or heat pump water heaters) or by focusing on increasing the saturation of more efficient equipment within a product type (air-source heat pumps, central/room air conditioners, electric/natural gas water heaters, etc.). This also includes the ancillary measures usually offered with equipment upgrades, such as duct sealing, tune-ups, or quality installation/assurance services.

The performance of these types of programs can also be enhanced by modifying the program design. For example, as mentioned above, most programs of this type target incentives toward the consumer. Some programs have begun targeting the supply chain—retailers, contractors, and manufacturers—because of the difficulty of convincing consumers to invest more money in more efficient and, hence, more expensive equipment.

Lastly, if homeowners are to be convinced of the added benefits of purchasing more efficient HVAC and water heating equipment, in particular the energy and non-energy benefits of a comprehensive home retrofit, programs need to expend funds training and educating contractors to act as marketers of these services. The reluctance of homeowners to invest large sums, which can reach or exceed \$10,000, for a comprehensive retrofit requires effective marketing and also behooves contractors and program administrators to tread carefully in order to avoid being perceived as selling unnecessary services.

Emerging Trends and Recommendations

Technologies

There are a number of ways that technological improvements can play a role in delivering greater energy savings when upgrading residential mechanical systems. A notable debate on the role of technology surrounds central versus zonal heating and cooling, in particular the relative efficiency

and cost-effectiveness of air-source heat pumps versus ductless heat pumps.¹⁹ Traditional central heating and cooling systems have begun to reach their maximum efficiency in that improvements to these systems are generating less and less incremental efficiency gains. In response, a number of program administrators and regional energy efficiency organizations have begun focusing on ductless heat pumps (DHP) for meeting heating and cooling loads, promoting them as a more efficient alternative to electric resistance heating equipment. Ductless heat pumps offer more zonal control and do not require lengthy, expensive, and often poorly completed installations and/or upgrades typical of central, forced-air heating and cooling systems. There are barriers to increasing the saturation of DHPs, however, specifically their high cost and contractors' unfamiliarity with the technology.

In the Southwest region of the U.S., several programs have begun offering rebates on evaporative cooling²⁰ systems as an efficient alternative to traditional central air conditioning systems. Evaporative coolers condition air through the evaporation of water, whereas traditional air conditioning systems use vapor-compression or absorption refrigeration cycles. Air temperatures can be dropped considerably through the phase transition of liquid water to water vapor using much less energy. In hot, dry climates, evaporative cooling has the additional benefit of conditioning the air with moisture. Evaporative coolers are less effective in cool and humid climates (like the upper Midwest), though they are capable of delivering cool air up to a certain level of humidity. While this is not a new technology, there have been several advances, such as two-state evaporative coolers, that have made them applicable in a wider variety of climates and have increased their operating efficiency.

In terms of water heating, heat pump water heaters (HPWH) are a technology that is enjoying a resurgence of popularity. Like ductless heat pumps, many program administrators and regional energy efficiency organizations are focusing their efforts on increasing the saturation of this technology due to its considerable savings potential relative to traditional electric resistance water heaters. HPWHs pull heat out of the surrounding air via a heat pump, but they also contain a backup electric heating element to meet peak demands. The efficiency of HPWHs is dependent upon the quality of installation, which, most importantly, affects the amount of time it spends in heat pump versus electric resistance mode.²¹ The development of ENERGY STAR criteria along with the increasing stringency of federal standards for water heaters are driving interest in this technology, though there are barriers to be surmounted, such as the quality of installations, the surrounding environment (not just climate, but the area of the home in which the unit is installed), and sizing. Unit price is also a barrier and there is some loss of savings in cooler climates, the latter of which will require the development of regional standards.

¹⁹ For information on how ductless heat pumps operate, visit <http://goingductless.com/>.

²⁰ See http://www.consumerenergycenter.org/home/heating_cooling/evaporative.html.

²¹ There are other factors, some arguably more important than the quality of installation, that also influence HPWH efficiency. These include proper sizing (relative to household demand), installation location, and climate region.

Condensing gas water heaters are a very promising new entry into the residential market. They work like a normal tank-type water heater, except that before the combustion gases are vented outside, the latent heat in those gases is captured and used to help heat the water in the tank. Condensing gas water heaters can achieve efficiency levels much higher than conventional and even high-efficiency gas storage units, although they are not nearly as efficient as high-efficiency electric storage units and heat pump water heaters. There are super-efficient condensing and “near-condensing” gas water heaters that achieve greater efficiency levels than standard condensing units, though they are currently niche products and relatively expensive.

While there are savings to be realized through the introduction of new products like DHPs and HPWHs, improving a forced air heating/cooling system to ensure it delivers conditioned air efficiently is a source of significant savings (proper sizing, duct sealing, etc.) if customers are not willing to install new and different technologies. Furthermore, there are considerable savings opportunities yet to be realized by increasing the market saturation of efficient equipment within existing product types, such as high-efficiency air-source heat pumps, central and room air conditioning units, and electric or natural-gas fired water heaters. ENERGY STAR has developed standards for the vast majority of heating, cooling, and water heating equipment, which has stimulated a large market of energy-efficient equipment, thereby offering consumers a wide variety of choice beyond products that only meet minimum federal standards. There is also a wide variety of products available that go beyond the ENERGY STAR specifications, for which many programs offer rebates.

Program Design

Much can be done to propel energy savings through program design improvements. Currently, these types of programs target consumers by providing rebates for individual installations of equipment, though more can be done to promote duct sealing, quality installation/assurance, and additional water heating measures (pipe insulation, low-flow faucet aerators and showerheads) in order to boost savings generated by comprehensive upgrades to the whole system. However, program administrators note that comprehensive, whole-home retrofits are superior to one-off installations in terms of driving energy savings, particularly because of the interactive effects of HVAC systems with the dynamics of the rest of the home. Still, for the foreseeable future, these types of programs will continue to be included in program portfolios, in part because homeowners are less inclined to invest large sums of money for comprehensive retrofits; motivating homeowners to invest in high-efficient HVAC and water heating equipment is a challenge in-and-of-itself.

Despite the best efforts of program administrators, homeowners simply do not understand the long-term value of installing energy-efficient equipment because it is difficult for them to see past the high up-front costs. To meet this challenge, programs are beginning to focus more on the supply chain, working with retailers, contractors, and manufacturers in order to increase the saturation of energy-efficient products, especially those products that have a very small market share because they are relatively new, such as ductless heat pumps and HPWHs. These entities also have a unique relationship with homeowners, which can be leveraged to educate homeowners on the energy and non-energy benefits of high-efficiency equipment, as well as to motivate them to invest in more measures along the way to a comprehensive, whole-home retrofit. Programs also are using funds to

train and educate contractors so that they can act as marketers of additional energy efficiency measure installations and services, though training and education are also important for programs that are offering installations of new products like ductless heat pumps and HPWHs.

To the degree that forced-air heating and cooling systems continue to be installed in homes, there will be a need for quality installation/assurance (QI/QA) services to maintain the operating efficiency of these systems.²² According to some in the industry, an alarming number of forced-air HVAC systems are installed poorly, rendering the efficiency of the units at a fraction of their rated efficiency. Many programs offer tune-ups for forced-air systems, but these services exist largely to address problems that arise due to the failure of contractors to install these systems properly in the first place. These programs have begun to offer quality installation/assurance services, which focus on equipment sizing, ductwork, and refrigeration charge to ensure optimal performance. QI/QA services require programs to invest funds in training and education contractors, but QI/QA can reduce the need for HVAC tune-ups, which themselves are often performed poorly and therefore yield little energy savings.

Finally, program administrators have found it extremely valuable to “internalize expertise.” That is, hiring individuals from the retail/contractor/manufacturing industries to leverage their knowledge in order to influence program design. Individuals from within these industries bring their expertise, which can be valuable in that they understand the needs of these businesses, making it easier for program administrators to promote services to them.

Marketing

The primary focus for augmenting marketing techniques is on adding an upstream component to the program. Most programs target consumers with rebates; however, program administrators have found that homeowners simply do not understand the long-term value of installing energy-efficient equipment because it is difficult for them to see past the high up-front costs. Currently, contractors are not willing or able to have a conversation with consumers on the long-term value of installing energy-efficient equipment, especially beyond one-off equipment replacements. So programs have begun to train and educate contractors so that they can market energy-efficient products and services to homeowners (such as the value of a comprehensive home energy retrofit) as well as bring in new participants.

There is also opportunity for program administrators to work with retailers and manufacturers by providing them incentives to increase sales or production of energy-efficient equipment. Sponsoring contractor competitions and awards programs for rebates and quality installation and verification

²² The Air Conditioning Contractors of America (ACCA), in collaboration with the American National Standards Institute (ANSI), developed the 2011 HVAC Quality Installation Verification Protocols for “those who intend to protect the value and integrity of the QI standard through qualified and objective examination of submitted HVAC system installations.” For more information, visit: <https://www.acca.org/industry/quality/quality-verification>.

services, as well as annual recognition celebrations for contractors, are innovative ways to increase participation and awareness among contractors. Leveraging the expertise of the supply chain to convey these benefits to consumers is potentially a more effective use of program funds, assuming proper training and education. Many purchases of HVAC and water heating systems are at retailers like Lowe's and Home Depot, so utilizing point-of-purchase marketing as well as training retailers' sales associates to extoll the benefits of energy efficiency when discussing products with consumers is important for driving energy savings. ENERGY STAR has developed resources that program administrators can utilize for retailer/sales outreach as well as developing point-of-purchase marketing strategies.²³ The Consortium for Energy Efficiency, through the CEE Forum, also provides resources on effective marketing and messaging campaigns for program administrators to utilize when coordinating with retailers.²⁴

Potential Savings

Below we present the potential savings that could be generated in 2030 by mechanical systems programs that incorporate the design elements discussed above. These savings will overlap to some extent with the savings from comprehensive residential weatherization programs.

Mechanical Systems	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	662	4,460	For 2030 from AEO 2012, includes heating, cooling, water heating, and pumps.
Average percent savings	20%	20%	Most mechanical equipment can save between 15%-30% of end-use consumption, so we assume savings are toward the upper end of that range in light of the non-equipment related drivers for increased energy efficiency.
Ultimate net participation rate	<u>50%</u>	<u>50%</u>	Assume participation is the same as participation in comprehensive home retrofit. Customers participating in home retrofit program achieve most of the savings from HVAC measure installations.
Potential long-term savings	66	446	

Examples

The Public Service Company of Colorado

The Public Service Company of Colorado (PSC CO), a subsidiary of Xcel Energy, currently offers its customers rebates for evaporative coolers and high-efficiency heating and cooling equipment, as well

²³ See http://www.energystar.gov/index.cfm?c=pt_reps_res_retail.pt_reps_res_retail.

²⁴ See <http://www.ceeforum.org/library/results/taxonomy%3A90.99%2C580>.

as high-efficiency water heaters. In 2011, Xcel began offering heat pump water heaters as part of its water heating rebate program; previously only homes heating water with natural gas were eligible for rebates. PSC CO's high-efficiency air conditioning program includes rebates for equipment (ranging from \$250-\$500) and quality installation services, for which standards were developed by the Air Conditioning Contractors of America. Previously PSC CO offered tune-ups in the form of a pilot, but found that these services were not cost-effective and that program funds were better spent on quality installation and other product/services.

<http://www.xcelenergy.com/>

Northwest Energy Efficiency Alliance (NEEA)

NEEA focuses on market transformation, working with utilities and other program administrators in its region to help them achieve their goals. Currently, NEEA is working with utilities in the region on promoting ductless heat pumps²⁵ and heat pump water heaters. NEEA is involved in developing regional standards for the performance of these products (northern climate specifications for HPWHs²⁶) as well as marketing methods. Between October 2008 and the end of 2011, HVAC contractors installed over 14,000 DHP in the Northwest, the equivalent of powering 4,400 homes each year by achieving savings of 25–50% on heating bills. In its DHP initiative, NEEA focused a lot of effort on marketing, training, and education, citing contractor/customer awareness as a major barrier to increased market saturation of this equipment.

<http://neea.org/>

National Grid (New York, Rhode Island, and Massachusetts)

National Grid, through programs offered by its subsidiaries in New York, Rhode Island, and Massachusetts and through sponsorship of Mass Save, offers rebates for heat pump water heaters and includes a Quality Installation Verification (QIV) service as part of its COOL SMART program. Heat pump water heaters were only recently added to its program portfolio: only units installed after January 1, 2012 are eligible for rebates. The pilot began in 2011, though program expenditures were limited to development and administration during the 2011 program year. The COOL SMART program emphasizes whole-system retrofit, including duct sealing, digital tune-ups, improved installation practices, and maintenance. The program is marketed through cooperative, upstream promotions with the HVAC industry and targeted outreach to HVAC contractors, along with traditional advertising in print and media. COOL SMART also promotes education and awareness utilizing manufacturer/distributor level marketing and training infrastructure to educate contractors and wholesalers.

²⁵ See <http://neea.org/initiatives/residential/ductless-heat-pumps>.

²⁶ See <http://neea.org/initiatives/emerging-technology/heat-pump-water-heaters>.

<http://www.masssave.com/residential/heating-and-cooling/>
http://www.nationalgridus.com/narragansett/home/energyeff/4_energystar.asp

Recommendations

Moving forward, mechanical systems programs will require holistic augmentations in order to achieve greater energy savings, from increasing the types and variety of eligible products to focusing marketing efforts on the supply chain. The introduction and resurgence of ductless heat pumps and heat pump water heaters, and evaporative coolers in hot, dry climates, offer significant opportunity for deeper savings in the future, especially given their low market saturation. Still, the saturation of very high-efficiency HVAC and water heating equipment (air-source heat pumps and electric and natural gas water heaters) remains low, so that efforts to increase their saturation can also provide large energy savings. Programs in which these types of equipment are eligible for rebates will need to include quality installation/assurance services as well, since forced-air system installations are often performed poorly, requiring frequent tune-ups that themselves are not always effective. Ultimately, programs should prioritize encouraging homeowners to invest in a comprehensive home energy retrofit, but for those with limited financial resources, upgrading individual pieces of equipment will remain a cost-effective venture.

Along with technological improvements, programs will need to allocate funds toward integrating the supply side into program design, i.e., retailers/contractors/manufacturers. Programs have historically targeted consumers with equipment rebates, but the inability of these programs to scale up due to a perpetual lack of understanding of the energy and non-energy benefits of energy efficiency equipment upgrades on the part of the homeowner highlights the importance of focusing design and marketing efforts on the supply chain. Leveraging the knowledge of these businesses and their unique relationship with consumers will be vital to educating and, ultimately, selling homeowners on the benefits of energy-efficient HVAC and water heating systems. Training and educating retailers' sales associates as well as the contractors providing installation services will ensure that homeowners are briefed on the benefits of energy efficiency from a variety of trusted sources. Program administrators should also consider hiring individuals from these industries to become part of program staff, which will help facilitate the development of relationships with these businesses, helping to streamline program design.

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RESIDENTIAL LOW-INCOME PROGRAMS

Synopsis

Low-income energy efficiency programs usually focus on lighting retrofits and weatherization of the home envelope along with other direct-install measures, which typically achieve savings of about 10% of home energy consumption. Ideally these services are just a stepping stone to a comprehensive home retrofit, but the fact that program measures are usually 100% subsidized by utilities (with the exception of some multifamily building measures, like boilers) greatly limits the ability of programs to subsidize more comprehensive measures, such as HVAC equipment or appliances. Although technology plays an important role in driving energy savings in these programs, program administrators must focus more efforts on augmenting program design to realize additional gains. In particular, low-income programs will benefit considerably by leveraging resources from the existing community of state and local government agencies and nonprofit organizations that serve the various needs of low-income households, especially with regards to marketing and outreach. Utilizing a statewide low-income network in conjunction with strong energy usage and demographic data at the community level (acquired through smart meters and/or existing databases) can also help programs identify high energy users, which in turn will help maximize energy savings. Additionally, programs must train and educate contractors to not only provide quality installation, but also to act as a program’s sales force, leveraging the existing relationship between contractors and customers, which will help to drive participation.

Background

Low-income programs target energy efficiency retrofits for households whose income falls at or below 125–200% of the federal poverty income guidelines in single-, multifamily, and manufactured housing (see the Manufactured Housing profile for discussion of the latter). According to the U.S. Census, almost 16% of households—over 12.2 million—have annual incomes below 125% of the federal poverty income guidelines. The U.S. Department of Energy’s Weatherization Assistance Program

(WAP) has provided weatherization services to over 6.4 million homes in 33 years, and 1.2 million between 2002 and 2010. Low-income households require more help with their energy bills than weatherization can provide, though, so there is still plenty of work left to be done, both in terms of weatherizing homes and in providing additional services (such as education) that will ensure low-income households benefit from energy efficiency well into the long-term.

These programs can target many various energy efficiency measures as well as housing types, which increases the complexity of program delivery given that a wide variety of services are offered under the guise of one program. Xcel Energy, for example, offers direct-install/energy kits and weatherization measures for single- and multifamily residences, as well as services for non-profit organizations that support low-income households.²⁷ In addition to utility-sector low-income programs, there a number of state agencies and non-governmental organizations that offer energy services to low-income customers, which include rate reduction programs, tariffs, and energy assistance programs (bill pay assistance). Given the breadth of support for low-income households, there is significant potential for overlap and collaboration across organizations, which we touch on further below.

Low-income programs target similar measures included in a home residential retrofit, focusing primarily on lighting and weatherization of the home envelope. Completing a whole-home retrofit is frequently a goal of low-income programs, so additional measures are often included, such as HVAC system repair and replacement, water heating measures, and occasionally replacing old, inefficient appliances like refrigerators and clothes washers. Some measure installations are substantially different in multifamily buildings, which present a different set of barriers to implementation, especially considering the owner/renter split incentive. Programs also commonly include energy savings kits (CFLs, low-flow faucet aerators and showerheads) and/or educational materials, the latter to help improve participants' understanding of how their behavior affects energy use in the home. There are some low-income programs that only offer direct install measures or the distribution of energy savings kits.

Low-income programs are most often 100% subsidized by the program in order to provide low- or zero-cost services to participants. Installing additional measures en route to a comprehensive retrofit quickly increases costs, and, coupled with heavy subsidization, often results in these programs failing benefit-cost tests. Programs frequently focus only on single-family households because of the significant barriers to implementing energy efficiency retrofits in multifamily buildings. For example, serving renters can be difficult (in single-family homes as well) because landlords are sometimes unwilling to invest in energy efficiency for their tenants. However, a significant portion of low-income households live in multifamily buildings, particularly in urban areas, so this segment of the market cannot be ignored (see Multi-Family Housing section in this report).

²⁷ We do not consider services for non-profit organizations in this profile.

Because the vast majority of states are allocated funds annually from the federally-funded Weatherization Assistance Program (WAP), under the auspices of the U.S. Department of Energy, leading low-income programs are usually coordinated with the state WAP and other low-income focused government and non-government organizations. This allows for the utilization of existing resources and infrastructure, as well as cost-sharing, which helps reduce administrative costs. Eligible participants usually receive free home energy audits from their local community action agency (CAA), which then arranges for weatherization and other services to be completed by a qualified contractor.

Drivers for Change

The most important drivers for change center on those efforts that facilitate the installation of measures that build toward a comprehensive, whole-home retrofit, such as cost minimization, and those that increase the overall participation of low-income households in the program. The goals of low-income programs vary depending on the participant and building type, but for residents, the goal should be to provide them the greatest energy savings per dollar invested.

Managing Costs

The cost of delivering services to eligible households is a primary barrier because low-income products and services are almost always installed and delivered with no co-payment from participating customers.²⁸ Generally, low-income households reside in relatively inefficient housing, so program administrators note that addressing the shell/home envelope is paramount to installing efficient HVAC systems or appliances as the savings are more cost-effective. Once the efficiency of the home envelope has been addressed, HVAC equipment can be properly sized for replacement and energy-efficient appliance upgrades can be identified, which will greatly add to the overall savings generated by a retrofit,²⁹ but installing HVAC systems and appliances quickly add to the overall project cost.

It is not uncommon for homes to require significant structural work prior to weatherization, especially the homes of high-energy users. Completing necessary structural work prior to weatherization services addresses potential health and safety issues to occupants and contractors (faulty electrical wiring, air-quality issues arising from mold), though it complicates the delivery of efficiency services and adds considerable costs to the overall project, without necessarily contributing to energy savings.

For homes or buildings occupied by renters, the cost barrier is often exacerbated by the need for property owners to maintain housing affordability (in certain subsidized housing). Rents can include

²⁸ This is true only if the “customer” is considered a resident. Some low-income programs leverage copayments from property owners, especially of multifamily buildings.

²⁹ Addressing energy efficiency opportunities in low-income buildings does not always transpire in this sequence, as heating equipment is often replaced at time-of-failure under emergency conditions.

electricity and space and water heating (in subsidized senior housing, for instance), so fluctuations in energy prices can prevent property owners from investing in energy efficiency. Energy price volatility is, of course, also a major concern for low-income renters and homeowners, who generally spend a larger portion of their income on energy. This susceptibility to fluctuations in energy prices highlights the importance of making energy-efficient improvements.

The cost barrier and susceptibility to price fluctuations mean that maximizing the energy saved per dollar invested is crucial to the success of low-income programs. Reducing administrative and overhead costs by augmenting program design is therefore another crucial driver for generating energy savings. Reducing administrative costs and increasing the effectiveness of program delivery frees up funds to achieve greater savings per participant.

Direct-Install Gets You in the Door

Most low-income programs offer a direct-install (DI) component, which helps to get contractors in the door and helps to build rapport with the home or building owner, an important facet considering the persistent split incentive between tenants and owners. Developing relationships with property owners will also help increase the potential for a comprehensive retrofit. But the scant financial resources devoted to low-income programs coupled with a focus on providing services at no cost to participants (and the general requirement that programs meet cost-effectiveness tests) greatly limits the scope of energy-efficient measures that can be installed beyond what is included in DI services. Still, direct install and lighting measures are relatively inexpensive and can have large impacts on energy consumption in low-income households.

Affecting Behavior Change

Program administrators also acknowledge the potential for behavioral measures to help low-income households better manage their energy use, which improves the persistence of savings over time. Educating participants is therefore extremely important, as low-income customers are less likely to be aware of the energy and non-energy benefits of energy efficiency and are also less likely to have the income to direct toward improvements.

Bolstering Participation

Maximizing participation helps achieve high savings per dollar of investment as well as meet social welfare goals typical of low-income programs. But marketing services to low-income households is a delicate process, considering their limited ability to invest money (and time) in minimizing their energy consumption. Coordinating marketing efforts with an existing statewide low-income network is crucial to leveraging funds and can have a profound impact on participation, provided that messaging is clear and consistent. So identifying effective methods and channels for marketing campaigns is critical.

Emerging Trends and Recommendations

Technologies

The types of measures that are installed in a low-income program vary considerably depending upon program funding and building type (single or multifamily, or manufactured housing). Installation of efficient lighting and weatherization measures (insulation and air sealing) should be a priority, along

with other low-cost measures such as low-flow faucet aerators and showerheads. Once the home is weatherized, inefficient HVAC units and water heating systems can be addressed. Some PAs include appliances in their list of measures, but fully subsidizing appliance replacement is very costly. Programs have also targeted LEDs for future inclusion. Programs also can set aside funding to invest in structural repairs (e.g., leaky roofs) in order to make homes safer as well as to protect insulation and other installed measures from damage. It is often cost-effective to outsource structural repairs to other low-income organizations, though, because weatherization contractors are usually unqualified to perform these tasks.

Advanced power strips have begun to make their way into low-income programs, in part as a behavioral component to help low-income households learn more about energy management. Weatherization contractors are unlikely to want to interfere with consumer electronics, however; whoever is charged with installing APS technology will need special training as they are not as simple to install as a surge protector.

Including DI measures is a low-cost way to engage in reconnaissance of the building stock within a municipality/community. This can be especially important for identifying equipment stock in multifamily buildings. Utilities often conduct residential appliance saturation surveys to get an understanding of the saturation of various technologies in homes, but these are usually focused on single family homes. Many low-income programs that provide services for multifamily buildings are only able to complete a dozen or so annually because of the cost, so DI proves to be a cost-effective method of establishing rapport with home and building owners as well as getting into the buildings to identify the greatest opportunities for generating energy savings.

Program Design

The opportunities for driving energy savings in low-income programs arise predominantly from tweaks in program design that, through operational efficiency gains, acquire and free-up funds for more comprehensive retrofits and increased participation.

In every state there are a variety of special interest groups serving low-income customers. They range from state energy offices, through which federal WAP funds are distributed, to economic development agencies, non-profit organizations, local government agencies, and community action agencies. This vast network must be tapped by program administrators in order to achieve operational efficiency gains that allow for a greater number of weatherization projects to be completed annually.

There are a number of ways for program administrators to collaborate with the existing low-income network within a state. First and foremost, it behooves program administrators to help establish—or participate in—a working group in order to collaborate and coordinate on all aspects of a low-income program, including program planning, delivery, implementation, standardization, education, marketing, training, evaluation, and quality assurance. Program administrators can work directly with WAP partners, which helps to reduce overhead costs by piggybacking on existing infrastructure. For example, potential participants can be identified through each state's Low-Income Home Energy Assistance Program (LIHEAP), particularly high-energy users for whom weatherization services are

critical to their overall welfare. Program administrators can facilitate marketing by engaging community and faith-based organizations as well. By contributing funding to developing or expanding existing networks, including their contractors, program administrators can ensure that those dollars go further than they would if they were acting alone. State WAPs already commit funds to training, purchasing equipment, and conducting evaluations, so program administrators can leverage this existing infrastructure by participating in its funding or coordination.

Furthermore, because most states have a number of organizations that offer services for low-income households, potential participants that are denied services based on issues such as the structural deficiency of a home can be referred to other organizations that may be able to provide assistance that will allow for weatherization to progress. Establishing and participating in a low-income support network ensures that potential participants do not come to a dead-end when structural issues preclude weatherization services from being completed. Targeting high-energy users—as mentioned above and discussed again below—will likely result in an increased focus on homes with structural issues as well as health and safety concerns that may preclude weatherization work (Gold et al. 2012).

Lastly, PAs must leverage the unique position of contractors as a means of selling services to potential participants. As in other home retrofit programs, utilizing contractors as part of the program's sales force allows program administrators to leverage the contractor/customer relationship, which is often stronger than a customer's relationship with their utility. Similar to the standardization of messaging, ensuring that training and education is effective and consistent statewide is vital to ensuring the proper installation of measures performed by contractors. Contractors must also be educated on the pertinent barriers of their service territory, such as language barriers, which is another benefit to leveraging statewide or local low-income network resources.

Marketing

The marketing channels through which low-income weatherization programs are advertised are critical to maximizing awareness and will vary depending on the community. Programs can piggyback existing marketing and outreach campaigns, which are usually coordinated by a statewide, low-income network. Some PAs have acknowledged having to spend little of their program funds on marketing and outreach by piggybacking existing marketing efforts, often covered by state WAPs.

Marketing at the community level is important for raising awareness and building trust with potential participants. Some program administrators have identified local food banks as an often untapped resource for advertising services and distributing products, such as CFLs. In addition to local food banks, faith-based community centers/events are additional venues offering significant potential for bolstering program awareness. This is not an approach that will be effective everywhere; some faith-based communities may be more closely knit in urban areas than rural, or vice versa. Programs⁰⁰ also are concentrating on building relationships with unemployment centers and medical service providers. State CAAs usually sponsor an annual conference, which offers another venue for program administrators to market their programs and develop relationships with partners.

Low-income weatherization programs that prioritize achieving deep savings will become more important as programs mature, so as to ensure their efficacy and cost-effectiveness as the pool of

potential participants contracts. Achieving deep savings for low-income participants also reduces the need for future revisits, decreasing long-term program costs. This shift in program focus will necessitate effective marketing and outreach efforts that specifically target high-energy users. It will also be necessary for program administrators to develop methods to identify high-energy users, which can be facilitated through the expansion of smart meters and increasing access to utility energy bill data. Economic data at the zip code level is widely available and can be cross-referenced with utility bill data in order to help identify high-energy users.

Potential Savings

Below we present the savings that could be generated in 2030 by low-income weatherization programs that incorporate the design elements discussed above. A caveat to the reader: our estimates are somewhat conservative because the U.S. Census only reports the percent of households below the federal threshold of 125% of median income, not 200%, which is becoming the standard for low-income weatherization programs.

Consumer Electronics	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	272	750	For 2030 from AEO 2012, Table 2. Assumes 15.5% of U.S. population is below 125% of federal threshold, from U.S. Census.
Average percent savings	10%	10%	From Xcel Colorado Low-Income Program, 2010 DSM Status Report.
Ultimate net participation rate	<u>90%</u>	<u>90%</u>	California Energy Commission has a statewide goal of providing services to 100% of eligible customers by 2020.
Potential long-term savings	24	68	

Examples

Pacific Gas & Electric (PG&E)

PG&E's Energy Savings Assistance (ESA) program utilizes a whole-house approach to provide free home weatherization, energy-efficient appliances and energy education services. California's four major investor-owned utilities actively leverage their resources for the ESA program in order to more effectively meet the California Energy Commission's goal of providing services to 100% of eligible customers by 2020. This includes coordinating actual program delivery and actively sharing their successful leveraging models so that others can try and duplicate these successes. The IOUs also coordinate with other state agencies to improve the efficacy of their efforts, including data sharing. Due to PG&E's large service territory and diverse demographics, it works to identify and implement effective outreach methods for segmenting and targeting its low-income customers, which includes multilingual television campaigns and community events. PG&E uses this information to bolster its program delivery, again, leveraging resources with local, state, and federal agencies as well as other organizations to increase coordination, efficiency and enrollment. PG&E also allocates funds to

effectively train and educate the workforce, for which efforts are coordinated statewide. In 2011, PG&E's ESA program serviced almost 130,000 homes and saved almost 48,000 MWh (PG&E 2012b).

<http://www.pge.com/myhome/customerservice/financialassistance/energysavingsassistanceprogram/>

District of Columbia Sustainable Energy Utility (DC SEU)

The DC SEU began service in 2011. Washington, D.C. has an above-average percent of its population living in multifamily buildings, both market-rate and low-income. In its first program year it offered a low-income multifamily program that provided direct installation of low-cost improvements (CFLs, aerators, showerheads, etc.). Through direct-installation programming, the DC SEU provided energy savings to low-income residents and to property owners in a rapid manner, with no need for analysis, engineering, and permitting. This initiative also provided a good means of entry to get to know the owners and managers of qualified low-income developments and to gather information about conditions on the ground that can help in future sustainable energy programming efforts. In 2012, the DC SEU continued to offer its direct install initiative, and also introduced an initiative for low-income projects that are being newly developed or rehabilitated. Working with project development teams, the DC SEU provides both technical assistance and financial incentives to maximize energy savings at the time when it is most cost-effective. Additionally, in 2012, the DC SEU offered solar installations to qualified low-income single-family homeowners in certain underserved Wards of the City. The DC SEU uses its strong community connections and contractor networks to increase awareness of its low-income initiatives.

<http://dcseu.com/for-your-business/low-income-multifamily>

Recommendations

Low-income programs target similar measures included in a home residential retrofit, focusing primarily on lighting and weatherization of the home envelope. However, the fact that program measures are usually 100% subsidized by utilities (with the exception of some multifamily building measures, like boilers) greatly limits the ability of programs to subsidize more comprehensive measures, such as HVAC equipment or appliances. While some programs have begun experimenting with behavior-related measures such as advanced power strips or in-home displays, limited program funds preclude programs from including costly (yet efficient) equipment as eligible program measures. Eligible measures therefore tend to be limited to lighting and home envelope measures, as well as other low-cost direct-install measures (low-flow showerheads, faucet aerators, etc.).

Growth in energy savings from low-income programs is going to be spurred primarily by augmenting program design in order to streamline program delivery and maximize the savings generated per project. Most states have a statewide network that focuses on delivering services specifically to low-income households and, therefore, includes a variety of non-energy related government agencies and non-profits. Programs must tap into these networks in order to leverage existing resources and infrastructure, which will facilitate the identification of potential participants and free up program funds that can instead be allocated to efforts focused on increasing participation and delivering energy savings. Utilizing these networks will also help programs identify high-energy users, such as through a state's LIHEAP, which can be further enhanced by the installation of smart meters.

One of the primary efficiencies gained by tapping into a state's low-income network is the leverage of resources dedicated to marketing and outreach. Uniform and consistent messaging is important to attracting participants. But the vehicles and venues through which services are marketed vary considerably across a state, especially when getting down to the community level. The barriers to participation can also vary widely across a state (demographics, such as languages, for example, or types of services demanded, which can vary by building type). Several program administrators and low-income government agencies/non-profits may operate within a single or group of communities, so leveraging existing resources will help prevent programs from reinventing the wheel as well as help identify opportunities for marketing and outreach that may otherwise have eluded them.

Lastly, program administrators must leverage the unique position of contractors as a means of selling services to potential participants. As in other home retrofit programs, utilizing contractors as part of the program's sales force allows administrators to leverage the contractor/customer relationship, which is often much stronger than a customer's relationship with their utility.

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RESIDENTIAL HOME RETROFIT PROGRAMS

Synopsis

The key to driving deeper energy savings from home retrofit programs, on the order to 20-30% energy savings, lies predominantly in increasing the participation of homeowners in comprehensive home energy retrofits, as opposed to one-off installations of energy-efficient measures or home envelope improvements. Homeowners, however, have largely avoided investing in comprehensive home retrofits—which target the home envelope through air sealing and insulation, as well as improvements to the HVAC system—because of the significant upfront costs and longer payback periods. Innovative financing mechanisms, such as on-bill financing, low- or zero-interest loans, or energy efficiency mortgages will be crucial to driving participation in comprehensive retrofit programs. Simplifying the application process to facilitate participation and providing homeowners with peace-of-mind by ensuring that they have access to a variety of well-trained, certified contractors to complete the work will also be important and will ensure that upgrades perform optimally to provide maximum comfort and savings. Clarifying the messaging and ensuring consistent marketing will also put customers at ease and increase their likeliness to participate.

Background

Comprehensive residential home retrofit programs, those that achieve 20-30% savings per home, target multi-measure packages of energy efficiency improvements in a home.³⁰ Residential energy efficiency programs span a wide range of efficiency measures and program approaches. They can include individual product upgrades, such as HVAC and lighting (e.g., by providing rebates to homeowners and/or contractors for their purchase and installation) as well as more comprehensive retrofits that also address the building envelope, such as insulation and air sealing. Program administrators select a list of eligible products, the scope of which can vary greatly and is limited by funding resources: some programs may limit rebates to improvements to lighting and the home envelope; others may go further to include maintenance and upgrades to HVAC systems as well as home appliances.

Some program administrators also leverage the Home Performance with ENERGY STAR (HPwES) program created by the U.S. Environmental Protection Agency and now administered by the U.S. Department of Energy, either as the sole vehicle for home retrofit projects or in tandem with their own program. Leveraging HPwES provides program administrators with a nationally recognized brand that has been delivering services for decades. HPwES focuses on assessing how improvements

³⁰ Deep energy retrofits (DER) are similar to comprehensive retrofits in that they take a “whole house” approach (air sealing, insulation, window replacement, HVAC and hot water system upgrades, lighting and appliance replacement), but differ in that the installed measures are generally more efficient (tighter insulation, high-efficiency windows, etc.). DERs usually include renewable technologies as well, such as solar photovoltaic or solar hot water systems. As a result, DERs generally target savings between 50%-75%, though many claim that 90% energy reductions are achievable with existing technologies, materials and construction practices. Affordable Comfort Inc. targets 75% energy reductions through its Thousand Home Challenge, for example (Walker et al. 2012).

to the entire home energy system can work together to deliver energy savings and ancillary benefits such as health and comfort, as opposed to one-off product replacements or limited upgrades typical of many utility or third-party administered programs. Still, while the focus of HPwES is on the home energy system, delivered services are sometimes limited to multiple individual product replacements due to customer resource constraints.

Homeowners are generally offered an energy audit/assessment, for which the fee is sometimes waived or rebated, to determine where improvements can be made. Energy audits are required for participants in HPwES programs, but not all administrators of autonomous home retrofit programs offer these assessments. Home retrofit programs usually include some direct installation component, which usually includes the installation of compact fluorescent lights, faucet aerators, and low-flow showerheads; for HPwES, the direct install component is recommended but not required. Homeowners and/or contractors then purchase eligible measures and submit the requisite information to their program administrator in order to receive the rebate, usually in the form of a cash rebate.

Drivers for Change

To maximize energy savings, home energy retrofits should be as comprehensive as possible, ideally focusing on improving the entire home energy system, starting with the home envelope. Today, most home retrofit programs, while often offering services for a comprehensive home retrofit, only deliver installation of one or two measures in addition to any direct install components. Some of the low-hanging fruit, such as efficient lighting, has been captured, but a considerable amount remains. However, as more of the relatively inexpensive potential is captured, the remaining energy efficiency potential will become more expensive to acquire. Achieving deeper energy savings in the future will then require a shift more towards comprehensive home retrofits and a focus on incorporating advanced technologies in end-uses such as lighting, where existing technologies (reflector lamps, three-way lamp dimmers) remain largely untapped .

The cost of achieving 20-30% savings with a home retrofit is an issue and arguably the primary hurdle for home retrofit programs. Comprehensive home retrofits can be expensive, so financing such improvements is a major barrier to participation. Providing rebates for comprehensive home retrofits is often insufficient for incentivizing homeowner action, so many programs incorporate or facilitate some sort of financing mechanism—loans, energy efficiency mortgages—to help pay for these costs, which shifts the vast majority of the investment to the homeowner. Convincing a participant to incur such debt can be a hard sell in-and-of-itself. This is exacerbated by the fact that homeowners are often more concerned with investing in aesthetic improvements than energy efficiency. Bundling energy efficiency upgrades when home owners are making other improvements can be effective, particularly since homeowners are likely already working with bankers to procure the necessary financing.

Finding a qualified contractor that provides quality services is another barrier that, when addressed, can have a noticeable impact on savings. Quality assurance on the part of the contractor is particularly important for the persistence of savings in the long-run: poorly installed products (insulation, duct sealing) are less likely to deliver savings over the entire rated lifetime of the measure and can result in other problems for the homeowner, such as moisture damage and insufficient ventilation. Likewise, as

demand for these services grow, it will be important for program administrators to retain a cadre of qualified contractors to meet this demand. Ensuring that contractors are capable of consistently meeting program requirements while maintaining a good relationship with program administrators and homeowners is crucial for the long-term success of a home retrofit program. Many program administrators require contractors to acquire certifications from the Building Performance Institute (BPI) to meet this need. Although quality control is still necessary to ensure contractors are meeting program and certification standards.

Providing homeowners with peace-of-mind during the implementation of a retrofit project—especially the more-expensive comprehensive home retrofits—is an often underappreciated facet of program delivery. While the concept can be operationalized in different ways, ensuring quality assurance on the part of the contractor is one such example. Another is offering “performance guarantees” or warranties where program administrators commit to addressing specific issues that surface post-retrofit. Facilitating customer involvement in a project from start to finish is a holistic approach to addressing this issue, with contractor certification being one specific component of this approach. Historically, applying for retrofit services and financing has largely been conducted on paper, but the integration of information technology and communication into program delivery has the ability to transform the market considerably. Allowing participants to apply for services, find a qualified contractor, apply for financing, and track the progress of a project in real-time entirely through the internet can assuage many potential participants’ concerns of their limited time and resources. Program administrators do acknowledge that participants value face time with contractors as well as interactions with program managers over the phone. The partial transition to web-based program delivery and consumer electronics (mobile devices, web-based software, etc.) can also mean a significant reduction in overhead and transaction costs on the part of the program administrator and its contractors.

Emerging Trends and Recommendations

Technologies

The savings potential available in the residential sector will be captured more by focusing on increasing program participation in comprehensive retrofits than through the one-off installation of new, high-efficient technologies. Many of the products within end-use categories have approached their technical savings potential for the foreseeable future, to the point where it is more cost-effective to target customer participation in comprehensive retrofits in order to drive deeper energy savings. Still, programs acknowledge there are significant cost-effective energy savings to be captured through the incorporation and installation of products that, to date, comprise a very small portion of market share in that end-use category. Program administrators have identified heat pumps—specifically ductless heat pumps and heat pump water heaters—and solid state lighting as three technologies that have considerable potential for generating energy savings. Ductless heat pumps and heat pump water heaters have been tested in most climate regions in the country and have been found to deliver consistent savings in most climates, though barriers to their adoption persist and will be difficult to surmount (see Mechanical Systems write-up).

There is still a substantial need for building shell improvements in many local markets—air and duct sealing are fairly new additions to home retrofit programs and complement traditional insulation and HVAC measure installations—which ensures that these measures will remain an important component of comprehensive home retrofit programs. Light-emitting diodes (LED), though still considerably more expensive than CFLs, are widely considered to be the next frontier in lighting, and costs are expected to decline drastically over the next 3-5 years. Smart power strips have also begun to make their way into home retrofit programs (see Plug Loads write-up), though the technology is quite new and customer awareness is practically non-existent.

Program Design

In order to drive up participation in home retrofit programs and, consequently, energy savings, there are many facets of program design that can be augmented so that deeper savings can be achieved within the same foundational program infrastructure.

An Attractive Financial Proposal for the Homeowner

It is not an easy task to convince a homeowner to invest thousands of dollars in an energy efficiency retrofit of their home. Experience shows that a comprehensive financial proposal, including low initial entry costs (e.g., free or low-cost “energy assessments”); cash rebates to reduce the total capital costs to the customer; and low-cost financing to address remaining front-end capital cost barriers, can be a very effective package for encouraging participation.

On-bill financing³¹ is also becoming a popular financing mechanism in the residential sector. On-bill financing allows property owners to repay their debt through a fee on their utility bill. The loan can be financed either by the utility or by a third-party, although the fee would be collected by the utility. The loan is attached to the property, so that the debt is transferred to the new owner when the property is sold. Property tax financing is a similar mechanism to on-bill-financing, except that, instead of a fee included on the utility bill, the local government issues a surcharge, or lien, on the annual property taxes.³²

21st Century Delivery

A primary objective continues to be the need to keep things “simple” for the homeowner. One promising area is the potential for efficiencies that can be realized through a transition to a central, web-based platform, where a project can be implemented and tracked by administrators, contractors, and participants almost entirely over the Internet. Some programs have worked with software developers to design project management software that streamlines the application and implementation process for both customers and contractors, freeing up resources for program

³¹ See Bell et al. 2011, On-Bill Financing for Energy Efficiency Improvements: A Review of Current Program Challenges, Opportunities, and Best Practices.

³² Visit <http://aceee.org/sector/state-policy/toolkit/financing-energy-efficiency> for more information on financing mechanisms.

administrators that can be used to generate greater participation and helping to automate processes that otherwise have existed only on paper. A single, central technology platform can also facilitate data collection, analytics, and reporting, which gives administrators a thorough, data-rich understanding of program performance (Case et al. 2012). A web-based system potentially allows for greater transparency as well, helping to provide customers with peace-of-mind. The growth of smart phone technology can also be utilized to enhance program delivery, allowing customers to apply for and track projects anywhere from their personal devices.

Courting Contractors

One of the greatest challenges to project implementation is the building of an elite contractor pool that is certified to deliver quality-assured installations. Identifying qualified contractors from the market has not always resulted in the selection of those that are the most-qualified because program administrators have not always been diligent in defining requirements nor have they dedicated resources to tracking contractor performance. The result is often unsatisfied customers that are unlikely to move forward with larger, more expensive projects, therefore leaving a vast sea of efficiency potential untapped.

Leading programs have thus begun to focus more time and resources towards identifying, training and retaining qualified contractors. When contractors apply to become certified to deliver services for a home retrofit program, programs often codify lists of requirements that must be met, both prior to application and while under contract, lists that some program administrators refine through customer research and focus groups. These requirements usually include both qualitative and quantitative metrics.

Some programs have also been moving toward an “open contractor” model, where all contractors are encouraged to apply instead of, perhaps, being hand-selected by program administrators themselves. In order for this model to succeed, programs must focus on quality assurance and control. For example, contractors can be required to bring in a certain number of jobs or leads before they are allocated work by the program administrator, at the least to show that they have some experience in delivering these services. Once a contractor is approved, the allocation of work is merit-based: each job completed by a contractor is scored and work is allocated based on these scores, using both qualitative and quantitative metrics. The efficacy of contractors’ work is also largely dependent on contractor training, another aspect of program design that programs have begun to fund more aggressively.

In addition to a more-concerted focus on quality-assurance, programs have also begun to encourage contractors to educate homeowners and market home retrofit programs themselves. In part this is to cut down on administrative costs, but more so because of the unique opportunity for contractors to leverage the relationship that they have with their customers, in order to highlight the benefit of deeper retrofits during direct install or one-off installations, for example. Program administrators have also noted that, beyond training contractors on how to market program services, there is a need to offer them training on how to effectively manage their business. Not necessarily because contractors are poor businesspeople, but rather because some contractors may be new entrants into the market or may be inefficient at meeting a sharp increase in demand for their services. Some

program administrators added that actively showing appreciation for their contractors—by sponsoring breakfasts or issuing awards—is a low-cost method of maintaining a good relationship.

Program Augmentations à la Carte

Below are some other ideas that program administrators have shared with us:

- **Utility Collaboration**—Since comprehensive home energy retrofit programs generate both electric and natural gas savings, the cost-effectiveness of programs can be enhanced through the joint implementation of programs by both electric and natural gas utilities. Beyond the ability to capture all energy savings when calculating program cost-effectiveness, utilities can also leverage resources to maximize their marketing and outreach efforts
- **Internalize the expertise**—Hiring individuals with expertise in relevant areas, such as financiers, and involving outside parties in program design can often facilitate relationships with entities crucial to program delivery and help with identifying barriers.
- Strive toward issuing every home a **home energy score** in order to establish benchmarks. Developing a miles-per-gallon equivalent for homes should be a common metric included in real estate listings. There is considerable pushback on this issue from real estate developers and appraisers on mandatory disclosure, however.
- Contractors commonly find **working conditions that jeopardize health and safety**. Program administrators should work to create an initiative that evaluates homes for health and safety issues, which generally arise in hard-to-reach communities (those traditionally underserved by energy efficiency programs) of low-to-moderate income households, such as rural areas.
- **Financing**—In order to finance comprehensive retrofit projects, program administrators suggest working with local lenders, such as credit unions, who are likely to compete for customers, which ultimately drives interest-rates down. Offering non-subsidized, no-money down or no-interest financing is also a powerful way to increase customer participation. On-bill financing, where homeowners can repay loans for a retrofit through their utility bills, is another mechanism that has started to take off, as are energy-efficient mortgages (Keesee 2012).
- **Use an appropriate cost-effectiveness test**—Because of the large customer investment required to achieve a comprehensive home energy retrofit, the Total Resource Cost (TRC) test as commonly applied (which counts all of the customer costs but none of the ‘non-energy’ benefits to the customer) often results in the program/project failing the TRC test. Either the TRC test must be calculated in a balanced way, that monetizes the customer non-energy benefits (e.g., comfort, health, increased property value, etc., which are often significant motivators for customer participation), or a more appropriate B/C test (e.g., the Utility Cost Test) needs to be utilized (Neme and Kushler 2010).

Potential Savings

Below we present the potential savings that could be generated in 2030 by comprehensive home retrofit programs that integrate the design elements discussed above.

Comprehensive Home Retrofit	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	940	2,235	For 2030 from AEO 2012, Delivered Energy Consumption by End-Use for Electricity and Natural Gas. Baseline excludes baseline usage from multifamily, appliance, and manufactured housing programs.
Average percent savings	25%	25%	Average Savings from Home Performance with ENERGY STAR.
Ultimate net participation rate	<u>50%</u>	<u>50%</u>	
Potential long-term savings	118	279	

Examples

Below we provide some examples of utilities or program administrators that are noteworthy for incorporating innovative strategies in order to drive greater participation and savings.

Clean Energy Works Oregon (CEWO)

Based out of Portland, Oregon, CEWO hired a software developer to design a web-based platform that is centrally managed and supported and allows participants to apply and track progress over the Internet in real-time over the course of a project. Through this web-based platform, participants can: 1) apply to the program and track the application process; 2) hire a contractor to conduct a home energy assessment and have them bid on a project; 3) apply for financing; and, 4) track progress in real time, with detailed information available on all aspects of the project. During CEWO's pilot phase, when it was Clean Energy Works Portland (CEWP), it negotiated and established the first community workforce agreement (CWA) for energy efficiency retrofits, which is an agreement that establishes requirements for worker training, wages and benefits, local/targeted hiring of workers, and contractor standards for a particular construction project or a set of projects. CWAs help to create work and training opportunities for community residents, collaborating with local contractors, workforce development programs and labor unions to generate long-term, sustainable careers in energy efficiency retrofits for workers in all trades. CEWP became CEWO in 2011, and as of May 2012, CEWO has retrofitted more than 1,200 homes with 130 new, quality jobs created.

<http://www.cleanenergyworksoregon.org/>

National Grid (Massachusetts)

National Grid's home retrofit program, called the MassSave® Home Energy Services (HES) program, provides eligible National Grid customers who own their own home or live in a building with 1 to 4 dwelling units with a no-cost home energy audit and incentives toward installing energy-efficient measures. It is a statewide program offered by all eight program administrators in Massachusetts. National Grid's lead vendor administering the program is Conservation Services Group (CSG). National Grid moved to an open contractor model in early 2011, as a result of an open and transparent process with interested stakeholders statewide, which allows additional opportunities for contractors to participate in the program and shift some of the delivery of audit services away from the CSG. CSG previously had conducted all audits, with weatherization work conducted by a

participating weatherization contractor, called an Independent Insulation Contractor (IIC). In the open contractor model, National Grid introduced Home Performance Contractors (HPCs) to complete audits and guide homeowners through the completion of the weatherization process. The intent was to provide consumers with more choice in terms of contractors, facilitate the audit to weatherization process by working with just one company through the HPC participation path, and overall, provide consumers with additional options (CSG audit with IIC weatherization work or work with an HPC throughout the whole process). National Grid and CSG developed qualitative and quantitative metrics with which to evaluate contractor performance and utilize a merit-based system to allocate work to IICs. HPCs are required to bring their own customers into the program and have developed innovative ways to reach customers at the local level through tabling at energy fairs, community events and partnering with local municipalities amongst other marketing techniques. National Grid now has over 90 contractors participating in the HES program, providing a positive investment to the local workforce by increasing customer choice and providing an opportunity for greater program participation and savings.

<https://www1.nationalgridus.com/HomeMA-MA-RES>

Efficiency Vermont (EVT)

Efficiency Vermont—Vermont’s sustainable energy utility, administered by the Vermont Investment Corporation—has been providing energy efficiency services for decades. As a result, much of the state’s low-hanging fruit, such as compact fluorescent lighting, has already been captured, such that it is costing more to acquire the remaining potential. Propane and fuel oil are also major heating fuels in the residential sector, a testament to the substantial rural population in the state. EVT has therefore had to push the envelope in order to meet its growing energy efficiency savings targets. EVT is shifting toward incorporating ductless heat pumps and solid state lighting into its program in order to drive deeper energy savings. EVT is also focusing on continuous engagement with their customers, in order to shift from one-off installations toward comprehensive home retrofits. Ultimately EVT wants to shift away from providing incentives altogether, so it is focused on innovative financing to fill the void that would be left in the absence of incentives.

http://www.encyvermont.com/for_my_home.aspx

Home Energy Solutions (HES)

The Home Energy Solutions program is supported by the Connecticut Energy Efficiency Fund (CEEF) and administered by Connecticut’s investor-owned utilities. Participants receive an energy assessment where the contractor makes on-the-spot improvements, including a blower-door test, caulking and sealing of critical air leaks, duct sealing, hot water-saving measures, installation of CFLs, and, depending on eligibility, rebates on appliances, HVAC systems, and insulation. The energy assessment and direct install measures, referred to as the HES “core services,” serve as a gateway to a comprehensive retrofit, which is encouraged by offering rebates to qualified customers as well as the availability of third-party financing. The comprehensive retrofit is a whole house approach leveraging the Home Performance with ENERGY STAR program. In 2011 the HES program achieved 23 GWh of energy savings.

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

Recommendations

The key to driving deeper energy savings from home retrofit programs, on the order to 20-30% energy savings, lies predominantly in increasing the participation of homeowners in comprehensive home energy retrofits, as opposed to one-off installations of energy-efficient measures or home envelope improvements. There is significant savings potential to be realized through individual measure improvements, but these savings will never compare with the overall energy and non-energy benefits created by a comprehensive home energy retrofit. Improvements to most program design elements will be necessary to truly capture the huge potential that exists in this market.

Residential home retrofit programs generally offer a set of energy efficiency measures intended to save a considerable amount of energy while lowering homeowners' energy costs and increasing the overall comfort of a home. Homeowners, however, have largely avoided investing in comprehensive home retrofits—which target the home envelope through air sealing and insulation, as well as improvements to the HVAC system—because of the significant upfront costs. Innovative financing mechanisms, such as on-bill financing, low- or zero-interest loans, or energy efficiency mortgages will be crucial to driving participation in comprehensive retrofit programs. Promoting or bundling energy efficiency improvements concurrent with aesthetic improvements to the home can also be a boon to participation, as homeowners are already investing in massive upgrades during which energy-efficient measures can often easily be installed.

Program administrators will need to augment a number of other design elements of their programs in order to increase energy savings. Program administrators recognize the importance of simplifying the application process to facilitate participation while providing homeowners peace-of-mind by ensuring that they have access to a variety of well-trained, certified contractors to complete the work, which will ensure that upgrades perform optimally to provide maximum comfort and savings. Involving contractors in the marketing of energy-efficient products and services is a low-cost method of educating homeowners (and contractors) on the benefits of energy efficiency, and can help push homeowners towards more comprehensive retrofits. And given the considerable financial investment, program administrators should consider offering warranties or performance guarantees on retrofit work so that homeowners are assured that any post-retrofit issues will be alleviated expediently and at no-cost to them.

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RESIDENTIAL NEW CONSTRUCTION

Synopsis

Savings from residential new construction can be bolstered by focusing on two tenets: increasing participation (going broader) and driving the market toward performance-based, ENERGY STAR new construction programs and beyond (going deeper). Training and educating homebuilders on the benefits of “above code” new construction programs and passing along this knowledge to homebuyers will be vital to increasing awareness and participation. How and where new construction programs are marketed will be equally important to driving participation. To maximize energy savings, program administrators should incorporate performance-based paths to qualifying for incentives, which will allow homebuilders greater flexibility in meeting program requirements. Performance-based paths also encourage home builders to experiment with home design, which serves as a means of educating homebuilders on the requirements of building super-efficient homes and paves the way for the ultimate goal of new construction programs: the standardization of high-efficiency homes in the market through the incorporation of energy efficiency improvements from these programs into building energy codes.

Background

Residential new construction programs generally target homebuilders with incentives to encourage them to invest in comprehensive, whole-home energy efficiency upgrades during construction of a new home or concurrent with a major renovation of an existing home, the points at which comprehensive upgrades are most cost-effectively implemented. Incentives are also targeted to prospective homebuyers to encourage them to purchase energy-efficient homes. Incentive levels are usually tiered to allow for various levels of investment in energy efficiency measures installed in a new home. The overall efficiency of a new home is often indicated by its Home Energy Rating System (HERS) index score, developed by the Residential Energy Services Network (RESNET).³³

Most current new construction programs implement the ENERGY STAR New Homes (ESNH) program, although some program administrators have developed packages of their own that target lower (or higher) savings than those achieved by ESNH. The ESNH program focuses on implementing comprehensive upgrades to the HVAC system and home envelope, including energy-efficient windows and appliances (refrigerators and dishwashers, for example). HVAC and home envelope end-uses are the end-uses covered by residential building codes, specifically the residential chapter of the International Energy Conservation Code (IECC). Energy-efficient appliances are another focus of the ESNH, though it is not uncommon for programs to include energy-efficient appliances beyond those required by the ESNH program.

Leaders in new home programs often provide several tiers of packages designed to achieve increasing levels of savings. For example, the first tier of a new home construction program may focus on achieving X% savings “above code”, relative to whichever residential building energy code has been adopted in that local jurisdiction or state. A new home can comply with IECC codes through either a “prescriptive path”, which is based on a predefined package of improvements, or a “performance path”, which is based on a customized package of upgrades. A second tier³⁴ typically implements the ESNH program,³⁵ which, currently, is designed to achieve at least 15% savings above the 2009 IECC. As with the IECC, new homes can qualify for ENERGY STAR certification by following a “prescriptive path” or a “performance path”.³⁶ Some programs also choose to add an extra tier, sometimes dubbed ENERGY STAR “Plus”, which is usually designed to achieve 30% savings or more

³³ <http://www.resnet.us/>

³⁴ Many PAs simply implement the ENERGY STAR® New Homes program as their first tier package, since the program design has largely already been developed by a nationally-recognized brand. Some PAs do offer “above code” packages to increase choice for those homebuilders who do not want to invest in the upgrades required under the ENERGY STAR® program.

³⁵ Currently at Version 3. http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_guidelines

³⁶ Requirements for the prescriptive and performance paths can be found here: http://www.energystar.gov/ia/partners/bldrs_lenders_raters/ES_Combined_Path_v_65_clean_508.pdf?5ffe-2235

above the 2009 IECC.³⁷ Finally, homebuilders can also earn federal tax credits for building homes that generate 50% savings above the 2003 IECC.³⁸

Drivers for Change

Fundamental Program Design

The majority of residential new construction programs implement the ENERGY STAR New Homes program because it is a nationally recognized brand with a proven record of providing cost-effective savings well-above code, between 15% and 30% above code. Still, many programs provide incentives for homes that target savings “above code”, but do not target ENERGY STAR qualification, as a means of providing greater choice for building or buying new homes that perform above code. Only half the states in the country require compliance with the 2009 IECC or above, however; many of the remaining states have no mandatory statewide codes or require compliance with codes that precede the 2006 IECC (BCAP 2012). So there are still significant cost-effective savings to be achieved in all states through new homes programs that incorporate ENERGY STAR standards or greater, but, above all, in those states that only require compliance with the 2006 IECC or below. Designing new construction programs based on the ENERGY STAR standard or beyond will be critical not only for achieving higher energy savings, but it will also give homebuilders an opportunity to become more familiar with the requirements (costs, equipment, etc.) of meeting efficiency levels targeted by future code iterations.

To Prescribe or to Perform?

Since new homes can comply with the IECC or qualify for ENERGY STAR certification via a performance-based path, there is some degree of flexibility in the types of measures that can be installed, provided that the home meets the minimum performance requirements of either the mandatory IECC building energy code or the ENERGY STAR Reference Design Home.³⁹ Modifying either the IECC or ENERGY STAR program requirements, however, requires program administrators to engage in energy modeling in order to ensure that these changes meet the minimum requirements specified by the IECC and ENERGY STAR specifications, which raises the question: to what degree should programs follow the performance path versus the prescriptive path? The answer is somewhat dependent upon available resources and the region in which the programs operate. Most programs combine the two, though program administrators have acknowledged that the flexibility of the performance-based path will allow for greater savings as a result of increased choice on the part of

³⁷ ENERGY STAR® notes on its website that there are additional features of its New Homes program that can “deliver a total energy efficiency improvement of up to 30% compared to typical new homes.” PAs with ENERGY STAR® “Plus” programs typically model them assuming the implementation of these additional features.

³⁸ http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_regional_specs.

³⁹ These minimum requirements vary by climate region, so the U.S. Environmental Protection Agency has developed regional specifications that vary by state and county:

http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_regional_specs

homebuilders, paving the way for new construction programs that go beyond ENERGY STAR and ENERGY STAR “Plus”, such as low-load, zero-net-energy, or passive homes.

Participation, Participation, Participation

The only mandatory requirements of the IECC and the ESNH program apply to the minimum efficiency levels of the measures installed. Otherwise, program administrators are free to design and promote their programs to best maximize participation, the other primary driver of energy savings in residential new construction programs. To drive participation higher than has been achieved historically, program administrators will need to determine how best to leverage the homebuilder relationship with homebuyers in order to market new homes programs, educating homebuilders so that they are more inclined to offer energy efficiency upgrades. Similarly, program administrators will have to determine how best to market the energy and non-energy benefits of these programs to homebuyers, so that they are encouraged to purchase an energy-efficient home. Both will require program administrators to evaluate what balance of incentives and education will achieve maximum support from homebuilders and awareness on the part of homebuyers.

Building Energy Code Stringency and Compliance

Another clear driver of energy savings of a residential new construction program is the stringency of a state or jurisdiction’s mandatory building energy codes. As more stringent building energy codes decrease the potential for incremental savings, the incremental savings become more expensive to achieve, so incenting homebuilders to build above code or to the ENERGY STAR standard becomes more costly due to a need for higher incentives (which are usually based on projected savings). Therefore, the more stringent the code, the more difficult it is to design a specification for a new homes program that cost-effectively achieves a program’s targeted savings levels. However, cost studies conducted by the Building Codes Assistance Project show that the additional costs are modest and the improved cash flow to homeowners covers those additional costs.⁴⁰ There are a number of states that adopt the latest version of the IECC residential building energy codes shortly after they are introduced, either due to legislative requirements or because of the understanding of the benefits of stringent buildings codes. As a result, building homes to achieve energy savings above code in these states will require a more concerted effort to design a specification that will achieve the minimum savings targets for the new homes programs. Massachusetts, for example, developed an above, or “stretch” code specification that is available for adoption at the jurisdictional level.⁴¹

To drive savings, programs can exert some influence on the number of homes that actually comply with a state or jurisdiction’s mandatory building energy codes, through program-financed code training and education, for example. Legally, the onus is on homebuilders to build homes to code and on code officials to verify compliance. But it is in the interest of programs to support efforts that reduce the demand for energy. Code officials are sometimes in short supply relative to the rate at

⁴⁰ <http://energycodesocean.org/incremental-cost-analysis>

⁴¹ <http://www.stretchcode.com/>

which new homes are constructed, however, an issue endemic to the vast majority of states. While program administrators cannot act as code officials, they can still have an impact on code compliance by supporting training and education as well as energy code compliance evaluation.

Emerging Trends and Recommendations

Technologies

In terms of specific technologies, some programs have begun incorporating ductless heat pumps and heat pump water heaters into their new construction programs for additional savings beyond the ESNH minimum requirements, as these products have a higher rated efficiency than the measure requirements listed in the ENERGY STAR national program requirements for those end-uses. Light emitting diodes (LEDs) are also beginning to make their way into new construction programs as they can provide greater savings (currently at greater cost) than ENERGY STAR qualified compact fluorescent lamps (CFLs). Since new homes programs target comprehensive, whole-home upgrades, some PAs noted the need to incorporate behavior measures into these programs, such as in-home display monitors, in order to give homeowners a better understanding about home energy system dynamics and provide them greater control over the various end-uses in their home.

For program administrators at the forefront of new construction programs, the ultimate goal is to incorporate technologies and structural design practices that can achieve low-load or passive-house⁴² homes. These homes require a system-based design that looks beyond technologies to achieve savings of at least 80% by maximizing efficiency gains in the home envelope and electrical, plumbing, and mechanical systems while also minimizing losses (heating and cooling). The foundation of low-load homes is a super-insulated, air-tight envelope that allows for dehumidification and ventilation. These walls are typically twice as thick as standard construction and air tight. Complementing a super-efficient home envelope with efficient equipment and structural design elements (such as orientation of windows and surface area considerations) and mechanical ventilation systems can lead a home to very low load requirements as well as superior comfort and air quality. While the up-front costs can be a barrier, some programs (Efficiency Vermont) have found that an 8%-15% incremental cost is offset by lower operating costs. A voluntary high-performance tier is a means to get homebuilders familiar with these design practices so they can ultimately become standardized.⁴³

Program Design

Training and Educating Contractors

The critical role of contractors in building energy-efficient new homes means that training and education campaigns are extremely important to driving the market for new homes. Achieving this

⁴² Visit the Passive House Institute and the Passive House Alliance for more information- <http://www.passivehouse.us>, <http://www.phalliance.com>

⁴³ The incremental costs are for a modular passive house relative to a modular code home, though there are a number of factors that lead to both higher and lower figures, such as the overall size of the home (VEIC 2012).

objective requires a delicate balance between incentive levels and education. The ultimate goal for programs is to wean homebuilders and homebuyers from incentives, relying on increasing awareness of the benefits of an energy-efficient home to drive participation (i.e., market transformation) and, ultimately, make energy-efficient new construction the standard practice; i.e., the benefits should drive the market. Programs can play an integral role in training and education by developing and supporting homebuilder workshops/seminars, and providing funding and other resources to homebuilders in their region. A number of national associations and organizations regularly convene trainings for home builders, or are generally reliable resources for pertinent programmatic information: the American Institute of Architects, Affordable Comfort Inc., the International Code Council, the National Association of Homebuilders, the Consortium for Energy Efficiency, the Association of Energy Services Professionals, and RESNET, to name a few. The methods and venues in which new construction programs are marketed will be paramount, the specifics of which we discuss below.

The Impact of Building Energy Codes

The increasing stringency of building codes in most states across the country is making it more difficult to achieve savings from building homes above code. To address this, program administrators are working with leading homebuilders/contractors (those that are already actively building ENERGY STAR qualified homes) to develop “above code” specifications as well as effective training and education programs that will increase the pool of qualified homebuilders, contractors and subcontractors, and help propel new construction programs forward. New construction programs can also work as a pathway to more stringent building code adoptions. By working with homebuilders through these programs, programs can encourage homebuilders to be more supportive of future energy code adoptions, proving to homebuilders that energy-efficient homes can be built cost-effectively. Incorporating the ENERGY STAR new homes standards or a similar, voluntary “stretch code”, for example, is an important first step toward garnering more support for stringent building energy code adoption in the future, as it will give homebuilders an opportunity to become more familiar with the requirements of meeting efficiency levels targeted by future code iterations.

The Role of the Program Administrator in Code Adoption and Compliance

Program administrators are also becoming more involved in facilitating code compliance in new construction because code adoption and compliance can help program administrators, in particular utilities, cost-effectively meet growing energy demand. There is a dearth of state and local code officials available for evaluating and verifying compliance, however, and new homes are often not built to code, both of which warrant program administrator involvement. Where states lack the resources to equip code officials with tools for evaluation, program administrators can step in to offer the use of equipment such as blower doors and thermal imaging devices. For states with mandatory energy savings targets (energy efficiency resource standards), establishing a methodology for attributing savings from compliance with building energy codes to the efforts of program

administrators is vital, though few states have been able to develop accepted methodologies thus far.⁴⁴ Program administrators can also leverage their relationships with homebuilders and other stakeholders to garner support for the adoption of stringent building energy codes, as well as through the development and support of energy code “collaboratives”, which is a group of stakeholders (utilities, homebuilders, state agencies) that come together in a forum to explore common interest around energy code adoption and compliance.⁴⁵

Marketing

In order for residential new construction programs to scale up and deliver deep energy savings, marketing the energy and non-energy benefits to homebuilders and homebuyers is paramount to increasing participation. A key to successful marketing is determining the most effective means of delivery. Program administrators can market programs to homebuilders through tradeshow and conferences (such as Affordable Comfort’s (ACI) and the National Association of Home Builders’ national and regional conferences), magazines, and other media (radio and television commercials, point-of-sale brochures, etc.). Program administrators can market to prospective homebuyers through similar means (community outreach events instead of conferences), but should focus primarily on various media (such as New Homes Magazine, program websites, etc.). A lot of outreach by programs is done through the local chapter(s) of the Home Builders Association.

A homebuyer’s primary concern is peace-of-mind: knowing that their new home will be efficient, comfortable and durable. Homebuyers are less concerned about the long-term savings of energy efficiency so homebuilders need to be trained to effectively engage in this conversation with homeowners. Program administrators acknowledged that, ultimately, their goal is for homebuilders/contractors to act as the primary sales force for residential new construction services. Homebuilders are in a unique position to influence the decisions of homebuyers and developers and, with proper training, can effectively extoll the benefits of implementing energy efficiency improvements in new homes.

Building labeling/rating is a tangible means of providing homebuyers with peace-of-mind, especially in situations where engaging in conversations about energy efficiency with a homebuyer is not enough. Giving homebuyers a print-out of the performance of a home, much like reviewing the performance of an automobile, facilitates their understanding and appreciation of the benefits an energy-efficient home can provide. The HERS rating index from RESENT is a well-known vehicle for rating the energy efficiency of homes, though it is not utilized in all markets. Program administrators can enter into memorandums of understanding with RESNET to have their homes energy rated by a

⁴⁴ See Wagner, C. and D. Lin, 2012, *Leveraging State-Utility Partnerships to Advance Building Energy Codes*, published by the National Association of State Energy Officials (NASEO) for information on states that have successfully developed savings attribution methodologies, such as California.

⁴⁵ NASEO also sponsored a webinar on April 17, 2012, titled Energy Codes Collaborative. To view a slide summary of the webinar, along with an audio recording, visit <http://www.naseo.org/codes/events/2012-04-17/>

certified RESNET rater and use the resulting rating as a marketing tool to homebuyers. ENERGY STAR certified homes, for example, are given an ENERGY STAR label to display, though homebuyers still need to review the home specifications to understand what that label represents. program administrators and homebuilders argue that marketing homes with their performance ratings is useful, but it is most effective in markets where building labeling/rating is required for the whole market, including existing homes, so that homebuyers are able to make more informed comparisons. program administrators can partner with their homebuilders or the statewide homebuilders association to promote statewide labeling, though realtors and appraisers have been known to oppose building labeling policies, in part because of the negative impact labeling can have on sales of homes that are relatively energy inefficient.

Potential Savings

Below we present the potential savings that could be generated through 2030 by residential new construction programs that integrate the design elements discussed above.

Residential New Construction	Elec.	Gas	Notes
	TWh	TBtu	
National energy use affected	20	62	For 2030 from AEO 2012 and limited to energy consumption from new construction, from Economy.com.
Average percent savings	50%	50%	Relative to the 2009 IECC; above ENERGY STAR Plus but not Low-Load or Passive House.
Ultimate net participation rate	50%	50%	10-20% current market share, 75% possible.
Potential long-term savings	5	16	

Examples

Arizona Public Service Company (APS)

The APS residential new home construction program offers two tiers of packages, one that implements the ENERGY STAR program targeting at least 15% savings and another dubbed ENERGY STAR Plus, which targets achieving a HERS rating of 70, equivalent to around 30% energy savings of a typical home. APS sponsors numerous training workshops geared to ensuring implementation accuracy, and also includes sales and/or technical training assistance. APS is implementing the latest version of ENERGY STAR new homes (Version 3) and is holding a number of trainings on the new specifications. APS markets its new homes program through a variety of media channels, including point-of-sale materials. In 2010, 11% of new homes were built above code: 10% built to the HPwES standard and 1% built to ENERGY STAR Plus.

http://www.aps.com/main/green/choice/choice_8.html

California Advanced Homes Program (CAHP)

Utilities in California have jointly developed a statewide program that highlights best practices in energy efficiency and offers generous incentives to builders and architects to create energy-efficient homes and communities for homebuyers. The program's goals are for 50% of residential new construction to be built at least 20% better than the 2008 Title 24 Energy Code (which exceeds the

2009 IECC in stringency) and 10% of residential new construction to be built at least 40% better than the 2008 Title 24 Energy Code. CAHP provides workshops and training throughout the year with an entire curriculum of classes and seminars to bring homebuilders up to speed on areas such as green building certification and utility incentive programs. Given California's diverse climate regions, CAHP has developed specifications so that homes in all 16 climate zones can achieve the program savings goals.

<http://www.californiaadvancedhomes.com/>

Mass Save

The Massachusetts New Homes with ENERGY STAR program was introduced in 1998 and in 2010, began offering three tiers of ENERGY STAR certification in addition to a Code Plus tier, which is a level above the Massachusetts statewide building energy code but shy of the ENERGY STAR certification standards, the latter providing an "avenue for broader reach as an entrée to ENERGY STAR". The program targets single and multifamily and is cross-promoting with the Mass Save lighting program to introduce solid state lighting as well. The program also supports "code amendments that add to energy efficiency and explore[s] with all entities the possibility of offering incentives to municipalities that adopt 'stretch code' revisions in their communities". Marketing efforts for the program are extensive, focusing on "homebuilder recruitment, continued training and support, public relations and the implementation of large scale multi-media advertising campaigns geared toward homebuilders, consumers, and trade ally groups [...] Hosting, sponsoring, and attending various trade show exhibitions and homebuilder conferences remain crucial to marketing the program". The program is focusing on marketing based on the HERS rater model, with training and technical assistance, and is working on expanding the current HERS rate network. During 2010 program administrators began adopting many of the new ENERGY STAR Version 3 specifications prior to its finalization in 2011 in order to remain early adopters of more stringent energy efficiency requirements nationwide. In 2010, over 1,800 new homes were upgraded through the program, comprising around 20% of housing completions and generating almost 5 GWh of electricity savings.

<http://www.masssave.com/residential/building-a-house-or-addition/>

Recommendations

Bolstering participation in residential new construction programs is vital to capturing greater energy savings, especially as building energy codes become more stringent. Training and education programs will be crucial to eliminating barriers to participation from homebuilders and homebuyers. There are a number of national associations and organizations, many with state chapters, that program administrators can partner with to establish training workshops/seminars and education campaigns. In addition to training homebuilders on the specifications of "above code" or ENERGY STAR qualified homes, training must be focused on arming homebuilders with the capacity to sell the benefits of energy-efficient homes to homebuyers, such as during a major renovation of a home.

Burgeoning participation will also be predicated by how these programs are marketed to homebuilders and homebuyers. Advertising at trade shows and conferences, along with publicizing through various forms of media, are integral to raising awareness. The marketing of energy-efficient

homes can also be facilitated through program support for building labeling and rating efforts. Homebuyers purchasing decisions can be influenced greatly when they are given resources/materials that highlight the performance of energy-efficient homes, much like reviewing the performance of automobiles is a necessary step in the process of purchasing a new car. Program administrators can enter in agreements with RESNET to use their HERS rating system as a marketing tool, however success of home energy ratings would be best achieved in markets where existing homes are also subject to building labeling requirements, allowing homebuyers to make informed comparisons of home performance across a variety of homes.

There is significant savings yet to be realized through new construction programs, which programs can target through new technologies installed through performance-based paths, such as ductless heat pumps, heat pump water heaters, and solid state lighting, as well as steps to optimize the entire home as a system. Program administrators should pay particular attention to increasing their efforts dedicated to homebuilder training as well as the marketing of these programs to both homebuilders and buyers. Getting homebuilders on board is important to increasing awareness and participation on the part of homebuyers. Allowing programs to get credit for supporting code compliance efforts is another means toward driving deeper savings from new homes, though few states have determined accepted methodologies for savings attribution. Similarly, new construction programs can also work as a pathway to more stringent building code adoptions. By working with homebuilders through these programs and helping them understand the requirements of building super-efficiency homes, program administrators can encourage homebuilders to be more supportive of future, more stringent energy code adoptions.

To generate greater savings, new construction programs should offer a variety of energy efficiency tiers in order to provide homebuilders and homebuyers different options for achieving energy efficiency above code. Flexibility is promoted by offering several tiers and allowing for both performance- and prescriptive-based qualification for incentives relative to those tiers, so it is important that homebuilders and homebuyers have choices when considering energy-efficient homes. However, maximizing savings will be facilitated mainly by focusing on performance-based paths, such as the ENERGY STAR standards, as this allows for custom combinations of measures for each home provided the overall design meets minimum performance requirements. Performance-based paths also allow homebuilders to experiment with building design to better understand how they will meet more stringent building energy codes in the future. This in turn will help lead the market toward the standardization of super-efficient new homes, such as low-load or passive-house homes.

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MANUFACTURED HOUSING

Synopsis

There has been a long history of energy efficiency programs for manufactured housing in the U.S., dating back to the mid-1980s. Many of these programs originated in the Pacific Northwest. This research identified four major types of manufactured housing energy efficiency programs: 1) high efficiency labeling programs (ENERGY STAR, etc.) for new construction, 2) weatherization, 3) utility-sector retrofit (incentive/rebate) programs and 4) home replacement. With the exception of several programs in the Northwest and one Florida program, we verified very few current utility sector manufactured housing programs. With decreasing federal weatherization funds and very few currently offered programs, it is possible that the manufactured housing market could provide electric and natural gas utilities with cost-effective energy savings for their portfolios.

Background

Energy efficiency programs targeting the manufactured housing sector have traditionally fallen into one of four categories: high efficiency labeling programs for new construction, weatherization, utility-sector retrofit (incentive/rebate) programs and home replacement. Weatherization and home replacement programs target low income homeowners living in energy-inefficient homes. Weatherization programs focus on retrofitting the building envelope to improve comfort and reduce energy costs for economically vulnerable residents. Programs in colder climates have also included upgrading furnaces to condensing models. Home replacement programs seek to replace homes that are too dilapidated to weatherize. Home replacement programs focus on pre-1976 manufactured homes, although other homes may also be eligible if weatherization is not cost-effective. Utility-sector retrofit programs provide incentives to customers to purchase or install energy saving devices in their homes. New construction programs provide incentives to manufacturers and consumers to build and purchase high efficiency homes, respectively.

In the manufactured housing sector, these program approaches can present a problem. A substantial portion of manufactured home residents do not qualify for low income weatherization programs or home replacement programs because their annual income is above the maximum threshold, but lack the capital to invest in high efficiency homes. Current lending practices create additional an additional financial barrier for buyers of manufactured homes as they frequently qualify only for a personal property or “chattel” loan, which features a high interest rate and short amortization schedule. These market forces create a gap, a kind of “income sandwich” that not only disadvantages sandwiched residents, but also overlooks ample cost-effective energy savings potential.

There are currently three utility-sector retrofit programs that serve residents who fall into the income gap: Progress Energy Florida (PEF), Central Lincoln People’s Utility District (CLPUD) in Oregon, and Puget Sound Energy (PSE) in Washington. The programs offered by CLPUD and PEF have specific funding levels for manufactured homes but use the same measures as programs for site built homes (insulation and cool roofs, respectively). PSE runs a program that provides duct testing and sealing for manufactured homes at no cost to the resident. We will discuss these programs further below.

Existing Program Models

High Efficiency Labeling Programs for New Construction

For decades, the northwest has led the nation in successful market transformation activities for manufactured homes. In the mid-1980’s Bonneville Power Administration (BPA) funded a pilot project called the Residential Conservation Demonstration Program, which led to the creation of the Super Good Cents (SGC) program for electrically heated homes in 1988. Through funding provided by BPA, the state energy offices of Washington, Oregon, Idaho, and Montana offered customer incentives of \$2,000-3,000 for purchases of high efficiency homes built to Super Good Cents specifications, which were over 50% more efficient than 1976 HUD Code and over 30% more efficient than 1994 HUD Code (Eklund et al. 1996; IEE 1996). In 1992, BPA extended SGC to include upstream incentives, offering regional manufacturers \$2,500 to build their homes to Super Good Cents specifications in an effort called the Manufactured Home (Resource) Acquisition Program (MAP) (Pratt and Smith 2002). MAP reduced the incentive to \$1,500 after the 1994 update to the HUD Code. Even without adjusting for inflation, the incentives provided to both customers and manufacturers were high by today’s standards. These two programs were great successes, leading to widespread adoption of higher insulation, lower air infiltration, better ventilation, and high efficiency windows, among other improved construction techniques (Eklund et al. 1996). Despite its success, MAP was discontinued in the summer of 1995 due to funding constraints.

In 1995 SGC homes represented the vast majority of new manufactured home sales in the northwest (Eklund et al. 1996). Manufacturers had retooled their construction facilities to build homes meeting SGC standards and manufactured home retailers relied on the SGC label to market their homes. In order to preserve the progress made by SGC, the Oregon Department of Energy bought the rights to SGC and leveraged the popularity of the program to transition into a market-based structure in which manufacturers paid a \$30 fee for each home labeled as an SGC home. Also at this juncture, the Oregon Department of Energy expanded the program to include homes heated with natural gas,

under the moniker Natural Choice. Together, SGC and Natural Choice comprised the Northwest Energy Efficient Manufactured Home (NEEM) program.

Unfortunately, the fee structure developed by the Oregon Department of Energy was only successful in Oregon, in which most of the regional manufacturers were located. In an effort to improve uptake in other states in the region, the Northwest Energy Efficiency Alliance (NEEA) began funding a similar fee-based program known as the Super Good Cents Venture program, which lasted from 1997 until 2001. During this five year period, market share of SGC homes began to slip, coinciding with the sales bust of the late 1990's (Pratt and Smith 2002). Yet even at its lowest point in the 1990s, market share of NEEM homes was still over 35%, and in the early 2000's when the Super Good Cents Venture program disbanded, market share had rebounded to about 70%. NEEM now uses ENERGY STAR as the high performance label for manufactured homes in the northwest. The NEEM program and its precursors demonstrated both the potential to build high performance manufactured homes and for those homes to *sell*. Since 1989, 68% of new manufactured homes in the northwest were built to high efficiency standards (Lubliner and Eckman 2012).

ENERGY STAR

In 1995 ENERGY STAR launched a program for new site-built homes, and in 1997 extended it to include manufactured homes. In order to qualify for ENERGY STAR recognition, a manufactured home builder must design the home in accordance with ENERGY STAR specifications, have it inspected in the plant after construction, and have it inspected in the field after installation according to a prescribed installation checklist. Manufacturers have the option to build homes based on set pre-qualified construction packages that are tailored to the four HUD climate zones, or use computer modeling software to design a home that meets energy performance criteria through other means. Through this latter method, a home builder could, for example, install less efficient appliances in exchange for tightening up the building envelope (EPA 2012). ENERGY STAR-labeled manufactured homes use about 30% less energy relative to 1994 HUD Code homes and have represented 9-10% of the market in the past several years (Gold and Nadel 2011).

ENERGY STAR and NEEM Collaboration

The NEEM program was well established in the northwest prior to creation of the ENERGY STAR program for manufactured homes. In an effort to maintain the existing demand for high efficiency homes created by NEEM and avoid the burden of competing program criteria for homebuilders, NEEM partners worked with ENERGY STAR to develop a co-branding strategy that was implemented in 2001. Under this program, ENERGY STAR serves as the brand and NEEM serves as the program administrator in the northwest. Since then, market share of NEEM/ENERGY STAR-qualified manufactured homes in the northwest has been as high as 80%, and is currently about 50% (Lubliner and Eckman 2012). Market emphasis on low purchase price has likely driven the recent decline in sales of NEEM homes (Eklund et al. 2012).

Incentives for ENERGY STAR Manufactured Homes

Until the end of 2011, manufactured homebuilders could receive a \$1,000 tax credit in exchange for building a manufactured home that used 30% less energy for heating and cooling than required by the 2004 IECC or that qualified for ENERGY STAR recognition. This tax credit has not been renewed as of August 2012. Kentucky currently offers a \$400 tax credit to a Kentucky taxpayer who sells an ENERGY STAR-qualified manufactured home (DSIRE 2012).

Many utility companies and cooperatives, predominantly those located in the northwest and southeast, offer financial incentives to consumers who purchase ENERGY STAR-qualified manufactured homes. These incentives can range from a few hundred dollars to over one thousand dollars and may be coupled with an incentive to the sales representative who brokers the deal. In South Carolina, residents who purchase an ENERGY STAR-qualified manufactured home can receive a sales tax credit up to \$300 and a personal tax credit up to \$750 (DSIRE 2012).

Weatherization

The Weatherization Assistance Program (WAP) is a DOE-sponsored national retrofit program for low income households created by the Energy Conservation and Production Act of 1976 (DOE 2012b). Through WAP, DOE distributes funds to states, who administer programs locally via their internal networks of contractors, non-profits, municipalities, and more. WAP retrofit projects implement cost-effective measures to improve both the building envelope and equipment systems. WAP projects for manufactured housing have tended to focus on ceiling, wall and belly insulation, air sealing, and duct sealing. These measures are most often cost-effective and provide substantial energy savings while improving indoor comfort and air quality. Appliances are rarely upgraded through WAP, although weatherization teams will inspect furnaces and air conditioners, cleaning or replacing the air filters if needed.

Federal appropriations for WAP have fallen in recent years from a 2009 peak of \$450 million down to \$68 million for FY 2012. This is the lowest funding level since 1978, shortly after the program's inception (Gaston 2012). Additional WAP funding may also come from the Low Income Home Energy Assistance Program (LIHEAP) and state and utility programs, although LIHEAP has also received budget cuts in recent years. Over the past several years, the American Recovery and Reinvestment Act (ARRA) provided an additional \$4.98 billion for WAP activities, resulting in over 600,000 retrofits through the end of 2011 and exceeding program goals. Though originally scheduled to expire in March 2012, WAP is authorized to use ARRA funds until depleted.

Federal WAP appropriations are apportioned to states by both a base allocation and an additional allocation derived from the state's low income population, climate, and energy expenditures per capita among low income households (DOE 2012b). Gross spending, spending per capita, and energy savings achieved in the manufactured housing sector varies by state. In North Carolina, about 30% of all WAP funds are allocated to manufactured homes, resulting in about 20% energy savings from an average investment of \$3,000 (Eldridge et al. 2010).

Utility-Sector Retrofit Programs

For retrofits, residents of manufactured homes are eligible for incentives to upgrade appliances and retrofit homes. Participation rates for manufactured home residents are unknown. Based on data regarding the frequency of home repairs and major appliance upgrades, we expect that participation rates are lower than among residents of site-built homes (Vermeer 1997). We know of only three utility programs that tailor incentive programs to manufactured homes.

Progress Energy Florida (PEF) offers a \$40 flat rate incentive to residents of manufactured homes who install a reflective roof coating. This compares to \$0.15/sq. ft. (up to a maximum of \$150) to residents of site-built homes. Other relevant incentives available to all residential customers include: covering 50% of \$60 duct test and up to \$150 for costs of duct repair; \$75 for attic insulation plus \$0.07/sq. ft. for every square foot of living space above 1,500 sq. ft.; up to \$350 for purchase of a new heat pump; up to \$250 for new windows and 50% of cost up to \$100 for solar window screens or window film; and \$0.20/sq. ft. up to \$300 for wall insulation (DSIRE 2012).

Central Lincoln People's Utility District (CLPUD) in Oregon offers \$0.18-0.20/sq. ft. up to 70% of the total project cost for attic and floor insulation improvements in manufactured homes, compared to \$0.40-0.70/sq. ft. for site built homes. CLPUD also offers \$750 for the purchase of a new ENERGY STAR-compliant manufactured home and incentives for ENERGY STAR appliances, windows, and lighting. Finally, CLPUD offers \$500-1,400 for purchases of ductless heat pumps (DSIRE 2012).

Puget Sound Energy (PSE) in Washington runs a unique program that provides duct testing and sealing for manufactured homes at no cost to the resident. The program offers three-levels of duct sealing based on home size and HVAC system architecture (number of vents, presence of crossover vent, etc.). Based on a 20-year measure lifetime and deemed savings averaging 800 kWh/year for a home in a moderate climate zone, both derived by the Northwest Power and Conservation Council Regional Technical Forum, PSE spends an average of \$375 per home (NWPCC 2012). Working with mobile home park managers, PSE program administrators have targeted manufactured home communities in order to maximize market penetration at the lowest possible cost (working on many homes in one location lowers project costs by decreasing travel time for work crews). Through this method, PSE tests and seals ducts in approximately 400 homes per month (Dodson 2012). Now in its fifth year, the program has been such a remarkable success that PSE is expanding the program's reach. While the program has predominantly served electricity customers, it has recently expanded to include some gas customer as well (Dodson 2012). Market penetration in mobile home communities is so high that program administrators must also look beyond parks. In addition to duct sealing, work crews survey lighting and shower fixtures. PSE provides an average of 1-2 efficient showerheads and 18-20 compact fluorescent light bulbs to customers with inefficient fixtures and lighting, again at no cost to the resident (Dodson 2012).

Home Replacement

While there are no permanent programs in the U.S. devoted to manufactured home replacement, a number of pilot programs have either been administered or are currently being administered in various regions of the country including in Maine, Tennessee, Montana, and Washington. Qualifications for participation vary, but generally require that participants fall below a certain

income threshold and live in a home suffering from significant degradation that prohibits cost-effective weatherization. Programs target residents of homes built prior to 1976 but may accept applicants with homes built later if the home's condition is very poor (some programs limit eligibility to pre-HUD Code homes). All pilot programs require replacing existing homes with an ENERGY STAR-labeled home.

To assist buyers, home replacement programs provide low or no interest loans that may be forgivable after a predetermined period of time (WSDOC 2012; MaineHousing 2012). Even with a 0% interest loan, program experience has shown that the mortgage costs for a new ENERGY STAR home can be a significant hurdle for prospective home buyers, including those with very high energy costs (WSDOC 2012). While field data detailing energy savings from these programs are unavailable, modeled energy savings suggest that participants should realize a net monthly savings of \$25-40 when accounting for the cost of the mortgage with an interest rate of 0% or 7% over 30 years (Salzberg et al. 2012). Over the lifetime of the home, this could add up over \$10,000 savings.⁴⁶

Compared to weatherization programs, home replacement programs serve relatively few households on account of high program costs. Excluding administrative costs, purchasing and installing a new ENERGY STAR manufactured home can cost around \$60,000 relative to several thousand dollars for weatherization (WSDOC 2012). While loan costs may be recouped, home replacement programs will still cost more per participant than weatherization programs. At the same time, energy savings are also much larger in replacement programs, and a new home will provide greater amenity to the resident over a longer period of time.

Drivers for Change

New Building Codes

The Department of Housing and Urban Development (HUD) Code governs construction quality, safety, and energy conservation standards for manufactured homes. The energy conservation portion of the HUD Code has not been updated since 1994. In response to the delay in updating the energy component of the HUD Code, in 2007 Congress gave the U.S. Department of Energy (DOE) authority through the Energy Independence and Security Act of 2007 (EISA) to establish new energy standards for manufactured housing. Although EISA required that DOE issue a final rule by December 2011, as of August 2012 only an Advance Notice of Proposed Rulemaking has been issued, which was released on February 22, 2010. The next step, a proposed rule, has been sent from DOE to the Office of Management and Budget (OMB), which must approve it before it is released to the public. We expect this release before the end of 2012.

It is not currently known what level of energy efficiency this code will require. However, EISA requires that DOE develop standards for manufactured housing that “shall be based on the most

⁴⁶ Assumes 30 year lifetime.

recent version of the International Energy Conservation Code (including supplements), except in cases in which the Secretary finds that the code is not cost effective, or a more stringent standard would be more cost effective, based on the impact of the code on the purchase price of manufactured housing and on total life-cycle construction and operating costs” (Pub. Law 110-140). Research has demonstrated that 30% savings above current HUD Code (roughly equivalent to 2012 IECC) is both achievable and cost-effective (Salzberg et al. 2012, McGinley et al. 2004, Conner et al. 2004).

After DOE adopts new energy standards, EPA will likely increase criteria for ENERGY STAR recognition as well. It is not known what level of energy efficiency EPA might seek. Still, this transition to higher efficiency will affect construction costs and purchase price for consumers (at least in the short term). For homebuyers who finance a home through a personal property loan, this incremental cost may be quite palpable. As a result of higher costs, federal-, state-, and rate payer-funded incentive programs for ENERGY STAR manufactured homes will likely need to reevaluate incentive levels.

Ductless Heat Pumps

Manufacturers and dealers have offered heat pump upgrades for manufactured homes for over a decade. Manufactured homes are typically shipped with the furnace installed “heat pump ready,” so this appliance decision can be made at the point of sale. Heat pump ready construction requires that the closet housing the furnace is sized to adequately contain the “A-frame” condenser unit of the heat pump and that a two-stage (heat pump applicable) thermostat is installed at the plant. The heat pump’s “A-frame” condenser unit, outdoor compressor cabinet and appropriate connections are added when the home is sold and sited (Duncan 2012).

More recently, researchers have examined the potential for using ductless heat pumps in manufactured homes. Ductless heat pumps, also called ductless mini-splits, are comprised of an air handler installed on an external wall, connected to a condensing unit, like that used for a conventional heat pump. Instead of distributing air throughout the home via ducts, ductless heat pumps provide all space conditioning from one area. In order to work most effectively, doors in the home need to be left open.

Ductless Heat Pumps are a particularly attractive technology for manufactured homes. The majority of manufactured homes are located in the south and other relatively temperate climates where heat pumps excel (Census 2011). Ducts in manufactured homes are notoriously leaky, even in relatively new homes (Manclark and Davis 1996). Resistance electric furnaces are the most common space heating appliance in manufactured homes and they are very energy-inefficient (EIA 2011). Incorporating ductless heat pumps into building designs for manufactured homes will address both of these issues. Bypassing the need for ductwork will eliminate delivery losses associated with duct leakage and also reduce construction costs. Using a heat pump will increase space conditioning efficiency by roughly a factor of two.

Ductless heat pumps are an emerging technology and costs are currently high, often exceeding those of ducted heat pumps (NEEA 2010). Obviating ducts will help offset some of these costs, and greater market penetration will reduce costs. Still, our analysis (Talbot 2012) finds ductless heat pumps cost-

effective as retrofits in today's market. With reduced costs in new construction they will be increasingly so.

There have been several case studies in the northwest evaluating the potential for ductless heat pumps to reduce space heating loads. We know of no studies examining the potential for ductless heat pumps to offset both space heating and cooling loads. Further field studies in a variety of climates will help quantify the energy efficiency potential for these systems and vet their cost effectiveness.

Target Market

Low-income residents predominate in the manufactured housing sector. The median household income for manufactured homes is \$30,000, and 22% of manufactured home residents have incomes at or below the federal poverty level. In comparison, the median household income for residents across the entire housing stock is \$47,000 (Census 2011). Many (23%) are retirees who live on fixed income, and 45% receive Social Security or other retirement benefits for at least part of their income (Census 2011).

Savings Potential

ENERGY STAR homes are 30% more efficient than new homes meeting the HUD Code. Heat pumps are about twice as efficient as electric furnaces, providing large savings from system replacement. Duct sealing through the PSE program has saved 800 kWh per home on average in a moderate climate. Talbot 2012 provides a full analysis of energy efficiency potential in the manufactured housing sector, which finds that the cost-effective potential by 2030 for electricity savings is 40% and 33% for natural gas usage. Our savings potential estimates below assume that 90% of the cost-effective potential is achieved by 2030.

Manufactured Housing	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	88.7	97.7	For 2030 from Talbot 2012; includes manufactured housing sector only
Average percent savings	45%	37%	Estimate of savings per participant derived from cost-effective potential in Talbot 2012
Ultimate net participation rate	<u>80%</u>	<u>80%</u>	Estimate derived from cost-effective potential in Talbot 2012
Potential long-term savings	32	29	From Talbot 2012: we estimate that 90% of cost-effective potential including new construction is achievable

Examples

High Performance Manufactured Home (HPMH) Super NEEM

The NEEM program in the Pacific Northwest has been successful in establishing a market for high performance manufactured homes. Over 155,000 (68%) of all manufactured homes built in the Pacific Northwest have been built to high efficiency standards (Larson and Hewes 2012). In an effort to raise

the energy efficiency bar beyond ENERGY STAR specifications, BPA has recently funded an effort to create a new high performance energy efficiency specification. This specification requires that qualifying manufactured homes use about 50% less energy than an Pacific Northwest “baseline” home (which, due to the large market share for high performance homes, is more efficient than a minimum HUD Code home). The “Super NEEM” home specification will require R45 ceiling insulation, R21 + R5 foam sheathing wall insulation, R-38 floor insulation, 0.22 u-value windows, and an overall U-value of 0.040, which compares to 0.079 for HUD code minimum performance and 0.065 for the Northwest baseline home.

Significantly, the Super NEEM home will also require a ductless heat pump and auxiliary resistance electric wall heaters instead of a forced-air furnace, a vented heat pump water heater, almost entirely high efficiency lighting, and ENERGY STAR-qualified dishwasher and refrigerator. This is the first high performance specification for manufactured homes to require high performance appliances in addition to improved building shell and ventilation performance. The total incremental cost is estimated at a little under \$10,000 and once launched, the program will offer a financial incentive to homebuyers.

MaineHousing Program

MaineHousing ran a pilot program from 2008-2009 to replace pre-1976 HUD Code homes with ENERGY STAR-qualified units. After the success of this initial pilot, MaineHousing expanded the program as a regular offering. In 2011 they replaced over 20 homes, with an average project length of 4-6 months. In this program, MaineHousing purchases the loan for a new home from a local bank and offers program participants a deferred and forgivable mortgage. In order to qualify for the program a resident must own the land on which they are currently living and owe no more than \$10,000 on their existing mortgage. As with other home replacement programs, costs per home are high. However, this program is able to help residents living very poor condition homes who would neither be able to afford a new home on their own nor qualify for weatherization due to the poor condition of the home.

Upgrade and Save Program

Though not currently offered, North Carolina’s Upgrade and Save program was a successful venture that sought to increase market penetration of ENERGY STAR® manufactured homes with heat pumps. The program offered a \$500 incentive per home to retailers who installed heat pumps in ENERGY STAR-qualified homes prior to sale. The program also offered a limited number of incentives to owners of recently purchased homes (built 2003 and later) to upgrade to heat pumps. These homeowners could receive up to \$1500 in matching funds to upgrade their electric furnace to a heat pump.

Retrofit Programs

The PSE program, mentioned earlier, is a particularly notable retrofit program for manufactured housing.

Recommendations

Weatherization

WAP has served as the primary program for manufactured housing retrofits in the United States. For low-income homeowners it serves as an important avenue for improved home energy performance. Of course, we would like to see federal WAP funding return to 2009 levels but, in the meantime, utility-sector programs could fill some of the gaps due to reduced funding. Comprehensive weatherization programs for manufactured housing can result in significant energy savings. Utilities might consider offering weatherization services to both residential customers that qualified for the federal program but were not served and residential customers that would not qualify for the federal program because they slightly exceeded the Weatherization income threshold.

Utility-Sector Programs

Our survey of utility-sector programs revealed one program that offered a substantively tailored approach to reaching residents of manufactured homes, the PSE duct testing and sealing program. PSE's program is particularly noteworthy because by offering duct sealing at no charge to the homeowner it addresses the primary barrier to increasing efficiency in manufactured homes: incremental cost. While this is an admittedly limited sample, this program's five years of success suggest that this model could work in other areas of the country. Deemed savings used by program administrators are based on a moderate climate zone and electricity rates in the northwest are below the national average (EIA 2012). In areas of the country with more extreme climates and/or higher utility rates, duct sealing should prove even more cost-effective. We recommend that program administrators in other areas of the country, particularly the south, conduct their own cost-effectiveness tests to determine whether PSE's program model could offer cost-effective savings for their programs.

Financing a Manufactured Home

The large majority (74%) of manufactured homes are financed with personal property loans, often called "chattel" loans, while only 22% are titled as real estate (Census 2011). The chattel mortgage system has far-reaching ramifications for the industry. Personal property loans carry higher interest rates and shorter amortization schedules. Historically, a typical mortgage rate is about 7% interest over 30 years, although interest rates at present (mid-2012) are usually much lower. By contrast, a typical chattel mortgage rate is 15% over 15 years. As a result, relatively small increases in purchase price can lead to significant increases in loan payments. For low- and fixed-income home buyers, this can make the difference between buying a minimum efficiency and an ENERGY STAR-labeled manufactured house. For this reason, working with retailers and financial institutions to help provide access to traditional mortgage rates for prospective buyers is an important step toward increasing market penetration of high performance manufactured homes.

Making High Performance Homes the Norm

The key point in programs like NEEM and Upgrade and Save is trying to make best practices the norm by offering upstream and midstream incentives. Particularly for manufactured homes, once a manufacturing facility incorporates features like duct testing, it may be cheaper to just do that for all of the homes rather than just a few. Similarly, with Upgrade and Save, if dealers make it standard practice to install heat pumps, the process can be streamlined. That's a big difference with

manufactured homes and the custom site-built industry. Programs to make high-efficiency homes the norm should be considered in other regions.

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MULTI-FAMILY HOUSING

Synopsis

Despite the challenges faced by multifamily housing energy efficiency programs, there are numerous existing successful multifamily programs. Streamlined programs that are straightforward, multi-fuel, comprehensive and not financially burdensome attract building owners. Cost-effective, stable, multi-year programs in which all participating utilities are adequately incentivized are attractive to utility companies. Program planning that secures the cooperation of the housing authorities and financing organizations, and program design that considers both the financial and time constraints of the building owners and the regulatory environment of the utilities, will help program operators break into this underserved, multifamily housing market.

Background

Multifamily buildings represent about a quarter of the housing units in the U.S. and comprise 20% of energy consumed by all housing units, yet have been greatly overlooked when it comes to implementing energy efficiency programs (ACEEE Multifamily Fact Sheet). Studies note that affordable housing, often multifamily, receives a disproportionately small share of available electric and natural gas utility energy efficiency funding and that states vary widely in their commitment of utility-sector energy efficiency program resources to multifamily housing (McKibben et al. 2012).

Energy efficiency programs for multifamily buildings range from the installation of energy-efficient light bulbs and reduction of hot water consumption to comprehensive energy efficiency programs including energy audits, contractor selection and oversight, financing and post-retrofit review of savings (McKibben et al. 2012).

It has been difficult to address the unique needs of the multifamily housing market through energy efficiency programs. Three major problems faced by such programs are:

1. These housing units represent a disproportionately large number of low-income residents and residents living below the poverty line. 71% of households living in multifamily buildings are low-income, earning less than \$40,000, while 28% are living below the poverty line (\$20,000). (EIA RECs website).
2. The split incentive problem—that is, the party who owns the property and is responsible for capital investments and upkeep (landlord) typically is not the same party who is responsible for paying energy costs (tenant). Over 80% of residents living in multifamily buildings rent (EIA RECs website).
3. Different energy utilities may provide service to the same multifamily building: electricity and natural gas. Energy savings opportunities exist for both types of fuels, but an integrated approach is needed to be most effective. Regulatory frameworks that govern different types of utilities may make such integrated approaches difficult, especially concerning program costs and determination of appropriate energy savings credits.

Despite these and other challenges, there are numerous existing successful multifamily energy efficiency programs. Generally, it remains an underserved market with large savings potential.

Drivers for Change

More energy savings per program portfolio. Providing energy efficiency programs to the largely untapped multifamily sector can help utilities meet their energy savings goals as established in states with “energy efficiency resource standards” (EERS). Such goals require that programs achieve greater penetration in previously underserved markets, particularly those that offer a large energy savings potential. Multifamily buildings in many utility service territories represent such opportunities.

Better customer service, greater participation and increased savings per energy efficiency program. If programs are designed with the needs of the multifamily building owners (free audit, straightforward paperwork, program guidance and assistance throughout the program, free measures or low-interest financing, etc.) and specific issues of the multifamily structures in mind, more multifamily owners will participate.

More energy savings per participant. Comprehensive, multi-fuel, “one-stop shopping” energy efficiency programs will get the greatest amount of energy efficiency out of each multifamily building at the lowest relative program cost. Without such integrated approaches, certain savings opportunities likely will not be captured and overall program costs will be higher since there likely will be duplicative administration and delivery costs (think of two different crews engaged in a project versus a single crew).

Significant long-term cost savings for agencies paying energy costs. A variety of state and federal agencies pay energy costs for qualified low-income tenants in multifamily housing. Properly designed utility-sector multifamily energy efficiency programs could help reduce the \$6.8 billion annual utility bill paid by the U.S. Department of Housing and Urban Development (HUD) (Bamberger 2010)

Emerging Trends and Recommendations

Program Design

Due to the different approaches by which states regulate utility energy efficiency policies, multifamily building owners must engage utilities or other program administrators based on each utility’s energy efficiency regulatory circumstances and the building owners’ needs. The most effective multifamily energy efficiency programs will be jointly funded by building owners and utility-sector programs and install multiple, long-lasting natural gas and electricity-saving measures. Building owners must work with regulators and legislators to align utility incentives with comprehensive multifamily energy efficiency programs and to encourage utilities to share electricity and natural gas consumption data according to research recently completed by ACEEE and CNT Energy (McKibben et al. 2012). This research identified the following issues to address in the design of effective multifamily programs:

Utility risk aversion and compliance focus. Regulated utilities generally have a compliance culture. These utilities tend to follow, but not exceed, the energy efficiency mandates with the idea that they must save some energy savings to achieve with future programs. In order to exceed the mandate, it is helpful to provide a profit incentive. Eighteen states offer some type of profit incentive to encourage utilities to exceed the current state energy efficiency mandate.

Incentives to oppose non-utility efficiency programs and regional coordination efforts. Some regulated utilities may also view non-utility efficiency programs as exhausting future energy savings. As a result, these utilities may oppose comprehensive energy efficiency programs that coordinate utility and non-utility programs. In these cases, the states must ensure that the utilities can apply their energy savings achieved through these coordinated efforts towards their state-mandated energy savings targets. For example, California, Florida, Massachusetts, Michigan, Minnesota and North Carolina apply this full attribution rule to American Recovery and Reinvestment Act-funded projects that involve utilities.

Shifting regulatory requirements discourage comprehensive programs. To encourage utilities to invest in comprehensive programs, states must maintain consistent criteria for the programs over time. The utilities must know that programs that are developed under one set of regulatory criteria will be assessed by that same criteria after the programs are implemented.

Program evaluation details can discourage multi-fuel programs. To encourage utilities to participate in multi-fuel programs, states must encourage geographically overlapping electric and natural gas utilities to design and implement comprehensive programs and ensure that each utility is allowed to claim its portion of the savings towards its goals.

Program evaluation details can discourage the use of financial leverage. To encourage utilities to participate in programs that leverage funds from other entities, states should ensure that the utilities are allowed to claim some or all of the savings achieved through leveraged funds.

Cost-benefit tests may discourage comprehensive programs. Screening energy efficiency measures for cost effectiveness at the individual measure level may unduly limit the number of measures addressed by programs. Instead, programs should address integrated portfolios of measures for cost-effectiveness screening.

Energy Efficiency Resource Standards (EERS) spending caps discourage comprehensive programs. Spending caps that are set too low may prevent utilities from meeting their savings targets. States should support expenditures on any energy efficiency program that results in savings that cost less than generating and delivering an equivalent amount of energy. Spending caps should be reviewed.

Constrained budgets and savings incentivize the utilities to get high first year savings and do not encourage investments in comprehensive programs with longer term savings. States should allow utilities to assess savings and spending targets on multiple year timeframes.

Data privacy concerns prevent sharing data needed for comprehensive programs. Program providers use utility customer energy consumption data to assess energy costs, prioritize buildings for improvement and secure financing. The consumption data is also used to evaluate energy efficiency programs. Data confidentiality is a critical issue for many tenants and building owners. Three approaches to address confidentiality are:

- (1) States could develop a comprehensive system, such as a data aggregator, who could combine data from multiple utilities and other sources and ensure the security of the data,

- (2) States could develop consistent data-sharing agreements for use by utilities, efficiency program designers and implementers and research institutions, and
- (3) The federal government could create a neutral aggregator based on the model presented in the Home Mortgage Disclosure Act which requires lending institutions to maintain mortgage loan information in a central registry.

Master metered vs. individually metered units. A prominent national organization that represents state consumer advocates, the National Association of State Utility Consumer Advocates (NASUCA), recently passed a resolution that addresses the issue of master metering versus individual metering of multifamily units.⁴⁷ This Resolution indicates that multifamily housing buildings often have a mix of master (owner-paid) and individual meters, which may result in the owner and tenants having to make multiple applications and/or apply to both “commercial” and “residential” programs, rather than being able to make a single application. It is important that programs are designed to take this issue account, and not require both residential and commercial applications.

Mix of building types. Another issue addressed by the NASUCA resolution is that a mix of building types, such as low-rise townhouse buildings and high-rise towers, on a multifamily property may result in the owner having to submit multiple applications and/or speak to different staff and departments at the utility company. This issue should also be taken into account when the program is designed. The process should be as simple and as straightforward as possible. The more obstacles that an owner encounters, the less likely he or she will be to participate in the program.

Target Market

The target market for this program is owners of multifamily housing. Multifamily housing includes small (2-4 units), medium (5-20 units) and large (over 20 units) structures. Both individual units and common areas should be addressed.

Marketing

The marketing message should emphasize the ease of the program for building owners, one-stop shopping and the assistance that the owner will receive throughout the process.

Savings Potential

McKibbin et al. (2012) estimated that, on a national level, cost-effective energy efficiency upgrades in multifamily buildings with five or more residential units could result in 15% electricity savings and 30% natural gas savings. Annual cost savings for these upgrades were estimated to be approximately \$3.4 billion (\$2.03 billion on electricity and \$1.34 billion on natural gas) for the multifamily sector.

⁴⁷ Resolution 2011-14, Urging an Equitable Expenditure of Energy Efficiency Funds on Affordable Multifamily Housing.

The Benningfield Group (2009) estimated that the achievable potential by the year 2020 was over 51,000 GWhs of electricity and over 2,800 Million therms of natural gas (or equivalent, for those regions that use other fuels). In this report, the Benningfield Group estimated that potential savings would have a value of nearly \$9 billion annually to property owners and tenants, compared to current energy costs of over \$31 billion.

Multi-Family Housing	Electricity	Gas	Notes
	TWh	TBtu	
National energy use affected	271	807	From EIA AEO Outlook 2030; 16.7% of total residential energy use is multifamily
Average percent savings	15%	30%	Based on review of program experience in McKibben et al. 2012
Ultimate net participation rate	<u>30%</u>	<u>30%</u>	
Potential long-term savings	12	73	

Examples

Chicago Area Energy Savers Program

The CNT Energy and Community Investment Corporation Energy Savers program in the Chicago area provides multifamily building owners a one-stop shop for energy efficiency.

Energy Savers provides a free energy audit of each building and identifies the most cost-effective energy efficiency improvements. The program helps the building owner secure low-cost financing, take advantage of energy efficiency incentives and grants offered by other entities (the utilities, the Illinois Department of Commerce and Economic Development and the Illinois Attorney General's office) and choose and supervise qualified contractors. Energy Savers' energy analysts review annual energy bills, create performance reports and make necessary adjustments to the building energy efficiency plan if savings are not as anticipated.

A typical multifamily building in the program is a 3-story, 24-unit masonry structure with 24,000 feet of heated space and approximately \$10,000 per year in energy costs. Program payback is approximately five years. From 2008 to 2011, Energy Savers upgraded over 7500 units.

The program's low cost loans, which are half the market rate, are provided by the Community Investment Corporation using a fund established by a number of the programs other partners. Funds developed by the utilities and the Illinois Department of Commerce and Economic Development are generated by the Illinois EERS. Utilities and program administrators have worked together to address data sharing, data attributions toward EERS targets and other programmatic issues, and are currently working to establish the utilities' ability to claim EERS credit from regional coordination efforts.

California Statewide Multifamily Rebate Program

Since 2002, California's four major investor-owned utilities collaboratively have offered a multifamily, multi-fuel rebate program, the California Statewide Multifamily Rebate Program. The IOUs work closely with members of the multifamily sector and meet regularly to discuss program issues,

coordinate marketing and efficiency messaging and ensure consistent program delivery. Each IOU offers the program in its own service area.

The program offers up to \$1500 for qualifying, permanently installed energy efficiency measures and improvements inside the tenants' dwellings and in common areas of residential apartment buildings, mobile home parks and condominium complexes of two or more units. The IOUs have focused on providing the service to individually metered tenant dwellings.

From 2004-2006, the program served over 410,000 housing units, resulting in annual savings of over 141 million kWh of electricity and almost 6 million therms of gas.

National Grid's EnergyWise, Multifamily Retrofit, and Home Energy Solutions

Since 1992, National Grid's multifamily retrofit program has grown significantly, expanding from Massachusetts to Rhode Island, New Hampshire and New York. The program serves public housing authorities, low-income and market rate multifamily facilities. Single family customers are included in the Rhode Island and New Hampshire programs. The program provides information and incentives to help customers replace inefficient equipment cost-effectively and was designed to address the split incentive problem. Although the program has historically focused on electricity savings, in 2010, Massachusetts and New York introduced a natural gas program.

National Grid's program is funded through a state legislated system benefit charge and is widely marketed through direct contact with interested customers and homeowners, property owners' associations, bill inserts, National Grid's website, home shows and direct mail. High energy-use facilities are served first.

At the first site visit, customers receive a comprehensive energy assessment. Customers receive energy education and the installation of low cost measures like ENERGY STAR light bulbs and energy saving hot water measures at no cost. Higher cost measures are screened for cost-effectiveness in multifamily facilities. Major measures are competitively bid for facilities with more than twenty units. In some cases, improvements may be implemented by related National Grid programs.

From 1998-2010, the electric program saved over 189,000 MWH and served over 242,000 customers. In 2010, the natural gas program saved over 553,000 and served over 5000 households.

Massachusetts' Low-Income Multifamily Retrofit Energy Program

In 2010, the Massachusetts' utilities redesigned their multifamily programs and launched the Low-Income Multifamily Retrofit Energy Program (LIMFREP). The program is administered by the utilities in collaboration with the Massachusetts Department of Housing and Community Development, public housing authorities (PHA), community development corporations (CDCs), non-profit owners, tenant organizations and community action agencies.

Eligible housing includes existing low-income multifamily buildings with five or more units owned by PHA or non-profits. Priority is given to high energy use buildings and buildings undergoing rehabilitation.

The measures are paid for through utility grants. Applications are reviewed by a screening committee that includes the PHAs, DSCs and the Low-Income Energy Affordability Network (LEAN). There are spending caps for total project and individual measure costs. Program administrators leverage other funding sources, including state and federal energy efficiency programs to achieve deeper savings.

LIMFREP conducts a comprehensive audit of the premises at no cost to the building owner. Generally the work is completed by contractors that are already providing services to other utility-funded programs.

From March 2010 through mid-January 2011, 175 applications had been received representing close to 10,000 low-income multifamily units. Actual work on buildings began in September 2010. Since that date, 3,000 units have been completed, and 4,000 to 5,000 units are expected to be completed in 2011. The electric utility-funded budget for 2011 is \$14 million, and the gas budget is \$8.5 million.

New York State Energy Research and Development Authority (NYSERDA) Multifamily Performance Program

NYSERDA's Multifamily Performance Program consolidated the agency's previous multifamily programs into one comprehensive program. The program offers both technical and financial assistance and serves both existing buildings and new construction projects. Residential buildings with five or more units that pay the state's system benefits surcharge are eligible to participate.

Based on incentive schedules, owners and developers can determine the incentive they would receive prior to applying for the program. The current version of the program, which began in 2010, challenges participants to reduce their energy usage by 15%.

Owners and developers choose their own energy service provider from a pre-approved list of energy consultants that lead them through the process of performing a comprehensive multifuel energy audit, developing an energy reduction plan tailored to their needs, implementing the plan and ensuring that the measures are properly installed.

From 2007-2011, the program served over 113,000 units with electricity savings of 171.7 million kWh and other fuel savings of 1,962,210 MMBTU. Average electricity and other fuel savings represented in excess of 20% savings over the baseline.

Efficiency Vermont's Multifamily Housing Program

Efficiency Vermont's Multifamily Housing initiative provides comprehensive treatment of all end uses to multifamily buildings. Project managers work one-on-one with design teams for all projects and evaluate all elements that contribute to the overall efficiency and performance of the building, including thermal shell, insulation, windows, space heating, hot water heating, air conditioning, electrical systems, ventilation, appliances, controls, and interactive effects among these systems.

The goal of this program is ensuring that buildings are ENERGY STAR rated, comfortable, affordable, and energy-efficient. Efforts are also made to educate property owners, designers, and installers about ways to improve buildings' overall energy performance and to maximize efficiency.

Since 2000, Efficiency Vermont’s multifamily housing projects have affected over 5,000 units, resulting in cumulative energy savings of more than 18,000 MWh per year (18 GWh cumulative annual to date) and cumulative demand savings of more than 4,000 kW.

Recommendations

Building owners and other housing industry players should be encouraged to engage with utilities, particularly in local and state energy efficiency regulatory proceedings, to align utility energy efficiency incentives with the building owners’ energy efficiency needs and to ensure that the multifamily sector receives a proportionate amount of energy efficiency program funding relative to single family housing.

Multifamily programs should be designed with the needs of the multifamily building owners (free audit, straightforward paperwork, program guidance and assistance throughout the program, free measures or low-interest financing, etc.) in mind. As a result, more multifamily owners will participate.

Multifamily programs should be designed to address issues specific to multifamily buildings (e.g., the split incentive problem, master vs. individually metered units, etc.). To address the issue of the split incentive, utility-sector energy efficiency programs for multifamily building owners should cover as much of the program cost as the cost-effectiveness tests will allow or provide low-interest financing for the building owner. Multifamily program participants should have one application to complete—not one for the residential portion of the building and one for the commercial part of the building.

Multifamily programs should be designed as “one-stop shopping”, multi-fuel, comprehensive programs to encourage program participation and maximize cost-effective energy savings per building. They also can leverage a variety of additional funding sources. Working with housing authorities and financing organizations is key to reach the greatest number of buildings and serve a much higher share of utility customers.

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BEHAVIOR-BASED ENERGY EFFICIENCY PROGRAMS IN THE RESIDENTIAL SECTOR: ENHANCED BILLING, REAL-TIME FEEDBACK, AND SOCIAL MARKETING

Synopsis

“Behavior-based” energy efficiency programs have received a lot of attention over the past several years, based on burgeoning interest in applying insights from the social sciences to energy use, and enabled by smart meters and social marketing campaigns. The definition of “behavior-based” energy efficiency is broad; here we focus on enhanced billing services, real-time feedback on energy consumption and social marketing in the residential sector.

Several themes emerged from our research in this area. First, that “customer engagement”—whether mediated through new hardware or software, or enabled through social marketing campaigns—is an innovative mechanism by which program administrators can pursue increased savings and potentially increase customer satisfaction with the program. Second, increasing customer engagement can be expensive, so new services and programs seek to increase cost-effectiveness by employing a multi-channel, “multi-touch” approach, as opposed to traditional “single-touch” financial incentives or hardware installations. Third, because the types of offerings in this area are so varied, and programs are not yet well established, average savings estimates in the range of 2-4% (depending on program type) are suggestive, but long-term persistence remains a question due to only a few years of robust data.

Background

Energy efficiency programs that take advantage of burgeoning research in the social sciences and new technological capabilities inherent to smart meters have gained a lot of attention over the past several years. To distinguish them from more traditional technology-focused efforts, these new programs are most commonly referred to as “behavior-based” energy efficiency programs, although this term is too imprecise for our purposes in this analysis. Here we will focus on residential energy efficiency programs that employ both informational and social components in attempting to better engage consumers and thereby increase energy savings.

Many of the programs and services reviewed for this analysis combine feedback on energy use with contextual information or social media to provide an additional level of insight to customers and to potentially motivate them to reduce energy use. Social marketing campaigns, benchmarking of energy use with like households, and access to social networking are three strategies that we will review below.

Previous research done by ACEEE found household electricity savings from all types of feedback ranging from 4-12% in pilots conducted over the 15 years from 1995-2010 in multiple countries (Ehrhardt-Martinez et al. 2010). An analysis of recent, large-scale real-time feedback pilots found electricity savings ranging from 0-19.5%, with average savings of 3.8% (Foster & Mazur-Stommen 2012).

Drivers for Change

There are at least four drivers for the growth of interest in behavior-based efficiency programs. First, the continued deployment of smart meters across the United States has the potential to provide the average household with more frequent information about its energy use, addressing the current lag—in the form of the monthly utility bill—between energy use and feedback about that use. According to Ahmed Faruqui of the Brattle Group, as of July 2012 approximately 33% of households across the country had smart meters installed, with 50% likely in five years (Faruqui 2012).

Second, higher state-mandated savings targets are challenging program administrators to both broaden and deepen their efforts to achieve savings from energy efficiency. For example, a July 2012 draft of the Massachusetts' second Three-Year Energy Efficiency Plan (State of Massachusetts 2012), required by the Green Communities Act, proposes an annual savings goal of 2.5% of retail sales starting in 2013, supported by a funding increase for energy efficiency programs to \$2.2 billion over three years. As part of the effort to meet such goals, utilities in the state have been conducting large-scale pilots of behavior-based programs since 2009 (delivered by Opower and C3—see below) that have resulted in average household electricity savings ranging from 0.4–5.7%, and gas savings of 0.8–1.5% (ODC 2012). Savings vary by program design, program administrator and fuel type.

A third driver of activity in this area is utilities' seeking a broader set of tools to better engage their customers and improve customer service. In particular, utilities seek to better inform customers about the incentives available to them for the purchase of energy-efficient products and services, to cross-train customer service to answer energy efficiency program questions, to reduce customer service calls overall, and to make additional data from smart meters more useful and actionable for customers.

Finally, interest in behavior-based programs also stems from a desire to increase savings by enrolling more customers in already existing programs. For example, the “Way to Save, Burlington!” program is testing a large-scale social or community-based marketing approach to educate members of the Burlington, Wisconsin, community about, and enroll them in, existing energy efficiency programs offered through Focus on Energy, Wisconsin's third-party efficiency program administrator. According to Opower, investing in the customer relationship can have a “halo effect,” increasing participation in existing customer efficiency programs (Gerney 2012). One evaluation found that this lift in program participation, however, accounted for only a very small percentage of total household energy savings, typically less than one-tenth of 1% (ODC 2012).

Emerging Trends

Technologies

While behavior-based programs are, by definition, focused on the social and behavioral aspects of energy use, in many cases emerging hardware and software technologies play a critical role in providing information and insight to customers. As mentioned above, the continued progress of smart meter deployment has the potential to provide households with more timely information about their energy use. Smart meters, by themselves, simply gather energy use data; this data must be processed and presented through additional software and hardware. Therefore smart meters, by

themselves, are generally necessary but not sufficient, to providing better feedback on energy use to households.

Pilots and programs that take advantage of the data collection abilities of smart meters also employ some type of in-home display or web portal that gives consumers access to processed energy-use data. The cost-effectiveness of a program appears to depend partially on the technologies used, with the installation of an in-home display and associated training being most expensive, and mailed reports being least expensive, with web portals providing energy use information falling somewhere in between.

In-home displays that provide real-time feedback on energy use have evolved over the past several years. As documented in Laitner (2012), costs for in-home displays appear to be dropping, from more than \$500 including installation several years ago (Foster & Mazur-Stommen 2012), to between \$100-300 in the past year or so.

Program Design

The behavior-based programs reviewed for this research are varied in their designs, and also differ from traditional program design in several ways. First, programs take advantage of established communications channels such as word-of-mouth, mailers, websites and smartphones to both enroll customers and to provide contextual energy-use information. This is in contrast to technology-focused programs that typically focus on installation of new technologies in the home. While behavior-based programs tend to focus instead on the provision of more useful information about energy usage, these types of programs are not restricted to merely changing energy-use behaviors. The feedback provided through a website or heard from a neighbor can also lead consumers to install more energy-efficient technologies. Therefore, it is not necessary to draw too fine a distinction between the types of energy-saving measures taken by participants in “behavior-based” and “technology-based” programs. In other words, behavior-based programs do not necessarily *require* the installation of new hardware to achieve energy savings, but they may *lead to* the installation of such technologies.

Savings from some behavior-based programs appear to depend on whether the program is designed as “opt-in” or “opt-out.” Opt-in program designs require that participants take action to enroll in the program, while opt-out program designs require that participants take action to remove themselves from the pool of participants. This distinction only applies to enrollment in the program; all program “participants” are effectively “opting in” when they decide to open a home energy report, log on to a website, talk to a friend, or take action based on information they receive from an in-home display. Opt-in programs tend to have higher savings and less reach, while opt-out programs tend to have lower savings and wider reach. Overall, the wider reach of the opt-out programs tends to compensate for their lower per-participant savings, leading to larger savings in the aggregate (ODC 2012; SEE Action 2012).

Traditional program designs have sought to increase program participation by increasing the level of incentives across the board to buy efficient technologies. An overarching commonality among the current generation of behavior-based programs is that they aim to provide information—on savings

tips and financial incentives—that is better customized to individual households. This type of customization ultimately seeks to better engage the customer by providing information and services that are timelier, more relevant, and more actionable than one-size-fits-all approaches.

Marketing

Traditional program designs have also sought to increase program participation by mass marketing campaigns. In our highly segmented age, this approach may no longer be enough. For example, Way to Save Burlington is a large-scale pilot testing social marketing in one community, the goal of which is to increase participation in existing programs offered through Focus on Energy, Wisconsin’s state-wide third-party energy efficiency program implementer. It tests the idea, common to other behavior-based programs, that multiple-channel, multiple-touch engagement with potential customers can drive and sustain participation in energy efficiency programs. New behavior-based programs take advantage of word-of-mouth advertising, the power of human sociability⁴⁸ and social media platforms to increase their reach.

Potential Savings

Given that the types of behavior-based programs reviewed here have been in existence for less than five years, and their varied designs and goals, estimates of savings potential should be taken as provisional. Efficiency programs developed by C3 Energy (Frank and Gamoran 2012; ODC 2012) and Opower (Allcott 2011; Connexus 2010; Davis 2011; KEMA 2010; Cooney 2011; ODC 2012) have several years of evaluation data, and real-time feedback programs such as Cape Light Compact’s Smart Home Energy Monitoring Pilot were recently reviewed in Foster & Mazur-Stommen (2012). Savings impacts resulting from The “Way to Save, Burlington!” program had not yet been evaluated as of this writing, so an estimate of savings from social marketing programs is not included here.

Given these caveats, in the table below we present the potential savings that could be generated through 2030 by the types of residential sector behavior-based programs that integrate the design elements discussed above.

⁴⁸ See the recent ACEEE white paper (Vigen & Mazur-Stommen 2012, forthcoming) on community-based social marketing for a more in-depth discussion of this concept and its potential impact on residential energy efficiency retrofits.

Enhanced Billing (Opower, C3; opt-out)	Electricity (TWh)	Gas (TBtu)	Notes
National energy use affected	1627	5550	In 2030 from AEO 2012; includes all residential end uses.
Average percent savings	2%	1%	Average of savings reported in Allcott (2011), Davis (2011), KEMA (2012), Cooney (2011), OCD (2012), PSE (2010) and Summit Blue (2009).
Ultimate net participation rate	99.5%	99.5%	Based on opt-out rate in ODC (2012)
Potential long-term savings (annually in 2030)	32	48	

Real-time Feedback (Opower, C3, Tendril; opt-in)	Electricity (TWh)	Gas (TBtu)	Notes
National energy use affected	1627	N/A	For 2030 from AEO 2012; includes all residential end uses. Evaluated savings estimates not available for natural gas.
Average percent savings	4%	N/A	Average of ODC (2012) and studies reviewed in Foster & Mazur Stommen (2012).
Ultimate net participation rate	10%	N/A	Based on estimate of percentage of population predisposed to respond to real-time feedback in EPRI (2011).
Potential long-term savings (annually in 2030)	7	N/A	

Examples

Opower

Opower is a software-as-a-service (SaaS) company that provides data management, data analysis and customer engagement services to utility energy efficiency program administrators. According to its website, Opower currently reaches 10 million households through its 70 utility partners in the United States and United Kingdom (Opower 2012).

The first and most well-known of its services is the Home Energy Report, which is sent to households under utility branding as a monthly addendum to the normal energy bill. Home Energy Reports provide additional information on a household's energy use and personalized energy-saving tips based on demographic profile. The design of the Home Energy Reports incorporates research on social norming that suggests that people's actions are influenced both by how they compare to their past selves (historical context) and to their "peer group" (social context). In this case, the peer group is composed of geographically and demographically similar households.

In addition to the Home Energy Reports, Opower has expanded its offerings in the past several years to include an off-the-shelf web portal, tools for utility customer service representatives, and the ability to send alerts about high energy use to consumers via email and smartphone. Like C3 Energy's services, Opower's web portal provides near real-time access to energy consumption information generated by a smart meter, historical energy use and personalized tips to save energy. It also incorporates the social norming information provided in the Home Energy Report, provides a high-bill analyzer (the most common reason for customer service calls) and helps customers on dynamic pricing plans to choose the most appropriate rate.

Unlike CLC's Smart Home Energy Monitoring Pilot, software-based services such as those provided by Opower and C3 Energy do not require the installation of new hardware, instead communicating with consumers through platforms that they already use, such as websites and smartphones. Eliminating the need to install hardware avoids program attrition due to installation problems, as was seen in several recent real-time feedback pilots (Foster & Mazur-Stommen 2012), and is likely more cost-effective.

Evaluations of utility pilots and full programs⁴⁹ using Opower's Home Energy Report have found average electricity savings ranging from 1.25–2.89% (Allcott 2011; Davis 2011; KEMA 2010; Cooney 2011; ODC 2012; PSE 2010; Summit Blue 2009) and gas savings of 0.81–1.5% (ODC 2012). Savings appear to increase over time (KEMA 2010; Cooney 2011), suggesting that there is learning taking place. There is not yet enough data to assess whether savings level off, or even decline, over longer periods.

According to Arkadi Gerney (2012), the challenges that utilities are trying to solve with services provided by Opower and similar companies are broadening. Utilities are seeking not only energy efficiency program implementation, but also greater customer engagement and demand response tools. Over the next one to three years, Opower aims to improve its ability to target financial incentives and savings tips more precisely to different customer segments.

C3 Energy

C3 Energy is an enterprise software company founded in 2009 that provides energy management software solutions for large commercial and industrial clients like Dow Chemical and Adobe, and, more recently, for utilities such as PG&E and Constellation Energy. With the acquisition of Efficiency2.0 in May 2012, the company is expanding its offerings into the small business and residential sectors.

C3 sees customer engagement and the provision of more timely, customized information as two core strategies for delivering energy savings in both the residential and C&I sectors—"reducing energy use by any means possible"—as well as increasing residential customer satisfaction with utility services.

⁴⁹ For example, by National Grid and NSTAR in Massachusetts.

Customer engagement, while a concern for utilities since the 1970s, has recently re-emerged with the rise of social media and information technologies as a potential means of meeting higher mandated savings targets cost-effectively.

In the residential sector, C3's services provide an energy profile of household energy use,⁵⁰ offer energy savings tips customized according to demographic profile, track energy use over time through an analysis of utility bills, provide feedback on the impact on energy use of actions taken, and reward program participation and customer who exceed their savings goals. Contacts at C3 said that its approach moves away from a "one touch" interaction with potential consumers that is typical of traditional rebate programs. While such programs offer consumers a one-time rebate of several hundred dollars to install a new energy-efficient technology, C3 argues that a "multiple touch" approach, common to the other offerings reviewed here, delivers more effective and cost-effective energy savings (Frank and Gamoran 2012). This more continuous engagement potentially enables utilities to get a foot in the door with customers, by offering "tiers" of energy-saving options that ramp up in savings impact and/or cost over time. This might be thought of as a way to build a "repeat customer" base for energy efficiency programs, lowering the cost of acquisition, and potentially increasing the cost-effectiveness of energy savings.

An evaluation report of the CUB Saver Program—a pilot funded by Commonwealth Edison (ComEd) and the Illinois Citizens Utility Board (CUB) that utilized Efficiency2.0's web portal services—found average energy savings of 6% during the course of the one-year pilot (July 2010—July 2011) (Harding and McNamara 2012). ComEd provided energy bill data from participating households, which served as the basis for calculating average savings from the program. Customer engagement with the web portal was measured by three metrics: the amount of time pilot participants spent on the site; the rate at which they opened email from the utility; and the number of page-views during each visit to the site. Over the course of the pilot, participants were found to open emails related to the pilot more frequently than the industry average, and to have a lower bounce rate from the website. Sixty-nine percent of participants also noted that their satisfaction with the utility would decrease if they were no longer able to participate in the pilot. The authors of the evaluation report argue that these results indicate that customer engagement is a valuable strategy for motivating utility customers to take energy-saving actions.

Several issues confront utilities looking for deeper and broader savings from customer engagement efforts over the next one to three years (Frank and Gamoran 2012). The first is the tension between savings persistence and cost-effectiveness. In programs that do not rely on installing more efficient technologies, savings tend to persist only with continued feedback and engagement, but this requires sustainable funding over the life of the program. How to get cost-effective, persistent savings from

⁵⁰ Based on the modeling of 100+ potential actions that each household can take, and self-reported actions.

non-technology-focused programs will be one issue going forward. A second related issue is how to ensure low-cost customer engagement for utilities.

The third issue is enabling of 3rd-party innovation in this space. Sources at C3 suggested that there is demand among utilities for outsourcing efficiency program administration to 3rd-party service providers that can also more strongly engage their customers (Frank and Gamoran 2012). Several policy and technical barriers stand in the way of innovation, including the lack of standard data exchange protocols (which is being addressed by the Green Button program), the lack of standardized EM&V protocols either at the state or federal levels, and relative immaturity of software to manage the data released by making policy changes in the first two areas.

Cape Light Compact Smart Home Energy Monitoring Pilot, Phase II

Over the course of a year starting in the spring of 2009, Cape Light Compact (CLC), a small distribution utility on Cape Cod and Martha's Vineyard, conducted the first phase of its Smart Home Energy Monitoring Pilot (SHEMP), to evaluate savings from a home energy monitoring system paired with social networking capabilities. CLC recruited one hundred qualifying households into the pilot, each of which was provided, free of charge, with home energy monitoring technologies, training on their use, and access to an online dashboard for the duration of the pilot.⁵¹ The hardware and online dashboard were provided by Grounded Power (now Tendril), and included a clip-on monitor attached to the home's electric panel, a wireless base station to receive data from the monitor and send it to Grounded Power through the home's router, and a web interface providing energy-use information down to the minute. Pilot participants also had the ability to interact with each other online during the pilot to trade savings tips and best practices. Phase I resulted in average savings of 9.3%.⁵²

A second phase of the pilot was conducted from July 2010–June 2011. Results from the planned evaluation report on Phase II were not available at this writing,⁵³ but information gathered from CLC (Kane 2012) provides some preliminary insight into the results. Changes in technology over the two years since the beginning of Phase I streamlined the installation process and allowed the technology to be more plug-and-play. Phase II also utilized hardware and software provided by Tendril, this time obviating the need for a clip-on monitor attached to the electric panel. This eliminated the need for an electrician, but surprisingly did not lower installation costs. In addition to the web portal in Phase I, the second phase of the pilot also included the professional installation and set-up of an in-home display that provided real-time access to energy use information, although the installation process was designed to be performed unaided by the homeowner.

⁵¹ The hardware was professionally installed by a team including a technician and electrician.

⁵² See Foster and Mazur-Stommen (2012) and PA Consulting (2010) for full discussions of the results of Phase I of the pilot.

⁵³ The third-party evaluation report will be available in late August 2012 (Kane 2012).

Unlike Phase I, pilot participants did not have a social networking capability, which will likely have a detrimental effect on savings. Phase II also ramped up its marketing efforts compared to Phase I—which was fully subscribed almost immediately. The response to the second phase of the pilot, however, was not as robust as the first phase, likely because early adopters in the community had already subscribed to the original pilot.

In its second 3-Year Energy Efficiency Plan (CLC 2012), required by Massachusetts' Green Communities Act, Cape Light Compact will increase budgets of its home energy assessments by 50% to \$28 million for FY2013-2015, which represents approximately 73% of its residential budgets (excluding low-income). Briana Kane, Senior Residential Program Coordinator at Cape Light Compact, speculated that the Smart Home Energy Monitoring Pilot would likely not become its own freestanding program—due to high per-household cost—but could be included as an offering in the utility's broader home energy assessment program (Kane 2012).

Way to Save, Burlington!

“Way to Save, Burlington!” is a three-year pilot program taking place in Burlington, Wisconsin, and funded by We Energies. The goal of the pilot is to increase participation in existing programs offered through Focus on Energy, Wisconsin's state-wide third-party energy efficiency program implementer. Started in 2010, the program will continue through 2013.

Traditionally, attempts to increase efficiency program participation have focused on increasing the financial incentives offered, i.e., giving households and businesses more money to install a new, more energy-efficient widget. The Way to Save, Burlington! Program was designed from the ground up to test an alternative: whether continuous, multiple-channel, multiple-touch engagement with the community can drive up—and sustain—participation in existing energy efficiency programs.

The program was designed around an “Energy Ambassador” and the community of Burlington itself, and is supported by educational campaigns, online energy savings information, a community-wide energy savings goal, an energy-saving pledge process, and “Energy Makeover” contests in homes, businesses, and schools. Kevin Duffy, Burlington's Energy Ambassador, described outreach and education efforts to the community as critical to the high levels of engagement in the program that he has seen. While he does some direct marketing, email blasts and radio spots, the best advertising for the program and for local energy efficiency is his “feet on the pavement” (Duffy and Niewald 2012). Kevin described the process of building trust within the community through these efforts as at least as critical to improving efficiency program participation as is education around the financial, environmental and other benefits of energy efficiency.

The city of Burlington, a small town of 10,500 people in the southeast corner of Wisconsin, was chosen to host the pilot for several reasons. It is typical of many towns in We Energies' service area, it is large enough to have an effect but small enough to measure impact, and it has a strong residential and industrial base, including a Nestle chocolate factory (Duffy and Hanna 2012). Burlington also has a varied development pattern featuring a 1920s-era mixed-use downtown surrounded by 1960s strip mall-like buildings, which allows for measurement of differential impacts across building types. Jim Niewald, a colleague of Kevin Duffy's at ICF—the program designer and implementer—noted that

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 by 14.6% 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.

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 T12⁵⁶ 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.

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

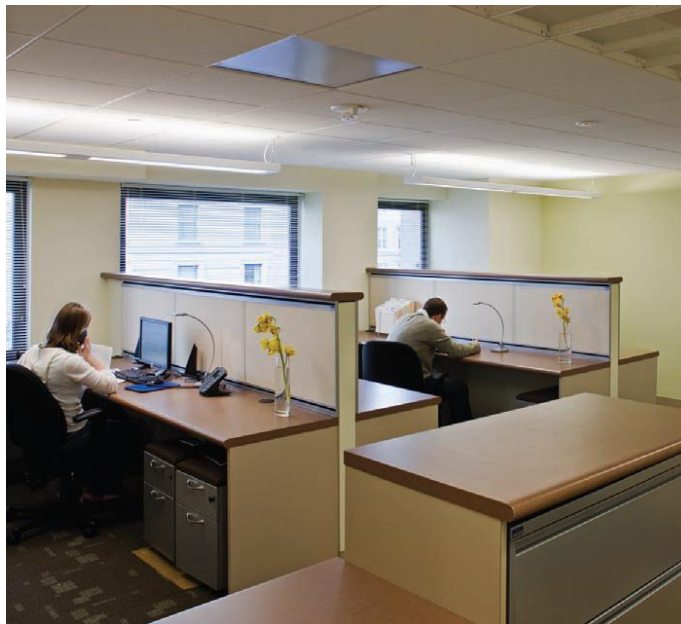


Photo of ACEEE Offices from Finelite 2009.
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Technologies

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 that 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 lamps⁶⁰, 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:

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	<u>80%</u>	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.encyvermont.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 commissioning⁶² 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 manager, 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 reduce 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	<u>85%</u>	<u>85%</u>	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	<u>30%</u>	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,

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

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.

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.

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.

<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 tons⁷¹. 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

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 Program⁷⁴ 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

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, PECE, 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 NYSEERDA’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>

NYSEERDA 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; Elneceve 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	<u>75%</u>	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

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

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 film⁷⁸, occupancy sensors, and vending misers⁷⁹. 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

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 “siloes” 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 (IDSMD). 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,

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	<u>60%</u>	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 as 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 period⁸²

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.

⁸²See 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 led 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 (Shiple, 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
	<u>TWh</u>	<u>TBtu</u>	
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	<u>12.5%</u>	<u>12.5%</u>	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 managers 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	<u>60%</u>	<u>50%</u>	
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 offer insight into best practices for next generation CHP program development, such as the importance 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

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 Order⁸⁶ 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 (SEEAAction 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).

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

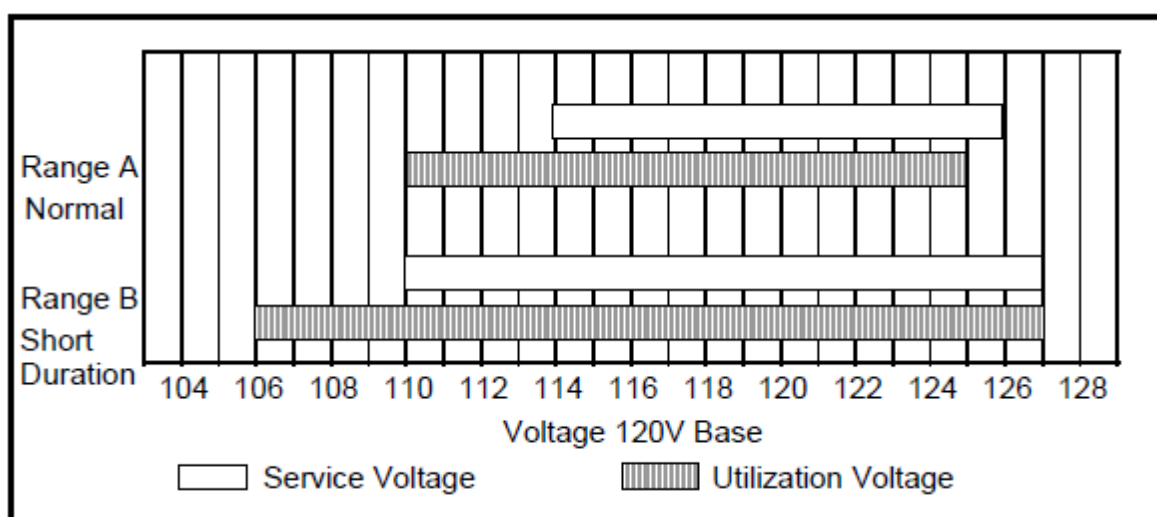
There are significant opportunities to improve the efficiency of distribution systems. In this section we focus on two such opportunities—voltage optimization and amorphous core transformers. A variety of studies find average savings from voltage optimization of just over 2% on appropriate circuits. 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 system⁸⁹ (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-thirds⁹⁰ 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/dlmethodology/>.

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 (NWPPCC 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) (NWPPCC 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

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 Amorphous 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

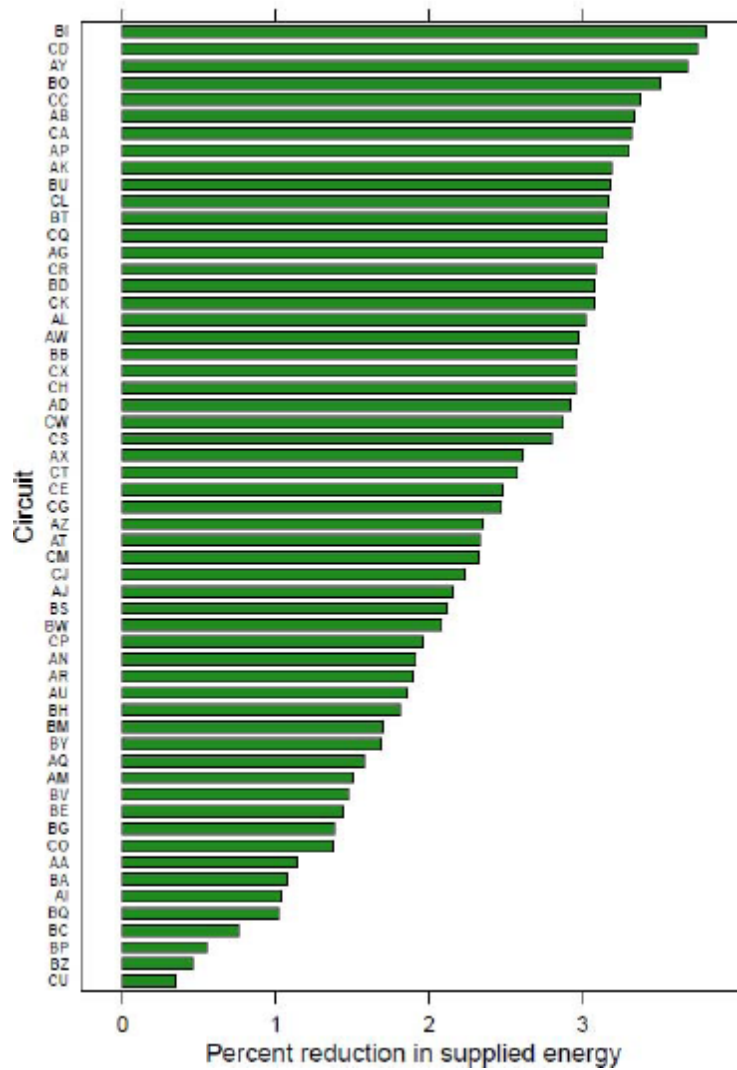
Unlike other energy efficiency programs the primary “marketing” is for a utility to decide internally to proceed. Utility management needs to be convinced that the savings are real and that there will not be adverse impacts on customers. All of the benefits should be examined together—customer energy 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



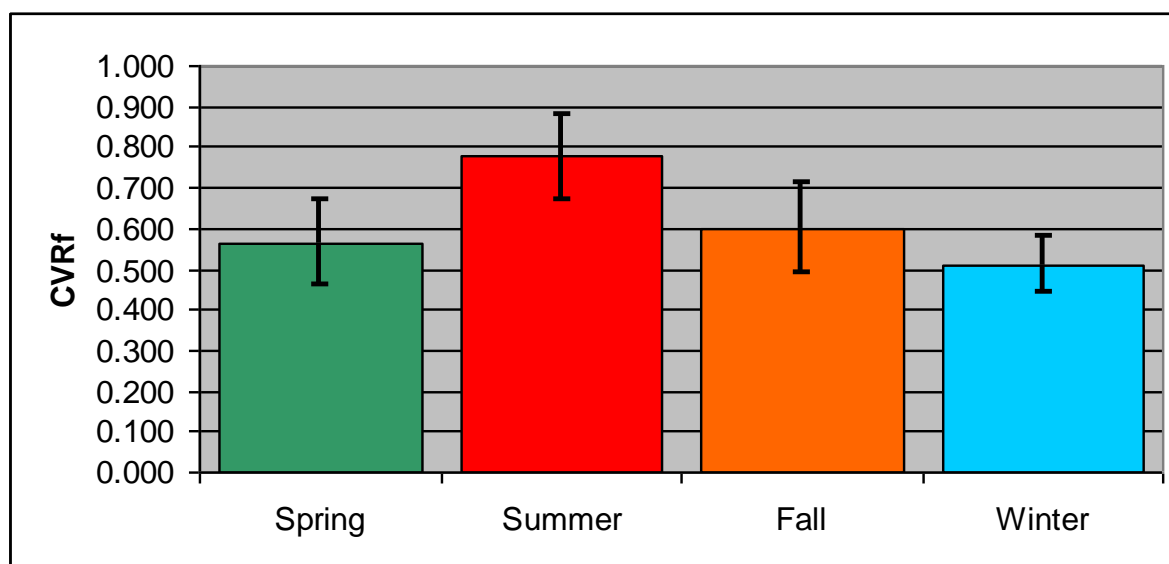
Source: Arritt, Short and Brooks. 2012.

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.

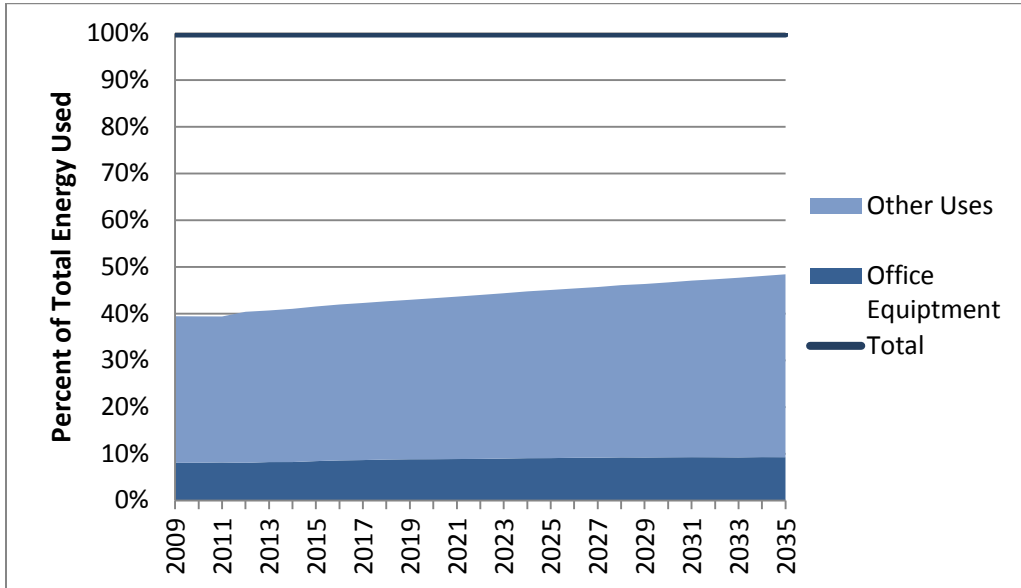
Background and Drivers for Change

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.

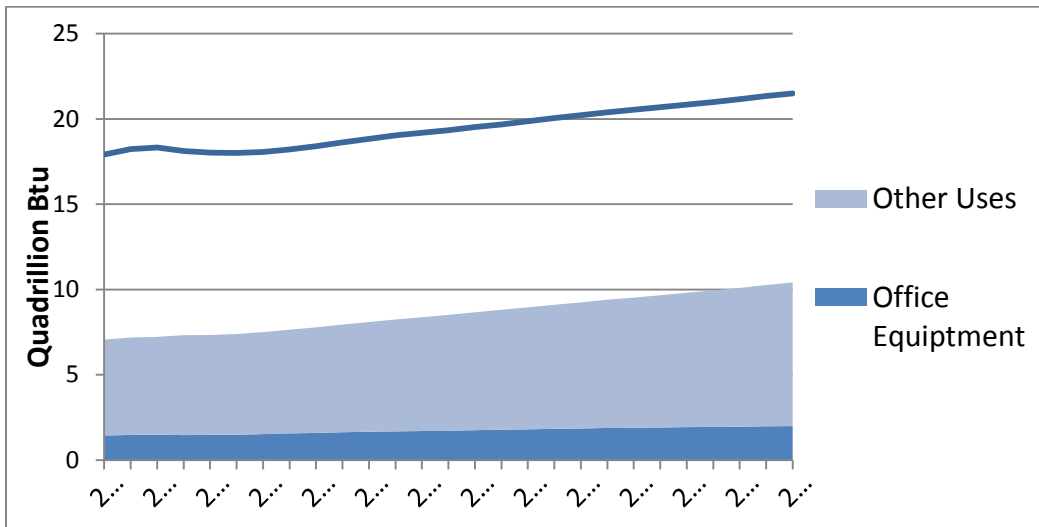
⁹⁵ ACEEE will be releasing a report summarizing available data in early 2013.

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



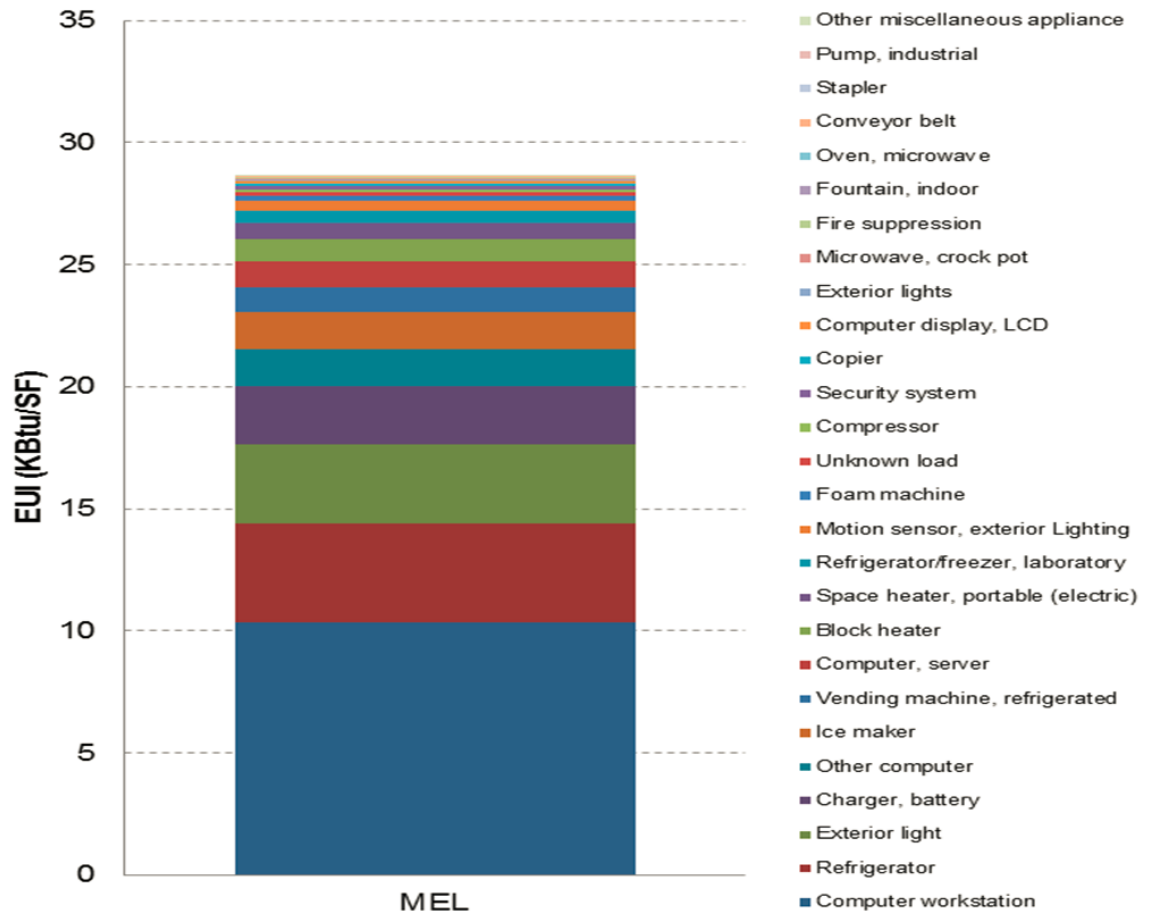
Source: EIA AEO 2012

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 TIAA (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
	<u>TWh</u>	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
	<u>TWh</u>	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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