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# 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 customers[1] 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:

<u>Residential Programs</u>

- 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.

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[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-cranks 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-gross[4] 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 where to be adopted at the maximum potential levels.

| Residential Lighting | Electricity | Gas | Notes |
|---|---|---|---|
| | **TWh** | **TBtu** | |
| National energy use affected | 135 | NA | For 2030 from *Annual Energy Outlook 2012* |
| 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.efficiencyvermont.com/for_my_home/ways-to-save-and-rebates/residential_lighting/residential_lighting_intro/general_info/overview.aspx

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[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 been 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 on the cusp of entering the U.S. market and gaining market share, this development will take time. It does not seem to 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. Pools 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. Topten 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 combing efforts among multiple communication channels in order to create more successful campaigns and do so most cost-effectively (getter 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.efficiencyvermont.org/docs/about_efficiency_vermont/annual_plans/EVT_AnnualPlan2012.pdf

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

Connecticut Light and Power: Home Energy Solutions and Home Energy Solutions—Home Performance

Connecticut Light and Power's (CL&P) appliance rebates are offered through its 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 CL&P-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. CL&P then sends the customer a formal letter of agreement outlining the incentives for the upgrades. Upon completion, the project is inspected by CL&P 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.

### 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

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[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.

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 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

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[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.

[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/.

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 3.0[13]), 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 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

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[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).

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 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

[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).

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 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.

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[16] See http://www.cee1.org/ and http://www.ceeforum.org/

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 | 80% | NA | 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 | |

## 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

[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

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 by 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

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

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 cooling[20] 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.

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

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[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.

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/manufacturer 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 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

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[22] The Air Conditioning Contractors of America (ACCA), in collaboration with the American National Standards Institute (ASNI), 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.

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 | 50% | 50% | 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 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

[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.

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 pumps[25] and heat pump water heaters. NEEA is involved in developing regional standards for the performance of these products (northern climate specifications for HPWHs[26]) 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.

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

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[25] See http://neea.org/initiatives/residential/ductless-heat-pumps.
[26] See http://neea.org/initiatives/emerging-technology/heat-pump-water-heaters.

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).

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,

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

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 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

[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.

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 | 90% | 90% | 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 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

[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).

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 on 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 financing[31] 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 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

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[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.

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 contactors 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 contactor" model, where all contactors 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 á 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 financers, 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 | 50% | 50% | |
| **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.efficiencyvermont.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 tier[34] 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

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[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

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[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.energytaxincentives.org/. The credit expired in 2011, but can be renewed by Congress.

[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

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[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-house[42] 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

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[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 tradeshows 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-terms 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

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[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 in the 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 | 80% | 80% | 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 ENEGY 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.

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[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 | 30% | 30% | |
| **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 sociability[48] 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 programs[49] 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.

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[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.

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[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