

EXECUTIVE SUMMARY

FRONTIERS OF ENERGY EFFICIENCY: NEXT GENERATION PROGRAMS REACH FOR HIGH ENERGY SAVINGS

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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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