Using Building Size to Optimize Electric Utility Energy Efficiency Incentives

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ABSTRACT

Electric utilities and government agencies across the U.S. offer financial incentives and subsidies to help end users offset the cost of energy efficiency measures (EEMs) installed in their facilities. These demand-side management programs are designed to reduce overall energy use to decrease strain on the grid, increase resiliency, meet regulatory requirements, and save money for both the utility and their customers. However, many utilities do not tailor their incentive programs to serve the needs of different building sizes. This occurs despite their customers' varying energy profiles, economic and staffing resources, appetite for specific technologies, and overall organizational goals. The EEMs and savings potential for small buildings have less complicated building systems and generally fewer resources for energy upgrades. They are not the same as those for large buildings with more complex energy systems and dedicated building engineering staff. Our study reviews common utility energy efficiency incentive structures and analyzes the lighting and cooling equipment in small, medium and large commercial buildings. It proposes that optimizing incentives for building size can help utility policy-makers increase the enrollment, cost effectiveness and overall energy savings of their energy efficiency programs.

INTRODUCTION

According to the U.S. Energy Information Administration (EIA), commercial buildings account for about 20% of all energy consumed in the U.S. [1] with electricity accounting for more than half of the energy consumed in commercial buildings [2]. Reducing end-user electrical energy demand is a cost-effective way to help investor-owned utilities (IOUs) to ease grid stress and meet regulatory requirements [3].

Many IOUs achieve energy reduction targets through demand-side incentive programs that encourage rate payers to reduce consumption through EEMs such as building retrofits. However, utilities often do not tailor incentives to suit buildings of various sizes, despite differences in equipment, energy consumption patterns, budget and staffing resources, and rates of renovation.

The following pages review common incentive structures and analyze how incentive structures can be tailored to buildings of various sizes. This article is a tool to help utility decision-makers and policy advisors design incentive programs that maximize energy reduction.

DATA SOURCE AND METHODOLOGY

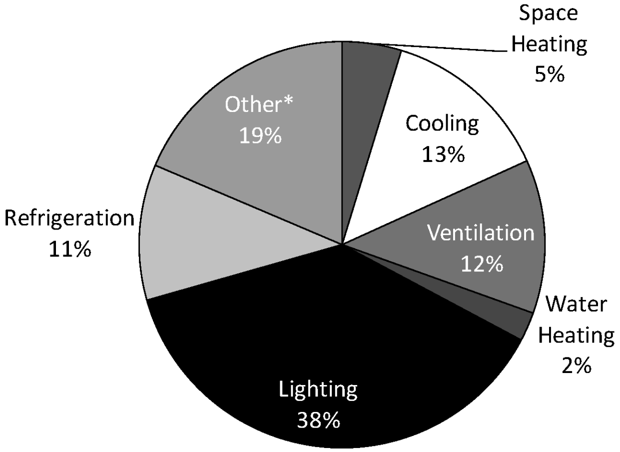
The EIA's 2012 Commercial Buildings Energy Consumption Survey (CBECS) served as the primary data source for this study. The CBECS represents a sample survey of 5.6 million commercial buildings across the 50 states and Washington D.C. The survey data provides information on energy-related building characteristics including geographic region; size and age; building activity, renovation rates, end use equipment, energy consumption and expenditures. Please note that 2012 CBECS data is being distributed to the public in stages and the energy consumption and expenditures data was not available at the time this article was written.

For this study, we reviewed utility incentive structures across the U.S. and grouped them into three categories: 1) prescriptive measures, which pay customers a set dollar amount for installing measures from a pre-qualified list of energy efficient equipment; 2) performance-based programs, which pay customers for actual energy savings at a set rate based on $/kWh saved; and 3) integrated design programs which provide incentives for whole-building energy efficiency design.

Next, using the 2012 CBECS data, we grouped U.S. buildings by size and analyzed the electricity-consuming equipment most prevalent in each group and the renovation rates in commercial buildings constructed before 2008. Buildings were grouped as follows:

- Small: 1,000 ft^2 to 25,000 ft^2
- Medium: 25,001 ft^2 to 200,000 ft^2
- Large: over 200,000 ft^2

For the purposes of this article, we analyzed only the lighting and cooling equipment of each group of buildings. According to the 2003 CBECS report [2], lighting and cooling systems accounted for the two equipment categories with the largest end use consumption.



*Includes cooking, office equipment, computers and other

Figure 1. Electricity Consumption (kWh) by End Use for All Commercial Buildings [4].

Using the CBECS data analysis, we identified the incentive structures that most effectively offer incentives for commercial building owners to implement EEMs for each building size.

REVIEW OF UTILITY ENERGY EFFICIENCY INCENTIVES PROGRAMS

Analysis has shown that energy consumers often do not invest in the most cost-effective energy efficiency measures [5]. Utility companies develop financial incentive programs to address this "efficiency gap," or "under-investment" in such measures. In addition to benefiting the utility, incentives help customers buy down the costs of EEMs to reduce their energy costs. Incentives also benefit society at large by reducing overall energy consumption, thus reducing greenhouse gas (GHG) emissions that lead to climate change.

Next we define and analyze three of the most commonly-employed electric efficiency incentive structures and identify the energy efficient technologies that are most suited to the following incentive structures: Prescriptive Programs, Performance-Based Programs and Whole-Building Integrated Design Programs.

Prescriptive Programs

Prescriptive programs provide pre-determined cash payments to customers when they implement EEMs from a pre-approved, prescribed list. These programs are the most straight-forward incentive programs and generally fall within one of the following two categories:

1. Rebate Programs: Utilities provide a pre-determined incentive to customers after they have either purchased or installed a qualified measure. Customers are responsible for purchasing and installing the measures at their facility.
2. Direct Installation Programs: Utilities provide a percentage cost share of the total installation cost to the customer for prescribed EEMs. Customers are not required to purchase or install the measures. Instead, the utility pays the installation contractor for completing installations and collects the remaining cost of the measure from the customer.

Prescriptive programs are most effective for customers who need one-for-one replacements of outdated equipment with tried-and-true technologies. The most common EEMs available in this type of program are lighting replacements, lighting controls, thermostats, electric motors, variable-frequency drives, and appliances. The prescriptive approach is less effective in accelerating technology shifts in the marketplace or spurring implementation of cutting-edge technologies. It is rarely employed for installations that require system design. As a result, prescriptive programs work best to help energy efficiency laggards improve their systems and facilities to market standards.

Prescriptive programs are easier for customers to understand and utilities to quantify. Resulting energy savings are generally based on deemed or calculated savings. For example, the savings calculation to replace an old, inefficient T12 lamp with an LED lamp provides predictable and reliable results given similar operating characteristics. As such, there is rarely a requirement for measurement and verification (M&V), reducing the time between application and incentive payment.

Performance-based Programs

Performance-based incentive programs provide cash payments for actual kWh and/or MBTU reductions. To verify actual energy savings, these programs often require pre- and post-installation technical analysis and sometimes require a formal M&V process. Equipment must meet certain standards such as ASHRAE 90.1 or a locally-enforceable energy code. Generally, performance-based incentives are based on savings at either the technology- or system-level, rather than whole-building energy savings.

Performance-based incentives offer customers more flexibility on how to achieve their energy savings and generally have higher incentive rates than prescriptive programs. Program rules can be complicated and projects applying for incentives through performance-based programs typically span longer periods—between 2 to 3 years—before a project is designed, funded, installed and commissioned. As a result, they are not typically as effective for building owners installing one-for-one replacements of simple technologies.

These programs are most effective for building owners seeking to install or retrofit more sophisticated building equipment and project scopes requiring design. Since energy audits and M&V are required, they have a benefit of providing building owners and operators with a better understanding of how their buildings consume energy. They help utilities stay informed about energy efficiency technologies and how their customers are consuming these technologies.

Whole-building Integrated Design Programs

Whole-building integrated design programs incentivize customers who want to implement energy efficiency holistically, at a whole-building level rather than an equipment- or system-level. Incentive structures vary greatly—projects could be incentivized on a dollar per square foot basis or on a percentage of total savings over a set baseline. Incentives are generally capped at a percentage of total project cost and sometimes have other utility-specific requirements for internal rates of return, resource costs or total utility costs. M&V is required for virtually all whole-building integrated design programs.

Most whole-building programs require building owners to conduct comprehensive energy audits and develop custom energy reduction plans for building owners implementing whole-building energy efficiency. The resulting energy reduction plans analyze how building systems interact with each other to optimize EEM selection and develop related commissioning plans. For example, energy-efficient lighting equipment such as LED lamps emit less heat than incandescent or fluorescent lighting equipment. Energy reduction plans consider this reduction in heat load when selecting or sizing heating and cooling equipment and identifying related setpoints.

Whole-building integrated design programs are most effective when utilities pay not only for verified energy savings, but also share the cost for energy assessments and energy reduction plans, with partial payments upon installation. This mitigates financial risks to customers and increases program participation. It also ensures that the customer is engaged in the program from project planning through installation, commissioning and M&V.

Whole-building integrated design programs are best suited to sophisticated building owners with dedicated building staff and higher capital budgets. Building owners have more to gain from these programs since energy savings and incentive rates are typically higher than performance-based incentives. However, due to the comprehensive nature of these programs, the resulting EEMs typically require a larger capital investment and the energy savings estimation and verification process requires dedicated staff or consulting engineering resources.

LIGHTING AND COOLING EQUIPMENT IN SMALL, MEDIUM AND LARGE COMMERCIAL BUILDINGS

Building square footage is a good indicator of the size and type of commercial building end use equipment as well as how often building owners upgrade these systems. Larger buildings will typically have central heating and cooling plants and piping distribution systems that connect to terminal units. While all commercial buildings generally have lighting and Heating, Ventilating and Air Conditioning (HVAC) equipment, the specific type of equipment varies greatly between small and large commercial facilities. Next we consider U.S. commercial buildings by size (small, medium and large) and analyze each building group based on lighting and cooling equipment and renovation rates provided in the 2012 CBECS data.

Lighting

Energy efficiency varies greatly between lighting types. For example, a 75-watt incandescent A-lamp, one of the least efficient lighting types, can be replaced with a 12-watt LED, which is currently the most energy efficient, commercially-available equivalent lighting type. This represents an electrical energy savings of over 80%, given that operating hours remain the same. Figure 2 identifies the lighting equipment that is most prevalent in small, medium and large commercial facilities.

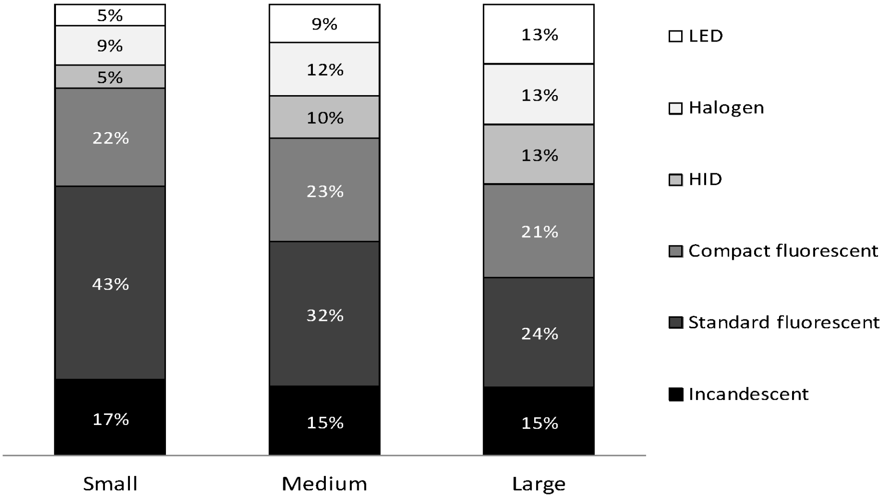


Figure 2. Lighting Equipment in Small, Medium and Large Buildings.

Compared to medium and large buildings, lighting in small buildings is the least efficient. Energy-efficient LEDs illuminate only 5% of small building area and inefficient incandescent bulbs illuminate 17% of area. Only 19% of small building area constructed before 2008 has upgraded lighting equipment—less than both medium and large buildings.

Lighting in medium commercial facilities is generally more efficient than small facilities but less efficient than large facilities. Energy-efficient LEDs illuminate 9% of medium building area and inefficient incandescent bulbs illuminate 15% of medium building area. About 31%

of medium building area constructed before 2008 has upgraded lighting equipment—more than small facilities but less than large buildings.

Lighting in large commercial facilities is the most efficient of the three building size groups. Energy-efficient LEDs illuminate 13% of large building area and inefficient incandescent lamps illuminate about 15% of large building area. About 54% of large building area constructed before 2008 has upgraded lighting equipment—again, more than both medium and small facilities.

Cooling Systems

The 2012 CBECS data identifies seven types of cooling equipment. There are great differences within each equipment type and generalizing energy consumption is more complicated than with lighting equipment (for example, residential central air conditioning can refer to split systems, ductless mini splits, etc.). Though it's difficult to draw conclusions about system efficiency based solely on equipment type, assumptions can be made based on renovation rates and the amount of floor space that needs to be cooled. Figure 3 identifies the cooling equipment that is most prevalent in small, medium and large commercial facilities.

Compared to medium and large buildings, cooling equipment serving small buildings is less complex and more decentralized. Nearly three quarters of the cooling systems use smaller, individualized cooling equipment. Additionally, only 22% of small building area con-

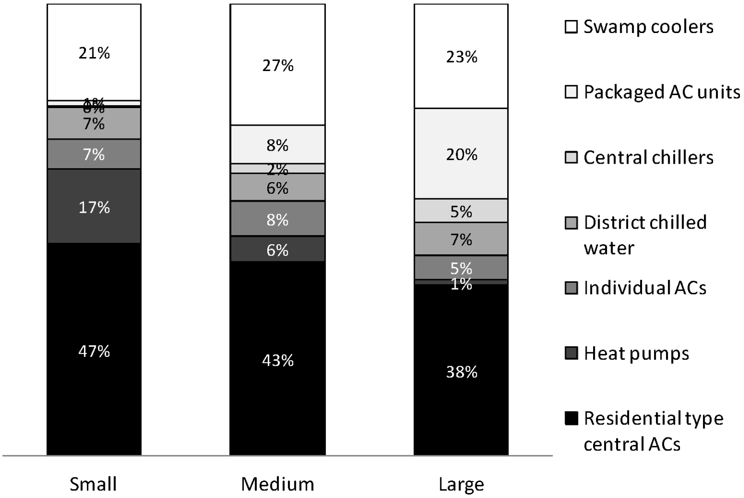


Figure 3. Cooling Equipment in Small, Medium and Large Buildings.

structed before 2008 has upgraded cooling equipment—less than both medium and large buildings. This indicates that smaller buildings tend to keep existing equipment in place until at least the end of its useful service life.

Cooling in medium commercial facilities varies greatly. Some buildings have packaged units that can be easily replaced while others employ central air conditioning systems. About 33% of medium building area constructed before 2008 has upgraded HVAC equipment—more than small facilities but less than large buildings.

Cooling systems in large facilities will need to operate at a higher capacity and cool more space than in smaller facilities. Systems in large buildings tend to be more centralized, as indicated by the prevalence of central chillers and district chilled water systems. About 51% of large building square footage constructed before 2008 has upgraded HVAC equipment—more than both medium and small facilities. This indicates that as buildings become larger, building owners and operators are likely to upgrade cooling equipment to match more sophisticated operational needs or improve their equipment using the most current and most efficient energy standards.

SUMMARY AND CONCLUSIONS

Energy efficiency incentive programs are intended to motivate customers to adopt technologies that they would not deploy without incentives. Based on our analysis, shown in Table 1, the size of a commercial building can be a good indicator of the incentive structure that would best motivate investment in energy efficiency upgrades that are most suited to the building's efficiency needs.

Table 1. Optimal Incentive Structures by Commercial Building Size.

	Target EEMs	Incentive Type
Small	Small change outs	Prescriptive
Medium	Small change outs, building system retrofits	Prescriptive and Performance-Based
Large	Comprehensive building retrofits	Performance-Based and Whole-Building Integrated Design

Small Buildings

The prevalence of inefficient lighting equipment, coupled with the comparatively low lighting upgrade rates, indicate that energy efficiency investment in small buildings lags behind other building types. As mentioned above, prescriptive programs are well-suited to help laggards bring their buildings up to the minimum standard or baseline for certain equipment. Additionally, the decentralized nature of cooling equipment in small facilities allows for equipment to be upgraded relatively easily without design work. As lighting and small cooling equipment upgrades are generally straightforward, one-for-one change outs, prescriptive incentives are the most effective in small buildings. The simplicity of prescriptive programs is also ideal for small building owners who are less energy-savvy than their large building counterparts and may lack education, motivation and the financial capital to implement energy efficiency projects.

Medium Buildings

The lighting and cooling equipment in medium-sized buildings varies greatly. The lighting equipment is less efficient than large buildings, but more efficient than small buildings. Cooling equipment types and renovation rates are similar—between small and large buildings. This seems to indicate that equipment and capital investment resources vary greatly between medium-sized buildings. Medium buildings require both one-for-one change outs of inefficient equipment and varying system-level cooling upgrades. A mix of prescriptive and performance-based incentives, which allow building owners to select their own equipment, is most effective for medium buildings.

Large Buildings

The relative prevalence of energy efficient lighting in large buildings shows that owners of these facilities are investing in their lighting infrastructure at higher rates than owners of medium and small buildings. This indicates that they are more likely to meet local codes and there is opportunity to promote more advanced lighting technologies. Large buildings have more building area to cool and thus cooling equipment has more capacity. Large buildings may have multiple cooling systems serving the same facility, indicating a need for whole-building system controls. High renovation rates and prevalence of efficient lighting, combined with larger capital budgets and more sophisticated staff resources, indicate that large buildings are good candidates for whole-building integrated design programs.

Best Practices for Utilities and Policy Makers

Utilities and policy makers need to integrate building size into their energy efficiency incentive program designs, marketing and implementation. Custom approaches would improve their incentive programs. Best practices include:

1. Analyze the mix of building sizes in their service territory when designing programs.
2. Customize market incentive programs to the building size demographics that are most suited to the particular incentive offering.
3. Use incentive programs to identify and address barriers to entry that are unique to building sizes including:

- Small Buildings: Education is a barrier to entry in this market segment. Customers typically fail to deploy latest technologies and may not be motivated to implement efficiency projects. It is therefore important to educate these building owners/tenants on the importance of energy efficiency and benefits to the utility, consumers and society as a whole. Additionally, small building owners may be less energy savvy than their medium and large building counterparts which makes the simple, straightforward approach of prescriptive programs a good match for this market segment.

- Medium Buildings: Lighting and cooling equipment vary and share characteristics of both small and large buildings. Incentive structures should be flexible allowing building owners to participate in prescriptive programs for smaller change-outs, while retaining the option to use performance based incentives for lighting controls or more complicated HVAC replacements and controls.

- Large Buildings: These buildings have more complex energy using systems. A barrier to entry for owners may be finding an incentive program that adequately addresses those complexities. This makes the holistic approach of the whole building integrated design incentive structure ideal as it encourages building owners to implement more comprehensive projects.

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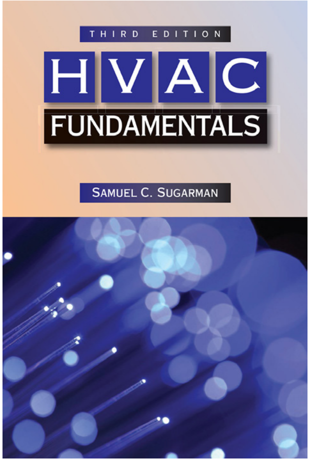

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