CONSORTIUM for BUILDING ENERGY INNOVATION

REPORT

Title: Analysis of Residential & Commercial Buildings: Alliance Commission on National Energy Efficiency Policy

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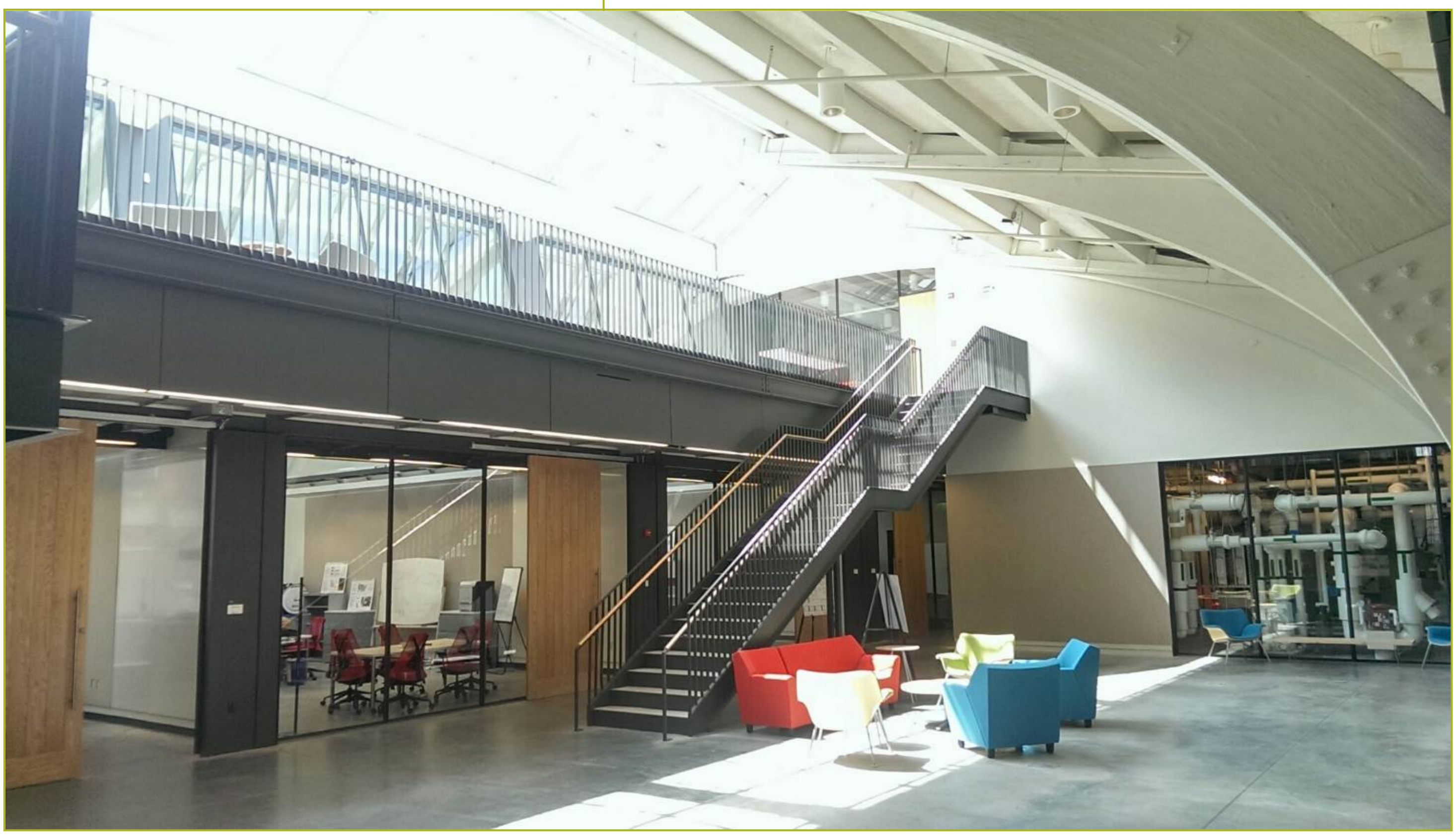

CBEI was referred to as the Energy Efficiency Buildings HUB at the time this report was developed.

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REPORT

Report Abstract

This report on Residential & Commercial Buildings is one of five research reports for the Alliance Commission on National Energy Efficiency Policy, which assesses the current state of efficiency within the economy and provides a review of the best local, state, and national practices.

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Disclaimer

Residential & Commercial Buildings:
Alliance Commission on National Energy Efficiency Policy

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Preamble

The Alliance Commission on National Energy Efficiency Policy was organized to study energy efficiency policies, programs and opportunities, and make consensus recommendations on the "next generation" of domestic policies, programs and practices to ensure that the U.S. can double its energy productivity (twice as much GDP from each unit of energy) from 2011 to 2030.

The work of the Commission will include an assessment of the current state of energy efficiency in the U.S. economy; a review and assessment of the best local, state and national practices; and the development of a key set of recommendations on policies and programs for the next administration and the 113th Congress to achieve the stated goal of doubling U.S. energy productivity by 2030.

This report on Residential & Commercial Buildings is one of five research reports which assess the current state of efficiency within the economy and review the best local, state, and national practices. These assessments will be used to support and provide the technical basis for the Commission's efforts to develop a set of recommendations for doubling the nation's energy productivity. The other reports will address the following areas: History and Rationale, Community Energy Planning & Mobility, Industry Products & Processes, and Power Generation and Smart Grid.

In order to provide a comprehensive assessment to the Commission, an additional report will conduct an integration analysis of the five research reports to identify common areas of consideration and areas of interdependency. It will also identify opportunities for the various sectors of the economy to work together and leverage each other.

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Introduction

The United States has over 223.9 billion square feet of residential buildings[1] (about 730 square feet per capita) and 71.6 billion square feet of commercial buildings[2] (about 240 square feet per capita). Spread over one level, the dwelling and commercial space together are equal to 10,600 square miles, about the size of Massachusetts. The majority of this space requires significant quantities of energy for heating, cooling and lighting to maintain the health, comfort and productivity of occupants. The U.S. also consumes significant amounts of domestic hot water, and use numerous appliances, electronics and other plugged-in equipment that draws electricity from the power grid.

Residential and commercial buildings account for 41.2 percent of total U.S. energy consumption[3], at a cost of roughly $400 billion per year.[4] Building sector energy consumption grew by 48 percent between 1980 and 2009.[5] The increase in consumption is driven primarily by population growth, which increases demand for more commercial space and dwelling units. Substantial increases in home size, use of air conditioning and electronics, and demand for other energy services were balanced by improvements in the energy efficiency of building systems and appliances achieved over this period. By 2035, building energy consumption is expected to be 15% higher than its 2009 levels.[6]This projection takes into consideration expected efficiency improvements based on current regulatory requirements and expected technology improvements.

Buildings are long-lived physical assets- once constructed they lock in many of their energy consumption attributes for decades. With only a quarter of homes today built in the last twenty years, the annual addition of new buildings is small compared to the existing building stock. Improving the energy efficiency of the building sector, therefore, requires a large-scale effort to upgrade the existing building stock as well as to improve new buildings.

The economics of making much of the necessary improvements are favorable based purely on capital costs and annual savings. Reducing energy use in buildings by 20% has the potential to save $80 billion.[7] According to one source, buildings in the U.S. represent an investment opportunity of $279 billion for energy efficiency retrofits. At this level, more than $1 trillion in energy savings could be realized over 10 years.[8] Energy efficiency improvements in buildings also have the potential to reduce 40 percent of U.S. carbon dioxide emissions caused by building operations and reduce air pollution. Finally, energy investments contribute to job growth in the professions involved in implementation and in the manufacture of equipment and building components.

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[1] RECS 2009; includes basements, finished attic space, and conditioned attached garage space.
[2] CBECS 2003
[3] EIA, http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption, based on Table 2.1a
[4] Wilson Sonsini Coodrich & Rosati, INNOVATIONS AND OPPORTUNITIES IN ENERGY EFFICIENCY FINANCE 3 2012.
[5] US DOE, EIA. Annual Energy Review 2010.Table 2.1a
http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0201a
[6] US DOE, EIA, Annual Energy Outlook 2012, DOE/EIA-0383 (based on Table 2)
[7] Wilson Sonsini Coodrich & Rosati, INNOVATIONS AND OPPORTUNITIES IN ENERGY EFFICIENCY FINANCE 3 2012
[8] The Rockefeller Foundation, DB Climate Change Advisors. 2012. United States Building Energy Efficiency Retrofits, Market Sizing and Financial Models

More efficient technology alternatives for building envelope, space heating, space cooling, water heating and lighting are available today. Although continued improvements in both efficiency and cost are important, proven technologies are ready to achieve significant energy efficiency improvements at a reasonable cost.

The structure of the private sector can sometimes impede the full capture of energy efficiency opportunities. This includes (1) a large number of different submarkets, (2) a variety of ownership and occupancy arrangements, and (3) a diverse set of stakeholders, including small builders and owners, (4) a vast array of regulatory oversight mechanisms, and (5) a focus on first cost. Conflicting goals arise in this landscape under ownership and tenancy changes and as the building enters different stages of its life cycle.

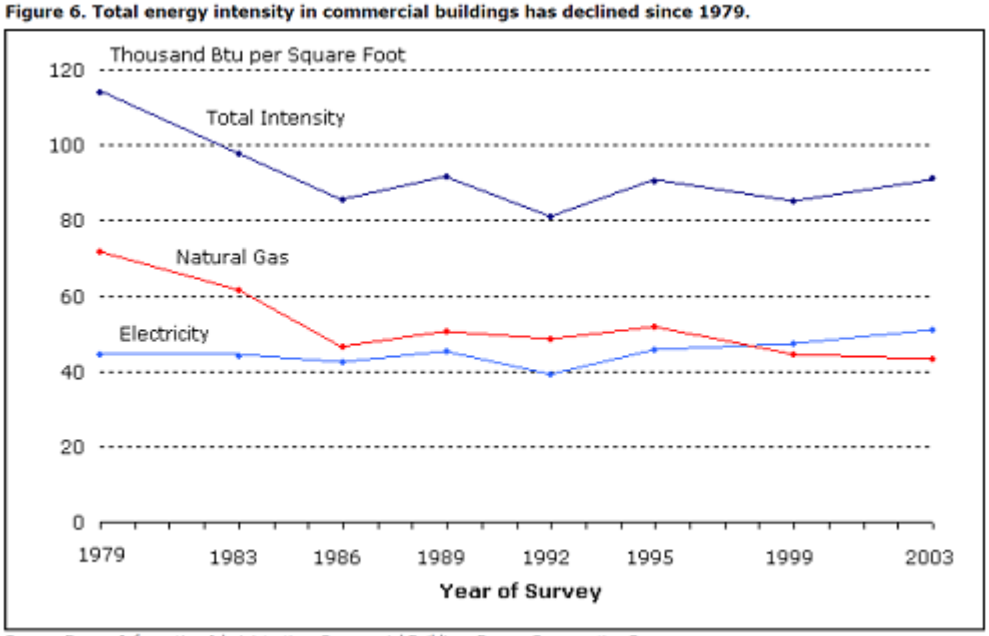
In this chapter, we discuss four major cross-cutting areas in building energy efficiency: investment, technology, human behavior and government policy.

Background Discussion

Energy Intensity in the Building Sector

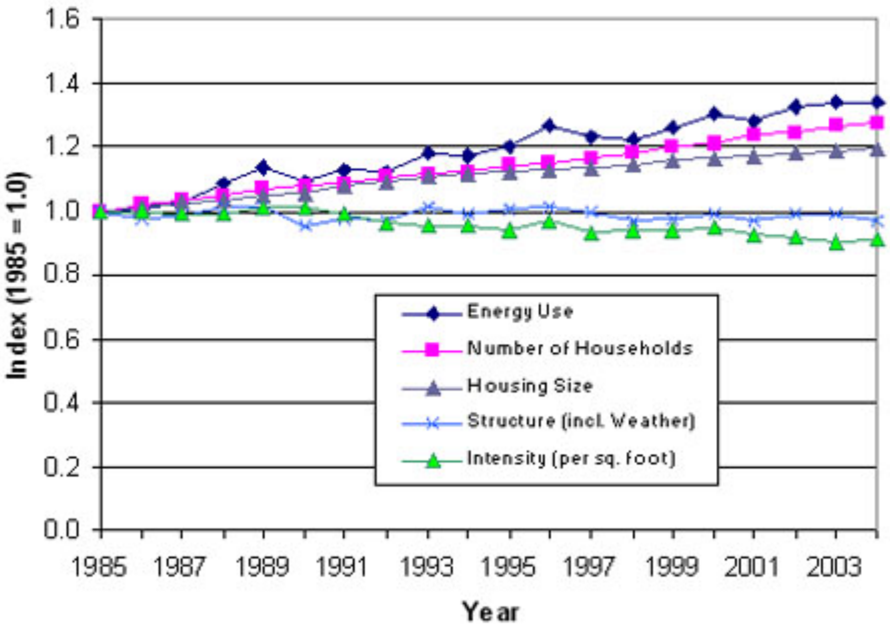
To better understand what drives total energy consumption in the commercial and residential sectors, it's instructive to compare energy intensity (annual energy used per unit area, such as million Btu per square foot) against total floor area. For example, a rise in floor area accompanied by a drop in total energy consumption implies that energy intensity decreased at a faster rate than floor space growth (i.e., improved energy efficiency).

Figure 6. Total energy intensity in commercial buildings has declined since 1979.



Source: Energy Information Administration, Commercial Buildings Energy Consumption Survey.

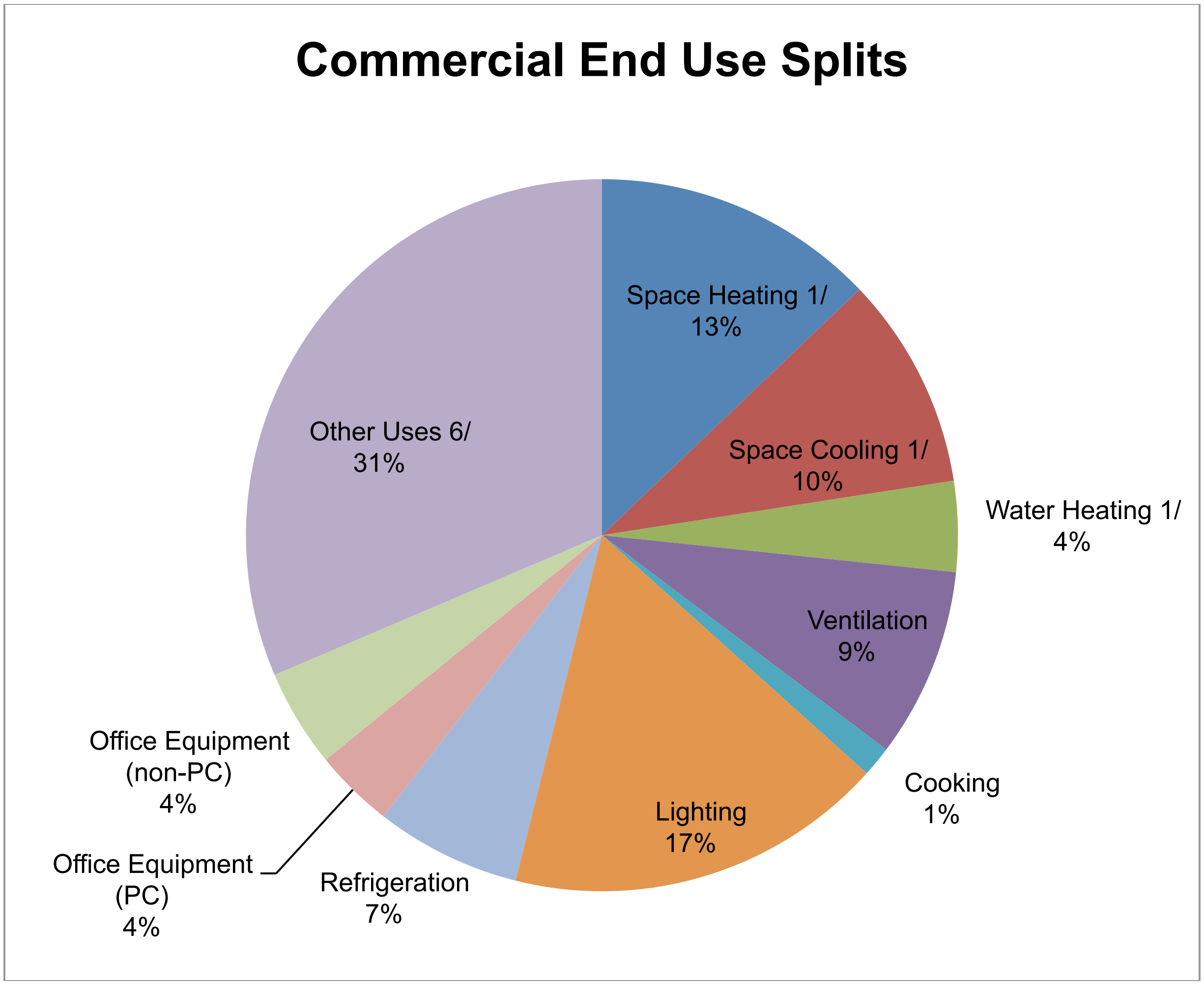
The total energy intensity for commercial buildings actually declined by nearly 25 percent from 1979 to 1986, mostly due to declines in natural gas intensity. From 1986 to 2003, total energy intensity fluctuated between 81 and 92 thousand Btu per square foot. Electricity intensity, on the other hand, has been rising since 1992, attributed to the demand for more services. This has been driven by the adoption and increased use of computers, office equipment, telecommunications equipment, and medical diagnostic and monitoring equipment. Cooling, humidity control, and ventilation requirements associated with such equipment have also played a role.

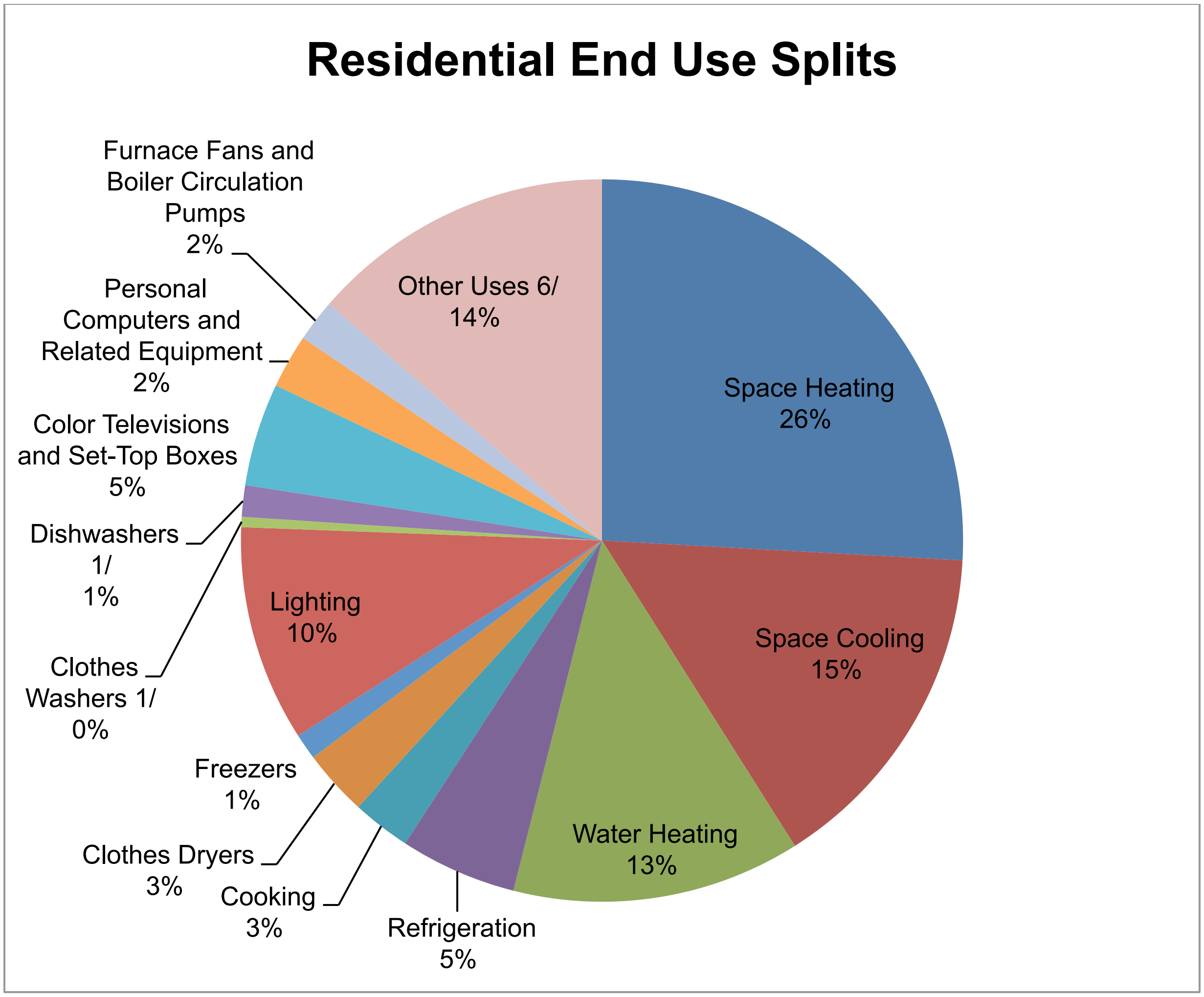


The residential sector has also experienced an overall decline in energy intensity, dropping about 25 percent from 1980 to 2005 (74 thousand Btu per square foot),[9] due to improvements in efficiency for space heating, air conditioning and major appliances. Newer homes also tend to feature better insulation and other characteristics, such as double-pane windows, that improve the building envelope. However, total United States energy consumption in homes continues to increase due to growth in the average size of housing units, increased use of electronics[10], air conditioning and other energy equipment.

Homes built since 1990 are on average 38 percent larger than homes built in earlier decades, a significant trend because most energy end-uses are correlated with the size of the home. As square footage increases, the burden on heating and cooling equipment rises, lighting requirements increase, and the likelihood that the household uses more than one refrigerator increases. Square footage typically stays fixed over the life of a home and it is a characteristic that is expensive, even impractical to alter to reduce energy consumption.[11]

[9] http://www.eia.gov/emeu/efficiency/recs_7c_table.htm
[10] For example, households with 3 or more TVs rose from 29% in 1980 to 44% in 2009; households with 2 or more computers rose from 6% in 1980 to 35% in 2009; and homes with central air conditioning rose from 27% in 1980 to 63% in 2009. http://www.eia.gov/totalenergy/data/annual/pdf/sec2_20.pdf
[11] http://205.254.135.7/consumption/residential/reports/2009-square-footage.cfm


Commercial End Use Splits
Space Heating 1/ 13%
Space Cooling 1/ 10%
Water Heating 1/ 4%
Ventilation 9%
Cooking 1%
Lighting 17%
Refrigeration 7%
Office Equipment (PC) 4%
Office Equipment (non-PC) 4%
Other Uses 6/ 31%



Factors Affecting Energy Intensity

Buildings display a wide range of energy intensities, depending on a multitude of factors, which can be broadly classified in two areas: (1) the building's physical characteristics and (2) its operational characteristics. Physical characteristics are those properties that are fixed for a given building: insulation, wall thicknesses, window types and sizes, materials of construction, dimensions, orientation, geographic location, HVAC system, water heating system, lighting fixtures, layout and more. Operational characteristics are those that can be influenced by the occupants, including the occupancy at different times, maintenance of mechanical systems, sensors and control systems, plug loads, demand response and occupant behavior. Both physical and operational characteristics have a large impact on energy use, and both can be modified.

Integrated design strategies can maximize energy savings, although for retrofits of an existing building there are limitations to how far one can go. It's not possible to re-orient a building, for example, or change the fundamental shape. Typically, a single system will be replaced without taking a holistic perspective. However, if the building envelope was improved at the same time a boiler was replaced, for example, it might be possible to down-size the boiler rather than replace it with one having similar capacity.

Decision-making Complexities

In the commercial building sector, energy efficiency measures implemented in a new building and during subsequent renovations are affected by the decision-making of capital providers, developers, users (lessees or owners), building professionals, and regulators.[12] A lack of awareness or alignment among decision-makers often results in foregoing opportunities for energy efficiency. Similarly, a lack of experience in integrated design, improved materials and the latest equipment leads to conservative decisions with respect to technology selection and implementation.

Awareness and Transparency

Building rating and disclosure programs are expanding in the U.S., promoting awareness and transparency with respect to building energy efficiency. A rating evaluates the energy efficiency of a home or building. Disclosure is the process of publicizing this efficiency score or other efficiency information about the building.[13] Rating and disclosure do not require a building owner to make energy improvements, but they do promote consumer awareness about the performance of buildings, which is a motivating force to make upgrades. Since most energy efficiency technologies are not readily apparent, a rating and disclosure mechanism summarizes the overall effect of a number of installed technologies on the energy performance of the structure, providing an "MPG" metric for buildings. A variety of disclosure programs have been implemented in numerous states and cities, often restricted to certain buildings, such as large commercial buildings, residential, or government buildings. Several voluntary rating systems are also currently used. These include the federal ENERGY STAR benchmarking program, Home Energy Rating System (HERS), ASHRAE Building Energy Quotient, Department of Energy's Home Energy Score, and others. There also are voluntary premium labels including ENERGY STAR New Homes, the U.S. Green Building Council's LEED rating system, and the Green Building Initiative's Green Globes,

Policy Background

Government policies represent critical tools to achieve transformation of the buildings market. Some policies push while other policies pull more efficient products and practices in to the market. Six categories encompass most of the policy options in use today.[14]

- Codes and standards: These mandate minimum efficiency thresholds for buildings, appliances, and/or equipment. As codes and standards strengthen over time, less efficient choices are removed from the marketplace, pushing builders and manufacturers to provide more efficient goods and services. At the building level, ASHRAE standards and the International Energy Conservation Code, once adopted by state and local governments, define mandatory practices for new construction and some renovations. Appliance and equipment efficiency standards are set at the federal level and by some

[12] Who Plays and Who Decides: The Structure and Operation of the Commercial Building Market, Innovologie, 2004
[13] http://www.buildingrating.org/
[14] California Long Term Energy Efficiency Strategic Plan, 2008

states. Codes and standards can be especially effective at achieving savings because they apply to *all* covered buildings and equipment.

- Education and information: Marketing, education and outreach all inform market participants about energy efficiency opportunities. Falling within this definition are labeling programs, benchmarking initiatives, internet-based comparisons to other buildings, school curricula, peer-to-peer exchanges, and other resources.

- Technical assistance and training: More in-depth education can help builders, installers, commercial building owners and managers, retailers and other professionals implement innovative efficiency measures.

- Customer Incentives: Rebates, tax incentives, innovative or discounted financing and non-financial support all pull consumers into choosing efficient options and can help give innovative technologies a toehold in the market.

- Energy Efficiency Resource Standards: Minimum resource standards compel electric and/or gas utilities to meet a significant percentage of their generation needs through demand-side or energy efficiency resources. These requirements have resulted in considerable energy efficiency investment across the country.

- Emerging technologies: Government support for research, development, demonstration and deployment helps develop energy efficient products and practices, and move them more quickly into the commercial marketplace.

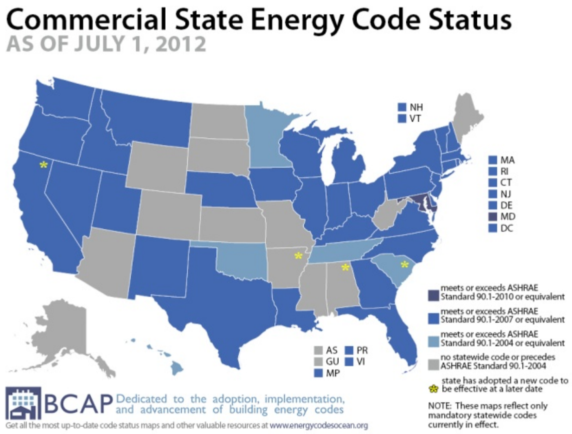
Mandatory policies are intended to ensure at least some minimum level of performance. Policies of a voluntary nature are intended to encourage performance above the minimum in terms of both physical and operational characteristics.

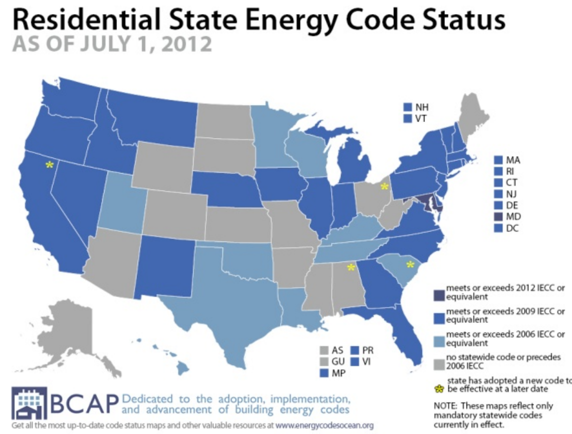
Building Energy Codes

Building energy codes define minimum design and construction requirements for residential and commercial building new construction and renovations. In the United States, the basis for most building energy codes are standards developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and codes developed by the International Code Council (ICC). These standards and codes are developed by a consensus approach and updated approximately every three years (raising the performance bar over time).

Building energy codes are adopted by state and local governments and become enforceable laws within a jurisdiction (e.g., municipality, county). Before adopting codes, state and local governments often make changes to reflect regional building practices or state-specific energy efficiency goals. This state-level adoption process leads to a patchwork of energy codes across the country, with different states implementing different versions of the IECC or ASHRAE 90.1 at any given time. Codes are enforced by local jurisdictions, and compliance with the codes is equally patchwork. The Department of Energy plays a role in assisting code development and state adoption of the most current versions of the codes, based on a process promulgated in Title

III of the Energy Conservation and Production Act (ECPA). DOE also provides assistance for enforcement and compliance improvements.





Equipment Efficiency Standards

Equipment efficiency standards address appliances and some plug loads. Appliances include not only refrigerators, dishwashers and clothes washers, but also residential and commercial furnaces, boilers, heat pumps, water heaters, air conditioners, light bulbs, linear fluorescent lamps and other equipment. Plug loads are electricity consuming items brought into a building after construction is finished, such as computers, copiers, printers, desk and floor lamps, space heaters, TVs and cell phone chargers (most of which do not currently have standards). Federal energy efficiency standards require manufacturers to produce equipment that meet a minimum threshold for performance. Congress has passed laws setting initial federal energy efficiency standards and establishing schedules for the U.S. Department of Energy (DOE) to review and revise these standards, based on the maximum level of energy efficiency that is technically feasible and economically justified. Federal law prohibits individual states from adopting more stringent standards, including in building codes.

Energy Efficiency Resource Standards

An Energy Efficiency Resource Standard (EERS) typically established by states, requires electric and/or gas utilities to meet a percentage of their generation from demand-side or energy efficiency resources. Today, half of all states have an EERS in place.[15] In practice, an EERS creates robust funding for building energy efficiency improvements, as utilities are compelled to offer incentives and other assistance to customers to meet their EERS requirements.

Ratings and Disclosure

As energy use cannot easily be seen, rating and disclosure of energy efficiency are necessary tools to enable consumers to choose efficient products and property. Yellow Energy Guide labels are required on many consumer appliances to provide consumers a comparison of efficiency to comparable products and an estimated cost of energy use (similar to vehicle fuel economy labels). Voluntary Energy Star labels mark premium efficient products. Other building rating programs and initiatives are discussed below.

[15] ACEEE (June 2012). Three decades and counting: a historical review and current assessment of electric utility energy efficiency investment in the states.

Financial Incentives

Financial incentives can effectively spur the adoption of energy conservation measures. A building owner might have the option, for example, to install a high efficiency furnace with an incentive that reduces the capital cost to a more financially attractive level. While they take a variety of forms, most are part of utility or state-run programs funded out of utility bills. More innovative approaches that incentivize whole building retrofits and integrated design practices have also been implemented or are under development in some states.

Capacity to Implement Energy Efficiency Improvements

Reducing energy use in the building sector requires a robust, skilled workforce. The Lawrence Berkley National Laboratory estimates that the national energy efficiency services sector (EESS) workforce will increase to 220,000 person years of employment (low-growth scenario) or 380,000 (high-growth scenario) by 2020. This represents a two to four-fold increase in the size of the EESS from the 2008 baseline.[16] Another study found clean economy jobs in 2010 in energy-saving building materials (161,896), HVAC and building control systems (73,600), green architecture and construction services (56,190), professional energy services (49,863), appliances (36,608), energy-saving consumer products (19,210), and lighting (14,298).[17]

Key challenges to growth include the following[18]:

- The lack of trained and experienced personnel, especially licensed design professionals, building managers and operating engineers;
- The lack of standard certification to ensure competence in some specialties;
- Retirement of experienced people in the "green" building and construction industry;
- The construction industry is largely unaware that the EESS is expanding; and
- Wide swings in funding that prevent long-term workforce development.

Cross-cutting Study Areas

Investment

Energy efficiency investments in commercial and residential buildings in the United States were approximately $18 to $20 billion in 2010. This total is comprised of $14.4 billion attributable to several specific investment mechanisms and $3.5 to $5 billion spent directly by building owners, small businesses, real estate companies and corporate entities. The specific investment mechanisms are dominated by utility efficiency programs at $6 billion (42 percent), followed by energy service company (ESCO) performance contracting at $4 to $5 billion per year (29 percent), and stimulus spending (22 percent). The balance of spending (about 5 percent of the

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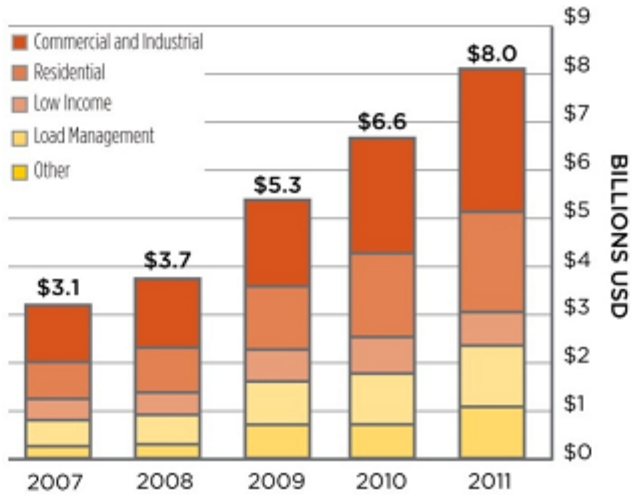
[16] http://eetd.lbl.gov/ea/ems/reports/lbnl-3163e.pdf

[17] Muro, M., Rothwell,J., & Saha, D. (2011). Sizing the economy: A national and regional green jobs assessment. Washington, DC. Brookings Institution Metropolitan Policy Program.

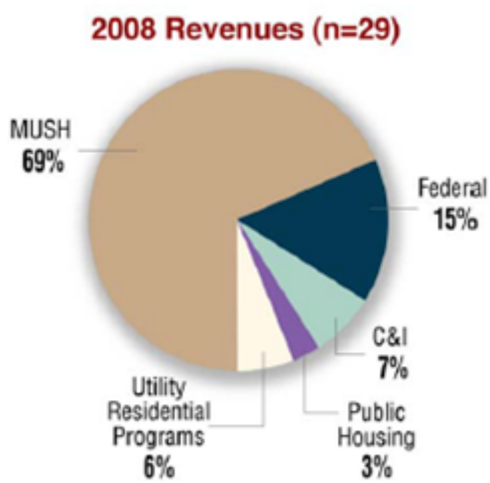
[18] http://eetd.lbl.gov/ea/emp/reports/lbnl-3987e.pdf

total) is comprised of banks, carbon markets, energy efficiency mortgages, forward capacity markets, property assessed clean energy (PACE) bonds, and energy service agreements (ESA).[19] Investment in efficiency from utility and state efficiency program budgets for the U.S. and Canada is increasing rapidly, with a compound annual growth rate of 19.7 percent from 2007 to 2011.[20]

Figure 2. US Combined Electric and Gas Program Budgets, 2007-2011



Only 25 percent of the $18 to $20 billion annual investment is financed via debt vehicles, mostly from ESCO performance contracting. This is the only debt vehicle that has reached an appreciable scale, however it is most common to the federal, municipal, university, schools and hospital (MUSH) building segments. Private residential and commercial buildings, where most energy saving opportunities exist, are barely touched by ESCOs. Some other investments are financed through a variety of broader vehicles, such as construction loans, home equity loans, purchase on credit and credit card debt. Many efficiency improvements are simply paid in cash.



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[19]. Hesser, T. G. 2012. *Energy Smart Technologies – Built Environment – Research Note*. Bloomberg New Energy Finance.

[20] Consortium for Energy Efficiency, 2011 Annual Report

The scale of opportunity for financing energy efficiency investments is tremendous. According to one study, in the commercial sector, an investment of $125 billion in positive energy conservation measures over the 2009 to 2020 period would reap a energy savings of $290 billion.[21] In the residential sector, the numbers are even larger ($229 billion investment, $395 billion energy savings). Together, the commercial and residential sectors could account for an annual savings of $78 billion. Another report identifies more than $279 billion that could be invested in residential, commercial and institutional buildings, yielding more the $1 trillion in energy savings over 10 years.[22]

Numerous debt financing models are available to open up the commercial and residential sectors. These including energy efficient mortgages (EEMs), PACE bonds, energy service agreements (ESAs), utility on–bill finance, and virtual utilities. However, the financing needs vary greatly by market segment: single-family home, multi-family housing and commercial buildings; individuals, companies, investment trusts, non-profit organizations and governments; owner-occupied, landlord and tenant; equipment upgrades, major retrofits and the incremental cost in new building construction. The market for financing faces a number of barriers that also vary.

Barriers

Actual financing of building efficiency projects is a fraction of its full potential. The primary barriers are:

- First cost issues
- Timing mismatch
- Split incentives
- Scalability
- Existing property or financing restrictions
- Uncertainty of savings and perception of risk

These barriers exist for numerous reasons, including the risk of not recovering development costs, limitations on additional indebtedness, cost access to project performance guarantees/insurance, difficulty for property owners and contractors to access programs, inability of land appraisals to account for energy efficiency, and a lack of standardized financing products.

First Cost Issues

When companies make trade-off between investments in "core" operations and energy efficiency improvements, energy efficiency typically loses. This occurs even with the sizable energy savings, short paybacks and dramatic improvements in work environments delivered by such projects. The high first costs of energy efficient lighting systems, for example, was a barrier cited by 73 percent of building managers in a 2009 survey.[23] This same issue applies to

[21] Granade et al. 2009. *Unlocking Energy Efficiency in the U.S. Economy*. McKinsey & Company.
[22] The Rockefeller Foundation, DB Climate Change Advisors. 2012. *United States Building Energy Efficiency Retrofits, Market Sizing and Financial Models*
[23] Building Design + Construction, First Cost, Client Pushback Biggest Barriers To Adoption Of High-Efficiency Lighting Systems, Say BD+C Readers, March 1, 2009, http://www.bdcnetwork.com/first-cost-client-pushback-biggest-barriers-adoption-high-efficiency-lighting-systems-say-bdc-reader.

consumers in the residential sector who are unwilling or unable to pay the increased initial cost for energy efficient technologies even though they decrease the total lifetime cost of home ownership, and if financed in a loan, typically yield net monthly savings.

Timing Mismatch

The disparity in the longer useful lives and payback periods of some energy efficiency improvements (e.g., HVAC equipment) and the sometimes shorter expected occupancy of an owner or lessee represents a disincentive …..?

Split Incentives

Split incentives occur when the tenant-- not the property owner--is responsible for paying a property's utility bill. While this contractual situation helps control daily energy use, it often hinders long-term investment in energy-efficiency for the following two reasons:

1. In most circumstances, a building owner would be expected to pay for building improvements, including any associated with energy efficiency. However, if the owner does not pay the utility bill, they would not reap the benefits of the lower utility bill resulting from the energy improvements. Consequently, a building owner has little incentive to invest in energy efficiency.
2. The opposite is true for the tenant. While tenants would see the benefit of the improvements reflected in their energy bill, they have little incentive to invest in permanent improvements to a building they do not own.

Similar split incentives occur for builders and current owners vs buyers and future owners—one pays the up-front cost but the other reaps the long-term savings (unless the purchase price fully reflects the energy efficiency)..

Scalability

Markets are fragmented in terms of the number of specialized submarkets and a large quantity of smaller buildings and individual owners. Financing any single efficiency project in many cases is not desirable due to transaction costs. Investors are looking for projects at large scales, with $100 million being an order-of-magnitude threshold. Aggregation, or creating a secondary market for loans, is a way to circumvent this but has its own complexities.

Existing Property or Financing Restrictions

Existing mortgages on mortgaged properties or under existing debt financing to property owners can impose restrictions on financing options. There are indebtedness limits on first mortgages, for instance, that can make financing in the residential and some commercial projects more difficult. Energy efficiency projects often do not create property that can be used to secure a loan.

Uncertainty of Savings and Perceptions of Risk

When energy cost savings are essential to the financial viability of a borrower, an outside investor financing a company's initial energy efficiency capital investment, will require a considerable degree of confidence that the resulting energy cost-savings will occur and deliver a reasonable return. While energy cost-savings are quite reliable for many energy efficiency investments, few players or mechanisms currently exist to measure and verify these savings—making it difficult and costly to collect and track the quantitative evidence required by investors. Until this data is more widely available, investors will continue to regard energy efficiency as inherently risky—preventing a broad expansion of this asset class.

Difficulty in Determining Credit Worthiness of Commercial Property
Most energy efficiency finance transactions require the host to make payment per contractual agreement. That contract could be a loan, lease or an energy savings based arrangement. This arrangement requires a capital provider to determine the creditworthiness of the contract counterparty (generally the host) in order to determine the likelihood of timely payment. If a building is owned and occupied by entities like a municipality, university or large corporation the creditworthiness of such obligor can be at least in part established by a rating provided by a rating agency. If the property is owned and occupied by a consumer (residential properties) the creditworthiness can be in part established by FICO scores. Commercial (and multifamily) properties are generally financed on a standalone basis (without owner guarantees) and there is no established methodology for assessing credit via ratings or FICO scores. Therefore, a lender/capital provider must undertake costly due diligence on the building to determine the credit – a significant investment of resources relative to the efficiency investment.

Financing Solutions - Opportunities

Opportunities for investing ratepayer funds, taxpayer funds, and associated policies will be addressed elsewhere in this and accompanying reports. The rest of this section will focus on financing.

Project Financing Models

A number of financing models are emerging to address the barriers that are holding back larger scale investments in energy efficiency. These include ESAs, PACE loans, utility on-bill finance, energy efficient mortgage, state and municipal loan programs, and virtual utilities. There is no one-size-fits-all solution; not all approaches can be applied to all market segments, and some require utility cooperation or regulatory support. A high degree of standardization, predictability, and scale, however, would all contribute greatly to greater penetration of energy efficiency financing.

Some of the most promising financing models are described below:

Energy Savings Performance Contracting
This approach is a method for developing and implementing comprehensive energy projects. An energy service company (ESCO) arranges financing and carries out the project, while the building owner pays back the loan from realized energy cost savings. Once a project is completed, the ESCO monitors energy savings and maintains the equipment over the contract term, which would typically be 10 to 20 years. The energy cost savings generally exceed the loan payments, and the customer shares in a portion of the savings. At the end of the contract term, the customer stops payments but can continue to reap all the benefits of energy savings. In

public buildings, the ESCO almost always guarantees savings to the customer, which creates a financial commitment for the ESCO to ensure performance of energy conservation measures.

ESPC projects can take several months to develop, due to complexities around contracts and the blending of funds from a number of sources. These characteristics, along with the effort necessary to validate energy savings, make transaction costs high. As a result, smaller projects (<$500k) are difficult to finance. The "MUSH" (municipal/university/state government/hospital) market is where most projects take place, due to the facilities being mostly owner-occupied, the absence of a first lien, and high creditworthiness.

Energy Services Agreements (ESA)

This financing mechanism builds on the historical use of power purchase agreements (PPAs) in power plant and renewable energy financing. Third parties negotiate the ESA with a customer, provide capital, develop projects, and manage installed equipment for large commercial and industrial projects. A special purpose entity (SPE) is usually set up with capitalization by third-party investors to finance the energy conservation measure(s). The host customer pays either a fixed or floating rate for the energy savings received. The SPE retains ownership of installed equipment and returns cash flows to investors. Ownership of environmental attributes, grants/rebates, and tax incentives also remain with the SPE. As a result, the project is treated as a service and an off balance sheet transaction. This is an attractive feature for many owners as the use of an SPE limits risk to the size of the individual project. The owner also avoids any up-front costs. The use of an SPE, however, results in higher transaction costs.

State and Municipal Loan Programs

The American Recovery and Reinvestment Act (ARRA) allocated almost $7 billion to state and local governments to finance energy efficiency and renewable energy programs. Because this was a one-time infusion of funds, some state and local governments have chosen to use the funds to set up revolving loan programs. Other states have revolving loan programs to fund efficiency in state buildings, such as the Texas LoanStar program. State programs promote collaboration among government departments, agencies, economic development organizations, private contractors, and third-party program administrators. Energy efficiency information and program offerings are concentrated into a single source.

Recently, a number of universities created internal revolving loan funds to use their endowments to finance energy efficiency improvements in their own buildings. This model could be used by hospitals, state and local governments and other entities in times of greater revenues.

Demand Response Payments

Demand response programs entail the use of building management system (BMS) controls to reduce energy consumption over short periods of time, typically during peak demand events. Benefits to a building owner include a payment from their electric utilities or demand response aggregators that can be directed to other building energy efficiency investments.[24]

[24] Morton, Jenny 2012. Demand response programs – use a demand response program to cut energy expenditures and generate revenue. Buildings. Viewed at http://www.buildings.com/tabid/3334/ArticleID/13458/Default.aspx on 7/27/2012.

Energy Efficient Mortgage

The energy efficient mortgage (EEM) provides homeowners with additional borrowing capacity and potentially better terms when purchasing a new energy efficient home or making energy efficiency improvements. The financing is rolled into the home mortgage. EEMs raise the cap of how much a homeowner can borrow because an efficient home is worth more and because the borrower can afford to pay more due to lower energy costs. The value of energy conservation measures and estimated energy savings must be determined by using the Home Energy Rating System (HERS) or an energy consultant. Under the current Federal Housing Administration EEM, the added mortgage amount cannot exceed 5% of the home value. There is a great deal of potential for EEMs but little actual use. The administrative complexity and cost for a rating has limited interest. In addition, performance risk is still a hurdle to acceptance. Recent experience with the real estate market collapse and the ensuing rise in default rates has created uncertainty in the market. In theory, however, EEMs pose less of a risk than traditional mortgages.

A proposed solution to achieve more widespread use is to revise underwriter guidelines for mortgages to ensure that energy efficiency performance allows for qualification of higher mortgage amounts, thus covering first costs and allowing an equity value to the owner. The SAVE Act sponsored by Senators Bennett and Isakson is designed to address the underwriting rules for all mortgages touched by the federal government.

Utility On-Bill Financing

Under this financing mechanism, a utility use ratepayer or shareholder funds to pay the up-front cost of an energy efficiency improvement, and the customer repays this cost through a charge on the monthly utility bill. This leverages the existing billing relationship between utilities and their customers and takes advantage of the access utilities have to information about energy usage and payment history. It also allows the threat of a service cut-off to provide significant assurance that the loan will be repaid. On-bill financing can take two forms: (1) an obligation tied to the customer, meaning that if the customer moves, the balance must be repaid, or (2) an obligation tied to the meter through a utility tariff so that the obligation survives changes in ownership. Changes in statutory authority may be required to enable an obligation to attach to a meter.

Utility On-Bill Repayment

On-Bill Repayment ("OBR") programs are similar to on-bill financing except that the capital is provided by third parties including banks and other investors. OBR may be possible without ratepayer, taxpayer, or utility funding. Lenders see OBR programs as beneficial from a credit perspective since building owners have a strong incentive to pay their utility bills. Credit can be further enhanced by having the obligation tied to the meter through a utility tariff so that it survives changes in building ownership. OBR programs can be designed to accommodate a wide variety of financing structures and vendor business models. Utilities are expected to be compensated by such a financing program for the billing services that they provide.

Property Assessed Clean Energy Financing

Commercial PACE programs allow local governments, subject to authorization by state law, to provide long-term financing of energy efficiency improvements on multi-family (>4 units) properties, commercial buildings and industrial facilities. The funding is secured by a lien on the property and is paid back through a charge on the owner's property tax bill. Loan pools are funded by issuing bonds or providing government grant funding or a combination of the two. The mortgage holder must consent before PACE applications are approved. Reduced monthly energy bills should more than compensate for the additional charge on the property tax bill. The debt obligation transfers with ownership.

This mechanism was also intended for energy efficiency and renewable energy projects in homes and received widespread interest by local governments around the country. However, in 2010 the Federal Housing Finance Agency (FHFA) issued a statement residential PACE financing. The FHFA reacted strongly against PACE and directed banks and Fannie Mae and Freddie Mac to secure their rights on any properties that could be encumbered by a PACE lien, including lowering mortgage caps to account for a possible future PACE lien and requiring consent to any future PACE liens. In a subsequent court-ordered rulemaking, FHFA has proposed even stronger rules. Some states are trying to avoid this problem by making the PACE lien secondary to the mortgage.

Credit Support and Enhancements

Instead of providing loan capital directly, a government can leverage limited funds by supporting loans provided by banks or others. A loan guarantee, such as those provided by DOE under a 2007 law , is a form of loan insurance, protecting the lender against default. A loan loss reserve is closely related, a specific sum set aside to cover losses from a portfolio of loans. An interest rate buy down pays part of the interest on a loan, reducing the effective rate for the borrower. These mechanisms can be used to reduce the cost of financing to the borrower without providing all the needed capital.

Access to Capital Markets

Another aspect of scaling up the financing of energy efficiency across the nation is attracting low-cost, long-term capital from the capital markets. While most of the above discussion addresses how to get the efficiency projects financed at the project level, this section addresses the challenge of financing the entire energy efficiency market at the lowest possible cost of capital.

Equity Capital Markets

There are two major opportunities in the equity capital markets: raising equity capital for the ESCO development companies, and raising capital for projects and installations through mechanisms such as Real Estate Investment Trusts (REITs) or Master Limited Partnerships (MLPs). There are several firms seeking clearance by the IRS to use a REIT structure for energy efficiency investments. Investors buy shares in REITs, which are traded on stock exchanges like companies. A REIT must have at least 75 percent of its assets in, or income from, real estate, and must distribute 90 percent or more of its income as dividends to its investors each year. If energy efficiency companies can qualify their activity as a REIT, they can get access to the equity capital markets. MLPs are limited partnerships that are publicly traded securities. As their use is currently limited by federal law to natural resource (primarily oil and gas) investments, the use of MLPs by the energy efficiency industry will require an act of Congress. Senators Coons and Moran have introduced such a bill in the U.S. Senate for renewable power and combined heat and power.

Debt Capital Markets

There are several segments of the debt capital markets that can be tapped by the energy efficiency industry, including but not limited to the Public Bond Market, Private Bond Market (institutional investors), and syndicated bank loan market. A key to successful access to the bond market is having bond ratings placed by Standard & Poors, Moody's and Fitch, the three major bond rating agencies. This will be especially important for some current efforts to "securitize" the cash flows from energy efficiency contracts, leases and loans into asset-based securities. Securitization requires, in most cases, that the legal documents for the underlying deals are identical. This is a current barrier because there is no national standard shared saving contract or efficiency financing paper – such standardization is needed before securitization can be done at scale. Bond rating also requires risk analysis, that in turn requires a database of historical performance of energy efficiency projects by sector, type of end user, geographic location and other factors. The development of standardized documentation and a database of project performance will enhance the prospects of reaching the debt capital markets to provide capital for efficiency projects.

Truly scaling up energy efficiency financing beyond local-level financing techniques will require tapping the capital markets. This can be done if the industry is willing to adapt itself to the special requirements, demands and practices of capital market investors. The capital markets will not adapt to the special needs of efficiency companies and projects; it is up to the efficiency industry to understand capital market investors and adapt the industry to meet those needs.

Case Studies

- Connecticut On-Bill Financing: Both United Illuminating (UI) and Connecticut Light & Power (CLP) have offered on-bill financing to small business customers since 2000, with capital from Connecticut's public benefits fund. UI currently offers zero-interest loans from $500 to $100,000 for up to four years, with repayment on utility bills. Typically they pay for an energy audit, and a contractor from an approved list carries out the measures; utility incentives cover 30-50% of the cost of recommended measures, and the loan covers the rest. From 2000-7 UI provided $21 million in loans for 2450 projects that were projected to save 670 million kWh. The default rate was under 1%. CLP has made over 7000 loans worth over $72 million in a similar program.Recently the utilities have established a similar residential loan program with loans from $2,000 to $20,000 for up to ten years.[25],[26],[27]

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[25] C.J. Bell, S. Nadel, and S. Hayes, *On-bill Financeing for Energy Efficienicy Improvements*, ACEEE, 2011.

[26] United Illuminating Company, Small Business and Municipal Loans,

[27] M. Hyams, ""On-Bill Financing" for Energy Efficiency," Mayor's Training Program, http://cleanefficientenergy.org/resource/mayor%E2%80%99s-training-program-case-study-%E2%80%9C-bill-financing%E2%80%9D-energy-efficiency.

- Vermont PACE Program: Vermont is implementing a residential PACE program under laws passed in 2009 and 2011 that has met FHFA concerns. 34 Vermont towns, including Burlington, have designated themselves as PACE districts. They generally contract with Vermont's "efficiency utility," Efficiency Vermont, to run the program. Financing is provided for up to $30,000 of improvements over up to 20 years; interest is set at market rates, a little above mortgage rates. The funds are paid back through a special assessment on property taxes. The assessment does not have a primary lien; however, the assessment is tied to the property and remains if the property is sold (including because of mortgage default). In addition, a small fee is included to create a loan loss reserve that protects municipalities in case of default.[28]

Policy Instruments & Conclusions

There is considerable potential to stimulate growth in energy efficient buildings through greater use of emerging financial models. Despite ample evidence of energy efficiency measures producing reliable energy cost savings, the mainstream financial community lacks experience and familiarity in this area and encounters difficulties in finding and gaining access to relevant and reliable data sets. Policy changes could catalyze the financing landscape. In broad terms, policies should emphasize standardization, risk reduction, and scaling up. In a few key areas, government policies have been or will be disabling to energy efficiency financing rather than enabling. Additional policy options should be considered to mitigate such impacts.

2.0 Technology

Building envelope components, mechanical systems (heating, cooling, ventilation and water heating), lighting, controls, appliances, electronics, and other electrical equipment are technologies that together define a building's capability to perform with respect to energy consumption. Most buildings fall short of their performance potential if not maintained. Actual performance can be downgraded significantly by wasteful operating behavior, shoddy installation, and poor maintenance practices (owner, operator, and occupant behavior). Sensors and information technologies can guard against these effects by detecting abnormalities and alerting building owners, occupants and operators to such problems.

Existing technologies can reduce energy consumption by 30 to 50 percent compared to the typical building.[29] Despite these cost effective solutions, existing energy saving technology is not being optimally deployed. New technology diffusion has been slow, and integrated approaches are not widely practiced.

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[28] PACE Vermont Wiki, http://pacevermont.wikispaces.com/Welcome+to+PACE+Vermont.

[29] See ASHRAE advance energy design guide series for 30% and 50% reductions compared to ASHRAE standard 90.1-2004 at http://www.ashrae.org/standards-research--technology/advanced-energy-design-guides.

A new building must be constructed to at least meet the current building energy codes, guaranteeing, in theory,[30] that it will meet some minimum allowable performance level. This requires the building to have sufficient insulation and code-compliant windows, lighting intensities, and installed HVAC equipment. Major appliances and electronics available for purchase also conform to the applicable minimum federal efficiency standards. The bar that must be met also rises over time as codes and standards are revised (model codes are updated on a three-year cycle, while federal standards are typically supposed to be reviewed every eight years).

To substantially impact U.S. total building energy consumption, we must also deliver major improvements in existing buildings.[31] There are millions of buildings that need to be improved, many small and mid-sized. As equipment wears out and requires replacement, newer equipment will generally be more efficient, which can produce gradual improvements. Integrated building system solutions, however, are rarely practiced during retrofit projects, and significant opportunities are missed.

Finally, many high-efficiency technologies remain "on the cusp." That is, these technologies are beyond the research stage but not in commercial use, or commercialized but not in common use. These include gas and electric heat pump water heaters, gas heat pumps and instantaneous water heaters.

Technology Barriers

The presence of a number of barriers explains the lack of adoption of better technology and technology combinations.

<u>Integrated Design</u>
The tendency to focus on the individual parts of a building rather than integrated systems is one reason for unrealized improvements. Unless integrated design becomes a common practice among architects, engineers and builders, buildings will continue to fall short of their true potential for saving energy. Conventional approaches embedded in the marketplace make it very difficult to move in the direction of integration. Sequential and compartmentalized design and construction processes encourage developers, architects, engineers, equipment and material suppliers, and owners to make independent decisions that generally are not aligned with a goal of energy optimization for building as a whole. For smaller building sizes, the players are simply unaware of the possibilities available, and are risk-averse to adopting innovative technologies.

<u>First-Cost Mentality</u>
The entrenched practice of awarding contracts to the lowest bidder precludes solutions that might have lower life-cycle costs and better performance capability, despite a higher first cost. Many

[30] There are numerous reasons why a code-driven minimum performance level might not be met in reality. For example, today's building codes do not require post-occupancy verification of building performance, the codes are not followed in every case, and building departments don't always have sufficient staff to conduct thorough inspections of work during construction. In addition, the levels required by codes are often kept low because of opposition to change or to higher construction costs.
[31] Renovations in general are not exempt from the prevailing building energy codes, although exemptions may apply to a variety of specific situations and conditions.

clients, including virtually all public entities, require general contractors to submit lump-sum bids and then select the lowest qualified bidder. General contractors likewise solicit multiple bides from specialized subcontractors. The fragmented bidding process blocks any tradeoffs between different pieces of equipment and envelope improvement options that might be positive in total, resulting in the best overall solution not being chosen.

On the residential side builders often will not add additional first cost for energy efficient technologies as it is difficult for the builders to recoup this cost in the price of the home, and generally the homeowner will not qualify for a higher mortgage amount. Thus it is incumbent upon the financing instruments to place an inherent value on energy efficiency, allowing owners to make a buy decision based on financial returns.

Split Incentives (the Principal-Agent Problem)

Separate individuals, different departments in an organization, or different companies incur the risks and benefits associated with each phase of a building project's life cycle, so no single individual or firm has a multidisciplinary life-cycle perspective. The party that bears the capital cost does not usually bear the full life-cycle operating costs. Overall project benefits may conflict with the self interest of an individual party, so are not pursued. A study that measured differences in implementation of energy efficient technologies by principals and agents (e.g., owners and users) found that residential energy use associated with the principal-agent problem (for refrigerators, water heating, space heating and lighting) amounted to over 3,400 trillion Btu in 2003, equal to 35 percent of site energy consumption.[32] Policies that solve the split incentive problem, therefore, stand to have a large impact.

Technology Opportunities

Newly developed technologies for building components and systems could yield substantial energy savings if successfully commercialized. Net zero energy buildings, which greatly reduce the energy consumption within the building and incorporate renewable power systems to offset the remaining energy use, may become more common as emerging technologies are made cost effective. However, adoption of these new technologies will be slow without effective policy initiatives to address the barriers.

Currently, the buildings industry can realize tremendous energy savings with available products and materials, if better design decisions are made, education of the stakeholders is improved on different levels, building controls and sensors are deployed in creative ways, and full advantage is taken of information technology and building informatics.

Integrated Solutions

Application of an integrated design approach is necessary for a deep retrofit or to construct a low-energy building. For large projects this might entail convening an integrated design team of building professionals using detailed modeling analysis. For any project, it means simply considering the interaction between building systems – for example, windows, lighting and

[32] Murtishaw and Sathaye. 2006. *Quantifying the Effect of the Principal-Agent Problem on US Residential Energy Use*. Lawrence Berkeley National Laboratory, LBNL-59773 Rev.

HVAC systems – to ensure that appropriate choices are made. This approach starts by considering load reduction options first, then system options, and finally physical plant options.

Controls and Sensor Technologies

Advanced building controls play a significant role in improving building energy performance, helping optimize and automate the operation of building systems, as well as detect performance degradation or fault conditions. Advanced controls connected to sensing technology respond rapidly to changing environments inside and outside of a building. Wireless controls have the potential to significantly reduce the cost of advanced sensing and control systems, particularly in existing buildings where installation of wiring can represent 20% to 80% of control project costs.[33]

Building Envelope Technologies

The building envelope presents efficiency opportunities in the areas of commissioning and quality control. The building envelope systems must include integration of window, wall, and roof system design with other building systems, such as controllable shading products, external fixed shading, interior lighting systems, and HVAC systems.

Glazing and window framing materials have seen tremendous change over the past 20 years. In the residential market, vinyl frames took a quarter of the market from wood frames, while double-pane sealed insulated glass units took market share from single-pane and unsealed double-pane windows. Advances in windows are needed in fixed glazing, dynamic glazing, and window system integration. Dynamic glazing (glass with variable visible transmittance (VT)), for example, can enable near real-time optimization of solar heat gains and glare control through windows.

"Cool roof" technology (high solar reflectance roofing) is a rapidly expanding trend in markets with high air conditioning loads. For example, the DOE announced a cool roof initiative in 2010, under which the agency will install a cool roof for new and replacement roofs at DOE facilities.[34] State and city governments are setting similar goals to combat the urban heat island effect. The U.S. Army also plans to use cool roofs on all of its facilities.[35] Acrylic-based elastomeric roof coatings (ERCs) are applied directly onto existing roof substrates. Research by ORNL, LBNL and Dow is focused on commercializing new solar reflective technologies that would increase by over 50 percent the energy savings that cool roofs offer for new and existing commercial buildings.[36]

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[33] (DOE, EERE, http://www1.eere.energy.gov/buildings/wireless_rd.html, accessed 7/20/12).

[34] U.S. Department of Energy. 2010. *DOE Takes Steps to Implement Cool Roofs across the Federal Government.* at http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=16175

[35] Department of the Army. 2010. Memorandum on Sustainable Design and Development Policy Update. http://www.asaie.army.mil/Public/IE/doc/Sustainable%20Design%20and%20Dev%20Policy%20Update.pdf

[36] U.S. DOE press release. 2011. DOE's Oak Ridge and Lawrence Berkeley National Labs Join with Dow Chemical to Develop Next-Generation Cool Roofs. http://energy.gov/articles/does-oak-ridge-and-lawrence-berkeley-national-labs-join-dow-chemical-develop-next

HVAC, Refrigeration Technologies

Space conditioning and refrigeration account for 44 percent of primary energy consumption in the buildings sector.[37] Improvements in this technology can reduce energy consumption substantially. From the whole building perspective, an integrated design approach that takes into consideration reduced heating and cooling loads due to other modifications (e.g., improved insulation, more efficient lighting) to produce the best results.

Technology is advancing in HVAC and refrigeration, but cost-effective new products that have entered the market remain underutilized. Some underutilized technologies include[38]:

- Energy recovery ventilation systems (commercial, integrated, and air handler integrated)
- Unitary commercial ground source heat pumps
- Advanced fan/blower technologies
- Commercial ductwork optimization
- Electronically commutated/permanent magnet/brushless DC motors
- Improved duct sealing
- Radiant heating and cooling
- Variable speed drives
- Building automation systems
- Air to water heat pump chillers
- Commercial condensing boilers
- Dedicated outdoor air systems
- Point of use water heating
- Residential heat pump water heaters
- Water to water heat pump chillers
- Active chilled beam cooling with DOAS
- Desiccant dehumidification systems
- Instantaneous water heaters
- Heat pump water heaters
- Gas heat pumps

The best available condensing gas fired boilers are over 120 percent more efficient than the average new gas-fired boilers in 2010. (Table 5.3.5, Commercial equipment efficiencies). Heat pump water heaters (HPWH) can attain much higher efficiencies than conventional electric water heaters. Yet the residential market for HPWHs has remained small because of long payback times, low perceived reliability, and the need for specialized installation and service.

Lighting, Daylighting and Lighting Control Technologies[39]

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[37] U.S. DOE, EERE. 2010. Buildings Energy Data Book (Table 1.1.5)

[38] Commercial Buildings Consortium. 2011. Next Generation Technologies, Barriers and Industry Recommendations for Commercial Buildings.

[39] The descriptions of lighting technologies in this section are largely based on a California Public Utilities Commission report – 2010 Lighting Technology Overviews and Best Practice Solutions, prepared by the California Lighting Center. http://cltc.ucdavis.edu/images/documents/publications_reports/2010_Lighting_Technology_Overview.pdf

A variety of lighting and control technologies are available to achieve 30 to 50 percent energy savings compared to current conventional approaches in the commercial and residential building sectors. Cost is a barrier, but is dropping rapidly for newer technologies.

Commercial lighting:

- *Task-ambient lighting* – Office space ambient lighting levels are decreased and task lighting is provided only in those places that need it. Savings of 40 to 50 percent are possible.
- *Multi-level switching with occupancy sensors* – occupancy sensors turn lights off in vacant offices and occupants can use reduced lighting when there is adequate daylight. Studies have measured 34 to 52 percent savings for multi-level switching.
- *High intensity discharge (HID) electronic/dimmable ballasts* – Common in retail stores, warehouses, gyms and auditoriums, new generations of HID electronic ballasts allow these lights to be dimmed without decreasing fixture life. Savings of 25 percent can be achieved. There is still a cost barrier and buyer wariness due to longevity concerns.
- *LED downlights* – Replacing incandescent downlights with LED can save 75 percent, while replacing CFLs can save 40 to 50 percent. Performance and cost vary widely, and some specifications are unreliable, creating general market uncertainty about the technology.
- *Dimmable/controllable fluorescent ballasts* – Offer the flexibility to adjust lighting output from fluorescent sources gradually. Dimming ballasts are widely available, but represent only 4 percent of the commercial market.
- *Daylight strategies and technologies* – Annual energy savings from daylight harvesting controls of 40 to 80 percent have been measured for commercial office spaces. Such controls are found in less than 2 percent of new commercial buildings and in a few retrofit buildings.

Residential lighting:

- *Dimmable CFLs* – though not universally accepted by consumers, CFLs have large energy saving potential – about 75 percent in comparison to incandescents. Conventional CFLs cannot be used with most commercially available dimmers, restricting their output to a single level and foregoing the savings that dimming would provide.
- *LED fixtures and systems* – Savings over incandescent can be up to 80 percent, but today's costs are high and reliability has been an issue.
- *Residential occupancy controls* – Up to a 50 percent savings with these controls, which are available but only have limited market penetration.

As described above, there are many options to improve commercial and residential lighting; however, a variety of barriers exist. Lighting upgrades are typically the first energy efficiency improvement made in commercial buildings due to their ease of upgrade and rapid payback. These tend to produce more modest results compared to newer lighting designs and controls.

Case Studies

- Defense Installation Energy Test Bed: The Defense Department created the Installation Energy Test Bed in 2009. An initiative of the Environmental Security and Technology

Certification Program, the test bed is a distributed activity rather than a facility. In an attempt to get technologies needed by the department across the "valley of death" the department will serve as "first user," testing the validity, cost, and impact of new technologies proposed in response to an open solicitation and selected by technical experts. For technologies that pass the test, the department's 300,000 buildings (by far the largest infrastructure of any organization) can serve as early customers, helping create a market and bring production to scale. Technology areas include building components, management and control technologies, tools for design assessment and decision making, smart microgrids and energy storage, and renewable energy generation. A few examples of tests include automated continuous commissioning at Naval Station Great Lakes, daylight redirecting window films, and microgrid energy management controls to improve energy efficiency and security.[40],[41]

Policy Instruments and Conclusions

Government policies and regulation should favor use of building controls in commercial and multi-family dwellings. Building controls, with proper design, installation and maintenance, offer a persistent and sustained low risk on retaining or improving financial and economic returns, particularly under increasing energy price volatility.

There are examples of efficiency programs in the United States that support an integrated approach and may serve as models for broader adoption. In California, "Savings By Design" is a nonresidential new construction energy efficiency program[42] that encourages energy-efficient building design and construction practices, offering up-front design assistance supported by financial incentives based on project performance. "Efficiency Vermont" offers financial incentives for custom energy efficient measures and energy efficient design. Design incentives help cover part of the cost of using integrated design methods. Construction and building incentives may cover up to half the incremental cost between standard equipment and energy efficient equipment.[43] New Jersey runs the "Pay for Performance Program," available to existing and new construction commercial and multi-family buildings. This comprehensive, whole-building approach to energy efficiency starts with an Energy Reduction Plan developed by an energy expert selected from their network of program partners.[44]

Finally, the federal government is the leading supporter of building efficiency research in the United States. Department of Energy support has played an important role behind electronic ballasts for fluorescent lights, low-e windows, improved refrigerator compressors, LED lighting, building simulation software, and many other innovations. The current buildings R&D budget is $220 million. Much of the support has been through the national labs, several of which have large concentrations of expertise in aspects of building efficiency, but DOE also supports

[40] SERDP and ESTCP, Installation Energy Test Bed, http://www.serdp.org/Featured-Initiatives/Installation-Energy.

[41] Jeffrey Marqusee, "Military Installations and Energy Technology Innovation" in *Energy Innovation at the Department of Defense*, 2012, http://bipartisanpolicy.org/sites/default/files/Energy%20Innovation%20at%20DoD.pdf.

[42] http://www.savingsbydesign.com/book/savings-design-online-program-handbook

[43] DSIRE web site. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=VT09F

[44] http://www.njcleanenergy.com/commercial-industrial/programs/pay-performance

corporate and university research, including the new Energy Efficient Buildings Hub. While dated, a review found the program very cost-effective, largely because of large billion-dollar paybacks from a few small million-dollar projects.[45] The federal government also plays an important role as a test bed and first adopter of innovative efficiency technologies, such as in the Defense Department's Environmental Security Technology Certification Program (ESTCP), described above, and the General Service Administration's Green Proving Grounds.

Although most R&D funding is federal, California's Public Interest Energy Research (PIER) program is a state-level example of RD&D funding, with an annual budget of $86.5 million. It supports projects in energy efficiency, renewable energy, advanced electricity technologies, energy-related environmental protection, and transmission and distribution, and transportation technologies. In the last decade, PIER has invested more than $700 million.[46]

3.0 Human Behavior

Human behavior characteristics need to be recognized when developing approaches for reducing energy consumption in residential and commercial buildings, since owners, operators and occupants of buildings are ultimately the ones who make decisions about how energy is used. This section considers human behavior from two vantage points:

> *Behavioral Energy Efficiency*. One key opportunity around behavior in buildings is the potential energy savings that can be generated by occupants changing behavior. Such opportunities include turning lights out and regulating building temperature.
>
> *Adoption of structural or device-driven Energy Efficiency*. A second key aspect of behavior is the potential to motivate people (home-owners and building managers, for example) to undertake physical improvements or purchase new appliances that save energy and money over time. For the residential (and potentially the commercial) market, the financial motivation (relatively short cost-recovery periods) may be insufficient to motivate people to make efficiency investments.

Behavioral-based energy efficiency (BBEE) programs are growing in use around the country, and represent a source of energy savings beyond traditional utility programs focused on encouraging adoption of EE technology. Utilities and others in the energy industry now use the science of behavior change to encourage energy efficiency. Behavioral based efforts hold the prospect of expanding both the breadth and depth of energy efficiency activity.

Behavior change program mechanisms and components include:

- Energy consumption feedback

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[45] National Research Council. *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*. Washington, DC: The National Academies Press, 2001.
[46] See http://www.energy.ca.gov/research/

- Commissioning and building energy management
- Building energy use benchmarking
- Social norms and marketing
- Customer tips and assistance
- Energy reduction commitments
- Financial incentives.

Feedback Mechanisms

BBEE programs employ an energy use feedback mechanism to show the user how much energy they have consumed compared to another point in time. This feedback can take many forms, including paper, web-based, in-home display and telephone. The frequency of information updating may influence impact, and can be augmented with comparisons, advice, on-line energy audit tools, and assistance.[47]

Commissioning and building energy management

Many commercial buildings are sophisticated systems; even when designed well, they must be tuned and maintained to function properly. Commissioning is the process of ensuring a new building works as designed and that the operations staff are trained to manage it (and recommissioning is necessary to keep a building operating well. Trained building energy managers also will help ensure energy is not being wasted. Effective building operations and maintenance is as important as capital retrofits in reducing energy use.

Building energy use benchmarking

Energy use benchmarking in commercial buildings is based on the idea that tracking energy use and comparing it to comparable buildings motivates owners and managers to examine their energy waste and seek savings. Energy Star Portfolio Manager has been used to track and benchmark energy use of 35 billion square feet (about 40 percent) of buildings space.[48] Cities and states are starting to require use and disclosure of Energy Star ratings for large buildings.

Social Norms and Marketing

Designing programs to leverage social norms and marketing is a potentially powerful way to motivate energy saving behavior. Comparing a household's energy use to that of other similar households is one way to use social norms for behavior change. For example, OPower sends customers a monthly or quarterly report that compares their energy consumption to their neighbors.[49] ENERGY STAR commercial benchmarking and other voluntary building labeling/rating programs also can serve this purpose, particularly when results are made public.

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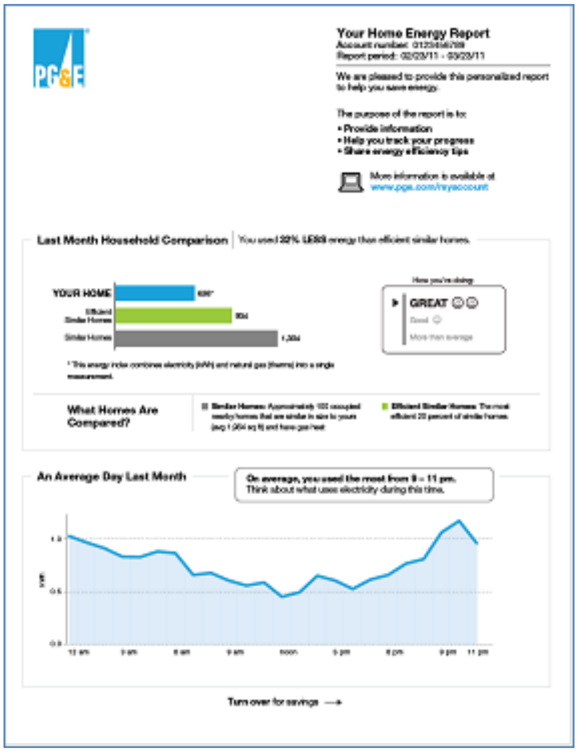
[47] Bonneville Power Administration. 2010. Residential Sector Research Findings for Behavior Based Energy Efficiency. At http://www.bpa.gov/energy/n/pdf/Behavior_Change_Report_Dec_2010_July_5.pdf

[48] ENERGY STAR® Overview of 2011 Achievements, http://www.energystar.gov/ia/partners/publications/pubdocs/2011_4-Pager_508c_060812.pdf?96a3-6cc0.

[49] Bonneville Power Administration. 2010. Residential Sector Research Findings for Behavior Based Energy Efficiency. At http://www.bpa.gov/energy/n/pdf/Behavior_Change_Report_Dec_2010_July_5.pdf



Customer Advice and Assistance

Change can be enabled by offering customers energy saving assistance. On-line resources can now go far beyond conveying information in print form, and include tools to perform home energy auditing and generate customer-tailored improvement recommendations. Average American homeowners do not fully comprehend their home energy consumption and also lack understanding of energy conservation measures available, so delivering clear information and offering easy-to-use tools enables informed choice and better energy performance.

Commitments and Goal Setting

Expressing commitment to take action can influence behavior change. Experiments have shown that commitments made by utility customers can result in up to a 10 percent savings.[50] Goal setting has also been shown to be effective. A goal-setting experiment conducted by OPower showed that goal setters save over three times as much energy as regular program participants.[51] At a corporate level, sustainability goals can drive behavior throughout the organization.

Financial Incentives

Offering rebates on equipment purchases, building retrofits, and new buildings has been practiced for decades under utility energy efficiency programs for both residential and commercial customers. These incentives, in addition to providing investment funds, can be used to influence behavior. In addition, a few utilities have tried incentives directly tied to overall achieved reductions in electricity or natural gas use, directly incentivizing behavior change.

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[50] Bonneville Power Administration. 2010. Residential Sector Research Findings for Behavior Based Energy Efficiency. At http://www.bpa.gov/energy/n/pdf/Behavior_Change_Report_Dec_2010_July_5.pdf

[51] Bonneville Power Administration. 2010. Residential Sector Research Findings for Behavior Based Energy Efficiency. At http://www.bpa.gov/energy/n/pdf/Behavior_Change_Report_Dec_2010_July_5.pdf

Small tax incentives (such as sales tax holidays for Energy Star products) also have been used to try to influence purchasing decisions beyond any actual financial impact.

Barriers

Many reasons have been identified why people and organizations do not implement energy efficiency that is in their economic interest. Economists particularly identify informational barriers that prevent people from knowing how to save energy or how much they will save. Behavioral economists point to psychological tendencies, especially with limited time and attention to devote to efficiency; eg people tend to revert to the status quo or to the norm or risk avoidance rather than make a different but more efficient.choice. Even when they are paying attention, as when they have an energy audit, people may only take measures with a very short payback (eg less than 3 years, or better than 30% return) due to other priorities for investments and perceived risk.
Traditional policies have limited influence on behavior. While standards may limit inefficient choices, it is rare to mandate action to improve efficiency. Incentives may need to be large enough to get attention and make payback periods short—thus a federal incentive for home improvements seemed to get a much greater response when it was temporarily raised from a 10% to 30% credit.

Behavior based programs have their own barriers. including concerns regarding (1) the lack of sufficient research on the effectiveness and persistence of behavior change strategies in terms of energy savings, (2) the impact of established measurement and evaluation methodologies that undercount the contribution of behavior change to energy savings, and (3) current rigid regulations that inhibit experimentation and innovation.[52]

Policy makers and regulators are expected to invest funds in new power generation capacity or in energy conservation programs to ensure future supplies and demands are appropriately balanced. Because the energy savings from behavior change programs have a relatively short track record and are more difficult to measure reliably, policy makers and regulators perceive a higher level of risk associated with pursuing such strategies. Consequently, greater reliance is placed on traditional, measured, and cost-effective programs.

Opportunities

<u>How large is the opportunity</u>?
BBEE can play a significant role in achieving energy reductions. One source estimates the potential savings for households (home and vehicle energy use) to be 22 percent, equal to 8.6 quadrillion Btu (quads) per year, or about 9 percent of the nation's annual consumption.[53] A number of studies have attempted to quantify behavioral effects, as summarized in the following table:

Program	**Energy savings**	**Evaluation method**

[52] Laitner et al. http://uc-ciee.org/downloads/Motivating_Policymakers_rev.pdf
[53] Laitner, Ehrhardt-Martinez, and McKinney. 2009. *Examining the Scale of the Behavior Energy Efficiency Continuum*. American Council for an Energy-Efficient Economy

Home Electricity Reports (OPower) – SMUD	1.9% (electricity) 1.4% excluding rebated measures	Participants compared to control group over 2 years
The Power Cost Monitor – A Treatment and Control Experiment – Wisconsin	1.5% (electricity) 3.8% savings by active users (41% of participants)	Participants compared to control group over 1.25 years
Real-Time Monitoring Pilot – Hydro One	6.5% (electricity)	Participants compared to control group over 2.5 years
The Energy Detective Pilot – Florida Solar Energy Center	7%	Measured energy use, controlling for weather, comparison with control group
Energy Saver – Citizens Utility Board (Illinois)	8% net savings per participant 6.6% compared to control group	Normalized pre and post usage, control group with similar characteristics
Energy Monitoring Pilot – Cape Light Compact/Grounded Power	9.3% average reduction	Participants compared to a control group

Sources: 2010 ACEEE Summer Study papers; Farnsworth, Gwen. *Can I Get Credit for That?* (ESource); Mendyk et al., *How Households Interact with In-Home Feedback Devices* (Energy Center of Wisconsin)

This sampling shows that different program designs and different populations will produce different results, but that the potential exists to achieve 5 to 10 percent reductions.

Enabling Technology

The only information most Americans receive about their electricity usage is a single monthly total—in fine print and expressed in “kWh”—and perhaps more importantly a cost based on that total. Advanced meters as part of a smart grid can collect usage over minutes or seconds rather than weeks, and do so in near real-time (in addition to allowing remote meter reading and other grid efficiencies).They enable other technologies that can affect electricity use (singly or in combination):

- Time-based pricing of electricity that better matches price signals received by consumers with the enormous variation in costs that utilities have to pay.
- Real-time consumer information on their energy usage and energy prices, through in-home displays and web and mobile applications.
- Direct control of loads through programmable communicating thermostats, smart appliances, dimmable addressable lighting, and other technologies. The control can be by the utility or by a third party that aggregates demand response and/or provides energy management services.

Advanced meters combined with time-based pricing can reduce both peak demand and total energy consumption. A 2009 study of 15 utility pilots found that time-based pricing of electricity reduced peak demand between 3 percent and 20 percent. Use of smart thermostats, in-home energy displays and load control systems increased the peak demandreductions to between 27 and 44 percent. Just consumer information about energy use can reduce total consumption by 5-15 percent.[54]

Effective Communications

Changing attitudes is important, but is insufficient. Research indicates that there is no direct link between values and action. For example, in one study, people who attended energy efficiency workshops reported knowing and caring more about energy conservation, but only 1 of the 40 participants changed behavior. Methods of communication that change both attitudes *and* behavior are necessary.[55]

Changing behavior involves using a number of different strategies. These include: associating message delivery with things that people like, providing a token of gratefulness, conveying the notion of scarcity, making something negotiable in a way that encourages adoption, encouraging pledges and commitments, providing prompts and reminders, offering feedback (e.g., progress toward goal), or using role models. These are all known to be effective strategies in campaigns for change.

Building Energy Management, Benchmarking and Disclosure

Today major appliances and cars are labeled for their efficiency, but someone buying a home or leasing office space usually has no way to know what kind of energy bills to expect. In a multi-tenant building, it may be impossible for tenants even to know how much energy they are using as often there is no submetering. In most states there are efficiency requirements for new building components and systems in codes, but no expectations regarding the management of energy use once the building is occupied. Yet homes use more energy than cars, and operations are as important to efficiency as assets.

Large commercial buildings are much more complex than homes. Over time performance of building systems may degrade, equipment may be replaced, occupant space and uses may change, and new staff may not be fully trained on building systems. For these reasons, periodic recommissioning is needed to "tune-up" a building to restore or enhance performance (and retrocommissioning is needed for buildings that that were not commissioned when new). New technologies for monitoring, modeling and controlling building systems are starting to allow there to be "ongoing" commissioning, in which skilled building operators can optimize performance on a continuous basis.

While estimating and controlling building energy use can be complicated, a new norm is needed that makes effective energy management a part of expected building management. The Federal government took a step in this direction, requiring designation of energy managers for large Federal facilities, benchmarking with disclosure of the buildings' energy use, and recommissioning to be evaluated as part of periodic energy audits. New York City requires large commercial buildings to benchmark and disclose energy use and eventually to submeter. Unless

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[54] Federal Communications Commission, National Broadband Plan, Chapter 12, http://www.broadband.gov/plan/12-energy-and-the-environment/.

[55] James, R. 2010. *Promoting Sustainable Behavior, A guide for successful communication*. University of California Berkeley Office of Sustainability

they demonstrate high efficiency, they are also required to conduct energy audits and retrocommissioning. New York City also has financing, green leasing and professional training programs coordinated with these measures.

Case Studies

- In 2010-11 Commonwealth Edison's Customer Application Program conducted a controlled test of home energy displays and pricing systems in Illinois. 8,000 customers were randomly selected from the 130,000 customers with advanced meters, and were randomly assigned to 27 different treatment groups (if they did not opt out). Over one year they tested 46 hypotheses using four different variable pricing approaches, two different in-home displays, a web-based information system, and a controllable thermostat. They found a small reduction in peak load in response to event notifications, and a larger response by customers with dynamic pricing; the largest response was by customers with critical peak pricing (very high rates at times of peak load), of whom 11.6% of participants reduced load by an average of 21.8% (ie 2.2% total load reduction) . They did not find statistically significant impacts from either basic or advanced in-home displays, but a low percentage of customers accepted such displays, so any impact may not have been seen.[56] Commonwealth Edison plans to install more than four million smart meters due to savings in utility operations even though customer energy savings are unclear.[57]

- A leading example of voluntary sharing of building energy performance data is the Greenprint Foundation and its Greenprint Performance Report, the 2010 volume of which had collective results for 1,623 properties in the Americas, Europe, and Asia, and covered 334 million square feet of commercial space. Building owners need reliable information about technology performance to guide their investment decisions. Building owners who create and manage information about performance in their own buildings need ways of comparing that performance with other building owners. But competitive and proprietary considerations create a constraint on information available to pro-active building owners seeking to assess their building energy performance. According to the Urban Land Institute, the Greenprint report is "one of the real estate industry's largest, most verifiable, transparent, and comprehensive energy benchmarking tools. It is unique in that it provides an open standard for measuring, benchmarking, and tracking energy use and resulting emissions on a building or portfolio basis."[58]

- DOE's Asset Rating Tool is is an effort to complement assessments of building performance "in use" such as Greenprint and EnergyStar Portfolio Manager. An asset rating system evaluates the physical characteristics of the building "as built" and assesses a building's

[56] The Effect on Electricity Consumption of the Commonwealth Edison Customer Applications Program: Phase 2 Final Analysis. EPRI, Palo Alto, CA: 2011. 1023644.
[57] Julie Wernau, "For many, ComEd's smart grid needs an explanation," Chicago Tribune April 23, 2012, http://articles.chicagotribune.com/2012-04-23/business/ct-biz-0424-smartgrid-confusion--20120423_1_smart-grid-smart-meters-comed.
[58] Information is available at: http://urbanland.uli.org/Articles/2012/Jan/RiggsGreenprint

energy efficiency independent of its occupancy and operational choices. By isolating the buildings technology from its operation, an asset rating system can provide detailed information that can enable building owners to identify and evaluate energy investments. According to PNNL, which is leading the tool project for DOE, "the purpose of an asset rating is to break out the infrastructure piece so that the system efficiency and the operation outcome can be considered separately. Separately evaluating the physical assets of the building eliminates the wide variation due to differences in operation, weather, plug loads, and occupancy, allowing buildings to be compared on an equal footing and providing the means for an owner to determine if the building is performing well because it is a highly efficient building or because it is well managed." [59]

Policy Instruments & Conclusions

Information is a critical component of efforts to improve outcomes through behavior. This critical role takes several forms, including: (1) improving decision-making by increasing information about energy efficiency, such as the promotion of common standards and measures, (2) conveying this information in ways that facilitate optimal decisions, such as the promotion of measures that internalize social costs and life-cycle costs and benefits, and (3) improving the performance of the market for energy efficiency by using information to get the prices right. All of these information strategies seek to support behavior by overcoming distortions and asymmetries that create market failures.

Effectively capturing the untapped potential benefits of behavior-based energy efficiency programs will require policy-makers to take the follow steps:

- Data access, data transfer and privacy rules must be clarified, especially as they pertain to smart meter data collection and direct third-party access to the data;
- Training in, and access to the latest results of behavior-based energy efficiency research and pilot programs is critical for localities to start adopting behavior programs;
- Funding for larger and longer-duration studies and utility pilots is needed across the country; and
- Appropriate measurement and verification protocols, such as the use of experimental design, must be adopted for behavioral measures.

A number of state and local governments also are adopting policies around commercial (and sometimes residential) building energy use benchmarking and disclosure, building energy management, and periodic or ongoing commissioning. To maximize the impact several policy actions are necessary:

- Uniform benchmarking and disclosure requirements, and attention to how to convey the data based on behavioral research, to make the data more accessible and friendly to users;
- Accepted standards and certifications for commissioning to ensure quality and a common understanding of the scope;

[59] Information available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21310.pdf

- Better data on energy use of different types of buildings in different climate zones for comparison (the last Commercial Buildings Energy Consumption Survey data is from 2003);
- Sub-metering of tenant-controlled energy use to allow monitoring, management, and financial impacts; and
- Utility data access (with privacy protections) to allow benchmarking of multi-tenant buildings.

Additional detail on data access issues and measurement and verification matters is given below.

Data Access

The collection of detailed energy use information, and the provision of that information to third party vendors and utility customers as a part of energy feedback programs, raises different regulatory and legal questions that state legislatures and utility commissions must address. While many general laws protect consumer privacy and data sharing, the increased frequency and resolution of smart meter data collection has raised new privacy concerns.

In a 2010 report, the DOE notes that the success of smart grid technologies to encourage energy savings will first require "the development of legal and regulatory regimes that respect consumer privacy, promote consumer access and choice regarding third-party use of their energy data, and secure potentially sensitive data to increase consumer acceptance of Smart Grid" (DOE, 2010). State utility commissions are the traditional regulatory body overseeing data sharing and privacy in this context.

A number of state utility commissions have open proceedings on customer energy data access and privacy issues, the effect of customer access to energy use on behavior and energy consumption, and the costs and benefits of such programs within the regulatory process. Examples include Arizona, California, Colorado, Minnesota, New York, North Carolina, Ohio, and Pennsylvania. In addition, a number of utilities have committed to providing customers data under the Green Button, a White House initiative.

Consistent Measurement and Verification Methodology for Behavioral Programs

To address the uncertainty that persists on the validity and magnitude of behavior change impacts, rigorous program evaluation methods are required. Two classes of validity need to be addressed: (1) internal validity - the validity of a behavior program for a given population of program participants over a given time frame; and (2) external validity - whether estimated program savings for a given population over a specific time can be applied to new situations (a different population at the same time, the current population participating in future years, or new populations in future years).

Governance – Federal, State, City

Introduction

Federal, state, and local governments play a variety of roles in the building sector energy efficiency landscape through legislating, regulating, incentivizing, leading by example, offering tools and training and goal setting.

The country began to show serious interest in the energy footprint of buildings starting with the "Energy Crisis" of the 1970s. States began to design and incorporate energy efficiency as part of their existing health and safety building codes. ASHRAE issued model building energy codes (Standard 90 -75) in 1975, but it wasn't until 1992 that Congress required the DOE to be actively involved in the development of energy codes. The Federal government has never served as the originating body for building energy codes, rather it functioned more as an advisor to standards setting bodies and state and local energy officials. The states have primacy for codifying building energy code requirements into law, and local governments generally handle implementation and enforcement. Building energy codes are arguably the cornerstone of policies intended to conserve building energy use, so having Federal, state and local involvement is essential.

For household appliances, California was the first state to promulgate a set of appliance efficiency standards in 1976. After initial legislation in 1975, the first national standards followed in 1987 for a range of home appliances. The National Appliance Energy Conservation Act superseded state appliance standards, bringing uniformity across the states, for those appliances that were covered by this legislation. In many instances, when California adopts a standard for a new product, other states follow, and then manufacturers and efficiency advocates negotiate a consensus federal standard.

The federal government also launched efficiency tax incentives and research programs in the 1970s. As the incentives expired and funding was slashed in the 1980s, some states began requiring utilities to run incentive and education programs. The rapid rise of ratepayer-funded programs, run by utilities or by state agencies, was halted by electric restructuring in the 1990s but has resumed with new policies over the last several years. Other state and local government programs were boosted by the 2009 Recovery Act.

A great deal of government action has taken place since the initial energy codes and appliance standards were developed in the 1970s. States and local governments continue to develop new policies on building codes, utility programs, and increasingly energy use benchmarking and disclosure. The Federal government, through the DOE, EPA and other agencies, exercises considerable influence over energy efficiency policy, through making its own buildings more efficient, setting appliance and other standards, public-private partnerships, targeted financial assistance measures, and research and development support and data collection.

Overview

Government works to improve the energy efficiency of buildings from many perspectives. The different levels of government each have strengths and weaknesses when it comes to legislative and regulatory action concerning energy efficiency. The Federal government has the benefit of scale, and as a result can put incentives in place that address entire national markets. It also can set uniform national standards, creating a compliance environment that doesn't vary state to state. The technical assistance and R&D support offered by the Federal government can make delivery of services and funding more efficient. Some of the Federal government benefits are also drawbacks, since tailoring policies to local and regional conditions isn't generally possible, and a one-size-fits-all approach can lead to unnecessary or burdensome regulations.

State and local governments provide policies tailored to their constituents and geographical differences. States and localities know their constituencies and can design programs that meet their unique state and local energy needs. This aspect is particularly evident in building energy codes, which are promulgated mostly at the state level. Certain technologies that are well suited to a specific area can also be incentivized at the state level. State and local governments are often on the front lines of providing the on the ground delivery of information, technical assistance and financial incentives. States and local governments also partner with Federal to administer State energy and weatherization assistance programs.

<u>Government as an energy consumer</u>

The Federal government is the largest consumer of energy in the United States. Based on reports by 30 agencies submitted to the DOE, it consumed 1.6 quads of primary energy in fiscal year (FY) 2007[60], which is equivalent to 1.5% of the total national energy consumption. Buildings accounted for 392.1 trillion Btus (0.392 quads), 56 percent of which was attributed to the DoD. As the largest energy consumer, the Federal government can have a discernible impact on national energy use.

Federal energy management activities are required under several pieces of energy legislation and executive orders:

- Energy management requirements of Title V of the National Energy Conservation Policy Act (NECPA), as amended, including overall energy reduction, energy audit, and procurement requirements
- Efficiency and fossil fuel reduction standards for new federal buildings in Sec. 305 of the Energy Conservation and Production Act, as amended
- The energy savings performance contract authority of Title VIII of NECPA, and separate authority for utility energy service contracts
- The renewable energy purchase goal of section 203 of the Energy Policy Act of 2005 (EPACT 2005)
- The energy management training requirements of section 157 of the Energy Policy Act of 1992 (EPACT 1992)
- Executive Order (EO) 13423 of January 24, 2007 (Strengthening Federal Environmental, Energy, and Transportation Management)
- The energy management requirements of the Energy Security and Independence Act of 2007
- EO 13514 of October 5, 2009 (Federal Leadership in Environmental, Energy, and Economic Performance). It expanded upon the energy reduction and environmental performance requirements of EO 13423.

[60] US Department of Energy. 2010. Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 2007.

The impacts of actions taken by Federal agencies in accordance with these requirements are evident in the energy use data from the last several decades. Recently released data for the period from 1975 to 2007 show some notable trends[61]:

- Overall, the Federal Government had reduced its energy use by 31 percent since 1975, with 35 percent less energy used in the facility sector
- Electricity use in Government facilities has increased by 36 percent since 1975 despite the overall drop in facility energy use, indicating the increased role of technology in use in the workplace and the associated plug-load required.

Further progress is expected as initiatives are implemented to achieve energy use and greenhouse gas reduction goals. For example, in December 2011, the President directed federal agencies to enter into at least $2 billion in performance-based contracts over the next two years to achieve substantial energy savings and to create jobs. In response to the directive, the GSA launched this year its Deep Retrofit Challenge, in which ESCOs will compete to significantly reduce energy use in 30 of its buildings (17 million square feet).[62]

States and municipalities have taken similar actions to reduce energy use in government buildings, demonstrating their commitment and leadership. For example, more than half of the states now integrate one or more green building rating systems into state building policies, with the majority emerging just in the past four years.[63] Similarly, there is wide adoption at the state and local level of Energy Star Portfolio Manager to track energy consumption and progress being made toward reduction goals.[64] In California, the state's Green Building Action Plan aims to reduce grid-based energy use by 20 percent of 2003 levels by 2015 at major state-owned facilities. In New York, through a series of Executive Orders under both Republican and Democratic administrations, the state improved the energy efficiency of state buildings and operations, resulting in significant cost savings to the State.

Government as a regulator

Government regulations applicable to building energy efficiency are found primarily in building energy codes and appliance efficiency standards. State building energy codes are typically based on a model code, such as the International Energy Conservation Code (IECC) and ASHRAE standards. A state will enact legislation or issue regulations to adopt a particular version of a code (e.g., the 2009 IECC), and modify and supplement it to suit the state's needs. These state codes are then administered by local jurisdiction, which is responsible for code inspections and enforcement.

This system has resulted in codes largely free of federal government involvement, adapted to regional needs, and suitable for local enforcement at an individual building level. At the same

[61] Temper, C. 2011. *Historical Federal Government Energy Use Data Available*. http://www.data.gov/communities/node/48/blogs/5548

[62] US General Services Administration. 2012. GSA Offers 30 Federal Buildings for Deep Energy Retrofits. http://www.gsa.gov/portal/content/129983

[63] http://www.dsireusa.org/solar/solarpolicyguide/?id=20 (accessed 7/23/12)

[64] http://www.energystar.gov/ia/business/government/State_Local_Govts_Leveraging_ES.pdf (accessed 7/23/12)

time, the effectiveness of model codes is compromised by a patchwork of state and local adoption, and low (or more often unknown) rates of compliance. There has been rapid improvement in the model codes, and somewhat greater adoption by the states, in the last few years.

The National Appliance Energy Conservation Act of 1987 established minimum efficiency standards for many household appliances, including refrigerators and freezers, central and room air conditioners, furnaces, clothes washers, dishwashers, and water heaters. Congress set initial federal energy efficiency standards based on agreements negotiated between manufacturers and efficiency advocates, and established schedules for the DOE to review these standards. Standards for a number of commercial, lighting and plumbing products were added in the Energy Policy Act of 1992 (EPAct), including some fluorescent and incandescent reflector lamps, electric motors, commercial water heaters; and commercial heating, ventilation, and air conditioning (HVAC) systems. Additional products were added in 1988, 2005 and 2007.[65]

Although states are prohibited from developing their own standards for appliances regulated at the Federal level, they can set efficiency standards for other products that are not covered by Federal law. Fourteen states have passed legislation setting efficiency standards for a variety of residential and commercial products beyond those already covered at the Federal level.[66]

Appliance standards have been remarkably successful. Refrigerators now use about 30% of the energy they did in the 1970s, and are expected to use about 25 percent less energy when the new standard takes effect in 2014. These energy savings are realized for refrigerators that are larger, have new features, and cost less. Overall existing standards are projected to save consumers more than $1.1 trillion in net savings through 2035. New standards could save an additional net $170 billion.[67] But for some appliances, manufacturers raise the point that after multiple rounds of standards there are diminishing returns to squeezing more savings from the same products.

Government as a Provider and Regulator of Information

Governments also play a key role in ensuring consumers have reliable and accessible information on energy efficiency and energy use to facilitate market adoption of energy efficiency. The EPA and DOE Energy Star program has been especially successful, with high consumer familiarity with its voluntary "premium" label for efficient products, typically aiming for the most efficient 25 percent of products in 60 categories. Energy Star estimates that in 2011 it helped consumers save $23 billion in utility bills and reduced greenhouse gas emissions equivalent to taking 41 million vehicles off the road.[68] The Federal Trade Commission oversees a mandatory comparative efficiency label (EnergyGuide) for many of the same products. They have been slowly expanding to cover some electronics. But while some studies show that categorical labels (such as letter grades or star ratings) used in Europe and by a number of other

[65] http://www.appliance-standards.org/products
[66] http://www.eia.gov/todayinenergy/detail.cfm?id=5670 (retrieved 7/23/12)
[67] A. Lowenberger et al. *The Efficiency Boom: Cashing In on Savings from Appliance Standards*, American Council for an Energy-Efficient Economy and Appliance Standard Awareness Project, 2012.
[68] ENERGY STAR® Overview of 2011 Achievements

countries are more effective, FTC has not implemented such a system due to concerns for potential confusion with Energy Star.[69]

There is no comparable consumer knowledge of the efficiency of buildings. There are two non-governmental labels with significant penetration for new buildings: the comparative Home Energy Rating System (HERS) is increasingly used by large production builders, and the broader LEED premium ratings for green commercial buildings are often required by governments and large private owners. Energy Star also has a comparative benchmarking system (Portfolio Manager) for energy use of existing commercial buildings and a premium designation for the top 25 percent of those buildings. And DOE is devising a voluntary Home Energy Score for existing homes. Each of these has a different scope, rating scale or threshold, and methodology.

A number of jurisdictions in the U.S. have deployed new mandates on commercial building owners to benchmark and in many cases also disclose the energy performance of their buildings using EPA Portfolio Manager. Cities such as New York, Washington DC, and Philadelphia are requiring owners to benchmark the energy intensity of buildings larger than 50,000 square feet and disclose these ratings through city government web sites. Seattle and San Francisco require benchmarking for commercial buildings larger than 10,000 sf. Seattle and Philadelphia require disclosure of the ratings to parties in leases, sales, and financing.[70]

A few jurisdictions in the US have deployed new mandates on the disclosure of residential energy performance. Examples include the City of Austin TX, the County of Montgomery MD, and the State of Kansas. In Austin, the sale of a home triggers a municipal ordinance passed in 2008 that requires an approved energy audit disclosed to potential buyers. In Montgomery County, a sale triggers the disclosure of utility bills to the potential buyer. In Kansas, a 2007 law requires the disclosure of an efficiency checklist to the potential buyer of a newly constructed home.[71]

Government as a facilitator

The Federal government has a number of initiatives designed to promote energy efficiency measures in the residential and commercial building sectors.

In February 2011, President Obama announced the Better Buildings Initiative to make commercial and industrial buildings 20 percent more energy efficient by 2020 and accelerate private sector investment in energy efficiency. The Better Buildings Initiative takes a combination of approaches to work toward this goal, which are intended to stimulate the market, improve appraisal practices, and update tax rules to increase retrofit activity.

A Federal Energy-Regional Innovation Cluster competition culminated in an award in early 2011 to The Pennsylvania State University to lead a consortium of industry and higher education

[69] Federal Register, Vol. 72, No. 167, Aug. 29, 2007

[70] For more information see http://www.imt.org/resources/detail/building-energy-transparency-a-framework-for-implementing...energy-rating-d

[71] For more information see http://www.imt.org/resources/detail/comparison-of-u.s.-residential-energy-disclosure-policies

representatives in transforming the energy efficiency market. Known as the Energy Efficient Buildings (EEB) Hub, this five-year collaboration, beginning in 2011, focuses on the buildings of Philadelphia and the surrounding region in Pennsylvania and New Jersey. Its energy efficiency goal is to reduce energy use in the U.S. commercial buildings sector by 20 percent by 2020. To reach this goal, the EEB Hub is concentrating on accelerating the adoption of advanced energy retrofits of average size commercial buildings

Government as an Energy Efficiency funder of energy efficiency research and development
Governments at the Federal and state levels offer funding on numerous fronts to stimulate adoption of energy efficiency technologies, tools, and practices for buildings. Both are engaged in supporting research, development and demonstration efforts to improve upon existing technologies and introduce innovative solutions into the market.

As discussed above, the primary funding for incentives for energy efficiency measures is from ratepayer-funded programs at the state or utility level. However, the federal government does provide tax incentives for a variety of energy –efficient building purchases. Current and recent tax incentives include:

- Energy Efficient Commercial Buildings Tax Deduction, for new buildings and improvements (Internal Revenue Code Section179D – sunsets in 2013)
- Business Energy Investment Tax Credit (ITC) – CHP, ground-source heat pumps, fuel cells, solar, small wind, microturbines,– (Internal Revenue Code Section 48 - sunsets in 2016)
- Residential Energy Efficient Property – ground-source heat pumps, fuel cells, solar, and small wind (Internal Revenue Code Section 25D – sunsets in 2016)
- Tax credit for home improvements, including windows, insulation, furnaces, air conditioners, and water heaters (Internal Revenue Code Section 25C - expired)
- New Energy Efficient Home Credit for builders (Internal Revenue Code Section 45L - expired)
- Credit for Energy Efficient Appliances for manufacturers (Internal Revenue Code Section 45M – expired)

These incentives have helped spur markets for efficient buildings and products, notably for new homes and appliances.

The federal government also funds limited assistance programs with appropriated funds, primarily through states. The State Energy Program helps state governments implement clean energy programs. The Weatherization Assistance Program helps community action agencies weatherize low-income homes. These programs, and the new Energy Efficiency and Conservation Block Grant program for local governments, received billions of dollars in the 2009 American Recovery and Reinvestment Act, but are now shrinking back to a fraction of that size.

Barriers : Need to move energy efficiency up in the value chain

Government has played a central role in fostering energy efficiency in buildings in the United States, as have governments elsewhere in the world. Yet there remain some impediments to pushing forward more rapidly, and there are actions that only the government can take (e.g., tax code changes) to address certain barriers in the marketplace.

Organizational barriers

Government agencies fall prey to the same forces that prevent private companies from making investments in energy efficiency. For example, bureaucracies sometimes resist action that is not standard practice or exposes an agency to risk, resulting in conservative decisions in the area of energy efficiency. In addition, for new buildings or renovations of government facilities, the bidding process for public projects is slanted toward choosing the lowest first cost option over options that might provide lower life-cycle costs. Yet another issue is that savings that are achieved flow back to the Treasury Department rather than benefit the agency. Internal policies have been implemented to combat some of these problems, particularly at the Federal level.

Ideological opposition to government action

Another barrier related to government policy is the ideological opposition to government action, even if it benefits consumers. A prime example is the debate over the imposition of light bulb efficiency standards starting in 2012, which traditional (inefficient) incandescent light bulbs do not meet. At the end of 2011, a congressional effort to repeal "the Democratic ban on the 100 Watt incandescent light bulb" culminated in a policy rider in a continuing funding resolution for FY 2012 that did not repeal the requirement but prohibited spending to administer it. Issues like this have negatively impacted the public view of new energy efficiency legislation.

Inconsistency of policies and programs at federal, state and utility levels

The United States currently lacks comprehensive policy strategy for energy efficiency. A strategic approach to improving energy efficiency in the United States would coordinate efforts across jurisdictions and sectors. Much of energy efficiency policy is set at a state or local level, but such policies may not effectively influence markets for most products, which are national or international.

Opportunities

Federal, state, and local governments

Government agencies can lead the market by being first adopters of technologies and practices for energy conservation. This is a win-win proposition: government reduces its energy consumption, saves taxpayer money and helps the market grow by reducing perceived risk.

Data collection, building rating, and disclosure

An area that continues to grow through government support is the establishment of data collection standards, benchmarking and rating programs, and energy disclosure requirements. In terms of mandatory requirements, this activity occurs primarily at the state and city levels of government. If implemented effectively, these new policies positively impact economic growth and energy savings by stimulating market demand for energy efficiency and encouraging building owners to make energy improvements. Disclosure of a building's good energy performance should improve the property value in the real estate market, while below average results could subtract from value.

Standards and codes

For commercial codes, the status of individual states varies from "no statewide code, or precedes ASHRAE 90.1-2004" (13 states, though two have adopted a new code that will be effective at a later date) to "meets or exceeds ASHRAE 90.1-2010 or equivalent" (1 state). The residential code status has a similar distribution.[72] If states adopted new code versions more quickly, greater energy savings would occur. The DOE, in its capacity as a technical advisor to the states, recommends that codes and standards be modified only under very specific, limited circumstances to avoid unintended consequences, confusion, and errors.[73] Al l states are required to adopt a commercial energy code, and "consider" a residential code, within two years after DOE determines that an update to the national model code saves energy, but there generally is no consequence for failure to do so. A stronger push for universal adoption and enforcement of model code improvements could have a large impact.

Funding for R&D

Federal government R&D funding for energy efficiency has lagged R&D funding for other forms of energy. Since DOE inception in 1978, energy efficiency received 15 percent of the funding, 17 percent went to renewable energy, 25 percent went to fossil and 37 percent went to nuclear. For 1945 to 2012, only 10% of funding was dedicated to energy efficiency.[74] A shift in this balance of funding could help accelerate deployment of energy efficiency technologies.

Case studies

- In 2011 the American Council for an Energy-Efficient Economy (ACEEE) ranked Massachusetts the #1 state in the nation in its energy efficiency scorecard. [75] Massachusetts' success in becoming energy efficient is the result of a multi-pronged regulatory approach that focuses on strategic reductions of the state's electrical load and natural gas requirements within the built environment.

  Massachusetts has one of the nation's most progressive building codes. In 2009, the state adopted the 2009 International Energy Conservation Code (IECC) and a more stringent "stretch code" that communities may adopt. It also created a Zero Net Energy Building Taskforce within its Department of Energy and Resources (DOER).[76] In coordination with the Massachusetts Energy Efficiency Advisory Council (EEAC), Massachusetts has been able to integrate its building code standards with a robust measurement and verification regime, yielding accurate and reliable streams of data for regulators to

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[72] http://energycodesocean.org/code-status
[73] http://www.energycodes.gov/amend-or-not-amend-model-energy-codes-and-standards
[74] Sissine, F. 2012. Renewable Energy R&D Funding History: A Comparison with Funding for Nuclear Energy, Fossil Energy, and Energy Efficiency R&D. Congressional Research Service. http://www.fas.org/sgp/crs/misc /RS22858.pdf
[75] ACEEE, 2011 State Energy Efficiency Scorecard.
[76] 780 CMR 115.00

consider.[77]

Massachusetts electric and natural gas utilities budgeted $376 million dollars for energy efficiency investments in 2011, with 6 state-based and 36 utility-sponsored rebate programs.[78] As of 2011 Massachusetts was one of only five states in the nation with a decoupling and performance incentive policy for both electric and natural gas utilities, which has enabled the use of an aggressive energy efficiency resource standard (EERS).[79] Beginning with the passage of the groundbreaking Green Communities Act of 2008,[80] the Massachusetts legislature developed a three-year, $2.1 billion EERS with an annual energy reduction target of 2.4 percent.[81] Running from 2010-2012, Massachusetts' current EERS has created an estimated incremental electrical savings of 840,000 MWh per year.[82] For its 2013-2015 EERS, Massachusetts is aiming for a three-year reduction total of 3,574,423 MWh.[83] In addition to electrical reductions, Massachusetts' EERS also created a statewide natural gas reduction requirement of 1.5 percent per year,[84] with a targeted reduction total of approximately 51 million therms between 2010 and 2012.[85] Based on 2010 data, EEAC estimates that Massachusetts' EERS saved enough energy to power 85,000 households and heat 14,000 households with natural gas.[86]

- Austin, Texas has long been a leader in building energy efficiency policies. The municipal utility, Austin Energy, runs what they say is the nation's oldest green building program (since 1990), along with a comprehensive set of rebate programs for retrofits in residential, multifamily and commercial buildings and free low-income weatherization. These programs have saved more total energy than the annual output of a 500 MW power plant.

  Austin Energy has also helped with innovative policies. In 2007 the City Council, as part of the Austin Climate Protection Plan, adopted the goal that the code by 2015 would require all new homes to be zero energy capable (use 65% less energy than new homes at that time) and require new commercial buildings to be 75% more efficient.

  Austin's Energy Conservation Audit and Disclosure ordinance was passed in 2008 and amended in 2011. Single family homes at least 10 years old are required to have an energy audit prior to sale, with results disclosed to the buyer. Multi-family buildings must

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[77] *See* ACEEE, 2011 State Energy Efficiency Scorecard.
[78] *See generally* http://www.dsireusa.org/incentives.
[79] ACEEE, 2011 State Energy Efficiency Scorecard.
[80] The Green Communities Act requires investor-owned utilities (IOUs) to achieve all available energy efficiency opportunities before purchasing additional power from nearby plants to accommodate growing demand. *See* http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/.
[81] D.P.U. Order 09- 116 through 09-120.
[82] Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan, April 30, 2012 Submission to EEAC.
[83] *Id.*
[84] D.P.U. Order 09-121 through 09-128.
[85] Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan, April 30, 2012 Submission to EEAC. Of note, Massachusetts' 2013-2015 EERS targets raise the statewide therm savings totals to over 70 million.
[86] Energy Efficiency as our First Fuel: Strategic Investments in Massachusetts' Energy Future, Prepared for the Massachusetts General Court,the Joint Committee on Telecommunications, Utilities and Energy, and the Department of Public Utilities, June 2011.

be audited by the time they are 10 years old, with results posted and provided to current and prospective tenants—and if the building uses at least 50% more energy than average, energy use must be reduced by at least 20%. Commercial buildings are required to benchmark their energy use annually (once phased in) using Energy Star Portfolio Manager, and report it to Austin Energy and to buyers.[87],[88],[89]

Policy Instruments and Conclusions

In order to reap the enormous potential of building efficiency, it is important that government at all levels, along with the private sector, work in concert. Support for R&D is necessary to overcome barriers to private sector investment and ensure technologies are available for efficiency. Incentives and government purchases help spur commercialization and deployment of these energy efficiency technologies. Making energy efficiency information more accessible and providing financing enables typical consumers to use new technologies and bring them to scale. Motivation may also be needed to use the information, financing, and incentives. But the largest savings come from incorporating cost-effective technologies into universal appliance and buildings standards. All are necessary—a consumer with good information but no source of capital will not make an efficiency investment.

Some areas require greater cooperation. Building codes generally require national development, state adoption, and local enforcement—unless all three levels work well, buildings end up wasting energy. Consumers seeking efficiency information about buildings and equipment from different rating systems must negotiate scales ranging from 0 (bad) to 10 (good), to 0 (bad) to 100 (good), to less than zero (good) to over 100 (bad), to, for example $57 (good) to $74 (bad).[90] Some consistency from the developers might make all the scales more effective. Policies to incentivize or require audits or retrofits or commissioning can only work if appropriate training and certifications are available. But when policies do work in concert, they can help achieve sustained energy efficiency improvements and innovation.

Conclusion

The United States, since the Arab Oil Embargo in 1973 and the subsequent "Energy Crisis" of the 1970's, has significantly improved the way Americans use energy. The U.S. economy has tripled in size since 1970 and three-quarters of the new demand for energy comes from an amazing variety of advances in energy efficiency.[91] Americans, driven by increasing energy

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[87] R. Sobin and N. Steele, "Austin, Texas: Building Efficiency Policy," Alliance to Save Energy, http://ase.org/resources/austin-texas-building-efficiency-policy.
[88] C. Haines and E. Mackres,, "Austin Energy Conservation Audit and Disclosure (ECAD) Ordinance," ACEEE, http://aceee.org/sector/local-policy/case-studies/austin-energy-con.
[89] Austin Energy website, www.austinenergy.com.
[90] These scales are respectively for DOE's new Home Energy Score, Energy Star commercial building energy performance rating system, RESNET's Home Energy Rating System (HERS), and Energy Guide for refrigerators.
[91] Laitener et.al.,The Long Term Energy Efficiency Potential: What the Evidence Suggests, ACEEE, January 12,2012.

prices, federal state and local energy laws, rules and regulations as well as advances in technology have been able to meet the needs of a growing economy by tapping the potential for improving the way energy is used. Over the decades to come, using American ingenuity, enlightened government policies and working in partnership with utilities and the private sector; advances in energy efficiency can continue to play a primary role in creating and retaining jobs, improving energy security and reliability and helping to improve the environment. Energy efficiency is a resource without equal.