CHAPTER 8

END-USE ENERGY EFFICIENCY

Executive Summary

Energy efficiency can be viewed as an energy resource, since the need for supply-side energy resources can be displaced by the adoption of more efficient equipment at homes and businesses or through changes in energy consumption patterns or practices.

Avoiding the consumption of energy through energy efficiency measures provides a clean energy resource that is immediately available. There is abundant energy savings potential available at a low cost through energy efficiency measures in all economic sectors in Texas.

Some energy efficiency will arise naturally in response to high fuel prices and concerns about air pollution and climate change. Further energy efficiency can be realized through public education efforts, commitments to sustainable development and climate change mitigation by businesses and other organizations, more stringent building codes, accelerated research and deployment of new technologies, utility demand-side management programs, and equipment efficiency standards.

Introduction

Definitions vary, but energy efficiency tends to be associated with the concept of using less energy to perform the same task through technology-based measures. By using more efficient equipment, the same output may often be obtained with fewer energy inputs. Whether behavioral or operational changes may be regarded as a form of energy efficiency is sometimes debated.

While we shall adhere to the more common engineering definition of energy efficiency in this chapter, it may be noted that economists tend to define energy efficiency much differently — as the level of energy usage associated with performing a task at a minimum cost.[1] Under this definition, technologies that use more physical units of energy (e.g., British thermal units, barrels of oil equivalent, etc.) may nonetheless be regarded as energy efficient if they are less expensive. For example, the substitution of electrical microwave drying equipment for natural gas-fueled product drying equipment at a manufacturing facility might require greater energy inputs (either in terms of BTUs or cost), but — under the economists' definition — might nonetheless be regarded as an energy efficient process if it performed the drying function at a lower total cost, by speeding the drying process, improving the quality of the product, and/or reducing product defects.

Conservation, demand response, and demand-side management are related concepts. Energy conservation tends to refer to simply using less energy. Demand response refers to changes in the temporal pattern of energy use through pricing programs (e.g., real-time pricing, interruptible tariffs, and time-of-use pricing) and load control programs (e.g., direct control of air conditioning equipment or the installation of under-frequency relays on industrial facilities). Demand response programs do not necessarily lower the overall consumption of energy. When energy efficiency, conservation, and demand response initiatives are undertaken by electric or natural gas distribution or retail utilities, such programs are often referred to as demand-side management.

Unlike renewable energy, energy efficiency is not a source of energy supply. However, it may provide similar benefits or may be regarded as an alternative to greater supply. Both renewable energy and energy efficiency are seen as ways to address the economic, national security, and environmental challenges associated with meeting the growing world demand for energy resources. Further, the combination of the two can be combined into a robust and effective sustainable energy strategy due to their complementary temporal, economic, and geographic characteristics.[2] The relationship is close enough that the small-scale generation of energy supplies through renewable energy technologies on the customer side of the meter (e.g., photovoltaic systems and solar water heaters) qualifies as an energy efficiency measure under the rules of the Public Utility Commission of Texas (PUCT) and is promoted through utility energy efficiency programs.

In the aftermath of the oil price shocks of the 1970s, federal and state policies to promote energy efficiency were devised. National programs (e.g., the Weatherization Assistance Program) were launched by the U.S. Department of Energy (DOE) to reduce wasteful energy consumption in homes and other buildings. Corporate Average Fuel Economy (CAFE) standards were established for automobiles. National research laboratories turned their attention to resolving the nation's energy crisis. Utilities were required to establish demand-side management programs to promote the adoption of energy efficient technologies and practices. Through the integrated resource planning (IRP) rules adopted in many states, utilities were required to treat demand-side resources on the same basis as supply-side resources in their resource plans. Solicitations were conducted for the procurement of demand-side resources from energy services companies.

While interest in energy efficiency faded in the 1980s and early 1990s as a result of lower energy prices and confusion over which entities might be responsible for continuing demand-side management programs, as retail electricity markets have become more competitive, interest in energy efficiency has climbed to new heights. The prices of some traditional energy resources are now at record levels. The use and production of fossil fuel energy resources has been linked to climate change. America's imports of crude oil remain at high levels.

In July 2006, the DOE and Environmental Protection Agency (EPA) jointly released a National Action Plan for Energy Efficiency, with the goal of "creat[ing] a sustainable, aggressive national commitment to energy efficiency." The action plan embodies the notion of treating increased efficiency as an energy resource; indeed, the first recommendation in the plan is for the U.S. to "recognize energy efficiency as a high-priority energy resource."[3] A long list of recent federal and state policy initiatives have sought to promote energy efficiency.

Market imperfections are thought to be responsible for the failure of consumers to achieve an optimal level of energy efficiency. Such failures may include a lack of information about cost-effective energy efficiency opportunities and new technologies, and a divergence in interests among various parties to economic transactions. For example, the economic interests of homebuilders and future homeowners may not be well aligned. Builders may have an interest to focus on minimizing the cost of construction, and grant inadequate attention to the comfort and energy costs of future residents. Similarly, landlords may pay inadequate attention to tenants' utility bills. If appropriate regulatory mechanisms are not put in place, utilities have little financial interest to reduce their sales and revenues through energy efficiency programs. Consequently, policies and programs to promote energy efficiency tend to focus on financial subsidies to offset the higher initial cost of energy efficient equipment, regulatory reforms to ensure that interests are better aligned, educational campaigns, the transformation of markets for energy-intensive equipment, building construction codes, and equipment efficiency standards.

Energy efficiency efforts since the 1970s have had an effect. The U.S. economy has grown significantly more energy-efficient. A recent report from the American Council for an Energy-Efficient Economy (ACEEE) notes that, by the end of 2008, U.S. energy consumption (as measured per dollar of economic output) will have been slashed to half of what it was in 1970 (from 18,000 Btus to about 8,900 Btus[4]), although changes in the structure of the American economy accounts for some of this decline. A recent study has concluded that states with aggressive energy efficiency efforts have reduced their rate of growth in electricity demand by about 60 percent, relative to the growth that would have occurred absent such programs.[5] Another recent study found evidence that states with strong commitments to energy efficiency successfully reduced commercial and industrial electricity intensity, although gains in the residential sector were not apparent.[6] Efficiency gains in transportation have been impressive. The National Academy of Sciences and the U.S. Department of Transportation concluded that CAFE standards "clearly contributed to increased fuel economy of the nation's light-duty vehicle fleet," and that in their absence, gasoline use would have been "about 2.8 million barrels per day greater than it is" [in 2001].[7] A new index from the DOE suggests that energy intensity in the U.S. dropped by 10 percent from 1985 to 2004, with the greatest gains occurring in the industrial sector.[8] However, there is some evidence that these figures may overstate energy efficiency achievements.[9]

Over the past few decades, Texas has been developing the policies, rules, programs, and infrastructure to more effectively exploit the state's vast potential for additional energy efficiency. Statewide building construction energy codes have been adopted. Goals for peak demand reduction from energy efficiency programs administered by the state's investor-owned electric utilities have been established and achieved. Goals for energy efficiency have been established for political subdivisions (e.g., government facilities) in the areas of the state that are in "non-attainment" or "near-non-attainment" status relative to federal air quality standards. Research at our state's universities has resulted in significant advances in energy efficiency. New firms have been established to develop, manufacture, and market the latest lighting, window, and energy storage technologies. An infrastructure for rating the energy efficiency of new homes and for conducting energy audits has also been developed.

Despite our state's achievements, there remains a vast untapped potential for energy efficiency in Texas. This chapter characterizes the state's energy efficiency resource base, describes existing programs and policies, delineates some key issues, and suggests means of advancing the efficient use of energy in Texas, the nation's largest energy consumer.

Resource

The quantification of energy efficiency potential is typically performed by comparing the actual level of energy consumption to the level that would result if all consumers adopted more efficient technologies.[10] "Technical potential" represents the savings that are possible regardless of the cost of energy efficiency measures. This may be calculated on an instantaneous (assuming that all equipment is immediately replaced with more efficient equipment) or phase-in basis (assuming that equipment is replaced with the most efficient equipment readily available in the marketplace at the end of the useful life or "burnout" of the existing equipment). "Economic potential" refers to the share of the technical potential that can be achieved under reasonable economic payback periods. Estimates of economic potential are sensitive to assumptions made about consumer payback periods or discount rates. Conservation supply curves may be used to depict economic potential. Finally, the "market potential" provides an estimate of the energy efficiency savings that can reasonably be expected from utility programs and other types of voluntary programs and policies.

Eleven studies examined by researchers at the ACEEE suggest that very substantial technical, economic, and achievable energy efficiency potential remains available in the U.S.[11] Across all sectors, these studies show a median technical potential of 33 percent for electricity (i.e., electricity usage could be reduced by one-third) and 40 percent for natural gas. Median economic potentials for electricity and gas are 20 percent and 22 percent respectively. The median achievable potential is 24 percent for electricity (an average of 1.2% per year) and 9 percent for gas (an average of 0.5% per year).

The Western Governors Association Energy Efficiency Task Force concluded that it is feasible to reduce electricity use in the western U.S. by 20 percent from projected levels by 2030 through best practices and programs.[12] McKinsey Global Institute suggests that the global growth in energy demand could be cut in half over the next 15 years from energy efficiency projects with an internal rate of return of 10 percent or more.[13]

The American Solar Energy Society (ASES) has sought to estimate the size of the energy efficiency industry in the U.S. This is a challenging task, since it is difficult to assign the portion of housing costs, appliance costs, jobs, and business activities that are clearly devoted exclusively to promoting energy efficiency. By ASES' count, the energy efficiency industry was responsible for $932.6 billion in revenues and 3.5 million jobs in the U.S. in 2006. These numbers reflect a wide variety of business, non-profit, and government-related activities. The vast majority of revenue and jobs created were through private industries, predominantly manufacturing and recycling related businesses.[14]

Achievable energy efficiency potential might best be gauged by examining the accomplishments of aggressive programs and policies across the country, although differences in climate, building stock, industrial base, and energy prices must be taken into consideration when considering the savings that might be achievable in a particular region. The National Action Plan for Energy Efficiency reports that energy efficiency programs are realizing significant energy savings in California and parts of the northeast U.S. Savings "on the order of 1 percent of electricity and natural gas sales" are "helping to offset 20 to 50 percent of expected growth in energy demand in some areas."[15]

Where are these opportunities to reduce energy use without lowering our standard of living? Our homes and commercial buildings can be constructed with materials that reduce air infiltration. Higher efficiency motors, air conditioners, and appliances can be used. Industrial processes can be redesigned to reuse what would otherwise be waste heat. Greater attention could be paid to energy costs when considering operating and maintenance practices. Some examples of energy efficiency opportunities are listed in **Exhibit 8-1**.

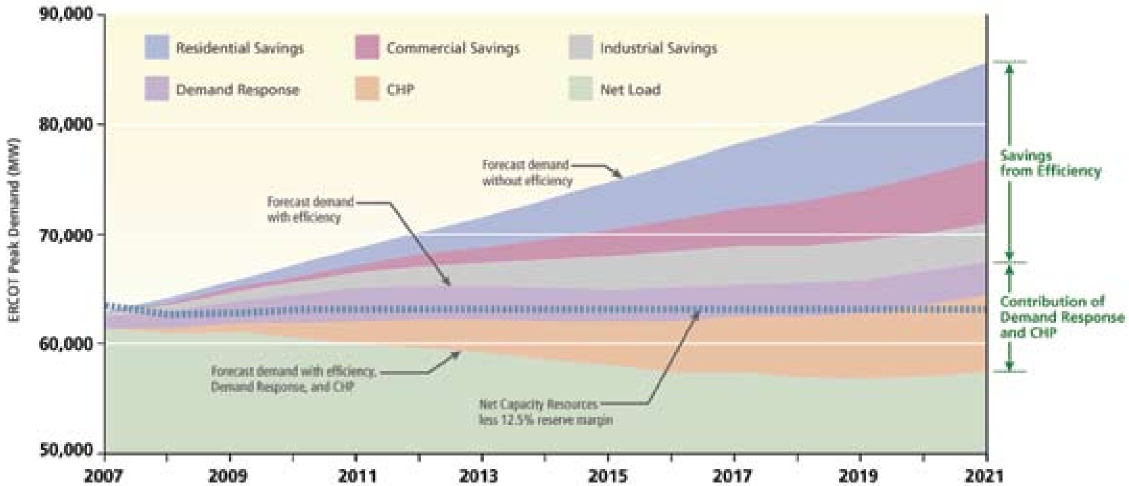
Two reports were sponsored by environmental groups in 2007 in an attempt to quantify the demand for energy that can be offset by implementation of advanced energy efficiency measures in Texas. The first, entitled *Power to Save: An Alternative Path to Meet Electric Needs in Texas*,[16] was prepared by Optimal Energy for the nonprofit groups National Resources Defense Council and Ceres. In this report, Optimal Energy reviewed the opportunities for implementing programs targeting residential and commercial customers with subsidies to participate in centralized demand reduction strategies, and posits that "ambitious energy efficiency actions can, over the next 15 years, eliminate over 80% of forecasted electric load growth at costs substantially cheaper than new electric supply." *Power to Save* also pointed to a vast (20,000 MW) potential for combined heat and power (CHP) in Texas, indicating that industrial users could use this method to generate both electricity and useful heat energy for use at their own facilities, thereby reducing their need to purchase power from a utility.[17]

Exhibit 8-1 Some Common Energy Efficiency Measures (Residential, Industrial, and Commercial)

RESIDENTIAL	
End Use or Category	**Description**
Weatherization	Apply caulk and weatherstripping.
HVAC and Geothermal Heat Pumps (GHPs)	Install more efficient air conditioning and space cooling equipment
Lighting	Install compact fluorescent or light emitting diode bulbs in lieu of incandescent bulbs
Appliances	Install Energy Star rated appliances in lieu of standard efficiency equipment
New Home Construction	Build new homes to Energy Star levels of efficiency
Envelope	Install spectrally-selective low-emissivity windows, reflective roofing, radiant barriers
Green Building	Adopt green building principles, leading to lower energy costs, lower water consumption, better indoor air quality, and other benefits
Photovoltaic Cells and Solar Water Heating	Reduce some electricity purchases with on-site electricity generation or water heating from solar technologies

INDUSTRIAL	
End Use or Category	**Description**
Pumps	Install more-efficient pumps and ensure that pumps are properly sized
Compressed Air Leaks	Eliminate leaks in compressed air equipment
Motors	Install high efficiency motors and use variable speed drives, where applicable
HVAC	Install more efficient air conditioning and space cooling equipment
Lighting	Upgrade lighting systems
Process Optimization	Ensure that the overall industrial process is designed and operated in an efficient manner
Pinch Technology	Ensure that sources and uses of heat in an industrial process are properly matched
Combined Heat and Power	Use waste heat from an industrial process for electricity generation, where applicable
Transportation	
Hybrid and Plug-in Hybrids	
Electric and Fuel Cell Vehicles	

Exhibit 8-2 Effect of Efficiency, Demand Response and CHP on Demand Forecasts



Source: Natural Resources Defense Council and Ceres, *Power to Save: An Alternative Path to Meet Electric Needs in Texas*, by Optimal Energy, Inc. (January 2007), http://www.ceres.org/pub/docs/Ceres_texas_power.pdf (Last visited July 18, 2007.)

COMMERCIAL	
End Use or Category	Description
HVAC and GHPs	Install more efficient air conditioning and space cooling equipment
Envelope	Install spectrally-selective low-emissivity windows, reflective roofing, radiant barriers
Lighting	Upgrade lighting systems
Office Equipment	Purchase Energy Star rated office equipment
Commissioning and Retrocommissioning	Use energy control systems more effectively
Photovoltaic Cells	Reduce some electricity purchases with on-site electricity generation from solar technologies

The second report, published by the American Council for an Energy-Efficient Economy (ACEEE) in March of 2007, is entitled, *Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy to Meet Texas' Growing Electricity Needs*.[18]

The ACEEE study proposed a series of nine "effective and politically viable" policies, two-thirds of them concerning energy efficiency, to reduce energy consumption and demand growth over the next 15 years. Some of these proposals echo and expand upon the recommendations in *Power to Save*, such as expanding utility energy efficiency programs; setting additional standards for electric appliances and equipment; and drafting more stringent building codes. In addition, the report proposes initiating an additional energy efficiency program for homes and commercial buildings; a state and municipal buildings efficiency program; and a market transformation initiative consisting of a series of short-term programs to educate the public on energy efficiency and offer rebates on energy efficient products.

ACEEE asserted that if its policies (including those concerning demand response, CHP and on-site renewable energy) are implemented, "Texas can meet its summer peak demand needs without any additional coal-fired power plants or other conventional generation resources." ACEEE also asserts that its energy-saving policies "would meet 8% of Texas's electricity consumption in 2013 and 22% in 2023." Thirty percent of the projected energy savings would come from utility efficiency programs; 30 percent from improved CHP policies; 22 percent from appliance standards and building-related programs; and the remainder from on-site renewable energy projects.[19]

Under the requirements of HB 3693 (2007 legislative session), the PUCT is presently commissioning a more in-depth assessment of the state's energy efficiency potential. The results of this study are expected to be released by the end of 2008.

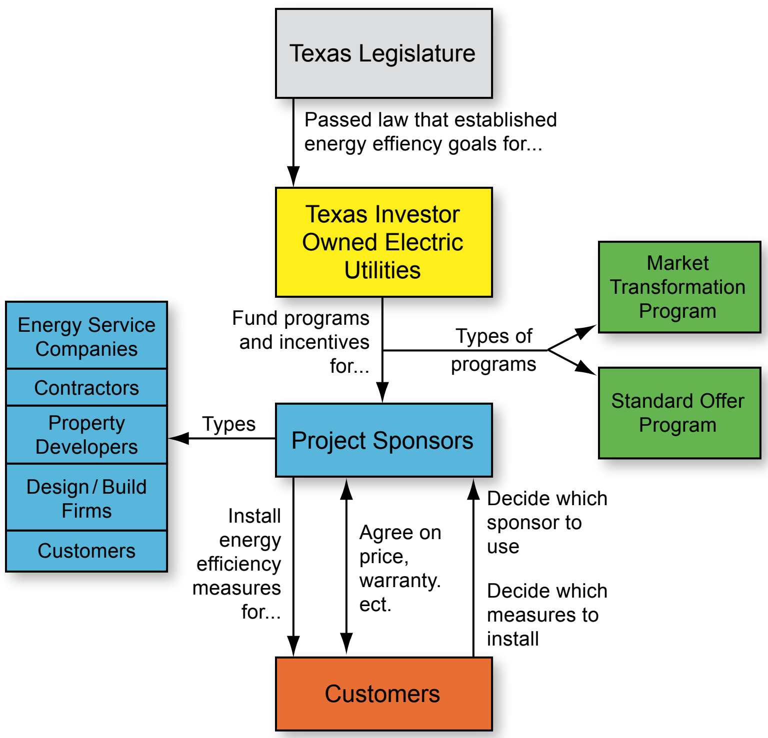
Exhibit 8-3 Examples of Energy Efficiency Strategies for Exploiting Energy Efficiency Opportunities

Opportunity	Strategies and Examples
New Home Construction	More stringent building construction code. Voluntary programs for home builders: • Austin Energy's Green Building program • Energy Star New Home program developed by the US EPA and implemented by many of the Texas' investor-owned electric utilities
Improve Performance of existing residential dwellings	Standard Offer programs: • Programs administered by the state's investor-owned electric utilities to provide financial subsidies to energy services companies and other organizations who perform weatherization activities. Energy audits Proposed programs to provide homebuyers with greater information about the energy performance of homes being sold. For low-income families, the federal Weatherization Assistance Program and its implementation through the Texas Department of Housing and Community Affairs
HVAC	Rebate programs (e.g., Austin Energy's program) Improve installation practices of equipment installers (e.g., Oncor's AC Installer Training program). Education about GHPs, programs of municipal community purchase and leasing of ground loops. Encourage AC distributors to stock more efficient equipment (e.g., Oncor's AC Distributor market transformation program).
Lighting	Buy down programs for compact fluorescent (CFL) bulbs The Mayors' Challenge program (organized by Environmental Defense and involving the mayors of the state's four largest cities). CFL give-away programs in lower-income neighborhoods (e.g., Houston in summer 2008).
Photovoltaic Cells	Federal tax credits. Rebate programs (e.g., Austin Energy) Net metering policies that permit consumers to receive a payment or credit for solar power injected into the grid. PV installer training programs.
Hybrid, Plug-in Hybrid, and electric vehicles	Federal tax credits. Greater access to HOV lanes on highways.

Utilization of the Resource

Utilization of Texas' energy efficiency resource involves tapping into the state's vast potential for energy efficiency improvements through utility energy efficiency programs, policy actions, government programs, university research, and innovations from the private sector. Policies and programs to promote energy efficiency may employ a variety of strategies. Financial rebates or tax credits may be offered to encourage consumers to purchase more energy efficient equipment. Building energy codes or appliance efficiency standards may be imposed by governments. Educational campaigns or training programs may be offered. Interventions may be undertaken at different levels of the supply chain for products and services. Some example strategies are outlined in **Exhibit 8-3**.

Exhibit 8-4 Overview of Texas Energy Efficiency Programs



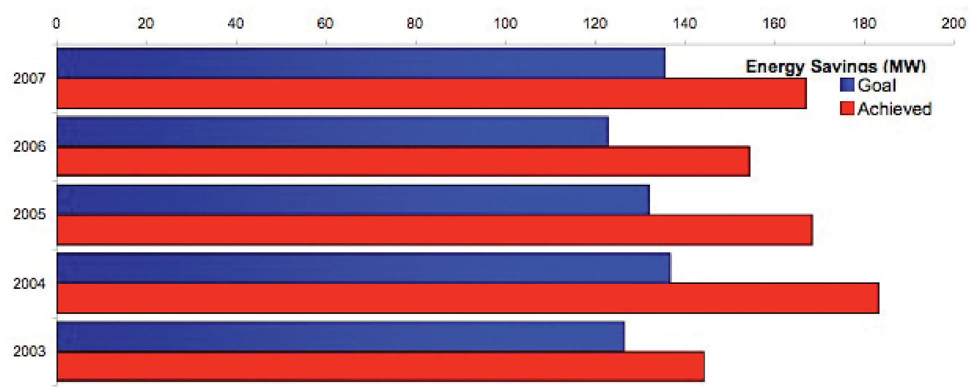
Source: Frontier Associates LLC. *Energy Efficiency Accomplishments of Texas Investor Owned Utilities*. June 16, 2008.

The energy efficiency programs administered by the state's investor-owned utilities have proven to be a particularly effective source of energy efficiency improvements. A goal for energy efficiency in Texas was initially established by legislation that opened portions of the state to retail competition for electricity – Senate Bill 7 in 1999. Under Section 39.905 of the Public Utility Regulatory Act, investor-owned utilities in Texas are responsible for administering various energy efficiency programs, while the competitive market for energy services works directly with energy consumers to implement qualifying energy efficiency measures. "Project sponsors" may include energy services companies, homebuilders, and consulting firms. The program structure is depicted in **Exhibit 8-4**. On a statewide basis, these programs have consistently exceeded their goals of meeting 10 percent of the projected growth in electrical demand through energy efficiency, as noted in **Exhibit 8-5**. Program goals for energy efficiency were changed through HB 3693 during the 2007 legislative session.

The state's larger municipal utility systems (e.g., Austin Energy and CPS in San Antonio) also offer a variety of innovative energy efficiency programs.

A number of successful public sector energy efficiency projects conducted outside of utility programs have demonstrated the potential savings that can be achieved through building commissioning, which involves the optimization of building systems including the HVAC system. One noteworthy example of a successful project is the Energy Conservation Program at Texas A&M University.

Exhibit 8-5 Total Energy Savings by IOUs, 2003-2007



Source: Frontier Associates LLC. *Energy Efficiency Accomplishments of Texas Investor Owned Utilities*. June 16, 2008.

Texas A&M University – College Station, Texas

Total Area Covered to date	**8,100,000 sq.ft.**
Project Cost to date	**$ 8,300,000**
Total Measured Savings to date	**$ 53,700,000**
Average Annual Savings	**$ 4,500,000**

With over 46,000 students, Texas A&M University has one of the largest student bodies in the United States. The main campus covers over one square mile, and is densely packed with buildings. The newer West Campus also has a large area but fewer buildings. With over 190 large buildings and over 18 million square feet of conditioned facilities, utility cost represented a major expense to the university in the 1990s. The Physical Plant Department spearheaded the Energy Conservation program, which was developed to fully manage resources from the Energy Systems Lab (ESL) of Texas Engineering Experiment Station (TEES) to help control these large utility costs.

EXHIBIT 8-6 Energy Use per Gross Square Feet with Campus Growth

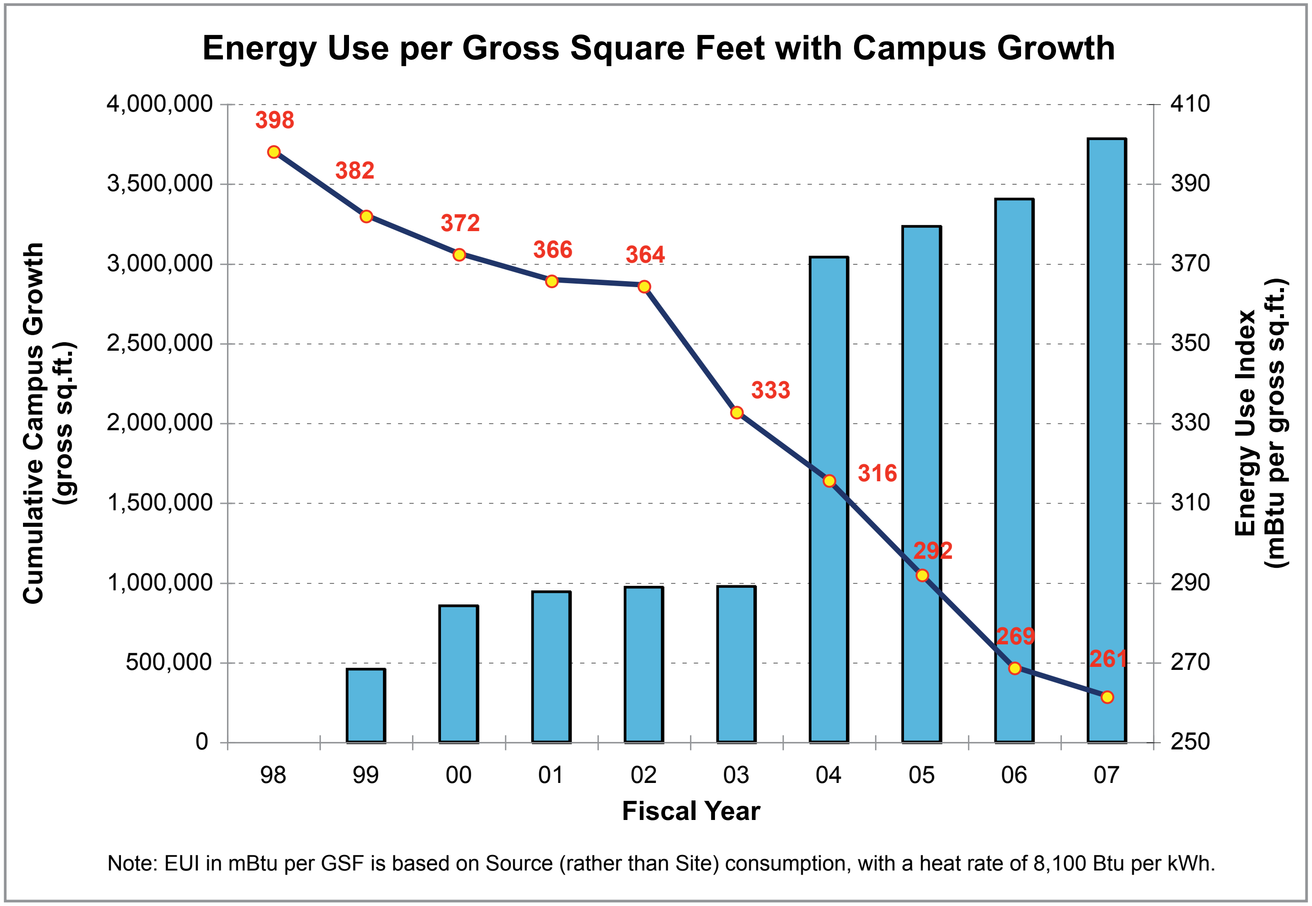


Exhibit 8-7 Energy Conservation Standards

Name	Description
ASHRAE *Advanced Energy Design Guides* (AEDG)[1]	A series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ASHRAE Standard 90.1-1999 Initial series of guides have an energy savings target of 30% which is the first step in the process toward achieving a net zero energy building Each 30% Guide addresses a specific building type
ASHRAE Standard 90.1-1999[2]	Energy Conservation Standard, established in 1999 Provides the fixed reference point for all of the 30% Guides in the Design Guide series Maintains a consistent baseline and scale for all of the 30% AEDG series documents
ASHRAE Standard 90.1-2010[3]	Incorporates goal to achieve 30% energy savings in the 2010 standard compared to ASHRAE Standard 90.1-2004 Savings obtained are part of ASHRAE's goal to achieve market-viable net-zero energy buildings by 2030
ASHRAE Standard 189P: Sustainable Buildings Standard to Define Green Buildings[4]	Proposed new standard that will provide minimum guidelines for green building. Addresses energy efficiency, a building's impact on the atmosphere, sustainable sites, water use efficiency, materials and resources, and indoor environmental quality for commercial buildings and major renovation projects Compilation of criteria that must be met in order for local building code officials to provide a Certificate of Occupancy for a facility Goal is to achieve a minimum of 30% reduction in energy cost (and carbon dioxide equivalent) over that in ASHRAE Standard 90.1-2007 First such green building standard in the United States

The state-of-the-art Continuous Commissioning® (CC®) process developed by the Energy Systems Laboratory has been applied as part of the campus program. CC® emerged from a program of implementing operational and maintenance improvements. CC® identifies and implements optimal operating strategies for buildings as they are actually being used rather than as the design intended. The DDC (Direct Digital Control) system and network on the TAMU campus, together with CC®, have become a powerful and effective tool for reducing energy use.

As of December 31, 2007, the CC® process has been applied to more than 80 buildings and all five central utilities plants on the Texas A&M campus resulting in substantial improvements to the operation of the buildings and plants. Dedicated CC® teams carry out daily operational optimization measures on the central chilled water and hot water distribution loops, the central plants and the campus buildings. Thus far, cumulative measured chilled water, hot water, and electricity savings achieved from Continuous Commissioning® on the Texas A&M campus have exceeded $50 million. CC® costs to date have been approximately $8.3 million.

The Texas LoanSTAR (loans to **S**ave **T**axes **A**nd **R**esources) Program is a highly successful energy efficiency program established by the State to help fund energy retrofits for public buildings. LoneSTAR uses a revolving loan mechanism which will allow it to continue indefinitely and benefit generations of future Texans. The program was initiated by the Texas Energy Office in 1988 and approved by the DOE as a statewide energy efficiency demonstration program. The quality control on all phases of LoanSTAR has made it one of the most successful and best-documented building energy efficiency programs, state or federal, in the United States. As of November 2007, LoanSTAR has funded a total of 191 loans totaling over $240 million dollars. As a result of these loans, the LoanSTAR Program has achieved total cumulative energy savings of over $212 million dollars, which result in direct savings to Texas taxpayers.[20]

The source of funding for LoanSTAR is petroleum violation escrow funds (PVE) received from the federal government. LoanSTAR is unique in a number of ways (including the acronym for its name, since its origins are in the Lone Star State). The size, $98.6 million, makes it the largest state-run building energy conservation program in the United States. The loans are targeted for public buildings, including state agencies, school districts, higher education, local governments and hospitals.[21]

The state's adoption of minimum building energy codes in 2001 pursuant to Senate Bill 5 was a key step toward improving the energy performance of new homes and commercial buildings. The International Energy Conservation Code was adopted for residential construction, while the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 90.1-1999 was adopted for new commercial structures. SB 5 has produced total annual electricity savings (2006) of 498,582 MWh/yr which includes 393,069 MWh/yr (78.8%) for single-family residential; 15,956 MWh/yr (3.2%) for multi-family residential; and 89,557 MWh/yr (18.0%) for new commercial buildings. Natural gas savings were calculated to be 576,680 MBtu for new residential and commercial construction.

Several organizations have joined forces to develop a series of reports providing information on how to obtain energy savings beyond the minimum codes adopted by the state. **Exhibit 8-7** provides a brief description of these design guides and lists new and proposed energy conservation standards.

Some areas of Texas (e.g., the City of Frisco) have adopted building codes that exceed the minimum standards adopted by the state. The cities of Houston and Dallas are actively considering stronger codes. Austin is home to the nation's oldest and largest voluntary "green building" program, which seeks to promote energy efficiency in addition to water conservation, the utilization of recycled building materials, improved indoor air quality, and other goals.

A new program developed by Texas Home Energy Raters Organization (Texas HERO) seeks to identify savings opportunities in existing residential dwellings through energy audits. The Center for the Commercialization of Electric Technologies seeks to commercialize a variety of advanced electric technologies to improve energy efficiency, grid security, economic development, and other goals.

The Energy Systems Laboratory at Texas A&M University has developed recommendations for achieving "15 percent above code" energy performance for single-family residences and commercial office buildings complying with ASHRAE Standard 90.1-1999 based on studies investigating the best mixture of measures to produce maximum energy reductions. For residential homes, the study found that for an electric/gas house, solar domestic hot water (DHW) systems and tankless water heaters resulted in 15.2 percent and 9.3 percent energy savings respectively, followed by 8.5 percent savings from moving HVAC units and ductwork into the conditioned space. Similarly, for an all-electric house, solar DHW systems resulted in 10.9 percent energy savings, followed by 8.7 percent savings from moving HVAC units and ductwork into the conditioned space.[22] For commercial buildings, results showed that reducing lighting loads and implementing occupancy sensors were the most effective individual measures for both electric/gas and all-electric buildings. Combining lowering the glazing U factor and lighting loads proved to be the two most effective strategies for the electric/gas building with savings of up to 20 percent. For the all-electric building, the combination of implementing occupancy sensors and resetting the cold deck from a constant to a variable setting (55F to 60:55F; 55:85F) to improve the performance of the cooling system proved to be most effective with savings up to 20 percent.[23]

Energy efficiency programs have also been established by private organizations and the government (at federal, state, and local levels) in an attempt to conserve energy, reduce greenhouse gas emissions and save money through a combination of efficiency measures. The 2030 Challenge, the Western Governors' Association Clean and Diversified Energy Initiative, and the Energy Independence and Security Act of 2007 are three relatively new initiatives that incorporate efficiency measures as a means to achieve energy saving goals. In addition, the State of Maryland and the City of Austin, Texas have enacted progressive measures to decrease their energy usage over the next few decades, with other states and regions following suit. **Exhibit 8-8** lists these programs, denoting the players involved, overall objectives, and the energy efficiency strategies identified to meet specified goals.

Exhibit 8-8 Energy Efficiency Initiatives

PROGRAMS		
Name	**Parties Involved**	**Goal**
2030 Challenge[5]	Architecture 2030 (non-profit organization and creator of program). As of May 2008, 17 organizations/companies have joined in Texas alone. • Numerous organizations and individuals including: The American Institute of Architects (AIA), US Green Building Council (USGBC), Leadership in Energy and Environmental Design (LEED), American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), State of New Mexico, etc.	Overall objective: To have "all new buildings and major renovations reduce their fossil-fuel GHG-emitting consumption by 50% by 2010, incrementally increasing the reduction for new buildings to carbon neutral by 2030". To accomplish this, Architecture 2030 has issued **The 2030 Challenge** asking the global architecture and building community to adopt the following targets: • New construction must meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional average annual energy use for the specific building type and an equal amount of existing areas should be renovated in the same manner annually • The fossil fuel reduction standard for all new buildings shall be increased by 10% each year through 2025, ultimately being carbon-neutral by 2030
Clean and Diversified Energy Initiative (CDEi)[6]	Western Governors' Association	Overall goal to encourage Western regions to "move toward a cleaner more diverse energy future" by identifying changes in state and local policies to achieve: • A 20% increase in energy efficiency by 2020 • Adequate transmission capacity for the region over the next 25 years • 30,000 megawatts of new clean and diverse energy generation by 2015 Specific energy efficiency measures include implementing electricity energy efficiency programs, more stringent building codes, and minimum efficiency standards for appliances. In addition, it encourages the use of financial subsidies and pricing policies to encourage a reduction in energy use, thereby increasing efficiency.
Energy Independence and Security Act of 2007[7]	Federal Government (Executive Order)	Includes provisions to improve energy efficiency in lighting and appliances, as well as requirements for federal agency efficiency and renewable energy use that will help reduce greenhouse gas emissions. Specific efficiency measures include: • Requiring all general purpose lighting in federal buildings to use Energy Star® products or products designated under the Energy Department's Federal Energy Management Program (FEMP) by the end of FY 2013. • Establishing new appliance efficiency standards • Creating an Office of High-Performance Green Buildings

STATE/CITY INITIATIVES		
Name	Responsible Agency	Goals
EmPOWER Maryland[8]	Maryland Energy Administration	Reduce energy consumption by 15% by the year 2015. Plan to accomplish this through the implementation of seven steps: 1. Improve building operations 2. Expand use of energy performance contracting 3. Increase state agency loan program 4. Require energy efficient buildings 5. Purchase Energy Star products 6. Expand community energy loan program 7. Ensure accountability
Austin Climate Protection Plan (Texas)[9]	City of Austin	Aggressive plan to reduce greenhouse gas emissions through the implementation of 5 distinct plans including utility and building plans that directly incorporate the following efficiency measures: **Utility Plan:** • Save 700 MW of energy through conservation/efficiency measures by 2020 **Homes and Buildings Plan:** Build all single-family homes to be zero net-energy capable by 2015 • Increase efficiency in all other new construction by 75% by 2015

Residential: Jim Sargent's Zero-Energy Home

Jim Sargent of Anderson-Sargent Custom Builder is leading the way in energy efficient homes for the North Texas area. In 2004 he joined forces with Building America to build a "first-of-its-kind Zero Energy Home" at Lone Star Ranch in Frisco, Texas. With a goal of building a home that consumes less energy than it can produce through renewable energy systems, Sargent and team constructed an energy efficient design plan that addressed durability, indoor environmental quality, water efficiency, and occupant comfort.[24]

All major systems of the house are integrated in order to maximize energy efficiency. The architectural design integrates function without sacrificing the aesthetic beauty of the home. Strategically placed windows and overhangs help the house stay cool in the summer and warm in the winter, foam insulation in the floor prevents heat loss, and the vented, reflective metal roof all work together to make the home as efficient as possible. Appliances and lighting are another key aspect of the house; energy efficient clothes washers and dishwashers save both energy (42% and 25%, respectively) and water (59% and 44%, respectively) compared to standard appliances, and the fluorescent lighting installed throughout the home helps reduce overall energy consumption. In addition, photovoltaics installed on the roof along with a solar water heater provide the renewable energy the house requires to maintain its zero-energy status. Together the integrated systems work seamlessly, reducing overall annual energy consumption by 45 percent compared to a conventional home of similar size. The zero-energy home comes with a price tag of about $1 million dollars; although this is not feasible in many circumstances, Sargent and team hope the project will provide an example of what houses could be like, and help people to integrate some of the energy efficiency measures into their own homes.[25]

Exhibit 8-9 Robert E. Johnson building designed to be a sustainable project with numerous Energy Conservation Design Measures (ECDMs)

Source: Suwon Song "Development of New Methodologies for Evaluating the Energy Performance of New Commercial Buildings", Department of Architecture, Now Research Professor, Yonsei University, South Korea.

Commercial: Robert E. Johnson Building

The Robert E. Johnson building is one of the first State of Texas office buildings built with an emphasis on high performance. It is a six-story, 303,389 ft^2 office building for State legislative support staff, which includes a large print shop and data processing center. The building was designed to be a sustainable project with numerous Energy Conservation Design Measures (ECDMs) designed to make the building more efficient than prevailing building code (i.e., ASHRAE Standard 90.1-1989). The building contains over 50 percent windows in the façade consisting of two types of low-e glazing. Deciduous live oak trees shade a significant portion of the south façade up to approximately the 3rd floor. Calibrated simulation was used to show that the building was 20.79% more efficient than the prevailing building codes due to its high efficiency windows, efficient heating and cooling systems (i.e., chillers, boilers, air handling units, pumps and cooling towers).[26],[27]

Economics

When exploring the economics of energy efficiency measures or programs, it is quite common to consider the costs and benefits from a variety of perspectives, including the consumer's, the utility's (if the measure might be promoted through a utility program), and the impacts of the measure on energy rates (if the measure could potentially affect the utility's revenues and consequently its cost and rate structure).[28] A total resource cost test seeks to combine each of these perspectives. A societal test might be employed if externalities, or other indirect costs, and benefits are thought to be worthy of consideration. Since programs to foster energy efficiency often involve subsidies, developing an awareness of the distributional impacts of the costs and benefits of a program may be important.

Because the range of energy efficiency measures and strategies has no limit, it is not feasible to fully characterize all of their costs and payback periods.

Key Issues

As noted earlier, there may be a variety of impediments to achieving an optimal level of energy efficiency. The availability of energy efficient products may be limited. Consumers may be unaware of opportunities to reduce their energy consumption and cost. Lower-income families may lack the capital to purchase premium-priced energy efficient products. Consumers may be unaware of the attractive payback periods associated with energy efficiency investments. The interests of landlords and tenants may diverge with respect to energy efficiency investments. Similarly, homebuilders and homeowners may have divergent interests. The environmental costs associated with energy use may not be adequately reflected in energy prices, leading to over-consumption of energy resources. In order to promote energy efficiency, policies and programs must be designed to effectively overcome these impediments.

A number of studies suggest that the direct effects of energy efficiency programs may become diminished due to rebound effects.[29] By reducing consumer energy costs, consumers will have more disposable income to spend on energy-using goods. A more efficient air conditioner might tempt a consumer to set it to a lower temperature. Consumers might be less concerned about turning out lights when leaving a home if their home is lit with compact fluorescent bulbs or LED lighting. Improvements in fuel efficiency appear to lead to a small increase in the use of automobiles.[30]

Energy efficiency efforts should be strategically targeted to consumers who would not otherwise undertake the energy efficiency measure. Free ridership, along with rebound effects and allegedly biased reporting, may contribute to some over-reporting of the savings associated with various energy efficiency programs.[31]

Information Sources

US Department of Energy: Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/

R & D at Texas A & M Energy Systems Laboratory
http://esl.eslwin.tamu.edu

American Council for an energy Efficient Economy
http://aceee.org/

Energy Efficiency Programs administered by the State's Investor-Owned Electric Utilities:
www.texasefficiency.com

Exhibit Endnotes

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