TOPIC PAPER #6

RESIDENTIAL COMMERCIAL EFFICIENCY

On July 18, 2007, The National Petroleum Council (NPC) in approving its report, *Facing the Hard Truths about Energy,* also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the Task Groups and their Subgroups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached Topic Paper is one of 38 such working document used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix E of the final NPC report provides a complete list of the 38 Topic Papers and an abstract for each. The printed final report volume contains a CD that includes pdf files of all papers. These papers also can be viewed and downloaded from the report section of the NPC website (www.npc.org).

NATIONAL PETROLEUM COUNCIL

**RESIDENTIAL/COMMERCIAL EFFICIENCY SUBGOURP
OF THE
DEMAND TASK GROUP
OF THE
NPC COMMITTEE ON GLOBAL OIL AND GAS**

TEAM LEADER

Mark P. Gilbert
Director, Economic Forecasting,
Corporate Planning & Budgeting
American Electric Power Co., Inc.

MEMBERS

Stephen A. Capanna
Research Associate
Alliance to Save Energy

Selin Devranoglu
Research Associate
Alliance to Save Energy

Leslie Black Cordes
Branch Chief
Energy Supply and Industry
U.S. Environmental Protection Agency

Joseph W. Loper
Vice President
Research and Analysis
Alliance to Save Energy

Matthew C. Rogers
Director
McKinsey & Company

Energy Efficiency Potential in American Buildings

Lead Authors: Joe Loper, Selin Devranoglu, and Steve Capanna
(Alliance to Save Energy)
Mark Gilbert (American Electric Power)

Summary

Buildings are major consumers of oil and gas nationally and globally, both directly, for heating, and indirectly, through the consumption of electricity. If "achievable" cost-effective energy-efficiency measures were deployed in residential and commercial buildings, energy use could be reduced by roughly 15-20% below business as usual projections.[1] The potential for cost-effective energy-efficiency improvements is heavily dependent on the price of energy, consumer awareness and perceptions, and the availability of energy-efficient products in the marketplace. These factors are significantly influenced by government policies.

The major barriers to energy-efficiency investments in residential and commercial buildings are low energy prices relative to incomes – due to market failures arising from externalities not being included in prices and government energy subsidies – split incentives, and consumers' lack of information.

While most energy consumed in buildings is for traditional uses such as heating, cooling and lighting, a growing portion is going to power new electric devices, many of which were rare or even nonexistent just a few years ago. Over the last several years, significant efficiency improvements have been made in building shells, systems and appliances, but they have been counterbalanced by additional energy services demand as a result of bigger homes and new electric devices.

To the extent that improved efficiency is recognized as a societal benefit– because of energy security or climate concerns, for example – government policies to promote energy efficiency are justified. To reduce energy consumption significantly below baseline will require policy-induced improvements in energy efficiency, along with slowed growth in demand for energy services. New energy-efficiency technologies could further expand the energy-savings potential.

Buildings Represent a Large and Growing Percentage of National Energy Use

When energy losses in the generation, transmission, and distribution of electricity are included, 40 percent of US energy is consumed in the residential and commercial

[1] Baseline projections taken from Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030*, Table 2, February 2007, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_2.xls; savings estimates taken from several studies, detailed below. "Achievable" means different things to different people, but in the studies we examined, it generally means that the measures are currently available and the savings can be realized with a reasonable level of effort and with acceptable reductions, if any, in perceived amenity value.

buildings sectors. Current projections indicate that building energy use will increase by more than one-third by 2030. Commercial building energy use is expected to increase by nearly half, due to continued growth in the service economy. Residential energy use is expected to grow at half that rate (25%). The combined energy use growth in residential and commercial buildings is expected to represent about 45% of total primary energy growth.[2]

Currently, buildings represent only about 6% of economy-wide petroleum consumption, a share projected to decline to about 4% by 2030.[3] The natural gas story is quite different. Buildings represent 55% of US natural gas consumption and are expected to be responsible for about three-quarters of the growth in natural gas consumption through 2030 (including gas used for electricity supplied to buildings). Commercial and residential buildings represent 52% and 25% of overall projected natural gas consumption growth from 2005-2030, respectively.[4]

Energy Use in Buildings

Twenty-nine percent of residential energy use is for space heating of which more than half (55%) comes from natural gas.[5] The remaining residential energy use is comprised of items such as small electric devices, small motors, outdoor grills, outdoor lighting, swimming pool and spa heaters – grouped by EIA under the rubric "other" – water heating, space cooling and lighting. Taken together, these represent the top-5 energy use categories in residential buildings.[6]

Energy use per household and per square foot of living space are expected to go down by 6% and 17%, respectively, over 2005-2030. However, improved efficiency per square foot will likely be partially offset by increased home size and square footage per person; from 2005 to 2030, the average home is projected to increase by 13%, while square footage per person will increase a projected 20%.[7]

Per capita residential energy consumption is projected to gradually increase through 2020 before peaking and declining to around 2005 levels by 2030.[8] Overall residential energy use is expected to increase relatively slowly from 2005-2030, by only about 23%.[9] Most of the expected increase in residential energy use results from new electric devices, larger televisions sets, larger homes and population growth.[10]

Miscellaneous uses – including automated teller machines, telecommunications equipment, medical equipment, pumps, data servers and emergency generators –

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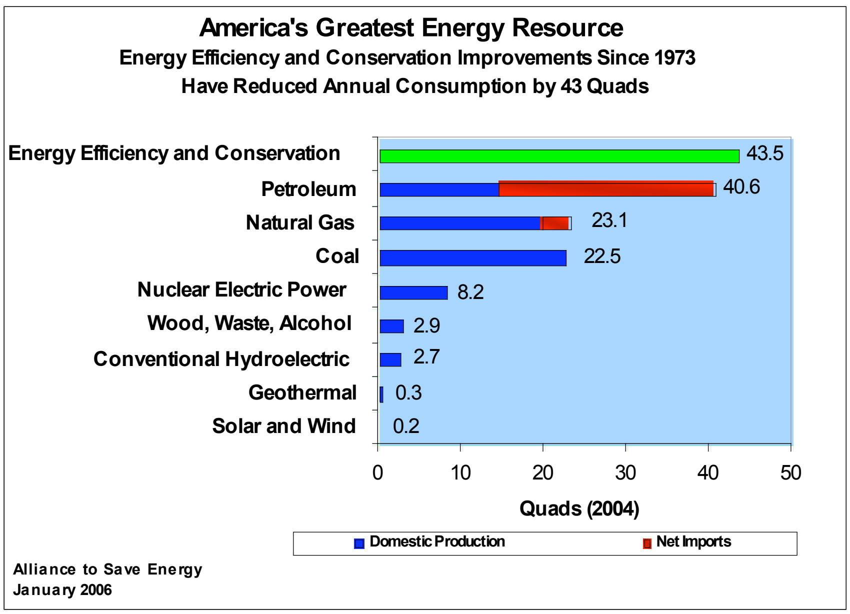
[2] EIA, *Annual Energy Outlook 2007*, Table 2.
[3] EIA, *Annual Energy Outlook 2007*, Table 2.
[4] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Table 2.
[5] The share from natural gas is even higher if gas used to generate electricity used for heating is included.
[6] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Table 4.
[7] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Tables 4 & 19.
[8] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Tables 4 & 19.
[9] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Table 4.
[10] EIA, *Annual Energy Outlook 2007*, p.74.

comprise almost one-third of commercial building energy use. Lighting is the second largest share at 21%. Space heating (12%), space cooling (10%), and office equipment (10%) round out the top-5 energy uses.[11]

New "other," miscellaneous uses are expected to be half of the growth in commercial energy use through 2030. Office equipment (both PC and non-PC) are expected to make up one-quarter of the growth, surpassing the energy increases in space heating or space cooling.[12] Overall, the energy intensity (energy per square foot) of commercial buildings is expected to increase slightly (2%) over the 2005-30 period.

Existing Efficiency



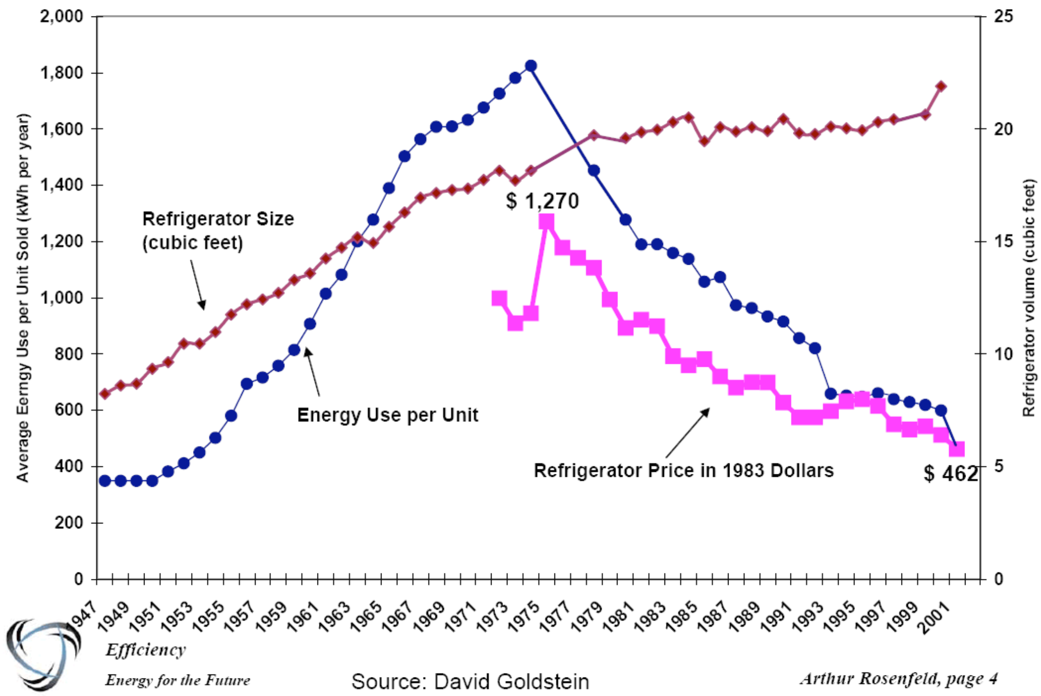
Across all sectors of the US economy, energy-efficiency and conservation improvements made since 1973 currently displace upwards of 43 quads annually (see figure). This represents more energy than the US consumes of any other single fuel type, including petroleum (40.6 quads in 2004), and almost twice the contribution of natural gas and coal (23.1 and 22.5 quads, respectively). Assuming the energy-efficiency savings since 1973 have been distributed among sectors in proportion to current energy demand, the residential and commercial sectors would be consuming a combined 17 quads more than they currently are, were it not for efficiency gains. Transportation and industry efficiency improvements have resulted in about 26 quads of avoided consumption.

There are many examples of efficiency improvements made since 1973 at the appliance and equipment levels. The average refrigerator sold today consumes about one-quarter of the energy of the average refrigerator sold in 1973. At the same time, average

[11] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Table 5.
[12] Calculations based on data from EIA, *Annual Energy Outlook 2007*, Table 5.

refrigerator prices have gone down and average size and amenities have increased (see chart).[13]

United States Refrigerator Use v. Time



Source: David Goldstein

Energy Policies Have Contributed to Energy-Efficiency Gains

As of 2000, policy-induced efficiency gains in buildings – including appliance standards, utility demand-side management programs (DSM), labeling programs and voluntary commitment programs – were saving as much as 4 quads annually (see chart below).[14] Annual savings from commercial and residential energy building codes in the US saved an additional 0.5 quads in 2000,[15] so as much as one quarter of the total building sector efficiency improvements resulted from policy-induced measures. The rest of the efficiency and conservation gains have occurred as a result of energy prices, natural technological improvements and equipment turnover (see chart below).[16]

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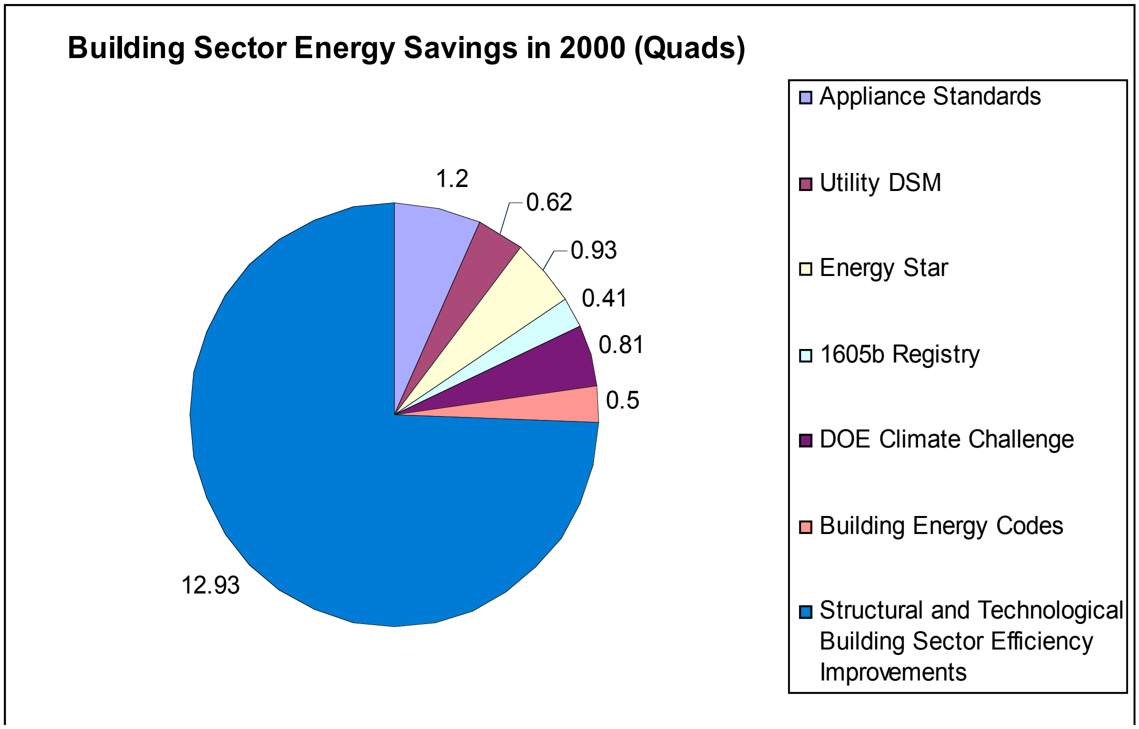
[13] Taken from Arthur H. Rosenfeld, "Past and Current Efficiency Successes and Future Plans," California Energy Commission, for ACEEE: Energy Efficiency as a Resource, Berkeley, California, September 26 & 27, 2005, http://www.aceee.org/conf/05ee/05eer_arosenfeld.pdf.

[14] Based on a table by Kenneth Gillingham, Richard Newell and Karen Palmer, *Retrospective Examination of Demand Side Energy Efficiency Policies*, June 2004, revised September 2004, Resources for the Future, Discussion Paper 04-19, p.2.

[15] Steven Nadel, *Supplementary Information on Energy Efficiency for the National Commission on Energy Policy*, American Council for an Energy-Efficient Economy, July 2004.

[16] Gillingham, et al, revised by Resources for the Future; Nadel, *Supplementary Information on Energy Efficiency for the National Commission on Energy Policy*, For savings estimates in which Gillingham, et al



Based in large part on Kenneth Gillingham, Richard Newell and Karen Palmer, *Retrospective Examination of Demand Side Energy Efficiency Policies*, June 2004, revised September 2004, Resources for the Future, Discussion Paper 04-19, p.2. See footnote 16 for certain caveats about the graph.

US efficiency improvements pale compared to some states, particularly California, where per capita electricity consumption has held steady since the 1970s – US per capita consumption increased by about 50% over that period – despite the advent of the digital age and the now omnipresent personal electronics, computers, and home appliances. The average Californian consumes just 7,000 kwh per capita, 42% better than the US average of 12,000 kwh per capita.[17] Part of this difference can be attributed to California's mild climate and other peculiarities unique to California.[18]

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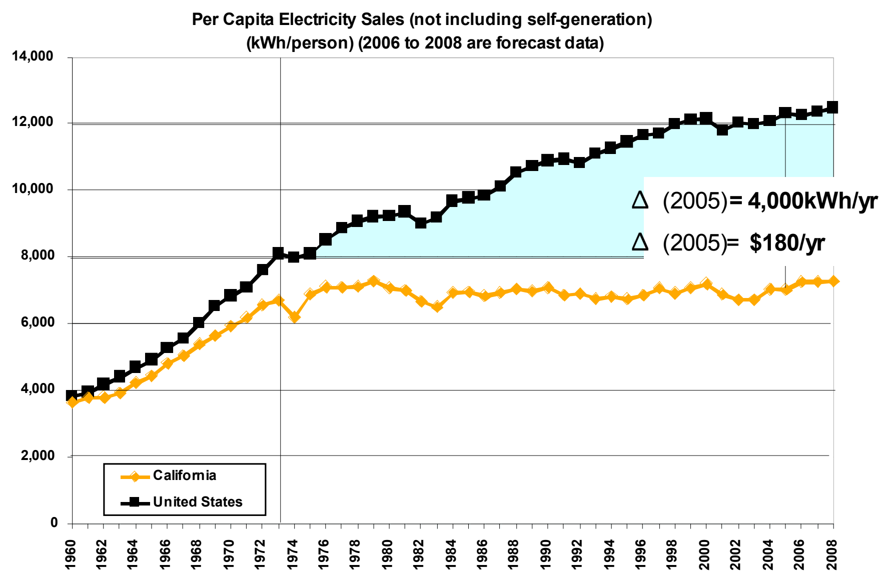
or Resources for the Future reported savings as "less than" a certain amount – namely, the ENERGY STAR, 1605B and Climate Challenge programs -- we assume the highest estimated savings. Actual savings are, in all likelihood, considerably smaller than those given. All data from 2000 except Energy Star savings, which are from 2001.

[17] Craig Canine, "California Illuminates the World," *OnEarth*, Natural Resources Defense Council, Spring 2006, http://www.nrdc.org/onearth/06spr/ca1.asp.

[18] Structural changes in the California economy, along with weather and high energy prices, may explain some of the State's lower per capita electricity use. Industry does consume less of the total electricity in California than in the nation at large (23.5% and 26.6%, respectively, according to EIA's *Annual Energy Review 2005* and data sent to us by John Wilson at the California Energy Commission.) But in 1980, industry represented 32.5% of electricity consumption in California and 39% in the US, so the shift has been proportional. According to the National Climatic Data Center, in an average year, California only has 904 cooling degree days, significantly lower than the national average of 1217, which manifests itself in reduced electric air conditioning consumption. High electricity prices could also have contributed to lower per capita electricity consumption. And a number of policies have been implemented that encouraged, or forced, the use of natural gas appliances in place of electric appliances. All said, most skeptics of the California experience would grant that at least a third to a half of the savings has come from efficiency

Some Efficiency Improvements Are Likely, Even Without Changes in Policy

As new, more efficient, appliances and equipment replace the existing stock, the stock efficiency will increase without policy interventions. Energy Information Administration (EIA) assumptions of the rate of efficiency improvement that will occur for various residential appliances and systems are shown in the table below. These improvements are driven by increased energy prices, existing product efficiency standards, and expected technology improvements. Even with these assumed energy-efficiency improvements, however, energy use in buildings is still expected to go up by one-third by 2030 (as noted above), although most of this growth can be attributed to the increasing number and size of buildings.



Source: Art Rosenfeld, *Improving Energy Efficiency, U.S. and West Coast*, Presentation for the Joint Commissions Energy Efficiency Workshop, December 1, 2006.

We're Nowhere Near the Maximum Efficiency Potential

The Annual Energy Outlook (AEO) base case is an attempt by analysts at EIA to predict efficiency improvements given projected energy prices and other factors influencing the penetration of various energy-saving technologies. Energy efficiency savings potential including additional policies, standards, behavioral changes and technological breakthroughs far exceed the efficiency included in the AEO reference cases. Specific estimates of the exact magnitude of this potential vary widely.

Estimates of achievable cost-effective reductions in building electricity use for commercial and residential buildings in the US range from 7-40% (see figures) below the

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improvements resulting from California's advanced buildings codes, appliance standards and utility demand side management programs.

reference case projections. The midrange appears to be around 20% for commercial buildings, and slightly less in residential buildings. In relation to the EIA AEO reference case this suggests building electricity – and maybe energy – use could reasonably be stabilized at today's levels – thus offsetting growth in the building stock for a couple of decades – with moderate to strong policy interventions.

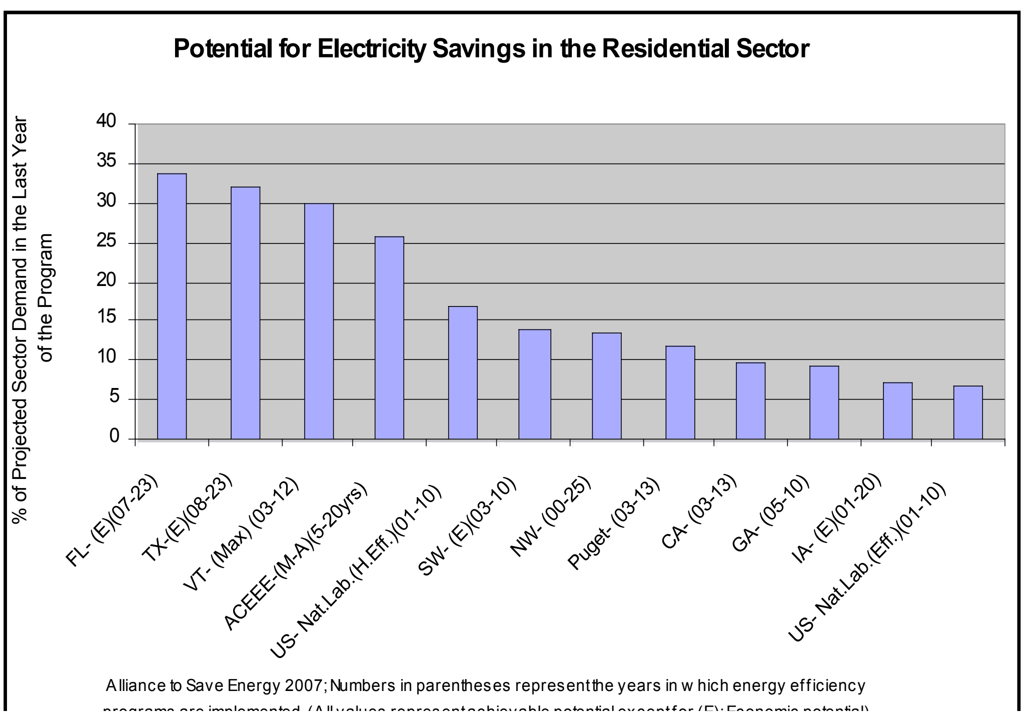
EIA (AEO 2007) estimates residential sector energy consumption (not just electricity consumption) would be 24% lower than in the reference case if "consumers purchase the most efficient products available at normal replacement intervals regardless of cost, and that new buildings are built to the most energy-efficient specifications available, starting in 2007." Energy-efficient building components would include, for example, solid-state lighting, condensing gas furnaces, and building envelope improvements such as high-efficiency windows and increased insulation.

Residential Stock Efficiency Improvements 2007-30 (EIA Projections)		
Category	Appliance	Efficiency Improvement (%)
Appliance	Refrigerator	22
	Freezer	8
Space heating	Electric heat pumps	9
	Natural gas heat pumps	14
	Geothermal heat pumps	5
	Natural gas furnace	5
	Distillate furnace	2
Space cooling	Electric heat pumps	20
	Natural gas heat pumps	10
	Geothermal heat pumps	6
	Central air conditioners	22
	Room air conditioners	7
Water heaters	Electric	3
	Natural gas	6
	Distillate fuel oil	0
	Liquefied petroleum gases	6
Building shell efficiency	Space heating – Pre 1998 homes	2
	Space cooling – Pre 1998 homes	2
	Space heating – New construction	7
	Space cooling -- New construction	1
Source: EIA, AEO 2007, table 21, http://www.eia.doe.gov/oiaf/aeo/supplement/sup_rci.xls.		

Similarly, EIA (AEO 2007) estimates that commercial building energy consumption in 2030 would be 13 percent less than projected in the reference case if "only the most efficient technologies are chosen, regardless of cost, and that building shells in 2030 are 50 percent more efficient than projected in the reference case [including] the adoption of improved heat exchangers for space heating and cooling equipment, solid-state lighting, and more efficient compressors for commercial refrigeration."

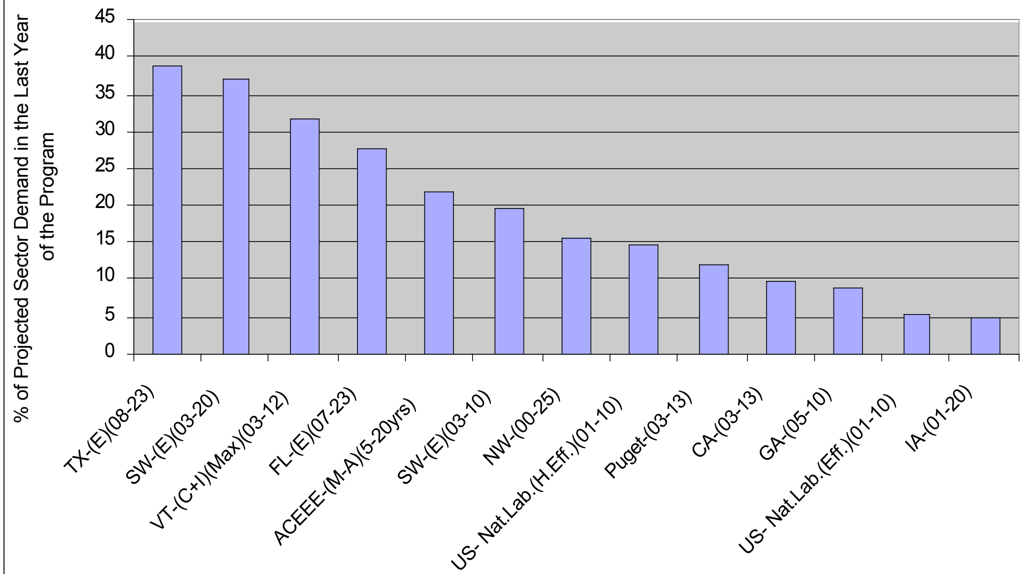
EIA efficiency potential estimates are on the high end of the residential studies we examined and on the low to mid range of the commercial estimates. Note, however, that the EIA projections assume that cost is no concern, so in as much as the other efficiency potential studies include cost-effectiveness tests, we would expect the EIA estimates to be at the high end of the studies. Furthermore, the other studies are for the most part examining the potential for electricity savings, not energy overall.

According to the McKinsey Global Institute study (2006) of energy-efficiency potential, if all energy efficiency measures with internal rates of return of 10% or better are implemented, US residential energy demand could be reduced by 36% below its 2020 baseline and commercial energy use could be reduced by 19%. Using the same investment criteria, McKinsey estimates global residential building energy demand could be reduced by 15% below baseline and global commercial building energy demand could be reduced by 20%.[19]



[19] McKinsey Global Institute, *Productivity of Growing Global Energy Demand: A Microeconomic Perspective,* November 2006.

As previously mentioned, most of the studies we examined estimated an efficiency potential of 10-20% in commercial buildings and 10-15% in residential buildings beyond business as usual, with the American Council for an Energy-Efficient Economy (ACEEE) studies estimating potentials as high as 35% for residential buildings in Florida and 40% for commercial buildings in Texas (see figures).[20]



Potential for Electricity Savings in the Commercial Sector

Alliance to Save Energy 2007; Numbers in parentheses represent the years in which energy efficiency

At the other extreme, the Electric Power Research Institute (EPRI) developed a supply curve for electric demand side measures in 2010 (see figure) – including residential and commercial buildings, and industry.[21] According to the EPRI analysis, by 2010 the US could reduce electricity use by about 150 TWh (3.9% of total US electricity consumption) with measures costing less than 10 cents per kwh and 210 TWh (5.5%) at 20 cents per kwh or less. For reference, electricity consumption in 2005 totaled about 3,800 TWh[22] and the retail price of electricity in 2005 was 9.5 cents/kwh for residential, 8.7 cents/kwh for commercial, and 5.7 cents/kwh for industry.[23] At these prices, about 50 TWh (1.3%) of electric efficiency improvements could be achieved. As the graph shows,

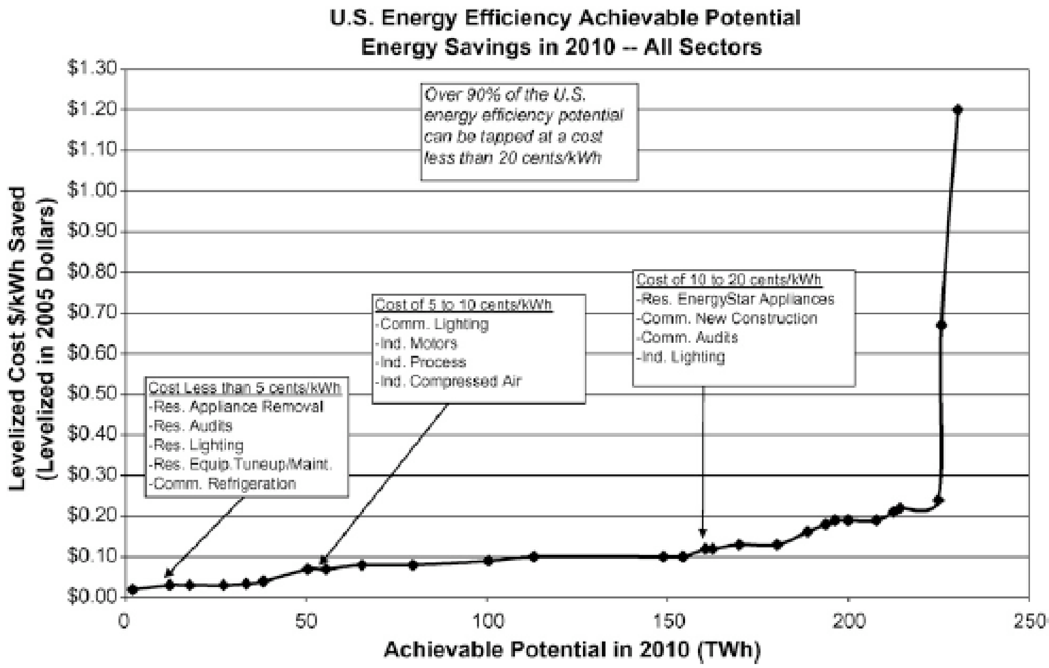
[20] Data from R. Neal Elliott et al, *Potential for Energy Efficiency and Renewable Energy*; Neal Elliott et al, *Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy*; Plunkett et al; Nadel et al, *The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S.*; Southwest Energy Efficiency Project; Northwest Power and Conservation Council; Puget Sound Energy; Global Energy Partners, LLC; ICF Consulting; S.W. Hadley; Interlaboratory Working Group.

[21] Clark Gellings, Greg Wikler and Debyani Ghosh, "Assessment of U.S. Electric End-Use Energy Efficiency Potential," *The Electricity Journal*, November 2006, Vol. 19, Issue 9, Elsevier Inc, 2006, p.67.

[22] Energy Information Administration, Electric Power Annual with data for 2005, November 2006, http://www.eia.doe.gov/cneaf/electricity/epa/epates2.html.

[23] EIA, *Electric Power Annual.*

after 225 TWh or so of savings have been achieved, the cost of efficiency improvements becomes prohibitively expensive.



Source: Clark Gellings, Greg Wikler and Debyani Ghosh, "Assessment of U.S. Electric End-Use Energy Efficiency Potential," *The Electricity Journal*, November 2006, Vol. 19, Issue 9, Elsevier Inc, 2006, p.67.

Potential Uncertainty

It is difficult to accurately measure energy efficiency potential. It seems everyone has different answers and different assumptions underlying their conclusions. Any number of factors will affect the efficiency potential, including the assumed energy costs, the time period studied, whether a cost-effectiveness test is included (and how it's defined), the assumed pace of technological change, the assumed costs of the measures, and what's already assumed in the baseline used for comparison.

Arguably, the biggest determinant of energy-efficiency potential is the assumed policy environment. Some studies of efficiency potential assume minimal intervention (e.g., Iowa assumes only appliance standards and information programs), while some (e.g., SWEEP, ACEEE-FL) assume aggressive codes and standards, electric efficiency resource requirements, etc. Even if policies are not prescribed in the studies, they would need to be implemented to achieve the estimated potential.

If "game-changing" policies were introduced such as a significant carbon tax or carbon cap, then the potential for achievable cost-effective energy-efficiency improvements would increase significantly. Efficiency potential is probably proscribed less by the availability of technology than by the willingness and ability to deploy that technology.

Barriers to Realizing Efficiency Potential

The notion of improved energy efficiency is very popular, with few opponents, unlike, say, a carbon tax. That is, there are few opponents until they are asked to pay for the efficiency improvements. Improved energy efficiency usually involves increased cost, including up-front capital investment, opportunity costs, cost of learning, concerns about disrupting operations, hassle factor, etc.

Barriers and Solutions to Deployment of Energy-Efficient Technologies[24]

Externality costs of energy – Energy consumers do not pay the full cost – e.g., increased air pollution, risk of catastrophic climate change, and national security costs – of their energy use. Thus consumers tend to under-invest in energy-efficiency measures and products.[25] SOLUTION: Carbon taxes, utility rebates, tax credits, and other financial incentives reduce the cost of energy-efficiency improvements relative to the price of energy and thus encourage energy-efficiency investments.

Tenant-landlord dilemma – Building owners often don't pay energy bills, so their incentive to invest in energy-saving products and equipment – like efficient windows, insulation, heating, and air conditioning – is limited. Building occupants, likewise, have limited incentive to invest in energy-efficiency improvements for property they don't own and will not replace systems built into a home for many years. SOLUTION: Codes and standards remove the most inefficient products and design practices from the new construction marketplace. Building energy labels allow renters and buyers to anticipate energy costs before entering a lease or purchase.[26]

Lack of information – Most consumers do not have the time or knowledge to investigate the energy-using characteristics of the products they use and the buildings in which they live and work. SOLUTION: Product and building labels give consumers information they need to make sound purchase decisions. Codes and standards remove energy-inefficient products and buildings from the marketplace.

Utility regulation – Reducing electricity and gas demand may cost less than building new power plants, transmission lines or pipelines to meet growing demand. Utility profits, however, are most often based on sales, thus providing an incentive to increase sales and discouraging utility investments in demand-side management. SOLUTION: Utility regulatory practices can be revised to decouple increased electricity consumption from an electric utility's bottom-line to ensure that utilities are not penalized – or ideally are rewarded – for actions they take to improve customer efficiency.[27]

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[24] Taken almost in entirety from Joe Loper, Lowell Ungar, David Weitz and Harry Misuriello, *Building on Success, Policies to Reduce Energy Waste in Buildings*, Alliance to Save Energy, July 2005, p.8.
[25] Some environmental externality costs have been partly internalized through pollution control regulations. Notable exceptions include mercury, sulfur dioxide and nitrogen oxides, which by many accounts (e.g, the Attorney General of New York) are under-regulated and, of course, carbon dioxide emissions are currently not regulated at all.
[26] Building labels may not help with individual apartments.
[27] For a literature review on the subject, see The Regulatory Assistance Project, "Decoupling/Financial Incentives." http://www.raponline.org/Feature.asp?select=78.

To the extent there is a societal value ascribed to energy-efficiency improvements, governments may want to subsidize some or all of these costs. Depending on the particular type of cost barrier, policy interventions might include a carbon tax or cap, increasing energy prices, investment tax incentives, building energy codes, product standards, regulatory reforms, utility rebates, consumer education, product and whole-building labeling, demonstration projects, and/or research and development.

Difficulty Addressing Energy Use in Existing Buildings

Buildings typically last decades if not centuries. Many of the features of buildings that affect their energy consumption – e.g., solar orientation, windows, tightness, wall thickness, and distance from public transportation – largely will go unchanged throughout the life of the building. Technologies and practices affecting these long-lived systems will be slow to penetrate the building stock and affect overall efficiency.

Building energy codes typically target only new buildings and major renovations, which is important because today's new buildings are tomorrow's existing buildings. Bolstering new building codes would improve overall building energy use, but to significantly impact building energy use, policies that induce significant savings in existing buildings are necessary. Appliance standards, labels, benchmarking, continuous commissioning and several other measures are examples of policies that target appliances and other equipment used in existing buildings.

Translating Efficiency into Reduced Energy Demand – "Consumption-Based Efficiency"

It is not always clear to what extent efficiency improvements are translated into actual reductions in energy demand. While the energy efficiency of homes has increased, so has home size. The average home's floor area more than doubled between 1950 and 2000, as did floor area per capita; both square footage per home and per capita have increased by more than half just since the 1980s. (See Figure)[28] Similarly, according to EIA's Residential Energy Consumption Survey (RECS), refrigerator energy use per household was roughly the same in 1993 and 2005, even though energy use per unit virtually halved during that time period.[29] While it is possible that two-refrigerator households would be commonplace regardless of unit efficiencies, it can at least be said that the demand for new energy services has increased as fast as efficiencies.

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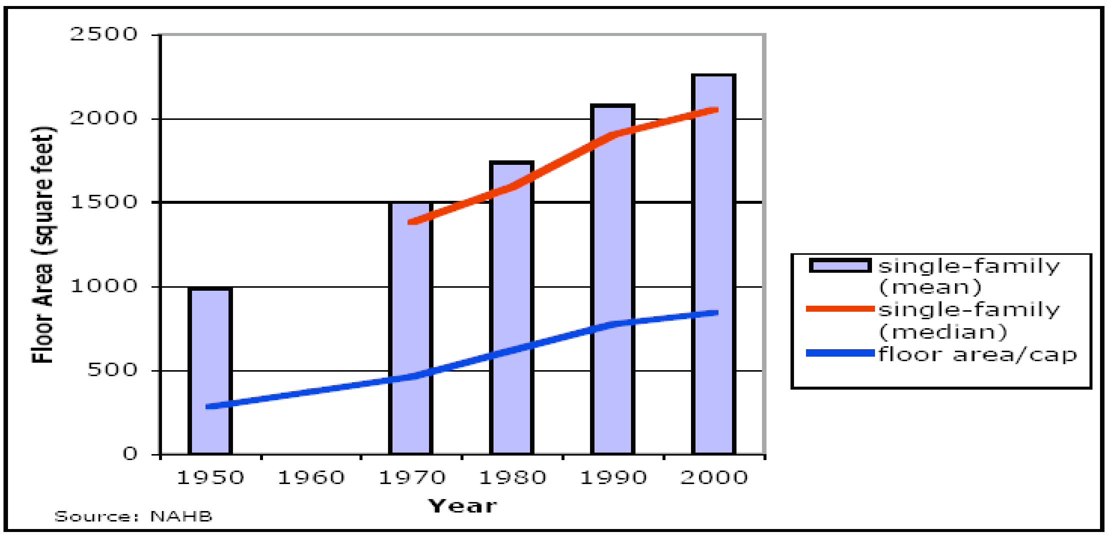
[28] National Association of Home Builders (NAHB), "Housing Facts: Figures and Trends 2003," 2003, Washington, DC.
[29] EIA, *Residential Energy Consumption Survey 1993*, 1993, Table 5.27, ftp://ftp.eia.doe.gov/pub/consumption/residential/rx93cet6.pdf & *Residential Energy Consumption Survey 2001*, 2001, Table CE5-1c, http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/appliances/ce5-1c_climate2001.pdf; estimated average household site electricity consumption for refrigerators was 5 million Btu in 2001 and 4.7 million Btu in 1993.

The demand for new energy services, such as second (and third) refrigerators and bigger homes, is driven by growing incomes, low energy prices, and reduced operating costs due, to some extent, to improved efficiency. Some reductions in demand from energy-efficiency improvements are "taken back" in the form of increased demand for less costly energy services – i.e., efficiency improvements result in lower energy costs for refrigeration which leads to increased demand for refrigeration. This snapback or rebound effect is estimated to be about 10-20% of the initial energy savings for most efficiency measures, although it can be as high as 50% in some cases, depending on several factors, including end-use and elasticity of demand.[30]

US House Size (floor area) Mean and Median 1950-2000[31]



Source: NAHB 2003

National Association of Home Builders (NAHB). 2003. "Housing Facts: Figures and Trends 2003." Washington, DC.

Some energy-efficiency programs may even be contributing to – or at least not dampening – the increased demand for bigger appliances. The categorization of energy-using products for purposes of standards and labeling development may provide some perverse incentives to purchase products that are bigger, more powerful or have more amenities. For example, ENERGY STAR (ES) label eligibility requirements for refrigerators vary by size – in some cases, the most efficient refrigerator in a larger class (which is therefore eligible for the ES label) may consume more energy than the least efficient in the smaller class (which is not eligible for the label). As a result, the ENERGY STAR label may inadvertently steer consumers toward "more efficient" refrigerators that are larger or have more amenities when the smaller refrigerator with fewer amenities and lower energy consumption might otherwise have been the choice.[32]

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[30] Howard Geller & Sophie Atali, *The Experience with Energy Efficiency Policies and Programmes in IEA Countries: Learning from the Critics*, International Energy Agency Information Paper, August 2005.
[31] As appears in Jeffrey Harris, Rick Diamond, Maithili Iyer, Chris Payne and Carl Blumstein, *Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency*, Environmental Energy Technologies Division, LBNL, 2006 ACEEE Summer Study on Energy Efficiency, p. 7-107.
[32] Harris et al., p. 7-108.

Policy Options for Increasing Efficiency of the Building Sector

Energy Pricing

- Price carbon and/or energy security into energy prices – as discussed above, there are environmental and national security costs that accompany energy consumption, but which are not currently included in the price of energy. Including these externalities, be it through a carbon tax, a carbon cap and trade, or a national security tax, would create more realistic energy prices and would encourage efficiency and conservation measures that currently are not cost-effective, as well as offer an incentive to consumers to modify their energy-consuming behavior. Measures which could become more cost-effective with higher energy prices include more stringent building codes and energy-efficiency appliance standards, research and development of alternative energy sources, and widespread dissemination of existing energy-efficient technologies.
- Consider revenue neutral tax reform – use revenues from a carbon or energy tax (or auction system, i.e. cap and trade) to reduce other tax burdens on investment or income, or to encourage and otherwise support investments in research, development and deployment of energy/carbon-reduction projects and technologies. Reducing sales or income taxes – especially on low-income consumers – not only could keep an energy tax revenue-neutral (making it more politically palatable), but could avoid placing an unfair burden on low-income consumers.

New and More Aggressive Appliance and Equipment Standards

Energy performance standards are an effective tool for improving the efficiency of appliances and other energy-using equipment. They target energy use in products that, individually, may not consume much energy but collectively represent a large portion of the nation's energy use.[33]

- Raise levels – DOE is scheduled to update several appliance and equipment efficiency standards by 2011. It is important that DOE issue the determinations, rulemakings and standards according to schedule, something it has not always been successful in doing in the past.
- New products – there are several products currently without efficiency standards for which a suggested standard has already been negotiated by industry stakeholders and environmental advocates. These standards include compact audio products (i.e. MP3 players), DVD players, pool heaters and residential furnaces and boilers, among several others. If all of the recommended standards were adopted on a national level, they could save an estimated 52 TWh of electricity in 2020 (about 2% of projected residential and commercial

[33] Excerpted from Loper et al, *Building on Success,* p.24.

consumption), and $54 billion for consumers and businesses from 2008 to 2030. They would also reap significant savings if implemented in individual states.[34]

<u>Building Energy Codes</u>

- Encourage state and local adoption of model energy codes - building energy codes reduce owners' and consumers' energy bills, save energy, and reduce pollution. To help states that wish to adopt their own building energy codes, national model energy codes are developed and updated every few years. Under federal law, states are required to adopt the updated model commercial code after the American Society of Heating, Refrigeration, and Air-Conditioning Engineers ASHRAE releases it and DOE issues a determination on the code (which it has taken them several years to do, in some cases). For residential codes, states are required to consider adopting a new code once DOE issues a determination, but they may reject it if they choose. In that case, they may adapt the model code to the state's particular needs, adopt an older version of the model code, adopt a code that is completely different from the national model code, or institute no energy code at all. In principle, states are required to submit a letter to DOE if they choose not to adapt the new code, but that law has not been strictly enforced. Currently, at least 41 states have adopted some form of energy building code, but their adoption is uneven.[35] For example, eight states have adopted the 2006 International Energy Conservation Code (IECC) as their residential energy code, while 16 states have energy codes that precede the 1998 IECC or follow no energy codes at all.[36]
- Develop and enforce a national commercial and residential code – building codes are implemented on a state-by-state basis. Opposition to a national code stems from the difficulty in enforcing a one-size fits all approach to buildings in vastly different climates. But the national model commercial energy code, has climate-specific recommendations, acknowledging the differences between buildings in different regions (e.g., Phoenix and Seattle.) And states can and should be allowed to make adjustments to the code to strengthen it, or adapt it for the inclusion of renewable energy, etc.
- Eliminate states' option to refuse to implement the model energy code but continue to allow them to adapt codes to best suit their particular state. States should have to justify their changes, however, to ensure that they do not render the codes meaningless as a way to avoid implementing them.
- Improve enforcement of existing codes – adoption of a building code does not guarantee energy savings – for that, code enforcement and compliance is essential. While there are over 90,000 code officials in the United States, code agencies are usually understaffed; if they need to prioritize, they will likely focus

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[34] Steven Nadel, Andrew deLaski, Maggie Eldridge, & Jim Kleisch, *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March 2006, http://www.standardsasap.org/a062.pdf.
[35] Largely excerpted from Loper et al, *Building on Success,* p.14.
[36] Building Codes Assistance Project, "Status of Residential State Energy Codes," March 2007, http://www.bcap-energy.org/map_page.php.

on building safety rather than energy performance. Inadequate training and supervision compounds the enforcement and compliance challenges. There is insufficient data to characterize national code compliance; however, at least some jurisdictions have reported that one-third or more of new buildings do not comply with critical energy code requirements for windows and air conditioning equipment, which are among the easiest energy-saving features to verify.[37]

If the US as a nation (or each state) adopted the most recent commercial and residential model energy codes (including future updates), improved compliance levels and applied model energy codes to manufactured housing, energy use would be reduced by about 0.85 quads annually, with cumulative savings through 2020 of about five quads. In 2020, the nation would reduce annual carbon dioxide emissions by more than 50 million metric tons, consumer energy bills would be almost $7 billion lower, and the construction of 32 new 400-MW power plants could be avoided.[38]

Existing buildings

Policies targeting existing building systems (as opposed to appliances and equipment) include, for example:

- Mandatory retrofits – Berkeley, California's Residential and Commercial Energy Conservation Ordinances, instituted in 1993, require energy conservation retrofits at the time of sale or when major retrofits are done. The ordinances cap the cost that must be incurred for compliance and provide an easily understood prescriptive compliance path.[39]
- Building audits and diagnostics – Energy audits are offered by many private energy consulting firms, energy services companies, and lighting, HVAC and control equipment vendors. Utilities and governments sometimes offer subsidies to help underwrite the cost of the audits.
- System tune-ups and commissioning – Building commissioning is "the process of ensuring that building systems and equipment are designed, installed, tested, and capable of being operated and maintained according to the owner's operational needs."[40] Several states offer financial and technical assistance for building commissioning and tune-ups, including (for example) Texas Loan Star program and the Energy Trust of Oregon, Inc., which work with organizations such as Texas A&M Energy Systems Laboratory and Portland Energy Conservation,

[37] Largely excerpted from Loper et al, *Building on Success*, pp.18-19. For a compilation of compliance studies, see U.S. Department of Energy, "Baseline Studies," January 12, 2007, http://www.energycodes.gov/implement/baseline_studies.stm. Arkansas reports 36 of 100 homes in the study sample did not meet the HVAC requirements of the state energy code.
[38] Largely excerpted from Loper et al, *Building on Success,* p.20.
[39] For more information, see Berkeley's Energy & Sustainable Development Office, which administers and oversees the program, at http://www.ci.berkeley.ca.us/sustainable/residents/ResSidebar/RECO.html.
[40] See Department of Energy, "Plan for Building Commissioning," July 8, 2004, http://www.eere.energy.gov/buildings/info/plan/commissioning.html.

Incorporated that have developed strong capacity in the building energy commissioning field.

- Tax incentives for retrofits – Several states offer tax incentives for buildings achieving LEED certification. The Energy Policy Act of 2005 created a federal tax deduction of $1.80 per improved square foot to owners of new or existing buildings who construct or reconstruct their buildings to reduce the building's total heating, cooling, ventilation, water heating and interior lighting energy cost by 50% or more compared to the ASHRAE Standard 90.1-2001 reference building. The provision also allows for partial tax deductions for efficiency improvements to individual building components.[41]
- Benchmarking and labeling programs – EPA's ENERGY STAR program provides resources through their Portfolio Manager program to help building operators and owners compare their buildings to other similar buildings, as well as an endorsement label for buildings that are in the top 25% efficiency for the class of buildings.
- Weatherization programs – The federal government and many states offer free or low-cost weatherization assistance for low-income households. These programs help reduce energy bills as well as billing payment arrears.

Consumption-Based Efficiency

Designing programs and policies that discourage (or at least don't encourage) increased demand for energy services (e.g., home size, amenities) is increasingly being explored, especially as part of building rating systems. Home rating systems in Portland, Oregon and Vermont, as well as the Leadership in Energy and Environmental Design rating for homes, provide credits for small homes.[42]

Some local governments now impose stricter efficiency standards or punishments on large homes. For example, Marin County, California requires that new homes over 3,500 square feet must be 25% more efficient than the state energy code and homes over 7,500 square feet must obtain 25% of energy requirements from on-site solar energy systems. Pitkin County and Aspen, Colorado impose fees on homes bigger than 5,000 square feet.[43]

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[41] Energy Policy Act of 2005, Section 1331; for more information see www.energytaxincentives.org.
[42] Harris, et al, p. 7-110.
[43] Harris, et al, p. 7-110.

Bibliography

Craig Canine, "California Illuminates the World," *OnEarth*, Natural Resources Defense Council, Spring 2006, http://www.nrdc.org/onearth/06spr/ca1.asp.

Neal Elliott, Maggie Eldridge, Anna Shipley, John "Skip" Laitner, and Steven Nadel, *Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy to Meet Texas's Growing Electricity Needs*, American Council for an Energy-Efficient Economy, Report Number E073, March 2007, http://aceee.org/pubs/E073.htm.

R. Neal Elliott, Maggie Eldridge, Anna M. Shipley, John "Skip" Laitner, Steven Nadel, Philip Fairey, Robin Vieira, Jeff Sonne, Alison Silverstein, Bruce Hedman & Ken Darrow, *Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands*, American Council for an Energy-Efficient Economy, Florida Solar Energy Center, and Energy and Environmental Analysis, Inc., Report E072, February 2007, http://www.aceee.org/store/proddetail.cfm?CFID=785209&CFTOKEN=22090724&ItemID=424&CategoryID=7.

Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030*, February 2007, http://www.eia.doe.gov/oiaf/aeo/index.html.

Energy Information Administration, *Annual Energy Review 2005*, July 27, 2006, http://www.eia.doe.gov/emeu/aer/contents.html.

Energy Information Administration, *Electric Power Annual with data for 2005*, November 2006, http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html.

Energy Information Administration, *Residential Energy Consumption Survey 1993*, 1993, ftp://ftp.eia.doe.gov/pub/consumption/residential/rx93cet6.pdf.

Energy Information Administration, *Residential Energy Consumption Survey 2001*, 2001, http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/appliances/ce5-1c_climate2001.pdf.

Howard Geller & Sophie Atali, *The Experience with Energy Efficiency Policies and Programmes in IEA Countries: Learning from the Critics*, International Energy Agency Information Paper, August 2005.

Clark Gellings, Greg Wikler and Debyani Ghosh, "Assessment of U.S. Electric End-Use Energy Efficiency Potential," *The Electricity Journal*, November 2006, Vol. 19, Issue 9, Elsevier Inc, 2006.

Kenneth Gillingham, Richard Newell and Karen Palmer, *Retrospective Examination of Demand Side Energy Efficiency Policies*, Resources for the Future, Discussion Paper 04-19, June 2004, revised September 2004, http://www.rff.org/Documents/RFF-DP-04-19REV.pdf.

Global Energy Partners, LLC, *California Summary Study of 2001 Energy Efficiency Programs*, March 13, 2003, http://www.calmac.org/publications/CALMAC_final_03-13-03.pdf.

S. W. Hadley, *The Potential for Energy Efficiency in the State of Iowa*, Oak Ridge National Laboratory, sponsored by The Iowa Energy Center, June 2001, http://www.ornl.gov/sci/engineering_science_technology/cooling_heating_power/Restructuring/IowaEEPotential.pdf.

Jeffrey Harris, Rick Diamond, Maithili Iyer, Chris Payne and Carl Blumstein, *Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency*, Environmental Energy Technologies Division, LBNL, 2006 ACEEE Summer Study on Energy Efficiency.

ICF Consulting, *Assessment of Energy Efficiency Potential in Georgia,* Prepared for Georgia Environmental Facilities Authority, May 5, 2005, http://www.georgiaenergyplan.org/suppmat/StrategiesforCapturingGeorgiasEEPotential.pdf.

Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, ORNL/CON-476 and LBNL-44029, November 2000, http://www.ornl.gov/sci/eere/cef/.

Joe Loper, Lowell Ungar, David Weitz and Harry Misuriello, *Building on Success: Policies to Reduce Energy Waste in Buildings*, Alliance to Save Energy, July 2005, http://www.ase.org/images/lib/buildings/Building%20on%20Success.pdf.

McKinsey Global Institute, *Productivity of Growing Global Energy Demand: A Microeconomic Perspective,* November 2006.

Steven Nadel, Andrew deLaski, Maggie Eldridge, & Jim Kleisch, *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March 2006, http://www.standardsasap.org/a062.pdf.

Steven Nadel and Bill Prindle, *Supplementary Information on Energy Efficiency for the National Commission on Energy Policy*, American Council for an Energy Efficient Economy, July 2004.

Steven Nadel, Anna Shipley, and R. Neal Elliott, *The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. - A Meta-Analysis of Recent Studies*, American Council for an Energy-Efficient Economy, ACEEE Conference Proceedings, August 2004, http://aceee.org/conf/04ss/rnemeta.pdf.

National Association of Home Builders (NAHB), "Housing Facts: Figures and Trends 2003," 2003, Washington, DC.

Northwest Power and Conservation Council, *The Fifth Northwest Electric Power and Conservation Plan*, May 2005, http://www.nwcouncil.org/energy/powerplan/plan/Volume1_screen.pdf.

John Plunkett, Phil Mosenthal, Chris Neme, *Electric and Economic Impacts of Maximum Achievable Statewide Efficiency Savings, 2003-2012: Results and Analysis Summary,* Optimal Energy, Inc., prepared for Vermont Department of Public Service, Public Review Draft, January 31, 2003, http://www.optenergy.com/pdf/vtpower.pdf.

Puget Sound Energy, *Least Cost Plan Update: Chapter IV. Electric and Natural Gas Conservation Potential Assessment*, August 2003, http://www.wutc.wa.gov/rms2.nsf/0/EA60E866AE7FC1A388256D970070B8A6/$file/04_elec_and_gas_conservation_potential_assessment.pdf.

The Regulatory Assistance Project, "Decoupling/Financial Incentives." http://www.raponline.org/Feature.asp?select=78.

Arthur H. Rosenfeld, "Past and Current Efficiency Successes and Future Plans," California Energy Commission, for ACEEE: Energy Efficiency as a Resource, Berkeley, California, September 26 & 27, 2005, http://www.aceee.org/conf/05ee/05eer_arosenfeld.pdf.

Art Rosenfeld, *Improving Energy Efficiency, U.S. and West Coast*, Presentation for the Joint Commissions Energy Efficiency Workshop, December 1, 2006.

Southwest Energy Efficiency Project, *The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest*, November 2002, http://www.swenergy.org/nml/New_Mother_Lode.pdf.

U.S. Department of Energy, "Baseline Studies," January 12, 2007, http://www.energycodes.gov/implement/baseline_studies.stm.

U.S. Department of Energy, "Plan for Building Commissioning," July 8, 2004, http://www.eere.energy.gov/buildings/info/plan/commissioning.html.