Reducing Carbon Dioxide Emissions through Improved Energy Efficiency in Buildings

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Introduction and Overview[1]

The US building sector is currently responsible for 2.3 gigatons (Gt) of CO_2 emissions[2] annually, roughly 40 percent of the US total. By 2050, based on current trends, US buildings will emit about 3.7 Gt of carbon a year, a 36 percent increase from today's levels.[3] By implementing aggressive but cost-effective energy-efficiency practices, US building emissions could be reduced by 35 percent from projected levels in 2050, largely eliminating the projected increase in energy use even without assuming major carbon pricing policies.[4]

Buildings are important to climate change not only because of how much energy they use, but also because of how long they last. About half of the buildings in the US were constructed before 1970,[5] and we can expect that more than half of today's buildings will still be in use by mid-century. The designs and technologies used in each new structure constitute a resource commitment that for better or worse will have an impact as long as the building stands (though the building may later be retrofitted with more efficient features). That enduring commitment affects the power grid, energy supplies, air quality, public health, the occupants' cash flow and the climate.

The good news is that individual buildings and the equipment inside them are becoming more efficient and less polluting. Commercial lighting power demand has been cut in half in recent years;[6] a home built in 2001 uses 12 percent less energy per square foot than one built in the 1980s;[7] and new refrigerators consume about one-fourth the energy of those sold 30 years ago.[8]

The bad news is despite these gains, overall energy consumption and carbon emissions from the buildings sector are rising because the number of buildings, their size and their "plug loads" all are growing. Residential energy use has increased by more than one-third since 1980 and commercial building use by nearly three-fourths.[9] Square footage

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[1] Thanks to Jeff Harris and Aleisha Khan for their review and helpful comments and to Joe Cohen for data research and analysis.
[2] Throughout this report, CO_2 emissions refer to energy-related CO_2 emissions only.
[3] Energy Information Administration (EIA), *Annual Energy Outlook 2008 with Projections to 2030*, March 2008, Table A18, with average percentage increases from 2006 to 2030 extended through 2050.
[4] According to EIA, in 2030, residential and commercial natural gas and electricity prices are projected to be lower than they are today. EIA, *Annual Energy Outlook 2008* Table A3.
[5] EIA, *Residential Energy Consumption Survey 2001*, Table HC1-4a, http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-4a_housingunits2001.pdf, and EIA, *Commercial Buildings Energy Consumption Survey 2003*, Table A1, http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set1/2003pdf/a1.pdf.
[6] Mark Heizer, P.E., *Saving Energy in Office Buildings, Heating, Piping and Air Conditioning* Engineering, May 2003, as cited in *Building on Success: Policies to Reduce Energy Waste in Buildings*, note 2, p. 68.
[7] EIA, *Residential Energy Consumption Survey 2001*, Table CE1-6.2u, http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/enduse/ce1-62u_sqft_useind2001.pdf.
[8] Natural Resources Defense Council, *Issues: Oil & Energy; Efficient Appliances Save Energy – and Money*, August 31, 2004, http://www.nrdc.org/air/energy/fappl.asp.
[9] EIA, *Monthly Energy Review*, March 2008, Tables 2.2 & 2.3, http://www.eia.doe.gov/emeu/mer/consump.html.

per home has increased by more than 50 percent since the 1980s,[10] air conditioning has become common, washers and dishwashers are standard appliances in most households, and the use of personal electronics has increased sharply. In commercial buildings, energy use per square foot increased 10 percent between 1992 and 2003,[11] in large part due to growing electricity use for computers, office equipment, and other electronics.

If, due to carbon policies or market factors, energy prices were to increase significantly, more energy-efficient measures and policies would become cost-effective.[12] Consequently, capturing the real cost of emitting greenhouse gas (GHG) emissions through carbon pricing is one of the most important actions that can be taken to stimulate significant reductions in building-related (and economy-wide) emissions.[13] Carbon pricing would encourage building efficiency improvements and, importantly, help slow and reverse the rapid growth in demand for energy services currently occurring as a result of increased house size and electric plug loads.

Even with extensive carbon pricing, significant additional policy efforts will be required to overcome market barriers and achieve the full cost-effective energy-efficiency potential in buildings. Major impediments to the implementation of cost-effective efficiency improvements include lack of information, the low cost of energy as a share of income (although the effect of this barrier could be mitigated through aggressive carbon pricing), and split incentives – for example those between tenants and landlords. (For more detail on barriers to energy-efficiency improvements, see Appendix 1)

Achieving an 80 percent reduction in CO_2 emissions below 1990 levels by 2050 (90 percent below our baseline projections) will require the full panoply of energy-efficiency policy tools, along with a major shift in the electric power sector fuel mix and significant advancement of current energy-related technologies.[14] Key energy-efficiency policy options include energy performance standards for appliances and equipment, building energy codes, utility and state demand-side management and market-transformation programs, tax incentives, and research and development of building technologies.[15]

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[10] National Association of Home Builders (NAHB), *Housing Facts: Figures and Trends 2003*, 2003, Washington, DC.

[11] EIA, *Commercial Buildings Energy Consumption Survey 2003*, Table C3, http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003excel/c3.xls; and *Commercial Buildings Energy Consumption Survey 1992*, Table 3.4, ftp://ftp.eia.doe.gov/pub/consumption/commercial/cbcetb92.pdf.

[12] According to EIA, in 2030, residential and commercial natural gas and electricity prices are projected to be slightly lower than they are today. EIA, *Annual Energy Outlook 2008* Table A3.

[13] Currently, the price of energy does not take into account the externality costs of the environmental damage that is done by emitting carbon.

[14] Reducing emissions by 80 percent below 1990 levels by 2050 is the commonly accepted target for the US in order to keep global temperatures from rising by 2 degrees Celsius above pre-industry temperatures. If not accompanied by similar (if less stringent in many places) emissions reductions throughout the rest of the world, however, US reductions will not be sufficient to forestall the temperature rise.

[15] Government energy management and location efficiency (e.g., "Smart Growth") policies are beyond the scope of this report.

In this report, we identify a set of energy-efficiency policies that would have a reasonable chance of cutting emissions growth from the buildings sector to nearly zero, a 35% cut from projected emissions. Again, while all of these policy options are, to a large extent, cost-effective on their own merits, their cost-effectiveness would increase greatly with economy-wide carbon pricing. The higher the price on carbon, the more energy can be saved cost-effectively through energy-efficiency policies, as well as through price-induced efficiency.

At current price levels, additional policies beyond those discussed in this report will be required to achieve emissions reductions of 80 percent below 1990 levels in the buildings sector, such as policies to reduce the carbon intensity of electric generation, promote investments in onsite renewable energy and slow growth in demand for energy services. The supply-side measures are beyond the scope of this paper, but we will briefly address one proposal aimed at reducing the size of residential buildings.

Buildings Carbon Reduction Policy Scenarios

To achieve building sector CO_2 emissions levels of 80 percent below 1990 levels in 2050 will require a 90 percent reduction from baseline projections. Economy-wide, projected 2050 emissions are about 7.8 Gt, compared to 5 Gt in 1990 and 6 Gt today.[16] In other words, achieving emissions levels of 80 percent below 1990 levels in 2050 would require a reduction of 6.8 Gt below baseline (5 Gt below today's emissions).

In the buildings sector, projected emissions are 3.7 Gt in 2050 compared to 1.7 Gt in 1990 and 2.3 Gt today. The building sector's share of emissions reductions would be roughly 3.3 Gt in 2050.[17] The energy-efficiency policies in this report are designed to capture nearly 40 percent of the CO_2 reductions needed in the buildings sector by 2050 – 1.26 Gt. Changes in the fuel mix, on-site renewable energy investments and further reduced demand for energy services would need to account for the remaining emissions cuts necessary to achieve the goal.

In December 2007, the Energy Independence and Security Act of 2007 (EISA) was enacted. This bill includes a number of new appliance efficiency standards, new criteria for federal and other buildings, and authorization of new federal programs.[18] After the bill was signed, the Energy Information Administration (EIA) significantly reduced its projections of GHG emissions due to expected impacts of the new law, as well as to independent changes in projected energy prices. Despite the lower projected baseline GHG emissions, however, several provisions that were included in previous iterations of the energy bill (including the House-passed H.R. 3221 in August and H.R. 6 in December and the Senate-passed H.R. 6 in June) and could have had at least as great an impact on building energy use were left out of the final bill, including a provision on building energy codes, a standard for renewable electricity and electricity savings, and tax incentives for energy-efficient buildings and equipment.

In this report, our baseline case is EIA's Annual Energy Outlook (AEO) 2008 reference scenario, which we call the "EISA (NAR)" (No Action Required) scenario, and which only includes savings from those EISA provisions that do not require rulemakings or appropriations to be implemented.[19] (See Appendix 2 for the savings estimates from EISA in 2050.) Buildings sector-related provisions from EISA that are incorporated into the baseline include new lighting energy-efficiency standards and new and updated appliance energy-efficiency standards for boilers, dehumidifiers, dishwashers, clothes

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[16] 2050 estimates projected by the Alliance to Save Energy (ASE), based on EIA, *Annual Energy Outlook 2008*, Table A18; historical emissions data from EIA, *Annual Energy Review 2006*, June 27, 2007, Table 12.2, p. 343.
[17] EIA, *Annual Energy Outlook 2008*, Table A18.
[18] EISA also included a major increase in corporate average fuel economy (CAFE) standards and a renewable fuel standard (RFS) for vehicles. That, of course, is outside the scope of this report, however.
[19] AEO 2008 does not take into account savings from external power supply efficiency standards even though EISA does not require further rulemaking for this provision.

washers, and walk-in refrigerators and freezers.[20] According to Alliance to Save Energy (ASE) calculations based on American Council for an Energy Efficient Economy (ACEEE) savings estimates, these provisions save 1.6 quads of energy in 2030 and nearly 2 quads in 2050. CO_2 reductions equal nearly 115 MMT of CO_2 in 2030 and 150 MMT in 2050.[21]

As a first step in meeting the carbon reduction targets, we propose full implementation of the provisions in EISA that need additional action before they take effect, including: issuing final rulemakings on the furnace fan, standby mode and regional heating and cooling standards, and funding of the Zero-Net-Energy Commercial Buildings Initiative (CBI). We further propose the enactment and implementation of the enhanced buildings codes, utility energy-efficiency programs, and tax incentives for appliances and commercial buildings that were included in the House-passed H.R. 3221, as well as the tax incentives for new energy-efficient homes and energy-efficiency improvements to existing homes that were included in the Senate-passed H.R. 6.

If fully implemented, these measures (discussed in greater detail below) would realize additional savings of 3.5 quads of energy in 2030 (7% below baseline) and 7.3 quads in 2050 (11% below baseline). Expected CO_2 reductions would equal around 207 MMT of CO_2 in 2030 and 431 MMT in 2050.[22] We call this the "EISA (AR)/HR3221+" (Action Required) scenario to reflect that continuing implementation and funding would be needed.

H.R. 3221 would have required electric utilities to reduce their carbon emissions through a renewable portfolio standard (RPS) requiring them to meet 15 percent of demand through renewable energy, of which end-use energy-efficiency programs could account for 27 percent. While the establishment of a national RPS with an energy-efficiency component would be a step in the right direction, utility energy-efficiency programs could achieve more.[23]

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[20] AEO 2008 projections also take into account savings from provisions to reduce energy consumption in Federal buildings, update the renewable fuel standard (RFS), increase the corporate average fuel economy (CAFE) standard for new light-duty vehicles, and implement industrial motor efficiency standards.

[21] ACEEE, *Energy Bill Savings Estimates as Passed by the Senate, ACEEE's assessment of the potential energy, carbon and economic savings*, December, 2007 http://www.aceee.org/energy/national/EnergyBillSavings12-14.pdf (Alliance calculations assume increase of savings proportional to baseline energy use through 2050)

[22] We assume that savings from most of the standards and policies will be ramped up in the future at the same rate at which energy use grows. This does not hold true for building codes, which will increase its annual savings as new buildings (and building renovations) subject to the code become a higher fraction of the stock. For more detailed assumptions and method for calculating building code impacts, see Appendix 3.

[23] In fact, ACEEE estimates that most of the savings achieved through the efficiency component of the RPS will probably occur even though the legislation did not pass. So while utilities would claim credit for energy-efficiency programs to the maximum four percent allowed by the law, actual additional savings due to the policy would only be 0.9 percent of baseline electricity sales (49 TWh). B. Prindle et al., *Assessment of the House Renewable Electricity Standard and Expanded Clean Energy Scenarios*, Report E079, ACEEE, December 2007. We assume that by 2050, there would be no additional savings from the efficiency component of the RPS.

Our "Real EERS" scenario includes an EERS that would require utilities to reduce electric sales by 1 percent annually compared to their previous year's sales through energy efficiency measures, and reduce natural gas sales annually by 0.5 percent of the previous year's sales, starting in 2010. If fully implemented, building energy use in 2050 would be reduced by an additional 14.54 quads (beyond the EISA (AR)/HR3221+ scenario) and CO_2 emissions would be reduced by an additional 0.81Gt.[24]

Finally, as a start to addressing the growing demand for energy services, we include a policy designed to curb the energy consumption increases associated with the trend toward increasingly bigger homes. Policies targeting growing home sizes, increased plug loads, and other lifestyle issues may ultimately need to be part of the climate policy arsenal. While most observers recognize this problem, policies to address it, other than carbon pricing, have been few and far between.

In 2007, however, the Chairman of the House Energy and Commerce Committee, Representative John Dingell (D-MI), proposed legislation to encourage owners of homes bigger than 3,000 square feet to achieve the US Green Building Council's (USBBC) Leadership in Energy and Environmental Design (LEED) certification.[25] Under Rep. Dingell's plan, if these homeowners did not achieve LEED certification, the federal home mortgage interest deduction would be phased out, based on the size of their home. For instance, a 3,100 square foot home would be eligible for 85 percent of the deduction, while a home of 3,900 square feet would only be eligible for 25 percent of the deduction, and homes larger than 4,200 square feet would no longer be able to claim any deduction at all. Assuming homeowners chose to obtain LEED certification, implementation of this policy – the "LEED large homes" scenario – could reduce energy use by as much as 0.5 quads and reduce CO_2 emissions by 0.03 Gt in 2050.[26]

By 2050, combined savings from implementation of the EISA (AR)/HR3221+, Real EERS, and the LEED large homes scenarios would approach 1.27 Gt and building energy consumption would be reduced by nearly 22.34 quads.[27]

[24] ASE calculations. Our baseline energy consumption was based on EIA projections through 2030, extended out at the same average annual rate of growth through 2050. We reduced this number by the annual 2050 savings we project for the H.R. 3221+ savings. Our Real EERS savings take into account the existing EERSs in several states, and phase those states in only when the national EERS would mandate greater savings than their current plan calls for.

[25] LEED is a benchmark rating system for the design, construction and operation of high performance green buildings in the US. For more information, see its website at http://www.usgbc.org/DisplayPage.aspx?CategoryID=19.

[26] Details of the Dingell proposal are provided in Appendix 4.

[27] In addition to the policies listed above, this report includes discussion of policies such as increasing and appropriating funds for weatherization assistance program, Energy Star and commercial buildings initiative. The savings from these measures are not included in the calculations because such saving estimates are not readily available and/or are uncertain.

Climate Action Plan for Residential and Commercial Buildings				
	Policies	**Description**	**Primary Energy Savings in 2050 (Quads)**	**Carbon Dioxide Reduction in 2050(MMT)**
EISA (AR)/ H.R. 3221+	Appliance Standards	Furnace Fan standard Process Regional heating and cooling standards Standby Mode	0.49	32.08
	RPS	Efficiency Component	0	0
	Building Codes	Improvement of building codes to achieve 30% savings by 2010 and 50% savings by 2020 in residential and commercial model building energy codes compared to the 2006 and 2004 requirements Manufactured housing code at least as stringent as the IECC national model code.	6.18	360
	Tax Incentives	Appliances Commercial Buildings New and Existing Homes	0.64	39.20
Real EERS		• Starting in 2010, electric utilities reduce electric sales annually by 1 percent of the previous year's sales through energy-efficiency measures • Natural gas utilities are required to reduce gas sales annually by 0.5 percent of the previous year's sales.	14.54	807.34
LEED Green Buildings Requirement for Large Homes		Starting in 2010, homes 3,000 square feet (sf) and larger would be required to obtain LEED certification. • Homes that do not comply would receive only partial mortgage interest deduction, according to the following phase-out schedule, falling from 85% of deduction for homes over 3000 sf to no deduction for homes over 4200 sf	0.49	30.00
Total Savings/Reduction beyond EISA (NAR)			22.34	1268.62

The figure below shows current CO_2 emissions from US buildings, US building CO_2 emissions in 1990, and projected US buildings sector CO_2 emissions in 2050 under four different scenarios:

1) a baseline case for US buildings sector emissions before the passage of EISA: "Pre-EISA Baseline";

2) the EISA (NAR) new baseline case reflecting the impacts of the provisions in EISA that do not require further action;

3) the EISA (AR)/HR3221+ scenario reflecting the energy-savings impacts of the building-related provisions in EISA that require further action, as well as the building-related provisions in H.R. 3221 and the building tax incentives in H.R. 6;

4) the +Real EERS case including a more stringent EERS along with the aforementioned policies; the +LEED case reflecting the additional impacts of the LEED large buildings policy discussed above.

As shown, the most aggressive case stabilizes CO2 emissions at roughly current levels. An additional 2 Gt reduction in CO2 emissions will need to be obtained through increased use of on-site renewable energy, other changes in the building and power generation fuel mix, or other energy services and energy-efficiency policies in order to achieve 80% below 1990 emissions levels in the buildings sector.

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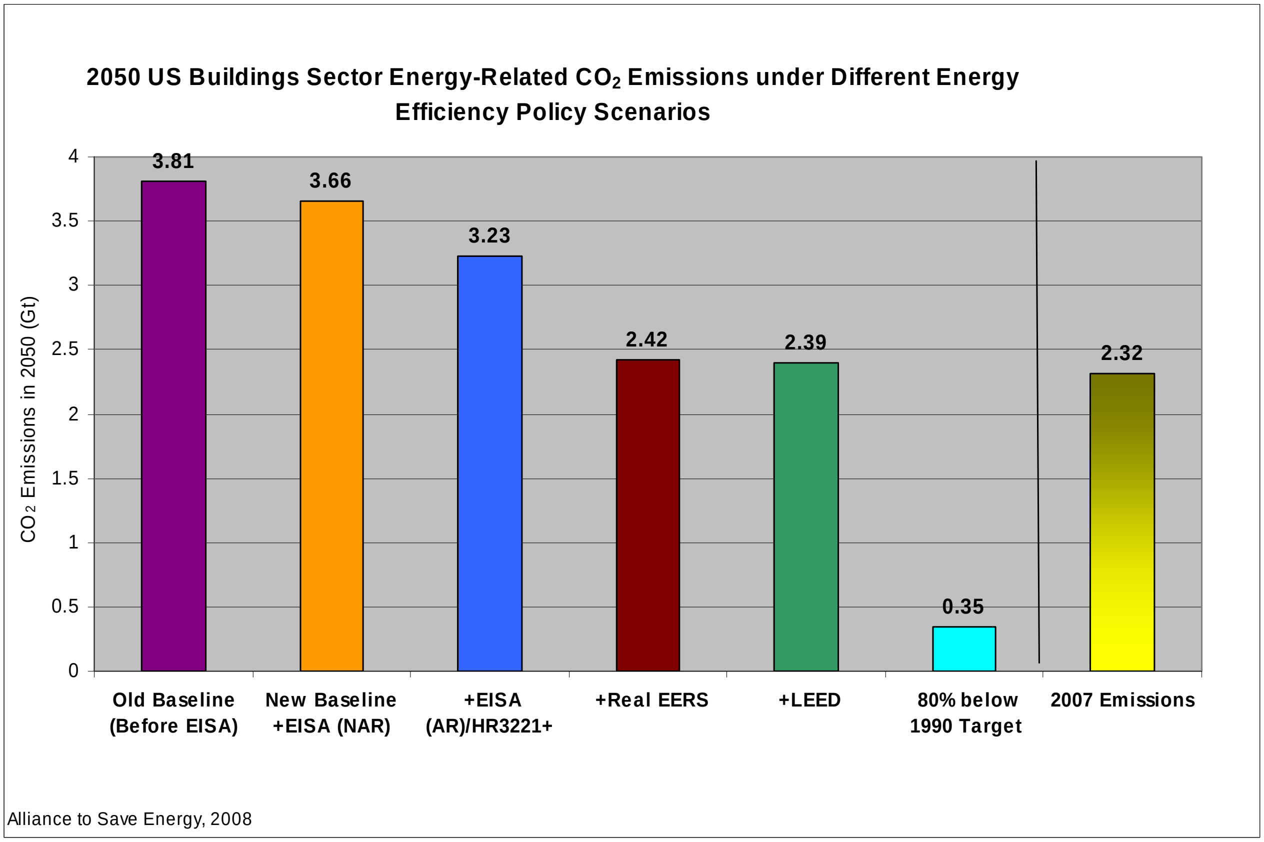
2050 US Buildings Sector Energy-Related CO2 Emissions under Different Energy Efficiency Policy Scenarios
CO2 Emissions in 2050 (Gt)
0
0.5
1
1.5
2
2.5
3
3.5
4
3.81
3.66
3.23
2.42
2.39
0.35
2.32
Old Baseline (Before EISA)
New Baseline +EISA (NAR)
+EISA (AR)/HR3221+
+Real EERS
+LEED
80% below 1990 Target
2007 Emissions
Alliance to Save Energy, 2008

Policies to Reduce Carbon Dioxide in Buildings[28]

Appliance and Lighting Standards

Energy-efficiency standards for residential and commercial appliances target energy use in products that, individually, may not consume much energy but collectively represent a large portion of the nation's energy use. Equipment subject to energy-efficiency standards was responsible for well over 50 percent of building energy consumption in 2007.[29]

Appliance and equipment standards complement building codes and other policies by targeting many products not subject to building codes and by ensuring that new appliances are more efficient than the appliances they replace. These standards will become even more important, since energy use in equipment and appliances not typically covered by building codes is expected to grow much faster than systems included in codes. For example, energy consumption from commercial building lighting, water heating, space heating and air conditioning – all of which are covered by building codes – is projected to increase 16 percent through 2030. Energy used by equipment typically external to building codes – e.g., office equipment, kitchen equipment, medical and lab equipment and other special-purpose equipment – is projected to increase 55 percent over the same period.[30]

Individual appliances often don't represent a large share of total building energy use, so residential consumers are unlikely to take the time to consider the energy implications of their purchase decisions. In commercial buildings, energy bills are frequently allocated by square footage rather than by actual energy use, so tenants have little incentive to consider energy performance when purchasing office supplies or appliances. Collectively, however, these purchases have a significant impact on building energy use.

As of 2000, appliance standards were saving an estimated 1.2 quads of energy annually in residential and commercial buildings.[31] The Appliance Standards Awareness Project (ASAP) estimates that future energy savings from existing standards (adopted before EISA) will equal 4.9 quads, the equivalent of the energy used by about 27 million American households, in 2020.[32] These savings could be much larger if the Department of Energy (DOE) met its congressionally prescribed schedules for developing and issuing

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[28] Portions of this section are adapted from Joe Loper, Lowell Ungar, David Weitz and Harry Misuriello, *Building on Success, Policies to Reduce Energy Waste in Buildings*, ASE, July 2005, p.24; and from Joe Loper, Selin Devranoglu, Steve Capanna, and Mark Gilbert, *Energy Efficiency Potential in American Buildings*, ASE and American Electric Power, 2007.
[29] EIA, *Annual Energy Outlook 2008*, Tables A2, A4 and A5.
[30] EIA, *Annual Energy Outlook 2008*, Table A4.
[31] Jennifer Thorne, Toru Kubo, and Steven Nadel, *Opportunity Knocks: Capturing Pollution Reductions and Consumer Savings from Updated Appliance Efficiency Standards*, Appliance Standards Awareness Project (ASAP), March, 2000
[32] Appliance Standards Awareness Project, *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March, 2006. http://www.standardsasap.org/documents/a062.pdf.

new appliance standards and if it set standards at the maximum feasible level as required by law.

ACEEE estimates that the buildings-related appliance standards in EISA will lead to annual savings in 2030 of 95.6 Terawatt-hours (TWh) of electricity, 518 billion cubic feet (bcf) of natural gas and nearly 1.1 quads of overall energy use, and will avoid the emission of 74 MMT of CO_2.[33] These energy savings represent almost one percent of overall US projected demand and nearly two percent of projected residential and commercial building demand.[34] In 2050, these savings are estimated to reach 1.3 quads and 92 MMT of CO_2 emissions.[35]

Issuing appliance standards on a timely basis

Determinations or standards for 25 products are currently pending, 14 of which are past due.[36] Some standards authorized in 1992 are still awaiting final rulemakings. After several states sued DOE for failing to meet legal deadlines, DOE is now operating under a schedule set as part of the lawsuit.

DOE's failure to issue standards prevents efficiency improvements in individual states, since they are generally precluded from issuing their own standards once the federal government develops standards on a particular product category. Federal preemption of state standards encourages manufacturers to support federal standards, since they would rather design their products to meet one national standard than have to tailor their products to different state laws. Consequently, a major driver for national standards has been the threat of states adopting their own standards. Many of the standards authorized in the Energy Policy Act of 2005 (EPAct 2005) were being adopted by states, for instance.[37] But if DOE fails to issue final rulemakings on passed standards then states – even those that previously enacted standards on a given product category – cannot pass or enforce standards, even though the federal standard cannot be implemented.

EPAct 2005 and EISA added a number of additional rulemakings to DOE's plate. EISA included new and updated energy-efficiency standards agreed upon by manufacturers and efficiency advocates for several appliances used in residential and commercial buildings, including residential clothes washers, dishwashers, and dehumidifiers; incandescent reflector lamps and metal halide fixtures; external power supplies; walk-in freezers; and

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[33] American Council for an Energy-Efficient Economy (ACEEE), *H.R. 3221 as Passed by the House: ACEEE's assessment of the potential energy and carbon savings*, August 21, 2007, http://www.aceee.org/energy/national/HouseBillSavings8-21.pdf.
[34] EIA, *Annual Energy Outlook 2008 with Projections to 2030*, Office of Integrated Analysis and Forecasting, U.S., March 2008, Table A2,.
[35] ASE calculations based on ACEEE estimates, March, 2008
[36] Personal Correspondence with Andrew Delaski, Appliance Standards Awareness Project, 31 March, 2008
[37] Appliance Standards Awareness Project, *State Appliance and Equipment Energy Efficiency Standards: Status and Implementation Dates*, July 2006, http://www.standardsasap.org/06stateupdate.pdf.

others.[38] EISA also directed DOE to issue rulemakings on other products on which there was not agreement, including refrigerators and electricity use by furnaces (for furnace fans).[39]

Recommendation: DOE should increase staff and funding for the appliance standards program, adhere to its schedule for rulemakings, and add the important rulemakings under EPAct 2005 and EISA to its schedule. If DOE fails to complete the updates, Congress should consider ending preemption of state standards for those products.

Furthermore, updating standards regularly is imperative in order to capture all of the available savings for a given product. Appliance and product standards save energy only as long as they are kept up to date. Because of technological breakthroughs, rising costs of energy, and market transformation, appliance efficiency changes rapidly, and existing standards stop pushing the market and begin to do nothing more than enforce the status quo.

Section 305 of EISA directs DOE to review each existing appliance and equipment standard within six years of the last final rule or three years of the last review, and, if warranted, to set an updated standard within two more years. It also sets a timetable for adopting standards for certain products set in the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) model commercial building energy standard. It makes revised standards effective three years after the final rule, as opposed to the five-year lag that previously existed for many products., Finally, it directs DOE to review test procedures for all covered products at least every seven years.[40]

Recommendation: DOE should set a schedule for periodic review of all standards and test procedures, as required in EISA.

DOE officials give several reasons for missing the deadlines, including a more time-consuming process for approving standards that was created during the Clinton administration and a one-year moratorium on new standards imposed by Congress at the same time. In some cases, manufacturers and advocacy groups have turned to Congress to legislate non-controversial, consensus-based standards to eschew DOE's onerous rulemaking process.

EISA eliminated the requirement for an advanced notice of proposed rulemaking when setting a standard (DOE still must issue analysis and a notice of proposed rulemaking before the final rule). In addition, EISA allows DOE to issue direct final rules on standards recommended jointly by manufacturers, states, and efficiency advocates. If there are adverse public comments, the direct final rule would be withdrawn, and DOE would enter into the standard rulemaking process.

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[38] ASE, *2007 Energy Bill Detailed Summary*, December 2007, http://www.ase.org/files/4172_file_energy_bill_2007_summary.pdf

[39] Section 304 and Section 311 of EISA

[40] For many products there are specific requirements to do one or two reviews of the standard. The new general requirements will apply after the end of the product-specific requirements.

Recommendation: DOE should take advantage of its new authority to issue standards more expeditiously.

Maximizing savings from standards

DOE is required by law to set appliance and equipment standards “to achieve the maximum improvement in energy efficiency [that] is technologically feasible and economically justified.”[41] Yet recent standards have been weaker than levels that DOE’s own analysis suggested would save consumers the most money. This is in large part because of language in the law that has been interpreted as preventing DOE from setting certain kinds of standards.

Despite manufacturers’ preference for a single national standard for each product, in the case of heating and cooling equipment, regional climate differences warrant different levels of efficiency, and in some cases different heating and cooling technologies. DOE inferred from the earlier law language[42] that it did not have the authority to set regional standards. As a result, the new federal standard[43] for residential furnaces is very weak – it does not take effect until 2015 but is already met by 99 percent of furnaces sold today – even though much more efficient “condensing” furnaces are very cost-effective in most regions and already make up more than half the market in some states.[44] EISA explicitly allows DOE to set different standards in up to two regions for furnaces and up to three regions for central air conditioners and heat pumps.

DOE also believes that it cannot set multiple standards for a single product, even if the product consumes two kinds of fuel (such as furnaces that use both natural gas and electricity), or when multiple criteria (such as total electricity use and peak electricity demand from air conditioners) would yield greater savings than a performance standard. Both the House and Senate-passed energy bills in 2007 included a provision to clarify DOE’s authority to set multiple standards in some cases, but the provision was not included in EISA.

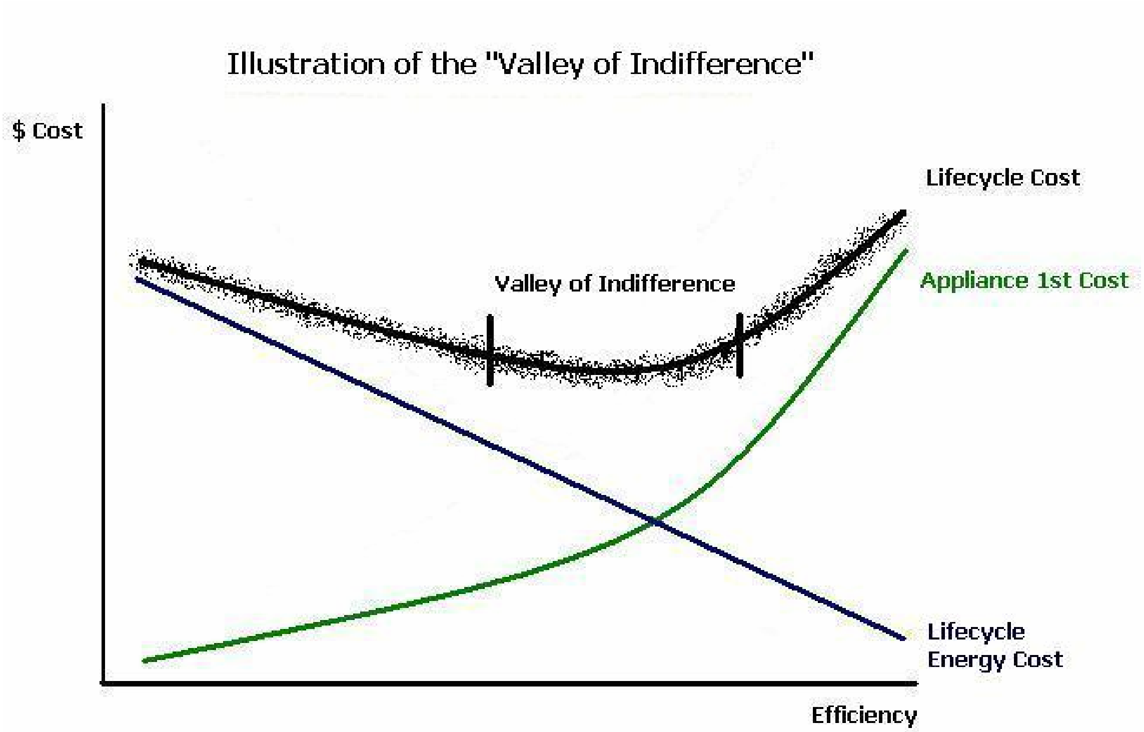
An additional shortcoming in current federal appliance standards is the lack of consideration for standby power. Standby power is power that appliances and electronics consume when not in use. For instance, the clock on a microwave oven continues to consume electricity even when the microwave is otherwise “off.” As of 2002, Lawrence Berkeley National Laboratory estimates that standby power represented five percent of

[41] The Energy Policy and Conservation Act, Section 325(o)(2)(A), 42 U.S.C. 6295(o)(2)(A)
[42] The National Appliance Energy Conservation Act (NAECA) of 1987
[43] Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers; Final Rule
[44] ASAP Press Release, *New U.S. Standard for Home Furnaces is a “Turkey” Missed Opportunity to Cut Energy Bills and Global Warming Emissions* November 19, 2007*, retrieved March 31, 2008,* http://www.standardsasap.org/news/press29.htm

residential electricity use in the United States.[45] EISA directs DOE to include standby power use in future standards.

Recommendation: DOE should immediately begin revising the standard for furnaces with consideration of a regional standard. Congress should clarify DOE's authority to set multiple standards for the same product. DOE should quickly revise its test procedures and standards to incorporate standby power.

Despite being required to do so, DOE rarely sets federal appliance and equipment standards that achieve the maximum cost-effective energy-efficiency. There is often a range of efficiency levels that represent lowest life cycle cost, sometimes referred to as the "valley of economic indifference" (see figure). DOE tends to choose the lowest-cost and lowest-efficiency level that satisfies the lowest life cycle cost criteria.[46] Additional cost-effective energy savings could be realized by establishing standards at the high end of the "valley," rather than the low end.



DOE also fails to analyze many factors in considering the cost-effectiveness of proposed standards. Typically DOE balances the value of the energy savings against the estimated increased cost of the product. But DOE does not factor in the impact of the reduced

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[45], Paolo Bertoldi, Bernard *Standby power use: How big is the problem? What policies and technical solutions can address it?* Lawrence Berkeley National Laboratory

[46] Utilities often make similar decisions on purchase of distribution transformers, choosing the least initial cost within a "band of equivalence" of estimated life-cycle costs, with similar impacts. An ACEEE survey is referenced in ACEEE comments on the distribution transformer rulemaking, 10/17/06.

energy demand on energy prices (notably for natural gas, for which a tight market leads to very high price elasticity), or the cost of environmental externalities, especially of reduced greenhouse gas emissions.

Recommendation: DOE should set the maximum cost-effective efficiency level for appliance and equipment standards to ensure standards with highest energy efficiency outcomes are picked across a range of products with similar life-cycle costs. In addition, DOE should consider environmental externalities while calculating the cost-effectiveness of standards and factor in other possible impacts of standards, such as lowering energy prices.

Light Bulb Standards

Lighting standards have enormous energy-saving potential in residential and commercial buildings. Commercial and residential lighting energy consumption accounted for 6 percent of total US energy consumption in 2006, and 15 percent of residential and commercial energy consumption.[47]

In recent years, advanced lighting technologies, including compact fluorescent lights (CFLs), halogen bulbs, and light-emitting diodes (LEDs) and have improved dramatically, and one company has announced a dramatically more efficient incandescent bulb. These technological improvements have led many areas to phase out traditional incandescent bulbs, the predominant lighting technology since the days of Thomas Edison. In February 2007, Australia announced plans to ban the incandescent light bulb by 2012.[48] Canada and the EU soon followed suit.[49]

Following a 2007 law in Nevada[50] and a planned rule in California on increasing the efficiency of light bulbs, (as well as interest by other states on this issue), Section 321 of EISA sets performance standards requiring general service light bulbs to achieve 25-30% savings compared to traditional incandescent bulbs by 2012 to 2014, and directs DOE to set a standard for 75% savings effective in 2020. This will effectively ban most traditional incandescent bulbs by 2014. States are allowed to adopt these standards slightly earlier. EISA also includes standards for metal halide fixtures and incandescent reflector lamps.

[47] EIA, AEO 2008, Tables A2, A4 & A5. (Commercial lighting energy use equaled 3.63 quads, 19.63 % of total commercial energy consumption, residential lighting energy use equaled 2.33 quads, 10.73 % of total residential energy consumption)
[48] BBC News, *Australia pulls plug on old bulbs*, February 20, 2007, http://news.bbc.co.uk/2/hi/asia-pacific/6378161.stm,
[49] Reuters, *Canada to ban incandescent light bulbs by 2012*, April 25, 2007, http://www.reuters.com/article/scienceNews/idUSN2529253520070425. EU plans to start phasing out incandescent bulbs in homes stating in 2009, leading to complete phase out in 2015. The proposal is signed on by 27 member nations, EU, Energy Commissioner http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/769 June 5, 2007
[50] Details on what Nevada's standard would have looked like in 2012 had federal legislation not been passed can be found at Southwest Energy Efficiency Project, *2007 Nevada Legislative Activities*, June 25, 2007, http://www.swenergy.org/legislative/2007/nevada/index.html. NV and CA are allowed to adopt this standard a year before the federal standard takes effect.

The lighting standards in EISA are expected to save more energy than any other existing appliance standard. ACEEE estimates that the lighting standards will save 0.9 quads of energy while avoiding the emission of more than 65 million metric tons of CO_2 in 2030.[51] Energy savings of 1.1 quads and CO_2 reductions of 87 MMT are projected in 2050.[52] In contrast to most standards, which make no difference in the function or appearance of the product, the light bulb standard will not only eliminate a whole class of light bulbs, in favor of much higher-priced bulbs, but also change the whole way we buy bulbs – a "100 watt" bulb as of 2012 will be able to use no more than 72 watts. Thus a consumer education and market transformation program is critical to smooth the transition to new technologies and metrics, speed the adoption of more efficient bulbs and ensure the success of the standard.

Recommendation: Congress should fund a significant consumer education campaign in coordination with the light bulb manufacturers and retailers. DOE should closely monitor exempted bulbs to prevent major loopholes, and should set strong revised standards in 2020.

[51] ACEEE, *Energy Bill Savings Estimates as passed by the Senate*, December 17, 2007, http://www.aceee.org/energy/national/EnergyBillSavings12-14.pdf.

[52] It is important for efficient light bulb policies to take into account the mercury content of the new, efficient bulbs as some bulbs might contain high levels of mercury without justifiable additional efficiency benefits.

Building Codes

Many energy-efficiency measures are most cost-effective if implemented during building construction or major renovations (including equipment replacement). It usually does not make economic sense to tear out walls just to install or upgrade insulation, for example. And while in most cases, it would be cost-effective for consumers to pay extra for high-efficiency windows at the time of construction or when they are already planning on replacing their existing windows, energy-efficiency savings alone seldom warrant replacing otherwise perfectly good windows with more efficient ones.

Insulation, windows and other built-in components of a home or commercial building frequently remain in place for the lifetime of the building, and heating and air conditioning systems often last for well over a decade. It is important, therefore, that energy efficiency be built into the roughly six billion square feet of homes and non-residential buildings constructed annually. And since only about two percent of the building stock is replaced annually, efficiency upgrades made today could still be saving energy 50 years from now.[53]

Building energy codes establish minimum energy performance requirements for, or specify energy-efficiency measures that must be incorporated into, new buildings and major retrofits. Building codes are adopted and administered by state and/or local governments. ACEEE estimates that the United States saved 0.5 quads in 2000, thanks to commercial and residential building energy codes alone.[54] Cumulatively, building codes have saved consumers over $8 billion on their energy bills.[55]

Adoption of Stronger Building Energy Codes

To help states and local governments adopt effective building energy codes, national model energy codes and standards are developed and updated every few years by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) and the International Code Council (ICC). Under federal law, states are required to adopt ASHRAE's latest energy standard for commercial buildings (Standard 90.1) after DOE determines it will save energy. For residential buildings, states are required to *consider* adopting the latest energy code of the ICC once DOE issues its determination. In addition to requiring buildings to be more energy-efficient, the most recent building energy codes are more user-friendly than previous versions, while still providing flexibility in how buildings are designed to meet performance requirements.

But it has proven difficult for states to keep up with the latest codes. Technically, states are required to submit a letter to DOE if they opt not to adopt the new residential energy

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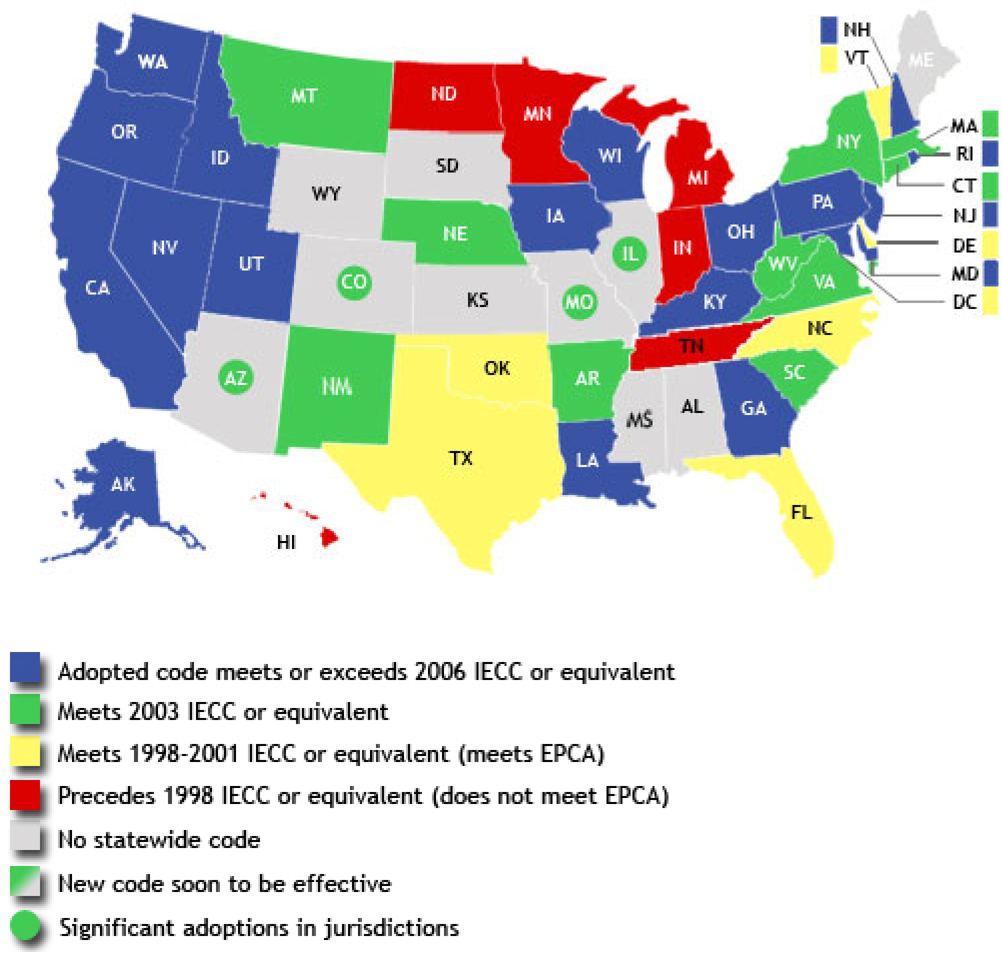
[53] EIA, *Annual Energy Outlook 2008*, Table 19, Table A4, Table A5, AEO projections of new construction through 2030: http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_19.xls. AEO projections of building stock: http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls. http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_5.xls.

[54] Steven Nadel and Bill Prindle, *Supplementary Information on Energy Efficiency for the National Commission on Energy Policy*, ACEEE, July 2004.

[55] Based on 2004 correspondence with Karen Mueller, Pacific Northwest National Laboratory.

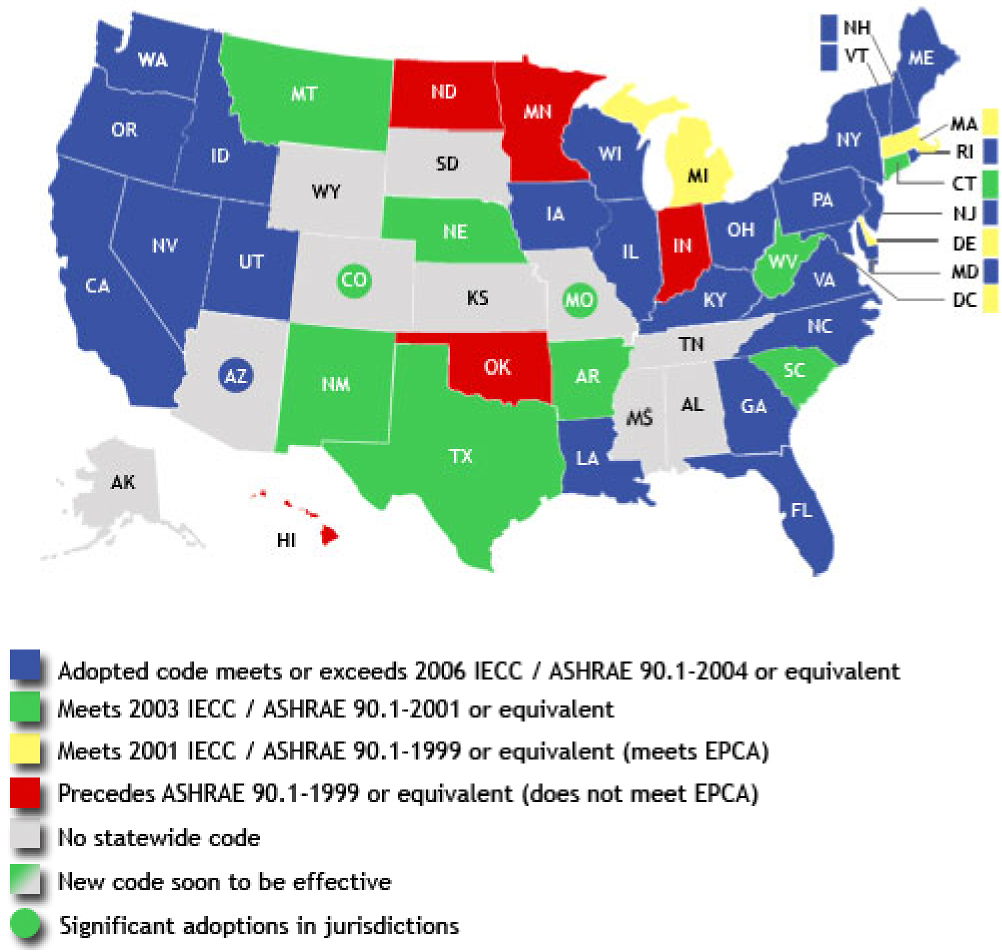
code, but that law has been widely ignored.[56] Currently, at least 43 states and Washington D.C. have some form of building energy codes in place, but most do not achieve equivalent savings to the latest model code. For example, 18 states have adopted a residential energy code that meets or exceeds the 2006 International Energy Conservation Code (IECC) (the most recent version), while 15 states have energy codes that precede the 1998 IECC or follow no statewide energy codes at all. Similarly, 24 states have adopted an up-to-date commercial building code or equivalent – the 2006 IECC or ASHRAE 90.1-2004 – while 14 states have commercial energy codes predating the ASHRAE 90.1-1999 code or have no code at all. The most recent model code for commercial buildings was updated in January 2008 with the release of ASHRAE Standard 90.1-2007, but this has yet to be adopted in any state.

Status of Residential State Energy Codes[57]



[56] Government Accountability Office, *ENERGY EFFICIENCY Long-standing Problems with DOE's Program for Setting Efficiency Standards Continue to Result in Forgone Energy Savings*, January 2007, pp. 27-28, http://www.gao.gov/new.items/d0742.pdf
[57] BCAP, *Status of Residential State Energy Codes*, September 2007, http://www.bcap-energy.org/map_page.php.

Status of Commercial State Energy Codes[58]



The absence of a statewide code does not necessarily indicate that there are no building codes in the state, as cities and counties in "home rule" states often adopt their own local building codes. For example, Phoenix, Chicago and Denver each have adopted a version of the IECC for residential buildings.[59]

The energy savings potential from building codes was highlighted in a study by the General Accountability Office (GAO) on Gulf Coast reconstruction following Hurricanes Katrina, Rita and Wilma in 2005. According to the GAO, if Louisiana and Mississippi adopted the latest model energy codes in their new residential buildings, their residents would save at least $20 to $28 million annually, equal to 24 to 28 percent of heating and

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[58] BCAP, *Status of Commercial State Energy Codes*, September 2007, http://www.bcap-energy.org/map_page.php.
[59] Building Codes Assistance Project (BCAP), *Status of Residential State Energy Codes*, and *Status of Commercial State Energy Codes*, September 2007, http://www.bcap-energy.org/map_page.php.

cooling costs.[60] Gulf state commercial buildings could see even more impressive savings, of 7 to 34 percent of overall energy costs, depending on building type. And GAO determined that larger savings still could be realized for both types of buildings through voluntary implementation of energy-efficiency measures beyond those found in the minimum building code and standard requirements.[61]

Recently there has been a strong movement to make a dramatic improvement in building energy codes. In 2007, ASHRAE adopted a goal that buildings meeting Standard 90.1-2010 should use 30% less energy than buildings that meet its 2004 standard. In that same year, DOE signed a memorandum of understanding to support ASHRAE's efforts, and in 2008, DOE announced that it would also work for a 30% improvement in residential model energy codes.[62] At development hearings in February 2008, the ICC energy code committee heard arguments in favor of a 30% improvement to the 2009 IECC.[63] While all the elements were not approved, the committee recommended significant improvements (approval contingent on an ICC membership vote) that are much larger than the efficiency improvements in previous editions of the model code.

Increasing Compliance with Building Energy Codes

Even in those states where the latest building codes have been adopted, the potential for much larger energy savings exists through greater enforcement of and compliance with the codes. Although there are tens of thousands of code officials in the United States, their responsibility and focus is on health and safety requirements. Energy efficiency is generally an area for which they are poorly trained and/or lack the staff to fully enforce. Lack of proper policies in place to enforce codes (i.e. plan reviews, site visits) compound the problem.

With roughly 100,000 home builders in the United States, the building industry is extremely diverse in size and capability.[64] While commercial building construction companies tend to be large, with extensive design and technical support for workers, most residential builders operate with just a few people.[65] This diversity presents a major barrier to the diffusion of new technologies and practices. Perhaps not surprisingly,

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[60] While the gross savings numbers are higher than would normally be expected, due to the large amount of buildings destroyed in the hurricanes, the savings percentages should be typical, given similar climate and existing codes.

[61] United States Government Accountability Office, *Report to Congressional Addressees, Energy Efficiency: Important Challenges Must Be Overcome to Realize Significant Opportunities for Energy Efficiency Improvements in Gulf Coast Reconstruction*, June 2007, pg. 5.

[62] ASHRAE Insights, *30% Energy Saving Is Target*, http://www.ashrae.org/publications/detail/16468

[63] 2007/2008 International Energy Conservation Code Committee, http://www.iccsafe.org/cs/codes/2007-08cycle/ROH/IECC.pdf

[64] National Association of Home Builders, *Our Organization*, http://www.nahb.org/page.aspx/generic/sectionID=89. "About one-third of NAHB's 235,000 members are home builders and/or remodelers."

[65] Although the largest building companies have thousands of employees and sophisticated support networks throughout the country. Pulte Homes, for example, employs 12,400 people and operates in 52 markets and 27 states. Pulte Homes, *Pulte Homes Fact Sheet*, March 2007, http://library.corporate-ir.net/library/14/147/147717/items/262187/InvestorFactSheet42007.pdf

therefore, home builders tend to be the most vocal opponents to new, more stringent building codes.[66] It takes many trained and skilled people working on separate but interdependent components of a typical house to improve energy performance. If local builders are given the necessary resources and training to understand the techniques and requirements of a new code, they are less likely to oppose its adoption and more likely to comply once it is adopted.

Insufficient data exist to estimate national energy code compliance rates,[67] but in some states, 33 percent 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.[68] According to 10 studies conducted in various states, the percentages of residential energy code compliance ranges from approximately 40 percent in Massachusetts to nearly 100 percent in Oregon. These studies were carried out with differing methodologies, so the results are not perfectly comparable, and many have sampling problems stemming from bias toward self-selection and convenience, usually leading to unrealistically high results.[69] Actual compliance could be much lower.

The Alliance to Save Energy estimates that aggressive building energy code development, adoption and enforcement, based on the building codes provisions in H.R. 3221 (described in the recommendation below), could reduce CO_2 emissions by 0.36 Gt and reduce energy use by 6.1 quads annually in 2050 (see Appendix 3).

Recommendation: The federal government should set national targets to improve the residential and commercial model building energy codes so that, compared to the 2006 and 2004 requirements, respectively, they achieve savings of 30 percent by 2010 and 50 percent by 2020. If ICC and ASHRAE fail to develop codes that meet these goals, DOE should modify the model codes to achieve at least this level of savings. States should be required to adopt the most recent ICC and ASHRAE energy codes for both residential and commercial buildings (or the DOE alternative model code), and to demonstrate high rates of compliance. DOE should increase assistance in setting and adopting better codes, and in training code officials to increase compliance and improve supervision.

Expand the Scope of Building Codes

Neither the ICC nor ASHRAE energy codes account for certain critical design decisions, such as building orientation; equipment in commercial kitchens, laundries, labs, medical facilities, etc.; or residential lighting and builder-installed appliances. As a result, major

[66] See, for example, National Association of Home Builders, *Energy Code Issues*, 2007, http://www.nahb.org/category.aspx?sectionID=817.
[67] A national compliance rate would be of limited usefulness in any case, since compliance varies dramatically from state to state, based on finances, supervision and training.
[68] For a compilation of compliance studies, see U.S. Department of Energy, *Baseline Studies*, 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.
[69] Brian Yang, BCAP, *Residential Energy Code Evaluations*, Presentation to 2005 National Workshop on State Building Energy Codes, June 29, 2005, http://www.energycodes.gov/news/2005_workshop/presentations/track_b/b_yang-res_ec_evaluations.ppt.

building energy loads and systems are outside the scope of the codes; these energy uses become increasingly significant as the code improves the efficiency of the covered energy uses and systems. While it would be challenging, efficiency requirements for total building energy use could have a major impact on whole-building energy performance.

In addition, state building codes are preempted from regulating the energy use of some kinds of appliances and equipment that have minimum federal efficiency standards (under the *National Appliance Energy Conservation Act*). These minimum standards therefore can, prohibit states building codes from requiring use of much more efficient equipment even when it is economically justified for use in new homes.

Recommendation: National model building energy codes requirements should be expanded to include any building component that appears on building drawings, including residential lighting and HVAC equipment, elevators, pumps, etc. Federal appliance standards preemption laws should be change to allow states to set higher code requirements where economically justified.

Manufactured Housing Standard

Manufactured houses represent roughly eight percent of new single-family housing starts, but are not subject to state and local building energy codes.[70] Manufacturers argue that since the components of manufactured homes are shipped from a few central locations across the country, it is difficult for them to comply with every different state and local building code. As a result, manufactured houses are regulated by the Department of Housing and Urban Development (HUD) within the federal government, not by state or local governments.[71]

HUD's current energy-efficiency requirements for manufactured houses are based on recommendations made by the National Fire Protection Association (NFPA) through its NFPA 501 code. Despite recent improvements, the NFPA 501 code remains less stringent than the IECC. EISA directed DOE, in consultation with HUD, to set revised energy conservation standards for manufactured homes based on the most recent version of the IECC. A 2003 study by Pacific Northwest National Laboratory showed that building manufactured housing to current IECC model energy code specifications would require greater up-front costs, but that the resultant energy cost savings would allow

[70] According to the US Census of Manufactures (http://www.census.gov/const/mhs/shiphist.xls), in 2006 the industry shipped 117,300 manufactured homes. According to the National Association of Home Builders, housing starts in 2006 totaled 1.5 million (see http://www.nahb.org/generic.aspx?sectionID=130&genericContentID=554). These figures mask a lot of annual variability. In 2001, one out of every 7.5 homes was manufactured and in some regions of the country – like the Pacific Northwest – manufactured housing can represent half of new housing starts. See http://www.eere.energy.gov/buildings/emergingtech/pdfs/mfghome.pdf. The Manufactured Housing Institute's web site provides definitions of manufactured housing. See http://www.manufacturedhousing.org/default.asp.

[71] National Manufactured Housing Construction and Safety Standards Act of 1974, Title VI, Public Law 93-383 (42 U.S.C. 5401)

owners to recoup their initial investment within about 5 to 8 years in most cases, well within the lifetime of the average manufactured house (30-50 years).[72]

Recommendation: Congress should appropriate funds for the manufactured housing provision in EISA. DOE should, in consultation with HUD, quickly develop and implement an energy efficiency standard for manufactured housing at least as stringent as the latest IECC code for residential buildings.

[72] These figures based on conversations and email correspondence with Craig Conner (Building Quality in Richland, Washington) and Mike Lubliner (Washington State University) and a study they authored titled *Revision of the Energy Efficiency Requirements in the Manufactured Home Construction and Safety Standards*, Prepared for the U.S. Department of Energy under contract DE-AC06-76RLO 1830, Pacific Northwest National Laboratory, Richland, Washington, July 2003. The IECC climate regions would need to be "mapped onto the three HUD climate zones," but this is reportedly not a difficult task. For additional background information, see Mike Lubliner, *Improving Energy Efficiency, Indoor Air Quality & Durability in HUD Code Manufactured Housing Standards*, Presentation to HUD Manufactured Housing Consensus Committee (MHCC), May 23, 2007, ftp://ftp.energy.wsu.edu/usr/miklub/mhcc_presentation_lubliner_final_to_hud.ppt

Utility and State Energy-Efficiency Programs

The Cooperation of electric and natural gas utilities in improvement of building energy efficiency is vital, since electricity and natural gas comprise more than 90 percent of the total energy used in buildings.[73] Utilities can implement several different types of efficiency programs that help reduce consumers' demand for energy, including providing rebates for consumer purchases of efficient products; design assistance for new buildings; energy audits for residential, commercial, and industrial customers; and conducting consumer education campaigns.

From 1989 to 2005, electric utilities spent over $30 billion on efficiency and demand response programs.[74] There is no reliable data on utility efficiency spending by gas utilities at that time but the figures are generally thought to be far lower.[75] In 1993 and 1994, electric utilities were spending $2.7 billion annually on utility efficiency programs, of which about $1.6 billion (60%) was for energy efficiency.[76] By 1994, annual energy savings from utility efficiency programs had reached 52.5 million MWh, just less than the current electricity consumption of Oklahoma.[77] According to EIA, utility efficiency programs in the early 1990s were costing most utilities under three cents per kilowatt-hour (kWh), which EIA concluded was "competitive or below the cost of new generating capacity."[78]

Utility efficiency spending declined considerably in the mid-1990s, due in large part to a shift toward greater competition among power generators. As states shifted away regulating utility planning and rates, utilities and regulators were concerned that the costs of efficiency programs would raise the price per kWh of utility-generated power and give an unfair competitive advantage to non-utility generators, who were not required to invest in energy efficiency.

After utility restructuring began in the mid 1990s introducing competition in electricity generation, few utilities developed and maintained energy-efficiency services as part of

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[73]EIA, *Monthly Energy Review*, March 2008, Table 2.2 and Table 2.3. http://www.eia.doe.gov/emeu/mer/pdf/pages/sec2_7.pdf and http://www.eia.doe.gov/emeu/mer/pdf/pages/sec2_5.pdf

[74] EIA, *Annual Energy Review 2006*, Table 8.13, http://www.eia.doe.gov/emeu/aer/elect.html.

[75] Data on electric utilities' DSM programs are collected by EIA. They curiously do not collect similar data on DSM spending by natural gas utilities. This was confirmed in personal correspondence from William Trappman, EIA, June 7, 2005.

[76] DSM activities also included load management programs. EIA, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, 1996, pp. 4-5, www.eia.doe.gov/cneaf/pubs_html/feat_dsm/contents.html.

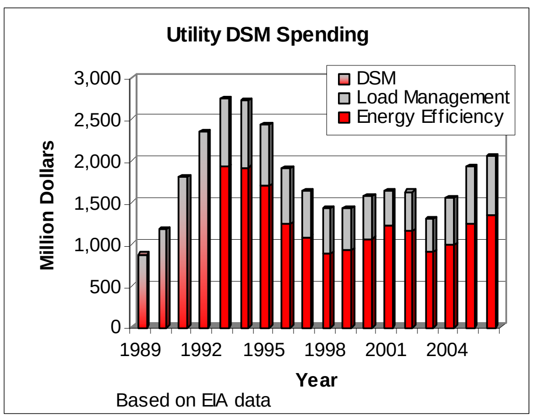
[77] EIA, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, 1996, p. 5, www.eia.doe.gov/cneaf/pubs_html/feat_dsm/contents.html.For data on States' energy use, see EIA, *State Electricity Profiles*, March 2007, http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html..

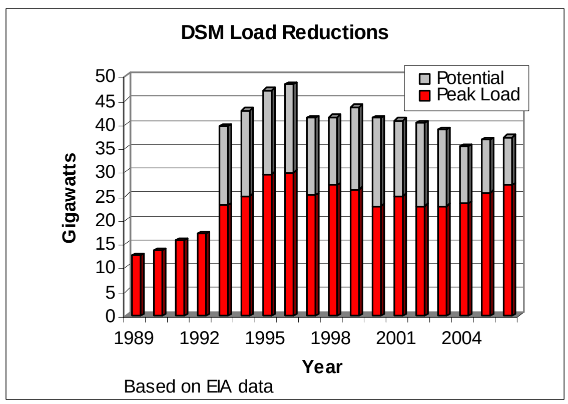
[78] EIA, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, 1996, p. 5, www.eia.doe.gov/cneaf/pubs_html/feat_dsm/contents.html. Note that the data EIA used for its calculations was reported by utilities. There was concern that some utilities may have been overstating savings. See, for example, Paul Joskow and Donald Marron, *What Does a Negawatt Really Cost: Evidence from Utility Conservation Programs, Energy Journal*, vol. 13, no. 4, 1992, pp. 47-74.

their core business strategy, and DSM expenditures declined precipitously. In 2002, reported electric utility efficiency spending had fallen to $1.3 billion, a 50 percent decline in nominal dollars compared to utility efficiency spending less than a decade earlier. In real terms, electric utilities were spending just 37 cents for every dollar they spent on DSM in 1994.[79]

Faced with lower spending on utility efficiency programs, 27 states (plus the District of Columbia) have created Public Benefit Funds (PBFs) for electric energy efficiency. PBFs are paid for by a kWh charge on electric bills, which varies from 0.004 to 0.421 cents per kWh.[80] Most of these programs are implemented by utilities, but some states have taken over administration of the programs through one or more contractors. Recent data from the Consortium for Energy Efficiency suggests that ratepayer funded spending has rebounded in recent years. In 2007, U.S. utility energy efficiency budgets totaled $2.16 billion, a 16% growth over 2006. Load management in 2006 accounted for $536 million and low-income programs totaled $438 million. When these programs are included, total 2007 spending by utilities equaled $3.14 billion.[81]

With the emergence of PBFs has come a greater willingness to fund energy-efficiency projects that transform markets for energy-efficiency equipment and services, as opposed to traditional utility efficiency programs which were designed to attain immediate and measurable savings for individual rate payers. Both are now a mainstay of utility energy-efficiency programs.





The resurgence in utility efficiency programs could result in significant energy savings in both residential and commercial buildings. A 2004 study examined energy savings from

[79] EIA, *Electric Power Annual 2003*, December 2004, http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html.
[80] Database of State Incentives for Renewables & Efficiency (DSIRE), *Public Benefits Fund for Energy Efficiency*, 2007, http://www.dsireusa.org/library/includes/seeallincentivetype.cfm?type=PBF&currentpageid=2&search=Type&EE=1&RE=0
[81] Consortium for Energy Efficiency, *Energy-Efficiency Programs: A $3.7 Billion U.S. and Canadian Industry, 2007 Report*, 2007. http://www.cee1.org/ee-pe/2007/2007EEPReport.pdf

utility efficiency programs in the commercial buildings sector from 1989-2001. The study found that traditional electric utility efficiency programs were responsible for reducing electricity intensity (amount of electricity used per square foot) in commercial buildings in 2001 by 1.9 percent nationwide compared to 1989. According to the study, market transformation programs were responsible for reducing electricity intensity in this sector by 5.8 percent compared to 1989. The findings suggest that the combined effects of these public programs reduced commercial sector retail electricity sales by 77.1 million MWh in 2001 alone, about 2.3 percent of total U.S. retail electricity sales.[82]

Perhaps the biggest administrative challenge of utility efficiency programs is verifying energy-efficiency savings and ensuring they are sustained and additional. Most state legislatures require program administrators – whether utilities or government agencies – regularly to demonstrate the effectiveness of their programs, generally every few years. Of course, evaluation is not free, so states must weigh the risk of funding ineffective projects against the costs of verifying project savings.

While these programs have been effective in lowering energy use, enormous potential for further savings remains. State studies of energy-efficiency potential for electricity suggest that most utilities could achieve additional annual savings of 1 percent or more of their sales.[83] A study conducted by the Alliance to Save Energy also found similar results[84] This is true even in states such as California and Vermont that have been implementing efficiency programs for many years. Utilities that have not yet developed and implemented DSM programs could have a greater range of low-cost efficiency improvements at their disposal, but they will have less experience and infrastructure to draw on to capture those savings.

Compensating and Incentivizing Utilities

Growth of these utility efficiency programs is hampered by utilities' concerns that reducing demand will hurt their profits, and their reluctance to pay for programs that ultimately reduce their sales and profits. In order to recoup the costs of implementing energy-efficiency programs, utilities raise the price of their remaining electricity sales slightly, either directly or through a tariff or surcharge on electricity bills. Some regulators allow utilities not only to recover their direct program costs, but also to recoup the lost revenue from reduced sales that result from effective utility efficiency programs, as a mechanism to counter utilities' inherent disincentive to implement (let alone pay for) programs that reduce their sales.

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[82] Marvin J. Horowitz, *Electricity Intensity in the Commercial Sector: Market and Public Program Effects*, Energy Journal, Vol. 25, No. 2, 2004.

[83] See Steven Nadel, Anna Shipley, and R. Neal Elliott, *The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies*, ACEEE, September 2004, http://aceee.org/energy/eeassess.htm#meta.

[84] Joe Loper, Selin Devranoglu, Steve Capanna, and Mark Gilbert, *Energy Efficiency Potential in American Buildings*, ASE and American Electric Power, 2007.

See Steven Nadel, Anna Shipley, and R. Neal Elliott, *The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies*, ACEEE, September 2004, http://aceee.org/energy/eeassess.htm#meta.

An increasing number of states are making broader changes in the rate structure to "decouple" utility profits from sales volume. Under traditional rate structures utilities receive compensation for fixed costs through "volumetric rates," and thus make more money if they increase, rather than decrease, sales. These decoupling strategies may be necessary (although not necessarily sufficient) in order to convince utilities to work in good faith to reduce their customers' demand. But decoupling and other compensation mechanisms also add extra layers of accounting complexity to an already complex industry.

Further resistance to utility energy-efficiency programs stems from industrial customers who object that rate-based utility efficiency programs may target electricity or natural gas consumption only in residential and commercial buildings. Since industry's energy bills are raised along with residential and commercial rates in order to allow utilities to recoup their utility efficiency costs, industrial customers are forced to pay for efficiency improvements from which they receive no direct benefit – except to the degree that successful utility efficiency programs help to dampen demand-driven energy price increases and price volatility.

EISA required state regulators to consider integrating electric and natural gas efficiency resources into their resource plans and removing the "throughput incentive" – utilities' incentive to increase their sales volume – through decoupling or other means. However, these "mandates to consider" have not always been followed in the past.

Recommendation: State regulators should integrate energy efficiency into electric and natural gas utility plans. Regulators should also consider modifying existing rate structures not to disincentivize utility efficiency investments and to decouple utility profits from energy sales. Regulators should be required to submit a written report to DOE on their findings and decisions on these considerations, with explanations for any exclusion of any of the above efficiency strategies.

Energy Efficiency Resource Standard

One way to spur effective energy-efficiency programs is through a performance requirement. An energy efficiency resource standard (EERS) requires electricity and natural gas utilities to meet a portion of their customers' needs through energy efficiency and load reduction programs, instead of by constructing new generation, transmission and distribution facilities. An EERS can be instituted in conjunction with or independent of a PBF. Utilities can meet their EERS requirements through efficiency programs and sometimes through combined heat and power, distribution efficiency improvements, or buying credits for the savings from other utilities or from non-regulated entities. Generally, some independent body is responsible for verifying the energy savings claimed by utilities.

EERSs are modeled on (and are frequently part of) renewable portfolio standards (RPSs), similar systems created to promote the use of renewable energy. While an EERS component is not always included in RPS mandates, doing so has become more commonplace over the last few years.[85] Currently, sixteen states have an EERSs, mostly as an eligible resource in an RPS, as a separate tier in an RPS, or as a separate requirement alongside an RPS.[86] These programs have been implemented despite opposition by RPS advocates concerned that energy-efficiency projects may displace other beneficial (renewable energy) projects, since DSM programs are typically cheaper than developing new renewable energy sources. As a result, states that incorporate an EERS in their RPS sometimes limit the percentage of the RPS that can be met through energy efficiency, or set a separate efficiency requirement.

Any national EERS would have to take into account the diversity of experience and potential energy savings between states. To address this variability, a national EERS could be modeled after other "cap and trade" schemes, allowing utilities that exceed required energy savings to sell "efficiency credits" to utilities that have failed to meet their goals. Trading of efficiency credits would allow the savings to be achieved at the least cost. Utilities with the lowest-cost efficiency improvements available could achieve greater savings than required and profit from trading with utilities that lack those opportunities. Utilities that have higher-cost improvements would be able to purchase the extra low-cost improvements and count them as their own. To the extent that utilities with low-cost efficiency measures would have implemented those measures even if they were not able to sell credits to utilities with higher efficiency costs, however, trading will also reduce the stringency of an EERS.

Energy-efficiency trading schemes have already been implemented in the United Kingdom, Italy, and France, and in New South Wales, Australia as well as in several states in the US. These could be used as models, though so far, only Italy has a significant volume of trading.[87] In some cases non-regulated companies, such as energy service companies, also can earn efficiency credits and sell them to utilities.

A national EERS could reap enormous energy and financial savings. The RPS provision in H.R. 3221 would allow utilities to meet up to 27 percent of their RPS requirement (equal to four percent of projected electricity consumption in 2020, the last year specified in the legislation) through utility efficiency programs. We assume that the efficiency component of the RPS is expected to result in no additional savings by 2030 as business

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[85] Union of Concerned Scientists, *Summary of Policies*, December 2004 and *State Renewable Energy Policies*, http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=114

[86] ASE, *Energy Efficiency Resource Standard*, Fact Sheet, September 2007.

[87] Italy, for example, has established compulsory targets for increased energy efficiency as compared to business-as-usual. Electric and gas utilities are required to deliver "white certificates" in proportion with the gas or electricity they distribute. "White Certificates" are issued to certify specific reductions in energy consumption carried out either by the utilities or third parties. The certificates are tradable among utilities. For discussion, see EU SAVE Programme, *White Certificates in MARKAL Models of Italy and Europe: Case Studies to Analyze Energy Efficiency Improvements*, presented to International Energy Workshop, IIASA-Laxenburg, Austria, June 24-26, 2003. (http://www.iiasa.ac.at/Research/ECS/IEW2003/ppt/Santi-2003.ppt#256,1,White Certificates in MARKAL Models of Italy and Europe: Case Studies to Analyze Energy Efficiency Improvement Policies).

as usual efficiency measures are anticipated to bring about more savings than mandated under this requirement.

A meta-analysis of regional energy-efficiency potential studies conducted by ASE found a median cost-effective energy-efficiency potential of around 20% in the US buildings sector by around 2020.[88] We assume that similar efficiency improvements (an additional 20% savings by 2035 and another 20% by 2050) are attainable in the future. Consequently, a much more stringent national EERS than has been introduced in Congress to date is warranted.

Recommendation: Develop a national EERS requiring electric utilities to achieve permanent savings equal to 1% of the previous year's electricity sales through energy efficiency every year from 2010 through 2050, and requiring natural gas utilities to achieve savings in the same way by 0.5% each year.

If a national EERS of this level was fully implemented, building energy use in 2050 would be reduced by roughly 14.54 quads and CO_2 emissions would be reduced by roughly 0.81 Gt.

[88] Joe Loper, Selin Devranoglu, Steve Capanna, and Mark Gilbert, *Energy Efficiency Potential in American Buildings*, ASE and American Electric Power, 2007.
See Steven Nadel, Anna Shipley, and R. Neal Elliott, *The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies*, ACEEE, September 2004, http://aceee.org/energy/eeassess.htm#meta.

Tax Incentives

Tax incentives are commonly used at both the federal and state levels to influence consumer and business purchasing decisions. Recently, different levels of government have offered tax incentives to consumers who purchase energy-efficient equipment or products. These incentives come in a variety of forms, including sales tax exemptions, income tax credits or deductions for purchases or production of energy-efficient products, and accelerated depreciation for energy-efficiency investments.

Tax incentives can help introduce new technologies into the marketplace and increase the market share of energy-efficient products by lowering their cost for consumers. Tax incentives also lower manufacturers' production risks and effective investment costs. As production volume and sales increase, the technologies become more readily available and affordable, allowing the tax incentives to be phased out. And by attracting the attention of manufacturers, distributors, retailers, and consumers through a multi-year and nationally consistent program, tax incentives can help markets embrace new energy-saving technologies.

A less obvious function of tax incentives for energy-efficient products is to counter the rather low cost of energy consumption relative to its actual cost to society. For example, since to a large extent the costs of GHG emissions are not included in energy prices, consumers will not take these costs into account when making purchasing decisions. As a result, they will tend to under-invest in energy efficiency. Tax incentives also can compensate for the tendency of consumers and businesses to ignore, or at least heavily discount, future energy costs compared to the initial cost of the equipment.

Further, considering the enormous subsidies that have been given (and continue to be given) to the energy industry, tax incentives for energy efficiency may simply level the playing field. According to a study by the GAO, the various energy supply industries – including oil, gas, coal, nuclear, renewable energy, and electricity – received $4.38 billion from various income and excise tax preferences in 2003, more than 20 times the tax preferences provided for energy efficiency and conservation at the time.[89]

The Energy Policy Act of 2005 (EPAct 2005) enacted many new tax incentives for the purchase of and investment in energy-efficiency products and technologies. Several are intended to encourage efficiency in buildings, including incentives for the construction and retrofits of new and existing commercial buildings, the purchase of energy-efficient heating and cooling equipment for new and existing homes and commercial buildings, and building improvements to existing homes and certain energy-efficient appliances (namely clothes washers, refrigerators and dishwashers).

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[89] See U.S. Government Accountability Office, *National Energy Policy: Inventory of Major Federal Energy Programs and Status of Policy Recommendations*, June 2005, p.7, www.gao.gov/cgi-bin/getrpt?gao-05-379. While the tax incentives passed in the Energy Policy Act of 2005 have changed the balance somewhat, they still do not approach the annual subsidies given to the other energy industries.

Unfortunately, all of the building-related incentives passed in EPAct 2005 expired at the end of 2007 or were extended only through 2008, which, in most cases, is not nearly a long enough window for consumers to take advantage of them. EPAct 2005 wasn't signed into law until August 2005, and the IRS did not issue the tax credit guidelines for most of the incentives until well into 2006 and in the case of the commercial building tax deduction, not until 2008.[90]

Unless the credits are extended by several years, they are unlikely to have much of an impact. For instance, businesses are eligible for the credit for new energy-efficient buildings only if the buildings are put into operation in the time frame of the credit. This means that the owner, architects and builders need to design, site, build, and open a commercial building to the rather stringent and complicated specifications of the tax credit within two years.[91] Reports indicate that few consumers have taken advantage of this incentive.

The *Extend the Energy Efficiency Tax Incentives Act of 2007* (S. 822 / H.R. 1385) would extend and improve the tax incentives for energy-efficient new homes, home improvements, and commercial buildings, and would add tax incentives for whole-home retrofits, building energy certifiers, and small commercial heating and cooling equipment. The *Super-Efficient Appliance Incentives and Market Transformation Act of 2007* (H.R. 2137 / S. 1525) would modify and extend the appliances tax credit. Many of the provisions also are in the House energy bill (H.R. 3221), and the Senate Finance Committee package (Senate Amendment 1704).

There are other potential barriers to achieving the energy savings promised by these incentives. If implemented poorly, tax incentives can be costly boondoggles or simply a waste of taxpayer time and energy.[92] Free-riders – consumers who receive a tax incentive for actions they would have taken irrespective of the incentive – should be a major concern when developing any tax incentive. Free-riders minimize the energy-savings impact of tax incentives and render market transformation programs little more than government handouts. Free-riders may be offset by "free-drivers," for example when one person takes advantage of a tax incentive and then brags about their purchase to another buyer. But tax credits do not induce energy savings if they simply pay people to do what they were already going to do.

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[90] For more information on energy-efficiency tax incentives, see the Tax Incentives Awareness Project, http://www.energytaxincentives.org/.

[91] This credit was initially due to expire at the end of 2007, although it's since been extended through 2008. But because this extension did not occur until December 2006, consumers have never known that the credit would exist more than two years in the future.

[92] The Energy Tax Act of 1978 included provisions for a homeowner tax credit equal to 15 percent of energy conservation investments up to $2000 – i.e., the maximum allowable credit was $300. These credits were criticized, along with other provisions related to other energy resources (e.g., synthetic fuels), in the 1980s by the EIA, which cited high prevalence of free-riders and said the incentives were insufficient to induce changes in behavior. EIA assessments of tax incentives included in various energy bills over the last several years have been similarly critical. See, for example, EIA, *Summary Impacts of Modeled Provisions of the 2003 Conference Energy Bill*, February 2004 and EIA, *Assessment of Selected Energy Efficiency Policies*, May 2005.

Likewise, tax incentives must require sufficient documentation to provide reasonable assurance that the prescribed efficiency measures are actually purchased, installed properly, and performing as specified. Otherwise, the incentives may have little energy impact while putting pressure on already-tight government budgets and/or inflating the price of the eligible measures. For certain products with efficiency ratings (like Energy Star qualified appliances) this may be easy. But in other cases, performance must be verified; merely showing that you have paid for a covered product is not sufficient. Of course, if taxpayers decide that the time they would have to spend documenting the effective installation of efficiency measures is worth more than the value of the incentive, its effectiveness will be limited as well.

The dueling necessities of facilitating compliance and assuring savings are often in conflict. Performance-based eligibility requirements, for example, place more burden and cost on the taxpayer than do cost-based requirements. Similarly, being overly concerned about free-riders could lead to freezing out some taxpayers who would otherwise have been motivated by the tax break. The reality is that almost any tax incentive will benefit some free-riders. But to the extent free-riders can be limited, the incentive becomes more effective.

Recommendation: Tax incentives for appliances, commercial buildings, existing and new homes as proposed in the Senate-passed version of H.R. 6[93] should be extended.

According to ACEEE, these extensions and modifications to the tax incentives would result in annual savings in 2030 of 24.4 TWh of electricity, 183 BCF of natural gas, 0.52 quads of energy and avoidance of nearly 27 MMT of CO_2 emissions. Projected savings in 2050 would equal nearly 0.64 quads and 39 MMT of CO_2 emissions.

Tax incentives need to be extended now (in some cases with adjustments), so that businesses and consumers can plan longer-term investments. If we continue to wait until the tax incentives are about to expire, and then extend eligibility for one or two years, the same difficulties will persist. By making new energy-efficient technologies more affordable, these tax incentives not only can lower energy prices by reducing demand, but also can develop innovative new industries with new jobs, reduce air pollution and greenhouse gas emissions, and improve the reliability of the electricity system. But they only will have these benefits if given enough time.

[93] This package, included in Amendment 1704, was approved by the Senate Finance Committee on 6/19/07 but failed to receive the 60 votes needed to overcome a filibuster on the Senate floor

Consumer Awareness, Technical Assistance

Consumer education programs also can accrue significant savings. EPA and DOE's Energy Star Program provides information on energy-efficient products and practices, builds awareness of energy-savings opportunities, and grants recognition to organizations that are leaders in energy efficiency. Energy Star is a voluntary partnership program aiming to help businesses, homeowners, consumers, and state and local governments save money by investing in energy efficiency, yielding multiple private and public benefits. In 2007 alone, Energy Star helped Americans avoid 40 million metric tons of GHG emissions – equivalent to the annual emissions from 27 million vehicles – and save about $16 billion on their utility bills. In 2007, Energy Star represented about one-third of the total GHG emissions reductions from EPA's climate change programs. The program benefits have grown steadily since 1992 and are poised to continue well into the future.[94]

With increased funding, Energy Star could be expanded to several additional areas. Under a home performance program, Energy Star could send well-trained contractors to make energy-efficiency retrofits on homes, offering on average 20 percent savings per home. Increased funding could also be used to fully develop Energy Star's pilot program ensuring quality installation of heating and cooling equipment, or to provide greater technical assistance to small and medium-sized manufacturers to improve the energy efficiency of their operations. Energy Star's commercial building rating system could be expanded to broadly penetrate into the buildings sector and help assess building investment and improvement opportunities. Further funding could also be used to increase outreach to utilities. As states continue promoting and funding energy efficiency, the Energy Star program's value in helping utilities understand energy efficiency and best practices will increase. Finally, additional funding could be used to explore new technologies and practices to be included in the Energy Star Program.

Recommendation: Double funding for the Energy Star program to over $100 million annually.

Historically, much of the energy savings realized in the United States has been driven by the states. The federal government can assist states by sharing resources and technologies through the State Energy Program and the Weatherization Assistance Program (WAP), which assists low-income residents in weather-proofing their homes to save on energy bills and increase their comfort.

Recommendation: Increase funding for the State Energy Program to $1 billion each year. Increase funding for the Weatherization Assistance Program to $2 billion annually.

[94] *Energy Star Overview of 2007 Achievements*, March 2008, Retrieved 26 March 2008 http://www.energystar.gov/ia/partners/publications/pubdocs/2007%20CPPD%204pg.pdf

Another program with considerable potential to reduce emissions and lower the cost of clean technologies is Zero-Net-Energy Commercial Buildings Initiative (CBI). EISA authorized CBI which aims to achieve an energy-neutral commercial buildings sector by 2050. If this goal is realized, the energy consumed in energy-neutral buildings would be offset by on-site renewable energy generation and renewable energy and energy-efficiency credits. CBI – an alliance of industry, academia, and government – would plan, coordinate, and implement comprehensive activities to transform energy performance in commercial buildings over the next few decades, through technology, market, and policy innovation. Founding sponsors of this initiative include the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, the American Institute of Architects, the United States Green Building Council, the World Business Council for Sustainable Development, Lawrence Berkeley National Laboratory, and the Alliance to Save Energy.

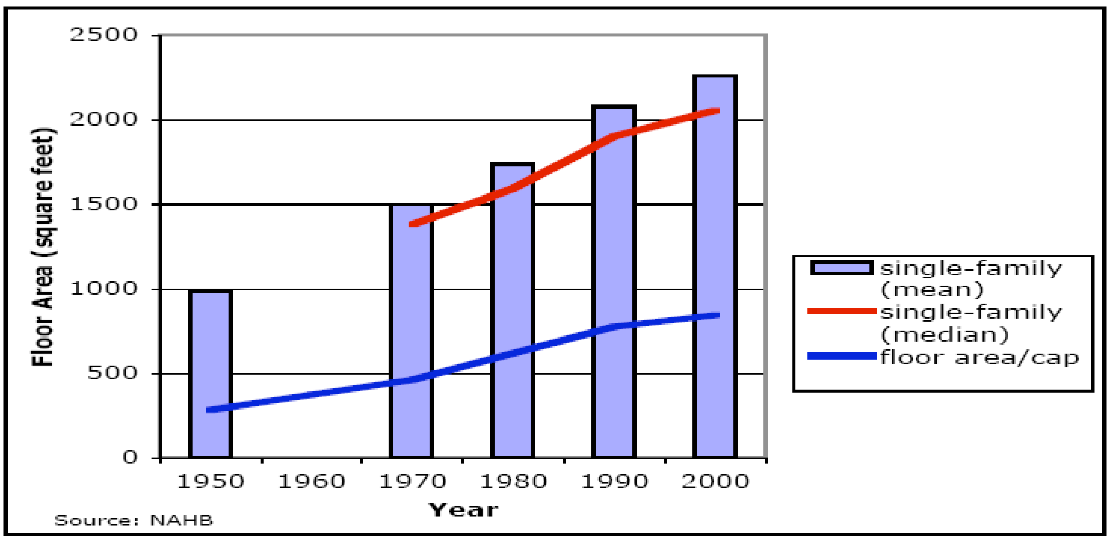
Recommendation: The federal government should appropriate $200 million annually to a Commercial Buildings Initiative, to be run by DOE in partnership with industry, with the goal of developing technologies, practices and policies that will lead to achieving a net-zero-energy commercial building sector by 2050.

Policies to Address Growing Demand for Energy Services

Increased energy efficiency is the preferred method for achieving reductions in energy demand. And energy efficiency, combined with a less carbon-intensive fuel mix, can go a long way to reducing CO_2 emissions by 80 percent below 1990 levels by 2050. One challenge, however, will be ensuring that the gains from increased efficiency and use of low-carbon fuels are not swamped by increased demand for energy services.

Over the last couple of decades, the energy efficiency of homes has increased dramatically. But 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)[95]

US House Size (floor area) Mean and Median 1950-2000[96]



Source: NAHB 2003

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

Similarly, according to EIA's Residential Energy Consumption Survey (RECS), refrigerator energy use per household was roughly the same in 1993 and 2001, even though energy use per unit virtually halved during that time period.[97] While it is possible that two-refrigerator households would be commonplace regardless of unit efficiencies, it

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[95] National Association of Home Builders (NAHB), *Housing Facts: Figures and Trends 2003*, 2003, Washington, DC.

[96] 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.

[97] 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.

can at least be said that the demand for new energy services has increased as fast as efficiencies.

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.[98]

But the biggest drivers of demand for new energy services are growing incomes, growing population, low energy prices and new technology. Currently, strategies aimed at reducing incomes or population to address energy services demand are not seriously discussed – but that may change if we are not able to address demand in other ways.

For now, we rely on more focused measures, including, for example, appliance buy-backs, which have long been used by utilities and governments to discourage consumers from putting their old and inefficient refrigerators in the basement. Several of the other policies already discussed in this report have similar effects.

Representative John Dingell’s recent proposal to phase out the mortgage interest deduction for homes of 3,000 square feet or more is intended to address the trend of increasing house size.[99] Reduced government expenditures resulting from this plan could easily amount to thousands of dollars, even for relatively modest homes.[100]

We estimate that this policy, if enacted in concert with our EISA(AR)/HR 3221+/Real EERS scenarios, would save 0.5 quads and avoid the emission of 30 million metric tons of CO_2 annually in 2050, assuming it spurred homeowners to achieve LEED certification rather than give up their deduction.[101]

Recommendation: Representative Dingell’s mortgage deduction elimination plan for owners of large single family homes should be implemented.

[98] 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.
[99] This proposal is discussed in greater detail on page seven.
[100] The mortgage interest deduction generally provides greater benefits to high income households, who tend to purchase more expensive homes and have higher marginal tax rates, than for lower income households. On average, tax payers with incomes exceeding $200k who took the deduction received twice as much (about $7,000-$7,300 compared to $3,000-$4,000) as taxpayers in the $100k-200k income bracket. This regressivity extends down through all the tax brackets, with the lowest income taxpayers benefiting the least.
[101] See Appendix 4 for more detail on our methods and assumptions.

Conclusion

Energy efficiency is expected to be one of the most important emission abatement options as the U.S. transitions to a carbon-constrained economy because of the long time frame needed to develop and deploy new major clean technologies; the difficulty of breaking our reliance on fossil fuels in the near future; and the high, untapped cost-effective potential of energy efficiency.

Energy-efficiency potential studies typically show median cost-effective energy-efficiency potential of around 20% of projected energy use in the buildings sector in 2020.[102] Assuming that similar efficiency improvements will be attainable in the future, the estimated energy efficiency potential for 2050 would be around 50% of business as usual projections. A recent study by McKinsey & Company suggests that most of the cost-effective energy-efficiency abatement options are found in the buildings sector.[103]

The prevalence of market barriers, such as split incentives and lack of information helps explain the underinvestment in energy efficiency in the buildings sector. despite the high economic potential is the existence of market barriers, such as split incentives and information barriers. (See Appendix 1). A recent study by the Lawrence Berkeley National Laboratory shows that around 25 percent of all residential energy use in US is subject to the principal-agent market barrier (when a tenant in a rented property pays the energy bills but is not responsible for the purchase or maintenance of energy-using appliances).[104] While a carbon pricing policy is the single most effective policy for achieving higher levels of energy efficiency, the existence of many non-price barriers may warrant additional energy-efficiency policies. Some energy-efficiency policies could also be implemented faster than a carbon pricing policy, resulting in early GHG emissions reductions.

In this paper, we propose policies that would diminish the impacts of market barriers to energy efficiency and achieve a 35 percent reduction in buildings sector energy-related CO_2 emissions from the projected levels for 2050, even in the absence of a carbon pricing policy. Building codes, appliance and lighting standards overcome split incentives and information barriers and would be called for even after the externality costs are incorporated into the price of energy. In fact, to the extent that the stringency of energy codes and standards are determined by cost-effectiveness tests, the stringency of codes and standards should be increased if energy prices increase.

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[102] Joe Loper, Selin Devranoglu, Steve Capanna (Alliance to Save Energy) and Mark Gilbert (American Electric Power) *Energy Efficiency Potential in American Buildings*, May
See Steven Nadel, Anna Shipley, and R. Neal Elliott, *The Technical, Economic, and Achievable Potential for Energy Efficiency in the United States: A Meta-Analysis of Recent Studies*, ACEEE, September 2004, http://aceee.org/energy/eeassess.htm#meta.

[103] *Reducing U.S. Greenhouse Gas Emissions: How much at what Cost?*, U.S. Greenhouse Gas Abatement Mapping Initiative, Executive Report , McKinsey Institute, December 2007, http://www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf

[104] Scott Murtishaw and Jayant Sathaye, *Quantifying the Effect of the Principal-Agent Problem on US Residential Energy Use*, Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, August 2006

Other policies, including energy-efficiency R&D, for example, address other non-price market barriers and may also remain necessary after all externality costs are included in the price of energy. By contrast, incorporation of externality costs in energy prices reduces the justification for tax incentives, and other programs aimed at reducing the cost of energy-efficiency investments.

The building energy-efficiency policies discussed in this report would nearly eliminate all projected growth in energy demand through 2050, a 35 percent reduction below projected CO_2 emissions in 2050, and nearly 40 percent of the way toward achieving a national emissions reduction goal of 80 percent below 1990 levels by 2050. Energy-efficiency improvements in industry, transportation and power generation, along with decarbonization of energy supplies through fuel switching and carbon capture and sequestration could make up much of the difference. Ultimately, further policies may be needed to address the rapid growth in demand for energy services that have negated the enormous efficiency savings achieved over the last 35 years– including larger homes with an expanding number of energy-using appliances and equipment.

Appendix 1

Barriers and Solutions to Deployment of Energy-Efficient Technologies[105]

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.[106] SOLUTION: Pricing externalities (e.g. greenhouse gases) through tax or cap and trade, 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.

Principal-agent (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 that are only cost-effective over a number of years (like many Energy Star appliances) on property they don't own. SOLUTION: Codes and standards remove the most inefficient products and design practices from the new construction marketplace. Building energy labels could allow renters and buyers to anticipate energy costs before entering a lease or purchase.[107]

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, providing an incentive to utilities to increase sales and discouraging utility investments in demand-side management programs. 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.[108]

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[105] Taken almost in entirety from Joe Loper, Lowell Ungar, David Weitz and Harry Misuriello, *Building on Success, Policies to Reduce Energy Waste in Buildings*, ASE, July 2005, p.8.

[106] 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 are under-regulated and, of course, carbon dioxide emissions are currently not regulated at all.

[107] Building labels may not help with individual apartments.

[108] For a literature review on the subject, see The Regulatory Assistance Project, *Decoupling/Financial Incentives*, http://www.raponline.org/Feature.asp?select=78.

Appendix 2

EISA Savings from Provisions with No Further Governmental Action Required[109]				
Source	**Policies**	**Description**	**Primary Energy Savings (Quads)**	**Carbon Dioxide (MMT)**
EISA (NAR)	Appliance Standards	External Power Supply Efficiency Standards Energy Standards for Home Appliances Walk-in Coolers and Freezers Electric Motors[110]	0.84	61.62
	Lighting Standards	Efficient Light Bulbs	1.14	86.50
Total; Baseline Savings/Reductions			1.98	149.12

[109] ASE calculations based on ACEEE savings estimates. ACEEE, *Energy Bill Savings Estimates as Passed by the Senate, ACEEE's assessment of the potential energy, carbon and economic savings*, December, 2007 http://www.aceee.org/energy/national/EnergyBillSavings12-14.pdf (Alliance calculations assume increase of savings proportional to baseline energy use through 2050)

[110] Some of the savings from electric motors would be realized in the industrial sector

Appendix 3

Energy and carbon savings relative to business as usual by implementing Sec. 304 of the House-passed H.R. 3221, "Updating state building energy efficiency codes"

	Cumulative savings 2010-2050		Annual Savings 2020	2030	2050
Total energy savings	**111,497**	trillion BTU (111 quads)	**895**	**2,627**	**6,115**
Carbon avoidance	**1,768**	MMT of carbon equivalent	**14**	**42**	**97**
CO2 avoidance	**6,484**	MMT of CO2 equivalent	**52**	**153**	**356**
Cost saved (mio $)	**1,104,624**	$1,105 bio	**8,854**	**26,063**	**60,505**
Nat. gas residential	18,343	trillion BTU	144	442	984
Fuel oil res.	2,763	trillion BTU	22	67	148
Electricity res.*	19,840	trillion BTU	156	478	1,064
Nat. gas commercial	12,007	trillion BTU	98	279	668
Fuel oil comm.	1,264	trillion BTU	10	29	70
Electricity comm.*	53,975	trillion BTU	439	1,253	3,004
Natural gas total	30,350	trillion BTU	242	721	1,652
Fuel oil total	4,026	trillion BTU	32	96	218
Electricity total*	73,814	trillion BTU	595	1,731	4,068

* All electricity savings are given in primary energy

Baseline

The **business-as-usual** assumptions, based on EIA projections are:

- The new homes built in each year use 0.1% less heating and cooling energy than homes built in the previous year.[111] At the same time, the annual amount of new construction decreases by 0.52% per year.[112] As a result, in the business-as-usual scenario, the total heating and cooling energy use of all newly constructed homes decreases by 0.63% each year.
- Annually, heating, cooling and lighting energy use from newly constructed commercial buildings increases by 0.27% over the energy use from the previous year's construction. The growth in commercial floor space is 1.2% but per-square-foot energy consumption for heating, cooling, and lighting decreases by 0.67%.[113] With annual construction growing 0.94% each year, the expected growth in energy

[111] EIA, *Annual Energy Outlook 200,*. Table 4: Residential Sector Key Indicators and Consumption http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.
[112] EIA, *Annual Energy Outlook 2008*, Table 19: Macroeconomic Indicators http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_19.xls.
[113] EIA, *Annual Energy Outlook 2008*, Table 5: Commercial Sector Key Indicators and Consumption. http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_5.xls.

consumption from heating, cooling and lighting in new buildings is 0.94%-(1.01*67%) = 0.27%.

Timeline

2009	President puts the policy in place. The International Code Council has already released the 2009 IECC, so it is too late to increase code stringency by 30%.
2011	DOE determines that ASHRAE 90.1-2010 has the potential to save 30% heating, cooling, and lighting energy over 90.1-2004. Two years after the enactment of the law, all states have to adopt the 2009 IECC, referencing ASHRAE 90.1-2007, or have an equivalent code. The 2009 IECC and ASHRAE 90.1-2007 are 5% more stringent than the 2006 IECC and ASHRAE 90.1-2004. This improvement is within the target range of code improvements envisaged by the EERE Building Technologies Program.
2012	All states achieve 90% compliance with the 2006 IECC or an equivalent code - as required by (b)(1) and (c)(2) of Sec. 304. The International Code Council finalizes the 2012 IECC, which now saves 30% heating and cooling energy beyond the 2006 IECC. DOE makes the relevant determination.
2014	3 years after DOE's determination, all states enforce ASHRAE 90.1-2010, achieving 90% compliance.
2015	3 years after DOE's determination, all states enforce the 2012 IECC, achieving 90% compliance.
2018	DOE determines that the 2018 IECC achieves 50% energy savings above the 2006 IECC.
2019	DOE determines that ASHRAE 90.1-2019 achieves 50% energy savings above ASHRAE 90.1-2004.
2021	3 years after DOE's determination, all states enforce the 2018 IECC, achieving 90% compliance. 3 years after DOE's determination, all states enforce ASHRAE 90.1-2019, achieving 90% compliance.

Energy code improvements beyond business as usual **after 2021** are outside the focus of these estimates.

Other assumptions

Energy uses affected by code

The "overall energy savings" of 30% and 50% required in Subsection (a) of Sec. 304 of H.R. 3221 cover heating and cooling for residential buildings and heating, cooling, and lighting for commercial buildings.

Renovations

- The annual amount of renovated floor space in residential and commercial buildings is equal to the amount of new construction per year.
- Residential renovations and additions achieve 35% of the savings potential from codes. Most of this is due to window replacements, which achieve about 25% savings. The other 10% come from additions, duct insulation, and building shell insulation.[114]
- In renovated commercial floorspace, 46% of the savings potential from codes is realized. This is based on data from Table B9 of the 2003 CBECS, which shows typical types of renovation: lighting upgrades (58% of renovations), insulation upgrades (23% of renovations), wall or roof replacements (43% of renovations), and window replacements (36%).[115] The lighting energy savings potential of codes is thus assumed to be realized in 58% of renovations, whereas the heating and cooling energy savings potential is assumed to be realized in about 34% of renovations.

[114] EIA's *Residential Sector Demand Module 2006, Model Documentation* states that it is estimated that a constant 1.2% of existing housing units are renovated each year, increasing the square footage of the heated living area by about one third. http://tonto.eia.doe.gov/FTPROOT/modeldoc/m067(2007).pdf.

[115] EIA, *Commercial Buildings Energy Consumption Survey 2003*, Table B9, December, 2006http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set3/2003pdf/b9.pdf

Appendix 4
Assumptions and Process to Calculate the Elimination of the Mortgage Interest Rate Deduction

According to the Residential Energy Consumption Survey (RECS), in 2001 25 percent (18.4 million) of single-family houses in the US were 3,000 square feet or bigger.[116] We assumed that this ratio would continue through 2050 (that is, that 25 percent of new homes would continue to be 3,000 square feet or more).[117]

Overall, the housing stock is projected to increase by an average of 0.9 percent annually through 2030.[118] We assume that this holds true for homes of more than 3,000 square feet as well. But annual construction is greater than 0.9 percent annually, since the above number does not take into account destruction of existing stock. According to AEO, the average annual new construction between 2010 and 2030 is about 1.4 percent of the housing stock in these years, which means that about 0.5 percent of the stock was destroyed per year.[119]

Since there is no existing projection for the US housing stock through 2050, we took the AEO projections through 2030, and, assuming that about 1.4% of the housing stock is replaced each year, we found that in 2050 alone, we expect there to be 621 thousand new single-family homes of greater than 3,000 square feet constructed. From 2010-2050, we expect new construction of a cumulative 15.6 million single-family homes of 3,000 square feet or more. Taking destruction into account, we project 12.9 million single-family homes of 3,000 square feet or more that predate 2010 to remain in 2050. We assume that the distribution of homes of different sizes remains the same as it was in 2001, as shown below.

square footage	Number of homes in 2001	Number of NEW homes by 2050	Number of Existing homes by 2050
3000-3499	6,600,000	5,600,000	4,600,000
3500-3999	3,800,000	3,200,000	2,700,000
4000 +	8,000,000	6,800,000	5,600,000
Total	18,400,000	15,600,000	12,900,000

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[116] EIA, *Residential Energy Consumption Survey 2001*, Table HC1-4a, 2001 http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-4a_housingunits2001.pdf

[117] This assumption may be slightly low. According to the *Annual Energy Outlook 2008*, the average house size is projected to increase through 2030. But the average in 2030 is still only 2,046 square feet, so it's impossible to say for sure whether the percentage of houses over 3,000 square feet will increase as well. http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.

[118] EIA, *Annual Energy Outlook 2008*, Table 4, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.

[119] EIA, *AEO projections of new construction through 2030*: http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_19.xls. AEO projections of housing stock: http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.

The average site energy consumption per square foot in buildings greater than 3,000 square feet in 2001 is given below (A).[120] The ratio of source to site energy consumption in residential buildings as found in the AEO for 2010-2030 is about 1.9 to 1.[121] Therefore, the average source energy consumption per square foot (B) is A * 1.9. The ratio is altered given the trend toward greater efficiency that is found even in the Business as Usual (BAU) baseline model. From 2004-2030, the average source energy consumption per square foot is reduced by an average of 0.7 percent per year. Continuing this trend through 2050 results in a decrease in energy intensity of 26 percent per square foot compared to 2006.[122] Assuming these results hold true for larger buildings, the BAU energy intensity in 2050 will be as shown (C). Finally, this intensity number will be even further reduced through the EISA(AR)/HR 3221+/Real EERS policies laid out in this report. Since these policies would save an estimated 40 percent below baseline, the new energy intensities would be as follows (D).

square footage	(A) Thousand Site btu/square foot, Current	(B) Thousand Source btu/square foot, Current	(C) Thousand Source Btu/square foot, BAU, 2050	(D) Thousand Source Btu/square foot, EISA(AR)/HR 3221+/Real EERS, 2050
3000-3499	39.3	75.2	55.7	33.4
3500-3999	38.8	74.2	55.0	33.0
4000 +	29.4	56.2	41.6	25.0

Representative Dingell's proposal applies to all existing homes, except those built before 1900. RECS does not have a category for homes built prior to 1900 – instead, it lists those built before 1949. But given the relatively small number of homes this encompasses, considering the average number of homes existing from each subsequent decade, we've assumed that all single-family homes larger than 3,000 square feet, new or existing, would be subject to this requirement.[123] We also assume that, if this legislation were passed, given the enormity of the mortgage interest deductions (a total of $64 billion is spent on the deductions each year[124]), the relatively low cost of the LEED certification process (currently estimated at $500-$3000 per house, but, according to LEED, this number would drop considerably with greater demand for certification[125]), and the cost-effective nature of the energy-efficiency improvements needed to be LEED-

[120] EIA, *Residential Energy Consumption Survey 2001*, http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/enduse/ce1-62u_sqft_useind2001.pdf

[121] In AEO2008, the estimated ratio for total versus delivered residential energy consumption in 2010 is 1.91 for 2010 and 1.94 for 2030 (http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls).

[122] EIA, AEO 2008, Table 4, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.

[123] EIA, *Residential Energy Consumption Survey 2001*, Table HC1-4a. Housing Unit Characteristics by Type of Housing Unit, 2001, http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-2a_construction2001.pdf.

[124] Pamela J. Jackson, *Fundamental Tax Reform: Options for the Mortgage Interest Deduction*, Congressional Research Service, The Library of Congress, August 8, 2005.

[125] Private correspondence with US Green Building Council (USGBC) employee, October 11, 2007.

certified, every owner of a large home would go through the LEED-certification process.[126]

For new buildings, LEED-certified homes are required to be ENERGY STAR-qualified, equal to 15-20 percent more energy-efficient than code requires.[127] LEED homes need 45 points to be certified, but larger homes need to achieve more points than a standard home would. A 3,900 square foot home (what we estimate to be the average size of a large home, based on the distribution of homes by square footage) with four bedrooms needs to achieve 54 points. Thirty-eight of the 130 possible LEED points are achieved through energy-efficiency improvements. Assuming an equivalent ratio of energy-efficiency points is used for achieving 54 points, the average large home would need to earn 16 efficiency points, equivalent to a 35 percent improvement in energy performance over a home built to code. Note that this 35 percent improvement does not apply to all of a home's energy consumption – it only applies to heating, cooling, ventilation, water heating and lighting (not most appliances or electronics). We estimate that the covered products account for 55 percent of a typical home's energy consumption.[128] So the average new large home in 2050 will have to be 19 percent (0.55 * .35 = .19) more efficient than baseline to be able to continue claiming the deduction.

Currently, however, there is no LEED certification or rating for existing residential buildings. USGBC is working to develop such a protocol, but it's unlikely that existing homes would be able to achieve savings of 35 percent greater than code.[129] It is probably unreasonable to expect existing buildings to achieve similar savings as new buildings without a complete renovation. We assume that existing large single-family homes would, under an eventual LEED certification, need to improve their energy-efficiency by half of the requirement for new buildings – an estimated (.55 * .175 = 10 percent) beyond baseline.

New single-family homes of 3,000 square feet or more would, in 2050, consume 1.77 quads under the EISA(AR)/HR 3221+/Real EERS scenario. Achieving LEED certification would save 19 percent (0.34) of those quads. Assuming that 45% the savings were from electricity, 41% from natural gas, and 14% from other fuels (based on our building codes calculations), this works out to 20 MMT of CO_2 savings.[130]

Existing large single-family homes under the EISA(AR)/HR 3221+/Real EERS scenario would consume 1.72 quads. LEED certification would therefore save 10 percent (0.17)

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[126] We estimate that the average loss in increased taxes paid from the mortgage interest deduction for taxpayers with large single-family homes earning between $50,000 and $75,000 per year would be about $320. If we assume that certification costs $1750 (which is probably high in 2050), these households would still earn back their certification costs in just over five years.

[127] For this calculation, we assume that code is equal to the baseline energy consumption per square foot.

[128] EIA, AEO 2008, Table 4, http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls. In 2030, residential energy use covered by the home energy ratings is projected to be 55% of overall residential energy use.

[129] In fact, USGBC is already working on developing a draft protocol for existing homes. Private conversation with USGBC employee, October 12, 2007.

[130] We assume that each quad of electricity emits 65 million metric tons $CO_2$and that each quad of natural gas and other fuels emits 53 MMT CO_2.

of those quads. This equates to 10 MMT of CO_2 savings. All told, savings would equal 0.51 quads and 30 MMT of CO_2 savings.[131]

It is possible further CO_2 reductions would be achieved through the other LEED points besides those for energy efficiency that would be achieved. These categories include water savings, resource efficiency, sustainable sites, vicinity to public transportation, and reduced heat island effect, among others. The savings that would result from these points are beyond the scope of this analysis.

[131] Our estimated savings may be slightly low, since we're assuming that all new and existing buildings would achieve the same energy consumption per square foot. It is likely that existing homes earning LEED certification before 2050 would be certified at 17.5 percent below baseline consumption for that year, and that these homes' energy intensity would not necessarily decrease along with baseline intensity. On the other hand, we assume that USGBC will have perfect information and will update LEED annually to reflect the new baseline energy intensity – this could exaggerate savings.