Reducing Carbon Dioxide Emissions through Improved Energy Efficiency in Buildings

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Introduction and Overview[1]

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,[2] making it likely that about 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 last as long as the building stands – unless the building is later 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;[3] a home built in 2001 uses 12 percent less energy per square foot than one built in the 1980s;[4] and new refrigerators consume about one-fourth the energy of those sold 30 years ago.[5] The bad news is despite these gains, overall energy consumption and carbon emissions from the buildings sector still are rising because the number of buildings, their size and their "plug loads" all are growing. Residential energy use has increased by one-third since 1980 and commercial building use by more than two-thirds.[6] Square footage per home has increased by more than 50 percent since the 1980s;[7] 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.[8]

The US building sector is currently responsible for 2.3 gigatons (Gt) of CO_2 emissions annually, roughly 40 percent of total. By 2050, based on current trends, US buildings

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[1] Thanks to Jeff Harris and Lowell Ungar for review and helpful comments.

[2] Energy Information Administration, *Residential Energy Consumption Survey 2001*, Table HC1-4a, http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-4a_housingunits2001.pdf, and Energy Information Administration, *Commercial Buildings Energy Consumption Survey 2003*, Table A1, http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set1/2003pdf/a1.pdf.

[3] 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.

[4] Energy Information Administration, *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.

[5] Natural Resources Defense Council, "Issues: Oil & Energy; Efficient Appliances Save Energy – and Money," August 31, 2004, http://www.nrdc.org/air/energy/fappl.asp.

[6] Energy Information Agency, *September 2007 Monthly Energy Review*, Tables 2.2 & 2.3, http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T02.03.

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

[8] Energy Information Administration, *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.

will emit about 4.3 Gt of carbon in 2050, an 86 percent increase from today's levels.[9] By implementing aggressive but cost-effective energy-efficiency practices, US building emissions could be reduced by nearly half from projected levels in 2050, even without assuming major carbon pricing policies.[10]

If, due to carbon policies or market factors, energy prices were to increase more dramatically than projected, more energy-efficient measures and policies would become cost-effective. Because of the importance of energy costs in determining which measures are cost-effective, accurately 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.[11] Carbon pricing would encourage building efficiency improvements and, importantly, help slow 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 policy efforts will be required to achieve the full cost-effective energy-efficiency potential in buildings. Major impediments to efficiency improvements include lack of information, 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 between, for example, tenants and landlords. (For more detail on barriers to energy-efficiency improvements, see Appendix 1)

Achieving 80 percent reductions in CO_2 emissions below 1990 levels by 2050 (92 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. The major energy-efficiency policy options are energy performance standards for appliances and equipment, building energy codes, utility demand-side management programs, market-transformation measures, tax incentives, and research and development of building technologies.[12]

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 zero. Again, while all of these policy options are, to a large extent, cost-effective on their own merits, their effectiveness and likely impact would increase exponentially with economy-wide carbon pricing. Consequently, the higher the price on carbon, the more energy can be saved through energy-efficiency policies.

At current price levels, additional policies beyond those discussed in this chapter will be required to achieve emissions reductions of 80 percent below 1990 levels in the buildings

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[9] Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030*, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, February 2007, Table A18, p. 164.
[10] 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 2007* Table A3, pp. 140-141.
[11] Currently, the price of energy doesn't take into account the externality costs of the environmental damage that is done by emitting carbon.
[12] Government energy management and location efficiency (e.g., Smart Growth") policies are beyond the scope of this chapter. We also do not discuss education and awareness programs, including labeling.

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.

Buildings Carbon Reduction Policy Scenarios

To achieve building sector CO_2 emissions levels of 80 percent below 1990 levels in 2050 will require a 92 percent reduction from baseline projections. Economy-wide, projected 2050 emissions are about 10 Gt, compared to five Gt in 1990 and six Gt today.[13] In other words, achieving emissions levels of 80 percent below 1990 levels in 2050 would require a reduction of nine Gt below baseline (five Gt below today's emissions).

The buildings sector's share of emissions reductions would be roughly four Gt in 2050, 80 percent of its projected emissions in 2050.[14] The energy-efficiency policies in this chapter are designed to capture 45 percent of the CO_2 reductions needed by 2050 – 1.8 Gt. Changes in the fuel mix, on-site renewable energy investments and reduced demand for energy services would need to account for the remaining emissions cuts necessary to achieve the goal.

In the summer of 2007, the US House of Representatives and Senate each passed energy bills containing substantial energy-efficiency provisions. While these bills are currently awaiting conferencing and final passage by both houses of Congress, they already have been thoroughly vetted by numerous stakeholders in the process of getting where they are. No doubt there will be significant changes before a final bill is enacted (if ever), but they serve as a good starting point for an aggressive effort to achieve CO_2 reductions with energy-efficiency policies.

As a first step in meeting the carbon reduction targets, we propose full implementation of the provisions in the House-passed H.R. 3221, including most notably appliance and equipment standards, enhanced buildings codes, utility energy programs and tax incentives. Background discussion and details of the major provisions are discussed below.[15] If fully implemented, these provisions could reduce projected 2030 building energy use by about one-fifth (11 quads) and would reduce CO_2 emissions in buildings by about 18 percent (0.6 Gt).[16]

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[13] 2050 estimates projected by the Alliance to Save Energy, based on EIA, *Annual Energy Outlook 2007*, Table A18, p. 164, historical emissions data from EIA, *Annual Energy Review 2006*, June 27, 2007, Table 12.2, p. 343.

[14] EIA, *Annual Energy Outlook 2007*, Table A18, p. 164.

[15] We recommend select provisions from the Senate-passed H.R. 6 as well, as detailed in the narrative, but for simplicity's sake, we refer to the aggregate of the energy bill provisions we recommend as "H.R. 3221 Extended." Note also that while H.R. 3221 tends to contain more aggressive building provisions, H.R. 6 is projected to achieve more significant energy savings due to its inclusion of a mandatory fuel economy improvement in passenger vehicles. That, of course, is outside the scope of this chapter, however.

[16] Based on Alliance and ACEEE estimates and projections from EIA, *Annual Energy Outlook 2007*, Table A2, pp. 138-139. All energy savings estimates are source energy, which includes energy consumed directly at the building site, as well as energy consumed by power plants to generate electricity consumed at the site.

By 2050, these policies would realize even larger reductions in energy and CO_2 emissions. Both primary energy use and CO_2 emissions would be reduced by roughly 25 percent below projected baseline, or 17 quads and 1.1 Gt, respectively.[17] This assumes that building codes increase by business-as-usual rates of efficiency improvement through 2050 and that the stringency relative to baseline of the other policies is constant.[18] We call this the "H.R. 3221 Enhanced" scenario to reflect that some of the policies in H.R. 3221 would need to be extended and updated through 2050.

Climate Action Plan for Residential and Commercial Buildings				
		Policies	**Energy Savings in 2050 (Quads)**	**CO_2 Reduction in 2050 (MMT)**
Enhanced H.R. 3221	Appliance Efficiency Standards	• Residential clothes washers, dishwashers, dehumidifiers, boilers • Updates for refrigerators, freezers and other appliances • Certain electric motors, external power supplies • Walk-in coolers and freezers • Furnace fan standard process, standby power • Regional variations in heating and cooling standards • Metal halide fixture standard	1.6	112.5
	Lighting Efficiency	• Incandescent reflector lamps. • General service light bulbs (would ban most traditional incandescent bulbs by 2012 to 2014), stronger standard effective 2020.	1.9	144.0
	Residential Building Efficiency	• 30% savings by 2010 and 50% savings by 2020 • Manufactured housing code at least as stringent as the IECC national model code.	12.2	707
	Commercial Building Efficiency	• Commercial Buildings Initiative (budget constrained)	1.8	122.0
	Efficiency Component of RPS	• Retail electric providers to increase renewable sources or energy-efficiency programs, rising from 2.75% of previous year's sales in 2010 to 15% in 2020-2039 • Energy efficiency limited to 27% of the standard, or 4% of electricity in 2020.	0	0

[17] Energy projections based on EIA, *Annual Energy Outlook 2007*, Table 2, pp. 138-139.

[18] We assume that all of the standards, policies and codes will be ramped up in the future at the same rate at which the economy grows. So the savings in 2030 will be proportionally equivalent to the savings in 2050. This does not hold true for building codes, which will increase its annual savings as new buildings (and building renovations) subject to code become a higher fraction of the stock. For instance, if, in 2030, 40 percent of the buildings were constructed after 2010, then the remaining 60 percent of the buildings will not adhere to the new, more stringent building codes. By 2050, if 80 percent of buildings are covered, then the savings will be twice as high. For more detailed assumptions and method for calculating building code impacts, see Appendix 2.

	Tax Credits	• Extend the commercial buildings deduction for five years, through 2013. • Extend the appliances tax credit with modified criteria.	0.3	19.7
Enhanced H.R. 3221 Total		• Total of savings by Enhanced H.R. 3221	17.7	1105.0
EERS Deluxe (Beyond Enhanced H.R. 3221)		• Starting in 2010, electric utilities reduce baseline electric sales by 0.6 percent annually through efficiency • Natural gas utilities are required to reduce baseline gas sales annually by 0.3 percent.	9.6	620
No Mortgage Interest Deduction 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: • 3000-3199 sf – 85% • 3200-3399 sf – 70% • 3400-3599 sf – 55% • 3600-3799 sf – 40% • 3800-3999 sf – 25% • 4000-4199 sf – 10% • 4200 plus sf – 0%.	0.8	48

H.R. 3221 requires electric utilities to reduce their carbon emissions through a renewable portfolio standard (RPS) requiring them to meet 17 percent of demand through renewable energy, of which four percent can be from end-use energy-efficiency programs. While the establishment of a national RPS with an energy-efficiency component is certainly a step in the right direction, utility energy-efficiency programs could achieve more.[19]

Our EERS Deluxe policy scenario assumes that, starting in 2010, electric utilities are required to reduce projected baseline electric sales by 0.6 percent annually through efficiency, and natural gas utilities are required to reduce baseline gas sales annually by 0.3 percent. If fully implemented, building energy use in 2050 would be reduced by an additional 9.6 quads (beyond the Enhanced HR 3221 scenario) and CO_2 emissions would be reduced by an additional 0.6Gt.[20]

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[19] In fact, ACEEE is updating their savings estimates to reflect the likelihood that most of the savings achieved through the efficiency component of the RPS will probably occur whether or not the legislation is passed. So although utilities would likely claim they were reducing their electricity sales through energy-efficiency programs by the maximum four percent allowed by the law, actual additional savings would probably only be equal to about one percent of their baseline electricity sales. We assume that by 2050, there would be no additional savings from the efficiency component of the RPS. Based on a conversation with Neal Elliot, ACEEE, October 5, 2007.

[20] Alliance to Save Energy 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 Extended savings. Our EERS deluxe 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.

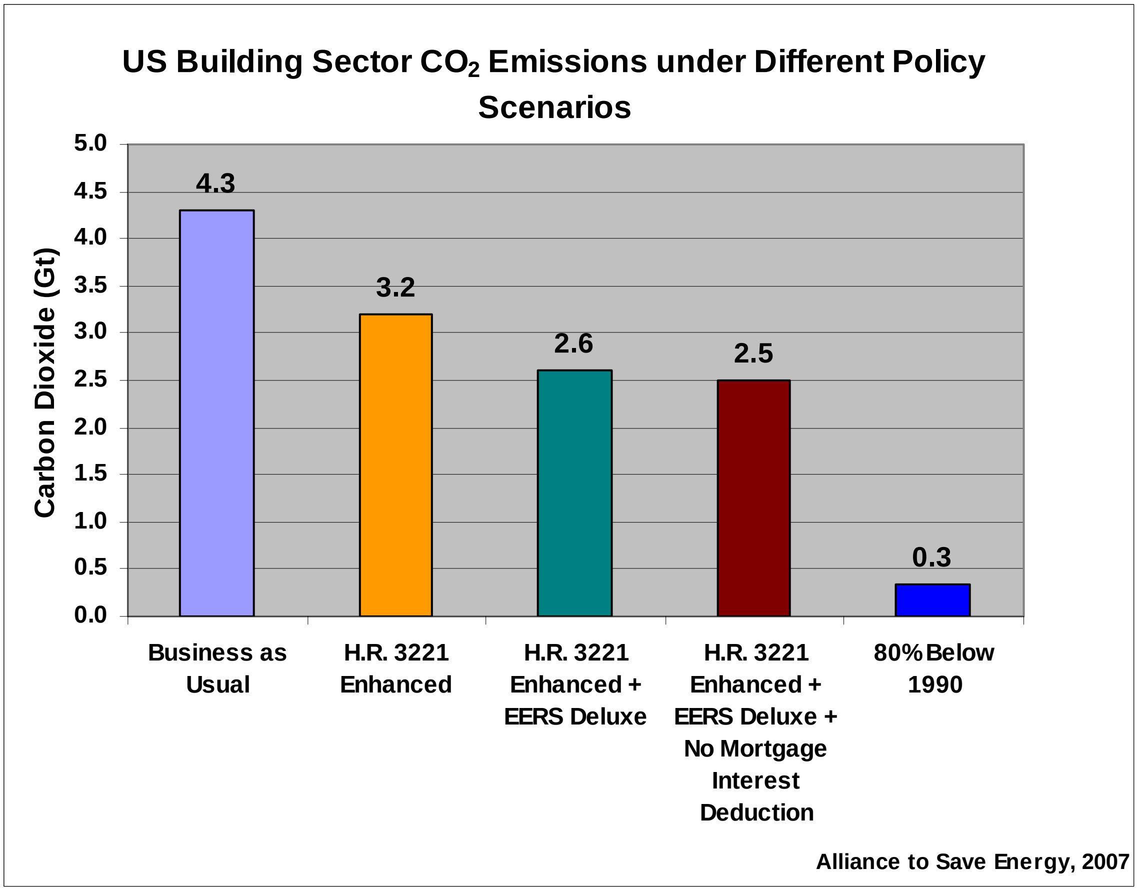
Finally, we include a policy designed to address the trend toward bigger and bigger homes. Policies targeting growing home sizes, increased plug loads, and other lifestyle issues may ultimately need to be part of the climate policy arsenal. While most observers recognize this problem, policies to address it, other than carbon pricing, have been few and far between. Recently, 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 Leadership in Energy and Environmental Design (LEED) certification.[21] 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 exact size of their home. For instance, a 3,100 square foot home would still 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. This policy, if fully implemented, could reduce energy use by as much as 1.4 quads and reduce CO_2 emissions by 0.08 Gt annually in 2050.[22]

By 2050, combined savings from the Enhanced H.R. 3221 policy package, the EERS Deluxe, and the Mortgage Interest Deduction would approach 1.8 Gt. Building energy consumption would be reduced by 28 quads and America's energy bill would be roughly $9 billion lower than currently projected under business-as-usual.

The figure below shows building sector CO_2 emissions under four different scenarios – business as usual; full implementation of H.R. 3221 provisions (including the extended building code improvements); H.R. 3221 combined with an aggressive energy efficiency resource standard; and all of the policies discussed, including the mortgage interest deduction, and compares them to the 80 percent below 1990 target. As shown, an additional 2.2 Gt reduction in CO_2 emissions will need to be obtained through increased use of on-site renewable energy or other changes in the building and power generation fuel mix.

[21] 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.

[22] These numbers based on implementation of the plan without any additional policies from H.R. 3221 or the EERS Deluxe. When combined with the H.R. 3221 Extended and EERS Deluxe policies, savings from this proposal are smaller – 0.8 quads and 0.05 Gt annually in 2050. Details of the Dingell proposal are provided in Appendix B.


US Building Sector CO_2 Emissions under Different Policy Scenarios
Carbon Dioxide (Gt)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4.3
3.2
2.6
2.5
0.3
Business as Usual
H.R. 3221 Enhanced
H.R. 3221 Enhanced + EERS Deluxe
H.R. 3221 Enhanced + EERS Deluxe + No Mortgage Interest Deduction
80% Below 1990
Alliance to Save Energy, 2007

Policies to Reduce Carbon Dioxide in Buildings[23]

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. The equipment covered by current energy-efficiency standards comprises well over 50 percent of building energy consumption.[24]

Appliance and equipment standards complement building codes and other policies by targeting many products that currently are beyond the reach of building codes and by ensuring that new appliances are more efficient than the appliances they replace. Energy use in systems typically covered by building codes is expected to grow relatively slowly compared to equipment and appliances that are not covered by codes. For example, energy consumption from commercial building lighting, water heating, space heating and air conditioning is projected to increase 22 percent through 2030. Energy used by equipment typically not included in 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.[25]

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, 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.[26] Future energy savings from existing standards will save the equivalent of the energy used by about 27 million American households in 2020.[27] But these savings could be much larger if the Department of Energy (DOE) met its congressionally prescribed schedules for developing and issuing new appliance standards. Determinations or standards for 16 products are currently pending or overdue. Some standards authorized in 1992 are still awaiting final rulemakings.

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[23] 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*, Alliance to Save Energy, July 2005, p.24; and from Joe Loper, Selin Devranoglu, Steve Capanna, and Mark Gilbert, *Energy Efficiency Potential in American Buildings*, Alliance to Save Energy and American Electric Power, 2007.
[24] EIA, *Annual Energy Outlook 2007*, Tables A2, A4 and A5, pp. 138-139 and 142-145.
[25] EIA, *Annual Energy Outlook 2007*, Table A4, pp. 142-143.
[26] Based on a table by Kenneth Gillingham, Richard Newell and Karen Palmer, *Retrospective Examination of Demand Side Energy Efficiency Policies*, June 2004, revised September 2004, Resources for the Future, Discussion Paper 04-19, p.2.
[27] 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

DOE's failure to issue standards is especially problematic since states are generally precluded from issuing their own standards once the federal government is granted authority to develop standards on a particular product category.[28] Federal preemption of state standards encourages manufacturers to support federal standards. Manufacturers would rather design their products to meet one national standard than have to tailor their products to different state codes. 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 in the process of being developed by states, for instance.[29]

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. Until now, DOE has not been allowed to set regional standards. As a result, the proposed federal standard for residential furnaces is very weak. In order to capture the most energy savings nationwide, DOE must have the authority to consider differing regional standards for heating systems and air conditioners, as proposed in the pending federal legislation.

New and updated energy-efficiency standards have been agreed upon by manufacturers and efficiency advocates for several appliances used in residential and commercial buildings, including residential clothes washers, dishwashers and incandescent reflector lamps, among many others.[30] These consensus standards were included in both the Senate-passed energy bill (H.R. 6, passed in June 2007) and the House-passed energy bill (H.R. 3221, passed in August 2007). Additional products included in H.R. 3221 include external power supplies, walk-in freezers and metal halide lamps, among others. H.R 3221 also directs DOE to develop a standard for electricity use by furnaces (for furnace fans) and for battery chargers.

Federal appliance standards currently do not include standby power use in their calculations. 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 residential electricity use in the United States.[31]

The American Council for an Energy Efficient Economy (ACEEE) estimates that the appliance standard provisions in H.R. 3221 would lead to annual savings in 2030 of 95.6 Terawatt-hours (TWh) of electricity, 518 billion cubic feet (bcf) of natural gas and overall energy use by nearly one quadrillion Btus (quad). These savings would result in

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[28] Joe Loper, Alliance to Save Energy, "Energy Efficiency Policies of State & Local Governments," August 31, 2007, presentation to the American Physical Association.
[29] Appliance Standards Awareness Project, "State Appliance and Equipment Energy Efficiency Standards: Status and Implementation Dates," July 2006, http://www.standardsasap.org/06stateupdate.pdf.
[30] Alliance to Save Energy, "Energy Efficiency in the House and Senate Energy Bills," August 2007, http://www.ase.org/section/_audience/policymakers/energybill/.
[31], Paolo Bertoldi, Bernard *Standby power use: How big is the problem? What policies and technical solutions can address it?* Lawrence Berkeley National Laboratory

the avoidance of 70 MMT of CO_2 emissions.[32] These energy savings represent almost one percent of overall US projected demand and nearly two percent of projected residential and commercial building demand.[33]

Recommendation: New and updated appliance efficiency standards should be developed for all of the products found in H.R. 3221. DOE should set standards for furnace fans and battery chargers. Standby power should be included in federal appliance standards. DOE should be directed to differentiate its standards by region to allow more sensible and effective standards for heating and cooling products.

Lighting standards have enormous energy saving potential in residential and commercial buildings. Commercial and residential lighting energy consumption accounted for six percent of total US energy consumption in 2006, and 15 percent of residential and commercial energy consumption.[34]

In recent years, advanced lighting technologies, including compact fluorescent lights (CFLs), light-emitting diodes (LEDs) and halogen bulbs have improved dramatically. It now seems very likely that incandescent bulbs, the predominant lighting technology since the days of Thomas Edison, could be phased out over the next decade or so. At least certain governments appear to be moving in that direction. In February 2007, Australia announced plans to ban the incandescent light bulb by 2012.[35] Canada soon followed suit.[36] In June 2007, Nevada passed Assembly Bill 178, effectively banning traditional incandescent light bulbs in 2012.[37] A similar proposal was considered in California, but was never voted on.[38]

H.R. 3221 contains a provision setting performance standards for general service light bulbs that would ban most traditional incandescent bulbs by 2012 to 2014, and set an

[32] American Council for an Energy-Efficient Economy, "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.
[33] Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030*, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, February 2007, Table A2, pp. 137-138.
[34] EIA, AEO 2007, Tables A2, A4 & A5.
[35] BBC News, "Australia pulls plug on old bulbs," February 20, 2007, http://news.bbc.co.uk/2/hi/asia-pacific/6378161.stm,
[36] Reuters, "Canada to ban incandescent light bulbs by 2012," April 25, 2007, http://www.reuters.com/article/scienceNews/idUSN2529253520070425.
[37] Details on what Nevada's standard will look like once it becomes effective in 2012 can be found at Southwest Energy Efficiency Project, "2007 Nevada Legislative Activities," June 25, 2007, http://www.swenergy.org/legislative/2007/nevada/index.html.
[38] California Assembly Bill Number 722, "How Many Legislators Does it Take to Change a Lightbulb Act," Introduced February 22, 2007. Assembly Bill 32 in California, which requires the California Air Resources Board (CARB) to develop strategies and mechanisms to reduce California's GHG emissions by 25 percent by 2020. Mandatory caps begin in 2012, but CARB has recommended that one early action California can take to reduce its emissions is to phase out incandescent light bulbs. See California Environmental Protection Agency, Air Resources Board, *Proposed Actions to Mitigate Climate Change in California*, April 20, 2007, http://www.fypower.org/pdf/GHG_AB32_EarlyActions.pdf.

even stronger standard effective 2020.[39] In an effort to encourage states to lead the way, it would also allow some states to adopt the standards before they took effect at the national level.

These lighting standards, if passed, would save more than all previous appliance standards combined. ACEEE estimates that, by 2030, the standards would result in annual savings of 143 TWh of electricity, 700 BCF of natural gas, and 1.44 quads of energy, while avoiding the emission of more than 100 million metric tons of CO_2.[40]

> Recommendation: A light bulb efficiency standard that would phase out traditional incandescent light bulbs by 2012-2014 and require efficiency comparable to compact fluorescent lights by 2020 should be developed.

Appliance and product standards save energy only as long as they are kept up to date. Eventually, thanks to technological breakthroughs, rising costs of energy, and market transformation, existing standards stop pushing the market towards greater intensity and begin to do nothing more than underline the status quo. So updating standards regularly is imperative in order to capture all of the available savings for a given product. Currently, however, there is no system in place that ensures that DOE will reevaluate all of their standards periodically.[41]

> Recommendation: DOE should be required 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. DOE should review test procedures for all covered products at least every seven years. A timetable should be developed for adopting standards for certain products set in the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) model commercial building energy code. Standards should become effective three years after the final rule, down from five years for several products. Finally, DOE should review test procedures for all covered products at least every seven years.

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 imposed by Congress when the new approval procedure was created. It seems clear that at least in some cases the rulemaking process is unnecessarily onerous. For example, with the standards passed in EPAct 2005, Congress passed legislation directing DOE to issue a rulemaking after consensus had already been reached between manufacturers and advocacy groups. In these cases,

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[39] H.R. 6 contained a Sense of the Senate resolution declaring the Senate's support for light bulb performance standards. Sen. Bingaman introduced S 2017 on lighting standards and held hearings in September 2007. This is the provision the Senate is expected to bring to an eventual Energy Bill Conference.

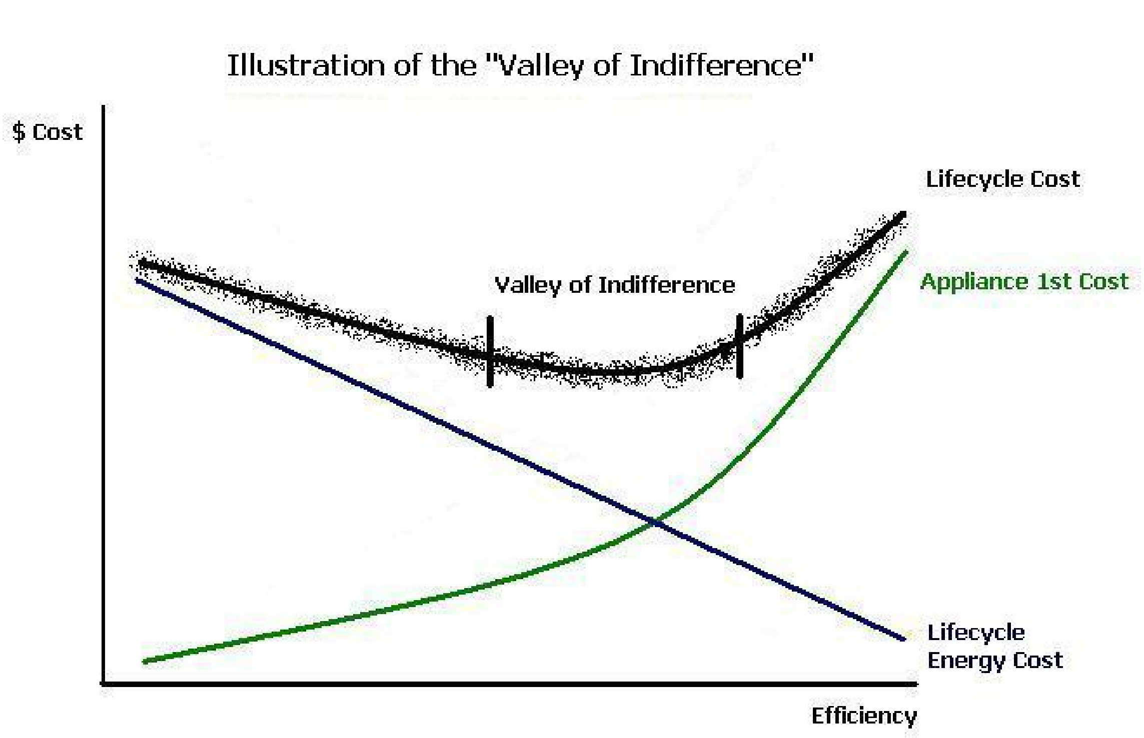
[40] American Council for an Energy-Efficient Economy, "H.R. 3221 as Passed by the House: ACEEE's assessment of the potential energy and carbon savings," August 21, 2007, http://www.aceee.org/energy/national/HouseBillSavings8-21.pdf.

[41] For some products there are requirements to do one or two reviews of the standard. There is no general system, however.

following a lengthy rulemaking process may unnecessarily delay the issuance of a non-controversial standard.

Recommendation: Allow 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 should be withdrawn, and DOE should enter into the standard rulemaking process. Further, eliminate the requirement for an advanced notice of proposed rulemaking (ANOPR) when setting a standard.

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. Additional cost-effective energy savings could be realized by establishing standards at the high end of the "valley," rather than the low end.



Recommendation: The maximum cost-effective efficiency level should be set by DOE 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.

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 and windows and other built-in components of a home or commercial building, frequently can 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 – even without any further policies in the future – 50 years from now.[42]

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 the state and/or local governments.

To help states (or local governments) that wish to adopt their own building energy codes, national model energy codes 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 model code for commercial buildings after DOE determines whether the code will save energy. For residential buildings, states are required to *consider* adopting the latest model energy code of the ICC once DOE issues its determination.

In principle, states are required to submit a letter to DOE if they opt not to adopt the new energy code, but that law has widely been ignored.[43] Currently, at least 42 states and Washington D.C. have adopted some form of energy building code, but their adoption is uneven. For example, 14 states have adopted a residential energy code that meets or exceeds the 2006 International Energy Conservation Code (IECC) (the most recent version), while 12 states have energy codes that precede the 1998 IECC or follow no energy codes at all. Similarly, 19 states have adopted the latest commercial building code or equivalent – the 2006 IECC or ASHRAE 90.1-2004 – while 13 states and Washington D.C. have commercial energy codes predating the ASHRAE 90.1-1999 code or have no code at all.

The absence of a statewide code does not necessarily indicate that there are no building codes in the state, as several major cities in states without energy-efficiency codes may

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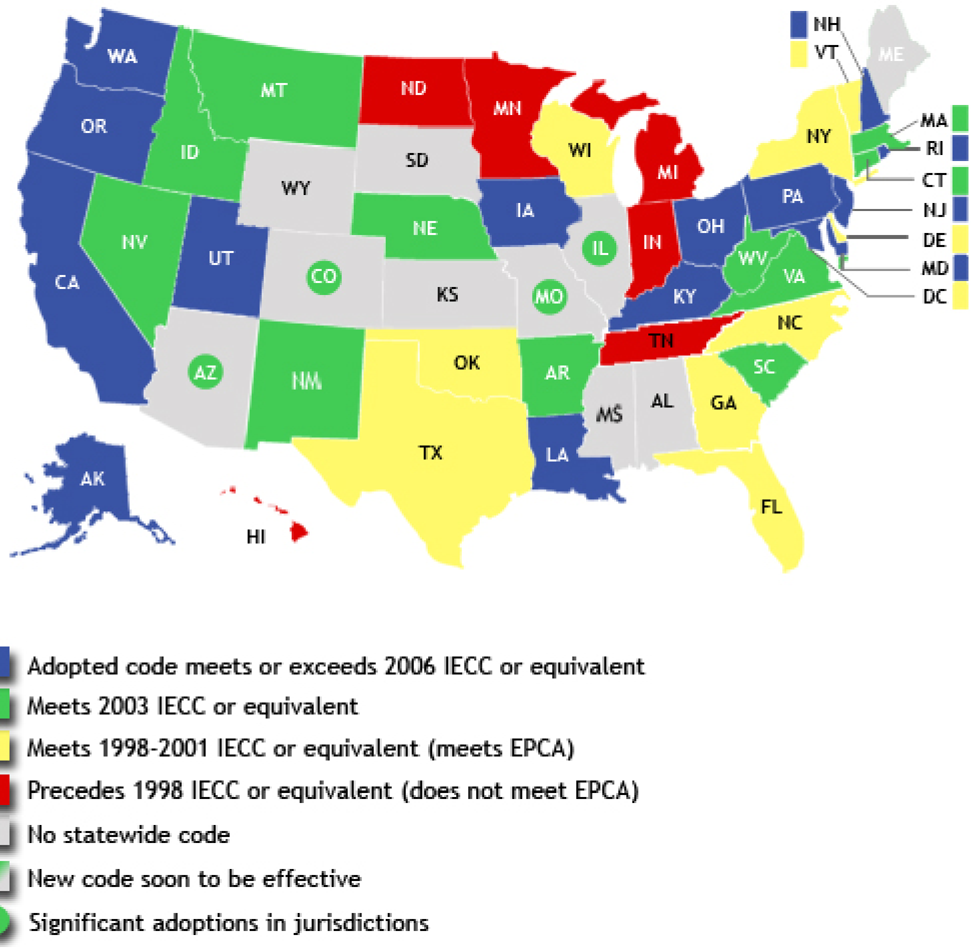
[42] EIA, Annual Energy Outlook 2007, Table A4, pp. 142-143 and Table A5, pp 144-145.
[43] Government Accountability Office, *ENERGY EFFICIENCY Long-standing Problems with DOE's Program for Setting Efficiency Standards Continue to Result in Forgone Energy Savings*, January 2007, pp. 27-28, http://www.gao.gov/new.items/d0742.pdf

have adopted their own local building codes. For example, Phoenix, Chicago and Denver each have adopted a version of the IECC for their residential buildings.[44]

Status of Residential State Energy Codes[45]



The disparity among states exists because of the autonomy granted to states and localities. Building codes are administered by 50 states and thousands of local authorities. Furthermore, building energy codes keep improving. 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 still can be difficult for states to keep up with the latest codes. The IECC guidance is updated every eighteen months, for instance, and a new edition is issued every three years.

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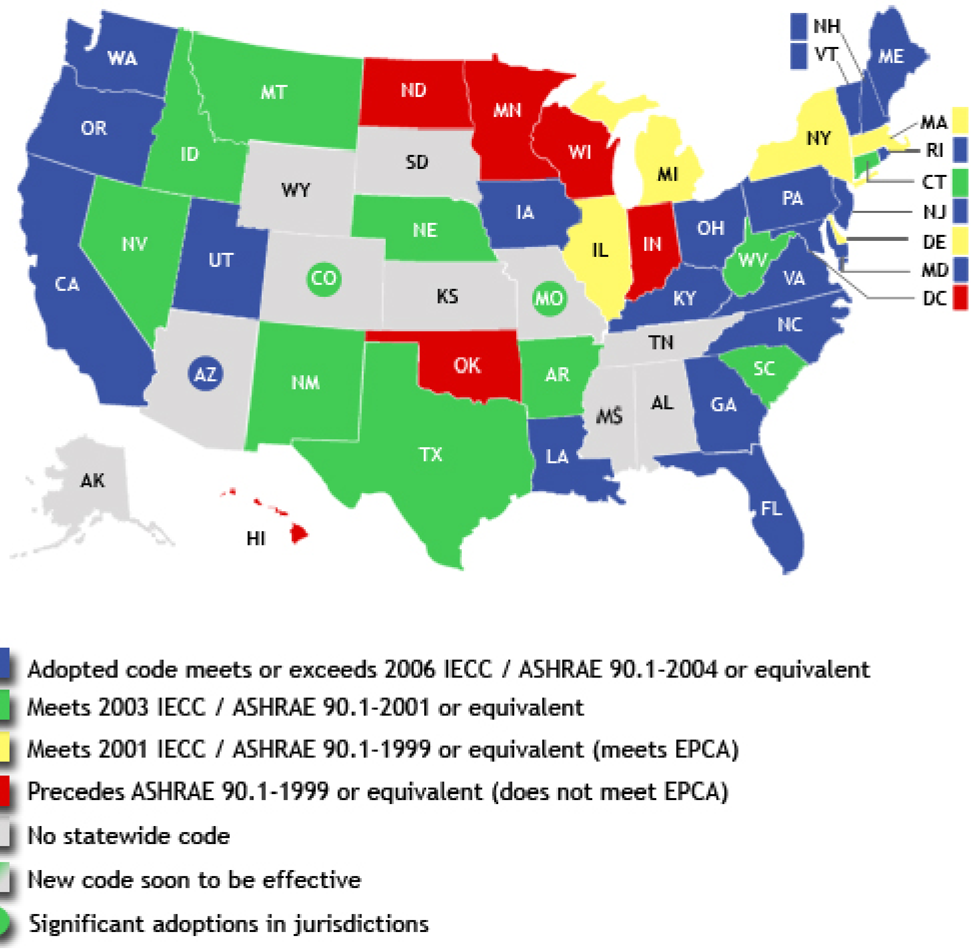
[44] Building Codes Assistance Project, "Status of Residential State Energy Codes," and "Status of Commercial State Energy Codes," September 2007, http://www.bcap-energy.org/map_page.php.
[45] Building Codes Assistance Project, "Status of Residential State Energy Codes," September 2007, http://www.bcap-energy.org/map_page.php.

Status of Commercial State Energy Codes[46]



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 extends well beyond the energy efficiency requirement in building codes, and code agencies still tend to be understaffed. As a result of too much work for too few employees, agencies need to prioritize which aspects of building codes to focus on. Code officials (understandably) tend to choose building code health and safety issues over energy performance. Lack of proper training or supervision of code officials and limited knowledge of energy code requirements by designers and builders compound the challenges of energy code enforcement and compliance.

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[46] Building Codes Assistance Project, "Status of Commercial State Energy Codes," September 2007, http://www.bcap-energy.org/map_page.php.

With roughly 100,000 home builders in the United States, the building industry is extremely diverse in size and capability.[47] While commercial building construction companies tend to be large, with extensive design and technical support for workers, most residential building firms operate with just a few people.[48] This diversity presents a major barrier to the diffusion of new technologies and practices. Perhaps not surprisingly, therefore, home builders tend to be the most vocal opponents to new, more stringent building codes.[49] 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,[50] but in some states, as many as one-third or more of new buildings do not comply with critical energy code requirements for windows and air conditioning equipment, which are among the easiest energy-saving features to verify.[51] 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 towards self-selection and convenience, usually leading to unrealistically high results.[52] Actual compliance could be much lower.

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

[48] 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

[49] See, for example, National Association of Home Builders, "Energy Code Issues," 2007, http://www.nahb.org/category.aspx?sectionID=817.

[50] 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.

[51] 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.

[52] Brian Yang, Building Codes Assistance Project, "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.

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

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Finally, neither the IECC nor ASHRAE codes account for certain critical design decisions, such as building orientation; commercial equipment in commercial kitchens, laundries, labs and medical facilities (etc.); or residential lighting and builder-installed appliances. As a result, the codes ignore major building energy loads and systems, which become increasingly significant as the rest of the code improves efficiency of the covered energy uses and systems. While it would be challenging, efficiency requirements for the buildings total energy use could have a major impact on whole-building energy performance.

ACEEE estimates that the United States saved 0.5 quads in 2000, thanks to commercial and residential building energy codes alone.[56] Cumulatively, building codes have saved consumers over $8 billion on their energy bills.[57]

The energy savings potential from building codes was highlighted in a recent study by the General Accountability Office (GAO) on Gulf Coast reconstruction following Hurricanes Katrina, Rita and Wilma in 2005. According to its report, 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 cooling costs.[58] Gulf state commercial buildings could see even more impressive savings, of seven to 34 percent of overall energy costs, depending on building type. And GAO determined that even larger savings could be realized for both types of buildings through voluntary achievement of energy-efficiency measures beyond those found in the minimum building code and standard requirements.[59]

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, could reduce CO_2 emissions in 2050 by 0.7Gt and reduce energy use by 12 quads annually by that date (see Appendix 1).

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[55] See, for example, National Association of Home Builders, "Energy Code Issues," 2007, http://www.nahb.org/category.aspx?sectionID=817.
[56] Steven Nadel and Bill Prindle, *Supplementary Information on Energy Efficiency for the National Commission on Energy Policy*, ACEEE, July 2004.
[57] Based on 2004 correspondence with Karen Mueller, Pacific Northwest National Laboratory.
[58] 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.
[59] 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.

Recommendation: A national model building code should be developed that, compared to the current national model code, achieves savings of 30 percent by 2010 and 50 percent by 2020. If ASHRAE and IECC fail to develop codes that meet these goals by these dates, DOE should develop its own model codes that achieve the maximum economically justifiable energy savings. These updates should ensure that any building component that appears on building drawings are included in the energy code requirements, including residential lighting and HVAC equipment, elevators, pumps, etc. States should be required to adopt the most recent ASHRAE or IECC energy codes for both residential and commercial buildings (or the DOE alternative model code), and to demonstrate high rates of compliance. Funding increases should be authorized for DOE assistance in training code officials to increase compliance and improve supervision.

Manufactured houses represent roughly eight percent of new single-family housing starts, but are not subject to building energy codes.[60] Manufacturers argue that since the homes are assembled at a central location and then shipped across the country, it is difficult for them to know the destination of every house. They therefore should not be controlled by state and local building codes, since they would constantly need to be adapted so as to comply with local standards. As a result, manufactured houses are regulated by the Department of Housing and Urban Development (HUD), and state and local governments are prohibited from issuing regulations on manufactured homes.

HUD has developed some energy-efficiency requirements for manufactured houses 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. Research from Pacific Northwest Labs shows 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 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).[61]

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[60] 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.

[61] 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.

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

Utility Programs

Electric and gas utilities have long been important partners in helping to improve building energy efficiency. Their cooperation is vital, since electricity and natural gas comprise more than 90 percent of the total energy used in buildings.[62] Utilities can implement several different types of utility 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 awareness campaigns.

From 1989 to 2005, electric utilities spent over $30 billion on efficiency and demand response programs.[63] There is no reliable data on utility efficiency spending by gas utilities but the figures are generally thought to be far lower.[64] At their peak 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.[65] By 1994, annual energy savings from utility efficiency programs had reached 52.5 million MWh, just less than the current electricity consumption of Oklahoma.[66] 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."[67]

Utility efficiency spending declined considerably in the mid-1990s, due in large part to a shift towards greater competition among power generators. Utilities and regulators were

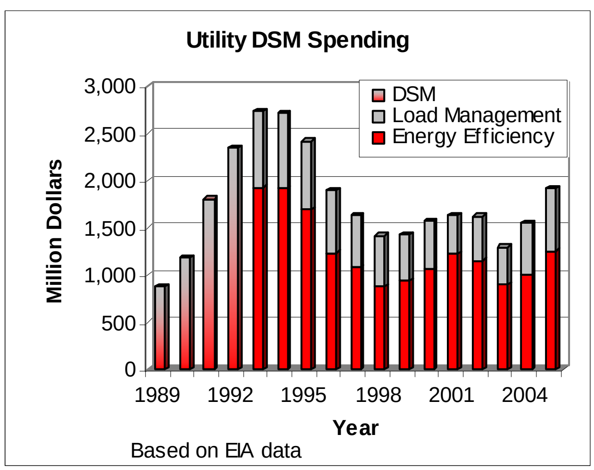
[62] Energy Information Administration, *Monthly Energy Review*, Department of Energy, September 2007, Table 2.2 and Table 2.3.
[63] EIA, *Annual Energy Review 2006*, Table 8.13, http://www.eia.doe.gov/emeu/aer/elect.html.
[64] Data on electric utilities' DSM programs are collected by EIA. They curiously do not collect similar data on DSM spending by natural gas utilities. This was confirmed in personal correspondence from William Trappman, Energy Information Administration, June 7, 2005.
[65] DSM activities also included load management programs. Energy Information Administration, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, Department of Energy, 1996, pp. 4-5, www.eia.doe.gov/cneaf/pubs_html/feat_dsm/contents.html.
[66] Energy Information Administration, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, Department of Energy, 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..
[67] Energy Information Administration, *U.S. Electric Utility Demand Side Management: Trends and Analysis*, Department of Energy, 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.

concerned that the costs of efficiency programs would raise the price per kWh of utility-generated power and give an unfair advantage to non-utility generators, who were not required to invest in energy efficiency.

Since utility restructuring began in the mid 1990s, few utilities have developed and maintained energy-efficiency services as part of their core business strategy, and DSM expenditures have declined precipitously. In 2002, reported electric utility efficiency spending had fallen to $1.3 billion, a 50 percent decline in nominal dollars compared to peak utility efficiency spending. In real terms, electric utilities were spending just 37 cents for every dollar they spent on DSM in 1994.[68]

Faced with lower spending on utility efficiency programs, 19 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 0.1 to 0.3 cents per kWh.[69] Recent data from the Consortium for Energy Efficiency suggests that utility spending has rebounded in recent years. From 2005 to 2006 alone, energy-efficiency budgets rose 13 percent, to $1.86 billion, not including load management or low income programs. When these programs are included, total 2006 spending by utilities equaled $2.6 billion.[70]

Along 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.



[68] Energy Information Administration, *Electric Power Annual 2003*, Department of Energy, December 2004, http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html.
[69] 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
[70] Consortium for Energy Efficiency, *U.S. Energy-Efficiency Programs: A $2.6 Billion Industry, 2006 Report*, 2007.

A resurgence in utility efficiency programs could result in significant energy savings in both residential and commercial buildings. A 2004 study examined energy savings from 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 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.[71]

In order to recoup the costs of implementing utility efficiency programs and the lost revenue from reduced sales when utility efficiency programs are effective, 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 their lost revenue as a mechanism to counter utilities' inherent disincentive to implement (let alone pay for) energy efficiency programs that reduce their 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.

Despite efforts to decouple utility profits from their sales, growth of each of these types of utility efficiency programs is hampered by utilities' concerns that reducing demand will hurt their profits, or that they will not be allowed to recover the full costs of their energy-efficiency programs. Further resistance 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. But industry's energy bills are raised along with residential and commercial rates in order to allow utilities to recoup their utility efficiency costs, requiring industrial customers 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.

Finally, decoupling and utility efficiency mechanisms may add extra layers of accounting complexity to an already complex industry. And perhaps the biggest administrative challenge of utility efficiency programs: verifying energy-efficiency savings and ensuring they are sustained. Most state legislatures require public benefits fund (PBF) program administrators – whether utilities or government agencies – to regularly 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.

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

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 0.1 percent to 1 percent of their sales.[72] 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.

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 transportation facilities. An EERS can be instituted in conjunction with or independent of a PBF.

EERSs are modeled on (and are frequently part of) renewable portfolio standards (RPSs), similar systems created to promote the use of renewable energy. Utilities can meet the requirements of their EERS through the same utility efficiency programs that many utilities are already implementing. Generally, some independent body is responsible for verifying the energy savings claimed by utilities.

While an EERS component is not always included in RPS mandates, doing so has become more commonplace over the last few years.[73] Currently, eight states have EERSs, either as a component of an RPS or as a separate requirement.[74] 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 generally limit the percentage of the RPS that can be met through energy efficiency.

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 (which works out to four percent of projected electricity consumption in 2020, the last level specified in the legislation) through utility efficiency programs. If this RPS was enacted and utilities took advantage of the maximum amount of energy efficiency permitted, it would reduce US electricity consumption by 1.6 quads and would avoid the emission of more than 100 MMT of CO_2 in 2050.[75]

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[72] 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*, American Council for an Energy-Efficient Economy, September 2004, http://aceee.org/energy/eeassess.htm#meta.
[73] 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
[74] Alliance to Save Energy, "Energy Efficiency Resource Standard," Fact Sheet, September 2007.
[75] Alliance to Save Energy projections. 1.6 quads is equal to three percent of projected building electricity consumption in 2050. Savings aren't equal to 4 percent of projected consumption because seven states already have EERSs in place that would guarantee savings equal to at least four percent of their electricity consumption in 2050.

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. Italy and the United Kingdom have already implemented energy-efficiency trading schemes, which could be used as models.[76]

Recommendation: Develop a national EERS for electric and natural gas utilities. Starting in 2010, electric utilities should be required to reduce baseline electric sales by 0.6 percent annually through efficiency, and natural gas utilities required to reduce baseline gas sales annually by 0.3 percent.

If a national EERS of this level was fully implemented, building energy use in 2050 would be reduced by roughly 11 quads and CO_2 emissions would be reduced by roughly 0.7Gt. Combined with H.R. 3221, the 2050 reductions would approach 1.7Gt.[77]

Recommendation: State regulators should be required to consider integrating energy efficiency into electric and natural gas utility plans. Regulators should also be required to consider modifying existing rate structures to incentivize 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.

Tax Incentives

Tax incentives are commonly used at both the federal and state levels to influence consumer and business purchasing decisions. Recently, many 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 and income tax credits or deductions for purchases of energy-efficient products and accelerated depreciation for energy-efficiency investments.

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[76] 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).

[77] Alliance to Save Energy estimates. See footnote 19 for details.

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 relatively low cost of energy consumption relative to their actual externality costs. For example, since to a large extent the energy-related costs of GHG emissions are not included in energy prices, consumers will not take these costs into account when making purchasing decisions. Instead, they will under-invest in energy efficiency compared to the investments they would make if these externalities were incorporated into the cost of a pound of coal, for instance.

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 preferences provided for energy efficiency and conservation at the time.[78]

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).

Unfortunately, all of the credits passed in EPAct are set to expire either at the end of 2007 or 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 several of the tax credit guidelines until well into 2006 or later.[79]

Unless the credits are extended, they are unlikely to have much of an impact. For instance, EPAct 2005 contained a credit for new energy-efficient commercial buildings.

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[78] 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.

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

But businesses are eligible for the credit only if it is 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 specifications of the tax credit within two years.[80] Reports indicate that few consumers have taken advantage of this incentive.

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.[81] 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 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 are not inducing energy savings if they simply pay people to do what they were already going to do.

Likewise, tax incentives must require sufficient documentation demonstrating that the prescribed efficiency measures are actually installed, installed properly, and performing as specified. Otherwise, the incentives will have little energy impact while putting pressure on already-tight government budgets and/or inflating the price of the eligible measures. Performance must therefore be verified; merely showing that you have paid for a covered product is not sufficient. Of course, if taxpayers decide that the burden to document the effective installation of efficiency measures is more trouble than it's worth, the effectiveness of the tax incentive will be limited as well, with taxpayers ignoring the overly cumbersome incentive.

These principles 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 it is still worthwhile to try to limit this effect.

Recommendation: The tax incentives for buildings should be extended. The residential tax credit for energy-efficient equipment should be extended through 2009, and should

[80] 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 this year, consumers have never known that the credit would exist more than two years in the future.

[81] 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, Energy Information Administration, *Summary Impacts of Modeled Provisions of the 2003 Conference Energy Bill*, February 2004 and Energy Information Administration, *Assessment of Selected Energy Efficiency Policies*, May 2005.

add a $300 credit for efficient natural gas fired heat pumps. The credit for oil furnaces should be raised to $300, and the level of efficiency necessary to claim the incentive for heat pumps, water heaters, and oil furnaces and boilers should be increased. The tax credit for energy-efficient new homes should be extended through 2011, and should builders constructing homes for their own personal should qualify for the credit as well. The commercial buildings tax deduction should be extended through 2013, and the amount of the deduction should be increased 25 percent. The energy-efficient appliances tax credit should also be extended, and the amount of the credits increased by varying amounts for dishwashers, clothes washers and refrigerators, and a new tax credit should be included for efficient dehumidifiers. Also, manufacturers currently cannot claim more than $75 million in tax incentives for these appliances; this cap should be removed for the most efficient refrigerators and clothes washers.

According to ACEEE, these extensions and modifications to the tax incentives would result in annual savings in 2030 of 34 TWh of electricity, 360 BCF of natural gas, 0.5 quads of energy and avoidance of nearly 36 MMT of CO_2 emissions.

Research, Development, and Deployment (RD&D) Programs

The Department of Energy and the Environmental Protection Agency currently spend about $700 million annually on energy efficiency-related research, development, demonstration and deployment programs (RDD&D).[82] Most of these funds go to DOE programs. The overall energy efficiency RDD&D budget has been flat or declining slightly over the last several years. The President's overall FY 2008 budget request for energy-efficiency programs within DOE's Office of Energy Efficiency and Renewable Energy is $515 million, down nearly $117 million (18 percent) from the FY 2006 appropriated level. This large cut follows a gradual slide from the $695 million that was appropriated for these programs in FY 2002. Funding for these programs in the annual Presidential budget request has decreased by one-third (37 percent) since 2002, after adjusting for inflation.[83]

Past federal RDD&D has successfully helped integrate several cutting-edge energy-saving technologies into the marketplace. A 2001 National Research Council report found that on average, a dollar invested in 17 DOE energy-efficiency research and

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[82] Alliance to Save Energy, "FY 2008 Federal Energy Efficiency Programs Funding," http://www.ase.org/content/article/detail/3974. This budget figure includes weatherization programs. Other agencies spend money on energy-efficiency programs as well (such as the US Agency for International Development, for instance), but their expenditures are small relative to EPA and DOE, and difficult to track accurately. For an analysis of spending on efficiency programs government-wide through 2004, see US Government Accountability Office, *Climate Change: Federal Reports on Climate Change Funding Should Be Clearer and More Complete*, Report to Congressional Requesters, August 2005, http://www.gao.gov/new.items/d05461.pdf.

[83] Testimony of Kateri Callahan, President, Alliance to Save Energy, to the House Appropriations Subcommittee on Energy and Water Development, March 16, 2007. DOE's industrial program has been particularly hard hit – its budget has gone from $106 million in 2002 to $56 billion in the president's 2006 budget request.

development (R&D) programs returned nearly $20 to the U.S. economy in the form of new products, new jobs, and lower energy bills to American homes and businesses. Environmental benefits were estimated to be of a similar magnitude.[84]

More than half of federal energy-efficiency funding in 2007 went towards programs focusing on building energy consumption.[85] Past buildings RDD&D has proven enormously successful. For instance, savings from just three of the technologies developed as part of DOE's buildings R&D – electronic ballasts for fluorescent lamps, low-e glass, and advanced compressors for refrigerators and freezers – equaled an estimated 4.7 quads of energy and $30 billion in net energy costs. The total cost of these three programs was about $12 million, which works out to a cost-benefit ratio of at least 1:2500, before considering the additional billions in reduced damage from air pollution and global warming.[86]

There are barriers to implementation to federal RDD&D, however, just as there is for virtually any government program. For one thing, some stakeholders argue that the government should not pick winners and losers. By investing in a broad portfolio of RDD&D programs, though, the government can perhaps sidestep this criticism. Another complaint is that it is difficult – if not impossible – to accurately measure the impact of most government programs. But just because the benefits are difficult to measure or predict does not mean they do not exist.

Other observers claim that government intervention distorts the marketplace. But the marketplace is already distorted by environmental and other externalities that are not currently included in standard cost-benefit analyses, and by the enormous subsidies given to various players in the energy industry. Further, certain key players in determining US energy consumption, such as the home construction industry, are highly segmented, comprised of tens of thousands of small businesses. Individually, these businesses do not have the resources to research the integration of buildings technologies into new or existing structures. Consequently, buildings energy efficiency RDD&D is underinvested in the marketplace.

Finally, in an era of soaring budget deficits, a costly war, and a destabilized (and potentially destabilizing) housing market, government budgets are tight. This leads some to conclude that the government should not spend increasingly precious government money on RDD&D programs that may not result in any tangible savings. But energy efficiency RDD&D programs are investments in the nation's future and will help to stimulate the economy, reduce imports, and ultimately strengthen government budgets.

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[84] National Research Council, *Energy Research at DOE—Was it Worth it? Energy Efficiency and Fossil Energy Research 1978 to 2000*, National Academy Press, Washington, D.C., 2001.

[85] Alliance to Save Energy, "FY 2008 Federal Energy Efficiency Programs Funding," http://www.ase.org/content/article/detail/3974. This number calculated by summing building technologies, half of the State Energy Program, most of the Federal Energy Management Program and all of Energy Star and weatherization.

[86] National Research Council, *Energy Research at DOE—Was it Worth it? Energy Efficiency and Fossil Energy Research 1978 to 2000*, National Academy Press, Washington, D.C., 2001.

And given the cost-benefit return seen in certain programs, one could argue that the fiscally imprudent behavior would be a failure to invest in further RDD&D.

Government RDD&D programs have the potential to transform entire sectors of our economy. One proposal included in H.R. 3221 is for a Commercial Buildings Initiative (CBI) that would result in a net-zero commercial buildings sector by 2050. This does not mean the sector would not consume energy in 2050; rather, it means the sector would achieve dramatic cuts in its energy consumption through building codes, advanced technologies and best practices, and the energy it did consume would be offset by on-site renewable energy generation and renewable energy and energy-efficiency credits.

ACEEE estimates that the proposed CBI, even if its effectiveness was not fully funded, could save 107 TWh of electricity, 800 BCF of natural gas, 1.4 quads of energy and avoid the emission of more than 90 MMT of carbon dioxide annually in 2030 while reducing peak demand by nearly 29,000 MW. Given the escalating nature of this program, these savings could be much greater in 2050.

Recommendation: The federal government should appropriate $200 million annually to an Energy Efficient 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. All new commercial buildings should be net-zero-energy by 2030 and half of all commercial building stock by 2040.

Other RDD&D programs would also accrue significant savings.

Recommendation: DOE and EPA should partner with industry to establish specifications and benchmarks that would allow for energy-efficiency ratings of equipment used in data centers, and of data centers as a whole.

Recommendation: The Weatherization Assistance Program (WAP), designed to assist low-income residents in weather-proofing their homes to save on energy bills and increase their comfort, should be reauthorized and allocated $1.4 billion annually from 2008-2012. A pilot project focusing on energy-saving components and grants for materials, benefits, and technologies not currently covered under the program should also be authorized. Funds equal to up to two percent of the WAP budget should be allocated to this project.

Historically, much of the energy savings realized in the United States has been driven by the states. The federal government can assist state energy programs by sharing resources and technologies through the State Energy Program.

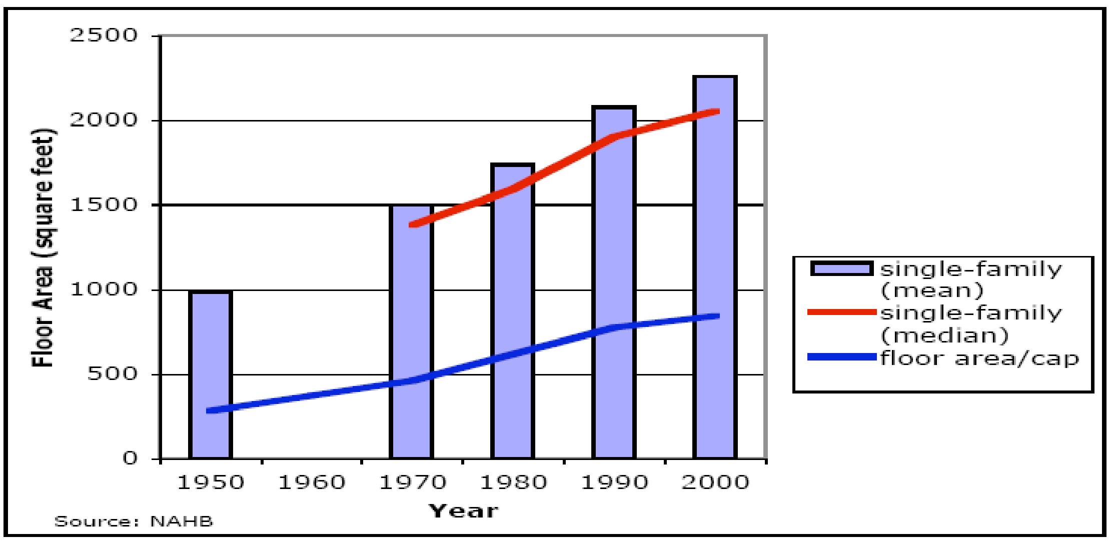
Recommendation: The State Energy Program should be reauthorized at $125 million annually from 2008-2012.

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 changes in fuel mix can go a long way to achieving CO_2 reductions 80 percent below 1990 levels. 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)[87]

US House Size (floor area) Mean and Median 1950-2000[88]



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 2005, even though energy use per unit virtually halved during that time period.[89] While it is possible

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

[88] 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.

[89] EIA, *Residential Energy Consumption Survey 1993*, 1993, Table 5.27, ftp://ftp.eia.doe.gov/pub/consumption/residential/rx93cet6.pdf & *Residential Energy Consumption Survey*

that two-refrigerator households would be commonplace regardless of unit efficiencies, it can at least be said that the demand for new energy services has increased as fast as efficiencies.

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.[90]

But the biggest drivers of demand for new energy services are growing incomes, population, low energy prices and new technology. Currently, reducing incomes or population to address energy services demand is not seriously discussed – it may need to be in the future.

For now, we rely on more focused measures, including, for example, appliance buy-backs, which have long been used by utilities and governments to encourage consumers from putting their old and inefficient refrigerators in the basement. Several of the other policies already discussed in this chapter, have similar effects. Outside of buildings, this type of policy can be illustrated through high occupancy vehicle lanes on highways, for example.

A recent proposal by Representative John Dingell (D-MI) is intended to address the trend of increasing house size. The Dingell proposal would phase out the mortgage interest deduction for new and existing homes that are 3,000 square feet or more, unless they obtain Leadership in Energy and Environmental Design (LEED) certification or were constructed before 1900.[91] Currently, all home owners who pay mortgage interest are allowed to deduct those interest payments when calculating their income tax liability. The tax savings can easily amount to thousands of dollars, even for relatively modest homes.[92]

The proposal would penalize the biggest houses more harshly than those just exceeding the 3,000 square foot threshold. Houses over 4,200 square feet would not be eligible for any deduction at all, while those at 3,001 square feet would still be able to claim 85

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.

[90] 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.

[91] The LEED rating is administered by the US Green Building Council and rates homes and buildings on a variety of environmental performance criteria, including energy performance.

[92] The mortgage interest deduction generally provides greater benefits to high income households, who tend to purchase more expensive homes, 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. For the same reason, the mortgage interest deduction tends to provide the greatest benefit to taxpayers with the most expensive homes – the most expensive homes also tend to be the largest.

percent of the full deduction. If homeowners chose to keep their deduction by achieving LEED certification, then the policy would result in energy and carbon emission reductions. If they chose to forfeit their deduction, the saved revenue would, under Rep. Dingell's plan, be used to expand the Earned Income Tax Credit.

We estimate that this policy, if enacted in concert with our H.R. 3221 and EERS Deluxe scenarios, would save .85 quads and avoid the emission of 50 million metric tons of CO_2 annually in 2050, assuming it spurred homeowners to achieve LEED certification rather than give up their deduction.[93]

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

[93] See Appendix 2 for more detail on our methods and assumptions.

Appendix 1

Energy and carbon savings relative to business as usual by implementing Sec. 304 "Updating state building energy efficiency codes"

			Annual savings by year		
			2020	**2030**	**2050**
Total Energy Savings	**216,120**	trillion BTU (216 quads)	1,661	5,021	12,092
Carbon avoidance	**3,428**	MMT of carbon equivalent	**26**	**80**	**192**
CO_2 avoidance	**12,568**	MMT of CO_2 equivalent	**97**	**292**	**703**
Cost saved (mio 2003 dollars at 2003 prices)	**1,647,800**	1.6 trillion - 2003 dollars	**12,617**	**38,269**	**92,275**
NG Res	35,293		239	808	2,032
Fuel oil Res	5,786		39	132	333
Elec. Res	16,779		114	384	966
NG Comm	35,767		287	835	1,980
Fuel oil Comm	3,482		28	81	193
Elec. Comm	119,013		954	2,780	6,588
NG Total	71,060		526	1,644	4,012
Fuel oil Total	9,268		67	214	526
Elec. Total	135,792		1,067	3,164	7,554

Baseline

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

- Per year, new homes use 0.53% less heating and cooling energy. This is mainly due to increased equipment efficiency (0.29% annual improvement for heating equipment and 0.79% improvement for cooling equipment).[94] At the same time, the annual increase in new construction is 1.1% per year.[95] As a result, in the business-as-usual scenario, the total heating and cooling energy use of all newly constructed homes increases by 0.57% each year.
- Annually, heating, cooling and lighting energy use from newly constructed buildings increases by 0.6% over the energy use from the previous year's construction. The growth in commercial floor space is 1.5% but commercial energy for heating, cooling, and lighting increases by only 0.82% (55% of the floor space growth).[96] With annual construction growing 1.1% each year, the expected growth in energy

[94] http://www.eia.doe.gov/oiaf/aeo/supplement/sup_rci.xls.
[95] http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf p. 142.
[96] http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf.

consumption from heating, cooling and lighting in new buildings is 1.1% * 55% = 0.6%.

Timeline

a. President puts the policy in place in **2009**. The International Code Council already released the 2009 IECC, so it's too late to increase code stringency by 30%.

b. ASHRAE 90.1-**2010** achieves 30% heating, cooling, and lighting energy savings over 90.1-2004. In **2011**, DOE makes the relevant determination.

c. Two years after the enactment of the law, in **2011**, 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.

d. By **2012**, all states enforce the 2006 IECC or an equivalent code at 90% compliance - as required by (b)(1) and (c)(2) of Sec. 304.

e. Also in **2012**, 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.

f. 3 years after DOE's determination, in **2014**, all states enforce ASHRAE 90.1-2010, achieving 90% compliance.

g. 3 years after DOE's determination, in **2015**, all states enforce the 2012 IECC, achieving 90% compliance.

h. In **2018**, DOE determines that the 2018 IECC achieves 50% energy savings above the 2006 IECC

i. In **2019**, DOE determines that ASHRAE 90.1-2019 achieves 50% energy savings above ASHRAE 90.1-2004.

j. In **2021**, 3 years after DOE's determination, all states enforce the 2018 IECC, achieving 90% compliance.

k. In **2021**, 3 years after DOE's determination, all states enforce ASHRAE 90.1-2019, achieving 90% compliance.

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

Other assumptions

<u>Energy uses affected by code</u>
The "overall energy savings" of 30% and 50% required in (a) of Sec. 304 of H.R. 3221 cover heating and cooling for residential buildings and heating, cooling, and lighting for commercial buildings.

Code compliance improvement

Prior to 2012, average code compliance across the U.S. is 50%.

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.
- Commercial renovations achieve 42% of the savings potential from codes. Table B9 of the 2003 CBECS shows typical types of renovation, including lighting upgrades (58% of renovations), insulation upgrades (23% of renovations), wall or roof replacements (43% of renovations), window replacements (36%) and annexes and additions (37%).[97]

[97] http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set3/2003pdf/b9.pdf

Appendix 2
Assumptions and Process to Calculate the Elimination of the Mortgage Interest Rate Deduction

According to the Residential Energy Consumption Survey (RECS), in 2001 there were 18.4 million single-family houses in the US of 3,000 square feet or more.[98] This represented 25 percent of single-family homes in the US that year.[99] We assumed that this ratio would continue through 2050 (that is, that 25 percent of new homes would continue to be of 3,000 square feet or more).[100]

Overall, the housing stock is projected to increase by an average of 1.1 percent annually through 2030, according to the *Annual Energy Outlook* (AEO).[101] We assume that this holds true for homes of more than 3,000 square feet as well. But annual construction is greater than 1.1 percent annually, since the above number does not take into account destruction of existing stock. According to the US Census Bureau, average annual new construction of single-family homes from 2002-2006 was nearly 1.5 million homes,[102] about 1.9 percent of the single-family housing stock in 2004, according to the AEO.[103] So we assumed that trend continued and that new construction equaled 1.9 percent of the housing stock per year, which means that about 0.8 percent of the stock was destroyed per year.

Since there is no existing projection for the US housing stock through 2050, we took the AEO projections through 2030, and, using their average annual increase of 1.1%, projected through 2050.[104] We found new buildings of greater than 3,000 square feet by dividing the overall single-family stock number by four. This means 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 20.8 million single-family homes of 3,000 square feet or more. Taking destruction into account, we project 12.1 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	7,449,195	4,242,249

[98] http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-4a_housingunits2001.pdf
[99] ibid
[100] If anything, this assumption may be slightly low. According to the *Annual Energy Outlook*, the average house size is projected to increase through 2030. But the average in 2030 is still only 2,004 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.
[101] Ibid.
[102] See, for example, http://www.census.gov/const/C40/Table2/tb2u2002.txt. We took the average calculation since new construction fluctuates due to economic and other factors.
[103] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.
[104] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.

3500-3999	3,800,000	4,288,930	2,442,507
4000 +	8,000,000	9,029,327	5,142,120
Total	18,400,000	20,767,453	11,826,876.35

The average site energy consumption per square foot in buildings greater than 3,000 square feet in 2001 is given below (A).[105] The ratio of source to site energy consumption in residential buildings as found in the AEO for 2006 is 1.9 to 1.[106] Therefore, the average source energy consumption per square foot (B) is A * 1.9. The ratio is altered given the trend towards 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.[107] 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 H.R. 3221 Extended and EERS Deluxe policies laid out in this chapter. 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, HR 3221 and EERS Deluxe, 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.[108] 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[109]), 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[110]),

[105] http://www.eia.doe.gov/emeu/recs/recs2001/ce_pdf/enduse/ce1-62u_sqft_useind2001.pdf
[106] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.
[107] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls.
[108] http://www.eia.doe.gov/emeu/recs/recs2001/hc_pdf/housunits/hc1-2a_construction2001.pdf.
[109] Pamela J. Jackson, *Fundamental Tax Reform: Options for the Mortgage Interest Deduction*, Congressional Research Service, The Library of Congress, August 8, 2005.
[110] Private correspondence with USGBC employee, October 11, 2007.

and the cost-effective nature of the energy-efficiency improvements needed to be LEED-certified, every owner of a large home would go through the LEED-certification process.[111]

For new buildings, LEED-certified homes are required to be ENERGY STAR-qualified, equal to 15-20 percent more energy-efficient than code requires.[112] 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 80 percent of a typical home's energy consumption.[113] So the average new large home in 2050 will have to be (.8 * .35 = 28 percent) 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. We assume that this legislation would spur USGBC to develop such a protocol, but it's unlikely that existing homes would be able to achieve savings of 35 percent greater than code.[114] 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 (.8 * .175 = 14 percent) beyond baseline.

New single-family homes of 3,000 square feet or more would, in 2050, consume 2.4 quads under the H.R. 3221/EERS Deluxe scenario. Achieving LEED certification would save 28 percent (0.66) of those quads. Assuming that one-third of the savings were from electricity, and two-thirds from natural gas (based on our building codes calculations), this works out to 0.04 Gt of CO2 savings.[115]

Existing large single-family homes under the H.R. 3221/EERS Deluxe scenario would consume 1.3 quads. LEED certification would therefore save 14 percent (0.19) of those

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[111] 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.

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

[113] http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_4.xls. In 2006, it works out to about 79 percent.

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

[115] We assume that each quad of electricity emits 65 million metric tons CO2 and that each quad of natural gas emits 53 MMT CO2.

quads. This equates to 0.01 Gt of CO_2 savings. All told, savings would equal 0.85 quads and .05 Gt of CO_2 savings.[116]

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.

[116] Our estimated savings may be slightly lower than they actually would be, 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.