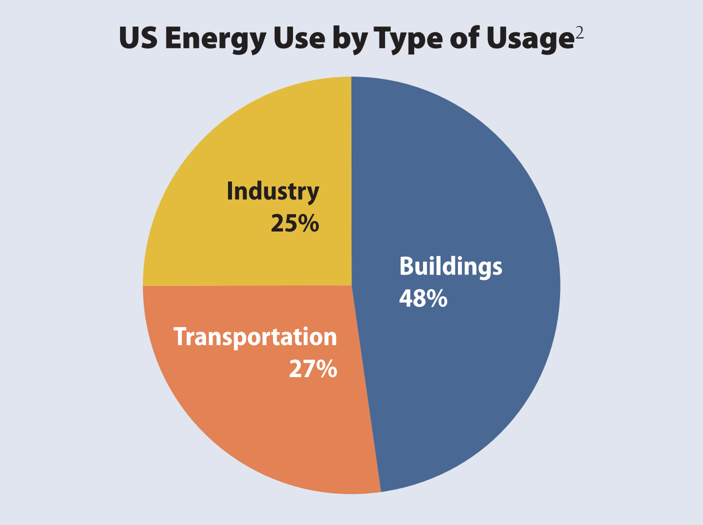
Chapter 15. Boost Building Energy Codes

1. Profile

"Energy efficiency" refers to technologies, equipment, operational changes, and in some cases behavioral changes that enable our society to enjoy equal or better levels of energy services while reducing energy consumption.[1] Efforts to improve efficiency in the generation, transmission, or distribution of electricity are covered in Chapters 1 through 5 and in Chapter 10. In contrast, Chapters 11 through 15 address different policy options for making the end-user's consumption of electricity more efficient. Chapter 11 focuses on policies that establish mandatory energy savings targets for electric utilities, the achievement of which is generally funded through revenues collected from customers themselves. Chapter 12 focuses on policies that create or expand the opportunities for voluntary, market-based transactions that promote energy efficiency as an alternative or supplement to government-mandated programs or regulatory requirements. Chapter 13 focuses on an emerging type of energy efficiency program, behavioral energy efficiency, that is worthy of separate treatment because it is sometimes included within the mandated programs described in Chapter 11 and sometimes implemented as a voluntary effort outside of those programs. Chapter 14 covers mandatory appliance efficiency standards that are imposed on manufacturers. This chapter, Chapter 15, covers mandatory building energy codes that are imposed on builders and developers.

Approximately half of US energy use is in buildings, with the remaining half split about evenly between industry and transportation, as noted in Figure 15-1. Building codes establish mandatory requirements for the building shell, mechanical equipment, and lighting systems. Although the other equipment within buildings, such as appliances and electronics (generally referred to as "plug loads"), may be separately regulated by appliance efficiency standards, the elements regulated by building codes have a very significant impact on building energy use and associated carbon emissions.

Figure 15-1



Building Energy Codes

Building energy codes establish minimum efficiency requirements for new and renovated residential and commercial buildings. This can reduce the need for energy generation capacity and new energy infrastructure while also reducing energy bills. Energy codes lock in future energy savings during the building design and construction phase, rather than through later, more expensive, renovations. By locking in efficiency measures at the time of construction, codes are intended to capture energy savings that are more cost-effective than the more limited retrofit

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[1] In contrast, some people use the term "energy conservation" to refer to actions that reduce energy consumption but at some loss of service. Neither term has a universally accepted definition and they are sometimes used interchangeably.

[2] See: http://www.buildingscience.com/documents/insights/bsi-012-why-energy-matters (from architecture2030.org).

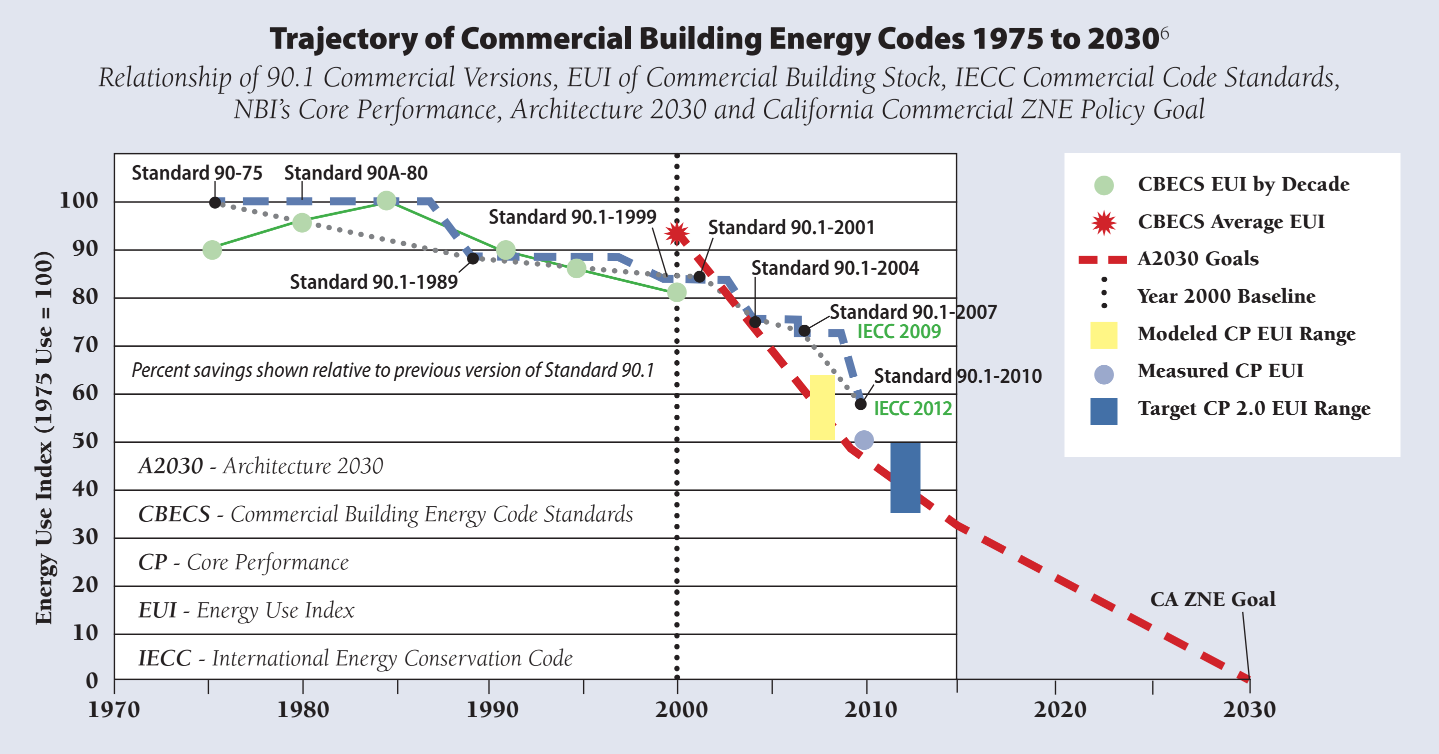
opportunities that are available after a building has been constructed. Energy code requirements are also intended to overcome market barriers to efficient construction in both the commercial and residential sectors. The primary market barrier is that the builder of new buildings is often not the party that will pay the energy bills; homeowners, renters, and business lessors are typically responsible for these operating costs. Builders thus may have no interest in energy-saving design features, especially ones that raise the complexity or costs of construction, and the future occupants of their buildings pay the price.

Over the past 30 years, code improvements have reduced total energy use by new buildings by approximately 40 percent. Planned improvements in Washington state, for example, seek to reduce current usage by an additional 70 percent by the year 2020. In California, the goal is to reduce net building energy usage to zero by 2030.[3]

The most advanced building codes today are denoted as zero net energy (ZNE), and lay out standards by which buildings produce as much energy as they use. One of several possible definitions of ZNE is that the amount of energy consumed by a building over the course of a typical year is less than or equal to the amount of renewable energy generated onsite. For example, if a building uses natural gas for space and water heating but has solar panels generating electricity, it could qualify as ZNE if the solar panels typically generate enough electricity annually to equal annual onsite electricity use, plus an additional amount that would be equivalent in energy to the onsite use of natural gas. It should be noted that ZNE codes do not require the building to produce the energy at the same time that it uses the energy.

Even ZNE buildings require connections to electricity grids and often to natural gas pipelines. An excellent example of a ZNE building is the Bullitt Center in Seattle, which incorporates very sophisticated building shell improvements and state-of-the-art heating, ventilation, and air conditioning equipment, captures incoming rainwater for onsite use, and includes a composting sanitary system. Although typical new code-compliant commercial buildings have an energy utilization index of about 50 (thousand British thermal units [BTU[4]]/year/square foot), the Bullitt Center achieves an energy utilization index of 18, and generates that much energy with an onsite photovoltaic solar system.[5]

Figure 15-2



Trajectory of Commercial Building Energy Codes 1975 to 2030[6]

Relationship of 90.1 Commercial Versions, EUI of Commercial Building Stock, IECC Commercial Code Standards, NBI's Core Performance, Architecture 2030 and California Commercial ZNE Policy Goal

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[3] See: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/

[4] A BTU is the amount of heat required to increase the temperature of a pint of water (which weighs exactly 16 ounces) by one degree Fahrenheit.

[5] See: http://www.bullittcenter.org/

[6] See: http://newbuildings.org/index.php?q=develop-roadmap

Figure 15-2 shows the actual achievement of commercial building energy codes since 1975, along with the trajectory that California has established to achieve ZNE by 2030. The trajectory of residential building energy codes has been similar.

Other Mandatory Building Efficiency Policies

In addition or as an alternative to building energy codes, another policy option is to establish mandatory energy-use benchmarking and disclosure requirements for building owners. These policies do not require specified levels of efficiency but provide information to consumers that is analogous to the mandatory EnergyGuide labels for appliances described in Chapter 14.[7] For example, Cambridge, Massachusetts adopted a Building Energy Usage and Disclosure Ordinance that requires the benchmarking and disclosure of building energy performance for large commercial, institutional, and multifamily buildings. The ordinance requires owners of the designated property types to annually benchmark and report to the city their properties' energy use, water use, and building information through the US Environmental Protection Agency's (EPA) *Portfolio Manager* tool. A requirement to provide benchmarks helps create awareness of energy use in such buildings.

Another alternative is to require energy audits or retrofit requirements. For example, New York City has established formal energy audit requirements for buildings over a certain size. As with benchmarks, required audits help focus building owners' attention on energy use and the means to improve it. Retrofit requirements were proposed in New York City by former Mayor Michael Bloomberg, but not adopted.

2. Regulatory Backdrop

Building codes and other mandatory building efficiency policies are generally adopted and implemented (and sometimes enforced) at the state and local level.

Building Energy Codes

Most building codes are based on national "model codes" developed by associations of code officials. The exception to this is in the manufactured housing (mobile home) sector, in which standards are adopted by the Federal Housing Administration.

The principal model energy code for residential buildings is the International Energy Conservation Code (IECC) developed by the International Codes Council. The commercial sector relies on either the IECC or a different model standard — ASHRAE 90.1 — that is produced by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). Many states customize the model codes in distinct ways for local applicability.[8] Several, for example, including California, Oregon, Washington, Florida, and some New England states, have adopted state-specific residential energy codes.

These codes include extensive requirements for building shell construction and major installed energy systems, including lighting, heating, cooling, and water heating. Table 15-1 identifies the primary elements of residential and commercial energy codes.

The most recent version of the IECC residential code is the "2015 edition," adopted by the Council in 2013.[9] Input

Table 15-1

Components of Building Energy Codes

	Residential	Commercial
Building Shell	Floor Insulation Wall Insulation Ceiling Insulation Glazing area Glazing efficiency	Overall building shell thermal performance Glazing efficiency (heat loss) Glazing reflectivity (heat gain)
Heating	Minimum furnace or heat pump efficiency Equipment sizing standards	Minimum equipment efficiency Equipment Sizing Standards
Cooling	Minimum air conditioner or heat pump efficiency Equipment sizing standards	Minimum equipment efficiency Equipment sizing standards
Water Heating	Equipment efficiency standards Piping insulation	Equipment efficiency standards Piping insulation

[7] Note that voluntary labeling and benchmarking programs for buildings and appliances are discussed in Chapter 12. Here in Chapter 15 we address only mandatory policies for buildings.

[8] See, for example, Georgia: http://www.dca.state.ga.us/development/constructioncodes/programs/documents/2012effective/effective/IECC-2012-effective.pdf; Washington: http://www.energy.wsu.edu/Documents/2009_2012%20WSEC%20Comparison.pdf; and Hawaii: http://energy.hawaii.gov/hawaii-energy-building-code

[9] Note that the year denotes a recommended date of adoption.

to that code was submitted in 2012. Based on experience with past updates, it is likely that only a few states will adopt and enforce that code by its target date of 2015. The IECC provides a website at which the status for each state's energy code adoption can be checked.[10]

The most expedient way to ensure that codes reduce energy use in new buildings is to create a rigorous code enforcement mechanism. Enforcement of building energy codes is often lax, as local government agencies tend to not see this as a key part of their role.[11] Because no other entity is charged with code enforcement, building energy codes are often only as effective as the integrity of the architects, engineers, and builders. Some states have made enforcement of energy codes a priority, but they are the exceptions. As a condition of receiving funding under the American Recovery and Reinvestment Act of 2009, each Governor was required to certify that his or her state was enforcing a minimum energy code for new construction.[12] Although these representations were made, the quality of code enforcement continues to vary around the country.[13]

The typical process for code adoption starts with a national association such as the International Code Council or ASHRAE periodically developing a national model code, along with extensive documentation of the consumer cost-effectiveness of the proposed measures. In the following years, states adopt this code as a local government obligation. Finally, local building officials undertake enforcement of the codes. It is important to note that buildings are normally subject to the code in effect when the building permit is issued; actual construction can lag beyond that date significantly. The result is that the buildings being completed today can be designed and built in conformance with weaker codes that may have been adopted years ago. However, because buildings last for a very long time, even gradual code improvements will pay very large, long-term benefits.

Each stage of this process is critical to code success. Effective enforcement of an obsolete code may in reality be no better than lax enforcement of a very good code. The former can ensure uniform mediocrity, the latter produces uneven results, including some excellent buildings and others less so, because a majority of building designers address code requirements at the design stage, leaving building officials primarily with the task of ensuring that the as-built structure is consistent with the approved plans.

Other Mandatory Building Efficiency Policies

As a supplement or alternative to building energy codes, a number of state and local jurisdictions have adopted mandatory building energy-use benchmarking, audit, and disclosure policies. These policies vary in their applicability to public, commercial, and residential buildings and in the details of the requirements. Generally, building owners covered by such a policy are required to measure their building's energy use, compare it to the average for similar buildings, and disclose the results. This allows the current owners and occupants of these buildings, as well as potential buyers or future occupants, to understand the building's relative energy performance. It also educates owners and occupants and helps them identify opportunities to cut energy waste and energy costs.

It is important to recognize that electric utilities can also take action independently to ensure that newly connected buildings are efficient. A few electric utilities have taken steps to implement energy efficient construction practices in new buildings where state and local government efforts have been inadequate. This may take the form of a surcharge for structures not meeting a standard beyond that enforced by the local government, or an incentive to go beyond the enforced standard (or both).[14] In one

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[10] See: http://www.iccsafe.org/gr/Pages/adoptions.aspx

[11] On the other hand, according to the ICC Code of Ethics, "The protection of the health, safety and welfare of the public by creating safe buildings and communities is the solemn responsibility of the International Code Council ("ICC") and all who participate in ICC activities." See: http://www.iccsafe.org/AboutICC/Documents/CodeOfEthics.pdf

[12] Alliance to Save Energy. (2009). Nation's Leading Building Energy Efficiency Experts Clarify ARRA Funding Ties to State Energy Code Adoption and Enforcement [Press release]. Available at: http://www.usgbc.org/Docs/News/State%20Bldg%20Codes%20White%20Paper%2012-1-09%20REV2-usgbc.pdf

[13] The Building Codes Assistance Project (BCAP) has developd a series of maps that provide a national snapshot of building energy code adoption and implementation status. See: Online Code and Environment Advocacy Network (Ocean). Available at: http://energycodesocean.org/code-status

[14] See, e.g.: Lazar, J. (1991, September). *Utility Connection Charges and Credits: Stepping Up the Rate of Energy Efficiency Implementation.* Presented at the 2nd International Conference On Energy Consulting, Graz, Austria. Available at: raponline.org/document/download/id/4664

case, a local public utility district in Washington adopted a $2000 connection charge for buildings not meeting a superior standard, plus a $2000 incentive for builders that did meet the superior standard. This was challenged by the manufactured housing industry, which asserted unsuccessfully that the utility had overstepped its authority in adopting a code, a function that was reserved to a federal agency for manufactured housing. The Washington Supreme Court ruled that the new facility charge was an exercise of rate-making properly within the authority of the utility, not subject to federal preemption.[15]

Air Pollution Regulations

Energy efficiency plays a prominent role in the emissions guidelines for carbon dioxide (CO_2) emissions from existing power plants that the EPA proposed in June 2014, citing its authority under section 111(d) of the Clean Air Act, as part of its "Clean Power Plan."[16] The EPA determined that the "best system of emission reduction" for existing power plants under the Clean Air Act consists of four "building blocks," one of which is end-use energy efficiency. Although states will not be required to include energy efficiency in their 111(d) compliance plans, the emissions rate goals for each state are based on an assumption that a certain level of energy savings (and thus, emissions reduction) is achievable. The level of savings that the EPA used to set each state's emissions rate goals is based on the demonstrated performance of leading states with respect to the kinds of ratepayer-funded energy efficiency programs described in Chapter 11 and a meta-analysis of energy efficiency potential studies. The EPA did not separately consider building energy codes as a component of the "best system of emission reduction," and the goals proposed for each state do not presume that building energy codes will be adopted or enforced.

States will apparently be able to use building codes and other mandatory building efficiency policies to reduce emissions and comply with any final regulation, so long as the policies go beyond "business as usual" projections of energy demand and are enforceable. However, the EPA offered little guidance in the technical support documents for the 111(d) proposal to help states with some of the particular challenges of evaluation, measurement, and verification (EM&V) for building energy codes and benchmarking requirements, such as the variable levels of code enforcement. For example, in the State Plan Considerations document, the EPA contrasts these kinds of policies with the types of ratepayer-funded energy efficiency policies described in Chapter 11, noting that, "In some cases, appropriate evaluation protocols and approaches have not been developed... In cases where appropriate EM&V methods do exist, there may also be less experience applying them." The EPA then cites two documents that offer examples of EM&V methods.[17] Later in the same document, the EPA characterizes EM&V procedures for building energy codes as "moderately well established" and for benchmarking programs as "less well established," and suggests that "programs and measures with less well developed EM&V approaches would require greater documentation in state plans of EM&V methods that will be applied."[18]

3. State and Local Implementation Experiences

State and local governments across the country have implemented building energy codes and similar policies for decades. These policies are very familiar to local government officials, in particular.

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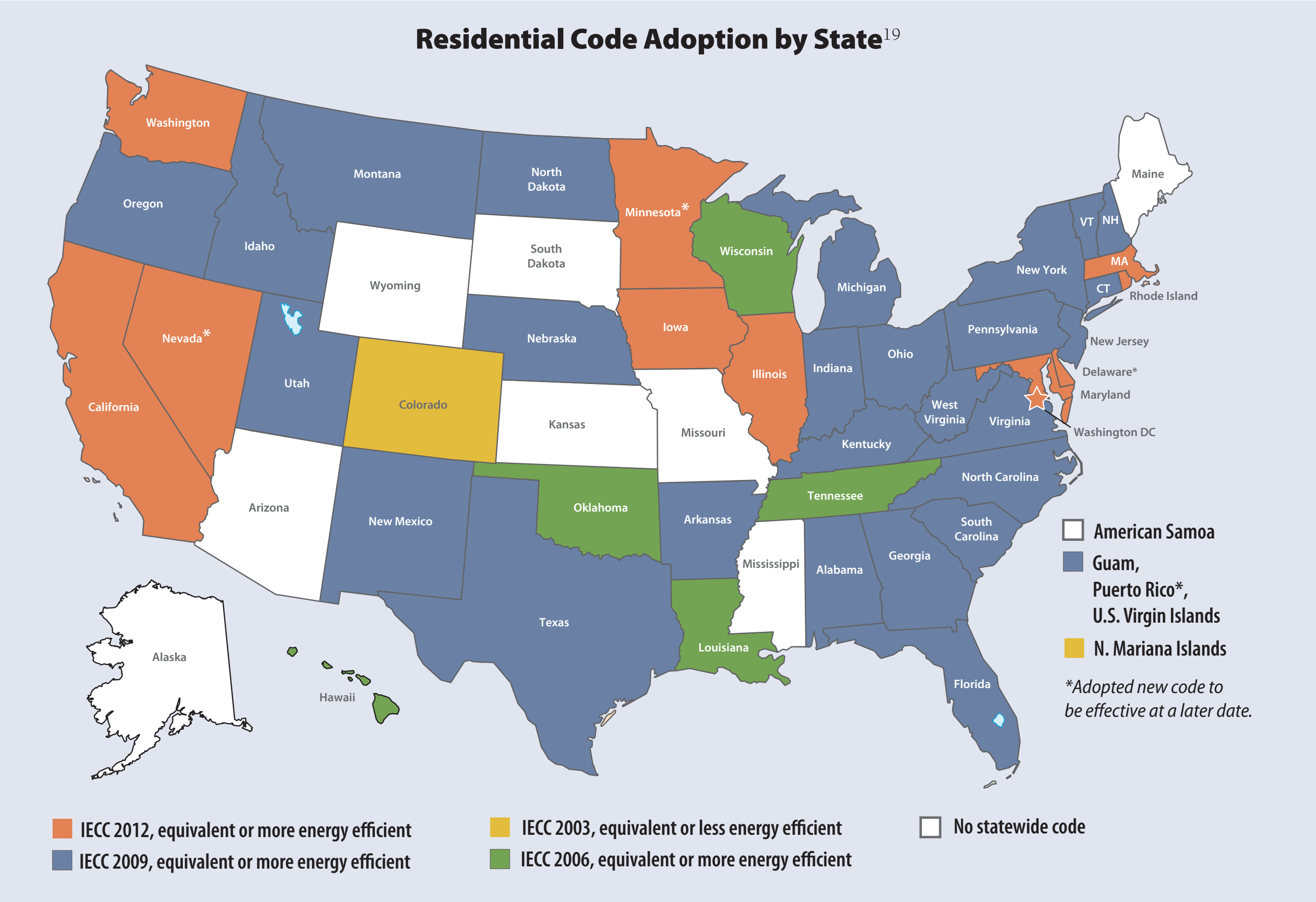
[15] Wash. Manufactured Housing Ass'n v. Pub. Util. Dist. No. 3, 124 Wash. 2d 381 (1994).

[16] Refer to: US EPA. (2014, June). *40 CFR Part 60 – Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule.* Federal Register Vol. 79, No. 117. Available at: http://www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf

[17] US EPA. (2014, June). *State Plan Considerations – Technical Support Document (TSD) for Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units,* pp. 112-113. Docket ID No. EPA-HQ-OAR-2013-0602, pp. 45-46. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-state-plan-considerations. The two documents cited by the EPA as examples of EM&V methods are: (1) Livingson, O. V., Cole, P. C., Elliott, D. B., & Bartlett, R. (2014, March). *Building Energy Codes Program: National Benefits Assessment: 1992-2040.* PNNL. Available at: http://www.energycodes.gov/sites/default/files/documents/BenefitsReport_Final_March20142.pdf; and (2) Meyers, S., Williams, A., & Chan, P. (2013, April). *Energy and Economic Impacts of US Federal Energy and Water Conservation Standards Adopted From 1987 Through 2012.* LBNL-6217E. Available at: http://eetd.lbl.gov/sites/all/files/standards_1987-2012_impacts_overview_lbnl-6217e.pdf

[18] Supra footnote 17 at pp. 47-50 Docket ID No. EPA-HQ-OAR-2013-0602.

Figure 15-3



Residential Code Adoption by State[19]

**Adopted new code to be effective at a later date.*

Building Energy Codes

Because each state must adopt codes, and local building officials are typically charged with enforcement, the simple directive in the American Recovery and Reinvestment Act of 2009 has limited meaning. Figures 15-3 and 15-4 illustrate state adoption of both residential and commercial energy codes. As is evident, many have obsolete codes in place, and several have no statewide code adoption whatsoever. Those shown in orange are the only states that have a more modern energy code in effect. Note that there is no characterization as to the degree of enforcement in either figure.

As noted previously, building codes are not only adopted by states, but also at the local level. A few local jurisdictions in the United States have adopted stricter energy codes than those promulgated by the state in which they are located.[20] These are known as "stretch codes." The city of Seattle, for example, has typically maintained a nonresidential energy code three to six years "ahead" of the state code.[21] This serves in part as a demonstration project for advanced code concepts.[22] The state of Oregon, which has adopted residential and commercial codes based on the IECC 2009, estimated total savings in 2009 from building energy codes of 1.17 GWh and 2.3 GWh in the residential and commercial sectors, respectively.[23] This was equivalent to more than seven percent of total retail electricity sales in Oregon in 2009.[24] In

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[19] See: http://www.energycodes.gov/adoption/states

[20] For examples, see the ACEEE "Residential Codes" page, available at: http://database.aceee.org/state/residential-codes

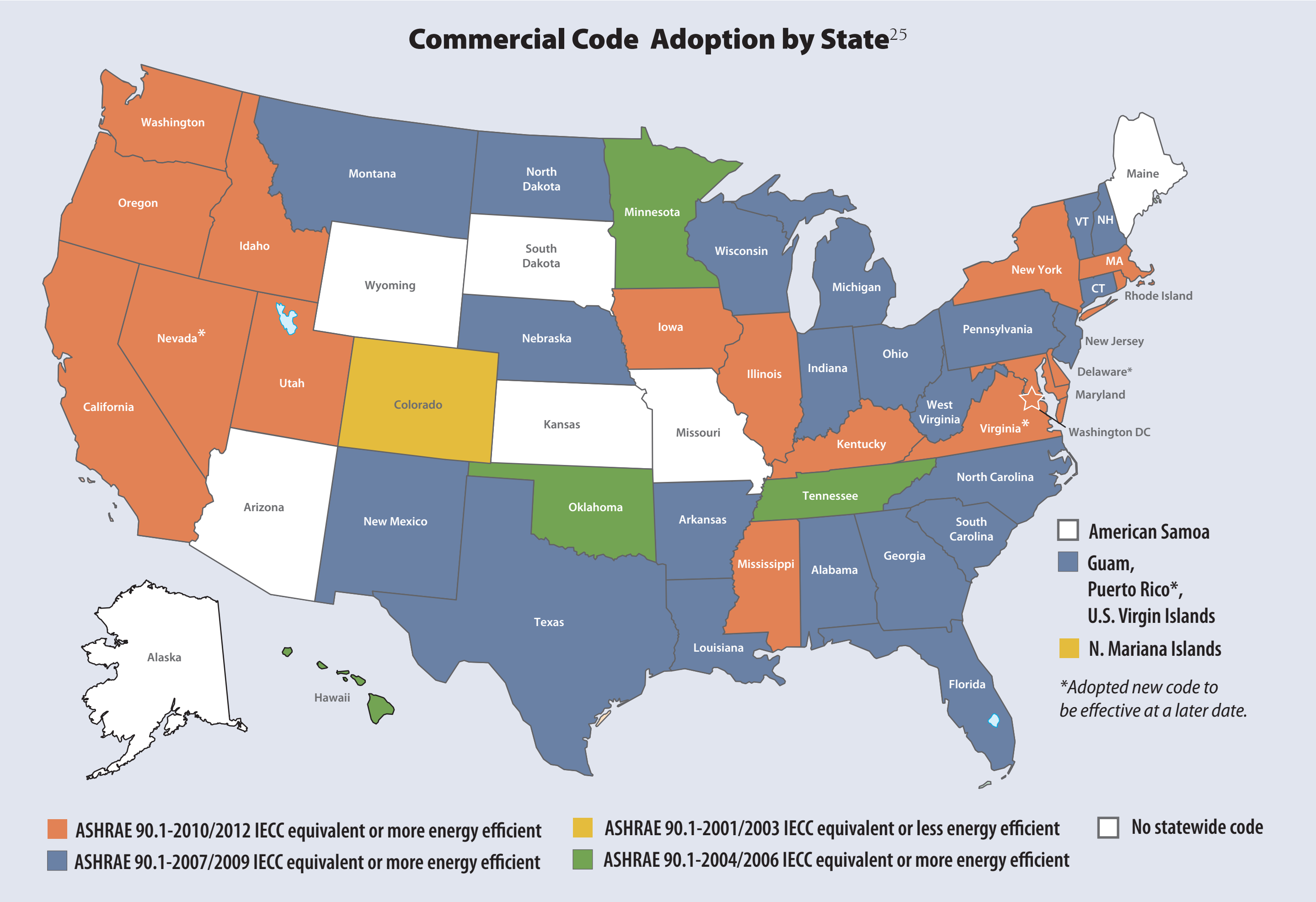
[21] The city is precluded by state law from adopting or enforcing a residential energy code that goes beyond the requirements of the state code, but this proscription does not apply to nonresidential codes.

[22] See: http://www.seattle.gov/DPD/codesrules/codes/energy/overview/

[23] Oregon Department of Energy, 2011-2013 State of Oregon Energy Plan. Available at: http://www.oregon.gov/energy/docs/reports/legislature/2011/energy_plan_2011-13.pdf

[24] Supra footnote 23.

Figure 15-4



Commercial Code Adoption by State[25]

Massachusetts, the Department of Energy Resources requires municipalities to adopt a stretch code for new buildings. The Green Communities program then assists cities and towns in the implementation of these codes, including funding and technical support.

Based on the implementation experiences of governments around the country, the key elements to code adoption, training, and enforcement include:

- Educating policymakers (legislators or state code agencies) as to the economic and environmental benefits of updated energy codes;
- Educating and training building design professionals and building contractors in the technical aspects of energy codes, so that mistakes that require costly rework are avoided; and
- Educating and training code enforcement officials (generally local government agencies) as to the details of energy code enforcement, and the health and safety benefits (which they consider their principal mission) of advanced energy codes.

Unless all of these elements are addressed, the full potential of code improvements is unlikely to be achieved.

Other Mandatory Building Efficiency Policies

With respect to building energy use disclosure, a growing number of cities, counties, and states have adopted some form of benchmarking, auditing, or disclosure requirement, as depicted in Figure 15-5. Among them are some of the largest cities in the United States, including San Francisco, Boston, New York, Chicago, Austin, Seattle, Philadelphia, Minneapolis, and Washington, DC. The laws vary as to size and type of buildings affected, and whether the energy use data must be disclosed publicly or just to tenants or buyers, among other features. Mandatory benchmarking can help drive builders, owners, and tenants to make better decisions about energy consumption.

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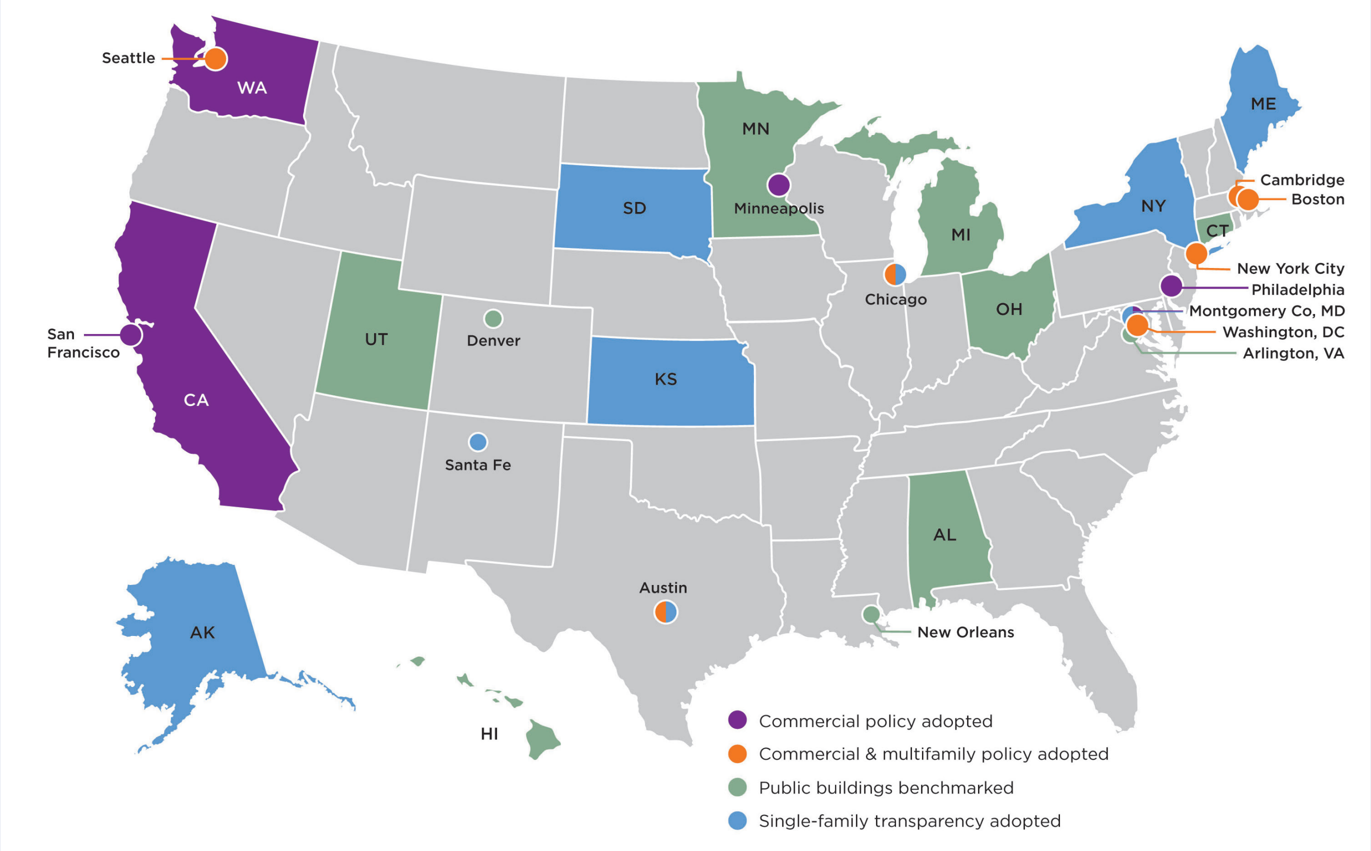
[25] See: http://www.energycodes.gov/adoption/states

Figure 15-5

US Building Benchmarking and Transparency Policies[26]



4. Greenhouse Gas Emissions Reductions

As explained in Chapter 11, the magnitude of emissions reductions attributable to energy efficiency measures depends first and foremost on the amount of energy that was (or will be) saved. However, the emissions reductions that result from those energy savings also depend on when energy was (or will be) saved, and which marginal electric generating units (EGUs) reduced (or will reduce) their output at those times.[27] Over the longer term, the more significant impact of energy efficiency programs and policies is that they can defer or avoid the deployment of new EGUs. The avoided emissions over that longer term will thus depend not so much on the characteristics of existing EGUs, but on the costs and development potential for new EGUs.[28]

In either the near term or the longer term, greenhouse gas (GHG) emissions reductions are proportional to energy savings, but not necessarily on a one-to-one basis (i.e., a

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[26] See: http://www.buildingrating.org/file/1538/download

[27] For example, the average CO_2 emissions rate from natural gas power generation in the United States is about 1100 lb per MWh, whereas the average emissions rate from coal power plants is twice as much as this rate. See: http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html

[28] The fact that energy efficiency programs can defer the need for new generating capacity means that they can also potentially extend the life of existing EGUs. New EGUs will tend to be lower emitting than the existing EGUs most prone to retirement, and the developers of new EGUs often size the units not only to meet load growth but also to replace an existing EGU. For example, they might develop a 200-MW EGU in anticipation of 150 MW of load growth, and thus some of the existing EGUs would run less or might choose to retire. Air regulators should be cognizant of this possibility, but not view it as a certainty or as an argument against using energy efficiency to reduce emissions. Older, less efficient, higher emitting EGUs will generally be dispatched less often (not more often) as a result of demand reductions, and the economic pressures that lead to a retirement decision will generally arise sooner (rather than later) as a result of energy efficiency programs.

one-percent reduction in energy consumption could reduce emissions by more or less than one percent, depending on how the emissions rates of the marginal or deferred EGUs compare to the system average emissions rates). Chapter 11 describes three methods for quantifying the short-term emissions impacts of energy efficiency programs: the average emissions method, the marginal emissions method, and the dispatch modeling method. Over a longer time period, the emissions rates of new natural gas-fired EGUs may represent a better proxy for avoided emissions.

The diurnal and seasonal "shape" of energy efficiency savings from building energy efficiency policies generally mirrors the usage patterns of the heating, cooling, and lighting loads of buildings. Because these loads are largely daytime and peak-centric, the savings are also peak-oriented. Because EGUs used to meet peak loads generally have higher than average emissions rates, the emissions reductions from efficiency improvements are likely to be above average (either reducing the use of existing peaking power plants, or avoiding the need for construction of new peaking power plants).[29]

Building Energy Codes

The Northwest Power and Conservation Council estimates that building energy codes have provided as much as 25 percent of cumulative energy savings from state energy efficiency policies in its region (Idaho, Montana, Oregon, and Washington) over the last decade.[30] Other studies suggest a range of 13 to 18 percent of achievable efficiency savings may be attributable to building codes.[31]

The difference between energy use in buildings under the IECC 2015 code and that under the 2006 code is approximately a 30-percent reduction. Because many jurisdictions have only adopted the 2006 IECC, upgrading to IECC 2015 is a very real energy savings opportunity with demonstrated cost-effectiveness. Therefore, adoption, implementation, and enforcement of the current energy code can be expected to reduce GHG emissions associated with new buildings by a similar percentage. Given a one- to two-percent rate of new building deployment (as a percentage of the existing building stock), this code upgrade alone could produce an 8- to 15-percent reduction in emissions associated with buildings, or a four- to eight-percent reduction in total emissions.

Going beyond the current code, to ZNE levels, could eliminate substantially all incremental GHG emissions from new buildings. California is expected to adopt such codes. If it does so, all new residential construction in California is expected to be ZNE by 2020 and new commercial construction is expected to be ZNE by 2030.[32]

In a GHG Abatement Measures document published with the 111(d) proposal, the EPA cites two national studies of energy efficiency potential that compared the relative opportunities provided by ratepayer-funded energy efficiency programs (i.e., those described in Chapter 11) and by building energy codes. The results of those two studies are summarized in Table 15-2.[33]

Table 15-2

Relative Savings Potential of Different Energy Efficiency Policy Options

Study	Year	Energy Efficiency Programs	Building Codes	Other
ACEEE	2030	77%	13%	10%
Georgia Tech	2035	82%	18%	0%

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[29] Evidence for this assertion can be found in data from the US EPA's eGRID database at: http://www.epa.gov/cleanenergy/energy-resources/egrid/. Non-baseload generators emit at levels about 25 percent higher than the average for all generation, nationally. The phenomenon of higher-than-average non-baseload emissions rates holds true in most regions of the country, with only a few exceptions.

[30] The Sixth Northwest Electric Power and Conservation Plan (Council Document 2010-09), Northwest Power and Conservation Council. (2010, February). Available at: http://www.nwcouncil.org/media/6284/SixthPowerPlan.pdf, cited in EPA GHG Abatement Measures Technical Support Document (Docket ID No. EPA-HQ-OAR-2013-0602), p. 5-10.

[31] US EPA. (2014, June). *GHG Abatement Measures – Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants: Emission Guidelines for Greenhouse Gas Emissions from Existing Stationary Sources: Electric Utility Generating Units.* Docket ID No. EPA-HQ-OAR-2013-0602, p. 5-11. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-ghg-abatement-measures

[32] California Energy Efficiency Strategic Plan, Zero Net Energy Action Plan: Commercial Building Sector 2010-2012. Available at: http://www.cpuc.ca.gov/NR/rdonlyres/6C2310FE-AFE0-48E4-AF03-530A99D28FCE/0/ZNEActionPlanFINAL83110.pdf

[33] See: Supra footnote 31 at pp. 5-10 and 5-11.

One issue to consider is how to measure energy savings and emissions reductions from codes, given the possibility of lax enforcement. One approach is to assume compliance with the most current code update, and credit energy savings and emissions reductions only for demonstrated "beyond code" measures achieved under state, local, or utility programs. Although this is not an accurate reflection of savings from codes, it avoids giving "credit" where energy waste results from lax implementation. Another approach is to measure typical performance nationally, and recognize any "above average" achievement as a code-related credit; this more accurately measures the savings, but may be viewed as rewarding compliance with a mandatory obligation.

Other Mandatory Building Efficiency Policies

An analysis by the EPA of 35,000 benchmarked buildings found that those buildings reduced consumption by an average of seven percent over three years.[34] A report commissioned by the California Public Utilities Commission found that benchmarking strongly correlated with building energy improvements and management actions, and was a strong catalyst for customer participation in utility rebate and incentive programs.[35] In addition, work by the Institute for Market Transformation on markets with existing benchmarking laws found that local businesses were experiencing significant new demand for energy efficiency services.

5. Co-Benefits

The implementation and enforcement of building codes can be expected to produce significant co-benefits, similar to those produced by other energy efficiency policies. In addition to the CO_2 emissions reductions noted previously, building codes are likely to result in reduced emissions of other regulated air pollutants associated not only with electricity production but also with the operation of heating, ventilation, and air conditioning, and other building systems (e.g., water supply and treatment). The magnitude of the air emissions co-benefits depends on the same factors that were discussed with respect to GHG emissions reductions.

The full range of co-benefits for society and the utility system that can be realized through building codes is summarized in Table 15-3.[36] Although not shown in

Table 15-3

Types of Co-Benefits Potentially Associated with Building Energy Codes

Type of Co-Benefit	Provided by This Policy or Technology?
Benefits to Society	
Non-GHG Air Quality Impacts	Yes
Nitrogen Oxides	Yes
Sulfur Dioxide	Yes
Particulate Matter	Yes
Mercury	Yes
Other	Yes
Water Quantity and Quality Impacts	Yes
Coal Ash Ponds and Coal Combustion Residuals	Yes
Employment Impacts	Yes
Economic Development	Yes
Other Economic Considerations	Yes
Societal Risk and Energy Security	Yes
Reduction of Effects of Termination of Service	Yes
Avoidance of Uncollectible Bills for Utilities	Yes
Benefits to the Utility System	
Avoided Production Capacity Costs	Yes
Avoided Production Energy Costs	Yes
Avoided Costs of Existing Environmental Regulations	Yes
Avoided Costs of Future Environmental Regulations	Yes
Avoided Transmission Capacity Costs	Yes
Avoided Distribution Capacity Costs	Yes
Avoided Line Losses	Yes
Avoided Reserves	Yes
Avoided Risk	Yes
Increased Reliability	Yes
Displacement of Renewable Resource Obligation	Yes
Reduced Credit and Collection Costs	Yes
Demand Response-Induced Price Effect	Yes
Other	Yes

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[34] Institute for Market Transformation. (2012). EPA Analysis Shows Big Benchmarking Savings [Press release]. Available at: http://www.imt.org/news/the-current/epa-analysis-shows-big-benchmarking-savings

[35] NMR Group, Inc. (2012, April). *Statewide Benchmarking Process Evaluation. Volume 1: Report.* Available at: http://www.calmac.org/publications/Statewide_Benchmarking_Process_Evaluation_Report_CPU0055.pdf

[36] For a detailed discussion of energy efficiency benefits, see: Lazar, J., & Colburn, K. (2013, September). *Recognizing the Full Value of Energy Efficiency (What's Under the Feel-Good Frosting of the World's Most Valuable Layer Cake of Benefits)*. Montpelier, VT: The Regulatory Assistance Project. Available at: http://www.raponline.org/document/download/id/6739

Table 15-3, building codes can also produce substantial benefits for the owners and occupants of efficient buildings, including reduced future energy bills, other resource savings (e.g., septic, well pumping), reduced operations and maintenance costs, increased employee productivity, higher property values, and more comfortable indoor environments. Low-income consumers may see additional benefits unique to their circumstances.

6. Costs and Cost-Effectiveness

Energy codes are among the most cost-effective sources of energy efficiency for many reasons. First, it is intuitive that the time of design and construction is the most economical time to install energy efficiency measures. Retrofit of state-of-the-art measures into existing buildings is more difficult and expensive, and often impossible. Second, measures installed as part of new construction are typically financed as part of building mortgages, which provide long-term, low-cost interest rates. In 2013, the Institute for Market Transformation found that every dollar spent on code compliance and enforcement efforts returns six dollars in energy savings, an impressive 600-percent return on investment.[37]

More recently, studies of ZNE costs and cost-effectiveness suggest that ZNE may become a cost-effective option for new construction. According to the California Zero Net Energy Buildings Cost Study, research and interviews already reveal "examples where commercial buildings achieved ZNE (or near-ZNE) status at little or no additional cost."[38]

The International Codes Council, developers of the IECC, studies the cost-effectiveness of proposed measures in each of the Council's code cycles. Focusing on consumer cost-effectiveness, they ask the question, "Does the building owner pay less, on a present value basis, over the life of the building for energy efficiency investments plus energy?" They do not consider other societal impacts, such as emissions, health, energy security, or other aspects of energy savings that also add value to energy efficiency.

It is important to appreciate the cost-effectiveness of building codes and the efficiency investment that code adoption can create. If buildings are not designed and constructed to be energy efficient initially, it is far more difficult and expensive to retrofit them to be energy efficient later. Inefficient new buildings represent "lost opportunities," because some energy savings can only be captured at the time of construction. Adding insulation and replacing windows is possible (but more expensive) and both are limited by the design of the structure. One recent study by the Pacific Northwest National Laboratory indicated that energy savings from business-as-usual implementation of building technologies would result in energy consumption levels that are 6.9 percent lower than the Reference Case by 2025. But in a scenario in which a greater effort is made to avoid "lost opportunities" in new buildings, primary energy consumption would be 17.8 percent lower than the Reference Case in 2025. Total primary energy savings are estimated to be 8.5 quadrillion BTU (QBTU) by 2025 in this more aggressive building efficiency scenario. In perspective, 8.5 QBTU is about equal to the total primary energy consumed by the state of California annually. The results of this study are summarized in Figure 15-6.[39]

Replacing lighting, heating, and cooling equipment is also possible, but more expensive and similarly constrained by design. The incremental cost of incorporating high-efficiency equipment during construction is relatively small, however – and often zero or negative. For example, improving building shell performance adds to the construction cost, but often enables installation of a smaller heating and cooling system, providing offsetting capital cost savings and space savings. Research by the Pacific Northwest National Laboratory published in 2008 found that there were limited data on the actual incremental costs of efficient building construction, but the data that were available indicated that in most cases, the cost premium for a building that achieved 30- to 50-percent energy savings

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[37] Stellberg, S. (2013, February). *Assessment of Energy Efficiency Achievable from Improved Compliance with US Building Energy Codes: 2013-2030.* Institute for Market Transformation. p.4. Available at: http://www.imt.org/uploads/resources/files/IMT_Report_Code_Compliance_Savings_Potential.pdf, citing to Institute for Market Transformation. (2010). *Policy Maker Fact Sheet Building Energy Code Compliance.*

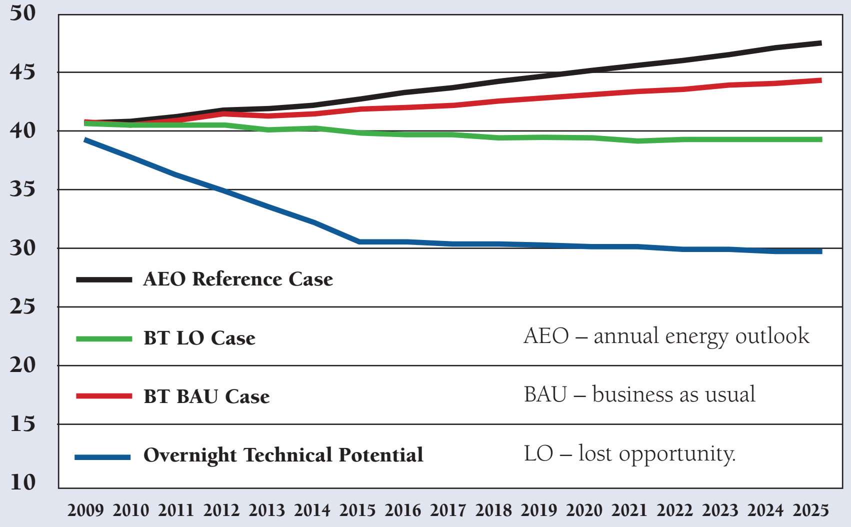
[38] *California Zero Net Energy Buildings Cost Study.* Pacific Gas and Electric Company Zero Net Energy Program. (2012, December). p. 3. Available at: http://www.cpuc.ca.gov/NR/rdonlyres/2CDD0FB7-E871-47C0-97D0-A511F5683B57/0/PGECAZNECostStudy.pdf

[39] Pacific Northwest National Laboratory. (2008, September). *Lost Opportunities in the Buildings Sector: Energy-Efficiency Analysis.* Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17623.pdf

Figure 15-6

Potential Lost Opportunity Savings[40]

Integrated Commercial+Residential Energy Consumption (QBTU, Primary)



Technical potential shown does not include the effect of overnight saturation of PV in the residential sector. See text for further discussion. Note also the Y-axis is truncated for display purposes.

when compared to a building built to ASHRAE Standard 90.1-2004 was less than four percent of total construction costs.[41] For this reason, building codes are sometimes referred to as "lost-opportunity" measures. This means that they prevent "lost opportunities" to reduce energy consumption after the fact.

7. Other Considerations

Some early efforts at building energy efficiency resulted in moisture buildup in buildings, mold, and other adverse impacts. In some cases, this led to structural damage and adverse health impacts, both of which required expensive remedies.[42]

The most current energy codes address this issue through a combination of materials specification, design requirements, and ventilation measures. This is one reason it is essential that the most current energy codes be adopted and enforced. Jurisdictions that choose to enforce prior energy codes rather than first upgrading them may not receive the benefit of improved or corrective materials, design, and techniques learned from earlier experience. As a result, they may put their constituents who build or acquire buildings at unnecessary health and financial risk.

The ZNE standards under consideration in California only require that a building produce enough energy to offset its consumption over a year. Hour-to-hour operation of buildings that produce power, however, may result in substantial export of power to the grid at certain times and substantial import of power from the grid at other times. Therefore, the achievement of ZNE goals in any jurisdiction depends heavily on grid operators having sufficient flexibility in the dispatch of storage and renewable resources in order to be able to actually accept surplus power *from* buildings (generally at mid day and on weekends), and to deliver renewable energy to those buildings during hours when their onsite energy demands exceed their ability to self-generate. This balancing effort is an important grid issue addressed in Chapters 20 and 23, and an important reason that utility involvement in energy code development and enforcement is important.

Thermal Storage Capacity

Air conditioning and water heating loads occur primarily during periods of high electricity use and are both candidates for thermal energy storage technologies that allow these loads to be served with intermittent renewable energy (wind and solar) or with off-peak excess generation from more efficient generating plants.[43]

Currently, the ASHRAE and IECC model codes do not

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[40] Supra footnote 39.

[41] Hunt, W. (2008, May). *Literature Review of Data on the Incremental Costs to Design and Build Low-Energy Buildings.* Pacific Northwest National Laboratory. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17502.pdf

[42] Meres, R., & Makela, E. (2013, July). *Building Energy Codes: Creating Safe, Resilient, and Energy-Efficient Homes.* p. 11. Institute for Market Transformation & Britt/Makela Group, Inc. Available at: http://www.imt.org/uploads/resources/files/non-energy_benefits_of_energy_codes_report.pdf

[43] In some regions, the incremental resources dispatched to serve off-peak loads may be more polluting coal units; in other regions, these loads may be served with wind, solar, or combined-cycle gas generation with low emissions.

require thermal storage within new buildings. Thermal storage (in the form of hot water, chilled water, or ice) can enable buildings to receive power at times when the incremental electricity supply resource is a lower cost and/or lower emitting generating unit, and deliver the desired end-use when it is needed.

Thermal storage resources can be as simple as residential electric water heaters controlled by a central utility dispatch system so that they heat water when low-cost/low-emission resources are available, and store that hot water for later use.[44] More sophisticated chilled water and ice storage systems can be added to commercial cooling systems.[45]

Use of thermal storage can enable a utility system to better manage the variable production of wind, solar, and other intermittent generating resources more easily, enabling a higher level of renewable energy production (refer to Chapter 20 for more information on this challenge). Although the storage systems may not save significant kilowatt-hours, the economic and environmental benefits can be significant.

Augmenting the model building energy codes with requirements for thermal energy storage may be one way for states to integrate more variable renewable generators and significantly reduce electric system emissions.

8. For More Information

Interested readers may wish to consult the following reference documents for more information on building codes.

- International Codes Council: Association of code officials that develops model codes for energy efficiency, as well as structural, fire, and other building attributes. (www.iccsafe.org)
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE): Association of energy professionals that develops model code for commercial building energy efficiency. (www.ashrae.org)
- New Buildings Institute: Non-profit organization dedicated to advancing the state of the science in new building design, construction, and equipment. (www.newbuildings.org)
- Energycodes.gov: Website operated by the US Department of Energy on the status of building code activity for each state.
- State and Local Energy Efficiency Action Network (SEE Action): Website operated by the US Department of Energy on innovative energy efficiency strategies being pursued by state and local entities. (https://www4.eere.energy.gov/seeaction/topic-category/commercial-and-public-building-energy-efficiency)
- Building Codes Assistance Project (BCAP): BCAP was founded as a joint initiative of the Alliance to Save Energy, the Natural Resources Defense Council, and the American Council for an Energy-Efficient Economy. BCAP hosts an Online Code Environment and Advocacy Network (OCEAN). (http://energycodesocean.org)

9. Summary

About half of US energy consumption is in buildings, and much of this is consumed in the heating, cooling, and lighting of those buildings, all aspects that are addressed by building energy codes. Modern energy efficiency codes can reduce building energy use dramatically; the most recent national code would reduce usage by about 30 percent below conventional building standards. Innovative "Zero Net Energy" codes can reduce net building use to zero.

Three key steps are necessary to achieve such savings:

- States and local governments must adopt current codes, such as the 2015 IECC and ASHRAE 90.1;
- Architects, engineers, builders, and local government building officials must be trained to successfully design, build, and inspect new buildings to ensure that they realize potential energy savings; and
- Local building officials must assertively enforce the codes.

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[44] Steffes Corp. (2013). *Grid-Interactive Renewable Water Heating*. Available at: www.steffes.com/LiteratureRetrieve.aspx?ID=72241

[45] Calmac Corp. (2014). *Frequently Asked Questions About Thermal Energy Storage*. Available at: http://www.calmac.com/frequently-asked-energy-storage-questions