U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Achieving Energy Savings and Emission Reductions from Building Energy Codes:

A Primer for State Planning

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Overview

Building energy codes are an important energy, cost and emission reductions policy that helps new and renovated buildings benefit from the latest in cost-effective energy efficiency measures such as high performance insulation, windows, lighting and heating, cooling, and refrigeration equipment. Building energy codes are estimated to save U.S. building owners about $5 billion annually, and many times that amount over the lifetime of the buildings[1]. There remain substantial additional savings to be achieved over the next fifteen years or more as model codes are updated, adopted, and implemented across the country. Annual savings could grow on the order of three-fold by 2030 nationally[1] with the actual savings dependent upon future code update cycles, the pace and breadth of adoption at the state and local level, and the effectiveness of implementation. Emission reductions would increase proportionally. Savings achieved within an individual state depend on the version of the current code, efforts to adopt and implement updated codes, the volume of construction and renovation, and climate conditions.

This paper:

- Briefly describes the role of state and local governments with respect to building energy codes;
- Provides examples of effective state and local efforts;
- Estimates potential savings through 2030 from building energy codes for a few example states with high potential;
- Gives a basic methodology for calculating savings and offers suggestions for how states can make progress in reducing energy use and costs through building energy codes;
- Highlights efforts the U.S. Department of Energy (DOE) is undertaking to improve the ability of states to effectively implement building energy codes as well as to estimate and measure the benefits from these codes; and
- Provides a listing of available tools and resources for state and local governments to derive the greatest benefit from building energy codes.

Building Energy Codes – The Opportunity

Buildings consume more than 40% of the energy we use nationally each year and about 70% of the electricity, resulting in estimated annual energy bills of over $400 billion. They are also responsible for 39% of carbon dioxide emissions[2].

Model building energy codes present a significant opportunity to save energy and avoid emissions of air pollutants in residential and non-residential buildings. In a given state, adoption of the newest versions of the building energy codes could reduce energy use and costs of new buildings and major renovations by 12 – 40%[3]. The specific savings depend upon factors such as the key characteristics of the buildings being improved (e.g. size, type) and prevailing climate conditions.

- Nationally, there is significant opportunity for savings. According to the Energy Information Administration (EIA), 18% of the buildings expected to be in existence in 2030 have yet to be built[4]–the stronger the code applied to these as-yet-unbuilt buildings, the more savings will accrue. Because the incremental cost of efficiency upgrades are lowest during design and construction, it is much more cost-effective to require upgrades through energy codes than for building owners to make efficiency retrofits after construction is completed.

1. http://www.energycodes.gov/building-energy-codes-program-national-benefits-assessment-1992-2040-0.
2. http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1
3. See state specific energy and cost analyses report at http://www.energycodes.gov/development/residential/iecc_analysis and http://www.energycodes.gov/development/commercial/cost_effectiveness
4. Annual Energy Outlook 2014: http://www.eia.gov/forecasts/aeo/

At the same time, the opportunity is much larger than new buildings because energy codes also apply to additions, remodels and renovations.

- ***Building energy codes require state and local action.*** There is no U.S. national energy code or standard, so building energy codes are adopted and implemented at the state and local levels of government. Adoption can occur directly by legislative action or through regulatory agencies authorized by the legislature. The most effective state adoption processes include legislation requiring an automatic review and update process with each new publication of the International Energy Conservation Code (IECC—the national model residential code) or ASHRAE Standard 90.1 (the commercial model energy code). Examples include:

  - **Maryland**[5] and **Illinois**[6] state laws require their respective building codes to incorporate the latest applicable IECC within 12 months of publication of the new code editions and local jurisdictions must begin implementing the state code within 6 months of its adoption by the state. In Maryland, the energy conservation requirements must be at least as stringent as the most recent version of the IECC.

  - **Massachusetts** is required by state legislation to review and update its code after each update to the IECC within one year of its publication. In addition, the State develops a "stretch" code which contains even higher requirements for energy efficiency[7]. Local jurisdictions must implement either the baseline code or the stretch code; implementation of the stretch code is one of the prerequisites for a municipality to be designated as a Green Community and receive the accompanying financial benefits under the Massachusetts Green Communities Grant Program.

For states that adopt a code but do not make it mandatory statewide, a best practice is for local jurisdictions to pass an ordinance stating that whatever has been adopted by the state will be effective in that jurisdiction.

- ***The importance of compliance***
  Code compliance is a critical activity – actual energy savings are achieved through code compliance, not code development or adoption. Design and construction professionals have a legal responsibility to design buildings that comply with the energy code on behalf of building owners and developers. Building officials enforce the code by verifying that what is built actually complies with the energy code. Adopting jurisdictions must therefore educate and support code officials to enforce the energy code, and the building design and construction communities must be prepared to comply with it. It is important for all stakeholders to know when a new or updated energy code is coming and to understand the requirements of that code; the more resources and training available for the new code, the more likely it is to be accepted, understood and used properly. Many states, jurisdictions, and territories start this education process several months in advance of an energy code change—sometimes before adoption itself. Examples include:

  - **Provide widespread Training**
    In **Texas**, energy code training is supported by the State Energy Conservation Office (SECO). In-person training is typically offered throughout the state during the nine months between the adoption of an updated energy code and its effective date, and it is marketed to code officials and the building design and construction industry. All enforcement personnel are required to be certified by ICC in the energy code. Additionally, free online training courses are offered on SECO's website. http://www.seco.cpa.state.tx.us/tbec/edutrain.php

  - **Create tools and programs that support compliance and enforcement**
    Georgia's residential building energy code requires that all new homes undergo testing for minimum air leakage requirements by a certified professional. To help meet the demand for certified professionals, the Georgia Department of Community Affairs (DCA) created the Duct and Envelope Tightness (DET)

5. Maryland SB 625 (2009) requires the Department of Housing and Community Development to update the state building code. http://mgaleg.maryland.gov/webmga/frmMain.aspx?ys=2009rs%2fbillfile%2fsb0625.htm.
6. The Illinois Energy Efficient Building Act requires the Illinois Capital Development Board to review and adopt future versions of the IECC. http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2614&ChapterID=5
7. http://www.mass.gov/eopss/consumer-prot-and-bus-lic/license-type/csl/stretch-energy-code-information.html

verifier program and reviews the courses provided by 3rd parties required for this certification. DCA also purchased testing equipment and made it available for rental.
http://www.dca.state.ga.us/development/constructioncodes/programs/det.asp
In **Ohio**, the Energy Code Ambassadors Program (ECAP) improves enforcement of building energy codes by offering local code officials direct interaction with trained, experienced code professionals who understand the challenges and constraints that are encountered in the field. Through training and open peer-to-peer sharing, the ECAP program empowers existing code professionals to develop their familiarity and expertise with energy codes and share their knowledge. Currently there are six Energy Code Ambassadors in Ohio, and partial program funding was provided by utilities. ECAP has also been implemented in Alabama, Idaho, Nevada, Texas, Utah, and Wyoming. http://energycodesocean.org/ecap

- **Convene Stakeholders**
  The **Idaho** Energy Code Collaborative is an open forum of key energy code stakeholders who meet regularly to address barriers to implementation of the energy code across the state. The collaborative conducts research, provides guidance to the state during the code update process, and makes free resources available to code officials and the construction industry in Idaho. Contact Ron Whitney, Idaho Department of Building Safety. (Ron.Whitney@dbs.idaho.gov)

Benefits and Future Potential of Building Energy Codes

- ***Who benefits and how***

  - **Consumers and homebuyers** are assured that they have purchased or rented a home that meets minimum standards for energy efficiency, and as a result will see lower utility bills and greater comfort than in areas without energy codes or improperly enforced ones.

  - **The construction industry** benefits from a "level playing field" on which energy codes are interpreted and enforced consistently across jurisdictions, thus reducing the time and cost associated with having to build differently in different jurisdictions. Consistent enforcement also results in more clearly distinguishing the energy advantages of new homes relative to existing homes.

  - **Code officials** are supported by education and training programs as well as getting access to tools and materials which assist in enforcement. They are also aided by training provided to the design and construction community as the more educated this group is the less time code officials have to spend being educators.

  - **Utilities** reduce the amount of energy they need to produce and their peak demand if codes are consistently enforced. In addition, utilities can improve the accuracy of their energy and peak demand forecasting. Also, if they are able to create code implementation/compliance programs, utilities can provide benefits to a larger number of their customers. Utility programs which provide incentives for homes that go beyond the energy code typically only reach a small portion of home builders while a utility-sponsored energy code program could include anyone building a new home.

  - **State and local governments** can reduce energy waste and greenhouse gas emissions while helping to ensure that their constituents live and work in comfortable, quality buildings with lower energy bills.

- ***Energy savings and emission reductions***[8]

  In ***2012 alone***, building energy codes saved the U.S. an estimated:

8. http://www.energycodes.gov/building-energy-codes-program-national-benefits-assessment-1992-2040-0.

- **$5 billion** on consumers' energy bills
- **0.5 quads** of full fuel cycle energy consumption (equal to energy produced by sixteen 1MW power plants operating full-time for a year)
- **40 billion** kWh in electricity use (equal to the electricity used by all the homes and buildings in Boston over six years)[9]
- **36 million metric tons (MMT)** in avoided CO_2 emissions (equal to taking 7.5 million cars off the road for a year)

If current trends in code adoption and compliance continue, the cumulative savings attributable to building energy codes from 2013-2040 in the U.S. are estimated to be[10]:

- **$186 billion** on consumers' energy bills
- **41.6 quads** of full fuel cycle energy consumption (equal to 42% of total U.S. energy use in a year)
- **3,643 billion kWh** in electricity use (approximately equal to the total amount of electricity used annually in Illinois)
- **3,178 MMT** in avoided CO_2 emissions (equal to taking 66 million cars off the road for ten years)

On an annual basis in 2030, savings would be on the order of three-fold compared to 2012[10].

The following are rough estimates of projected annual energy savings in TBTU (trillion BTUs) and kWh in 2030 for several high-potential states if they adopted the latest national model codes (2015 IECC and ASHRAE 90.1-2013) in 2017[10].

State	Annual Total Energy Savings in 2030 (Trillion BTUs)	Annual Electricity Savings in 2030 (billion kWh)
Texas	25.9	5.82
Florida	20.1	4.99
Massachusetts	13.5	2.24
North Carolina	12.3	2.40
New York	11.0	2.05
Georgia	10.7	2.54
Pennsylvania	10.2	1.97
Virginia	9.6	1.92
Arizona	7.3	1.72
Illinois	7.2	1.42

- ***Example of a successful state program***
  The State of **Washington** has been a national leader in energy codes for 30 years. It has one of the most

9. http://www.epa.gov/cleanenergy/energy-resources/calculator.html
10. Pacific Northwest National Laboratory conduced analysis based on methodology documented in this published report: http://www.energycodes.gov/building-energy-codes-program-national-benefits-assessment-1992-2040-0.

advanced codes in the country, and it has consistently supported compliance and enforcement through training and education of code officials and others, the creation of state-specific compliance tools and materials and a technical assistance hotline. The state has invested in building codes for the long term by providing stable funding for these activities. Utilities have funded much of this work in recognition of the low-cost energy savings that energy codes deliver. An evaluation study published in 2013 documented the success of these efforts for the residential energy code. Compliance with the code was found to be 96% and the ratio of achieved energy savings to potential energy savings was estimated at 97%. See http://neea.org/docs/default-source/reports/washington-residential-energy-code-compliance.pdf?sfvrsn=13.

A Basic Formula for Projecting and Monitoring Savings from Energy Codes

For states interested in calculating energy savings resulting from the adoption of a specific code version, the following offers a brief introduction to the information needed and how to apply it. The basic formula is:

Per Unit Savings x Number of Units x Compliance Rate

Per Unit Savings are calculated separately for residential and commercial buildings after a new code is passed. The unit for residential is homes and for commercial is kWh per square foot. For each change in the code, the new requirement is compared to the old requirement and a savings estimate is created using engineering calculations, energy modeling or a credible outside source. For commercial buildings, per unit savings must be calculated by building type. A new code requirement may save substantial energy in restaurants, for example, but none in warehouses. Residential requirements should be reviewed to see if they have different impacts for single family versus multifamily homes and for gas versus electric heating. Note that in many cases, DOE has or can calculate state-level Per Unit Savings. For more information on what is available for a specific state, contact the energy codes help desk at http://www.energycodes.gov/resource-center/help-desk.

Number of Units requires both current and forecast data. For residential, current permit data can be obtained from state records or national/federal sources[11]. The forecasted number of new construction homes is available from state economic forecasts or data companies such as McGraw-Hill. For commercial, state permit records can be used for current permit data and construction forecast data is available from state economic forecasts or national data companies such as McGraw-Hill. The number of units is typically estimated for 20-30 years from the date a new code goes into effect. For commercial buildings, the number of units must be estimated separately for each building type so that the building-specific Per Unit Savings are applied only where appropriate. This 'weighting' exercise is critical since individual code changes may save a large amount of energy but apply to only a single building type or, conversely, may save a moderate amount of energy per unit but have a very large cumulative impact if it applies to all building types. The same may be true in residential for particular code changes. Ultimately, the weightings are used to generate two overall per unit savings estimates, one for residential and one for commercial.

Compliance Rate is an adjustment factor that accounts for the reality that not all buildings meet every code requirement. DOE is working to develop methodologies to generate information on how energy savings vary with differing levels of compliance. (See the next section for more information.) If a state has conducted compliance studies for either residential or commercial buildings, the results should be used in the equation. If state-specific data does not exist, placeholder estimates should be used which can be developed by expert panels familiar with state construction practices.

11. Well-known sources are the National Association of Homebuilders (http://www.nahb.org/generic.aspx?genericContentID=45409) and the US Census Bureau (http://www.census.gov/construction/nrc/)

Savings from the above equation should be assumed to begin accruing six months after a code becomes effective. This time lag accounts for the transition period when there are still buildings being constructed which were permitted under the old code even though the new code is in effect.

The above formula produces a gross savings estimate. If net savings, which account for naturally occurring changes in the market or other variables, are desired these should be calculated independently and then used to adjust the above results.

Note that while this approach is aimed at new construction it can also work for additions and remodels, though determining the number of units for these is challenging. For the commercial sector a strict focus on new construction may miss a significant amount of savings.

Calculating the Impact of Compliance Activities

There is currently no well-tested, widely accepted methodology for determining energy savings from programs aimed at increasing energy code compliance rates. The lack of such a methodology limits utility involvement in energy codes as they have no way to claim savings toward efficiency goals or targets. DOE is now testing a methodology for measuring energy savings resulting from education, training and outreach efforts aimed at increasing compliance with residential energy codes. More information on this Residential Energy Code Field Study is available at http://www.energycodes.gov/residential-energy-code-field-study. Preliminary results are expected in late 2015-early 2016. The methodology will be revised based on experience gained in the test project; a public review draft should be available in mid- to late-2015 and the end result is intended to be a dependable and defensible approach which can be used by states or utilities to determine energy savings and return on investment. Commercial approaches are still in the development phase.

Steps for States Interested in Increasing Benefits from Energy Codes

If energy codes have:

- **Not been a focus in your state**, use state-specific DOE technical and economic analyses to publicize their potential benefits. Use these as the basis to encourage updating the current state energy code as far as possible, preferably to the current version of the national model code. Work with utilities and their regulators to ensure that credit for code-related savings can be claimed. Promote and support training and education for local government officials to raise their awareness of the importance of the energy code and give them the knowledge and tools needed to properly enforce it. An excellent resource for most states is their regional energy efficiency organization; these are the six organizations and the states they serve:
  - Northwest Energy Efficiency Alliance (WA,OR, MT, ID)
  - Southwest Energy Efficiency Project (AZ, CO, NM, NV, UT, WY)
  - Midwest Energy Efficiency Alliance (IL, IN, IA, KS, MI, KY, MO, OH, MN, WI, ND, SD)
  - South-Central Partnership for Energy Efficiency as a Resource (TX, OK)
  - Southeast Energy Efficiency Alliance (AL, AK, FL, GA, LA, MS, NC, SC, TN, VA)
  - Northeast Energy Efficiency Partnership (CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT, DC)

  The Building Codes Assistance Project is a national organization which supports energy code activity and serves all states.

- **Received some attention in your state**, research and implement best practices for both adoption and implementation including adopting recent model codes and undertaking additional code implementation practices. Work with stakeholder groups to emphasize the benefits of achieving high compliance with the code.

- **Been emphasized in your state**, share your success strategies, materials and results with other states, particularly measurements or estimates of energy savings and emissions reductions. Continuing to improve codes and increase compliance rates will provide further benefits.

DOE Resources for State and Local Governments

- ***State and local technical assistance***

  - **Software tools to demonstrate code compliance**. DOE provides and maintains free COM*check* and RES*check* software to facilitate demonstration of compliance with the model energy codes and, in some cases, state-specific codes. This software is widely used throughout the country. http://www.energycodes.gov/compliance/tools

  - **Training materials for construction and enforcement communities.** DOE develops training materials, including slide decks and resource guides, for every model energy code. These resources help the construction and enforcement communities stay up-to-date. See the first bullet of the "Steps for interested states" section below for other organizations which provide resources. http://www.energycodes.gov/resource-center/training.

  - **State-level cost-benefit analyses for code updates.** With each update to the model code, DOE produces cost-benefit studies and presents the results on a state-by-state basis which helps states evaluate the code and understand its benefits during the adoption process. For the current versions of the national model codes (2015 International Energy Conservation Code and ASHRAE Standard 90.1-2013), DOE will be providing each state with a customized report detailing the costs and benefits for both residential and commercial buildings. These will be available in late 2015. http://www.energycodes.gov/development/residential/iecc_analysis http://www.energycodes.gov/development/commercial/cost_effectiveness

  - **Utility savings estimator from increased code compliance.** A tool developed by DOE to estimate the expected energy savings and emissions reductions based on several input factors. The tool can help interested stakeholders evaluate the potential impact of a code against a given baseline. http://www.energycodes.gov/resource-center/utility-savings-estimators

  - **Help desk.** DOE provides a technical assistance help desk for stakeholders to submit specific code compliance questions and/or request assistance using DOE-provided resources. Most inquires receive a response within 48 hours. http://www.energycodes.gov/resource-center/help-desk

- ***Strategies to Improve Residential Compliance Rates and Measure Results***
  DOE's Building Energy Codes Program is currently funding projects in eight states (Pennsylvania, Maryland, Kentucky, Georgia, Alabama, Arkansas, Texas, North Carolina) to investigate whether investments in education, training, and outreach programs can produce a measurable reduction in single-family residential building energy use. (See http://www.energycodes.gov/residential-energy-code-field-study.) If these activities are demonstrated to be successful, non-government entities, particularly utilities, could be attracted to make substantial investments in similar programs. The three phases of each project are:

  - Measure current single-family residential energy code energy use using a methodology that provides statewide results with 90% reliability

  - Implement an education, training, and outreach program designed to increase single-family residential building energy code compliance

  - Measure the post-program single-family residential energy code energy use using the same methodology employed in the pre-program study

Other Available Resources

- **Success with the 2012 IECC and 2009 IECC,** Advanced Energy and Southeast Energy Efficiency Alliance. Illustrated field guides showing both what complies and what does not comply with the code. http://www.seealliance.org/policy-initiatives/initiatives/energy-codes/energy-codes-success-manuals/

- **IECC Additions, Alterations, Renovations, and Repairs Brochures,** Institute for Market Transformation. Explains in practical terms the code requirements for these types of projects. http://www.imt.org/resources/detail/iecc-additions-alterations-renovations-and-repairs-brochures

- **Energy Code Implementation: A Planning Guide for Building Departments,** Southwest Energy Efficiency Project. http://www.swenergy.org/data/sites/1/media/documents/publications/documents/ENERGY%20CODE%20IMPLEMENTATION.pdf

- **Policy Action Toolkit,** Building Codes Assistance Project. States and local jurisdictions that are interested in adopting new (or updating existing) code legislation can benefit by reviewing actions others have taken. BCAP provides sample legislation of individual state code reform to assist directly in code development and adoption and more broadly regarding successful strategies and tactics. http://energycodesocean.org/policy-action-toolkit.

- **Attributing Building Energy Code Savings to Energy Efficiency Programs,** Northeast Energy Efficiency Partnerships. Examines what mechanisms have been and could be used to encourage the development of code support programs by utilities or other program administrators (PAs) in an environment comparable to the resource acquisition arena in which conventional energy-efficiency programs function. Informs and assists PAs and regulators interested in exploring and pursuing opportunities for supporting building energy codes. http://www.neep.org/attributing-building-energy-code-savings-energy-efficiency-programs

- Adoption and Compliance toolkits. These are regionally (Northeast) focused but include other national resources helpful to include here: http://www.neep.org/sites/default/files/resources/Code-Adoption-Toolkit_0.pdf and http://www.neep.org/sites/default/files/resources/Code-Compliance-Toolkit.pdf.

- **Building Energy Code Advancement through Utility Support and Engagement,** American Council for an Energy-efficient Economy. Discusses approaches to evaluation, measurement and verification of savings from energy code compliance and summarizes related activity across the country. Appropriate activities for utilities are identified and program concepts for utilities are provided based on best practices in leading states. http://www.aceee.org/research-report/a126. Also on utilities claiming savings from codes, see http://www.mwalliance.org/sites/default/files/uploads/MEEA_2015_Utility-Partnerships-Claimed-Savings-for-Codes-Adoption-and-Compliance.pdf.

- **Third-Party Building Code Enforcement,** Institute for Market Transformation. Describes the use of private sector companies to verify compliance with buildings codes on behalf of the government regulatory agency. Describes jurisdictions with successful third-party enforcement programs, as well as companies that provide building department services across the U.S., and makes recommendations for establishing such a model. http://www.imt.org/resources/detail/third-party-building-code-enforcement-a-service-delivery-strategy-with-cost. Also on third-parties, see http://www.mwalliance.org/sites/default/files/uploads/MEEA_2015_Memo-Third-Party-Plan-Review-Inspection-Program-for-Illinois.pdf.

- **Energy Code Impacts on New Construction Activity.** Empirical demonstration that adoption of increasingly stringent energy codes did not negatively impact new construction activity in the Southeast. http://www.seealliance.org/policy-initiatives/initiatives/energy-codes/codeswhitepaper/. A similar document for the Southwest is http://www.swenergy.org/programs/buildings/CommercialConstruction.htm

- **Additional resources** are available through a number of energy code stakeholder organizations: http://www.energycodes.gov/resource-center/related-links.

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For more information, visit: buildings.energy.gov

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