Assessment of Energy Efficiency Achievable from Improved Compliance with U.S. Building Energy Codes: 2013 – 2030

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Abstract

This report presents the results of a state-by-state analysis of the potential energy and cost savings from improving compliance with building energy codes to 100 percent from current levels. The report also examines 45 statewide compliance evaluation studies, providing a summary of evaluation methods and key findings. Evidence in most states indicates that staggering rates of non-compliance, as high as 100 percent in some jurisdictions, have eroded the gains from energy code development and adoption. The projected national savings from bringing just a year's worth of new residential and commercial construction in the U.S. up to full compliance is 2.8-8.5 quadrillion Btu annually, or $63-$189 million in annual energy cost savings. This equates to lifetime savings of up to $37.1 billion. The magnitude of the energy code-compliance problem presents a significant opportunity for policymakers and energy efficiency program administrators to save homeowners and businesses billions of dollars in energy costs simply by improving enforcement of existing building energy codes.

Introduction

Building energy codes are a critical tool for state and local governments to ensure a minimum standard of energy performance, comfort, and building durability in new construction. Thanks to continuous improvements in model codes such as the 2012 International Energy Conservation Code (IECC) and ASHRAE 90.1-2010, structures that comply with today's building codes can outperform older or non-compliant buildings by a wide margin, saving energy across their lifetimes.

Just as important as the stringency of the prevailing codes is the effort and resources devoted to code implementation and enforcement. However, evidence in most states indicates that staggering rates of non-compliance, as high as 100 percent in some jurisdictions, have eroded the gains from code development and adoption. Lack of resources, education, and political will are frequently cited causes of non-compliance. As with any code inspection, verifying compliance with the energy code takes staff time and training. When budgets are stretched, fire and safety codes take precedence over energy code enforcement. New code updates, when not accompanied by training and outreach to the building community, can be overlooked or misinterpreted by unprepared design and construction professionals.

The magnitude of the energy code-compliance problem presents a significant opportunity for policymakers and energy efficiency program administrators. Simply improving implementation and enforcement of existing energy codes—through training events, outreach campaigns, third-party inspections, or dedicated funding for local building departments—can help save homeowners and business billions of dollars in energy costs. And, given that improvements in a building's energy efficiency are simplest and most cost-effective during the construction stage, these savings come at a relatively modest cost. Research suggests that each dollar invested in compliance enhancement can achieve $6 in energy savings.[1]

This study estimates the state-by-state energy savings potential from increasing code compliance rates to 100 percent from current levels. Section 1 of the report provides an overview of the state of noncompliance with energy codes in the U.S., including a literature review of 45 statewide compliance evaluation studies. Section 2 describes the approach, data sources, and key assumptions used in the savings assessment, followed by the presentation of key findings in Section 3.

[1] Institute for Market Transformation. 2010. *Policy Maker Fact Sheet Building Energy Code Compliance*.

We analyze each state's potential based on projected construction volume, current code levels, and climate zone, among other factors. Given the significant knowledge and data gaps surrounding current code compliance rates, we refrain from making state-specific assumptions of baseline compliance. Rather, we assess each state's potential for a range of hypothetical baseline compliance levels:

- High savings scenario: 25 percent baseline compliance.
- Low savings scenario: 75 percent baseline compliance.

There are many challenges in accurately forecasting the potential savings from energy codes activities, in part due to the high degree of uncertainty in baseline compliance rates and future construction levels, code adoption, energy demand, and prices. This exercise should be considered a useful first step in understanding the potential gains from investments in improved compliance with existing building energy codes across the United States.

1. Noncompliance: Where Are We Now?

A key step in evaluating the potential savings from enhancing compliance with energy codes is the assessment of baseline compliance rates. Unfortunately, while anecdotal reports from the field and one-off reports in select states provide some data, our understanding of the true rates of compliance across the U.S. is limited.

Energy code compliance is typically measured by collecting field data from a random sample of permitted projects in a particular territory. The high cost of such state-wide, on-site evaluations—upwards of $250,000 each[2]—limits the ability of jurisdictions to undertake routine assessments. However, over the past ten years, several statewide or regional studies have attempted to evaluate current construction practices against various codes. Additionally, as a condition for accepting funds under the American Recovery and Reinvestment Act of 2009 (ARRA), each state committed to documenting and achieving 90 percent compliance with a code that meets or exceeds the 2009 IECC and ASHRAE-90.1-2007 by the year 2017. A number of states have already commissioned efforts to measure and monitor code compliance rates. The sections below provide an overview of this existing code compliance literature.

[2] Northeast Energy Efficiency Partnerships. 2012. "State Building Energy Code Compliance Studies – Lessons Learned." *Model Progressive Building Energy Codes Policy — 2012 Update.*

1.1 Evaluating Compliance: Methodologies and Issues

There is no single methodology for conducting an assessment of code compliance, and studies vary widely in the approach or metric for defining "compliance". The most commonly used methods rely on some form of a prescriptive checklist or simulation modeling. Under both methodologies, the aggregate compliance rate is computed as the percent of homes or buildings sampled that pass/fail or, alternatively, the average degree of compliance in all buildings. Below is a list of the most commonly employed approaches:

- **Pass-Fail / Trade-off:** This method analyzes the technical or prescriptive compliance with code elements, allowing certain components to fall below the code requirements if compensated with above-code trade-offs. The trade-off analysis (or "Overall Building UA Compliance Path") is typically completed using REScheck™ or COMcheck™ software to compare the overall UA-value of the home with envelope, lighting, or HVAC tradeoffs to the overall UA-value of an identical home built to the prescriptive requirements.

- **PNNL-BECP Protocol:** Compliance is defined as the weighted average rate of individual code requirements satisfied by the sample buildings. Project-level compliance defined as the percent compliance with PNNL checklist items, valued at one, two, or three points based on the relative energy impact.

- **Simulated Performance:** A building is deemed in compliance if its modeled energy usage is less than the modeled energy use of a code-compliant building.

- **Average Compliance Margin:** For each code element or on an aggregate level, this method measures the average percentage by which the sampled houses are above or below the code requirements.

The variability of study design and compliance metric challenges attempts to compare results across jurisdictions. In addition, there are several key methodological limitations that call into question the accuracy and statistical significance of many existing compliance evaluations.[3] The first is the common problem of sampling design and

[3] For a more detailed review of best practices and shortfalls in compliance evaluations, see Brian Yang, Building Codes Assistance Project. 2005. *Residential Energy Code Evaluations: Review and Future Directions*, and Harry Misuriello et al. 2010. "Lessons Learned from Building Energy Code Compliance and Enforcement Evaluation Studies." In, *Proceedings of the 2010 ACEEE Summer Study on Energy Efficiency in Buildings.*

self-selection bias. Obtaining a random sample of buildings is unfeasible in many circumstances, given cost and time restraints, geographic distribution of permits, and resistance from select builders or building departments to grant permission for access to building plans and construction sites.

Second, and perhaps most important for the purposes of this report, most compliance evaluations stop short of evaluating the energy impact of non-compliance with specific measures. Additional analysis is needed to translate the raw or aggregate compliance scores from a checklist or pass-fail approach into the anticipated energy effects. This calculation depends on an understanding of the degree of compliance (i.e. marginally or substantially below or above code) and relative energy impact of the code measure (i.e. wall insulation compared to a perhaps less serious documentation infraction), which required detailed building inspections and post-inspection modeling.

A handful of states have attempted to make the jump from a prescriptive compliance score to an assessment of the energy impact of noncompliance with the energy code. A 2012 New York study conducted for NYSERDA estimates the lifetime “lost savings” from five years of new residential and commercial construction in the state of approximately $1.3 billion. A 2010 study of Massachusetts homes evaluated the potential annual savings from enhanced code compliance with select components: wall insulation, basement insulation, duct sealing, and 50 percent high efficacy lamp requirement. They estimate a lifetime savings potential for homes built between 2011 and 2013 of between 867,058 MMBtu and 1,634,877 MMBtu depending on housing growth and baseline compliance assumptions.[4] Assuming a conservative, average retail price of $12/MMBtu[5], this equates to lifetime savings of approximately $10—20 million for just three years of new residential construction in Massachusetts.

1.2 PNNL-BECP Compliance Evaluation Protocol

To encourage consistency across compliance assessments, the U.S. Department of Energy (DOE) and its Building Energy Codes Program (BECP) recently developed a set of recommended code compliance evaluation protocols, published in the 2011 report *Measuring State Energy Code Compliance* by the Pacific Northwest National Laboratory (PNNL).[6] The PNNL-BECP protocols are comprised of a checklist that quantifies component and equipment efficiencies, documentation,

[4] See NMR and Cadmus, 2010.
[5] Mix of fuels (electricity, natural gas, and fuel oil) and associated prices ignored for simplification.
[6] Pacific Northwest National Laboratory. 2010. *Measuring State Energy Code Compliance.* PNNL-19281. Prepared for the U.S. Department of Energy.

installation quality, and other requirements of the IECC and ASHRAE 90.1. Each code requirement is weighted on a scale of 1 to 3 based on the direct energy impact. A compliance “score” of 0-100 percent is calculated for each building based on the proportion of checklist points that were met. A jurisdiction’s overall compliance rate is constructed by averaging evaluated buildings’ scores, weighted by size and location. The evaluation protocol was field tested in eight DOE-funded evaluation pilots. However, these studies faced significant methodological and sample design issues, questioning the accuracy of the reported results.[7]

1.3 Compliance Evaluation Studies

As a first step to this report, IMT conducted a review of residential and commercial code compliance studies. In total, we reviewed 45 studies. Tables 1 and 2 below present a summary of the methods and findings of each study. The reported compliance rates must be interpreted and compared with caution for the reasons identified in section 1.1 above. Ultimately, it was determined that there is insufficient data to credibly and uniformly assess a baseline compliance rate for each state. For the purposes of the savings potential analysis, each state was modeled under a standard range of compliance rates with bounds at 25 and 100 percent. See Section 2.2 for a more detailed discussion.

Nevertheless, this existing compliance literature is presented here to provide a rough indication of measured compliance rates and help the reader assess whether a particular state’s actual potential may fall on the low/high end of the results presented in Chapter 3.

[7] The DOE Compliance Pilots were intended to test the PNNL compliance measurement protocol, not to obtain an accurate compliance rate in each state.

Table 1: Statewide Energy Code Evaluation Studies

State	Code	Compliance Rate		Approach	Source
		Residential	Commercial		
AR	'92 MEC	**55%**	--	Pass-Fail/Trade-off *(ARKcheck™)*	Brown, E (1999)
AR	2003 IECC	NW Region: **57%** Outside NW: **95%**	--	Pass-Fail/Trade-off	Brown (2006)
CA	2001 Title 24	**73%**	--	Pass-Fail/Trade-off	Itron (2004)
CA	2005 Title 24	Lighting: **28%** Windows: **68%** Duct sealing: **73%**	Controls: **44%** Cool roofs: **50%** Duct test/seal.: **100%**	Pass/Fail *(partial credit given)*	Quantec (2007)
CA	2005 Title 24	Lighting: **113%** Duct sealing: **59%** Windows: **80%**	Overall: **62%** Skylights: **8%** Duct Sealing: **81%** Cool Roof: **65%** Controls: **79%**	Pass/Fail	HMG (2009)
CO	'96 MEC	Insulation: **0%** Duct leakage: **10%** Slab-on-grade Wall assembly: **50%** Basement insul.: **92%** *(partial results)*	--	Pass/Fail	City of Fort Collins (2002)
CT	2006 IECC	Equipment sizing: **3%** Insulation: **4%**	--	Pass/Fail	NMR et. al. (2012)
GA	2006 IECC	--	HVAC controls: **21%** Infiltration: **54%** Duct sealing: **64%** Controls: **70%** Pipe sealing: **78%**	Pass/Fail	Towson (2011)
HI	HI MEC	Lighting: **87%** Controls: **38%** Envelope: **80%** HVAC: **42%**		Pass/Fail	Eley (1999)
ID	1996 IRES	**51.9%**	--	N/A	N/A (Yang, 2005)
IL	2009 IECC	**87.2%** (significant sampling bias)	Not statistically significant	PNNL-BECP Checklist	APEC (2011)
IN	2003 IECC	--	Range by bldg types: Lighting: **-270%-82%** Envelope: **-3%-16%**	Avg Compliance Margin *(COMcheck™)*	ICC-BMG (2005)
IA	'92 MEC – 2000 IECC	Single Family **66 - 60%** **4.6 - 2.8%%**	Multifamily **66 - 60%** **21.5 - 37.5%%**	Pass/Fail Avg Compliance Margin (% above/below)	BMG (2003)
IA	2009 IECC	Overall: **70.1%** Lighting: **12%** Air sealing: **78%** Duct sealing: **68%** Exterior wall insulation: **45%** *(partial results)*	--	PNNL-BECP Checklist	Bishop (2011)

Table 1 (Continued): Statewide Energy Code Evaluation Studies

State	Code	Compliance Rate		Approach	Source
		Residential	Commercial		
LA	2000 IECC	65.3%	--	N/A	N/A (Yang, 2008)
ME	2003 IECC no mandatory code	**<19%** **17%**	--	Pass-Fail/Trade-off Simulated Performance	VEIC (2008)
ME	2009 IECC no mandatory code	--	Overall: **<40%** Envelope: **60%** Mechanical: **80-93%** Controls: **18%** Lighting: **66%**	Pass-Fail/Trade-off	ERS (2011)
MA	MA '98	Envelope: **46.4%** Duct sealing: **20%**	--	Pass-Fail	XENERGY (2001)
MA	2006 IECC	**0%** **0%** **50%** **92%**	--	Checklist Overall UA Simulated Performance HERS Index	NMR-KEMA (2011)
MA	2006/2009 IECC	--	0% 83%	Pass-Fail / Trade-off PNNL-BECP Checklist	Kema (2012)
MN	Category 2, Category 1, and Chapter 7672	--	--	N/A	Shelter Source, 2002
MT	2009 IECC	**60.5%** **80.6%** **63.5%** (*partial results)*	--	PNNL-BECP Checklist Weighted Checklist A* Weighted Checklist B**	Cadmus (2012)
NE	2003 IECC	--	**64.7%**		
NV	'92 MEC '93 MEC '95 MEC '98 MEC	**1.91%** **1.22%** **-10.61%** **-10.61%**	--	Avg Compliance Margin (% above/below)	Britt-Makela (2003)
NY	ECCCNYS '02 (2001 IECC)	Study homes: **25%** "Composite" home: **0%**	--	Overall UA	VEIC (2004)
NY	ECCCNYS '07 ASHRAE 90.1-'04 and '07	**61%** **73%** **64%**	**21%** **83%** **0-100%**	Pass-Fail/Trade-off PNNL-BECP Checklist Simulated Performance	VEIC (2012)
ND	2009 IECC	Ceiling insul.: **68-95%** Found. insul.: **21-91%** Windows: **69%** Doors: **75%**	--	Pass-Fail (*Survey)*	Pedersen et al. (2010)
OR	OR '93	**<95%**	--	N/A	Frankel and Baylon (1994)

Table 1 (Continued): Statewide Energy Code Evaluation Studies

State	Code	Compliance Rate		Approach	Source
		Residential	Commercial		
PA	2003 IECC	**25%** **42%** **67%**	--	Pass-Fail/Trade-off Simulated Performance Overall UA	Turns (2008)
RI	2009 IECC	N/A	**73%**	PNNL-BECP	DNV KEMA et al. (2012)
RI	2009 IECC	**0%** **38%** **4%** (26% below code) **6%** (48% below code)	--	Pass-Fail PNNL-BECP Annual Energy Cost Overall Building UA	NMR et al. (2012)
UT	2006 IECC	**86.5%**	--	PNNL-BECP	Navigant (2011)
VT	RBES	**35-40%**	--	Overall UA	West Hill (1999)
VT	1997 VT-RBES	**59%**	--	Overall UA	West Hill (2003)
VT	2004 VT-RBES	**20%** **61%** **70%** **-9%**	--	Pass-Fail Trade-off (VTCheck) Any of the above Avg UA Compl Margin	NMR et. al. (2009a)
WA	WA '94	--	Overall: **47%** Lighting: **72%** HVAC: **74%** Envelope: **78%**	Pass-Fail	Baylon (1992)
WA	WA '97	93.6%	--	N/A	Warwick et al (1993)
WA	WA '94	--	Overall: **59%** Lighting: **83%** HVAC: **80%** Envelope: **86%**	Pass-Fail	Baylon and Madison (1996)
WI	90.1-'04/'06 2004 IECC	N/A	N/A	N/A	Swartz (2009)
WI	90.1-'07/2009 IECC	--	**95%**	PNNL-BECP Checklist	Spalding (2011)

* Compliance is defined as the weighted average rate of individual code requirements satisfied by the sample buildings. Project-level compliance defined as the percent compliance with 8 compliance items determined to be of the most importance to code compliance, weighted equally.

** Compliance is defined as the weighted average rate of individual code requirements satisfied by the sample buildings. Project-level compliance defined as the percent compliance with 63 compliance items, each weighted according to its contribution to a prototypical home's energy usage of the item they apply to.

Table 2: Regional Energy Code Evaluation Studies

Region	Code	Compliance Rate		Approach	Source
		Residential	Commercial		
Pacific Northwest (OR, WA)	OR '98 WA '97	--	Multifamily **79.9%** **97.7%**	Overall UA (DBL CHECK)	Ecotope (2000)
Pacific Northwest (ID, MT, OR, WA)	N/A '95 MEC OR '93 WA '94	--	Multifamily **51.9%** **86.8%** **100%** **93.6**	Overall UA	Ecotope (2001a)
Pacific Northwest (ID, MT, OR, WA)	ASHRAE 90.1-'89 OR '96 WA '94	--	Envelope: **42-86%** HVAC: **86-100%** Lighting: **60-92%**	Pass-Fail	Ecotope (2001b)
ID	2003 IECC	Single Family Overall: **47%** Windows: **88%** Wall: **39%** Floor: **8%** Roof: **13%**	Multifamily Overall: **26%** Windows: **74%** Wall: **29%** Floor: **11%** Roof: **50%**	Pass-Fail / Tradeoff	Ecotope (2008a)
OR	OR '06 (>2000 IECC)	Single Family Overall: **77%** Windows: **85%** Wall: **80%** Floor: **83%** Roof: **96%**	Multifamily Overall: **30%** Windows: **42%** Wall: **76%** Floor: **78%** Roof: **81%**		
WA	WA '06 (>2000 IECC)	Single Family Overall: **73%** Windows: **85%** Wall: **58%** Floor: **65%** Roof: **95%**	Multifamily Overall: **75%** Windows: **78%** Wall: **74%** Floor: **87%** Roof: **95%**		
Pacific Northwest (ID, MT, OR, WA)	OR '98, WA '01 ASHRAE 90.1-'89, 2000 IECC	--	Lighting: **79%** Envelope: **82%**	Pass-Fail	Ecotope (2008b)

2 Overview of Methodology

The following section outlines the methodology followed in modeling the savings potential by state. Despite an effort to standardize the approach across states, there remain significant differences in available data, assumptions, and approach. Results across states should be compared with discretion.

2.1 New construction

New residential construction forecasts by state were derived using U.S. Census Bureau data on new single-family and multifamily housing permits from 1990-2011. Single family permit levels are projected to rise 20 percent and 30 percent in 2012 and 2013, respectively, and a conservative 10 percent each year thereafter, reflecting a recovery of new housing construction from current recessionary levels. Multifamily permits are projected to rise 20 percent in 2012 and six percent each year thereafter. This trend in construction activity levels out to a conservative 1.5 million single-family starts and 480,000 multifamily starts in 2022.

New commercial construction forecasts by state were derived from U.S. EIA Annual Energy Outlook 2012-2035 forecasts for U.S. commercial construction. The CoStar database was used to distribute square footage by state based on historic construction levels. Forecasts for years 2013-2015 were diminished to reflect near-term recessionary conditions.

Residential and commercial construction forecasts exclude the estimated state market share of ENERGY STAR, LEED, or other voluntary beyond-code programs, as these buildings are assumed to meet or exceed the minimum code requirements. In states without a mandatory statewide code—AL, AK, AZ, CO, KS, ME, MS, ND, SD, and WY—we estimate the share of new construction subject to the energy code based on jurisdictional adoption status and 2011 U.S. Census Bureau residential permit figures by county and/or city.

Although the potential savings from existing buildings are likely significant, this analysis was restricted to code compliance in new construction given the uncertainty of data for residential retrofits/renovations.

2.2 Baseline Compliance

After a thorough literature review of compliance evaluation studies, we determined that there is insufficient data to credibly evaluate the baseline compliance rate for each state. Instead, we apply uniform compliance assumptions for each state. The endpoints were set as follows:

- High savings scenario: low (25 percent) baseline compliance.
- Low savings scenario: high (75 percent) baseline compliance.

Compliance is defined at the whole-building level– for example, a rate of 75 percent signifies that ¾ of all buildings were in full compliance with the code. The degree of non-compliance was captured using an “energy loss factor”, which represents the average energy losses per home due to non-compliance. We assume a default energy loss factor of 15 percent for each state (i.e. a non-compliant building uses 15 percent more energy than an identical building constructed to code). This loss factor is consistent with the average non-compliance impacts found in baseline compliance evaluations.

We make the simplifying assumption that baseline compliance levels remain stable over time, due to the difficulty in accurately forecasting factors that may contribute positively or negatively to a state’s overall compliance rate, such as new code changes, builder training, new enforcement mechanisms, or market transformation.

2.3 Energy Consumption

Residential

Baseline energy use intensities for the residential sector were derived primarily from the PNNL publication series, “Energy and Cost Savings for New Single and Multifamily Homes: 2012 IECC as Compared to the 2009 IECC”. These reports provide an estimate of the consumption intensity for space heating, water heating, cooling, and lighting under each state’s current code, the 2009 IECC, and the 2012 IECC.

In states where a PNNL analysis was unavailable—CA, FL, IL, MD, NC, OR, and WA—baseline consumption was constructed using data from the 2009 Residential Energy Consumption Survey (RECS). For each climate zone and fuel type, we derive an estimate of average space heating, water heating, and space cooling consumption for new homes. To capture the mix of space- and water-heating types—natural gas and electric space—we assign weights to each consumption intensity based on the distribution of homes by principal water or space heating fuel in each Census Region or state, as reported in RECS. The RECS database does not track a separate consumption estimate for lighting. For simplifying purposes, we assume an average annual consumption of 2,000 Btu per household for lighting.

Average multifamily consumption was estimated by multiplying single-family figures by the average ratio of multifamily to single-family energy consumption for code-covered uses.

Commercial

Baseline energy use intensities for the commercial sector (Btu/ft2) were derived primarily from the EIA's 2003 Commercial Buildings Energy Consumption Survey (CBECS). We derive an estimate of the average annual consumption for each end use—heating, cooling, water heating, lighting, and ventilation—by fuel type, vintage, and climate zone.

Natural gas and electric consumption for space and water heating reflect the annual usage in an exclusively natural-gas heated building or an exclusively electric-heated building, respectively. To capture the mix of natural gas and electric space and water heated buildings, we assign weights ($Share_{fuel,enduse}$) to each consumption intensity based on the distribution of structures by principal water or space heating fuel in each Census Region or state, according to EIA's 2003 Commercial Building Energy Consumption Survey. For example, $Share_{NG,WH}$ represents the percent of buildings in that state using natural gas as the principal water heating fuel.

Given these inputs, we use the following equations to create a weighted average energy profile for the "typical" home or commercial building in each state:

(1) $Consumption_{NG,Total} = (Share_{NG,SH} * Consumption_{NG,SH}) + (Share_{NG,WH} * Consumption_{NG,WH})$

(2) $Consumption_{E,Total} = (Share_{E,SH} * Consumption_{E,SH}) + (Share_{E,WH} * Consumption_{E,WH}) + Consumption_{E,SC} + Consumption_{E,L} (Share_{E,V} * Consumption_{E,V})$

where:

$Consumption_{fuel,enduse}$ =	average annual consumption per household for the indicated fuel and end use
$Share_{fuel,enduse}$ =	share of households using principally the indicated fuel for the indicated end use, and
$Consumption_{Fuel,Total}$ =	weighted average annual consumption of the indicated fuel for a code compliant home.

NG = Natural Gas	SH = Space Heating
E = Electricity	WH = Water Heating
L = Lighting	V = Ventilation

2.4 Evaluation of Potential Savings

The total potential energy savings is calculated for each fuel type by multiplying the noncompliance energy impact by baseline energy consumption, and scaling by the number of new noncompliant single and multifamily units. The final calculation process used is shown in Figure 1 below.

Figure 1: Breakdown of Calculations

$$\left(\text{Non-Compliance Energy Impact}\right) = \left(\text{New Construction (units or ft}^2\text{)} - \text{Beyond code market share (units or ft}^2\text{)}\right) \times \left(\text{Non-compliance Rate (\%)}\right) \times \left(\text{Code Compliant Energy Consumption, }_{\text{Natural Gas, Electricity}}\right) \times \left(\text{Non-compliance Energy Impact (\%)}\right)$$

To estimate the net lifetime savings of the compliance effects in a particular year, we multiply the single year savings estimates by an expected 25 year savings lifetime. We assume constant real electricity and natural gas prices at 2011 levels, as published in the Energy Information Administration (EIA) State Energy Data (SEDS) database. We conservatively exclude the impact of rising fuel costs as a result of tightening environmental standards or other political, regulatory or market influences.

3. Key Findings

3.1 National Results

Table 3: National Savings Potential from Enhanced Code Compliance in New Construction

Total U.S. Savings	**Low Case** *(75% baseline compliance)*		**High Case** *(25% baseline compliance)*	
	Millions ($)	Trillion Btu	Millions ($)	Trillion Btu
Annual, 1st Year	$62.94	2.83	$188.63	8.48
Annual, 10th Year	$1,229.41	54.33	$3,685.51	162.87
Lifetime savings of 1 year of new construction	$12,364.89	653.81	$37,094.66	1,961.43

3.2 State-Level Results

Table 4: Annual Dollar Savings Potential from Enhanced Code Compliance in New Construction

Total Energy Savings ($)	Low Case (75% baseline compliance)		High Case (25% baseline compliance)	
	1st Year	10th Year	1st Year	10th Year
Northeast				
Connecticut	$645,490	$13,241,884	$1,936,469	$39,725,653
Delaware	$310,458	$5,603,293	$931,375	$16,809,879
District of Columbia	$405,169	$7,415,499	$1,215,508	$22,246,498
Maine	$308,752	$5,412,601	$926,257	$16,237,804
Maryland	$1,237,435	$25,656,630	$3,712,305	$76,969,889
Massachusetts	$1,357,097	$27,461,981	$4,071,291	$82,385,943
New Hampshire	$347,665	$6,486,029	$1,042,995	$19,458,086
New Jersey	$1,956,979	$35,204,384	$5,870,937	$105,613,153
New York	$3,413,084	$63,777,826	$10,239,253	$191,333,478
Pennsylvania	$2,127,585	$40,918,735	$6,382,754	$122,756,204
Rhode Island	$161,585	$3,492,941	$484,754	$10,478,824
Vermont	$160,840	$2,559,821	$482,519	$7,679,464
Midwest				
Illinois	$1,374,176	$28,958,305	$4,122,529	$86,874,914
Indiana	$1,197,131	$23,521,746	$3,591,392	$70,565,239
Iowa	$533,118	$9,856,217	$1,599,353	$29,568,650
Kentucky	$572,433	$10,498,909	$1,717,299	$31,496,727
Michigan	$1,454,592	$28,907,131	$4,363,775	$86,721,394
Minnesota	$1,114,979	$21,417,213	$3,344,938	$64,251,638
Missouri	$571,142	$12,808,337	$1,713,427	$38,425,011
Nebraska	$446,482	$8,338,745	$1,339,445	$25,016,234
North Dakota	$145,180	$2,324,339	$245,659	$4,268,292
Ohio	$1,517,269	$32,246,315	$4,551,806	$96,738,944
South Dakota	$102,365	$1,821,198	$307,095	$5,463,594
West Virginia	$1,053,477	$16,420,666	$3,160,431	$49,261,999
Wisconsin	$508,187	$11,226,530	$1,524,562	$33,679,590
Southeast				
Alabama	$1,123,762	$21,514,269	$3,371,287	$64,542,807
Florida	$4,330,515	$92,424,599	$12,991,546	$277,273,798
Georgia	$2,810,029	$54,773,143	$8,430,088	$164,319,428
Mississippi	$158,397	$3,878,781	$475,191	$11,636,343
North Carolina	$2,293,681	$44,633,267	$6,881,043	$133,899,800
South Carolina	$1,446,663	$26,698,631	$4,339,990	$80,095,894
Tennessee	$1,482,081	$29,088,359	$4,446,244	$87,265,076
Virginia	$5,703,542	$95,296,820	$17,110,625	$285,890,460
South Central				
Arkansas	$576,781	$10,477,407	$1,730,342	$31,432,221
Kansas	$278,414	$6,236,522	$835,242	$18,709,566
Louisiana	$844,591	$14,461,936	$2,533,774	$43,385,807
Oklahoma	$693,190	$13,258,102	$2,079,569	$39,774,307
Texas	$6,572,731	$126,459,151	$19,718,194	$379,377,453
Northwest				
Alaska	N/A	N/A	N/A	N/A
Idaho	$271,939	$5,170,050	$815,818	$15,510,151
Montana	$149,240	$2,754,974	$447,720	$8,264,923
Oregon	$585,563	$11,093,425	$1,756,688	$33,280,276
Washington	$1,211,898	$23,255,414	$3,635,695	$69,766,243
Wyoming	$8,629	$140,094	$25,886	$420,281
Southwest				
Arizona	$901,690	$18,912,482	$2,705,069	$56,737,446
California	$5,083,859	$113,059,731	$15,251,576	$339,179,194
Colorado	$1,125,542	$23,230,432	$3,376,625	$69,691,296
Hawaii	$434,985	$8,516,328	$1,304,955	$25,548,985
Nevada	$874,554	$20,522,613	$2,623,662	$61,567,838
New Mexico	$282,341	$5,232,872	$847,022	$15,698,616
Utah	$671,976	$12,739,118	$2,015,927	$38,217,353
U.S. Total	$62,939,263	$1,229,405,797	$188,627,907	$3,685,512,665

Table 5: Annual Energy Savings Potential from Enhanced Code Compliance in New Construction

Total Energy Savings (MMBtu)	Low Case (75% baseline compliance)		High Case (25% baseline compliance)	
	1st Year	10th Year	1st Year	10th Year
Northeast				
Connecticut	26,005	506,963	78,014	1,520,890
Delaware	10,000	178,886	30,000	536,657
District of Columbia	14,868	269,916	44,604	809,749
Maine	16,597	283,416	49,792	850,248
Maryland	41,989	869,842	125,967	2,609,526
Massachusetts	58,761	1,118,282	176,284	3,354,847
New Hampshire	16,360	291,424	49,080	874,272
New Jersey	84,685	1,472,705	254,054	4,418,115
New York	135,760	2,425,192	407,281	7,275,576
Pennsylvania	108,257	2,032,845	324,772	6,098,536
Rhode Island	6,829	142,086	20,488	426,258
Vermont	7,485	117,617	22,456	352,851
Midwest				
Illinois	88,243	1,784,648	264,728	5,353,943
Indiana	76,419	1,445,536	229,258	4,336,607
Iowa	32,629	597,383	97,886	1,792,148
Kentucky	29,208	531,763	87,624	1,595,288
Michigan	84,457	1,611,061	253,372	4,833,182
Minnesota	70,252	1,323,902	210,757	3,971,706
Missouri	29,859	661,893	89,577	1,985,678
Nebraska	28,174	510,972	84,522	1,532,916
North Dakota	8,573	136,899	18,147	302,854
Ohio	85,212	1,756,340	255,637	5,269,019
South Dakota	7,252	128,606	21,757	385,817
West Virginia	37,970	602,256	113,909	1,806,768
Wisconsin	25,575	521,233	76,726	1,563,700
Southeast				
Alabama	42,089	805,219	126,268	2,415,658
Florida	147,580	3,228,141	442,740	9,684,424
Georgia	102,148	2,011,016	306,445	6,033,047
Mississippi	6,887	168,301	20,662	504,904
North Carolina	100,953	1,984,417	302,858	5,953,250
South Carolina	54,513	1,016,612	163,538	3,049,836
Tennessee	67,183	1,303,404	201,549	3,910,213
Virginia	234,089	3,975,510	702,268	11,926,531
South Central				
Arkansas	30,588	552,063	91,764	1,656,189
Kansas	14,109	308,970	42,327	926,909
Louisiana	41,519	705,303	124,558	2,115,908
Oklahoma	35,966	681,504	107,898	2,044,512
Texas	283,282	5,451,167	849,846	16,353,502
Northwest				
Alaska	N/A	N/A	N/A	N/A
Idaho	21,443	398,453	64,328	1,195,358
Montana	11,383	199,147	34,148	597,442
Oregon	28,416	540,263	85,247	1,620,790
Washington	64,757	1,238,605	194,270	3,715,814
Wyoming	725	11,629	2,175	34,886
Southwest				
Arizona	36,885	778,205	110,656	2,334,616
California	189,056	3,985,803	567,169	11,957,409
Colorado	72,566	1,419,569	217,699	4,258,708
Hawaii	4,649	93,387	13,947	280,162
Nevada	40,900	949,881	122,700	2,849,643
New Mexico	16,978	304,536	50,935	913,608
Utah	48,467	893,280	145,402	2,679,839
U.S. Total	2,828,554	54,326,052	8,478,090	162,870,312

Table 6: Annual Electricity Savings Potential from Enhanced Code Compliance in New Construction

Total Electricity Savings (MWh)	Low Case (75% baseline compliance)		High Case (25% baseline compliance)	
	1st Year	10th Year	1st Year	10th Year
Northeast				
Connecticut	2,649	59,891	7,947	179,674
Delaware	2,046	37,462	6,138	112,386
District of Columbia	2,708	53,715	8,123	161,145
Maine	1,003	19,531	3,009	58,594
Maryland	9,181	196,907	27,544	590,722
Massachusetts	5,681	126,449	17,042	379,348
New Hampshire	1,238	25,620	3,715	76,860
New Jersey	8,863	172,261	26,589	516,783
New York	13,238	271,620	39,714	814,861
Pennsylvania	11,596	245,363	34,789	736,088
Rhode Island	784	18,520	2,351	55,561
Vermont	395	6,772	1,186	20,315
Midwest				
Illinois	9,570	221,855	28,711	665,565
Indiana	8,069	173,231	24,207	519,692
Iowa	3,779	76,010	11,338	228,030
Kentucky	5,133	97,198	15,400	291,594
Michigan	7,554	166,896	22,663	500,688
Minnesota	7,653	158,499	22,960	475,498
Missouri	5,120	121,446	15,361	364,337
Nebraska	3,537	71,127	10,611	213,382
North Dakota	1,361	22,333	1,864	35,393
Ohio	9,954	230,219	29,862	690,656
South Dakota	707	13,304	2,121	39,912
West Virginia	7,163	112,069	21,488	336,206
Wisconsin	3,617	86,630	10,850	259,891
Southeast				
Alabama	8,536	167,674	25,609	503,022
Florida	38,777	841,587	116,330	2,524,761
Georgia	24,185	481,451	72,555	1,444,354
Mississippi	1,502	37,049	4,505	111,146
North Carolina	20,931	428,097	62,792	1,284,292
South Carolina	12,363	234,579	37,090	703,737
Tennessee	12,483	246,945	37,448	740,836
Virginia	48,557	838,743	145,670	2,516,228
South Central				
Arkansas	5,207	99,998	15,621	299,993
Kansas	2,426	57,163	7,277	171,489
Louisiana	7,377	129,272	22,132	387,817
Oklahoma	6,401	130,427	19,203	391,281
Texas	56,286	1,139,542	168,857	3,418,625
Northwest				
Alaska	N/A	N/A	N/A	N/A
Idaho	2,025	42,780	6,075	128,339
Montana	862	17,457	2,586	52,370
Oregon	5,187	102,462	15,561	307,387
Washington	11,855	235,336	35,566	706,008
Wyoming	41	702	122	2,107
Southwest				
Arizona	7,458	163,390	22,375	490,169
California	30,242	702,652	90,726	2,107,955
Colorado	7,537	169,142	22,612	507,426
Hawaii	1,233	23,998	3,698	71,995
Nevada	7,985	194,929	23,954	584,788
New Mexico	1,845	37,176	5,534	111,529
Utah	5,159	107,258	15,477	321,775
U.S. Total	459,058	9,414,739	1,374,955	28,212,611

Table 7: Annual Natural Gas Savings Potential from Enhanced Code Compliance in New Construction

Total Natural Gas Savings (MMBtu)	Low Case (75% baseline compliance)		High Case (25% baseline compliance)	
	1st Year	10th Year	1st Year	10th Year
Northeast				
Connecticut	16,966	302,606	50,898	907,817
Delaware	3,019	51,060	9,058	153,180
District of Columbia	5,630	86,633	16,889	259,898
Maine	13,175	216,772	39,524	650,315
Maryland	10,661	197,966	31,982	593,899
Massachusetts	39,378	686,819	118,133	2,060,456
New Hampshire	12,135	204,005	36,404	612,016
New Jersey	54,443	884,927	163,329	2,654,780
New York	90,591	1,498,385	271,773	4,495,156
Pennsylvania	68,689	1,195,634	206,067	3,586,901
Rhode Island	4,156	78,892	12,468	236,676
Vermont	6,137	94,511	18,410	283,534
Midwest				
Illinois	55,588	1,027,647	166,763	3,082,940
Indiana	48,886	854,448	146,659	2,563,344
Iowa	19,733	338,026	59,200	1,014,078
Kentucky	11,692	200,109	35,076	600,327
Michigan	58,681	1,041,588	176,044	3,124,764
Minnesota	44,138	783,080	132,415	2,349,241
Missouri	12,388	247,503	37,165	742,509
Nebraska	16,105	268,275	48,315	804,826
North Dakota	3,929	60,696	11,788	182,089
Ohio	51,248	970,801	153,743	2,912,402
South Dakota	4,840	83,211	14,520	249,632
West Virginia	13,530	219,862	40,591	659,585
Wisconsin	13,235	225,638	39,704	676,914
Southeast				
Alabama	12,962	233,092	38,886	699,275
Florida	15,268	356,528	45,804	1,069,583
Georgia	19,626	368,235	58,878	1,104,706
Mississippi	1,763	41,887	5,289	125,660
North Carolina	29,534	523,688	88,603	1,571,065
South Carolina	12,327	216,195	36,982	648,586
Tennessee	24,590	460,792	73,771	1,382,375
Virginia	68,407	1,113,602	205,220	3,340,806
South Central				
Arkansas	12,821	210,857	38,464	632,570
Kansas	5,833	113,921	17,498	341,763
Louisiana	16,347	264,207	49,040	792,621
Oklahoma	14,125	236,469	42,376	709,406
Texas	91,228	1,562,890	273,683	4,688,669
Northwest				
Alaska	N/A	N/A	N/A	N/A
Idaho	14,533	252,482	43,600	757,447
Montana	8,441	139,583	25,323	418,749
Oregon	10,717	190,648	32,151	571,943
Washington	24,305	435,605	72,915	1,306,816
Wyoming	586	9,233	1,759	27,698
Southwest				
Arizona	11,437	220,697	34,310	662,092
California	85,867	1,588,257	257,600	4,764,770
Colorado	46,848	842,433	140,544	2,527,300
Hawaii	443	11,502	1,328	34,505
Nevada	13,655	284,755	40,964	854,264
New Mexico	10,684	177,685	3,315	86,114
Utah	30,864	527,299	92,591	1,581,896
U.S. Total	1,262,184	22,201,634	3,757,812	66,157,959

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