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National Cost-Effectiveness of the Residential Provisions of the 2015 IECC

June 2015

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U.S. DEPARTMENT OF
ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

The U.S. Department of Energy (DOE) Building Energy Codes Program (BECP) supports the development and implementation of model building energy codes and standards for new residential and commercial construction. These codes set the minimum requirements for energy-efficient building design and construction and impact energy use over the life of the buildings. Building energy codes are developed through consensus-based public processes. DOE participates in the code development process by recommending technologically feasible and economically justified energy efficiency measures for inclusion in the latest model codes. Ensuring the cost-effectiveness of model code changes also encourages their adoption and implementation at the state and local levels. Pacific Northwest National Laboratory (PNNL) conducted this analysis to support DOE in evaluating the energy and economic impacts associated with updated codes in residential buildings.

This analysis focuses on one- and two-family dwellings, townhomes, and low-rise multifamily residential buildings based on the International Energy Conservation Code (IECC). The IECC is developed by the International Code Council (ICC) on a 3-year cycle through a public development and public hearing process[1]. While proponents of code changes often include the energy and cost-effectiveness criteria for their respective code change, the IECC process does not include an energy or cost-effectiveness analysis of the entire edition of the code.

PNNL evaluated the cost-effectiveness of the changes in the prescriptive and mandatory residential provisions of the 2015 edition of the IECC, hereafter referred to as the 2015 IECC, compared to those in the 2012 and 2009 IECC. The simulated performance path and the Energy Rating Index (ERI) path (introduced in the 2015 IECC) are not considered in this analysis due to the wide variation in building construction characteristics they allow.

The process of examining the cost-effectiveness of the code changes has three main parts:

- Identification of the building components affected by the updates to the prescriptive and mandatory residential provisions of the IECC
- Assessment of construction costs associated with these updates
- Cost-effectiveness analysis of the updates using the incremental costs of these updates and the associated energy impact

The current analysis builds on the PNNL technical report titled *2015 IECC: Energy Savings Analysis* (Mendon et al. 2015) which identified the prescriptive and mandatory changes introduced by the 2015 IECC compared to the 2012 IECC and determined their energy savings impact. Because many states are still using the 2009 edition of the IECC (or equivalent), additional energy analyses are conducted to develop energy savings estimates for the 2015 IECC compared to the 2009 IECC using the 15 IECC climate zones and moisture regimes.

DOE has an established methodology for determining the energy savings and cost-effectiveness of residential building energy codes (Taylor et al. 2012). This methodology forms the basis of the present

[1] See *http://www.iccsafe.org/about-icc/overview/about-international-code-council* /

analysis and defines three cost-effectiveness metrics to be calculated in assessing cost-effectiveness of code changes:

- Life Cycle Cost (LCC)
- Simple Payback
- Cash Flow

Table ES.1 summarizes the weighted LCC savings per home for the 2015 IECC over the 2012 and 2009 IECC for each climate zone aggregated over all residential prototype buildings. Tables ES.2 and ES.3 summarize the associated simple payback periods and impacts on consumer cash-flows. The results show that construction based on the 2015 IECC is cost-effective when compared to construction based on the 2012 and 2009 IECC across all climate zones. Simple payback ranges from immediate to 3.8 years for construction based on the 2015 IECC when compared to construction based on the 2012 IECC and from 2.2 to 8.1 years when compared to construction based on the 2009 IECC. In all cases, homeowners see positive cash flows in less than two years.

Table ES.1. Life Cycle Cost Savings for the 2015 IECC

Climate Zone	Compared to the 2012 IECC ($/residence-yr)	Compared to the 2009 IECC ($/residence-yr)
1	+193	+4,418
2	+119	+5,725
3	+156	+6,569
4	+154	+8,088
5	+153	+7,697
6	+142	+11,231
7	+200	+17,525
8	+438	+24,003

Table ES.2. Simple Payback Period for the 2015 IECC

Climate Zone	Compared to the 2012 IECC (Years)	Compared to the 2009 IECC (Years)
1	0.0	6.6
2	3.8	8.1
3	3.4	7.9
4	1.4	5.1
5	1.6	3.9
6	1.0	4.9
7	0.0	3.1
8	0.2	2.2

Table ES.3. Impacts on Consumers' Cash Flow from Compliance with the 2015 IECC

Climate Zone	Compared to the 2012 IECC		Compared to the 2009 IECC	
	Net Annual Cash Flow Savings (for Year 1)	Years to Cumulative Positive Cash Flow	Net Annual Cash Flow Savings (for Year 1)	Years to Cumulative Positive Cash Flow
1	+$ 13	0	+$ 103	1
2	+$ 5	1	+$ 103	2
3	+$ 6	0	+$ 125	2
4	+$ 7	0	+$ 236	1
5	+$ 5	0	+$ 263	1
6	+$ 6	0	+$ 340	1
7	+$ 8	0	+$ 672	0
8	+$ 18	0	+$ 1,024	0

Acknowledgements

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Acronyms and Abbreviations

ACH50	air changes at 50-pascal pressure differential
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BC3	Building Component Cost Community
BECP	Building Energy Codes Program
Btu	British thermal unit(s)
CF	cubic foot (feet)
CFM	cubic feet per minute
CPI	Consumer Price Index
DOE	U.S. Department of Energy
ECPA	Energy Conservation and Production Act
EIA	Energy Information Administration
ERI	Energy Rating Index
EUI	Energy Use Intensity
°F	degree(s) Fahrenheit
ft^2	square foot(feet)
hr	hour(s)
ICC	International Code Council
IECC	International Energy Conservation Code
IPC	International Plumbing Code
IRC	International Residential Code
kWh	kilowatt-hour(s)
LCC	life cycle cost
MEC	Model Energy Code
million Btu	million British thermal units
PID	proportional, integral, derivative
PNNL	Pacific Northwest National Laboratory
SHGC	solar heat gain coefficient
yr	year(s)

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1.0 Introduction

The U.S. Department of Energy (DOE) supports the development and adoption of energy-efficient building energy codes. Title III of the Energy Conservation and Production Act (ECPA), as amended, requires DOE to participate in the development of model building energy codes and assist states in the adoption and implementation of these codes (42 U.S.C. 6831 et seq.). Section 304(a), as amended, of ECPA provides that whenever the 1992 Model Energy Code (MEC), or any successor to that code, is revised, the Secretary of Energy (Secretary) must make a determination, not later than 12 months after such revision, whether the revised code would improve energy efficiency in residential buildings, and must publish notice of such determination in the Federal Register. (42 U.S.C. 6833(a)(5)(A)).

Building energy codes set the minimum requirements for energy-efficient building design and construction for new buildings and impact energy consumed by the building over its life. These are developed through consensus-based public processes which DOE participates in by proposing changes which are technologically feasible and economically justified. Pacific Northwest National Laboratory (PNNL) provides technical analysis and support to DOE during the development processes.

This analysis focuses on one- and two-family dwellings, townhomes, and low-rise multifamily residential buildings. The basis of the energy codes for these buildings is the International Energy Conservation Code (IECC). The IECC is updated on a 3-year cycle, i.e., a new edition of the code is published every 3 years, by the International Code Council (ICC). The 2015 edition of the IECC, hereafter referred to as the 2015 IECC, was published in June 2014 (ICC 2014). Subsequently, DOE published a notice of determination in June 2015 (DOE 2015). DOE's 2015 IECC determination analyses indicate a small increase in energy efficiency in one- and two-family dwellings, townhomes, and low-rise multifamily residential buildings subject to 2015 IECC compared to the 2012 IECC.

1.1 Purpose

The IECC is developed through a public process administered by the ICC.[1] While proponents of code changes often include the energy and cost-effectiveness criteria for their respective code change, the IECC process does not include an energy or cost-effectiveness analysis of the entire edition of the code. Ensuring the cost-effectiveness of model code changes encourages their adoption and implementation at the state and local levels. In support of this goal, DOE conducts cost-effectiveness analyses of the latest edition of the code compared to its predecessor(s), following the publication of an updated edition of the IECC. These analyses are conducted at the national and state level by accounting for regional construction and fuel costs.

DOE provides technical assistance, such as the present cost-effectiveness analysis, to states to ensure informed decision-making during their consideration of adopting, implementing, and enforcing the latest model building energy codes. Figure 1.1 shows the status of the adoption of residential building energy codes as of May 2015 (BECP 2015). Because many states are still using the 2009 IECC (or equivalent), the present analysis evaluates the cost-effectiveness of the 2015 IECC compared to both the 2012 and the 2009 IECC.

[1] See *http://www.iccsafe.org/about-icc/overview/about-international-code-council/*

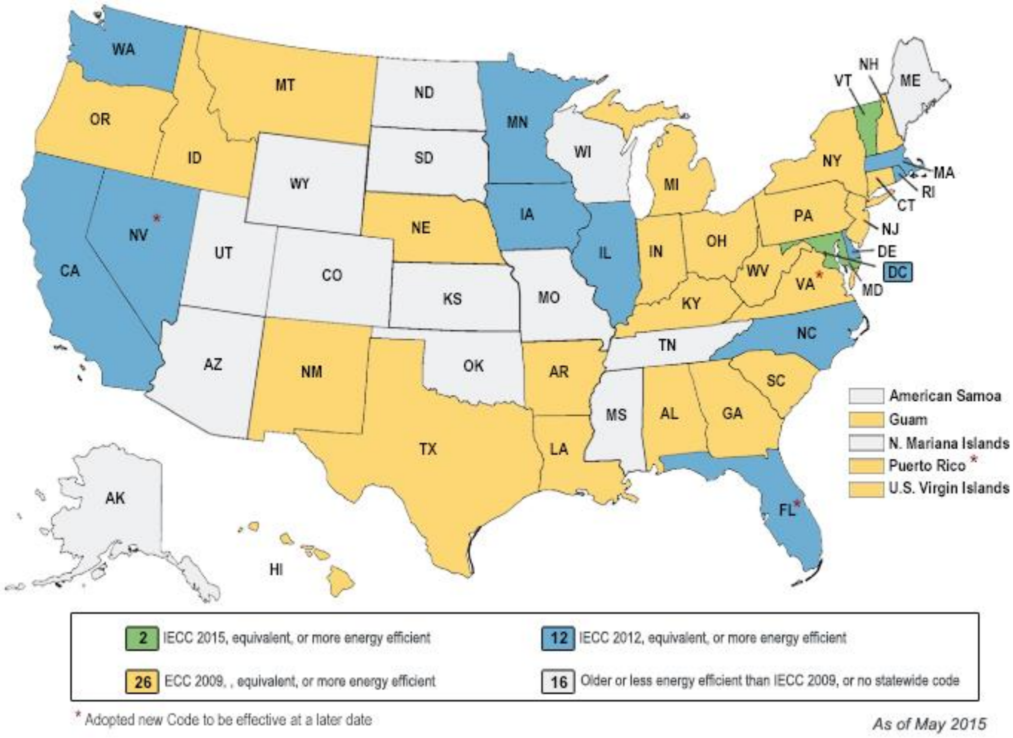

Figure 1.1. Current Residential Building Energy Code Adoption Status in the U.S. (BECP 2015)

1.2 Overview

The present analysis examines the cost-effectiveness of the prescriptive and mandatory residential provisions of the 2015 IECC. The simulated performance path and the Energy Rating Index (ERI) path (introduced in the 2015 IECC) are not considered in this analysis due to the wide variation in building construction characteristics they allow. While some states choose to adopt amended versions of the IECC, the present analysis focuses on the un-amended provisions of the 2015, 2012, and 2009 IECC. The methodology established by DOE for determining the energy savings and cost-effectiveness of residential building energy codes (Taylor et al. 2012) forms the basis of this cost-effectiveness analysis.

1.2.1 Building Prototypes

The DOE methodology uses a suite of 32 residential prototype building models to represent the U.S. new residential building construction stock. This suite, summarized in Table 1.1**Error! Reference source not found.**, was created based on residential construction data from the U.S. Census (2010 and 2012) and the National Association of Home Builders (NAHB 2009). Detailed descriptions of the 32 prototype building models and operational assumptions are documented in previous reports by Mendon et al. (2013 and 2014).

Table 1.1. Residential Prototype Buildings

No.	Building Type	Foundation Type	Heating System Type
1	Single-family	Vented Crawlspace	Gas-fired Furnace
2	Single-family	Vented Crawlspace	Electric Furnace
3	Single-family	Vented Crawlspace	Oil-fired Furnace
4	Single-family	Vented Crawlspace	Heat Pump
5	Single-family	Slab-on-grade	Gas-fired Furnace
6	Single-family	Slab-on-grade	Electric Furnace
7	Single-family	Slab-on-grade	Oil-fired Furnace
8	Single-family	Slab-on-grade	Heat Pump
9	Single-family	Heated Basement	Gas-fired Furnace
10	Single-family	Heated Basement	Electric Furnace
11	Single-family	Heated Basement	Oil-fired Furnace
12	Single-family	Heated Basement	Heat Pump
13	Single-family	Unheated Basement	Gas-fired Furnace
14	Single-family	Unheated Basement	Electric Furnace
15	Single-family	Unheated Basement	Oil-fired Furnace
16	Single-family	Unheated Basement	Heat Pump
17	Multifamily	Vented Crawlspace	Gas-fired Furnace
18	Multifamily	Vented Crawlspace	Electric Furnace
19	Multifamily	Vented Crawlspace	Oil-fired Furnace
20	Multifamily	Vented Crawlspace	Heat Pump
21	Multifamily	Slab-on-grade	Gas-fired Furnace
22	Multifamily	Slab-on-grade	Electric Furnace
23	Multifamily	Slab-on-grade	Oil-fired Furnace
24	Multifamily	Slab-on-grade	Heat Pump
25	Multifamily	Heated Basement	Gas-fired Furnace
26	Multifamily	Heated Basement	Electric Furnace
27	Multifamily	Heated Basement	Oil-fired Furnace
28	Multifamily	Heated Basement	Heat Pump
29	Multifamily	Unheated Basement	Gas-fired Furnace
30	Multifamily	Unheated Basement	Electric Furnace
31	Multifamily	Unheated Basement	Oil-fired Furnace
32	Multifamily	Unheated Basement	Heat Pump

Energy models created for the determination analysis of the 2015 IECC as well as earlier state and national cost-effectiveness analyses of the 2012 IECC (Mendon et al. 2015 and 2013) are leveraged in the present analysis. Annual energy simulations are carried out using *EnergyPlus*™ *Version 8.0* (DOE 2013). Additionally, a new semi-conditioned single-family residential building model is created to capture the impact of new alternative provisions of the 2015 IECC applicable to certain home configurations in the new “tropical climate zone” introduced by the 2015 IECC.

1.2.2 Climate Locations

The analysis uses the eight standard IECC temperature-oriented climate zones covering the entire United States, as shown in Figure 1.2 (Briggs et al. 2003). The thermal climate zones are further divided into moist (A), dry (B), and marine (C) regions where appropriate resulting in 15 combined temperature/moisture zones (out of 24 that are theoretically possible). For this analysis, a specific city was selected to represent each climate zone. Additionally, a new city was added to evaluate the impact of the newly defined “tropical climate zone” in the 2015 IECC. Thus, the 16 cities used in this analysis are:

- 1-tropical: Honolulu, Hawaii (very hot, moist)
- 1A: Miami, Florida (very hot, moist)
- 2A: Houston, Texas (hot, moist)
- 2B: Phoenix, Arizona (hot, dry)
- 3A: Memphis, Tennessee (warm, moist)
- 3B: El Paso, Texas (warm, dry)
- 3C: San Francisco, California (warm, marine)
- 4A: Baltimore, Maryland (mixed, moist)
- 4B: Albuquerque, New Mexico (mixed, dry)
- 4C: Salem, Oregon (mixed, marine)
- 5A: Chicago, Illinois (cool, moist)
- 5B: Boise, Idaho (cool, dry)
- 6A: Burlington, Vermont (cold, moist)
- 6B: Helena, Montana (cold, dry)
- 7: Duluth, Minnesota (very cold)
- 8: Fairbanks, Alaska (subarctic)

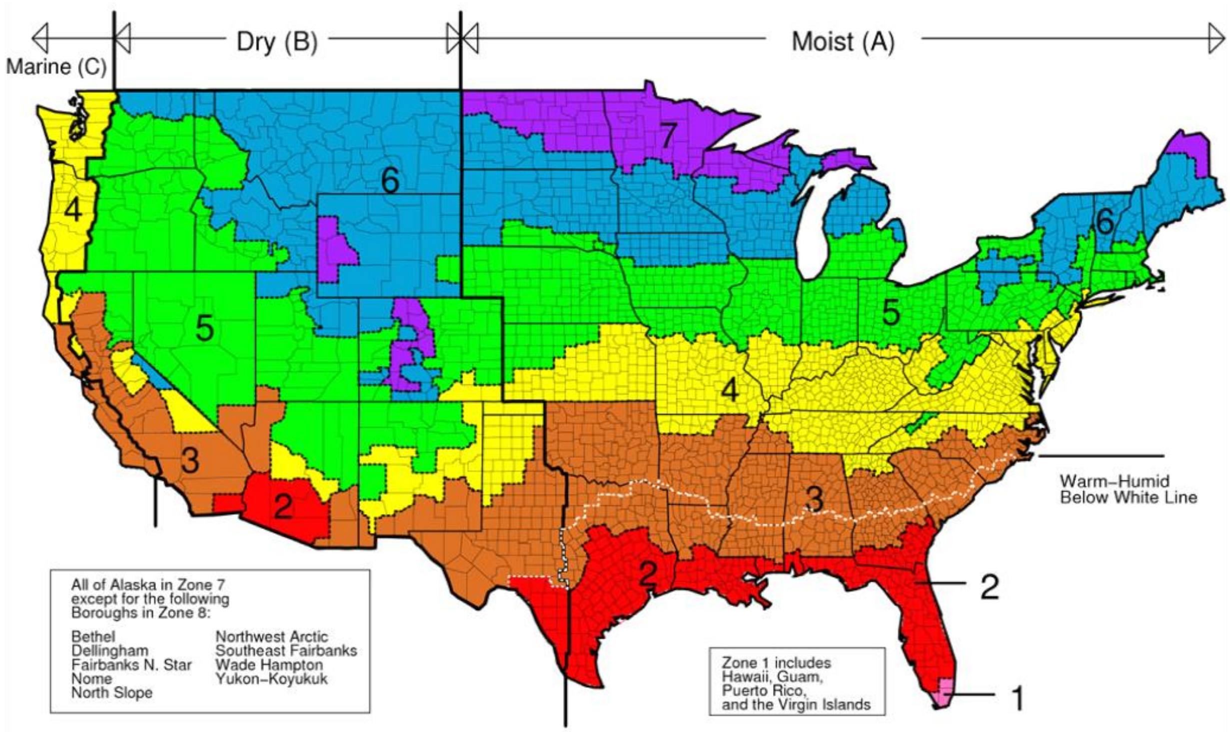

Figure 1.2. Climate Zone Map

1.2.3 Weighting Factors

Weighting factors for each of the 32 residential prototype buildings are developed for each of the climate zones using new residential construction starts and residential construction details from the U.S. Census (2010 and 2012) and NAHB (2009). These weighting factors are used to aggregate energy and costs across all building types for each climate zone. Tables 1.2 through 1.5 summarize the weights aggregated to building type, foundation type, heating system, and climate zone levels. Table 1.6 shows the detailed weighting factors for all 32 residential prototype buildings.

Table 1.2. Weighting Factors by Building Type

Bldg. Type	Weight (%)
Single-family	82.7
Multifamily	17.3

Table 1.3. Weighting Factors by Foundation Type

Bldg. Type	Weight (%)
Crawlspace	26.6
Slab-on-grade	47.9
Heated Basement	14.2
Unheated Basement	11.3

Table 1.4. Weighting Factors by Heating System

Bldg. Type	Weight (%)
Gas-fired Furnace	49.7
Electric Furnace	6.1
Oil-fired Furnace	1.6
Heat Pump	42.7

Table 1.5. Weighting Factors by Climate Zone

Climate Zone	Weight (%)
1	1.2[1]
2	20.5
3	26.1
4	23.2
5	20.8
6	6.9
7	1.3
8	0.0

[1] The tropical climate zone accounts for 50% of all single-family construction starts in climate zone 1.

Table 1.6. Weighting Factors for the Residential Prototype Building Models by Climate Zone (CZ)

Bldg. Type	Foundation	Heating System	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	Weights by Prototype
Single-family	Crawlspace	Gas-fired Furnace	0.14%	1.29%	2.69%	2.50%	2.58%	0.61%	0.14%	0.00%	9.95%
Single-family	Crawlspace	Electric Furnace	0.01%	0.33%	0.35%	0.16%	0.07%	0.02%	0.01%	0.00%	0.93%
Single-family	Crawlspace	Oil-fired Furnace	0.00%	0.00%	0.01%	0.02%	0.11%	0.04%	0.00%	0.00%	0.18%
Single-family	Crawlspace	Heat pump	0.11%	1.56%	4.20%	3.86%	0.94%	0.23%	0.07%	0.00%	10.97%
Single-family	Slab-on-grade	Gas-fired Furnace	0.16%	5.91%	5.66%	2.65%	3.25%	0.76%	0.15%	0.00%	18.55%
Single-family	Slab-on-grade	Electric Furnace	0.01%	1.25%	0.88%	0.18%	0.09%	0.02%	0.01%	0.00%	2.43%
Single-family	Slab-on-grade	Oil-fired Furnace	0.00%	0.01%	0.01%	0.03%	0.15%	0.05%	0.00%	0.00%	0.26%
Single-family	Slab-on-grade	Heat pump	0.31%	7.21%	5.91%	3.68%	1.14%	0.30%	0.08%	0.00%	18.64%
Single-family	Heated Basement	Gas-fired Furnace	0.02%	0.05%	0.21%	1.41%	3.45%	1.43%	0.26%	0.00%	6.83%
Single-family	Heated Basement	Electric Furnace	0.00%	0.01%	0.02%	0.07%	0.08%	0.05%	0.01%	0.00%	0.24%
Single-family	Heated Basement	Oil-fired Furnace	0.00%	0.00%	0.00%	0.02%	0.19%	0.07%	0.00%	0.00%	0.29%
Single-family	Heated Basement	Heat pump	0.01%	0.08%	0.36%	1.79%	1.20%	0.59%	0.13%	0.00%	4.17%
Single-family	Unheated Basement	Gas-fired Furnace	0.01%	0.11%	0.34%	1.08%	2.75%	0.94%	0.11%	0.00%	5.35%
Single-family	Unheated Basement	Electric Furnace	0.00%	0.02%	0.03%	0.05%	0.06%	0.02%	0.00%	0.00%	0.18%
Single-family	Unheated Basement	Oil-fired Furnace	0.00%	0.00%	0.00%	0.03%	0.36%	0.13%	0.00%	0.00%	0.53%
Single-family	Unheated Basement	Heat pump	0.01%	0.14%	0.57%	1.20%	0.89%	0.32%	0.05%	0.00%	3.18%
Multifamily	Crawlspace	Gas-fired Furnace	0.05%	0.10%	0.74%	0.58%	0.65%	0.17%	0.03%	0.00%	2.32%

Table 1.6. (continued)

Bldg. Type	Foundation	Heating System	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	Weights by Prototype
Multifamily	Crawlspace	Electric Furnace	0.00%	0.20%	0.25%	0.04%	0.01%	0.00%	0.00%	0.00%	0.51%
Multifamily	Crawlspace	Oil-fired Furnace	0.00%	0.00%	0.00%	0.01%	0.02%	0.01%	0.00%	0.00%	0.05%
Multifamily	Crawlspace	Heat pump	0.03%	0.16%	0.63%	0.80%	0.09%	0.02%	0.01%	0.00%	1.74%
Multifamily	Slab-on-grade	Gas-fired Furnace	0.10%	0.54%	1.37%	0.59%	0.75%	0.21%	0.04%	0.00%	3.60%
Multifamily	Slab-on-grade	Electric Furnace	0.00%	0.77%	0.79%	0.07%	0.01%	0.01%	0.00%	0.00%	1.66%
Multifamily	Slab-on-grade	Oil-fired Furnace	0.00%	0.00%	0.00%	0.02%	0.03%	0.01%	0.00%	0.00%	0.06%
Multifamily	Slab-on-grade	Heat pump	0.21%	0.73%	0.79%	0.76%	0.12%	0.03%	0.01%	0.00%	2.66%
Multifamily	Heated Basement	Gas-fired Furnace	0.01%	0.00%	0.03%	0.41%	0.86%	0.44%	0.07%	0.00%	1.83%
Multifamily	Heated Basement	Electric Furnace	0.00%	0.00%	0.01%	0.03%	0.01%	0.01%	0.00%	0.00%	0.06%
Multifamily	Heated Basement	Oil-fired Furnace	0.00%	0.00%	0.00%	0.02%	0.04%	0.01%	0.00%	0.00%	0.08%
Multifamily	Heated Basement	Heat pump	0.00%	0.01%	0.06%	0.40%	0.12%	0.07%	0.03%	0.00%	0.69%
Multifamily	Unheated Basement	Gas-fired Furnace	0.00%	0.01%	0.09%	0.33%	0.59%	0.23%	0.03%	0.00%	1.28%
Multifamily	Unheated Basement	Electric Furnace	0.00%	0.01%	0.01%	0.03%	0.01%	0.00%	0.00%	0.00%	0.07%
Multifamily	Unheated Basement	Oil-fired Furnace	0.00%	0.00%	0.00%	0.03%	0.08%	0.01%	0.00%	0.00%	0.12%
Multifamily	Unheated Basement	Heat pump	0.00%	0.02%	0.09%	0.35%	0.11%	0.03%	0.01%	0.00%	0.61%
Weights by Climate Zone			1.20%	20.52%	26.10%	23.22%	20.82%	6.87%	1.26%	0.01%	100.00%

1.3 Report Contents and Organization

This report is divided into three parts. Chapter 2 provides a summary of residential code changes in the 2015 IECC compared to the 2012 IECC and the details of the code changes considered in the present cost-effectiveness analysis. Chapter 3 details the methodology and cost items for the code changes considered in this analysis. Finally, Chapter 4 provides an overview of the economic analyses and summarizes the aggregated results of the cost-effectiveness analysis at the climate zone level.

Additional details about the building energy models created for simulating the energy use of buildings built to meet the provisions of the various editions of the IECC are provided in Appendix A. Appendix B provides disaggregated energy costs and cost-effectiveness results for each building type.

2.0 Changes Introduced in the 2015 IECC

Following the publication of the 2015 IECC, DOE conducted both a qualitative and a quantitative energy savings analysis of that code compared to its immediate predecessor, the 2012 IECC (DOE 2015). All the changes introduced in the 2015 IECC were identified, and their impact on energy efficiency was qualified. Out of the 76 code changes identified:

- 2 were identified as detrimental (i.e., increased energy use)
- 6 were identified as beneficial
- 5 were identified to have a negligible impact
- 62 were identified as neutral
- 1 was deemed unquantifiable

Eight of the code changes were identified as having quantifiable energy impacts, and six of these were subjected to a quantitative analysis using whole-building energy simulations of the 32 PNNL residential prototype buildings across the 16 IECC climate zones. The other two code changes relate to an increase in efficiency for historic buildings and a decrease in efficiency of sunrooms. The current suite of residential prototype models does not include historic buildings or sunrooms and thus, the impact of these two code changes cannot be captured quantitatively. However, the impact of these two code changes is expected to be very small due to the magnitude of changes and the small portion of the new residential building stock they affect.

Table 2.1 summarizes the characterization of the six approved code changes with quantifiable energy impacts considered in the determination analysis and subsequently, the present cost-effectiveness analysis.

Table 2.1. Approved Code Change Proposals with Quantified Energy Impacts

Proposal Number	Code Section(s) Affected[a]	Description of Changes
RE107-13	R403.2.1 (IRC N1103.2.1)	Increases insulation requirements for return ducts in attics from R-6 to R-8.
RE125-13, Part I	R403.4.1 (IRC N1103.4.1), R403.4.1.1 (NEW) (IRC N1103.4.1.1 (NEW)), R403.4.1.2 (NEW) (IRC N1103.4.1.2 (NEW)), Chapter 5, IPC [E] 607.2.1, [E] 607.2.1.1 (NEW), [E] 607.2.1.1.1 (NEW), [E] 607.2.1.1.2 (NEW), IPC Chapter 14, IRC P2905 (NEW), IRC P2905.1 (NEW)	Adds new language on heated water circulation systems and heat trace systems. Makes IECC, IRC, and IPC consistent and clarifies requirements for these systems only if they are installed.

(a) Code sections refer to the 2012 IECC.

Table 2.1. (continued)

Proposal Number	Code Section(s) Affected[(a)]	Description of Changes
RE132-13	R403.4.2 (IRC N1103.4.2), Table R403.4.2 (IRC Table N1103.4.2)	Deletes requirement for insulation on DHW pipes to kitchen and the generic requirement on long/large-diameter pipes. However, adds DHW pipe insulation for all 3/4-inch pipes.
RE136-13, Part I	R403.4.2 (NEW) (IRC N1103.4.2 (NEW)), IPC 202, IPC [E]607.2.1.1 (NEW), IRC P2905 (NEW), IRC P2905.1 (NEW)	Adds demand control requirements for recirculating systems that use a cold water supply pipe to return water to the tank.
CE66-13, Part II	R301.4 (NEW) (IRC N1101.10.3 (NEW)), R406 (NEW) (IRC N1106 (NEW))	Defines a new "Tropical" climate zone and adds an optional compliance path deeming semi-conditioned residential buildings having a list of pre-defined criteria as code compliant in this climate zone.
CE362-13, Part II	R403.2 (New) (IRC N1103.2 (New))	Adds requirement for outdoor setback control on hot water boilers that controls the boiler water temperature based on the outdoor temperature.

(a) Code sections refer to the 2012 IECC.

3.0 Construction Cost Estimates

This chapter describes the methodology used for calculating the incremental costs of construction of the 2015 IECC compared to the 2012 IECC and the 2009 IECC. Detailed incremental cost estimates for the new provisions of the 2015 IECC considered in this analysis are provided along with a summary of total incremental costs by building type and climate zone.

3.1 Methodology

The present analysis includes only the prescriptive and mandatory provisions of the IECC pertaining to residential buildings. The first step in evaluating the cost-effectiveness of these changes introduced by the 2015 IECC is estimating their incremental construction costs. Data sources used for these estimates include but are not limited to:

- Building Component Cost Community (BC3) data repository (DOE 2012)
- Residential construction cost data collected by Faithful+Gould under contract with PNNL (Faithful + Gould 2012)
- RSMeans Residential Cost Data (RSMeans 2015)
- National Renewable Energy Laboratory's (NREL's) National Residential Efficiency Measures Database (NREL 2012)
- Cost data from prominent and commonly recognized home supply stores

The incremental costs, summarized in Table 2.1, are calculated separately and then added together to obtain a total incremental cost by climate zone and building type.

Previously, PNNL conducted cost-effectiveness analyses of the 2012 IECC compared to the 2009 and 2006 IECC (Lucas et al. 2012). This study used the cost estimates from the previous study, revised to reflect newer versions of data sources (e.g., RSMeans and the consumer price index).

3.2 Incremental Cost Estimates for New Provisions of the 2015 IECC

The incremental construction costs associated with the six changes in Table 2.1 are detailed below.

3.2.1 Alternative Requirements for a New "Tropical" Climate Zone

The 2015 IECC adds a new "tropical" climate zone that includes Hawaii, Puerto Rico, American Samoa, U.S. Virgin Islands, Commonwealth of Northern Mariana Islands, and islands in the area between the Tropic of Cancer and Tropic of Capricorn and includes an alternative set of prescriptive requirements for certain configurations of single-family homes that fall in this new "tropical" climate zone.

The prescriptive requirements for single-family homes in the new tropical climate zone that changed in the 2015 IECC compared to the 2012 and the 2009 IECC are:

- Window glazing in conditioned space required to have a solar heat gain coefficient (SHGC) of 0.40 or lower (0.25 in the 2012 and 2009 IECC), and;

- Ceiling insulation required to be R-15 (R-30 in the 2012 and 2009 IECC).

Faithful+Gould reports a cost reduction of $4.15/ft^2 of window glazing area when SHGC increases from 0.25 to 0.4 (Faithful+Gould, 2012). Adjusting these costs from the 2012 report to 2015 dollars using the 2012 and 2015 Consumer Price Index (CPI) results in a cost reduction of $4.13/ft^2. Assuming 180 ft^2 conditioned space glazing from the prototype building model, the cost reduction per single-family home is estimated to be $743.40.

Faithful+Gould reports a cost reduction of $0.422/ft^2 of ceiling insulation when the R-value decreases from R-30 to R-15 (Faithful+Gould 2012). Adjusting these costs from the 2012 report to 2015 dollars using the 2012 and 2015 CPI results in a cost reduction of $0.424/ft^2. RSMeans (2015) reports a cost reduction of $0.64/ft^2 for the same reduction in ceiling R-value. This analysis assumes a conservative cost reduction of $0.424/ft^2 of ceiling insulation. Assuming 1,200 ft^2 ceiling area from the prototype building model, the cost reduction per single-family home is estimated to be $508.80.

Thus, the total cost reduction from this code change is estimated to be $1252.20 per single-family home. Construction in the new tropical climate zone accounts for approximately half of all new single-family housing starts in climate zone 1. This code change is assumed to apply only to 35% of the single-family homes in the tropical climate zone because only 35% of new single-family residential buildings built in this climate zone are expected to opt for the proposed alternative path (Mendon et al. 2015).

3.2.2 Insulation Requirements for Return Ducts in Attics

The 2015 IECC increases the insulation required on return ducts in attics to a minimum of R-8 (8 ft^2-hr-°F/Btu) where ducts are three inches or greater in diameter and to R-6 (6 ft^2-hr-°F/Btu) where they are less than 3 inches in diameter. R-6 insulation was previously required on all return ducts. This code change is assumed to impact all single-family prototype building models with slab-on-grade foundations which are assumed to have ducted air-distribution systems with return ducts located in the unconditioned attic, based on the 2014 Building America House Simulation Protocols (Wilson et al. 2014).

The NREL National Residential Efficiency Measures Database provides cost estimates for insulating ducts with R-6 and R-8 at various levels of leakages (NREL 2012). Incremental costs for increasing the duct insulation from R-0 to R-6 and from R-0 to R-8 at each of the leakage levels are reported and average $0.10/ft^2 of duct insulation. These costs are adjusted to 2015 dollars using the 2012 and 2015 CPIs, resulting in an incremental cost of $0.10/ft^2.

A second cost estimate was derived from home supply store websites which listed prices of R-6 and R-8 duct insulation for 4 in. wide and 25 ft. long ducts, resulting in an incremental cost of $0.03/ft^2. For this analysis, to be conservative, PNNL decided to use the higher incremental cost of $0.10/ft^2.

Wilson et al. (2014) report the maximum return duct surface area for homes that are two stories or higher to be 19% of the finished floor area. At 2,400 ft^2 of conditioned floor area, the incremental cost of increased duct insulation from R-6 to R-8 is estimated to be 2,400 ft^2 x 19% x $0.10/ft^2=$45.38 per single-family home and is assumed to apply only to single-family homes with slab-on-grade foundation (Mendon et al. 2015).

3.2.3 DHW Pipe Insulation Requirements

While the 2009 IECC did not require any domestic hot-water piping insulation, the 2012 IECC contains detailed requirements for insulating domestic hot-water pipes. The 2015 IECC deletes a requirement for insulation on hot-water pipes to kitchen spaces and deletes a generic requirement for insulation on long and large-diameter pipes. These changes lower overall efficiency in the 2015 IECC compared to the 2012 IECC. However, the 2015 IECC adds a requirement for pipe insulation on 3/4 in. pipes that previously applied only to pipes with diameters greater than 3/4 in. Because 3/4 in. is the most common size for the long trunk lines in typical residences, this improvement more than compensates for the efficiency losses from the deletion of insulation requirements for kitchen and long and large-diameter pipes.

The BC3 database reports an average cost of $0.87/linear ft. of pipe for just the insulation materials (DOE 2012). This cost adjusted to 2015 dollars results in a cost of $0.86/linear ft. Similar cost information obtained from home supply store websites — averaged over different R-values — was approximately $1/linear ft. Labor cost was estimated at $1/linear ft. for each case based on professional judgement. Thus, the total cost of insulating the pipes including materials and labor is estimated to be $1.86/linear ft.

This provision of the 2015 IECC requires an additional length 11 ft. of 3/4 in. pipe to be insulated for single-family homes and an additional length of 24.5 ft. of 3/4 in. runs to be insulated for multifamily homes, when compared with the 2012 IECC. Meanwhile, the length of 1/2 in. kitchen pipes that does not need insulation under the 2015 IECC compared to the 2012 IECC is estimated to be 18 ft. and 20 ft. for single-family and multifamily homes, respectively (Mendon et al. 2015). So, effectively, under the 2015 IECC for single-family homes, 7 ft. of pipes do not need insulation compared to the 2012 IECC. For multifamily homes, the 2015 IECC effectively requires pipe insulation on an additional 4.5 ft. of pipes compared to the 2012 IECC. Thus, this code provision results in a cost reduction of $13.03 for single-family homes and an incremental cost of $8.37 for multifamily homes for the 2015 IECC compared to the 2012 IECC.

3.2.4 Demand-Activated Control for Recirculating Systems

The 2015 IECC adds new requirements for heated water circulation systems and heat trace systems to be controlled by demand-activated circulation systems, making the IECC consistent with the International Residential Code (IRC) and the International Plumbing Code (IPC). It also adds demand control requirements for recirculating systems that use a cold-water supply pipe to return water to the tank. These code changes do not require the addition of circulation systems to homes; the added requirements are applicable only when these systems are present in the home. This change is assumed to affect only multifamily buildings that have a central hot-water system which are assumed to already have hot water recirculation systems and account for 50% of all new multifamily buildings (Mendon et al. 2015). The 2012 and 2009 IECC do not include requirements for demand-activated control of hot-water recirculation systems.

Demand control for central domestic hot water systems can be simply based on a manually activated switch or involve flow-sensors that signal the demand for hot water to the central hot water system. Because the present analysis assumes this code change applies only to multifamily buildings with central water heating systems alone, a flow-sensor based control is considered to be more appropriate.

A recent pilot study conducted by Nicor Gas investigating the performance of demand-control recirculation systems in two multifamily buildings reports an incremental cost of $1,200 for a demand-control recirculation system over a standard continuously operating “no-control” recirculation system (Nicor Gas 2014). A California Codes and Standards Enhancement Initiative study reports a similar incremental cost of $1,000 for parts and $200 for installation, based on interviews conducted with manufacturers (CASE 2011). Finally, a cost-effectiveness study of demand-controlled water heater thermostat controllers in multifamily buildings conducted by the Southern California Gas Company in 2005 reports an incremental cost of $1,400 for a multifamily building with less than 30 units (SCG 2005).

This analysis assumes an average incremental cost of $1,200 per multifamily building with a centralized hot-water system. Normalizing based on the number of apartment units in the multifamily building prototype and then adjusting to account only for the 50% of the multifamily buildings that have a central hot-water system according to Mendon et al. (2015), the final incremental cost for this measure is estimated to be $33.33 per apartment unit.

3.2.5 Outdoor Air Temperature Setback Control for Hot-Water Boilers

The 2015 IECC adds a requirement for hot-water boilers supplying heat to the building through one- or two-pipe heating systems to be equipped with an outdoor setback control that lowers the temperature of the hot water based on outdoor air temperature. This code change is assumed to apply to only oil-fired hot-water boilers used for space heating in multifamily buildings (Mendon et al. 2015). The 2012 and 2009 IECC do not include requirements for outdoor air temperature setback control for hot-water boilers.

The cost associated with the code change is calculated based on Tekmar self-contained units which are ready to install and retail between $150 and $250. Adding 1.5 hours for installation for an L1 crew (1 electrician and 1 plumber) with a labor rate of $85.30 per hour and approximately $25 for miscellaneous parts (RSMeans 2015), the total cost estimate for the system inclusive of parts and labor is about $403 per multifamily building.

A second cost point is identified by calculating the cost of individual parts that constitute a temperature-based reset system from RSMeans (2015). The parts include:

- an outdoor air temperature sensor at an average price of $25,
- a proportional-integral-derivative (PID) microcontroller at an average price of $200 (cost varied between $30 and $350 depending upon the functionality), and
- miscellaneous parts like wires and screws at an estimated $50.

It is also estimated that the PID controller will require about 3 hours of programming by a technician with a labor rate of $50 per hour (RSMeans 2015). The installation is assumed to require 1.5 hours for an L1 crew (1 electrician and 1 plumber) with a labor rate of $85.30 per hour (RSMeans 2015). Thus, the total incremental cost for this measure is estimated to be $553.

This analysis assumes an incremental cost of $550 per multifamily building with oil-fired boilers. Normalizing based on the number of apartment units in the multifamily building prototype, the final incremental cost for this measure is estimated to be $30.55 per apartment unit and applies to only the multifamily prototype buildings with oil-fired boilers.

3.3 Summary of Incremental Costs

Table 3.1 summarizes the incremental costs for each new code provision of the 2015 IECC evaluated in the present analysis compared to the 2012 IECC.

Table 3.1. Construction Cost Increase of the New Provisions of the 2015 IECC

Provision	Specifications	Scope	Associated Cost	Incremental Cost Used in Analysis ($/residence-yr)
Alternative requirement for new "tropical" climate zone	Window glazing SHGC up to 0.4 from 0.25	35% of all new single-family homes in the new "tropical" climate zone	$(4.13)/ft^2$	($743.40)
	Ceiling insulation down to R-15 from R-30	35% of all new single-family homes in the new "tropical" climate zone	$(0.422)/ft^2$	($508.80)
Insulation for return ducts in attics	Increase to R-8 from R-6	Single-family homes with slab-on-grade foundation types in all climate zones	$0.10/ft^2$	$45.38
DHW pipe insulation	New insulation requirement for shorter 3/4inch pipes; insulation requirement removed from 1/2 inch kitchen pipes	Single- and multifamily homes in all climate zones	$1.86/lin. ft.	$(13.03) and $8.37 for single-family and multi-family homes respectively
Demand-activated control for recirculation system	New controls requirement for central domestic hot water systems	50% of multifamily homes in all climate zones	$1,200 per multi-family home	$33.33 per apartment unit
OAT setback control for hot water boilers	New controls requirement for central hot water boilers	Multifamily homes with oil fired boilers in all climate zones	$550 per multi-family home	$30.55 per apartment unit

The total incremental costs for the 2015 IECC compared to those of the 2012 IECC and the 2009 IECC are summarized in Table 3.2 and Table 3.3, respectively. Negative costs indicate a reduction in incremental costs based on the provisions of one edition of the code compared to another.

Table 3.2. Total Construction Cost Increase for the 2015 IECC Compared to the 2012 IECC

Climate Zone	2,400 ft^2 House			1,200 ft^2 Apartment/Condo[a]	
	Slab-on-grade	Unheated Basement, or Crawlspace	Heated Basement	Slab, Unheated Basement, or Crawlspace	Heated Basement
1	$32	$(13)	$(13)	$33	$33
1-tropical[b]	$(1,265)	$(1,265)	$(1,265)	$33	$33
2	$32	$(13)	$(13)	$33	$33
3	$32	$(13)	$(13)	$33	$33
4	$32	$(13)	$(13)	$33	$33
5	$32	$(13)	$(13)	$33	$33
6	$32	$(13)	$(13)	$33	$33
7	$32	$(13)	$(13)	$33	$33
8	$32	$(13)	$(13)	$33	$33

(a) For multifamily homes with an oil-fired boiler, an additional incremental cost of $30.55 for the outdoor air temperature reset applies to all climate zones.
(b) This cost applies to 35% of all new single-family homes in the tropical climate zone. The tropical climate zone accounts for around 50% of all new single-family construction starts in climate zone 1.

Table 3.3. Total Construction Cost Increase for the 2015 IECC Compared to the 2009 IECC

Climate Zone	2,400 ft^2 House			1,200 ft^2 Apartment/Condo[a]	
	Slab-on-grade	Unheated Basement, or Crawlspace	Heated Basement	Slab, Unheated Basement, or Crawlspace	Heated Basement
1	$1,585	$1,553	$1,553	$848	$848
1-tropical[b]	$1,152	$1,152	$1,152	$848	$848
2	$1,920	$1,888	$1,888	$968	$968
3	$2,495	$2,463	$2,463	$1,175	$1,175
4	$2,005	$1,973	$1,973	$1,012	$1,012
5	$1,493	$1,461	$1,715	$827	$865
6	$2,718	$2,686	$2,686	$1,266	$1,266
7	$2,718	$2,686	$2,686	$1,266	$1,266
8	$2,718	$2,686	$2,686	$1,266	$1,266

(a) For multifamily homes with an oil-fired boiler, an additional incremental cost of $30.55 for the outdoor air temperature reset applies to all climate zones.
(b) This cost applies to 35% of all new single-family homes in the tropical climate zone. The tropical climate zone accounts for around 50% of all new single-family construction starts in climate zone 1.

4.0 Economic Analysis

This chapter provides an overview of the methodology used in evaluating the cost-effectiveness of the prescriptive and mandatory provisions of the 2015 IECC compared to those of the 2012 and the 2009 IECC. Cost-effectiveness results for Life Cycle Cost (LCC) savings, simple payback, and cash flow are calculated for each building type in each climate zone, and the results are weighted using factors detailed in Section 1.2.3 to aggregate results to the climate zone level.

4.1 DOE Residential Cost-effectiveness Methodology

DOE developed a standardized methodology for determining the cost-effectiveness of residential energy code changes through a public Request for Information (76 FR 56413). The established methodology[1] describes the process of assessing energy savings and cost-effectiveness and is used by DOE in the evaluation of published codes as well as code changes proposed by DOE for inclusion in the IECC (Taylor et al. 2012). The methodology forms the basis of this cost-effectiveness analysis by:

- defining an energy analysis procedure, including definitions of two building prototypes (single-family and multifamily), identification of preferred calculation tools, and selection of climate locations to be analyzed;
- establishing preferred construction cost data sources;
- defining cost-effectiveness metrics and associated economic parameters, and;
- defining a procedure for aggregating location-specific results to state, climate-zone, and national levels.

Per the methodology, DOE calculates three metrics from the perspective of the homeowner: LCC, Simple Payback, and Cash Flow. LCC is the primary metric used by DOE for determining the cost-effectiveness of an overall code or individual code change. The economic parameters used in the present cost-effectiveness analysis are summarized in Table 4.1.

Table 4.1. Summary of Economic Parameters Used in Current Analysis

Parameter	Value
Mortgage Interest Rate	5%
Loan Term	30 years
Down-Payment Rate	10% of home price
Points and Loan Fees	0.7% (non-deductible)
Analysis Period	30 years
Property Tax Rate	0.9% of home price/value
Income Tax Rate	25% federal
Inflation Rate	1.6% annual
Home Price Escalation Rate	Equal to Inflation Rate

[1] See DOE Residential Energy and Cost Analysis Methodology at: http://www.energycodes.gov/development/residential/methodology

4.2 Fuel Prices and Escalation Rates

Data published by the EIA are used to determine the latest national average fuel prices for the three fuel types considered in this analysis—electricity, natural gas, and fuel oil. The EIA reports an average annual residential electricity price of $0.121/kWh for 2013 (EIA 2015a). This average price for electricity is used in the analysis to avoid seasonal fluctuations and regional variations. EIA reports a national annual average cost of $10.97/1000 cubic foot (CF) for natural gas for 2014 and an average heat content of 1,031 Btu/CF for natural gas delivered to consumers in the same year (EIA 2015b, 2015c). The resulting national average cost of $1.061/therm for natural gas is used in this analysis. EIA reports a national annual average cost of $3.329/gallon for No. 2 fuel oil for 2014 (EIA 2015d). The heat content of No. 2 fuel oil is assumed to be 138,000 Btu/gallon (NCHH 2015), resulting in a national average cost of $24.12/million Btu for fuel oil used in this analysis.

Fuel escalation rates are calculated separately for electricity, natural gas and fuel oil using annual projected fuel prices published in the 2014 Annual Energy Outlook (EIA 2014). Because the EIA projections end in the year 2040 and the present analysis period of 30 years requires consideration of fuel escalation rates until the year 2045, the projected fuel prices are assumed to increase exponentially between years 2041 to 2045. The resulting nominal fuel escalation rates of 1.06% for electricity, 1.21% for natural gas, and 1.16% for fuel oil are used in this analysis.

4.3 Energy Cost Savings

The calculation of cost-effectiveness metrics primarily requires annual energy cost savings and the associated incremental costs. Energy estimates from Chapter 3 are converted to energy costs using latest fuel prices described in Section 4.2. Table 4.2 summarizes the annual energy costs savings per home for the 2015 IECC compared to the 2012 and 2009 IECC, aggregated over all 32 residential prototype building models using weighting factors described in Section 1.2.3.

Table 4.2. Average Annual Energy Costs Savings for the 2015 IECC

Climate Zone	Compared to the 2012 IECC ($/residence-yr)	Compared to the 2009 IECC ($/residence-yr)
1	5	179
2	7	220
3	8	256
4	7	353
5	5	353
6	6	497
7	8	841
8	18	1,199

4.4 Life Cycle Cost

LCC is the primary metric used by DOE to determine the cost-effectiveness of the overall code or specific code changes. LCC is the total consumer cost of owning a home for a single homeowner calculated over a 30-year period. The economic analysis assumes that initial costs are mortgaged, that homeowners take advantage of the mortgage interest deductions, and that long-lived efficiency measures retain a residual value after the 30-year analysis period.

Table 4.3 shows the LCC savings (discounted present value) per home over the 30-year analysis period for the prescriptive and mandatory provisions of the 2015 IECC compared to those of the 2012 IECC and the 2009 IECC. These savings are aggregated over all 32 residential prototype buildings using weights described in Section 1.2.3.

Table 4.3. Life Cycle Cost Savings for the 2015 IECC

Climate Zone	Compared to the 2012 IECC ($/residence-yr)	Compared to the 2009 IECC ($/residence-yr)
1	+193	+4,418
2	+119	+5,725
3	+156	+6,569
4	+154	+8,088
5	+153	+7,697
6	+142	+11,231
7	+200	+17,525
8	+438	+24,003

4.5 Simple Payback

Simple payback is a commonly used measure of cost-effectiveness, defined as the number of years required for the sum of the annual return on an investment to equal the original investment. Simple payback does not take into consideration any financing of the initial costs through a mortgage or favored tax treatment of mortgages. In other words, simple payback is the ratio of the incremental cost of construction and the first-year energy cost savings. The simple payback is reported for information purposes only and is not used as a basis for determining the cost-effectiveness of the 2015 IECC.

Table 4.4 shows the simple payback period of the 2015 IECC when compared to the 2012 and the 2009 IECC aggregated over all 32 residential prototype buildings using weights described in Section 1.2.3. As seen from the table, the simple payback period for the 2015 IECC compared to that of the 2012 IECC ranges from immediate to 3.8 years, while the simple payback period for the 2015 IECC compared to that of the 2009 IECC ranges from 2.2 to 8.1 years, depending on climate zone.

Table 4.4. Simple Payback Period for the 2015 IECC

Climate Zone	2015 IECC Compared to the 2012 IECC (Years)	2015 IECC Compared to the 2009 IECC (Years)
1	0.0	6.6
2	3.8	8.1
3	3.4	7.9
4	1.4	5.1
5	1.6	3.9
6	1.0	4.9
7	0.0	3.1
8	0.2	2.2

4.6 Cash Flow

Most houses are financed and the financial implications of buying a home constructed to meet the provisions of the 2015 IECC compared to the provisions of the 2012 or 2009 IECC is important to homeowners. Mortgages spread the payment for the cost of a house or an apartment over a long period of time and the cash flow analysis clearly depicts the impact of mortgages. This analysis assumes a 30-year fixed-rate mortgage and that the homebuyers will deduct the interest portion of the payments from their income taxes.

Table 4.5 shows the impact of the provisions of the 2015 IECC on a typical consumer's cash flow compared to that of the 2012 and the 2009 IECC aggregated over all 32 residential prototype buildings using weights described in Section 1.2.3. On average, beginning in year one, there is a net positive cash flow per year to the customer for the 2015 IECC-compliant home when compared to the 2012 and 2009 IECC-compliant homes. Positive cumulative savings, including payment of up-front costs, are achieved in less than two years in all cases.

Table 4.5. Impacts on Consumer Cash Flow from the 2015 IECC

	2015 IECC Compared to the 2012 IECC		2015 IECC Compared to the 2009 IECC	
Climate Zone	Net Annual Cash Flow Savings (in Year 1)	Years to Cumulative Positive Cash Flow	Net Annual Cash Flow Savings (in Year 1)	Years to Cumulative Positive Cash Flow
1	+$ 13	0	+$ 103	1
2	+$ 5	1	+$ 103	2
3	+$ 6	0	+$ 125	2
4	+$ 7	0	+$ 236	1
5	+$ 5	0	+$ 263	1
6	+$ 6	0	+$ 340	1
7	+$ 8	0	+$ 672	0
8	+$ 18	0	+$ 1,024	0

5.0 Conclusions

As seen from the cost-effectiveness results presented in Chapter 4, residential buildings constructed to the prescriptive and mandatory requirements of the 2015 IECC save homeowners money over the life of their homes compared to those built to the prescriptive and mandatory requirements of the 2012 and the 2009 IECC. Although the prescriptive and mandatory provisions of the 2015 IECC only vary slightly from the 2012 IECC, they are substantially more energy efficient and cost-effective than the provisions of the 2009 IECC. Many states that are currently using the 2009 IECC may find the cost-effectiveness results presented in this report useful in moving towards more energy efficient residential building energy codes like the 2015 IECC.

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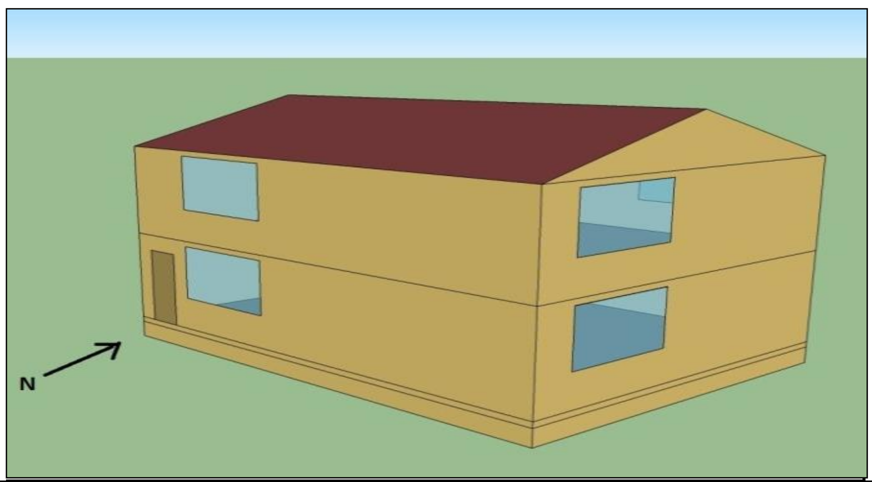
Appendix A

Prototype Building Model Description

A.1. Single-Family Prototype Model

	Item	Description	Data Source
General			
	Vintage	New Construction	
	Locations	See under Section 1.42.2	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Available fuel types	Natural Gas/Electricity/Fuel Oil	
	Building Type (Principal Building Function)	Residential	
	Building Prototype	Single-family Detached	
Form			
	Total Floor Area (sq. feet)	2,400 (30' x 40' x 2 stories)	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Building shape		

	Item	Description	Data Source
General			
	Aspect Ratio	1.33	
	Number of Floors	2	
	Window Fraction (Window-to-Floor Ratio)	Average Total: 15.0% divided equally among all facades	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Window Locations	All facades	
	Shading Geometry	none	
	Orientation	Back of the house faces North (see image)	
	Thermal Zoning	The house is divided into three thermal zones: 'living space', 'attic' and 'crawlspace', 'heated basement', 'unheated basement' when applicable.	
	Floor to ceiling height	8.5’	
Architecture			
	Exterior walls		
	Construction	Wood-Frame Walls (2x4 16" O.C. or 2x6 24" O.C.) 1" Stucco + Building Paper Felt + Insulating Sheathing (if applicable) + 5/8" Oriented Strand Board + Wall Insulation + 1/2" Drywall	
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	IECC Requirements Residential; Walls, above grade, Wood Frame	IECC
	Dimensions	based on floor area and aspect ratio	
	Tilts and orientations	Vertical	
	Roof		
	Construction	Asphalt Shingles	

	Item	Description	Data Source
General			
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	IECC Requirements Residential; Roofs, Insulation entirely above deck	IECC
	Tilts and orientations	Gabled Roof with a Slope of 4/12	
	Window		
	Dimensions	based on window fraction, location, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below	
	U-factor (Btu / h * ft^2 * °F)	IECC Requirements Residential; Glazing	IECC
	SHGC (all)		
	Operable area	100%	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Four Foundation Types are Modeled- i. Slab-on Grade ii. Vented Crawlspace Depth 2' iii. Heated Basement - Depth 7' iv. Unheated Basement- Depth 7'	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Insulation level	IECC Requirements for floors and basement walls	IECC
	Dimensions	based on floor area and aspect ratio	

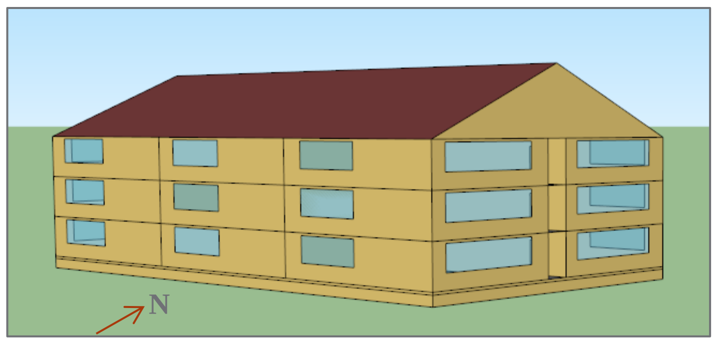
	Item	Description	Data Source
General			
	Internal Mass	8 lb/ft^2 of floor area	IECC 2015 Section 404
	Infiltration (ACH)	2006 IECC: 8 Air Changes/Hour at 50 Pa (8 ACH50) 2009 IECC: 7 Air Changes/Hour at 50 Pa (7 ACH50) 2012 IECC: 5 or 3 Air Changes/Hour at 50 Pa (5 or 3 ACH50) depending on climate zone	
HVAC			
	System Type		
	Heating type	Four Heating System Types are Modeled- i. Gas Furnace ii. Oil Furnace iii. Electric Furnace iv. Heat Pump	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Cooling type	Central DX Air-Conditioner/Heat Pump	
	HVAC Sizing		
	Cooling	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	SEER 13	Federal minimum efficiency
	Heating	AFUE 78% / HSPF 7.7	Federal minimum efficiency
	HVAC Control		

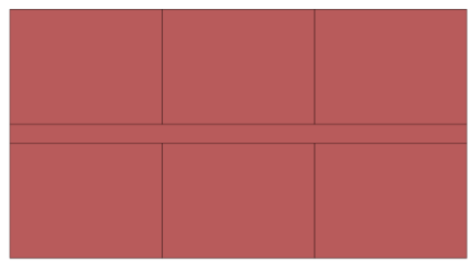
	Item	Description	Data Source
General			
	Thermostat Setpoint	75°F Cooling/72°F Heating	
	Thermostat Setback	No setback	
	Supply air temperature	Maximum 110 F, Minimum 52 F	
	Ventilation	60 CFM Outdoor Air; Continuous Supply	2015 IRC
	Supply Fan		
	Fan schedules	See Appendix A.3	
	Supply Fan Total Efficiency (%)	Depending on the fan motor size	Residential Furnaces and Centralized Air Conditioners and Heat Pumps Direct Final Rule Technical Support Document.[1]
	Supply Fan Pressure Drop	Depending on the fan supply air cfm	
	Domestic Hot Water		
	DHW type	Individual Residential Water Heater with Storage Tank	
	Fuel type	Natural Gas/Electricity	
	Thermal efficiency (%)	EF = 0.59 for Gas-fired Water Heaters EF = 0.917 for Electric Water Heaters	Federal minimum efficiency
	Tank Volume (gal)	40 for Gas-fired Water Heaters 52 for Electric Water Heaters	Reference: Building America Research Benchmark
	Water temperature setpoint	120 F	
	Schedules	See Appendix A.2	
Internal Loads & Schedules			
	Lighting		

[1] Residential Furnaces and Central Air Conditioners and Heat Pumps Direct Final Rule Technical Support Document – Chapter 7 'Energy Use Characterization' http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_07_energy-use_2011-04-25.pdf

	Item	Description	Data Source
General			
	Average interior power density (W/ft^2)	Living space: Lighting Power Density is 0.68 W/sq.ft.(For interior lighting) Lighting loads for Garage and Exterior Lighting have also been included	Reference: 2014 Building America House Simulation Protocols
	Interior Lighting Schedule	See Appendix A.3	
	Internal Gains		
	Load (Btu/day)	17,900 + 23.8 x CFA + 4104 x Nbr See Appendix A.4 for the detailed calculations	Reference: IECC 2015 and Building America Research Benchmark
	Internal gains Schedule(s)	See Appendix A.3	
	Occupancy		
	Average people	800 ft2/per person for conditional total and 1601 ft2/per person for total	
	Occupancy Schedule	See Appendix A.3	

A.2. Multifamily Prototype Model

	Item	Description	Data Source
General			
	Vintage	New Construction	
	Location	See Section 1.2.2.	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Available Fuel Types	Natural Gas/Electricity/Fuel Oil	
	Building Type	Residential	
	Building Prototype	Low-rise Multifamily	
Form			
	Total Floor Area	Whole Building- 23,400 sq.ft Each Dwelling Unit - 1200 sq.ft	
	Building Shape		Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Aspect Ratio	Whole Building- 1.85 Each Dwelling Unit - 1.33	
	Number of Floors	3	
	Number of Units per Floor	6	
	Orientation	Back of the house faces North (see image)	

	Item	Description	Data Source
	Dimensions	Whole Building - 120' x 65' x 25'6" Each Dwelling Unit - 40' x 30' x 8'6"	
	Conditioned Floor Area	Each Dwelling Unit- 1200 sq.ft	
	Window Area (Window-to- Exterior Wall Ratio)	23% WWR (Does not include breezeway walls)	
	Exterior Door Area	Each Dwelling Unit - 21 sq.ft Whole Building - 378 sq.ft	
	Shading Geometry	None	
	Thermal Zoning	Each floor has 6 dwelling units with a breezeway in the center. Each dwelling unit is modeled as a separate zone. The other thermal zones are: attic, breezeway and foundation (basements and crawlspace only) 	
	Floor to ceiling height	8.5’	
Architecture			
	Exterior walls		
	Construction	Wood-Frame Walls (2x4 16" O.C. or 2x6 24" O.C.) 1" Stucco + Building Paper Felt + Insulating Sheathing (if applicable) + 5/8" Oriented Strand Board + Wall Insulation + 1/2" Drywall	
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	IECC Requirements Residential; Wood-Frame Wall R-value	IECC

	Item	Description	Data Source
	Dimensions	Each Dwelling Unit: 40' x 8'6" and 30' x 8'6"	
	Tilts and orientations	Vertical	
	Roof		
	Construction	Built-up Roof: Asphalt Shingles+ 1/2 in. OSB	
	U-factor (Btu / h * ft^2 * °F) and/or R-value (h * ft^2 * °F / Btu)	IECC Requirements Residential; Ceiling R-value	IECC
	Tilts and orientations	Gabled Roof with a Slope of 4/12	
	Window		
	Dimensions	based on window fraction, location, glazing sill height, floor area and aspect ratio	
	Glass-Type and frame	Hypothetical window with the exact U-factor and SHGC shown below.	
	U-factor (Btu / h * ft^2 * °F)	IECC Requirements Fenestration U-Factor & SHGC	
	SHGC (all)		
	Operable area	100%	
	Skylight		
	Dimensions	Not Modeled	
	Glass-Type and frame	NA	
	U-factor (Btu / h * ft^2 * °F)		
	SHGC (all)		
	Visible transmittance		
	Foundation		
	Foundation Type	Four Foundation Types are Modeled- i. Slab-on Grade ii. Vented Crawlspace Depth 2' iii. Heated Basement - Depth 7' iv. Unheated Basement- Depth 7'	Reference: Methodology for Evaluating Cost Effectiveness of Residential Energy Code Changes
	Insulation level	IECC Requirements for floors, slabs and basement walls	

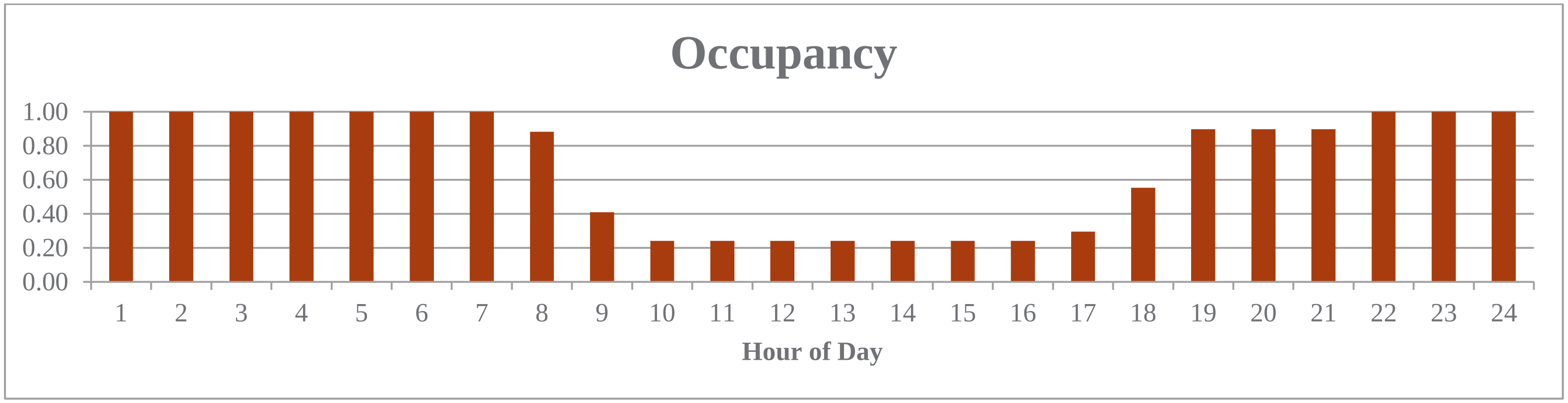
	Item	Description	Data Source
	Dimensions	based on floor area and aspect ratio	
	Internal Mass	8 lb/ft^2 of floor area	IECC 2006 Section 404
	Infiltration (ACH)	2006 IECC: 8 Air Changes/Hour at 50 Pa 2009 IECC: 7 Air Changes/Hour at 50 Pa 2012 IECC: 5 or 3 Air Changes/Hour at 50 Pa depending on climate zone	
HVAC			
	System Type		
	Heating type	Four Heating System Types are Modeled- i. Gas Furnace ii. Oil Furnace iii. Electric Furnace iv. Heat Pump	
	Cooling type	Central DX Air-Conditioner/Heat Pump (1 per unit)	
	HVAC Sizing		
	Cooling	autosized to design day	
	Heating	autosized to design day	
	HVAC Efficiency		
	Air Conditioning	SEER 13	Federal Minimum Equipment Efficiency for Air Conditioners and Condensing Units
	Heating	AFUE 78% / HSPF 7.7	Federal Minimum Equipment Efficiency
	HVAC Control		
	Thermostat Setpoint	75°F Cooling/72°F Heating	
	Thermostat Setback	No setback	
	Supply air temperature	Maximum 110 F, Minimum 52 F	
	Ventilation	45 CFM Outdoor Air per dwelling unit; Continuous Supply	2015 International Residential Code (IRC)
	Supply Fan		
	Fan schedules	See Appendix A.3	

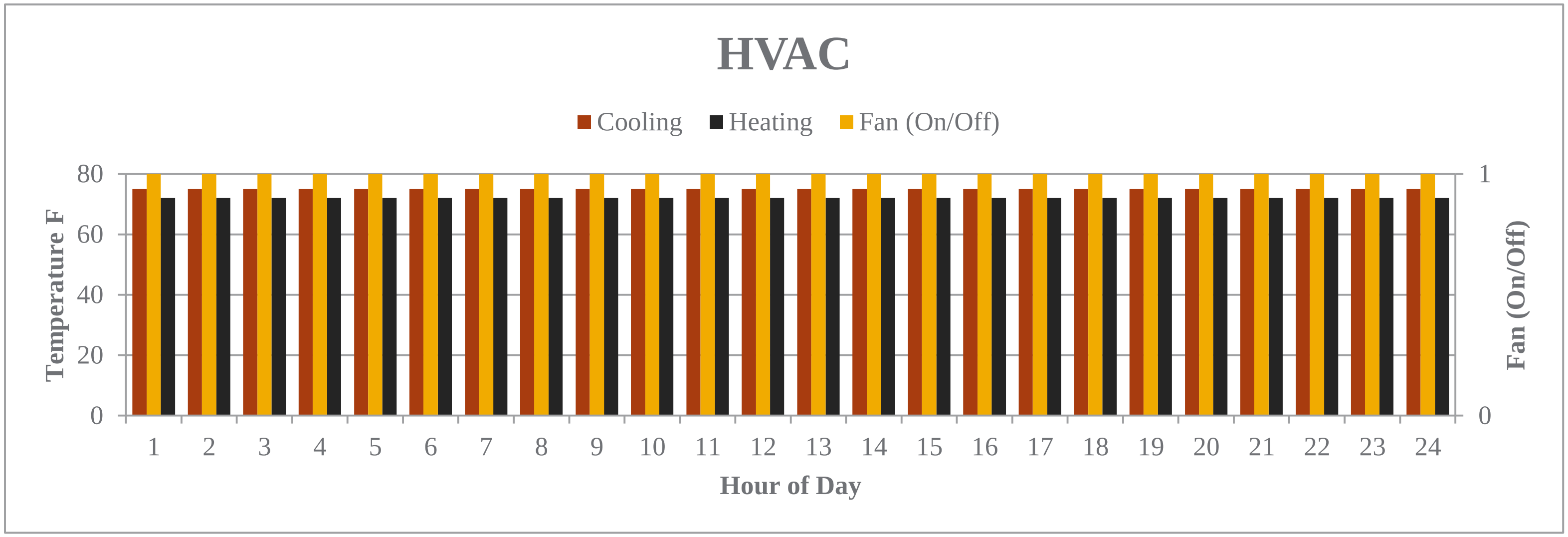
	Item	Description	Data Source
	Supply Fan Total Efficiency (%)	Fan efficiency 58%; Motor efficiency 65% (PSC motor)	Residential Furnaces and Centralized Air Conditioners and Heat Pumps Direct Final Rule Technical Support Document[1]
	Supply Fan Pressure Drop	0.6" w.g.	
	Service Water Heating		
	SWH type	Individual Residential Water Heater with Storage Tank	
	Fuel type	Natural Gas / Electricity	
	Thermal efficiency (%)	EF = 0.59	Federal Minimum Equipment Efficiency
	Tank Volume (gal)	40	
	Water temperature setpoint	120 F	
	Schedules	See Appendix A.3	
Internal Loads & Schedules			
	Lighting		
	Average power density (W/ft^2)	Apartment units: Lighting Power Density is 0.82 W/sq.ft.(For interior lighting) Lighting loads for Garage and Exterior Lighting have also been included	2014 Building America House Simulation Protocols
	Interior Lighting Schedule	See Appendix A.3	
	Internal Gains		
	Internal Gains (Btu/day per Dwelling Unit)	$17{,}900 + 23.8 \times CFA + 4104 \times N_{br}$ See Appendix A.4 for the detailed calculations	
	Internal Gains Schedule(s)	See under Appendix A.3	

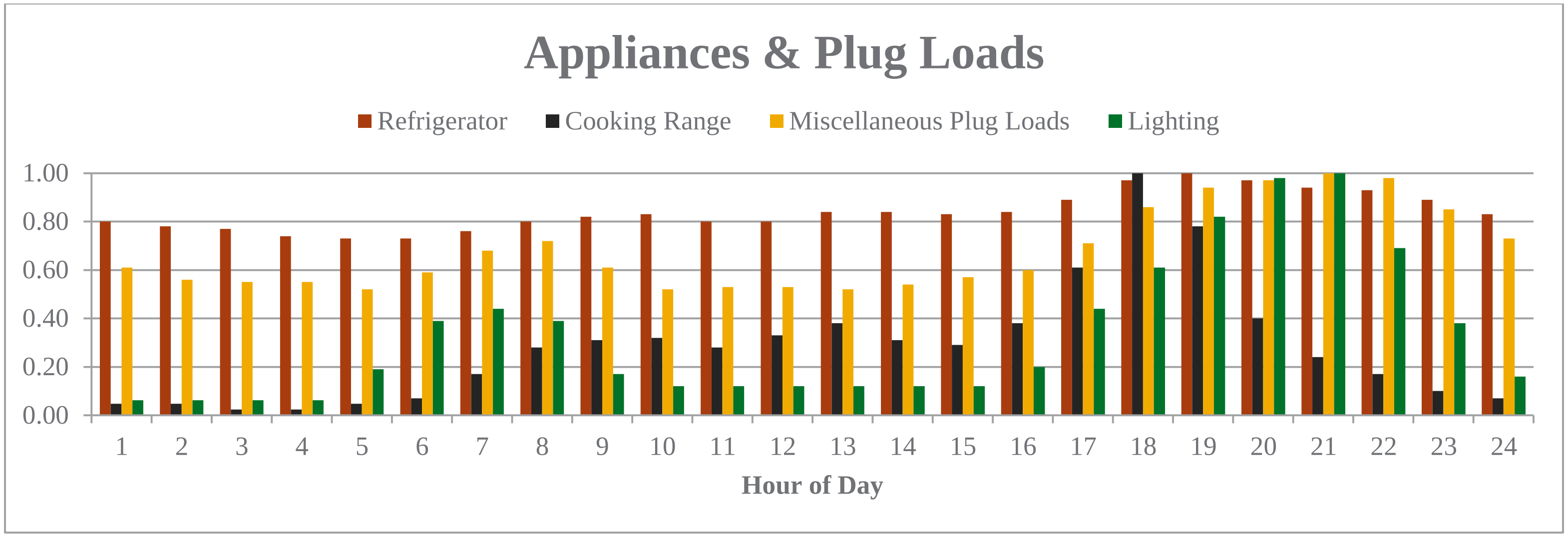
[1] Residential Furnaces and Centralized Air Conditioners and Heat Pumps Direct Final Rule Technical Support Document: Chapter 7 'Energy Use Characterization' Residential Furnaces and Centralized Air Conditioners and Heat Pumps Direct Final Rule Technical Support Document

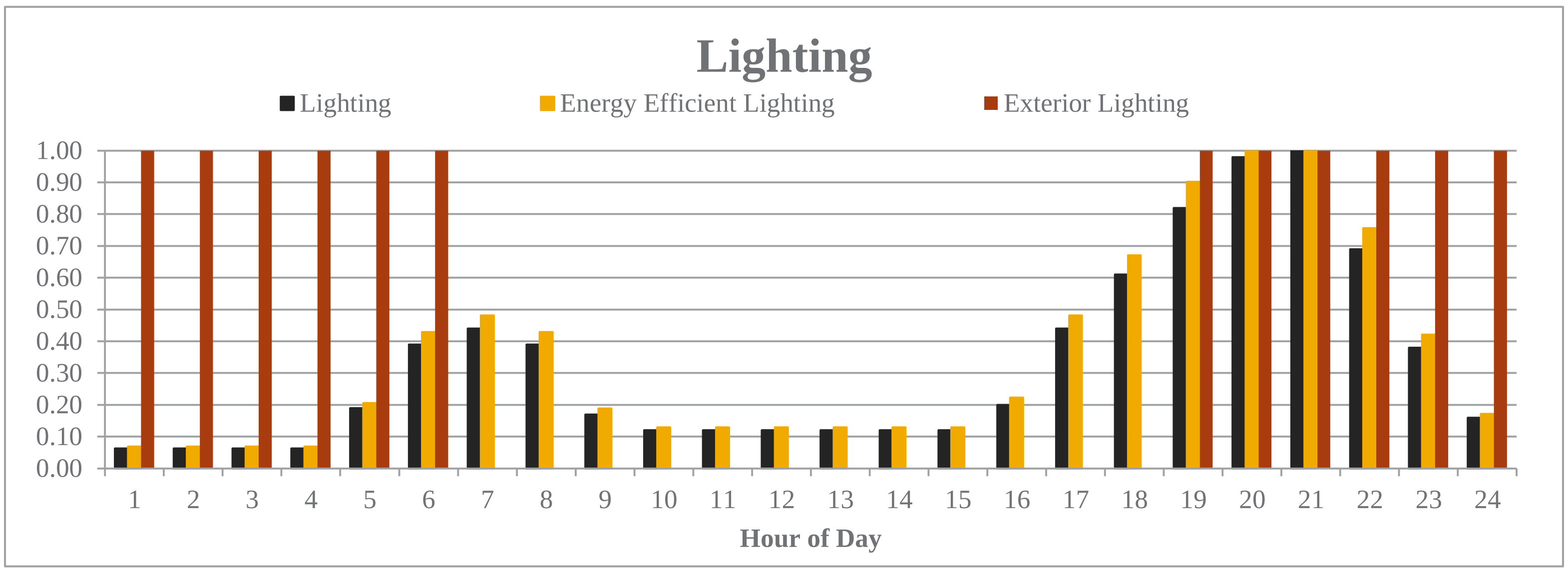
	Item	Description	Data Source
	Occupancy		
	Average people	2 people/apartment unit	
	Occupancy Schedule	See Appendix A.3	

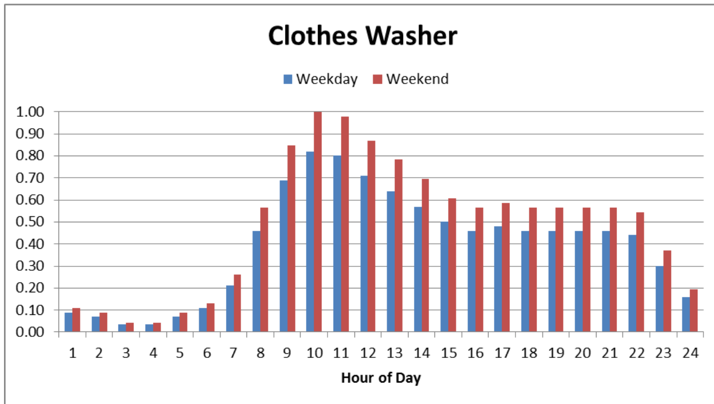
A.3. Schedules

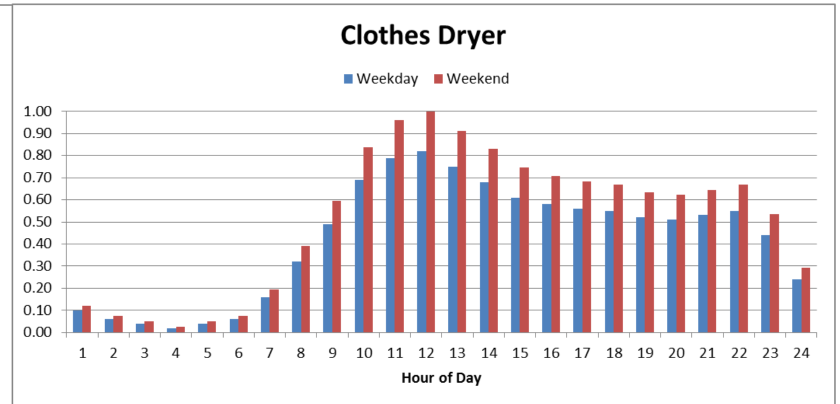


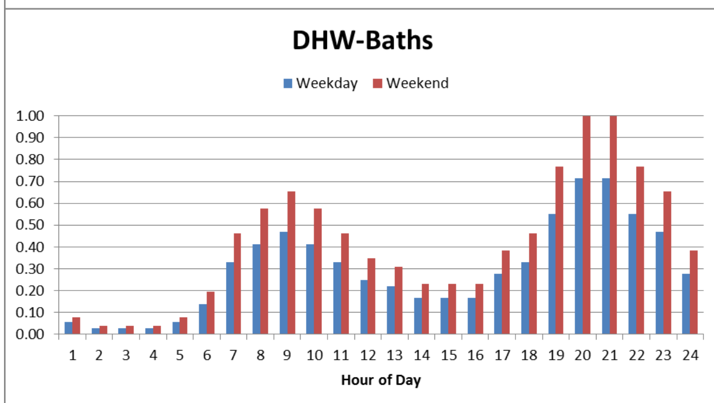


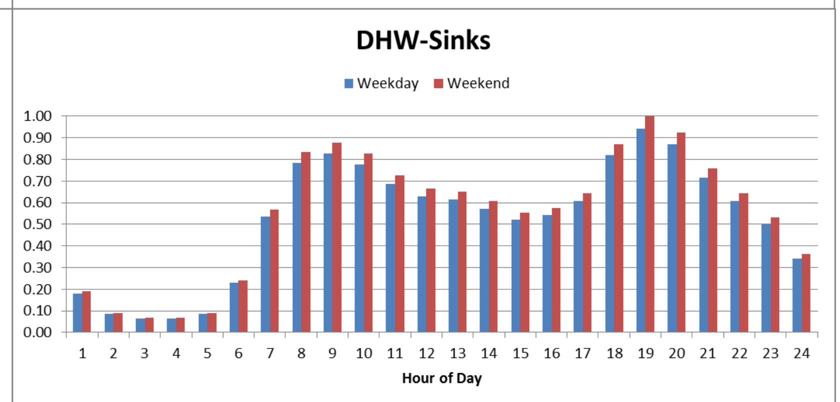

Appliances & Plug Loads
Refrigerator
Cooking Range
Miscellaneous Plug Loads
Lighting
1.00
0.80
0.60
0.40
0.20
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day

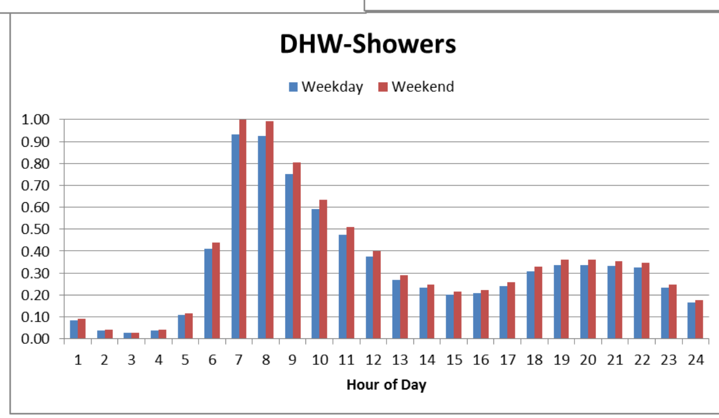

Lighting
Lighting
Energy Efficient Lighting
Exterior Lighting
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day


Clothes Washer
Weekday
Weekend
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day


Clothes Dryer
Weekday
Weekend
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day


DHW-Baths
Weekday
Weekend
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day


DHW-Sinks
Weekday
Weekend
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day


DHW-Showers
Weekday
Weekend
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day

A.4. Internal Gains Assumptions

A.4.1 Total Internal Gains for the single-family prototype for the 2009, 2012 and 2015 IECC

Appliance	Power	Total Electricity (kWh/yr)	Fraction Sensible	Fraction Latent	Fraction of electricity use not turned into heat	Internal Heat Gains (kWh/yr)		
						2009 IECC	**2012 IECC**	**2015 IECC**
Refrigerator	91.09 W	668.90	1.00	0.00	0.00	669	669	669
Clothes Washer	29.6 W	109.16	0.80	0.00	0.20	87	87	87
Clothes Dryer	222.11 W	868.15	0.15	0.05	0.80	174	174	174
Dishwasher	68.33 W	214.16	0.60	0.15	0.25	161	161	161
Range	248.97 W	604.90	0.40	0.30	0.30	423	423	423
Misc. Plug Load	0.228 W/sq.ft	3238.13	0.69	0.06	0.25	2429	2429	2429
Miscellaneous Electric Loads	182.5 W	1598.00	0.69	0.06	0.25	1199	1199	1199
IECC adjustment factor	0.0275 W/sq.ft	390.56	0.69	0.06	0.25	293	293	293
Lighting			1.00	0.00	0.00	1345	1164	1164
Occupants	3 Occupants					2123	2123	2123
Total					**kWh/yr**	**8902**	**8721**	**8721**
					kBtu/yr	**30373**	**29755**	**29755**
					Btu/day	**83213**	**81522**	**81522**

A.4.2 Total Internal Gains for the multifamily prototype for the 2009, 2012 and 2015 IECC (per dwelling unit)

Appliance	Power	Total Electricity (kWh/yr)	Fraction Sensible	Fraction Latent	Fraction of electricity use not turned into heat	Internal Heat Gains (kWh/yr)		
						2009 IECC	2012 IECC	2015 IECC
Refrigerator	91.09 W	668.90	1.00	0.00	0	669	669	669
Clothes Washer	29.6 W	109.16	0.80	0.00	0.2	87	87	87
Clothes Dryer	222.11 W	868.15	0.15	0.05	0.8	174	174	174
Dishwasher	68.33 W	214.16	0.60	0.15	0.25	161	161	161
Range	248.97 W	604.00	0.40	0.30	0.3	423	423	423
Misc. Plug Load	0.228 W/sq.ft	1619.00	0.69	0.06	0.25	1214	1214	1214
Miscellaneous Electric Loads	121.88 W	1067.00	0.69	0.06	0.25	800	800	800
IECC adjustment factor	0.0275 W/sq.ft	195.28	0.69	0.06	0.25	146	146	146
Lighting			1.00	0.00	0	405	351	351
Occupants	2 Occupants					1416	1416	1416
Total					**kWh/yr**	**5495**	**5440**	**5440**
					kBtu/yr	**18748**	**18562**	**18562**
					Btu/Day	**51364**	**50855**	**50855**

Appendix B

Disaggregated Energy Costs and Life Cycle Cost Savings

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
1	tropical	Crawlspace	Electric Resistance	multifamily	739	660	650	1.55%	12.10%	2502	117
1	tropical	Crawlspace	Electric Resistance	single-family	879	744	743	0.01%	15.39%	2762	1244
1	tropical	Crawlspace	Gas-fired Furnace	multifamily	742	661	657	0.61%	11.43%	2420	8
1	tropical	Crawlspace	Gas-fired Furnace	single-family	916	783	783	0.01%	14.47%	2713	1244
1	tropical	Crawlspace	Heat Pump	multifamily	738	659	649	1.55%	12.02%	2489	117
1	tropical	Crawlspace	Heat Pump	single-family	869	738	738	0.01%	15.14%	2698	1244
1	tropical	Crawlspace	Oil-fired Furnace	multifamily	842	761	752	1.14%	10.60%	2549	36
1	tropical	Crawlspace	Oil-fired Furnace	single-family	876	741	741	0.01%	15.37%	2750	1244
1	moist	Crawlspace	Electric Resistance	multifamily	776	682	671	1.54%	13.55%	2782	121
1	moist	Crawlspace	Electric Resistance	single-family	1518	1274	1273	0.06%	16.14%	5940	25
1	moist	Crawlspace	Gas-fired Furnace	multifamily	755	668	664	0.62%	12.09%	2536	10
1	moist	Crawlspace	Gas-fired Furnace	single-family	1410	1195	1195	0.02%	15.27%	5412	17
1	moist	Crawlspace	Heat Pump	multifamily	755	671	661	1.57%	12.55%	2598	122
1	moist	Crawlspace	Heat Pump	single-family	1424	1214	1214	0.06%	14.76%	5320	25
1	moist	Crawlspace	Oil-fired Furnace	multifamily	873	779	771	1.01%	11.64%	2765	21
1	moist	Crawlspace	Oil-fired Furnace	single-family	1589	1352	1352	0.04%	14.94%	5793	23
1	tropical	Heated Bsmt.	Electric Resistance	multifamily	735	655	645	1.48%	12.19%	2505	107
1	tropical	Heated Bsmt.	Electric Resistance	single-family	859	715	715	0.01%	16.78%	2920	1244
1	tropical	Heated Bsmt.	Gas-fired Furnace	multifamily	721	639	635	0.60%	11.97%	2448	4
1	tropical	Heated Bsmt.	Gas-fired Furnace	single-family	894	750	750	0.01%	16.06%	2910	1243
1	tropical	Heated Bsmt.	Heat Pump	multifamily	716	639	629	1.52%	12.10%	2452	107
1	tropical	Heated Bsmt.	Heat Pump	single-family	841	703	703	0.01%	16.45%	2818	1244
1	tropical	Heated Bsmt.	Oil-fired Furnace	multifamily	825	746	735	1.47%	10.97%	2571	75
1	tropical	Heated Bsmt.	Oil-fired Furnace	single-family	855	712	712	0.01%	16.74%	2901	1244
1	moist	Heated Bsmt.	Electric Resistance	multifamily	756	656	646	1.51%	14.59%	2873	111
1	moist	Heated Bsmt.	Electric Resistance	single-family	1522	1262	1262	0.06%	17.11%	6213	25
1	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	728	633	629	0.62%	13.66%	2681	5
1	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1415	1179	1178	0.02%	16.74%	5796	17
1	moist	Heated Bsmt.	Heat Pump	multifamily	728	638	628	1.56%	13.78%	2696	112
1	moist	Heated Bsmt.	Heat Pump	single-family	1429	1201	1200	0.06%	15.99%	5646	25
1	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	844	743	735	1.12%	12.91%	2896	29
1	moist	Heated Bsmt.	Oil-fired Furnace	single-family	1590	1335	1334	0.04%	16.07%	6115	23
1	tropical	Slab-on-grade	Electric Resistance	multifamily	744	658	646	1.72%	13.10%	2644	136
1	tropical	Slab-on-grade	Electric Resistance	single-family	860	719	717	0.26%	16.63%	2943	1232
1	tropical	Slab-on-grade	Gas-fired Furnace	multifamily	745	654	649	0.81%	12.86%	2615	30
1	tropical	Slab-on-grade	Gas-fired Furnace	single-family	896	754	752	0.23%	16.05%	2957	1230
1	tropical	Slab-on-grade	Heat Pump	multifamily	742	656	645	1.74%	13.14%	2646	138
1	tropical	Slab-on-grade	Heat Pump	single-family	854	714	713	0.26%	16.58%	2919	1232
1	tropical	Slab-on-grade	Oil-fired Furnace	multifamily	846	758	748	1.31%	11.60%	2706	57

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
1	tropical	Slab-on-grade	Oil-fired Furnace	single-family	858	717	715	0.27%	16.62%	2934	1233
1	moist	Slab-on-grade	Electric Resistance	multifamily	773	666	655	1.75%	15.27%	3009	142
1	moist	Slab-on-grade	Electric Resistance	single-family	1430	1168	1164	0.34%	18.63%	6364	40
1	moist	Slab-on-grade	Gas-fired Furnace	multifamily	752	650	644	0.80%	14.31%	2825	28
1	moist	Slab-on-grade	Gas-fired Furnace	single-family	1324	1087	1085	0.24%	18.08%	5883	16
1	moist	Slab-on-grade	Heat Pump	multifamily	754	656	645	1.75%	14.45%	2849	139
1	moist	Slab-on-grade	Heat Pump	single-family	1345	1116	1113	0.25%	17.28%	5758	18
1	moist	Slab-on-grade	Oil-fired Furnace	multifamily	869	762	753	1.22%	13.37%	3025	47
1	moist	Slab-on-grade	Oil-fired Furnace	single-family	1503	1245	1242	0.29%	17.36%	6254	33
1	tropical	Unheated Bsmt.	Electric Resistance	multifamily	703	627	617	1.55%	12.16%	2432	107
1	tropical	Unheated Bsmt.	Electric Resistance	single-family	774	649	649	0.02%	16.13%	2576	1244
1	tropical	Unheated Bsmt.	Gas-fired Furnace	multifamily	706	629	625	0.61%	11.51%	2359	4
1	tropical	Unheated Bsmt.	Gas-fired Furnace	single-family	810	688	688	0.01%	15.13%	2538	1243
1	tropical	Unheated Bsmt.	Heat Pump	multifamily	702	626	617	1.55%	12.09%	2421	107
1	tropical	Unheated Bsmt.	Heat Pump	single-family	764	643	643	0.02%	15.85%	2511	1244
1	tropical	Unheated Bsmt.	Oil-fired Furnace	multifamily	801	723	715	1.14%	10.66%	2481	28
1	tropical	Unheated Bsmt.	Oil-fired Furnace	single-family	771	647	647	0.01%	16.11%	2565	1244
1	moist	Unheated Bsmt.	Electric Resistance	multifamily	738	647	637	1.54%	13.62%	2697	112
1	moist	Unheated Bsmt.	Electric Resistance	single-family	1443	1221	1220	0.06%	15.43%	5541	25
1	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	719	635	632	0.62%	12.13%	2464	6
1	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1341	1145	1145	0.03%	14.64%	5077	18
1	moist	Unheated Bsmt.	Heat Pump	multifamily	718	637	627	1.56%	12.64%	2526	112
1	moist	Unheated Bsmt.	Heat Pump	single-family	1356	1164	1164	0.06%	14.19%	5005	25
1	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	830	740	733	0.99%	11.71%	2687	12
1	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	1516	1300	1299	0.05%	14.29%	5427	23
2	dry	Crawlspace	Electric Resistance	multifamily	871	759	749	1.42%	14.10%	3212	127
2	dry	Crawlspace	Electric Resistance	single-family	1943	1628	1627	0.04%	16.27%	7522	26
2	dry	Crawlspace	Gas-fired Furnace	multifamily	770	686	682	0.62%	11.41%	2592	11
2	dry	Crawlspace	Gas-fired Furnace	single-family	1586	1361	1361	0.02%	14.18%	5910	18
2	dry	Crawlspace	Heat Pump	multifamily	792	712	701	1.53%	11.52%	2652	129
2	dry	Crawlspace	Heat Pump	single-family	1611	1399	1399	0.05%	13.16%	5676	26
2	dry	Crawlspace	Oil-fired Furnace	multifamily	949	846	841	0.65%	11.46%	3004	-21
2	dry	Crawlspace	Oil-fired Furnace	single-family	1944	1650	1649	0.04%	15.15%	7111	23
2	moist	Crawlspace	Electric Resistance	multifamily	868	756	743	1.74%	14.41%	3252	169
2	moist	Crawlspace	Electric Resistance	single-family	1906	1573	1572	0.06%	17.55%	7848	28
2	moist	Crawlspace	Gas-fired Furnace	multifamily	678	611	606	0.84%	10.65%	2315	27
2	moist	Crawlspace	Gas-fired Furnace	single-family	1338	1147	1146	0.03%	14.34%	5327	19
2	moist	Crawlspace	Heat Pump	multifamily	744	677	664	1.97%	10.75%	2450	172
2	moist	Crawlspace	Heat Pump	single-family	1430	1243	1242	0.07%	13.09%	5233	28

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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2	moist	Crawlspace	Oil-fired Furnace	multifamily	934	825	813	1.51%	13.04%	3228	101
2	moist	Crawlspace	Oil-fired Furnace	single-family	1857	1556	1555	0.05%	16.27%	7229	26
2	dry	Heated Bsmt.	Electric Resistance	multifamily	880	758	747	1.35%	15.09%	3387	117
2	dry	Heated Bsmt.	Electric Resistance	single-family	2037	1678	1677	0.04%	17.68%	8302	25
2	dry	Heated Bsmt.	Gas-fired Furnace	multifamily	754	661	657	0.61%	12.80%	2745	7
2	dry	Heated Bsmt.	Gas-fired Furnace	single-family	1565	1308	1307	0.02%	16.45%	6487	18
2	dry	Heated Bsmt.	Heat Pump	multifamily	773	686	676	1.51%	12.50%	2746	118
2	dry	Heated Bsmt.	Heat Pump	single-family	1596	1363	1363	0.05%	14.59%	6045	26
2	dry	Heated Bsmt.	Oil-fired Furnace	multifamily	939	825	810	1.80%	13.78%	3366	144
2	dry	Heated Bsmt.	Oil-fired Furnace	single-family	2007	1671	1670	0.04%	16.80%	7863	23
2	moist	Heated Bsmt.	Electric Resistance	multifamily	863	745	733	1.68%	15.14%	3350	157
2	moist	Heated Bsmt.	Electric Resistance	single-family	2017	1660	1659	0.05%	17.75%	8266	28
2	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	661	587	582	0.83%	12.05%	2450	22
2	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1380	1162	1162	0.03%	15.82%	5796	19
2	moist	Heated Bsmt.	Heat Pump	multifamily	724	652	639	1.94%	11.77%	2544	159
2	moist	Heated Bsmt.	Heat Pump	single-family	1479	1269	1268	0.07%	14.27%	5657	28
2	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	903	795	785	1.23%	13.04%	3157	54
2	moist	Heated Bsmt.	Oil-fired Furnace	single-family	1949	1623	1622	0.05%	16.76%	7666	26
2	dry	Slab-on-grade	Electric Resistance	multifamily	857	736	722	1.94%	15.83%	3439	188
2	dry	Slab-on-grade	Electric Resistance	single-family	1827	1488	1476	0.78%	19.17%	8170	175
2	dry	Slab-on-grade	Gas-fired Furnace	multifamily	766	673	666	1.00%	12.95%	2793	56
2	dry	Slab-on-grade	Gas-fired Furnace	single-family	1496	1255	1248	0.55%	16.57%	6361	91
2	dry	Slab-on-grade	Heat Pump	multifamily	789	702	688	1.87%	12.78%	2822	168
2	dry	Slab-on-grade	Heat Pump	single-family	1533	1311	1305	0.44%	14.87%	5999	72
2	dry	Slab-on-grade	Oil-fired Furnace	multifamily	938	824	815	1.09%	13.10%	3253	40
2	dry	Slab-on-grade	Oil-fired Furnace	single-family	1835	1519	1508	0.71%	17.81%	7724	158
2	moist	Slab-on-grade	Electric Resistance	multifamily	852	728	711	2.29%	16.49%	3523	230
2	moist	Slab-on-grade	Electric Resistance	single-family	1801	1444	1432	0.84%	20.52%	8512	185
2	moist	Slab-on-grade	Gas-fired Furnace	multifamily	671	592	585	1.17%	12.91%	2574	58
2	moist	Slab-on-grade	Gas-fired Furnace	single-family	1259	1045	1040	0.54%	17.39%	5851	69
2	moist	Slab-on-grade	Heat Pump	multifamily	736	657	642	2.39%	12.83%	2708	213
2	moist	Slab-on-grade	Heat Pump	single-family	1350	1142	1135	0.62%	15.93%	5774	94
2	moist	Slab-on-grade	Oil-fired Furnace	multifamily	917	795	782	1.69%	14.70%	3454	118
2	moist	Slab-on-grade	Oil-fired Furnace	single-family	1756	1432	1421	0.74%	19.10%	7862	154
2	dry	Unheated Bsmt.	Electric Resistance	multifamily	826	719	709	1.42%	14.15%	3105	117
2	dry	Unheated Bsmt.	Electric Resistance	single-family	1848	1556	1555	0.05%	15.87%	7116	26
2	dry	Unheated Bsmt.	Gas-fired Furnace	multifamily	732	652	648	0.62%	11.45%	2520	7
2	dry	Unheated Bsmt.	Gas-fired Furnace	single-family	1504	1295	1295	0.02%	13.90%	5628	18
2	dry	Unheated Bsmt.	Heat Pump	multifamily	752	675	665	1.53%	11.56%	2574	119

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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2	dry	Unheated Bsmt.	Heat Pump	single-family	1533	1336	1335	0.06%	12.90%	5421	26
2	dry	Unheated Bsmt.	Oil-fired Furnace	multifamily	901	802	797	0.63%	11.56%	2921	-28
2	dry	Unheated Bsmt.	Oil-fired Furnace	single-family	1851	1578	1578	0.04%	14.74%	6729	23
2	moist	Unheated Bsmt.	Electric Resistance	multifamily	822	717	705	1.74%	14.28%	3114	157
2	moist	Unheated Bsmt.	Electric Resistance	single-family	1831	1524	1523	0.06%	16.83%	7380	28
2	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	645	581	576	0.84%	10.64%	2252	22
2	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1283	1104	1103	0.03%	13.98%	5105	19
2	moist	Unheated Bsmt.	Heat Pump	multifamily	706	644	631	1.96%	10.66%	2368	159
2	moist	Unheated Bsmt.	Heat Pump	single-family	1376	1203	1202	0.07%	12.66%	5005	28
2	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	885	781	771	1.29%	12.87%	3088	59
2	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	1787	1508	1508	0.05%	15.62%	6826	26
3	dry	Crawlspace	Electric Resistance	multifamily	874	696	681	2.13%	22.07%	4650	198
3	dry	Crawlspace	Electric Resistance	single-family	1984	1370	1369	0.07%	30.99%	13368	30
3	dry	Crawlspace	Gas-fired Furnace	multifamily	630	542	536	1.06%	14.91%	2903	37
3	dry	Crawlspace	Gas-fired Furnace	single-family	1278	968	967	0.04%	24.31%	7998	20
3	dry	Crawlspace	Heat Pump	multifamily	733	647	632	2.32%	13.88%	3037	201
3	dry	Crawlspace	Heat Pump	single-family	1409	1116	1115	0.09%	20.88%	7688	30
3	dry	Crawlspace	Oil-fired Furnace	multifamily	931	766	754	1.61%	19.02%	4391	99
3	dry	Crawlspace	Oil-fired Furnace	single-family	1897	1354	1353	0.06%	28.67%	12022	28
3	marine	Crawlspace	Electric Resistance	multifamily	767	573	556	3.05%	27.53%	4973	246
3	marine	Crawlspace	Electric Resistance	single-family	1900	1168	1167	0.10%	38.59%	15469	33
3	marine	Crawlspace	Gas-fired Furnace	multifamily	441	376	369	1.79%	16.38%	2520	55
3	marine	Crawlspace	Gas-fired Furnace	single-family	919	629	628	0.07%	31.67%	7661	21
3	marine	Crawlspace	Heat Pump	multifamily	575	510	492	3.49%	14.39%	2698	250
3	marine	Crawlspace	Heat Pump	single-family	1078	828	827	0.14%	23.32%	6929	34
3	marine	Crawlspace	Oil-fired Furnace	multifamily	795	634	623	1.67%	21.60%	4291	69
3	marine	Crawlspace	Oil-fired Furnace	single-family	1725	1098	1097	0.09%	36.42%	13481	30
3	moist	Crawlspace	Electric Resistance	multifamily	1046	814	798	1.90%	23.68%	5621	209
3	moist	Crawlspace	Electric Resistance	single-family	2450	1652	1651	0.06%	32.60%	16630	31
3	moist	Crawlspace	Gas-fired Furnace	multifamily	687	580	574	1.03%	16.53%	3255	42
3	moist	Crawlspace	Gas-fired Furnace	single-family	1442	1060	1060	0.04%	26.48%	9267	20
3	moist	Crawlspace	Heat Pump	multifamily	821	704	688	2.22%	16.15%	3582	212
3	moist	Crawlspace	Heat Pump	single-family	1653	1244	1243	0.08%	24.80%	9740	31
3	moist	Crawlspace	Oil-fired Furnace	multifamily	1070	859	845	1.66%	21.00%	5225	132
3	moist	Crawlspace	Oil-fired Furnace	single-family	2298	1593	1592	0.06%	30.71%	14854	28
3	dry	Heated Bsmt.	Electric Resistance	multifamily	816	652	638	2.16%	21.80%	4385	185
3	dry	Heated Bsmt.	Electric Resistance	single-family	1920	1334	1333	0.07%	30.57%	12879	30
3	dry	Heated Bsmt.	Gas-fired Furnace	multifamily	597	515	509	1.06%	14.71%	2794	33
3	dry	Heated Bsmt.	Gas-fired Furnace	single-family	1296	990	989	0.04%	23.67%	7926	19

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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3	dry	Heated Bsmt.	Heat Pump	multifamily	701	619	605	2.29%	13.74%	2941	187
3	dry	Heated Bsmt.	Heat Pump	single-family	1455	1158	1157	0.09%	20.52%	7767	30
3	dry	Heated Bsmt.	Oil-fired Furnace	multifamily	864	717	704	1.76%	18.45%	4081	104
3	dry	Heated Bsmt.	Oil-fired Furnace	single-family	1850	1330	1329	0.06%	28.16%	11627	28
3	marine	Heated Bsmt.	Electric Resistance	multifamily	713	543	527	3.06%	26.17%	4541	230
3	marine	Heated Bsmt.	Electric Resistance	single-family	1789	1119	1118	0.11%	37.52%	14374	33
3	marine	Heated Bsmt.	Gas-fired Furnace	multifamily	416	363	357	1.76%	14.17%	2282	50
3	marine	Heated Bsmt.	Gas-fired Furnace	single-family	901	648	647	0.07%	28.21%	7002	21
3	marine	Heated Bsmt.	Heat Pump	multifamily	549	492	475	3.43%	13.54%	2551	234
3	marine	Heated Bsmt.	Heat Pump	single-family	1115	871	870	0.14%	22.00%	6820	34
3	marine	Heated Bsmt.	Oil-fired Furnace	multifamily	740	598	587	1.77%	20.65%	3961	69
3	marine	Heated Bsmt.	Oil-fired Furnace	single-family	1634	1066	1065	0.09%	34.83%	12446	30
3	moist	Heated Bsmt.	Electric Resistance	multifamily	980	758	743	1.93%	24.18%	5433	195
3	moist	Heated Bsmt.	Electric Resistance	single-family	2399	1613	1612	0.06%	32.77%	16407	31
3	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	649	543	537	1.04%	17.21%	3219	36
3	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1465	1079	1078	0.04%	26.42%	9361	20
3	moist	Heated Bsmt.	Heat Pump	multifamily	784	668	654	2.21%	16.59%	3536	198
3	moist	Heated Bsmt.	Heat Pump	single-family	1704	1283	1282	0.08%	24.75%	9947	31
3	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	991	798	785	1.55%	20.73%	4889	100
3	moist	Heated Bsmt.	Oil-fired Furnace	single-family	2260	1565	1564	0.06%	30.81%	14700	28
3	dry	Slab-on-grade	Electric Resistance	multifamily	855	676	657	2.79%	23.12%	4736	270
3	dry	Slab-on-grade	Electric Resistance	single-family	1885	1275	1261	1.14%	33.10%	13572	228
3	dry	Slab-on-grade	Gas-fired Furnace	multifamily	625	536	528	1.42%	15.56%	2963	71
3	dry	Slab-on-grade	Gas-fired Furnace	single-family	1204	894	887	0.71%	26.29%	8146	81
3	dry	Slab-on-grade	Heat Pump	multifamily	726	636	618	2.81%	14.88%	3148	252
3	dry	Slab-on-grade	Heat Pump	single-family	1334	1040	1032	0.76%	22.64%	7869	108
3	dry	Slab-on-grade	Oil-fired Furnace	multifamily	912	748	732	2.17%	19.78%	4451	167
3	dry	Slab-on-grade	Oil-fired Furnace	single-family	1802	1262	1250	0.98%	30.62%	12205	185
3	marine	Slab-on-grade	Electric Resistance	multifamily	742	558	538	3.69%	27.57%	4860	301
3	marine	Slab-on-grade	Electric Resistance	single-family	1841	1127	1110	1.47%	39.67%	15460	261
3	marine	Slab-on-grade	Gas-fired Furnace	multifamily	436	377	370	1.96%	15.16%	2410	67
3	marine	Slab-on-grade	Gas-fired Furnace	single-family	881	598	592	1.00%	32.83%	7667	75
3	marine	Slab-on-grade	Heat Pump	multifamily	569	509	490	3.70%	13.87%	2631	269
3	marine	Slab-on-grade	Heat Pump	single-family	1048	803	798	0.65%	23.83%	6942	61
3	marine	Slab-on-grade	Oil-fired Furnace	multifamily	775	622	608	2.25%	21.55%	4209	128
3	marine	Slab-on-grade	Oil-fired Furnace	single-family	1668	1057	1043	1.28%	37.44%	13455	206
3	moist	Slab-on-grade	Electric Resistance	multifamily	1020	780	759	2.68%	25.57%	5856	306
3	moist	Slab-on-grade	Electric Resistance	single-family	2339	1536	1518	1.17%	35.10%	17068	286
3	moist	Slab-on-grade	Gas-fired Furnace	multifamily	677	562	553	1.50%	18.33%	3441	85

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3	moist	Slab-on-grade	Gas-fired Furnace	single-family	1361	970	962	0.79%	29.29%	9609	105
3	moist	Slab-on-grade	Heat Pump	multifamily	807	681	661	2.97%	18.12%	3824	293
3	moist	Slab-on-grade	Heat Pump	single-family	1566	1146	1133	1.08%	27.64%	10190	189
3	moist	Slab-on-grade	Oil-fired Furnace	multifamily	1042	827	808	2.21%	22.45%	5390	202
3	moist	Slab-on-grade	Oil-fired Furnace	single-family	2190	1479	1464	1.05%	33.17%	15263	241
3	dry	Unheated Bsmt.	Electric Resistance	multifamily	828	661	647	2.12%	21.90%	4446	184
3	dry	Unheated Bsmt.	Electric Resistance	single-family	1921	1322	1321	0.08%	31.23%	13103	30
3	dry	Unheated Bsmt.	Gas-fired Furnace	multifamily	601	517	512	1.05%	14.76%	2809	32
3	dry	Unheated Bsmt.	Gas-fired Furnace	single-family	1230	926	926	0.04%	24.71%	7878	19
3	dry	Unheated Bsmt.	Heat Pump	multifamily	699	617	603	2.30%	13.68%	2927	187
3	dry	Unheated Bsmt.	Heat Pump	single-family	1365	1078	1077	0.09%	21.12%	7583	30
3	dry	Unheated Bsmt.	Oil-fired Furnace	multifamily	882	728	716	1.60%	18.75%	4187	88
3	dry	Unheated Bsmt.	Oil-fired Furnace	single-family	1837	1306	1305	0.06%	28.95%	11813	27
3	marine	Unheated Bsmt.	Electric Resistance	multifamily	722	542	525	3.06%	27.23%	4716	229
3	marine	Unheated Bsmt.	Electric Resistance	single-family	1854	1137	1136	0.10%	38.73%	15199	33
3	marine	Unheated Bsmt.	Gas-fired Furnace	multifamily	419	358	352	1.78%	15.95%	2423	49
3	marine	Unheated Bsmt.	Gas-fired Furnace	single-family	890	605	604	0.07%	32.08%	7558	20
3	marine	Unheated Bsmt.	Heat Pump	multifamily	545	485	468	3.48%	14.08%	2592	234
3	marine	Unheated Bsmt.	Heat Pump	single-family	1053	806	805	0.15%	23.56%	6871	34
3	marine	Unheated Bsmt.	Oil-fired Furnace	multifamily	751	601	591	1.65%	21.31%	4085	57
3	marine	Unheated Bsmt.	Oil-fired Furnace	single-family	1683	1067	1066	0.10%	36.67%	13285	30
3	moist	Unheated Bsmt.	Electric Resistance	multifamily	990	772	758	1.89%	23.46%	5348	194
3	moist	Unheated Bsmt.	Electric Resistance	single-family	2381	1605	1604	0.06%	32.61%	16238	31
3	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	654	553	547	1.02%	16.37%	3139	36
3	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1396	1023	1023	0.04%	26.71%	9108	20
3	moist	Unheated Bsmt.	Heat Pump	multifamily	781	672	657	2.20%	15.85%	3428	198
3	moist	Unheated Bsmt.	Heat Pump	single-family	1611	1212	1211	0.09%	24.84%	9565	31
3	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	1011	815	802	1.52%	20.61%	4938	99
3	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	2233	1547	1547	0.06%	30.74%	14516	28
4	dry	Crawlspace	Electric Resistance	multifamily	999	814	796	2.18%	20.28%	4661	250
4	dry	Crawlspace	Electric Resistance	single-family	2336	1630	1629	0.07%	30.25%	14510	34
4	dry	Crawlspace	Gas-fired Furnace	multifamily	639	557	550	1.22%	13.89%	2650	57
4	dry	Crawlspace	Gas-fired Furnace	single-family	1331	1012	1011	0.04%	24.02%	7675	21
4	dry	Crawlspace	Heat Pump	multifamily	820	733	715	2.45%	12.78%	2928	254
4	dry	Crawlspace	Heat Pump	single-family	1582	1257	1256	0.10%	20.61%	7766	34
4	dry	Crawlspace	Oil-fired Furnace	multifamily	1038	864	846	2.08%	18.50%	4489	198
4	dry	Crawlspace	Oil-fired Furnace	single-family	2177	1562	1560	0.07%	28.32%	12797	31
4	marine	Crawlspace	Electric Resistance	multifamily	989	824	805	2.29%	18.57%	4326	270
4	marine	Crawlspace	Electric Resistance	single-family	2418	1752	1751	0.07%	27.61%	13822	35

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
4	marine	Crawlspace	Gas-fired Furnace	multifamily	561	495	488	1.46%	13.03%	2373	64
4	marine	Crawlspace	Gas-fired Furnace	single-family	1202	931	931	0.05%	22.57%	6819	21
4	marine	Crawlspace	Heat Pump	multifamily	786	711	691	2.70%	12.03%	2747	276
4	marine	Crawlspace	Heat Pump	single-family	1537	1243	1242	0.10%	19.18%	7209	35
4	marine	Crawlspace	Oil-fired Furnace	multifamily	985	845	829	1.86%	15.85%	3859	158
4	marine	Crawlspace	Oil-fired Furnace	single-family	2199	1623	1622	0.07%	26.25%	12095	32
4	moist	Crawlspace	Electric Resistance	multifamily	1170	928	910	1.94%	22.26%	5688	254
4	moist	Crawlspace	Electric Resistance	single-family	2857	1943	1942	0.06%	32.03%	18208	34
4	moist	Crawlspace	Gas-fired Furnace	multifamily	683	580	573	1.18%	16.05%	3023	58
4	moist	Crawlspace	Gas-fired Furnace	single-family	1494	1095	1094	0.04%	26.76%	9105	21
4	moist	Crawlspace	Heat Pump	multifamily	889	769	751	2.37%	15.52%	3516	259
4	moist	Crawlspace	Heat Pump	single-family	1835	1377	1375	0.09%	25.04%	10128	34
4	moist	Crawlspace	Oil-fired Furnace	multifamily	1166	950	932	1.91%	20.03%	5215	200
4	moist	Crawlspace	Oil-fired Furnace	single-family	2619	1818	1817	0.06%	30.60%	16035	31
4	dry	Heated Bsmt.	Electric Resistance	multifamily	920	747	730	2.26%	20.64%	4435	234
4	dry	Heated Bsmt.	Electric Resistance	single-family	2220	1531	1530	0.08%	31.11%	14229	34
4	dry	Heated Bsmt.	Gas-fired Furnace	multifamily	601	524	518	1.24%	13.88%	2555	51
4	dry	Heated Bsmt.	Gas-fired Furnace	single-family	1317	999	998	0.05%	24.19%	7654	21
4	dry	Heated Bsmt.	Heat Pump	multifamily	777	695	678	2.45%	12.66%	2814	237
4	dry	Heated Bsmt.	Heat Pump	single-family	1593	1266	1265	0.10%	20.63%	7810	34
4	dry	Heated Bsmt.	Oil-fired Furnace	multifamily	947	794	776	2.36%	18.08%	4124	212
4	dry	Heated Bsmt.	Oil-fired Furnace	single-family	2083	1479	1478	0.07%	29.02%	12588	31
4	marine	Heated Bsmt.	Electric Resistance	multifamily	915	757	739	2.37%	19.19%	4183	254
4	marine	Heated Bsmt.	Electric Resistance	single-family	2292	1642	1641	0.08%	28.42%	13534	35
4	marine	Heated Bsmt.	Gas-fired Furnace	multifamily	526	464	457	1.48%	13.04%	2293	58
4	marine	Heated Bsmt.	Gas-fired Furnace	single-family	1177	914	914	0.05%	22.39%	6681	21
4	marine	Heated Bsmt.	Heat Pump	multifamily	747	676	658	2.69%	11.90%	2646	258
4	marine	Heated Bsmt.	Heat Pump	single-family	1554	1261	1260	0.10%	18.95%	7206	35
4	marine	Heated Bsmt.	Oil-fired Furnace	multifamily	908	779	764	1.92%	15.91%	3656	145
4	marine	Heated Bsmt.	Oil-fired Furnace	single-family	2093	1534	1533	0.07%	26.77%	11802	31
4	moist	Heated Bsmt.	Electric Resistance	multifamily	1077	847	830	2.01%	22.89%	5441	238
4	moist	Heated Bsmt.	Electric Resistance	single-family	2742	1841	1839	0.07%	32.93%	17991	34
4	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	637	538	532	1.22%	16.50%	2942	52
4	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1481	1082	1082	0.04%	26.98%	9100	21
4	moist	Heated Bsmt.	Heat Pump	multifamily	842	726	709	2.38%	15.75%	3420	242
4	moist	Heated Bsmt.	Heat Pump	single-family	1862	1392	1391	0.09%	25.29%	10329	34
4	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	1061	868	851	1.94%	19.75%	4797	178
4	moist	Heated Bsmt.	Oil-fired Furnace	single-family	2523	1734	1733	0.06%	31.30%	15830	31
4	dry	Slab-on-grade	Electric Resistance	multifamily	968	778	753	3.12%	22.20%	4881	366

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
4	dry	Slab-on-grade	Electric Resistance	single-family	2204	1488	1466	1.48%	33.49%	15113	360
4	dry	Slab-on-grade	Gas-fired Furnace	multifamily	631	547	537	1.73%	14.85%	2738	104
4	dry	Slab-on-grade	Gas-fired Furnace	single-family	1245	920	911	0.98%	26.83%	7976	130
4	dry	Slab-on-grade	Heat Pump	multifamily	803	709	686	3.23%	14.64%	3155	342
4	dry	Slab-on-grade	Heat Pump	single-family	1482	1145	1133	1.12%	23.59%	8226	195
4	dry	Slab-on-grade	Oil-fired Furnace	multifamily	1005	831	808	2.75%	19.62%	4582	284
4	dry	Slab-on-grade	Oil-fired Furnace	single-family	2053	1427	1408	1.31%	31.41%	13336	296
4	marine	Slab-on-grade	Electric Resistance	multifamily	958	785	758	3.33%	20.83%	4608	399
4	marine	Slab-on-grade	Electric Resistance	single-family	2327	1626	1600	1.57%	31.22%	14907	423
4	marine	Slab-on-grade	Gas-fired Furnace	multifamily	552	484	474	2.03%	14.20%	2468	111
4	marine	Slab-on-grade	Gas-fired Furnace	single-family	1143	857	847	1.18%	25.92%	7308	149
4	marine	Slab-on-grade	Heat Pump	multifamily	770	686	661	3.61%	14.15%	3001	374
4	marine	Slab-on-grade	Heat Pump	single-family	1468	1149	1133	1.34%	22.81%	7965	241
4	marine	Slab-on-grade	Oil-fired Furnace	multifamily	957	812	790	2.66%	17.46%	4051	260
4	marine	Slab-on-grade	Oil-fired Furnace	single-family	2110	1506	1484	1.45%	29.67%	13001	350
4	moist	Slab-on-grade	Electric Resistance	multifamily	1129	875	848	3.01%	24.87%	6050	402
4	moist	Slab-on-grade	Electric Resistance	single-family	2706	1772	1746	1.49%	35.49%	19050	438
4	moist	Slab-on-grade	Gas-fired Furnace	multifamily	668	558	548	1.81%	18.07%	3222	116
4	moist	Slab-on-grade	Gas-fired Furnace	single-family	1402	989	978	1.07%	30.20%	9569	158
4	moist	Slab-on-grade	Heat Pump	multifamily	865	733	708	3.42%	18.14%	3853	379
4	moist	Slab-on-grade	Heat Pump	single-family	1725	1245	1227	1.48%	28.89%	10862	295
4	moist	Slab-on-grade	Oil-fired Furnace	multifamily	1124	902	878	2.68%	21.90%	5437	306
4	moist	Slab-on-grade	Oil-fired Furnace	single-family	2477	1659	1636	1.37%	33.97%	16780	366
4	dry	Unheated Bsmt.	Electric Resistance	multifamily	943	772	755	2.18%	19.97%	4411	233
4	dry	Unheated Bsmt.	Electric Resistance	single-family	2280	1573	1572	0.08%	31.06%	14535	34
4	dry	Unheated Bsmt.	Gas-fired Furnace	multifamily	608	532	526	1.21%	13.61%	2545	50
4	dry	Unheated Bsmt.	Gas-fired Furnace	single-family	1282	962	962	0.05%	24.96%	7681	21
4	dry	Unheated Bsmt.	Heat Pump	multifamily	781	700	683	2.43%	12.46%	2795	237
4	dry	Unheated Bsmt.	Heat Pump	single-family	1539	1212	1210	0.10%	21.37%	7814	34
4	dry	Unheated Bsmt.	Oil-fired Furnace	multifamily	979	820	803	2.05%	17.94%	4202	178
4	dry	Unheated Bsmt.	Oil-fired Furnace	single-family	2121	1502	1501	0.07%	29.23%	12859	31
4	marine	Unheated Bsmt.	Electric Resistance	multifamily	936	785	767	2.28%	18.03%	4064	252
4	marine	Unheated Bsmt.	Electric Resistance	single-family	2368	1719	1718	0.07%	27.47%	13518	35
4	marine	Unheated Bsmt.	Gas-fired Furnace	multifamily	535	474	467	1.44%	12.61%	2272	57
4	marine	Unheated Bsmt.	Gas-fired Furnace	single-family	1164	901	901	0.05%	22.65%	6684	21
4	marine	Unheated Bsmt.	Heat Pump	multifamily	748	680	662	2.68%	11.54%	2603	258
4	marine	Unheated Bsmt.	Heat Pump	single-family	1505	1216	1215	0.11%	19.28%	7129	35
4	marine	Unheated Bsmt.	Oil-fired Furnace	multifamily	932	805	791	1.79%	15.13%	3593	134
4	marine	Unheated Bsmt.	Oil-fired Furnace	single-family	2150	1589	1588	0.07%	26.14%	11831	31

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
4	moist	Unheated Bsmt.	Electric Resistance	multifamily	1104	879	862	1.94%	21.90%	5358	237
4	moist	Unheated Bsmt.	Electric Resistance	single-family	2807	1897	1896	0.06%	32.45%	18130	34
4	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	649	553	547	1.18%	15.77%	2894	52
4	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1454	1056	1056	0.04%	27.40%	9083	21
4	moist	Unheated Bsmt.	Heat Pump	multifamily	845	735	718	2.35%	15.07%	3327	242
4	moist	Unheated Bsmt.	Heat Pump	single-family	1804	1344	1343	0.09%	25.55%	10154	34
4	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	1098	902	886	1.81%	19.35%	4848	168
4	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	2571	1773	1772	0.06%	31.05%	15978	31
5	dry	Crawlspace	Electric Resistance	multifamily	1101	922	903	2.09%	18.01%	4409	278
5	dry	Crawlspace	Electric Resistance	single-family	2653	1946	1944	0.07%	26.71%	14054	36
5	dry	Crawlspace	Gas-fired Furnace	multifamily	630	557	549	1.32%	12.77%	2326	67
5	dry	Crawlspace	Gas-fired Furnace	single-family	1351	1061	1060	0.05%	21.54%	6680	21
5	dry	Crawlspace	Heat Pump	multifamily	887	798	778	2.46%	12.32%	2831	283
5	dry	Crawlspace	Heat Pump	single-family	1774	1430	1429	0.09%	19.47%	7617	36
5	dry	Crawlspace	Oil-fired Furnace	multifamily	1097	938	918	2.15%	16.32%	4081	235
5	dry	Crawlspace	Oil-fired Furnace	single-family	2420	1808	1807	0.06%	25.34%	12235	32
5	moist	Crawlspace	Electric Resistance	multifamily	1376	1111	1091	1.81%	20.75%	5954	292
5	moist	Crawlspace	Electric Resistance	single-family	3445	2411	2410	0.06%	30.07%	19859	37
5	moist	Crawlspace	Gas-fired Furnace	multifamily	730	623	616	1.23%	15.68%	2933	73
5	moist	Crawlspace	Gas-fired Furnace	single-family	1655	1232	1231	0.04%	25.59%	9042	22
5	moist	Crawlspace	Heat Pump	multifamily	1062	911	891	2.24%	16.13%	3931	297
5	moist	Crawlspace	Heat Pump	single-family	2350	1737	1736	0.08%	26.11%	12369	37
5	moist	Crawlspace	Oil-fired Furnace	multifamily	1322	1092	1070	2.00%	19.01%	5348	265
5	moist	Crawlspace	Oil-fired Furnace	single-family	3113	2212	2211	0.05%	28.98%	17297	33
5	dry	Heated Bsmt.	Electric Resistance	multifamily	994	812	793	2.27%	20.18%	4485	261
5	dry	Heated Bsmt.	Electric Resistance	single-family	2451	1726	1725	0.08%	29.65%	14621	36
5	dry	Heated Bsmt.	Gas-fired Furnace	multifamily	582	507	500	1.39%	14.02%	2381	61
5	dry	Heated Bsmt.	Gas-fired Furnace	single-family	1298	999	998	0.05%	23.05%	7066	22
5	dry	Heated Bsmt.	Heat Pump	multifamily	828	740	721	2.51%	12.85%	2814	265
5	dry	Heated Bsmt.	Heat Pump	single-family	1742	1396	1394	0.09%	19.97%	7907	36
5	dry	Heated Bsmt.	Oil-fired Furnace	multifamily	984	831	813	2.12%	17.36%	3976	192
5	dry	Heated Bsmt.	Oil-fired Furnace	single-family	2249	1622	1621	0.07%	27.92%	12743	32
5	moist	Heated Bsmt.	Electric Resistance	multifamily	1276	1017	998	1.88%	21.78%	5855	274
5	moist	Heated Bsmt.	Electric Resistance	single-family	3324	2283	2282	0.06%	31.36%	20214	37
5	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	681	577	570	1.26%	16.36%	2915	65
5	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1634	1209	1209	0.04%	26.04%	9321	22
5	moist	Heated Bsmt.	Heat Pump	multifamily	1007	858	839	2.26%	16.74%	3917	278
5	moist	Heated Bsmt.	Heat Pump	single-family	2362	1732	1731	0.08%	26.73%	12930	37
5	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	1216	997	979	1.83%	19.45%	5123	202

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
5	moist	Heated Bsmt.	Oil-fired Furnace	single-family	3009	2105	2103	0.06%	30.10%	17605	33
5	dry	Slab-on-grade	Electric Resistance	multifamily	1061	868	840	3.17%	20.78%	4800	422
5	dry	Slab-on-grade	Electric Resistance	single-family	2518	1767	1740	1.50%	30.90%	15333	438
5	dry	Slab-on-grade	Gas-fired Furnace	multifamily	616	538	528	1.95%	14.37%	2472	122
5	dry	Slab-on-grade	Gas-fired Furnace	single-family	1267	957	946	1.10%	25.29%	7245	156
5	dry	Slab-on-grade	Heat Pump	multifamily	862	756	729	3.58%	15.41%	3246	415
5	dry	Slab-on-grade	Heat Pump	single-family	1669	1285	1265	1.54%	24.23%	8708	319
5	dry	Slab-on-grade	Oil-fired Furnace	multifamily	1056	889	864	2.87%	18.23%	4318	329
5	dry	Slab-on-grade	Oil-fired Furnace	single-family	2293	1643	1620	1.37%	29.36%	13335	363
5	moist	Slab-on-grade	Electric Resistance	multifamily	1337	1056	1024	2.97%	23.37%	6430	491
5	moist	Slab-on-grade	Electric Resistance	single-family	3318	2242	2208	1.53%	33.47%	21225	577
5	moist	Slab-on-grade	Gas-fired Furnace	multifamily	716	601	589	1.98%	17.73%	3155	147
5	moist	Slab-on-grade	Gas-fired Furnace	single-family	1572	1128	1114	1.20%	29.11%	9693	210
5	moist	Slab-on-grade	Heat Pump	multifamily	1032	863	831	3.64%	19.44%	4450	493
5	moist	Slab-on-grade	Heat Pump	single-family	2238	1577	1547	1.94%	30.88%	13785	510
5	moist	Slab-on-grade	Oil-fired Furnace	multifamily	1285	1042	1011	2.98%	21.30%	5740	426
5	moist	Slab-on-grade	Oil-fired Furnace	single-family	2991	2053	2023	1.44%	32.36%	18492	485
5	dry	Unheated Bsmt.	Electric Resistance	multifamily	1043	878	859	2.08%	17.56%	4139	260
5	dry	Unheated Bsmt.	Electric Resistance	single-family	2597	1905	1903	0.07%	26.69%	13780	36
5	dry	Unheated Bsmt.	Gas-fired Furnace	multifamily	600	532	525	1.31%	12.43%	2221	60
5	dry	Unheated Bsmt.	Gas-fired Furnace	single-family	1308	1023	1023	0.05%	21.80%	6573	21
5	dry	Unheated Bsmt.	Heat Pump	multifamily	845	763	744	2.43%	11.89%	2674	265
5	dry	Unheated Bsmt.	Heat Pump	single-family	1734	1395	1393	0.09%	19.65%	7532	36
5	dry	Unheated Bsmt.	Oil-fired Furnace	multifamily	1037	892	874	1.96%	15.67%	3792	189
5	dry	Unheated Bsmt.	Oil-fired Furnace	single-family	2367	1767	1766	0.06%	25.41%	12030	32
5	moist	Unheated Bsmt.	Electric Resistance	multifamily	1304	1062	1043	1.80%	20.05%	5529	273
5	moist	Unheated Bsmt.	Electric Resistance	single-family	3392	2388	2387	0.06%	29.64%	19317	37
5	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	695	598	591	1.22%	15.06%	2759	65
5	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1616	1206	1205	0.04%	25.39%	8807	21
5	moist	Unheated Bsmt.	Heat Pump	multifamily	1012	875	855	2.21%	15.46%	3665	278
5	moist	Unheated Bsmt.	Heat Pump	single-family	2321	1719	1718	0.08%	25.98%	12179	37
5	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	1251	1043	1023	1.94%	18.26%	4949	236
5	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	3062	2187	2186	0.05%	28.60%	16833	33
6	dry	Crawlspace	Electric Resistance	multifamily	1343	1066	1044	2.07%	22.32%	6631	327
6	dry	Crawlspace	Electric Resistance	single-family	3322	2260	2259	0.07%	32.01%	21524	39
6	dry	Crawlspace	Gas-fired Furnace	multifamily	683	577	569	1.45%	16.64%	3340	85
6	dry	Crawlspace	Gas-fired Furnace	single-family	1533	1111	1111	0.05%	27.56%	10207	22
6	dry	Crawlspace	Heat Pump	multifamily	1070	916	894	2.44%	16.48%	4443	332
6	dry	Crawlspace	Heat Pump	single-family	2303	1687	1685	0.09%	26.83%	13630	39

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
					2009 IECC	2012 IECC	2015 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC	2015 IECC compared to 2012 IECC	2015 IECC compared to 2009 IECC
6	dry	Crawlspace	Oil-fired Furnace	multifamily	1283	1056	1035	2.06%	19.34%	5714	264
6	dry	Crawlspace	Oil-fired Furnace	single-family	2981	2061	2060	0.06%	30.90%	18803	35
6	moist	Crawlspace	Electric Resistance	multifamily	1469	1141	1119	1.89%	23.82%	7517	318
6	moist	Crawlspace	Electric Resistance	single-family	3714	2458	2456	0.06%	33.87%	24976	38
6	moist	Crawlspace	Gas-fired Furnace	multifamily	730	605	597	1.36%	18.30%	3699	82
6	moist	Crawlspace	Gas-fired Furnace	single-family	1686	1188	1187	0.05%	29.59%	11570	22
6	moist	Crawlspace	Heat Pump	multifamily	1131	938	916	2.33%	18.98%	5120	323
6	moist	Crawlspace	Heat Pump	single-family	2591	1794	1792	0.08%	30.84%	16838	39
6	moist	Crawlspace	Oil-fired Furnace	multifamily	1386	1115	1089	2.29%	21.37%	6554	329
6	moist	Crawlspace	Oil-fired Furnace	single-family	3325	2235	2234	0.06%	32.82%	21789	34
6	dry	Heated Bsmt.	Electric Resistance	multifamily	1209	951	930	2.21%	23.11%	6268	307
6	dry	Heated Bsmt.	Electric Resistance	single-family	3065	2053	2052	0.07%	33.05%	20630	39
6	dry	Heated Bsmt.	Gas-fired Furnace	multifamily	622	526	518	1.52%	16.80%	3179	78
6	dry	Heated Bsmt.	Gas-fired Furnace	single-family	1450	1050	1049	0.05%	27.68%	9830	23
6	dry	Heated Bsmt.	Heat Pump	multifamily	999	855	834	2.48%	16.56%	4250	311
6	dry	Heated Bsmt.	Heat Pump	single-family	2252	1651	1649	0.09%	26.78%	13366	39
6	dry	Heated Bsmt.	Oil-fired Furnace	multifamily	1153	941	921	2.20%	20.16%	5439	246
6	dry	Heated Bsmt.	Oil-fired Furnace	single-family	2756	1883	1881	0.07%	31.73%	17992	35
6	moist	Heated Bsmt.	Electric Resistance	multifamily	1372	1058	1037	1.94%	24.42%	7255	298
6	moist	Heated Bsmt.	Electric Resistance	single-family	3601	2355	2354	0.06%	34.64%	24786	38
6	moist	Heated Bsmt.	Gas-fired Furnace	multifamily	686	567	559	1.37%	18.46%	3573	74
6	moist	Heated Bsmt.	Gas-fired Furnace	single-family	1675	1180	1180	0.05%	29.56%	11498	22
6	moist	Heated Bsmt.	Heat Pump	multifamily	1076	889	868	2.33%	19.29%	4993	303
6	moist	Heated Bsmt.	Heat Pump	single-family	2597	1794	1792	0.08%	30.98%	16936	39
6	moist	Heated Bsmt.	Oil-fired Furnace	multifamily	1289	1030	1009	2.07%	21.75%	6280	256
6	moist	Heated Bsmt.	Oil-fired Furnace	single-family	3232	2152	2151	0.06%	33.46%	21615	34
6	dry	Slab-on-grade	Electric Resistance	multifamily	1300	1012	978	3.29%	24.71%	7009	525
6	dry	Slab-on-grade	Electric Resistance	single-family	3207	2117	2082	1.66%	35.08%	22664	590
6	dry	Slab-on-grade	Gas-fired Furnace	multifamily	668	559	547	2.23%	18.08%	3468	158
6	dry	Slab-on-grade	Gas-fired Furnace	single-family	1461	1025	1012	1.33%	30.75%	10726	212
6	dry	Slab-on-grade	Heat Pump	multifamily	1036	866	832	3.96%	19.74%	4942	544
6	dry	Slab-on-grade	Heat Pump	single-family	2196	1540	1508	2.09%	31.34%	14917	540
6	dry	Slab-on-grade	Oil-fired Furnace	multifamily	1246	1006	976	3.02%	21.68%	6100	415
6	dry	Slab-on-grade	Oil-fired Furnace	single-family	2870	1926	1896	1.56%	33.93%	19775	493
6	moist	Slab-on-grade	Electric Resistance	multifamily	1431	1094	1060	3.10%	25.89%	7881	536
6	moist	Slab-on-grade	Electric Resistance	single-family	3609	2333	2295	1.62%	36.40%	26006	638
6	moist	Slab-on-grade	Gas-fired Furnace	multifamily	717	588	576	2.16%	19.73%	3838	161
6	moist	Slab-on-grade	Gas-fired Furnace	single-family	1619	1108	1093	1.33%	32.48%	12096	231
6	moist	Slab-on-grade	Heat Pump	multifamily	1102	896	862	3.84%	21.78%	5570	545

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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6	moist	Slab-on-grade	Heat Pump	single-family	2479	1668	1633	2.13%	34.14%	17723	597
6	moist	Slab-on-grade	Oil-fired Furnace	multifamily	1354	1072	1040	3.05%	23.25%	6883	455
6	moist	Slab-on-grade	Oil-fired Furnace	single-family	3224	2115	2083	1.54%	35.40%	22710	540
6	dry	Unheated Bsmt.	Electric Resistance	multifamily	1274	1020	999	2.05%	21.57%	6188	306
6	dry	Unheated Bsmt.	Electric Resistance	single-family	3278	2238	2236	0.07%	31.77%	21131	39
6	dry	Unheated Bsmt.	Gas-fired Furnace	multifamily	651	555	547	1.43%	15.98%	3170	77
6	dry	Unheated Bsmt.	Gas-fired Furnace	single-family	1500	1086	1086	0.05%	27.60%	10054	23
6	dry	Unheated Bsmt.	Heat Pump	multifamily	1019	879	858	2.41%	15.83%	4176	311
6	dry	Unheated Bsmt.	Heat Pump	single-family	2271	1664	1663	0.09%	26.80%	13463	39
6	dry	Unheated Bsmt.	Oil-fired Furnace	multifamily	1218	1009	989	1.96%	18.81%	5380	229
6	dry	Unheated Bsmt.	Oil-fired Furnace	single-family	2938	2037	2036	0.06%	30.70%	18472	35
6	moist	Unheated Bsmt.	Electric Resistance	multifamily	1392	1094	1074	1.87%	22.90%	6969	297
6	moist	Unheated Bsmt.	Electric Resistance	single-family	3667	2444	2442	0.06%	33.40%	24389	38
6	moist	Unheated Bsmt.	Gas-fired Furnace	multifamily	696	582	574	1.34%	17.50%	3485	74
6	moist	Unheated Bsmt.	Gas-fired Furnace	single-family	1654	1167	1167	0.05%	29.44%	11353	22
6	moist	Unheated Bsmt.	Heat Pump	multifamily	1077	903	882	2.29%	18.12%	4777	302
6	moist	Unheated Bsmt.	Heat Pump	single-family	2552	1786	1785	0.08%	30.06%	16271	38
6	moist	Unheated Bsmt.	Oil-fired Furnace	multifamily	1316	1068	1047	2.00%	20.44%	6079	257
6	moist	Unheated Bsmt.	Oil-fired Furnace	single-family	3281	2219	2217	0.05%	32.43%	21311	34
7		Crawlspace	Electric Resistance	multifamily	1806	1371	1347	1.77%	25.42%	9456	365
7		Crawlspace	Electric Resistance	single-family	4712	3041	3039	0.05%	35.51%	32337	41
7		Crawlspace	Gas-fired Furnace	multifamily	836	671	661	1.37%	20.87%	4426	99
7		Crawlspace	Gas-fired Furnace	single-family	2042	1377	1376	0.04%	32.62%	14553	24
7		Crawlspace	Heat Pump	multifamily	1469	1178	1154	2.08%	21.44%	6899	369
7		Crawlspace	Heat Pump	single-family	3538	2431	2430	0.07%	31.32%	22317	42
7		Crawlspace	Oil-fired Furnace	multifamily	1651	1297	1267	2.29%	23.25%	8090	403
7		Crawlspace	Oil-fired Furnace	single-family	4182	2729	2728	0.05%	34.78%	28153	37
7		Heated Bsmt.	Electric Resistance	multifamily	1689	1274	1251	1.80%	25.93%	9082	342
7		Heated Bsmt.	Electric Resistance	single-family	4571	2916	2915	0.06%	36.24%	32038	41
7		Heated Bsmt.	Gas-fired Furnace	multifamily	782	626	618	1.39%	21.06%	4253	91
7		Heated Bsmt.	Gas-fired Furnace	single-family	2008	1352	1352	0.04%	32.67%	14370	23
7		Heated Bsmt.	Heat Pump	multifamily	1397	1114	1091	2.08%	21.90%	6739	347
7		Heated Bsmt.	Heat Pump	single-family	3521	2402	2400	0.07%	31.83%	22542	42
7		Heated Bsmt.	Oil-fired Furnace	multifamily	1540	1201	1178	1.93%	23.54%	7719	288
7		Heated Bsmt.	Oil-fired Furnace	single-family	4062	2625	2624	0.05%	35.41%	27873	37
7		Slab-on-grade	Electric Resistance	multifamily	1765	1320	1279	3.06%	27.52%	9928	652
7		Slab-on-grade	Electric Resistance	single-family	4614	2919	2870	1.67%	37.78%	33622	831
7		Slab-on-grade	Gas-fired Furnace	multifamily	820	650	635	2.32%	22.54%	4610	204
7		Slab-on-grade	Gas-fired Furnace	single-family	1981	1296	1277	1.46%	35.53%	15266	307

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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7		Slab-on-grade	Heat Pump	multifamily	1432	1125	1083	3.73%	24.37%	7503	679
7		Slab-on-grade	Heat Pump	single-family	3414	2276	2226	2.20%	34.80%	23779	855
7		Slab-on-grade	Oil-fired Furnace	multifamily	1614	1251	1210	3.30%	25.06%	8453	605
7		Slab-on-grade	Oil-fired Furnace	single-family	4086	2610	2568	1.61%	37.15%	29311	706
7		Unheated Bsmt.	Electric Resistance	multifamily	1716	1320	1297	1.74%	24.40%	8740	342
7		Unheated Bsmt.	Electric Resistance	single-family	4666	3039	3037	0.05%	34.92%	31558	41
7		Unheated Bsmt.	Gas-fired Furnace	multifamily	797	646	638	1.34%	19.96%	4151	90
7		Unheated Bsmt.	Gas-fired Furnace	single-family	2013	1362	1361	0.04%	32.41%	14306	23
7		Unheated Bsmt.	Heat Pump	multifamily	1400	1135	1112	2.04%	20.57%	6423	346
7		Unheated Bsmt.	Heat Pump	single-family	3491	2417	2415	0.07%	30.82%	21746	42
7		Unheated Bsmt.	Oil-fired Furnace	multifamily	1569	1248	1222	2.09%	22.13%	7447	340
7		Unheated Bsmt.	Oil-fired Furnace	single-family	4140	2723	2722	0.05%	34.25%	27508	37
8		Crawlspace	Electric Resistance	multifamily	2402	1831	1804	1.50%	24.90%	11918	424
8		Crawlspace	Electric Resistance	single-family	6222	4099	4097	0.05%	34.15%	40345	45
8		Crawlspace	Gas-fired Furnace	multifamily	1048	826	815	1.26%	22.17%	5456	121
8		Crawlspace	Gas-fired Furnace	single-family	2619	1769	1768	0.04%	32.49%	17843	25
8		Crawlspace	Heat Pump	multifamily	2173	1720	1693	1.61%	22.10%	9829	426
8		Crawlspace	Heat Pump	single-family	5343	3685	3683	0.05%	31.07%	32097	46
8		Crawlspace	Oil-fired Furnace	multifamily	2153	1656	1632	1.46%	24.22%	10505	306
8		Crawlspace	Oil-fired Furnace	single-family	5493	3644	3642	0.04%	33.70%	35092	40
8		Heated Bsmt.	Electric Resistance	multifamily	2260	1711	1685	1.53%	25.46%	11518	398
8		Heated Bsmt.	Electric Resistance	single-family	6079	3955	3953	0.05%	34.97%	40355	45
8		Heated Bsmt.	Gas-fired Furnace	multifamily	986	775	765	1.27%	22.41%	5256	111
8		Heated Bsmt.	Gas-fired Furnace	single-family	2584	1737	1736	0.04%	32.81%	17791	25
8		Heated Bsmt.	Heat Pump	multifamily	2073	1631	1604	1.61%	22.60%	9620	401
8		Heated Bsmt.	Heat Pump	single-family	5305	3620	3618	0.05%	31.79%	32572	46
8		Heated Bsmt.	Oil-fired Furnace	multifamily	2015	1550	1527	1.48%	24.21%	9911	284
8		Heated Bsmt.	Oil-fired Furnace	single-family	5373	3525	3523	0.04%	34.43%	35081	40
8		Slab-on-grade	Electric Resistance	multifamily	2357	1758	1704	3.10%	27.71%	12895	901
8		Slab-on-grade	Electric Resistance	single-family	6121	3926	3850	1.92%	37.10%	42971	1305
8		Slab-on-grade	Gas-fired Furnace	multifamily	1032	801	781	2.53%	24.31%	5787	297
8		Slab-on-grade	Gas-fired Furnace	single-family	2562	1682	1652	1.75%	35.50%	18935	493
8		Slab-on-grade	Heat Pump	multifamily	2130	1644	1587	3.48%	25.53%	10958	949
8		Slab-on-grade	Heat Pump	single-family	5217	3481	3402	2.26%	34.79%	34892	1363
8		Slab-on-grade	Oil-fired Furnace	multifamily	2115	1597	1551	2.88%	26.68%	11250	689
8		Slab-on-grade	Oil-fired Furnace	single-family	5400	3489	3424	1.87%	36.60%	37333	1113
8		Unheated Bsmt.	Electric Resistance	multifamily	2292	1778	1752	1.47%	23.55%	10886	397
8		Unheated Bsmt.	Electric Resistance	single-family	6168	4113	4111	0.04%	33.34%	39133	45
8		Unheated Bsmt.	Gas-fired Furnace	multifamily	1003	804	794	1.23%	20.85%	5044	111

Climate zone	Moisture regime	Foundation	Heating system	Prototype	Energy Cost ($/residence-yr)			Energy Cost Savings (%)		LCC Savings (2015 $)	
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8		Unheated Bsmt.	Gas-fired Furnace	single-family	2592	1770	1769	0.04%	31.75%	17346	25
8		Unheated Bsmt.	Heat Pump	multifamily	2078	1669	1643	1.57%	20.91%	9018	400
8		Unheated Bsmt.	Heat Pump	single-family	5283	3679	3677	0.05%	30.40%	31147	45
8		Unheated Bsmt.	Oil-fired Furnace	multifamily	2057	1609	1586	1.42%	22.90%	9620	282
8		Unheated Bsmt.	Oil-fired Furnace	single-family	5447	3657	3656	0.04%	32.88%	34045	41

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