PNNL-24354

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Cost-Effectiveness Analysis of the Residential Provisions of the 2015 IECC for the State of Utah

June 2015

VV Mendon
M Zhao

U.S. DEPARTMENT OF
ENERGY

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

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

**Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov**

**Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm**

This document was printed on recycled paper.

(9/2003)

PNNL-24354

Cost-Effectiveness Analysis of the Residential Provisions of the 2015 IECC for the State of Utah

VV Mendon
M Zhao

June 2015

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

Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

This analysis was conducted by Pacific Northwest National Laboratory (PNNL) in support of the U.S. Department of Energy's (DOE) Building Energy Codes Program. DOE supports the development and implementation of energy efficient and cost-effective residential and commercial building energy codes. These codes set the minimum requirements for energy-efficient building design and construction and ensure energy savings on a national level. The basis of the residential building energy codes is the International Energy Conservation Code (IECC) published by the International Code Council (ICC). The IECC is developed and published on a three-year cycle, with a new edition published at the end of each cycle.

The present analysis evaluates the cost-effectiveness of the latest 2015 edition of the IECC published in June 2014 (ICC 2014), over the 2012 Utah State Energy Code for the state of Utah[1]. The scope of work is limited to one- and two-family dwelling units, town-homes, and low-rise multifamily residential buildings covered by the residential provisions of the 2015 IECC. The new Energy Rating Index (ERI) path included in the 2015 IECC is not in the scope of this analysis due to the large variation in building configurations it allows

DOE has established a methodology for determining energy savings and cost-effectiveness of various residential building energy codes (Taylor et al. 2012). This methodology forms the basis of the present analysis and this report provides additional information used in calculating the cost-effectiveness of the 2015 IECC over the 2012 Utah State Energy Code.

PNNL conducted energy simulations using DOE's *EnergyPlus version 8.0* software (DOE 2013). The two PNNL residential prototype building models representing a single-family and a multifamily building were expanded to 32 building models to represent the combinations of commonly used heating systems and foundation types. These 32 models were simulated across the three climate-zones occurring in the state of Utah resulting in an expanded set of 96 building energy models. The annual energy consumption for space heating, cooling, domestic hot water heating, and lighting was extracted for each case and converted to energy cost using latest fuel prices for the state of Utah. Corresponding incremental construction costs associated with the residential provisions of the 2015 IECC were calculated and adjusted using the construction cost multiplier for the state of Utah to reflect local construction costs. Finally, a Life-Cycle Cost (LCC) analysis was conducted for each case for evaluating cost-effectiveness of the 2015 IECC over the 2012 Utah State Energy Code.

The 2015 IECC yields positive benefits for Utah homeowners. Moving to the 2015 IECC from the 2012 Utah State Energy Code is cost-effective over a 30-year life cycle as summarized in Tables ES.1 through ES.4. Average annual energy cost savings are $297 for the 2015 IECC. On average, Utah homeowners will save $3,759 with the 2015 IECC in life cycle costs over the life of the home. Each year, the reduction to energy bills will significantly exceed increased mortgage costs. After accounting for up-front costs and additional costs financed in the mortgage, homeowners should see net positive cash flow (i.e., cumulative savings exceeding cumulative cash outlays) in two years for the 2015 IECC. In addition, the average simple payback period for the whole state is 7.4 years.

[1] Available at http://murray.utah.gov/index.aspx?NID=168

Table ES.1. Total Energy Cost Savings for the 2015 IECC Compared to the 2012 Utah State Energy Code

Climate Zone	Savings ($/year)	Percent Savings
3	$464	32.1
5	$274	22.3
6	$290	25.2
State Average	$297	23.9

Table ES.2. Life-Cycle Cost Savings for the 2015 IECC compared to the 2012 Utah State Energy Code

Climate Zone	Savings
3	$5,825
5	$3,546
6	$3,253
State Average	$3,759

Table ES.3. Consumers' Cash Flow from Compliance with the 2015 IECC Compared to the 2012 Utah State Energy Code

	Cost/Benefit	Zone 3	Zone 5	Zone 6	State Average
A	Down payment and other up-front costs	$372	$206	$283	$236
B	Annual energy savings (year one)	$464	$274	$290	$297
C	Annual mortgage increase	$202	$112	$153	$128
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	$1	$1	$1	$0
E = [B-(C+D)]	Net annual cash flow savings (year one)	$261	$161	$136	$169
F = [A/E]	Years to positive savings, including up-front cost impacts	2	2	2	2

Note: Item D includes mortgage interest deductions, mortgage insurance, and property taxes for the first year. Deductions can partially or completely offset insurance and tax costs. As such, the "net" result appears relatively small or is sometimes even negative.

Table ES.4. Simple Payback Period for the 2015 IECC Compared to the 2012 Utah State Energy Code (Years)

Zone 3	Zone 5	Zone 6	State Average
7.5	7.0	9.1	7.4

Acronyms and Abbreviations

ACH50	Air-changes at 50-Pascal pressure differential
BC3	Building Component Cost Community
BECP	Building Energy Codes Program
CFL	compact fluorescent lamp
CFM	cubic feet per minute
DOE	U.S. Department of Energy
ECPA	Energy Conservation and Production Act
ERI	Energy Rating Index
ICC	International Code Council
IPC	International Plumbing Code
IRC	International Residential Code
IECC	International Energy Conservation Code
LCC	Life-Cycle Cost
PNNL	Pacific Northwest National Laboratory
SHGC	solar heat gain coefficient

Contents

Tables

1.0 Introduction

The U.S. Department of Energy (DOE) supports the development and implementation of energy-efficient and cost-effective building energy codes. Title III of the Energy Conservation and Production Act (ECPA), as amended, mandates that DOE participate in the development of model building energy codes and assist states in adopting and implementing these codes. The designated residential model energy code is the International Energy Conservation Code (IECC) published by the International Code Council (ICC).

This analysis was conducted by the Pacific Northwest National Laboratory (PNNL) to support DOE's Building Energy Codes Program (BECP). This report documents the cost-effectiveness analysis of the residential provisions of the latest 2015 edition of the IECC, hereafter referred as the 2015 IECC, compared with the 2012 Utah State Energy Code[1] for residential buildings in the state of Utah. The scope of work is limited to one- and two-family dwelling units, town-homes, and low-rise multifamily residential buildings covered by the mandatory and prescriptive provisions of the 2015 IECC. The new Energy Rating Index (ERI) path included in the 2015 IECC is not in the scope of this analysis due to the large variation in building configurations it allows.

DOE has established a methodology for determining energy savings and cost-effectiveness of various residential building energy codes (Taylor et al. 2012). The DOE methodology forms the basis of the present analysis and this report provides additional information used in calculating the cost-effectiveness of the 2015 IECC over the 2012 Utah State Energy Code.

The report contains three main parts:

- Energy Analysis – Chapter 2 in the report identifies the code changes between the 2012 Utah State Energy Code and 2015 IECC, applicable to residential buildings in the state of Utah. The PNNL residential prototype building models are customized to reflect the requirements of the two codes. Representative locations for each IECC climate-zone occurring in the state of Utah are identified to represent the variability in construction and energy code requirements throughout the state. Energy savings for the 2015 IECC over the baseline of 2012 Utah State Energy Code are calculated and converted to energy costs using latest fuel prices specific to the state of Utah.
- Economic Analysis – Chapter 3 documents the estimated incremental costs associated with the code changes identified in the Energy Analysis. The Life-Cycle Cost (LCC), simple payback period, and annual consumer cash flow for the requirements set by the 2015 IECC over the 2012 Utah State Energy Code are then calculated. The economic parameters used in determining the three cost-effectiveness metrics are summarized in this section.
- Results – Chapter 4 summarizes the energy and consumer benefits of the 2015 IECC compared to the 2012 Utah State Energy Code for each climate-zone within the state of Utah as well as the aggregated results for the whole state of Utah.

[1] Available at http://murray.utah.gov/index.aspx?NID=168

2.0 Energy Analysis

The present analysis focuses on the prescriptive and mandatory provisions of the 2012 Utah State Energy Code and 2015 IECC. The first step in evaluating the cost-effectiveness of energy code changes is the estimation of energy use for each case. This section describes the prescriptive and mandatory provisions of the 2015 IECC which result in a quantifiable impact on energy, the residential prototype building models used to quantify the energy impact of these changes, the conversion of energy savings into energy cost savings and the methodology used to aggregate the results to the climate-zone and state level.

2.1 2015 IECC Provisions with a Quantifiable Energy Impact Applicable to the State of Utah

The 2015 edition of the IECC was published by the ICC in June 2014 (ICC 2014). Following its publication, DOE conducted a determination analysis of the code changes in the 2015 IECC compared to its predecessor, the 2012 IECC (DOE 2015). Out of the 76 code change proposals approved for inclusion in the 2015 IECC compared to the preceding 2012 IECC, 6 were considered beneficial and out of these only five apply for the climate-zone occurring in the state of Utah. A detailed discussion and analysis of all code change proposals identified for 2015 IECC is documented by Mendon et al. (2015).

The 2012 Utah State Energy Code is comparable to the 2006 IECC in some respects. Previously, PNNL had conducted a cost-effectiveness analysis of the 2012 and 2009 editions of the IECC compared with the 2006 edition for the state of Utah in 2012 (Lucas et al., 2012). This earlier study identified the changes between the 2012 and 2009 IECC compared to the 2006 IECC, applicable to the state of Utah. Due to the similarities between the 2012 Utah State Energy Code and the 2006 IECC, the present analysis builds on the data presented in the previous report as applicable and adds information about code changes introduced by the 2015 IECC. The additional changes introduced by the 2015 IECC that specifically apply to the state of Utah are summarized below.

2.1.1 Insulation Requirements for Return Ducts in Attics

The 2015 IECC increases the required insulation 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. The 2012 Utah State Energy Code requires all return ducts to be insulated to a minimum of R-6. This code change impacts all the single-family prototype building models with slab-on-grade foundation because these prototype buildings are assumed to have ducted air-distribution systems with return ducts located in the unconditioned attic per Building America House Simulation Protocols (Wilson et al. 2014).

2.1.2 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 affects only homes that have a hot water recirculation system. The 2012 Utah State Energy Code does not include requirements for demand-activated control of hot water recirculation systems.

2.1.3 Outdoor Air Temperature Setback Control for Hot Water Boilers

The 2015 IECC adds a requirement that hot water boilers supplying heat to the building through one- or two-pipe heating systems be equipped with an outdoor setback control that lowers the temperature of the hot water based on outdoor air temperature. This requirement applies to hot water boilers used for space heating. The code only requires an outdoor setback control to be added to the hot water boiler; it does not specify the control strategy or temperatures for the setback control. This analysis employs the same conservative control strategy used in PNNL’s determination analysis for evaluating the impact of this proposal (Mendon et al 2015). The 2012 Utah State Energy Code does not include requirements for outdoor air temperature setback control for hot water boilers.

2.2 Summary of Changes between the 2012 Utah State Energy Code and the 2015 IECC

Table 2.1 and Table 2.2 summarize the key code changes between the 2015 IECC and the 2012 Utah State Energy Code.

Table 2.1. Comparison of Insulation Requirements Analyzed for the 2012 Utah State Energy Code and the 2015 IECC

Climate Zone	Code	Ceiling (R-value)	Skylight (U-factor)	Fenestration (Windows and Doors)		Wood Frame Wall (R-value)	Floor (R-value)	Basement Wall* (R-value)	Slab** (R-value and depth)
				U-factor	SHGC				
3	2012 UT Code	30	0.65	0.65	0.40	15	19	0	0 ft.
	2015 IECC	49	0.55	0.35	0.40	20	19	10/13	10, 2 ft.
5	2012 UT Code	38	0.60	0.35	NR	19 or 13+5	30	10/13	10, 2 ft.
	2015 IECC	49	0.55	0.32		20	30	15/19	10, 2 ft.
6	2012 UT Code	49	0.60	0.35	NR	19 or 13+5	30	10/13	10, 4 ft.
	2015 IECC		0.55	0.32		20+5	30	15/19	10, 4 ft.

* The first number is for continuous insulation on the interior or exterior of the home and the second number is for cavity insulation at the interior of the basement wall. Only one of these two has to be met.
** The first number is R-value. The second value refers to the vertical depth of the insulation around the perimeter.
NR = not required
SHGC = solar heat gain coefficient

Table 2.2. Comparison of Additional Code Requirements Analyzed for the 2012 Utah State Energy Code and the 2015 IECC

Measure Description	2012 Utah State Energy Code	2015 IECC
Insulation Requirements for Return Ducts in Attics	R-6	R-8 (diameter ≥ 3 inches) R-6 (diameter < 3 inches)
Demand-Activated Control for Recirculating Systems	NR	Required
Outdoor Air Temperature Setback Control for Hot Water Boilers	No setback	Temperature setback based on Outdoor Air Temperature
Tested Max Air Leakage Rate (ACH50)	5	3
Duct Leakage (cfm/100 ft^2)	10	4
High Efficacy Lighting	NR	75%

2.3 Estimation of Energy Usage and Savings

In order to estimate the energy impact of residential code changes, PNNL has developed a single-family prototype building and a low-rise multifamily prototype building to represent typical new residential building construction (BECP 2012, Mendon et al. 2013 and Mendon et al. 2015). The characteristics of the single-family prototype and the low-rise multifamily building are described below:

- Single-Family Prototype: A two-story home with a 30-ft by 40-ft rectangular shape, 2,400 ft^2 of conditioned floor area excluding the basement, and windows that are approximately 15% of the conditioned floor area with window areas equally distributed along the four cardinal directions.
- Multifamily Prototype: A three-story building with 18 units (6 units per floor), each unit having conditioned floor area of 1,200 ft^2 and window area equal to approximately 23% of the exterior wall area, equally distributed along the four cardinal directions.

These two building types are further expanded to cover four common heating systems (natural gas, heat pump, electric resistance and oil), and four common foundation types (slab-on-grade, heated basement, unheated basement, crawlspace), leading to an expanded set of 32 residential prototype building models. Furthermore, the state of Utah has three climate-zones leading to a set of 96 prototype building models for this analysis. This set of 96 prototype building models was used to simulate the energy usage for typical homes built to comply with the requirements of the 2015 IECC and those built to comply with the requirements of the 2012 Utah State Energy Code using DOE's *EnergyPlus*™ software, version 8.0 (DOE 2013). Energy savings associated with space heating, space cooling, water heating and lighting were extracted from the two sets of energy models and converted into costs using the latest fuel prices for the state of Utah.

2.4 Fuel Prices

The energy savings from the simulation analysis are converted to energy cost savings using the most recent state-specific residential fuel prices from DOE's Energy Information Administration (EIA 2014a, EIA 2014b, EIA 2014c). The fuel prices used in the analysis for the state of Utah are shown in Table 2.3.

Table 2.3. Fuel Prices for the State of Utah

Electricity ($/kWh)	Gas ($/Therm)	Oil ($/MBtu)
0.105	0.920	21.659

2.5 Aggregation Scheme

Energy results are averaged to the climate-zone and overall state level. To determine these averages, the results are first combined across foundation types and heating system types for single-family and multifamily buildings using weighting factors. The distribution of different heating systems for the state of Utah is derived from data collected by the National Association of Home Builders data (NAHB 2009) and is summarized in Table 2.4.

Table 2.4. Heating Equipment Shares

Heating System	Percent Share	
	Single-Family	Multifamily
Natural Gas	77.8	97.2
Heat Pump	19.4	2.8
Electric Resistance	2.6	0
Oil	0.2	0

The distribution of different foundation types for the state of Utah is derived from the Residential Energy Consumption Survey data (EIA 2009) and is summarized in Table 2.5. The single-family and multifamily results are combined for each climate zone in the state and the climate zone results are combined to determine a state average weighted using housing starts from the 2010 U.S. Census data (Census 2010 and 2012). The distribution of single- and multifamily building starts is summarized in Table 2.6.

Table 2.5. Foundation Type Shares

Foundation Type	Slab-on-grade	Heated Basement	Unheated Basement	Crawlspace
Percent Share	26.7	36.6	11.0	25.6

Table 2.6. Construction by Building Type and Climate Zone

Climate Zone	Housing Starts	
	Single-Family	Multifamily
3	873	11
5	5,084	857
6	926	398

3.0 Economic Analysis

This section summarizes the cost-effectiveness analysis. PNNL calculated three primary economic metrics to evaluate cost-effectiveness:

- Life-Cycle Cost (LCC): Full accounting over a 30-year period of the cost savings, considering energy savings, the initial investment financed through increased mortgage costs, tax impacts, and residual values of energy efficiency measures
- Cash Flow: Net annual cost outlay (i.e., difference between annual energy cost savings and increased annual costs for mortgage payments, etc.)
- Simple Payback: Number of years required for energy cost savings to exceed the incremental first costs of a new code

3.1 Incremental Costs

In order to evaluate the cost-effectiveness of the changes introduced by the 2015 IECC over the 2012 Utah State Energy Code, PNNL estimated the incremental construction costs associated with these changes. For this analysis, cost data sources consulted by PNNL include but are not limited to:

- Building Component Cost Community (BC3) data repository (DOE 2012)
- Construction cost data collected by Faithful+Gould under contract with PNNL (Faithful + Gould 2012)
- RSMeans Residential Cost Data (RSMeans 2015)
- National Residential Efficiency Measures Database (NREL 2014)
- Cost data from home supply stores

Because the 2012 Utah State Energy Code is similar to the 2006 IECC in some respects, the estimated costs of implementing the prescriptive and mandatory provisions of the 2012 IECC over the 2006 IECC, as applicable to this analysis are leveraged from the earlier PNNL study (Lucas et al. 2012). The costs of implementing the prescriptive provisions of the 2015 IECC are added to the adjusted costs to derive the total costs of implementing the prescriptive provisions of the 2015 IECC over the 2012 Utah State Energy Code. These estimated incremental costs are summarized in Table 3.1. The costs are higher for homes with heated basements due to the additional insulation requirements for basement walls. These costs are adjusted downwards by 11.7% (multiplied by 0.883) to reflect local construction costs in the state of Utah based on location factors provided by Faithful + Gould (2011).

Table 3.1. Total Construction Cost Increase for the 2015 IECC Compared to the 2012 Utah State Energy Code

	Single-family Building		Multifamily Unit	
Climate Zone	**Slab, Unheated Basement, or Crawlspace**	**Heated Basement**	**Slab, Unheated Basement, or Crawlspace**	**Heated Basement**
3	$3,332	$3,774	$1,508	$1,572
5	$1,975	$2,200	$1,056	$1,089
6	$3,062	$3,287	$1,454	$1,486

3.2 Economic Parameters Used in Evaluating Cost-Effectiveness

The financial and economic parameters used in calculating the LCC and annual consumer cash flow are based on the DOE cost-effectiveness methodology (Taylor et al. 2012) and summarized below for reference:

- New home mortgage interest rate (fixed rate)
  - 5.0% mortgage interest rate (fixed rate)
  - Loan fees equal to 0.7% of the mortgage amount
  - 30-year loan term
  - 10% down payment
- Other rates and economic parameters:
  - 5% nominal discount rate (equal to mortgage rate)
  - 1.6% inflation rate
  - 25% marginal federal income tax and 6.85% marginal state income tax
  - 0.9% property tax
  - Insulation has 60-year life with linear depreciation resulting in a 50% residual value at the end of the 30-year period
  - Electronic controllers for boilers have a 15-year life resulting in a one-time replacement at the end of the 15th year during the 30-year analysis period
  - Windows, duct sealing, and envelope sealing have a 30-year life and hence no residual value at the end of the analysis period
  - Light bulbs have a 6-year life and are replaced four times during the 30-year analysis period

4.0 Results

This section summarizes the results of the assessment of cost-effectiveness of the 2015 IECC relative to the 2012 Utah State Energy Code. Results for each of three primary cost-effectiveness metrics, LCC, simple payback, and annual cash flow, are presented for each climate-zone within the state of Utah as well as the state average.

4.1 Life-Cycle Cost

Table 4.1 shows the LCC savings (discounted present value) over the 30-year analysis period for the 2015 IECC compared to the 2012 Utah State Energy Code. These savings assume that initial costs are mortgaged, that homeowners take advantage of the mortgage interest tax deductions, and that efficiency measures retain a residual value at the end of the 30 years. As shown in Table 4.1, LCC saving aggregated at the state level is $3,759 for the 2015 IECC.

Table 4.1. Life-Cycle Cost Savings of the 2015 IECC Compared to the 2012 Utah State Energy Code

Code	Zone 3	Zone 5	Zone 6	State Average
2015 IECC	$5,825	$3,546	$3,253	$3,759

4.2 Cash Flow

Most houses are financed and the financial impact of buying a home that complies with the 2015 IECC requirements is important to customers. Mortgages spread the payment for the cost of a house over a long period of time (the simple payback fails to account for the impacts 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 4.2 shows the impact of the improvements in the 2015 IECC on the consumers' cash flow. On average, there is a net positive cash flow to the consumer of $169 per year beginning in year one for the 2015 IECC. Positive cumulative savings, including payment of up-front costs, are achieved in two years.

Table 4.2. Impacts to Consumers' Cash Flow from Compliance with the 2015 IECC Compared to the 2012 Utah State Energy Code

	Cost/Benefit	Zone 3	Zone 5	Zone 6	State Average
A	Down payment and other up-front costs	$372	$206	$283	$236
B	Annual energy savings (year one)	$464	$274	$290	$297
C	Annual mortgage increase	$202	$112	$153	$128
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	$1	$1	$1	$0
E = [B-(C+D)]	Net annual cash flow savings (year one)	$261	$161	$136	$169
F = [A/E]	Years to positive savings, including up-front cost impacts	2	2	3	2

Note: Item D includes mortgage interest deductions, mortgage insurance, and property taxes for the first year. Deductions can partially or completely offset insurance and tax costs. As such, the "net" result appears relatively small or is sometimes even negative.

4.3 Simple Payback

Table 4.3 shows the simple payback period which is the simple division of the incremental construction cost by the first-year energy cost savings. It yields the number of years required for the energy cost savings to pay back the incremental cost investment without any consideration of financing of the initial costs through a mortgage and the favored tax treatment of mortgages. As Table 4.3 shows, the simple payback period from moving to the 2015 IECC from the 2012 Utah State Energy Code averages 7.4 years.

Table 4.3. Simple Payback Period, Relative to the 2012 Utah State Energy Code (Years)

Code	Zone 3	Zone 5	Zone 6	State Average
2015 IECC	7.5	7.0	9.1	7.4

4.4 Energy Cost Savings

Table 4.4 shows the estimated annual energy costs, including heating, cooling, water heating, and lighting per home that result from meeting the requirements of the 2012 Utah State Energy Code and 2015 IECC.

Table 4.4. Annual Energy Costs for 2012 Utah State Energy Code and 2015 IECC

Climate Zone	2012 Utah State Energy Code					2015 IECC				
	Heating	**Cooling**	**Water Heating**	**Lighting**	**Total**	**Heating**	**Cooling**	**Water Heating**	**Lighting**	**Total**
3	$403	$613	$188	$243	$1,447	$183	$471	$156	$173	$983
5	$497	$282	$225	$226	$1,230	$343	$266	$185	$162	$956
6	$496	$217	$231	$208	$1,152	$319	$204	$189	$150	$862
Average	**$487**	**$307**	**$222**	**$225**	**$1,241**	**$322**	**$278**	**$183**	**$161**	**$944**

Table 4.5 shows the total energy cost savings as both a net dollar savings and as a percentage of the total energy costs. Results are averaged across single- and multifamily housing starts, foundation type, and heating system type. As can be seen from the table, annual energy cost savings per year for the 2015 IECC compared to the 2012 Utah State Energy Code range from $464 in Zone 3 to $290 in Zone 6. On a percentage basis, energy cost savings average 23.9% for the 2015 IECC over the 2012 Utah State Energy Code.

Table 4.5. Total Energy Cost Savings for the 2015 IECC Compared to the 2012 Utah State Energy Code

Climate Zone	Savings ($/year)	Percent Savings
3	$464	32.1
5	$274	22.3
6	$290	25.2
State Average	$297	23.9

5.0 References

BECP. 2012. Residential Prototype Building Models developed by DOE's Building Energy Codes Program. Available at http://www.energycodes.gov/development/residential/iecc_models/

Census. 2010. *Characteristics of New Housing*. U.S. Census Bureau, Washington, D.C. Available at http://www.census.gov/construction/chars/completed.html

DOE. 2012. *Building Component Cost Community*. U.S. Department of Energy, Washington, D.C. Available at http://bc3.pnnl.gov/

DOE. 2013. *EnergyPlus Energy Simulation Software, Version 8.0*. U.S. Department of Energy, Washington, D.C. Available at http://apps1.eere.energy.gov/buildings/EnergyPlus/

DOE. 2015. *Determination Regarding Energy Efficiency Improvements in the 2015 International Energy Conservation Code (IECC)*. U.S. Department of Energy, Washington, D.C. Available at http://www.energycodes.gov/sites/default/files/documents/2015_IECC_Determination.pdf

EIA. 2009. *2009 Residential Energy Consumption Survey Data, HC8.1*. U.S. Energy Information Administration, Washington DC. Available at http://www.eia.gov/consumption/residential/data/2009/

EIA. 2014a. *Natural Gas Monthly*. U.S. Energy Information Administration, Washington D.C. Available at http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_a.htm

EIA. 2014b. *Electric Power Monthly*. U.S. Energy Information Administration, Washington D.C. Available at http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

EIA. 2014c. *Petroleum Marketing Monthly*. U.S. Energy Information Administration. Washington D.C. Available at http://www.eia.gov/petroleum/marketing/monthly/

Faithful + Gould. 2011. *Residential Energy Efficiency Measures: Location Factors.* Faithful+Gould for Pacific Northwest National Laboratory. Available at http://bc3.pnnl.gov/sites/default/files/Location_Factors_Report.pdf

Faithful + Gould. 2012. *Residential Energy Efficiency Measures: Prototype Estimate and Cost Data.* Faithful+Gould for Pacific Northwest National Laboratory. Available at http://bc3.pnnl.gov/sites/default/files/Residential_Report.pdf

ICC. 2014. *2015 International Energy Conservation Code*. International Code Council, Washington, D.C.

Lucas RG, ZT Taylor, VV Mendon and SG Goel. 2012. *Utah Energy and Cost Savings for New Single- and Multifamily Homes: 2009 and 2012 IECC as Compared to the 2006 IECC*. Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.energycodes.gov/sites/default/files/documents/UtahResidentialCostEffectiveness.pdf

Mendon VV, RG Lucas and SG Goel. 2013. *Cost-Effectiveness Analysis of the 2009 and 2012 IECC Residential Provisions – Technical Support Document*. Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.energycodes.gov/sites/default/files/documents/State_CostEffectiveness_TSD_Final.pdf

Mendon VV and ZT Taylor. 2014. *Development of Residential Prototype Building Models and Analysis System for Large-Scale Energy Efficiency Studies Using EnergyPlus*. 2014 ASHRAE/IBPSA-USA Building Simulation Conference, Atlanta, GA.

Mendon VV, ZT Taylor, SU Rao and YL Xie. 2015. *2015 IECC: Energy Savings Analysis*. Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.energycodes.gov/sites/default/files/documents/2015_IECC_FinalDeterminationAnalysis.pdf

NREL. 2014. *National Residential Efficiency Measures Database*. National Renewable Energy Laboratory, Golden, Colorado. Available at http://www.nrel.gov/ap/retrofits/

NAHB. 2009. *Builder Practices Reports*. National Association of Home Builders, Upper Marlboro, Maryland. Available at http://www.homeinnovation.com/trends_and_reports/data/new_construction

RSMeans. 2015. *2015 RS Means Residential Cost Data*. Construction Publishers & Consultants. Norwell, MA.

Taylor ZT, N Fernandez, and RG Lucas. 2012. *Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes*. Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.energycodes.gov/sites/default/files/documents/residential_methodology.pdf

Wilson E, C Engebrecht Metzger, S Horowitz, and R Hendron. 2014. *2014 Building America House Simulation Protocols*. National Renewable Energy Laboratory, Golden, Colorado. Available at http://energy.gov/sites/prod/files/2014/03/f13/house_simulation_protocols_2014.pdf

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

U.S. DEPARTMENT OF
ENERGY

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

www.pnnl.gov