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Cost-Effectiveness Analysis of the Residential Provisions of the 2018 IECC for Rhode Island

April 2021

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U.S. DEPARTMENT OF ENERGY

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Acronyms and Abbreviations

BC3	Building Component Cost Community
BECP	Building Energy Codes Program
CPI	Consumer Price Index
DOE	U.S. Department of Energy
EIA	Energy Information Administration
ERI	Energy Rating Index
ICC	International Code Council
IECC	International Energy Conservation Code
LCC	Life-Cycle Cost
NAHB	National Association of Home Builders
PNNL	Pacific Northwest National Laboratory

Highlights

> The 2018 IECC provides cost-effective savings for residential buildings in Rhode Island. Moving to the 2018 IECC from the current base code of 2012 IECC is cost-effective for single-family and low-rise multifamily residential buildings in all climate zones in Rhode Island.

The average statewide economic impact (per dwelling unit) of upgrading to the 2018 IECC is shown in the table below based on typical cost-effectiveness metrics. [1]

Metric	Compared to the 2012 IECC
Life-cycle cost savings of the 2018 IECC	$258.42
Simple payback period of the 2018 IECC	4.4 years
Net annual consumer cash flow in year 1 of the 2018 IECC[2]	$15.59
Annual (first year) energy cost savings of the 2018 IECC ($)[3]	$22.42
Annual (first year) energy cost savings of the 2018 IECC (%)[4]	0.9%

[1] A weighted average is calculated across building configurations and climate zones.
[2] The annual cash flow is defined as the net difference between annual energy savings and annual cash outlays (mortgage payments, etc.), including all tax effects but excluding up-front costs (mortgage down payment, loan fees, etc.). First-year net cash flow is reported; subsequent years' cash flow will differ due to the effects of inflation and fuel price escalation, changing income tax effects as the mortgage interest payments decline, etc.
[3] Annual energy savings is reported at time zero, before any inflation or price escalations are considered.
[4] Annual energy savings is reported as a percentage of end uses regulated by the IECC (HVAC, water heating, and interior lighting).

Cost-Effectiveness Results for the 2018 IECC for Rhode Island

This section summarizes the cost-effectiveness analysis in terms of three primary economic metrics:

- 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
- Consumer Cash Flow: Net annual cost outlay (i.e., difference between annual energy cost savings and increased annual costs for mortgage payments, etc.)
- Simple Payback Period: Number of years required for energy cost savings to exceed the incremental first costs of a new code, ignoring inflation and fuel price escalation rates

LCC savings is the primary metric used by the U.S. Department of Energy (DOE) to assess the economic impact of residential building energy codes. Simple payback period and the Consumer Cash Flow analysis are reported to provide additional information to stakeholders. Both the LCC savings and the year-by-year cash flow values from which it is calculated assume that initial costs are mortgaged, that homeowners take advantage of mortgage interest tax deductions, that individual efficiency measures are replaced with like measures at the end of their useful lifetimes, and that efficiency measures may retain a prorated residual value at the end of the 30-year analysis period.

1. Life-Cycle Cost

The Life-Cycle Cost (LCC) analysis computes overall cost savings per dwelling unit resulting from implementing the efficiency improvements of a new energy code. LCC savings is based on the net change in overall cash flows (energy savings minus additional costs) resulting from implementing a new energy code. LCC savings is a sum over an analysis period of 30 years. Future cash flows, which vary from year to year, are discounted to *present values* using a discount rate that accounts for the changing value of money over time. LCC savings is the economic metric used by DOE for decision making purposes.

Table 1 shows the LCC savings (discounted present value) over the 30-year analysis period for the 2018 IECC compared to the 2012 IECC.

Table 1. Life-Cycle Cost Savings of the 2018 IECC compared to the 2012 IECC

Climate Zone	Life-Cycle Cost Savings ($)
5A	$258.42
Note: Warm-humid climate zones are labeled "WH"	

2. Consumer Cash Flow

The Consumer Cash Flow results are derived from the year-by-year calculations that underlie the Life-Cycle Cost savings values shown above. The specific cash flow values shown here allow an assessment of how annual cost outlays are compensated by annual energy savings and the time required for cumulative energy savings to exceed cumulative costs, including both increased mortgage payments and the down payment and other up-front costs.

Table 2 shows the per-dwelling-unit impact of the improvements in the 2018 IECC on Consumer Cash Flow compared to the 2012 IECC.

Table 2. Consumer Cash Flow from Compliance with the 2018 IECC Compared to the 2012 IECC

	Cost/Benefit	**5A**
A	Down payment and other up-front costs	$10.60
B	Annual energy savings (year one)	$22.42
C	Annual mortgage increase	$5.78
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	$1.05
E = [B-(C+D)]	Net annual cash flow savings (year one)	$15.59
F = [A/E]	Years to positive savings, including up-front cost impacts	0.68

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.

3. Simple Payback Period

The simple payback period is a straightforward metric including only the costs and benefits directly related to the implementation of energy-saving measures associated with a code change. It represents the number of years required for the energy savings to pay for the cost of the measures, without regard for inflation, changes in fuel prices, tax effects, measure replacements, resale values, etc. The simple payback period is useful for its ease of calculation and understandability. Because it focuses on the two primary characterizations of a code change—cost and energy performance—it allows an assessment of cost effectiveness that is easy to compare with other investment options and requires a minimum of input data. DOE reports the simple payback period because it is a familiar metric used in many contexts. However, because it ignores many of the longer-term factors in the economic performance of an energy-efficiency investment, DOE does not use the payback period as a primary indicator of cost effectiveness for its own decision-making purposes.

Table 3 shows the simple payback period for the 2018 IECC for Rhode Island. The simple payback period is calculated by dividing the incremental construction cost by the annual energy cost savings assuming time-zero fuel prices. It estimates the number of years required for the energy cost savings to pay back the incremental cost investment without consideration of financing of the initial costs through a mortgage, the favored tax treatment of mortgages, the useful lifetimes of individual efficiency measures, or future escalation of fuel prices.

Table 3. Simple Payback Period for the 2018 IECC Compared to the 2012 IECC

Climate Zone	Payback Period (Years)
5A	4.4

Overview of the Cost-Effectiveness Analysis Methodology

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 help adopting states and localities establish minimum requirements for energy-efficient building design and construction, as well as ensure significant energy savings and avoided greenhouse gas emissions.

The present analysis evaluates the cost-effectiveness of the prescriptive path of the 2018 edition of the International Energy Conservation Code (IECC), relative to the 2012 IECC. The analysis covers one- and two-family dwelling units, townhouses, and low-rise multifamily residential buildings covered by the residential provisions of the 2018 IECC. The IECC's simulated performance path and the new Energy Rating Index (ERI) path are not in the scope of this analysis due to the large variety of building configurations those paths allow. While buildings complying via these paths are generally considered to provide equal or better energy performance compared to the prescriptive requirements, the intent of these paths is to provide additional design flexibility at a cost dictated by the builder or homeowner. DOE has established a methodology for determining energy savings and cost-effectiveness of various residential building energy codes (Taylor et al. 2012). The LCC analysis described in the methodology balances upfront costs with longer term consumer savings and is therefore DOE's primary economic metric for its decision-making processes.

1. Estimation of Energy Usage and Savings

In order to estimate the energy impact of residential code changes, PNNL 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. 2014). The key characteristics of these prototypes are described below:

- **Single-Family Prototype**: A two-story home with a roughly 30-ft by 40-ft rectangular shape, 2,376 ft^2 of conditioned floor area excluding the conditioned basement (if any), and window area equal to 15% of the conditioned floor area equally distributed toward the four cardinal directions.
- **Multifamily Prototype**: A three-story building with 18 dwelling 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 (not including breezeway walls) equally distributed toward the four cardinal directions.

These two building prototypes are further expanded to cover four common heating systems (natural gas furnace, heat pump, electric resistance, oil-fired furnace) and four common foundation types (slab-on-grade, heated basement, unheated basement, crawlspace), leading to an expanded set of 32 residential prototype building models. This set is used to simulate the energy usage for typical homes built to comply with the requirements of the 2018 IECC and those built to comply with the requirements of the 2012 IECC for one location in each climate zone[1] in the state using DOE's *EnergyPlus*™ software, version 8.6

[1] One location is simulated for each combination of climate zone and moisture regime (Moist, Dry, Marine) that exists in the state.

(DOE 2016). Energy savings of the 2018 IECC relative to the 2012 IECC, including space heating, space cooling, water heating and lighting, are extracted from the simulation results.

2. 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 2019a, EIA 2019b, EIA 2019c). The fuel prices used in the analysis are shown in Table 4.

Table 4. Fuel Prices used in the Analysis

Electricity ($/kWh)	Gas ($/Therm)	Oil ($/MBtu)
$0.21	$1.41	$23.08

3. Financial and Economic Parameters

The financial and economic parameters used in calculating the LCC and annual consumer cash flow are based on the latest DOE cost-effectiveness methodology (Taylor et al. 2015) to represent the current economic scenario. The parameters are summarized in Table 5 for reference.

Table 5. Economic Parameters used in the Analysis

Parameter	Value
Mortgage interest rate (fixed rate)	5.00%
Loan fees	0.7% of the mortgage amount
Loan term	30 years
Down payment	10% of home value
Nominal discount rate (equal to mortgage rate)	5.00%
Inflation rate	2.52%
Marginal federal income tax	12%
Marginal state income tax	5.99%
Property tax	1.50%

4. Aggregation Scheme

Energy results, weighted by foundation and heating system type, are provided at the state level and separately for each climate zone within the state. The distribution of heating systems for Rhode Island is derived from data collected by the National Association of Home Builders data (NAHB 2009) and is summarized in Table 6. The distribution of foundation types is derived from the Residential Energy Consumption Survey data (EIA 2009) and is summarized in Table 7. The single-family and multifamily results are combined for each climate zone in the state and the climate zone results are combined to calculate a weighted average for the state using housing starts from the 2010 U.S. Census data (Census 2010). The distribution of single- and multifamily building starts is summarized in Table 8.

Table 6. Heating Equipment Shares

Heating System	Share of New Homes (percent)	
	Single-Family	Multifamily
Natural Gas	57	66
Heat Pump	11	3
Electric Resistance	1	1
Oil	31	30

Table 7. Foundation Type Shares

Foundation Type	Slab-on-grade	Heated Basement	Unheated Basement	Crawlspace
Share of New Homes (percent)	17	23	47	13

Table 8. Construction Shares by Climate Zone

Climate Zone	Share of New Homes (percent)	
	Single-Family	Multifamily
5A	100	100

Incremental Construction Costs

In order to evaluate the cost-effectiveness of the changes introduced by the 2018 IECC over the 2012 IECC, PNNL estimated the incremental construction costs associated with these changes. For this analysis, cost data sources consulted by PNNL include:

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

The consumer price index (CPI) is used to adjust cost data from earlier years to the study year (US Inflation Calculator 2019). The estimated costs of implementing the prescriptive provisions of the 2012 IECC over the 2009 IECC are taken from an earlier PNNL study that evaluated the cost-effectiveness of the 2012 IECC (Lucas et al. 2012). The additional costs of implementing the prescriptive provisions of the 2015 IECC over the 2012 IECC are taken from the National 2015 IECC Cost-Effectiveness study (Mendon et.al. 2015). The national scope costs from those studies are adjusted to reflect local construction costs in Rhode Island using location factors provided by Faithful+Gould (2011). The incremental costs of implementing the provisions of the 2018 IECC over the 2015 IECC are described in *National Cost-Effectiveness of the Residential Provisions of the 2018 IECC* (Taylor 2021).

Table 9 and Table 10 show the incremental construction costs associated with the 2018 IECC compared to the 2012 IECC for an individual dwelling unit. Table 9 shows results for a house and Table 10 shows results for an apartment or condominium. These have been adjusted using a construction cost multiplier, 1.082, to reflect local construction costs in Rhode Island based on location factors provided by Faithful + Gould (2011).

Table 9. Total Single-Family Construction Cost Increase for the 2018 IECC Compared to the 2012 IECC ($)

	Single-family Prototype House			
Climate Zone	**Crawlspace**	**Heated Basement**	**Slab**	**Unheated Basement**
5A	$38.93	$88.90	$88.90	$38.93

Table 10. Total Multifamily Construction Cost Increase for the 2018 IECC Compared to the 2012 IECC ($)[1]

	Multifamily Prototype Apartment/Condo			
Climate Zone	**Crawlspace**	**Heated Basement**	**Slab**	**Unheated Basement**
5A	$117.85	$117.85	$117.85	$117.85

[1] In the multifamily prototype model, the heated basement is added to the building, and not to the individual apartments. The incremental cost associated with heated basements is divided among all apartments equally.

Energy Cost Savings

Table 11 and Table 12 show the estimated annual per-dwelling unit energy costs of end uses regulated by the IECC, which comprise heating, cooling, water heating, lighting, fans, and mechanical ventilation that result from meeting the requirements of the 2018 and the 2012 IECC.

Table 11. Annual (First Year) Energy Costs for the 2012 IECC

Climate Zone	2012 IECC						
	Heating	**Cooling**	**Water Heating**	**Lighting**	**Fans**	**Vents**	**Total**
5A	$875.27	$286.36	$378.13	$258.26	$167.48	$0.00	$1,798.02

Table 12. Annual (First Year) Energy Costs for the 2018 IECC

Climate Zone	2018 IECC						
	Heating	**Cooling**	**Water Heating**	**Lighting**	**Fans**	**Vents**	**Total**
5A	$860.59 (-1.7%)	$286.29 (0.0%)	$377.06 (-0.3%)	$240.87 (-6.7%)	$166.52 (-0.6%)	$0.00 (0.0%)	$1,764.82 (-1.8%)

Table 13 shows the first year energy cost savings as both a net dollar savings and as a percentage of the total regulated end use energy costs. Results are weighted by single- and multifamily housing starts, foundation type, and heating system type.

Table 13. Total Energy Cost Savings (First Year) for the 2018 IECC Compared to the 2012 IECC

Climate Zone	First Year Energy Cost Savings	First Year Energy Cost Savings (percent)
5A	$22.42	0.9

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