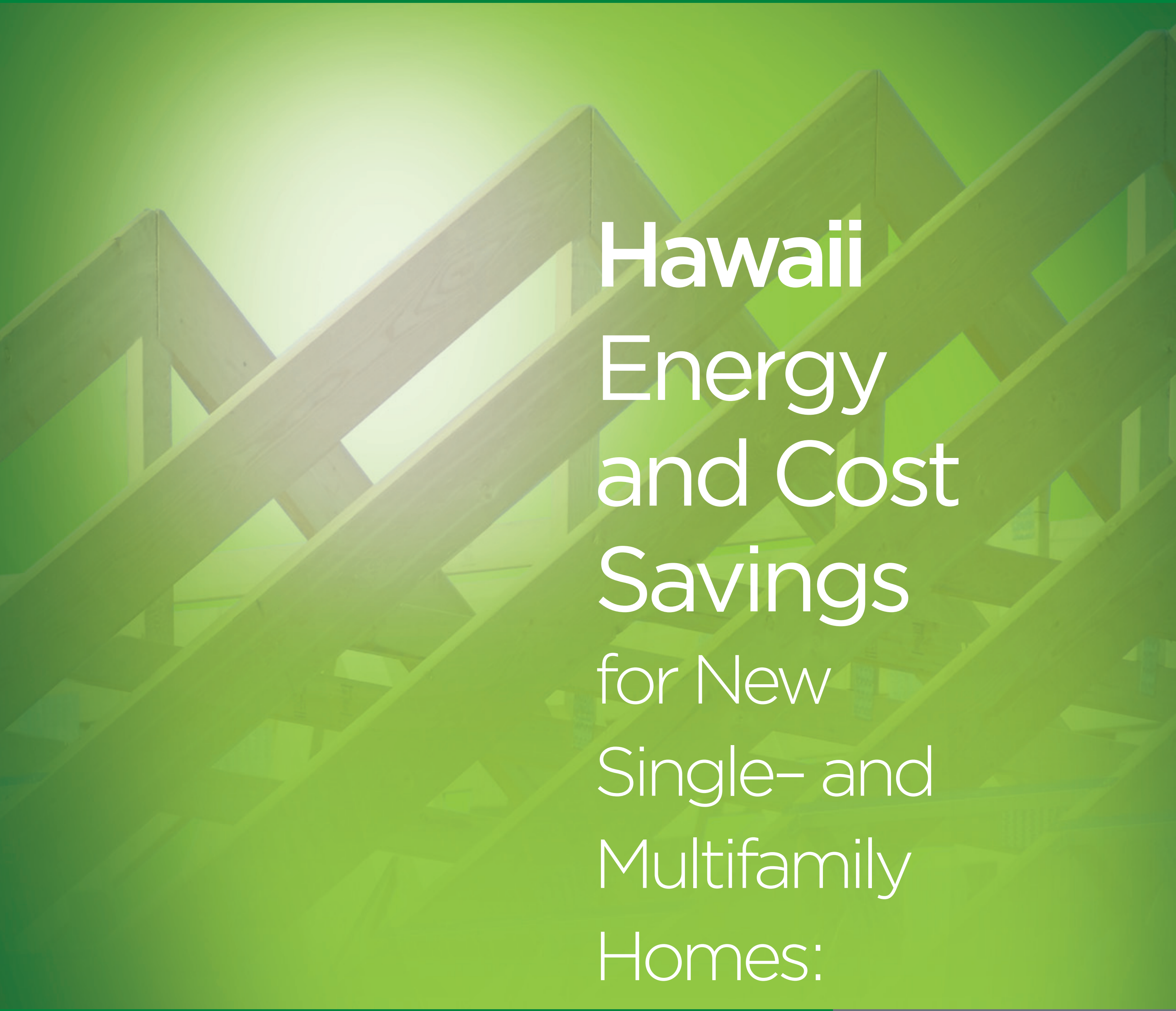
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM



Hawaii Energy and Cost Savings for New Single– and Multifamily Homes:

2012 IECC as Compared to the 2009 IECC

Building Energy Codes

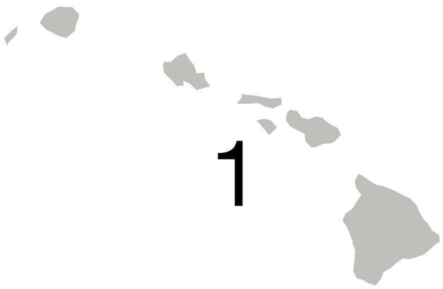


Figure 1. Hawaii Climate Zone

Hawaii Energy and Cost Savings for New Single– and Multifamily Homes: **2012 IECC** as Compared to the **2009 IECC**

The 2012 International Energy Conservation Code (IECC) yields positive benefits for Hawaii homeowners.

Moving to the 2012 IECC from the 2009 IECC is cost-effective over a 30-year life cycle. On average, Hawaii homeowners will save $8,860 with the 2012 IECC.

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 flows (i.e., cumulative savings exceeding cumulative cash outlays) in 1 year for the 2012 IECC. Average annual energy savings are $541 for the 2012 IECC.

Highlights

Cost-effectiveness against a 2009 IECC baseline::

- Life-cycle cost savings, averaged across building types, are $8,860 for the 2012 IECC
- Simple payback period is 3.6 years for the 2012 IECC

Consumer savings compared to a 2009 IECC baseline:

- Households save an average of $541 per year on energy costs with the 2012 IECC
- Net annual consumer savings, including energy savings, mortgage cost increases, and other associated costs in the first year of ownership, average $430 for the 2012 IECC
- Energy costs, on average, are 16.8% lower for the 2012 IECC

Cost-Effectiveness

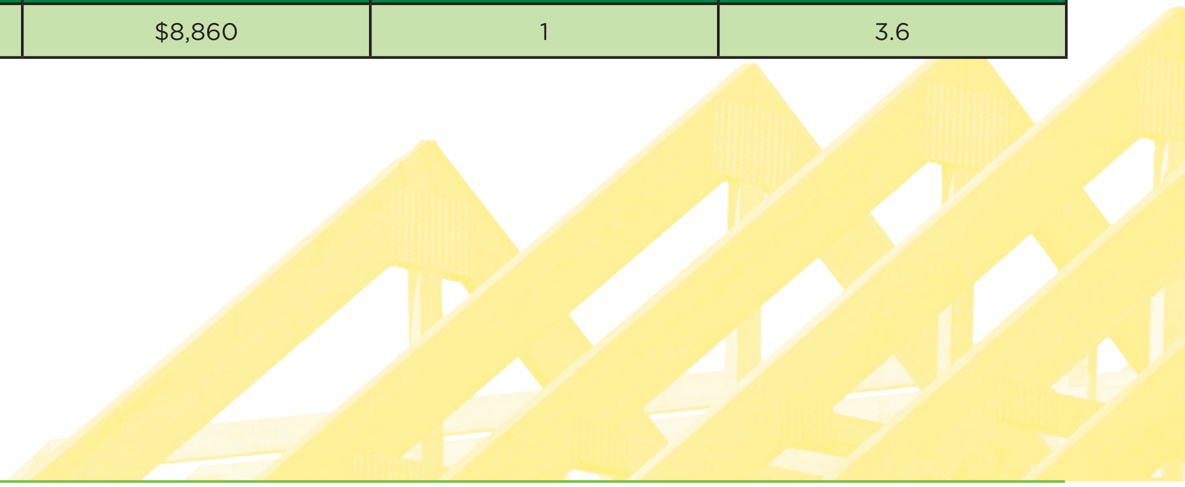
The U.S. Department of Energy (DOE) evaluates the energy codes based on three measures of cost-effectiveness:

- **Life-Cycle Cost**: 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

Life-cycle cost is the primary measure by which DOE assesses the cost-effectiveness of the IECC. These savings assume 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. As shown in Table 1, life-cycle cost savings are $8,860 for the 2012 IECC compared to the 2009 IECC.

Table 1. Average Life-Cycle Cost Savings from Compliance with the 2012 IECC, Relative to the 2009 IECC

	Life-Cycle Cost Savings ($)	Net Positive Cash Flow (Years)	Simple Payback (Years)
2012 IECC	$8,860	1	3.6



Consumer Savings

Annual consumer cash flows impact the affordability of energy-efficient homes. Based on this analysis, Hawaii homeowners, on average, should see average annual energy cost savings of $541 and achieve a net cumulative savings that accounts for an increased down payment in addition to energy costs, mortgage costs, and tax-related costs and benefits in 1 year when comparing the 2012 IECC to the 2009 IECC. Table 2 summarizes these results.

Table 2. Impacts to Consumers' Cash Flow from Compliance with the 2012 IECC Compared to the 2009 IECC

	Consumers' Cash Flow (Average)	2012 IECC
A	Down payment and other up-front costs	$208
B	Annual energy savings (year one)	$541
C	Annual mortgage increase	$113
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	-$2
E = [B-(C+D)]	Net annual cash flow savings (year one)	$430
F = [A/E]	Years to positive savings, including up-front cost impacts	1

Note: The current baseline energy code in Hawaii is the Hawaii Energy Conservation Code, which is based on the 2009 IECC but with modifications and alternatives. The data presented herein is based on a direct comparison of the prescriptive requirements of the 2009 and 2012 IECC as applied to Hawaii, and does not account for the Hawaii Energy Conservation Code modifications and alternatives to the 2009 IECC.

The U.S. Department of Energy (DOE) provides estimates of energy and cost savings from code adoption:

- **National**: Energy cost savings (only)
- **Climate Zone**: Energy cost savings, life-cycle cost savings, and consumer cash flows
- **State**: Energy cost savings, life-cycle cost savings, consumer cash flows, and simple paybacks

For more information on how these estimates were developed, visit the DOE Building Energy Codes website: **www.energycodes.gov/development/residential**

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Building Energy Codes
For information on Building Energy Codes, visit **www.energycodes.gov**

Technical Appendix A

Methodology

An overview of the methodology used to calculate these impacts is provided below. Further information as to how these estimates were developed is available at the U.S. Department of Energy's (DOE) Building Energy Codes website.[1]

Cost-Effectiveness

Pacific Northwest National Laboratory (PNNL) calculated three cost-effectiveness metrics in comparing the 2012 International Energy Conservation Code (IECC) to the 2009 IECC. These are:

- 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

LCC is a robust cost-benefit metric that sums the costs and benefits of a code change over a specified time period. LCC is a well-known approach to assessing cost-effectiveness. DOE uses LCC for determining the cost-effectiveness of code change proposals, and for the code as a whole, because it is the most straightforward approach to achieving the desired balance of short- and long-term perspectives.

The financial and economic parameters used for these calculations are as follows:

- New home mortgage parameters:
  - 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 8.25% 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
  - 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

Energy and Economic Analysis

This analysis determined the energy savings and economic impacts of the 2012 IECC compared to the 2009 IECC. Energy usage was modeled using DOE's EnergyPlus™ software for two building types:

[1] www.energycodes.gov/development/residential

1. Single-Family: A two-story home with central air conditioning, a 30-ft by 40-ft rectangular shape, 2,400 ft^2 of floor area, a slab-on-grade foundation, and windows that cover 15% of the wall area, equally distributed on all sides of the house
2. Multifamily: A three-story building with 18 units (6 units per floor) with a slab-on-grade foundation, each unit having conditioned floor area of 1,200 ft^2 and window area equal to approximately 10% of the conditioned floor area, equally distributed on all sides of the building. Each unit has central air conditioning

Each of these building types, single-family and apartment/condo in a multifamily building has but one unique foundation type:

- Slab on grade

There were no heating systems including in the analysis of Hawaii and hence we assume:

- No heating fuel types

This results in only 2 unique (2 ×1 × 1) building types as can be seen from Tables A.1 and A.2.

PNNL incorporated the prescriptive requirements of the 2009 and 2012 IECC when modeling the impacts of changes to the code. Whenever possible, PNNL uses DOE's EnergyPlus model software to simulate changes to code requirements. However, in some cases, alternative methods are employed to estimate the effects of a given change. As an example, in order to give full consideration of the impacts of the 2012 IECC requirement for insulating hot water pipes (or shortening the pipe lengths), a separate estimate was developed for hot water pipe insulation requirements in the 2012 IECC, which results in a 10% savings in water heating energy use (Klein 2012).

Energy and economic impacts were determined separately for the single-family and multifamily buildings. However, the cost-effectiveness results are reported as a single overall state average. Then single-family and multifamily results were combined to determine a state average weighted by housing starts from 2010 U.S. Census data as shown in Table A.3.

Table A.1. Heating Equipment Shares

Heating System	Percent Share			
	Single-Family		Multifamily	
	2009 IECC	2012 IECC	2009 IECC	2012 IECC
Natural gas	0	0	0	0
Heat pump	0	0	0	0
Electric resistance	0	0	0	0
Oil	0	0	0	0

Table A.2. Foundation Type Shares

Foundation Type	Slab on Grade	Heated Basement	Unheated Basement	Crawlspace
Percent share	100	0	0	0

Table A.3. Construction by Building Type

Housing Starts	
Single-Family	**Multifamily**
2,203	515

Differences Between the 2009 IECC and the 2012 IECC

The Hawaii Energy Conservation Code is based on the 2009 IECC but has modifications and alternatives. This analysis does not account for these modifications to the 2009 IECC. Instead, this analysis is a direct comparison of the prescriptive requirements contained in the two versions of the IECC (2009 and 2012) as applied to Hawaii.

All versions of the IECC have requirements that apply uniformly to all climate zones, and other requirements that vary by climate zone. Highlights of the mandatory requirements across all buildings include:

- Building envelope must be caulked and sealed. The 2012 IECC adds a requirement that the building must be tested and a level of leakage that is no more than a maximum limit must be achieved.
- Ducts and air handlers must be sealed. Testing against specified maximum leakage rates is required in the 2012 IECC if any ducts pass outside the conditioned space (e.g., in attics). Supply and return ducts in attics, and all ducts in crawlspaces, garages, or otherwise outside the building envelope must be insulated.
- For both the 2009 IECC and the 2012 IECC, a minimum percentage of the lighting bulbs or fixtures in the dwelling must be high-efficacy lighting.
- A certificate listing insulation levels and other energy efficiency measures must be posted on or near the electric service panel.

A comparison of significant IECC requirements is contained in Table A.4 and Table A.5. Of these, the most significant changes in the 2012 IECC compared to the 2009 IECC are the requirements for pressure testing of the building envelope and ducts/air handlers, and for insulating service hot water pipes. The requirement for high-efficacy lamps, while significant, is somewhat abated by a superseding federal regulation banning the manufacture or import of less efficient lamps at common watt levels that takes effect in 2012 to 2014.

Table A.4. Comparison of Major Requirements That Do Not Vary by Climate Zone

Requirement	2009 IECC	2012 IECC
Building envelope sealing	Caulked and sealed, verified by visual inspection against a more detailed checklist	Caulked and sealed, verified by visual inspection and a pressure test against a leakage requirement
Ducts and air handlers	Sealed, verified by visual inspection, and pressure tested against a specified leakage requirement, or all ducts must be inside building envelope	Sealed, verified by visual inspection, and pressure tested against a specified leakage requirement, or all ducts must be inside building envelope
Supply ducts in attics	R-8	R-8

Requirement	2009 IECC	2012 IECC
Return ducts in attics and all ducts in crawlspaces, garages, or otherwise outside the building envelope	R-6	R-6
Insulation on hot water pipes for service water heating systems	None	R-3 except where pipe run length is below a diameter-dependent threshold
Insulation on hot water pipes for hydronic (boiler) space heating systems	R-3	R-3
High-efficacy lamps (percent of lighting in the home)	50% of lamps	75% of lamps or 75% of fixtures
Certificate of insulation levels and other energy efficiency measures	Yes	Yes

Requirements such as insulation levels and fenestration (window, door, and skylight) U-factors can vary by the eight zones in the United States. Table A.5 shows these requirements. Hawaii has one climate zone (Zone 1) as defined in the IECC.

Table A.5. Comparison of Major Requirements That Vary by Climate Zone

Climate Zone	IECC	Components										
		Ceiling (R-value)	Skylight (U-factor)	Fenestration (windows and doors)		Wood Frame Wall (R-value)	Mass Wall* (R-value)	Floor (R-value)	Basement Wall** (R-value)	Tested Max Air Leakage Rate (air changes per hour)	Slab*** (R-value and depth)	Crawl Space** (R-value)
				U-factor	SHGC							
1	**2009**	30	0.75	NR	0.3	13	3/4	13	NR	NR	NR	NR
	2012				0.25					5		
2	**2009**	30	0.75	0.65	0.3	13	4/6	13	NR	NR	NR	NR
	2012	38	0.65	0.4	0.25					5		
3	**2009**	30	0.65	0.5	0.3	13	5/8	19	5/13****	NR	NR	5/13
	2012	38	0.55	0.35	0.25	20	8/13			3		
4	**2009**	38	0.6	0.35	NR	13	5/10	19	10/13	NR	10, 2 ft	10/13
	2012	49	0.55		0.40	20	8/13			3		
5	**2009**	38	0.6	0.35	NR	20	13/17	30	10/13	NR	10, 2 ft	10/13
	2012	49	0.55	0.32			15/19		15/19	3		15/19
6	**2009**	49	0.6	0.35	NR	20	15/19	30	15/19	NR	10, 4 ft	10/13
	2012		0.55	0.32		20+5				3		15/19
7 and 8	**2009**	49	0.6	0.35	NR	21	19/21	38	15/19	NR	10, 4 ft	10/13
	2012		0.55	0.32		20+5				3		15/19

* The second number applies when more than half the insulation is on the interior side of the high mass material in the wall.

** The first number is for continuous insulation (e.g., a board or blanket directly on the foundation wall) and the second number is for cavity insulation (i.e., if there is a furred-out wall built against the foundation 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.

**** Basement wall insulation is not required in the warm-humid region of Zone 3 in the southeastern United States.

NR = not required

SHGC = solar heat gain coefficient

While exemptions or allowances in the code are not included in this analysis, the code does allow for some of these depending on the compliance path. Examples include the following:

- One door and 15 ft^2 of window area are exempt
- Skylight U-factors are allowed to be higher than window U-factors
- Five hundred square feet or 20% of ceiling area of a cathedral ceiling, whichever is less, is allowed to have R-30 insulation in climate zones where more than R-30 is required for other ceilings

Incremental First Costs

Table A.6 shows the costs of implementing the prescriptive measures of the new code. Costs are provided for both the reference home and apartment/condo moving from the 2009 IECC to the 2012 IECC. The costs derive from estimates assembled by Faithful + Gould (2012) and a number of other sources.[2] The original cost data were based on a national average. The costs are adjusted upwards by 28.8% (multiplied by 1.288) to reflect local construction costs based on location factors provided by Faithful + Gould (2011).

Table A.6. Total Construction Cost Increase for the 2012 IECC Compared to the 2009 IECC

2,400 ft^2 House	1,200 ft^2 Apartment/Condo
$2,136	$1,117

Results

Life-Cycle Cost

Table A.7 shows the LCC savings (discounted present value) of the 2012 IECC over the 30-year analysis period. 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 A.7, LCC savings are $8,860 for the 2012 IECC.

Table A.7. Life-Cycle Cost Savings Compared to the 2009 IECC

	State Average
2012 IECC	$8,860

Cash Flow

Because most houses are financed, consumers will be very interested in the financial impacts of buying a home that complies with the 2012 IECC requirements compared to the 2009 IECC. 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). In this analysis, a 30-year fixed-rate mortgage was assumed. It was also assumed that homebuyers will deduct the interest portion of the payments from their income taxes.

[2] The Faithful + Gould cost data and other cost data for energy efficiency measures are available on the "BC3" website at http://bc3.pnnl.gov/.

Table A.8 shows the impacts to consumers' cash flow resulting from the improvements in the 2012 IECC. Up-front costs include the down payment and loan fees. The annual values shown in the table are for the first year.

The savings from income tax deductions for the mortgage interest will slowly decrease over time while energy savings are expected to increase over time because of escalating energy prices. These tables also include increases in annual property taxes because of the higher assessed house values. The net annual cash flow includes energy costs, mortgage payments, mortgage tax deductions, and property taxes but not the up-front costs. The time to positive cash flow includes all costs and benefits, including the down payment and other up-front costs.

As shown in Table A.8, on average, there is a net positive cash flow to the consumer of $430 per year beginning in year one for the 2012 IECC. Positive cumulative savings, including payment of up-front costs, are achieved in 1 year. Results are averaged across home type (single- and multifamily).

Table A.8. Impacts to Consumers' Cash Flow from Compliance with the 2012 IECC Compared to the 2009 IECC

	Cost/Benefit	State Average
A	Down payment and other up-front costs	$208
B	Annual energy savings (year one)	$541
C	Annual mortgage increase	$113
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	-$2
E = [B-(C+D)]	Net annual cash flow savings (year one)	$430
F = [A/E]	Years to positive savings, including up-front cost impacts	1

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 in sometimes even negative.

Simple Payback

Table A.9 shows the simple payback period, which consists of the construction cost increase divided by first-year energy cost savings. This calculation yields the number of years required for the energy cost savings to pay back the initial investment. Simple payback does not consider financing of the initial costs through a mortgage or favored tax treatment of mortgages.

As Table A.9 shows, the simple payback period from moving to the 2012 IECC from the 2009 IECC averages 3.6 years.

Table A.9. Simple Payback Period, Relative to the 2009 IECC (Years)

Code	State Average
2012 IECC	3.6

Energy Cost Savings

All fuel prices were obtained from the DOE Energy Information Administration and are recent residential prices specific to Hawaii (DOE 2012a). For this analysis, electricity prices were set to $0.284/kWh. Energy prices are assumed to escalate at the rates published in DOE's *Annual Energy Outlook* (DOE 2012b).

Table A.10 shows the estimated annual energy costs, including cooling, water heating, and lighting per home that result from meeting the requirements in the 2009 IECC and 2012 IECC. Table A.11 shows the total energy cost savings as both a net dollar savings and as a percentage of the total energy use.[3]

Table A.10. Annual Energy Costs for 2009 IECC and IECC 2012

	2009 IECC				2012 IECC			
	Cooling	**Water Heating**	**Lighting**	**Total**	**Cooling**	**Water Heating**	**Lighting**	**Total**
State average	$2,182	$600	$434	$3,216	$1,763	$540	$372	$2,675

As can be seen from Table A.11, annual energy cost savings for the 2012 IECC compared to the 2009 IECC average $541. On a percentage basis, energy cost savings are 16.8% with the 2012 IECC.

Table A.11. Total Energy Cost Savings Compared to the 2009 IECC

	2012 IECC	
	Savings ($/yr)	**Percent Savings**
State average	$541	16.8%

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[3] The percent savings is the annual energy cost savings for cooling, water heating, and lighting divided by the total baseline annual energy cost for cooling, water heating, and lighting.