

# REPORT

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## Hawaii Building Energy Code Stringency Assessment and Savings Forecast

Prepared for  
Department of Business, Economic Development, and Tourism  
State of Hawaii

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## Executive Summary

This analysis finds that the Hawaii Code (2009 International Energy Conservation Code with amendments) provides equal or greater energy savings when compared to the 2009 IECC for residential buildings and ASHRAE Standard 90.1-2007 for nonresidential buildings. The Hawaii amendments are included for reference in Appendix 3 of this report.

**Residential buildings.** The energy consumption of an air-conditioned home complying with minimum requirements of the Hawaii Code is likely to be 2% to 3% higher than the same home complying with the minimum 2009 IECC requirements. The Hawaii Code also includes homes without air conditioning in the scope of the envelope requirements, providing improved comfort as well as likely energy savings in cases when homeowners install room air conditioners. The magnitude of those savings is difficult to quantify, but it seems reasonable to assume that it will more than offset the 2% to 3% penalty in air-conditioned homes. Therefore, the net impact of the amendments is that the Hawaii Code provides equal or greater energy savings for residential buildings compared to the 2009 IECC.

**Nonresidential buildings.** One of the Hawaii Code amendments reduces stringency for nonresidential building while four other amendments provide increased savings. Therefore, the question is whether lost savings due to reduced stringency is offset by the additional savings due to the other amendments. The modeling and research carried out as part of this analysis show that:

- The Hawaii Code cool roof insulation exception for nonresidential buildings increases energy consumption by roughly 5% for buildings following that compliance path.
- The commissioning requirement should provide average savings of at least 5%.
- The occupancy-based guest room controls should provide at least 5% savings in hotels.
- Submetering requirements should provide average savings of at least 5% in tenant occupied buildings.
- The inclusion of unconditioned buildings within the scope of the envelope requirements will likely provide improved comfort and some energy savings in cases where room air conditioners or spot coolers are used.

The net impact of the amendments is that the Hawaii Code provides equal or greater energy savings for nonresidential buildings compared to the 2009 IECC and ASHRAE 90.1-2007.

**Energy savings forecast.** The Hawaii Code is expected to provide electricity savings of 642 MWh/yr in 2013, increasing to 3,397 MWh/yr in 2023, 5,779 MWh/yr in 2030 and 6,800 MWh/yr in 2033. Those estimates are savings for the Hawaii Code vs. the 2009 IECC and ASHRAE Standard 90.1-2007. Those estimates are net savings, in which an increase in residential energy consumption is offset by savings in commercial construction. Please see the section titled Energy Savings Forecast on page 19 for details.

## Introduction

This report assesses the stringency of the building energy code (Hawaii Code) approved by the Hawaii State Building Code Council in February 2012. The approved code applies to both residential and nonresidential buildings and consists of the 2009 International Energy Conservation Code (2009 IECC) with specific Hawaii amendments. The following codes are the benchmark for this assessment:

- Residential buildings: 2009 IECC without amendments
- Nonresidential buildings: ASHRAE Standard 90.1-2007 (note that the Hawaii Code allows 90.1.-2007 as a compliance alternative for nonresidential buildings)

The purpose of this assessment is to determine whether the Hawaii Code meets or exceeds these benchmark codes or achieves equivalent or greater energy savings.

A review of a preliminary version of this stringency assessment was provided by Kosol Kiatreungwattana of the National Renewable Energy Laboratory in September 2012.

## Summary of Hawaii Amendments

A set of amendments to the 2009 IECC were approved by the State Building Code Council in February 2012. Those amendments are included as an attachment to this report. This section provides a brief summary.

- The scope of the envelope requirements is extended to apply also to unconditioned, habitable spaces (HI amendment to 101.5.2)
- Hawaii amendments provide alternatives for residential envelope compliance:
  - Wall insulation tradeoffs allow reduction in insulation for walls that are light color or shaded by overhangs. The reduction is also allowed if 90% of permanent lighting is high efficacy (HI amendment to Table 402.1.1)
  - Four options for ceiling heat-gain reduction are included: insulation, radiant barrier plus ventilation, radiant barrier plus cool roof, or a roof heat gain factor calculation (new section 402.1.6)
  - Steel-frame walls do not require R-5 continuous insulation if they qualify for one of four exceptions: light color, overhang shading, high-efficacy lighting, or high efficiency air conditioner (HI amendment to 402.2.5)
  - North-facing and well-shaded windows are exempt from the SHGC requirement (HI amendment to 402.3.3)
  - Air leakage exemption for unconditioned dwellings, which exempts them from sealing requirements but applies alternative requirements for minimum natural ventilation vent area and ceiling fan stub-ins (HI amendment to 402.4.1.1)
  - Air leakage allowance for jalousie windows, sets a higher tested air leakage threshold for jalousies (HI amendment to 402.4.4)

- No roof insulation is required in a commercial building roof that has a qualifying cool roof membrane, at elevations below 2,400 ft. (HI amendment to 502.2.1)
- An area weighted average is allowed for commercial window SHGC compliance (HI amendment to 502.3.3)
- Mechanical systems commissioning and completion requirements. The designer is required to provide a written statement of system completion (HI amendment to 503.2.9)
- Hotel thermostat and lighting controls. Automatic controls are required that detect whether the room is occupied and adjust the thermostat and lighting accordingly. Interlock switches are also required on lanai doors to shut off AC when the door is open (HI amendment to 505.2.3)
- Tenant electrical submetering is required for tenants occupying 1,000 ft<sup>2</sup> or more (HI amendment to 505.7)

## Residential Stringency Assessment

The baseline for comparison for residential buildings is the 2009 IECC. The Hawaii Code is equal to the 2009 IECC except for a number of amendments. Therefore, this residential code assessment addresses each of those Hawaii amendments and their likely energy impact.

Each of the residential amendments is presented in Table 1 alongside the corresponding 2009 IECC requirement. In each case a determination is indicated regarding whether the 2009 IECC or the Hawaii Code is more stringent. This assessment shows that in some cases the Hawaii Code is more stringent and in others the 2009 IECC is more stringent. In some cases an EnergyPlus simulation model was used to evaluate the impact of the Hawaii amendment.

The energy consumption of an air-conditioned home complying with minimum requirements of the Hawaii Code is likely to be 2% to 3% higher than the same home complying with the minimum 2009 IECC requirements. The Hawaii Code also includes homes without air conditioning in the scope of the envelope requirements, providing improved comfort as well as likely energy savings in cases when homeowners install room air conditioners. The magnitude of those savings is difficult to quantify, but it seems reasonable to assume that it will more than offset the 2% to 3% penalty in air-conditioned homes. Therefore, the net impact of the amendments is that the Hawaii Code provides equal or greater energy savings compared to the 2009 IECC.

**Table 1. Residential Assessment Summary**

2009 IECC	Hawaii Amendment	Discussion
101.5.2. Exempts unconditioned buildings from envelope compliance. Specifically, exempts buildings for which peak design rate of energy usage for space conditioning is less than 3.4 Btuhr-ft <sup>2</sup> .	Includes habitable unconditioned spaces in scope of envelope requirements.  The intent of the amendment is that all residences meet the envelope requirements, which will help improve comfort of unconditioned dwellings.	<b>Hawaii Code is more stringent.</b>  It is expected that this amendment will save energy by reducing the number of homes that add air conditioning after construction and will improve the efficiency of homes that do add air conditioning after construction.

2009 IECC	Hawaii Amendment	Discussion
<p>Table 402.1.1. Mass wall insulation requirement is R-3 exterior or R-4 interior</p>	<p>Allows reduction of R-5 interior insulation or R-4 exterior insulation for walls that meet one of three criteria.</p> <ol style="list-style-type: none"> <li>1. Exterior surface light reflectance <math>\geq 0.64</math></li> <li>2. 90% high efficacy lighting</li> <li>3. Overhang shading with projection factor <math>\geq 0.3</math> on non-north walls</li> </ol> <p>This amendment effectively allows uninsulated mass walls if the project meets one of the three criteria.</p> <p>The intent of this amendment is to provide a potentially lower-cost path to equal energy savings.</p>	<p><b>Varies depending on exception.</b></p> <p>See Table 4 for analysis results, which show that option 1 is slightly more stringent and options 2 and 3 are slightly less stringent.</p> <p>Solar heat gain is the primary source of cooling load for residences in Hawaii. Therefore, reflective walls and overhangs provide alternate paths for cooling load reduction.</p> <p>The high efficacy lighting exception increases the existing 50% limit in the 2009 IECC to 90%.</p>
<p>Table 402.1.1. Ceiling insulation requirement is R-30</p>	<p>New section 402.1.6 provides four ceiling insulation alternatives for dwellings located below 2,400 ft elevation. The intent of these amendments is to provide potentially lower-cost paths to equal performance. In most Hawaii residences the reduction of solar heat gain through the roof is the primary concern.</p> <ol style="list-style-type: none"> <li>1. Roof insulation. R-30 at attic ceiling or R-19 under roof</li> <li>2. Radiant barrier + attic ventilation</li> <li>3. Radiant barrier + cool roof</li> <li>4. Roof heat gain factor <math>\leq 0.05</math> (combines U-factor, surface absorptance, and radiant barrier)</li> </ol>	<p><b>2009 IECC is more stringent</b></p> <p>See Table 2 for analysis results.</p> <p>For dwellings located above 2,400 ft elevation there is no difference in stringency.</p> <p>For dwellings below 2,400 ft elevation there are paths that allow less than R-30 insulation when other heat-gain reduction measures are used. However, in some cases R-19 is accepted without additional heat gain measures. Therefore, this amendment is likely to be slightly less stringent on aggregate.</p>

2009 IECC	Hawaii Amendment	Discussion
<p>402.2.5. Steel frame walls require R-13 cavity insulation + R-5 continuous insulation</p>	<p>Buildings at elevation lower than 2,400 ft are exempt from the R-5 continuous insulation requirement if they meet one of the following criteria:</p> <ol style="list-style-type: none"> <li>1. Exterior surface light reflectance <math>\geq 0.64</math></li> <li>2. 90% high efficacy lighting</li> <li>3. Overhang shading with projection factor <math>\geq 0.3</math> on non-north walls</li> <li>4. Central air conditioner with SEER <math>\geq 14</math>.</li> </ol> <p>The intent of this amendment is to provide a potentially lower-cost path to equal energy savings, considering that solar heat gain and air conditioning energy is the primary concern in Hawaii.</p>	<p><b>Hawaii Code is equal or more stringent, depending on exception.</b></p> <p>See Table 3 for analysis results.</p> <p>In Hawaii's climate solar heat gain is the primary source of cooling load. Reflective walls and overhangs provide alternate paths for cooling load reduction.</p> <p>The high efficacy lighting exception increases the existing 50% limit in the 2009 IECC to 90%.</p> <p>The minimum SEER by Federal regulation is SEER 13.</p>
<p>402.3.3 Up to 15 ft<sup>2</sup> of glazing area is exempted from the U-factor and SHGC requirements</p>	<p>In addition, north-facing windows and windows shaded with overhangs providing a projection factor of <math>\geq 1.0</math> are exempt from the SHGC requirements.</p> <p>This amendment is based on the fact that solar heat gain is the primary concern for residential windows in Hawaii, and well-shaded windows can be exempted from the SHGC requirement with little energy penalty</p>	<p><b>IECC is more stringent for north-facing windows.</b> <b>Hawaii code is equal or more stringent for non-north-facing windows.</b></p> <p>See Table 5 for analysis results.</p> <p>The energy impact is likely to be small because solar heat gain will be very low through the exempted windows.</p>
<p>402.4.1.1 building envelope sealing required to limit infiltration</p>	<p>Unconditioned dwellings are exempted from the sealing requirements. In addition, unconditioned dwelling must meet minimum requirements for natural ventilation vent area and must include stub-ins for ceiling fans.</p>	<p><b>Hawaii Code is more stringent.</b></p> <p>Unconditioned dwelling envelope is not covered by the 2009 IECC, while the Hawaii amendment includes requirements to improve comfort and potentially offset the future addition of air conditioning.</p>

2009 IECC	Hawaii Amendment	Discussion
402.4.4 Windows, skylights and sliding glass doors must meet air leakage limits of 0.3 cfm/ft <sup>2</sup> to minimize infiltration	A higher limit of 1.2 cfm/ft <sup>2</sup> is added for jalousie windows.  Jalousies are a common choice in Hawaii where they provide the benefit of high net vent area for natural ventilation.	<b>IECC is more stringent.</b>  There is likely to be some natural ventilation benefit during mild weather to allowing the use of jalousie windows; however, there is also likely to be some increased infiltration and increased air conditioning energy during hot weather conditions.

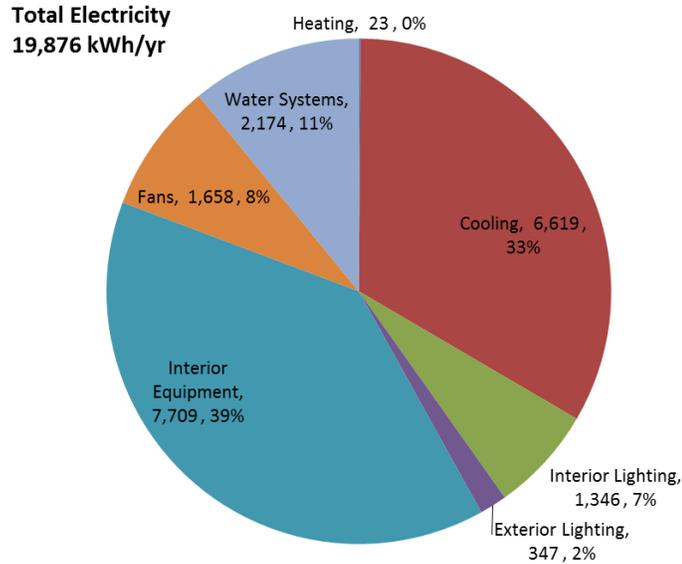
## Residential Energy Impact

In summary, the electricity consumption of an air-conditioned house complying with the Hawaii Code is equal to or slightly higher than the consumption for a 2009 IECC house, depending on which Hawaii Code compliance path is followed. The range in performance is from 0% to 6% above baseline electricity consumption. Equal performance results from a choice of baseline roof (R-30) and window (SHGC-0.30) compliance options. The worst-case path includes roof design option #2 (ventilation + radiant barrier) combined with clear glass on the north side. There are many possible compliance path combinations, and the likely average case results in electricity consumption of 2% to 3% above the 2009 IECC baseline. The average impact calculated for forecast purposes is estimated to be an increase of 2.3%, as described on page 9.

A simulation model was used to evaluate the energy impact of several Hawaii Code amendments. Results for those alternatives are presented in this section. Please see Appendix 1 for more details on the EnergyPlus simulation model and assumptions. This prototype home simulation model was selected because it was developed by Pacific Northwest National Laboratory for evaluating energy code savings.

The electricity consumption results for the baseline residential model are illustrated in Figure 1. Total annual electricity consumption is 19,876 kWh per year. The largest end use is air conditioning (cooling + fan) at 41%. This model represents a 2,400 ft<sup>2</sup> two-story house with 24 hour per day air conditioning and with electric resistance water heating. As a result the consumption is higher than the average existing Hawaii dwelling due to both the size and the continuous air conditioning. The average Hawaii residential electricity customer consumes about 7,000 kWh/yr of electricity<sup>1</sup>. However, that average includes both single-family and multi-family dwellings, and many of those existing homes have little or no air conditioning. Many existing homes also have solar water heating. It is expected that the energy consumption predicted by this prototype model is reasonably accurate for a large air-conditioned home even though it is higher than the average existing dwelling unit.

<sup>1</sup> 2011 Hawaii Data Book, Table 17.09, DBEDT



**Figure 1. Residential Baseline Model Electricity Consumption (kWh/yr) (EnergyPlus model results; see also Appendix 1 for assumptions)**

### Roof Insulation

The impact of Hawaii Code amendments for residential roof insulation is illustrated in Table 2. The first option for R-30 insulation is essentially equal to the IECC 2009 baseline. Options 2, 3 and 4 are less stringent than the baseline requirement, resulting in an increase in electricity consumption of 4.3%, 1.8% and 3.1% respectively.

**Table 2. Results for Residential Roof Alternatives**

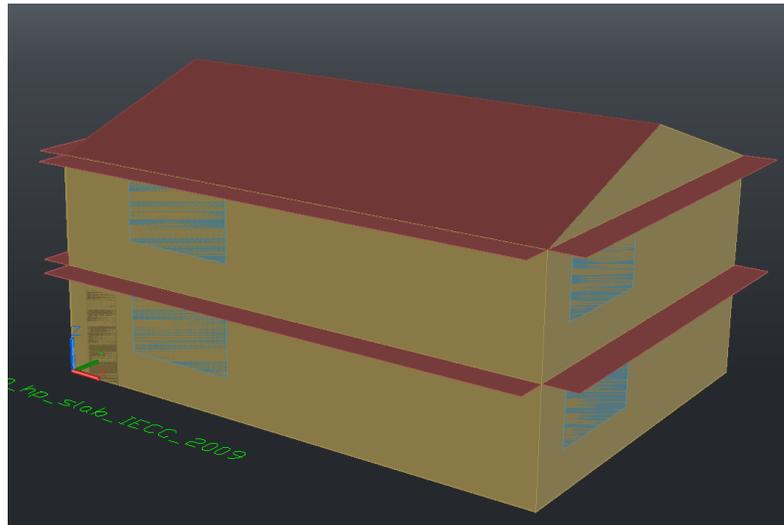
Roof Alternatives	kWh/yr	Difference
Option 1: baseline R-30	19,876	--
Option 2: ventilation + radiant barrier	20,730	4.3%
Option 3: radiant barrier + cool roof	20,236	1.8%
Option 4: RHGF = 0.05 (cool roof + R-3)	20,491	3.1%

### Metal Frame Walls

The impact of Hawaii Code amendments for residential metal-frame walls is illustrated in Table 3. Electricity consumption compared to the baseline is nearly equal or lower in all cases. The two cases that reduce solar heat gain, reflective walls and overhangs, both perform slightly better than the baseline. The alternatives for high efficacy lighting and higher efficiency air conditioner provide nearly equal performance to the baseline.

**Table 3. Results for Residential Metal-Frame Wall Alternatives**

Metal Wall Alternatives	kWh/yr	Difference
Baseline: R-13 + foam board sheathing (U-0.082)	19,790	--
Alt 1: R-13 + 64% reflectance	19,495	-1.5%
Alt 2: R-13 + 90% high efficacy lighting	19,806	0.1%
Alt 3: R-13 + overhangs with PF=0.3	19,441	-1.8%
Alt 4: R-13 + SEER 14 air conditioner	19,828	0.2%



**Figure 2. Residential Model Showing Wall Overhang Shading**

### Mass Walls

The impact of Hawaii Code amendments for residential mass walls is shown in Table 4. The first alternative, high reflectance walls, performs better than the baseline. The other two alternatives, high efficacy lighting and overhang shading, do not completely offset the energy penalty due to eliminating mass wall insulation.

**Table 4. Results for Residential Mass Wall Alternatives**

Mass Wall Alternatives	kWh/yr	Difference
Baseline: Mass wall with insulation (U-0.197)	20,836	--
Alt 1: no insulation + 64% reflectance	20,402	-2.1%
Alt 2: no insulation + 90% high efficacy lighting	21,917	5.2%
Alt 3: no insulation + overhangs with PF=0.3	21,165	1.6%

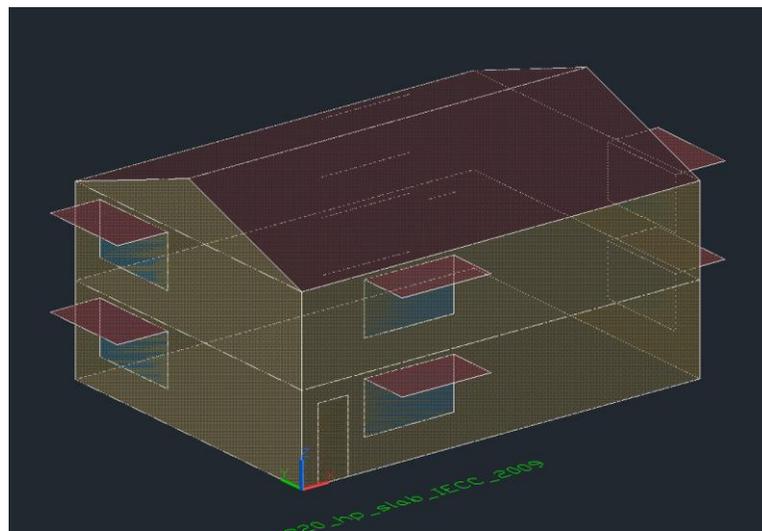
### Residential Window Shading

The impact for residential window shading exceptions in the Hawaii Code amendments is shown in Table 5. Allowing clear glass on north-facing windows results in an increase in electricity consumption compared

to the baseline. The exception allowing clear glass with overhang shading on non-north orientations provides slightly better performance than the baseline. The combination of both exceptions results in a slight increase in electricity consumption compared to the baseline.

**Table 5. Results for Residential Window Shading Exceptions**

Window Shading Exceptions	kWh/yr	Difference
Baseline: SHGC 0.30 for all windows	19,876	--
Alt 1: clear glass on north windows	20,157	1.4%
Alt 2: clear glass + overhangs (PF=1.0) on non-north	19,802	-0.4%
Alt 1 + Alt 2	20,086	1.1%



**Figure 3. Residential Model Showing Window Overhang Shading**

### Overall Energy Impact for Residential Prototype

As noted above, the impact will vary depending on the selected compliance paths. As a rough estimate of the likely combined impact of the Hawaii Code amendments the simulation results described above are combined for a net increase of 451 kWh/yr for the prototype single-family house, equal to about 2.3%. These calculations are summarized in Table 6 and are based on the following assumptions.

- Each of the four roof options listed in Table 2 is followed equally. In other words, each option accounts for 25% of new construction. The net impact is an increase of 457 kWh/yr per home.
- Each of the four steel frame wall alternatives in Table 3 is also followed equally, resulting in a net savings of 147 kWh/yr per home or 0.7%. Assuming that 75% of new homes have steel frames, the overall net savings drops to 110 kWh/yr.
- The fraction of new residences with mass walls is assumed to be very small; therefore that impact is not included in this estimate.
- For windows, each of the four options listed in Table 5 is followed equally, and the net impact is an increase of 104 kWh/yr.

Table 6 also includes second set of simulation results using a reduced air-conditioning schedule. The original PNNL prototype model assumed 24-hour per day cooling, which is not the norm in Hawaii where natural ventilation provides cooling for much of the year and where high electricity rates provide incentive for conservation. The following air-conditioning schedule was implemented in the EnergyPlus model to represent more typical operation. The results are listed in the right-hand column in Table 6.

- Jan 1 – Feb 28: No air-conditioning
- Mar 1 – Mar 15: 4pm- 7pm (3 hours/day)
- Mar 16 – May 31: 4pm – 8pm (4 hours/day)
- Jun 1 – Oct 31: 2pm – 8pm (6 hours/day)
- Nov 1 – Nov 15: 4pm – 7pm (3 hours/day)
- Nov 15 – Dec 31: No air-conditioning

**Table 6. Estimate of Energy Impact for Prototype 2,400 ft<sup>2</sup> Single-Family House**

<b>Roof Alternatives</b>	<b>kWh/yr</b> (Original PNNL model assumption, 24/7 air conditioning)	<b>kWh/yr</b> (Reduced air conditioning schedule)
Option 1: baseline R-30	19,876	15,391
Option 2: ventilation + radiant barrier	20,730	16,021
Option 3: radiant barrier + cool roof	20,236	15,708
Option 4: RHGF = 0.05 (cool roof + R-3)	20,491	15,835
Average	20,333	15,739
Baseline: R-30	19,876	15,391
<b>Difference (kWh/yr)</b>	<b>457</b>	<b>348</b>
<b>Metal Wall Alternatives</b>	<b>kWh/yr</b>	
Alt 1: R-13 + 64% reflectance	19,495	15,155
Alt 2: R-13 + 90% high efficacy lighting	19,806	15,244
Alt 3: R-13 + overhangs with PF=0.3	19,441	15,113
Alt 4: R-13 + SEER 14 air conditioner	19,828	15,465
Average	19,643	15,244
Baseline: R-13 + foam board sheathing	19,790	15,296
Difference (kWh/yr)	(147)	(52)
<b>75% of difference (assuming 75% of new homes use steel framing)</b>	<b>(110)</b>	<b>(39)</b>
<b>Window Shading Exceptions</b>	<b>kWh/yr</b>	
SHGC 0.30 for all windows	19,876	15,391
Alt 1: clear glass on north windows	20,157	15,572
Alt 2: clear glass + overhangs (PF=1.0) on non-north	19,802	15,356
Alt 1 + Alt 2	20,086	15,535
Average	19,980	15,463
Baseline: SHGC 0.30 for all windows	19,876	15,391
<b>Difference (kWh/yr)</b>	<b>104</b>	<b>72</b>
<b>Total Net Impact</b>		
Roof Alternatives	457	348
Metal Wall Alternatives	(110)	(39)
Window Shading Exceptions	104	72
<b>Net increase in electricity (kWh/yr)</b>	<b>451</b>	<b>381</b>
Net increase in electricity (%)	2.3%	2.5%

## Nonresidential Stringency Assessment

ASHRAE 90.1-2007 is the benchmark code for nonresidential buildings. This analysis shows that the Hawaii Code is likely to provide equal or greater energy savings compared to 90.1-2007. This nonresidential assessment is presented in two parts.

1. First is a comparison of the 2009 IECC to 90.1-2007, showing that the 2009 IECC provides equal or greater energy savings.
2. Second is a comparison of the Hawaii Code to the 2009 IECC, showing that the Hawaii Code is likely to provide equal or greater savings.

The Hawaii Code also permits the use of 90.1-2007 as a compliance option for nonresidential buildings. Therefore, buildings following that option will, of course, meet the stringency of 90.1-2007.

### Nonresidential Assessment - 2009 IECC vs. ASHRAE 90.1-2007

A 2009 assessment by Pacific Northwest National Laboratory<sup>2</sup> identified differences between the 2009 IECC and 90.1-2007. The purpose of that assessment was to aid states in determining whether the 2009 IECC meets or exceeds 90.1-2007. That assessment identified a list of key differences to be considered, and those differences are summarized in Table 7 along with a discussion of the likely impact for buildings in Hawaii.

In some cases the 2009 IECC is more stringent and in other cases 90.1-2007 is more stringent. In general, the envelope requirements of the 2009 IECC are equivalent or more stringent. In cases where the HVAC requirements are different, they are typically more stringent in 90.1-2007. However, most of the HVAC differences apply for only specific building or system types and do not apply generally. The water heating requirements of the 2009 IECC are equal or more stringent. Lighting requirements are essentially equal.

In aggregate the relative stringency will vary from one building to the next, but in most cases the difference will be very small. The summary in Table 7 indicates that the 2009 IECC is likely to provide equal or greater savings when compared to ASHRAE 90.1-2007.

**Table 7. Key Differences –2009 IECC vs. ASHRAE 90.1-2007**

2009 IECC	90.1-2007	Discussion
No separate category for semi-heated buildings.	Includes separate envelope requirements for semi-heated buildings.	<b>No difference.</b> Semi-heated buildings are very rare or non-existent in Hawaii's climate
Glazing sloped at more than 15 degrees from vertical is considered a skylight	Glazing sloped at more than 30 degrees from vertical is considered a skylight	<b>Varying case-by-case impact</b>

<sup>2</sup> Conover, David, et al. *Comparison of Standard 90.1-2007 and the 2009 IECC with Respect to Commercial Buildings*, December 2009, Pacific Northwest National Laboratory.

2009 IECC	90.1-2007	Discussion
Walls considered “above grade” if more than 15% of area is above grade.	Above-grade wall requirement applies to above-grade portion and below-grade requirement to below-grade portion.	<b>2009 IECC more stringent.</b> Impact is likely small, but some below grade portions of walls may require more insulation under the IECC
40% window-wall-ratio limit calculated based on above-grade wall area.	40% window-wall-ratio calculation includes below-grade wall area	<b>2009 IECC more stringent.</b> Buildings with below grade walls would be allowed more window area under 90.1-2007.
Opaque envelope, metal-building insulation requirement is R-16	Metal building insulation requirement is R-13	<b>2009 IECC more stringent.</b> The insulation requirement for metal building walls is slightly more stringent in 2009 IECC. Other opaque envelope insulation requirements are identical.
SHGC requirement varies depending on overhang projection factor: 0.25 for PF < 0.25 0.33 for 0.25 ≤ PF < 0.50 0.40 for PF ≥ 0.50	SHGC requirement is 0.25, with multipliers available for overhang shading (Table 5.5.4.4.1).	<b>2009 IECC more stringent.</b> Without overhangs the two codes are equal. With overhangs, the 2009 IECC requirement will be more stringent in most cases, especially when PF < 0.25 and PF > 0.50.
Skylight area limited to 3% of roof area	Skylight area limited to 5% of roof area	<b>2009 IECC more stringent</b>
Skylight U-factor 0.75	U-1.98 with curb or U-1.36 with curb	<b>2009 IECC more stringent</b>
Skylight SGHC 0.35	SHGC 0.36 for up to 2% roof area SHGC 0.19 for 2.1% – 5%	<b>Varies.</b> IECC 2009 more stringent if area less than 2% or greater than 3%. 90.1 more stringent if area is between 2% and 3%.
No credit for roof reflectance	Allows reduced roof insulation with qualifying cool roof (Table 5.5.3.1)	<b>2009 IECC more stringent</b>
HVAC sizing limited to load calculations	No specific sizing requirement	<b>2009 IECC more stringent</b>

2009 IECC	90.1-2007	Discussion
No requirement	HVAC system optimum start control required for systems > 10,000 cfm	<b>90.1-2007 more stringent</b>
No requirement	Dehumidification (6.5.2.3) limits the use of reheat and simultaneous heating and cooling for dehumidification, with a number of exceptions.	<b>90.1-2007 more stringent</b>
Service water heating equipment efficiency (Table 504.2)	Service water heating equipment efficiency (Table 7.8)	<b>2009 IECC equal or more stringent</b>
Interior lighting power allowances (Table 505.5.2)	Two interior lighting power allowance methods. The building area method (Table 9.5.1) is equivalent to IECC. The space-by-space method (Table 9.6.1) is an alternate path that can be less stringent.	<b>Little difference.</b>

### Nonresidential Assessment - Hawaii Code vs. 2009 IECC

As the second step in this assessment, the Hawaii Code is compared to the 2009 IECC. Table 8 describes the Hawaii Code amendments alongside a description of the corresponding section of the 2009 IECC. In each case a determination of relative stringency is described. In the following section, more discussion of energy impact is included.

One of the amendments reduces stringency compared to the 2009 IECC while four other amendments provide increased savings. Therefore, the question is whether lost savings due to reduced stringency is offset by the additional savings due to the other amendments. In brief,

- The cool roof insulation exception increases energy consumption by roughly 5% for buildings following that compliance path.
- The commissioning requirement should provide average savings of at least 5%.
- The occupancy-based guest room controls should provide at least 5% savings in hotels.
- Submetering requirements should provide average savings of at least 5% in tenant occupied buildings.
- The inclusion of unconditioned buildings within the scope of the envelope requirements will likely provide saving in future avoided air conditioning energy.

The net impact of the amendments is that the Hawaii Code provides equal or greater energy savings for nonresidential buildings compared to the 2009 IECC and ASHRAE 90.1-2007.

**Table 8. Nonresidential Assessment – Hawaii Code vs. 2009 IECC**

2009 IECC	Hawaii Amendment	Discussion
<p>101.5.2. Exempts unconditioned buildings from envelope compliance. Specifically, exempts buildings for which peak design rate of energy usage for space conditioning is less than 3.4 Btuhr-ft<sup>2</sup>.</p>	<p>Includes habitable unconditioned spaces in scope of envelope requirements.</p> <p>The intent of the amendment is that all habitable buildings meet the envelope requirements, which will help improve comfort of unconditioned dwellings.</p>	<p><b>Hawaii Code is more stringent.</b></p> <p>It is expected that this amendment will save energy by reducing the number of buildings that add air conditioning after occupancy and will improve the efficiency of buildings that do add air conditioning after construction.</p>
<p>502.2.1 Roof insulation requirement for climate zone 1 is:</p> <ul style="list-style-type: none"> <li>• R-15 for insulation above roof</li> <li>• R-19+R-5 thermal block for metal building</li> <li>• R-30 for attic and other</li> </ul>	<p>For buildings at elevation below 2,400 ft, no insulation is required if the roof has initial reflectance of <math>\geq 0.70</math> and extended reflectance <math>\geq 0.55</math>.</p> <p>The intent is to provide a potentially lower cost alternative to insulation. In Hawaii solar heat gain reduction is the primary role of roof insulation, and a cool roof membrane will significantly reduce heat gain.</p>	<p><b>IECC is more stringent.</b></p> <p>An EnergyPlus simulation analysis shows that electricity consumption increases by 5% for a medium-sized office building that follows the cool roof exception. See Table 9 for simulation results.</p> <p>The impact will vary between building types and will vary based on building dimensions.</p>
<p>502.3.3 Maximum fenestration SHGC limits</p>	<p>Allows an area-weighted average SHGC to be used for compliance</p>	<p><b>No impact.</b></p> <p>Not net increase in solar heat gain.</p>
<p>503.2.9 HVAC System Completion requirements include air balancing, hydronic system balancing and O&amp;M manuals</p>	<p>Requirements added for system commissioning and commissioning plan, which require that the design professional provide written certification of system completion prior to occupancy.</p> <p>In addition, more detail is added to the balancing requirements.</p>	<p><b>Hawaii Code is more stringent.</b></p> <p>The commissioning requirement has potential for significant energy savings. See page 17 for discussion. One study reports 13% average savings. Savings of at least 5% are considered likely.</p> <p>The additional balancing requirements have potential for minor additional savings.</p>

2009 IECC	Hawaii Amendment	Discussion
<p>505.2.3 Sleeping unit controls. Requires a master switch in hotel guest rooms controlling permanently wired luminaires and switched receptacles.</p>	<p>Hotel thermostat and lighting controls. Automatic controls are required that detect whether the room is occupied and adjust the thermostat and lighting accordingly. Interlock switches are also required on lanai doors to shut off AC when the door is open</p>	<p><b>Hawaii Code is more stringent.</b></p> <p>Significant savings are expected due to automatic control of both lighting and thermostat.</p> <p>In addition, significant savings should be provided by HVAC interlock switches on balcony doors.</p> <p>Hotels represent a significant fraction of construction in Hawaii, so this amendment should have a large impact.</p> <p>Savings of at least 5% seem reasonable for hotel buildings. See page 17 for further discussion of likely savings for occupancy based controls.</p>
<p>505.7 requires separate electrical metering for individual dwelling units</p>	<p>Expands the submetering requirement to all nonresidential buildings and requires electrical submetering for all tenants occupying at least 1,000 ft<sup>2</sup>.</p>	<p><b>Hawaii Code is more stringent.</b></p> <p>While not guaranteeing energy savings, submetering provides energy consumption information to tenants and increases the incentive to conserve.</p> <p>Savings of at least 5% seem likely for tenant-occupied buildings that fall under the scope of this requirement.</p> <p>See page 18 for further discussion of likely savings for submetering.</p>

## Nonresidential Energy Impact

### Cool Roof Exception

EnergyPlus simulation results show that electricity use increases by about 5% when the Hawaii Code’s nonresidential cool roof exception is followed. Results are summarized in Table 9. That exception allows an uninsulated roof if a qualifying cool roof membrane is installed. The magnitude of the impact will vary between building types and will vary based on building dimensions. These results are for a three-story office building model that was developed by Pacific Northwest National Laboratory for use in energy code studies. The impact will like be greater in one and two story buildings and lower in taller buildings. More information about the prototype building model is included in Appendix 2.

Two sets of simulation results are presented in Table 9. The base roof meets minimum 2009 IECC requirements for a U-factor of 0.062 and has a roof surface solar reflectance of 30%. The Hawaii Code roof has no insulation and a U-factor of 0.52. The cool roof reflectance is assumed to be 55%, accounting for aged performance. If the reflectance were assumed to be 70%, which is the minimum requirement for new roof reflectance, then the energy penalty would be only 2% rather than 5%.

It is important to note that not all nonresidential buildings will follow this compliance exception. Therefore, the statewide average impact will be lower.

**Table 9. Nonresidential Simulation Results, Electricity Consumption (kWh/yr)**

	<b>BASE ROOF U-factor = 0.062 Reflectance = 30%</b>	<b>Hawaii Code Exception COOL ROOF, NO INSULATION U-factor = 0.52 Reflectance = 55%</b>	<b>DIFFERENCE (%)</b>
Heating	4,754	11,435	140.5%
Cooling	270,645	299,399	10.6%
Interior Lighting	153,611	153,611	0.0%
Exterior Lighting	62,925	62,925	0.0%
Interior Equipment	226,829	226,829	0.0%
Fans	32,988	36,240	9.9%
<b>Total</b>	<b>751,751</b>	<b>790,439</b>	<b>5.1%</b>

### Commissioning

The energy savings achieved through commissioning will vary among buildings. A 2009 study by Lawrence Berkeley National Lab estimated an average of 13% source energy savings for new construction.<sup>3</sup> It is reasonable to expect energy savings of at least a 5% percent due to the Hawaii Code's requirement for commissioning.

### Hotel Sleeping Unit Controls

A 2010 study commissioned by Pacific Gas & Electric found an average of 25% guest-room energy savings for occupancy-based controls based on field monitoring. A simulation study estimated 15% HVAC savings for on/off control and 5% HVAC savings for temperature setback control.<sup>4</sup>

A 2011 report prepared for the California Energy Commission to support energy code development estimates guest-room occupancy controls produced HVAC savings of 12-25% and guest room lighting savings of 16%.<sup>5</sup>

<sup>3</sup> Mills, Evan, "Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions", LBNL, July 21, 2009.

<sup>4</sup> PG&E, Emerging Technologies Program, "Application Assessment Report #0825, Occupancy-Based Guestroom Controls Study", April 10, 2010.

<sup>5</sup> California Utilities Statewide Codes and Standards Team, "Guest Room Occupancy Controls", October 2011.

Based on these studies, the savings due to the Hawaii Code requirements for sleeping unit controls could reasonably be expected to be at least 5% for hotel buildings. That savings estimate is based on assumptions that guest room HVAC accounts for about 25% of total hotel energy use and guest room lighting accounts for about 10%. The remainder of the hotel energy consumption is assumed to be due to hot water, plugs loads, cooking, and lighting and HVAC for support-areas and would not be affected by this code requirement.

### Submetering

Submetering does not guarantee any energy savings, but provides greater incentive to tenants to consume less energy. A report by the National Science and Technology Council describes studies of submetering's impact on residential buildings showing savings of 0 to 20%. No studies were identified on the impact in nonresidential buildings, however case studies were presented claiming savings of 30% and 18% due to tenant submetering.<sup>6</sup>

The impact of the submetering requirement in the Hawaii Code will vary among buildings. It seems reasonable to expect an average of about 5% energy savings for the tenant-occupied buildings that fall under the scope of this requirement.

### Overall Energy Impact for Nonresidential Buildings

The estimate for the combined impact of the four measures discussed above is an energy savings of 7.5% for hotels and 3.5% for other nonresidential buildings compared to ASHRAE Standard 90.1-2007, equal to roughly 1.21 kWh/ft<sup>2</sup> per year for hotels and 0.49 kWh/ft<sup>2</sup> for other nonresidential buildings. The savings estimate is summarized in Table 10. That estimate is based on the following assumptions.

- Average electricity consumption for new buildings is 16.1 kWh/ft<sup>2</sup> per year for hotels and 14.0 kWh/ft<sup>2</sup> per year for other nonresidential buildings. (See table notes for sources)
- One-half of new nonresidential buildings use the cool roof exemption, resulting in an average increase of 2.5%, equal to 0.40 kWh/ft<sup>2</sup> in hotels and 0.35 kWh/ft<sup>2</sup> in other nonresidential buildings
- Mechanical system commissioning provides an average of 5% savings, equal to 0.81 kWh/ft<sup>2</sup> in hotels and 0.70 kWh/ft<sup>2</sup> in other nonresidential buildings.
- Hotel sleeping unit controls save 5% in hotels, equal to 0.81 kWh/ft<sup>2</sup>.
- Submetering saves 5% and applies to 20% of nonresidential buildings, equal to 0.14 kWh/ft<sup>2</sup>. Potential savings in hotels are not included because submetering would likely affect only a small part of their total energy consumption.

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<sup>6</sup> "Submetering of Building Energy and Water Use", National Science and Technology Council, October 2011.

**Table 10. Nonresidential Electricity Impact Estimate (kWh/ft<sup>2</sup>-yr)**

	Hotel	Other	Notes
<b>Baseline electricity consumption</b>	<b>16.1</b>	<b>14.0</b>	Sources: Hotel, Evan Mills, LBL, referencing T. Van Liew, HECO, 2003 "Other", office simulation model, described on page 26.
Cool roof exemption	0.40	0.35	2.5% increase
Commissioning	(0.81)	(0.70)	5% savings
Sleep unit occupancy controls	(0.81)	0.00	5% savings in hotels
Submetering	0.00	(0.14)	5% savings in 20% of "other" buildings
<b>Net impact (kWh/ft<sup>2</sup>/yr)</b>	<b>(1.21)</b>	<b>(0.49)</b>	
<b>Net impact (%)</b>	<b>-7.5%</b>	<b>-3.5%</b>	

## Energy Savings Forecast

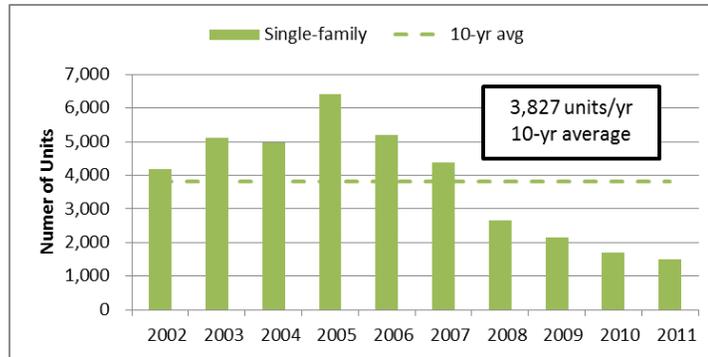
This section of the report includes construction forecasts for both residential and nonresidential projects followed by forecasts of energy impact in the years 2013, 2023 and 2033. The energy impact estimate compares the Hawaii Code to the 2009 IECC for residential buildings and to ASHRAE Standard 90.1-2007 for nonresidential buildings.

### Residential Construction Forecast

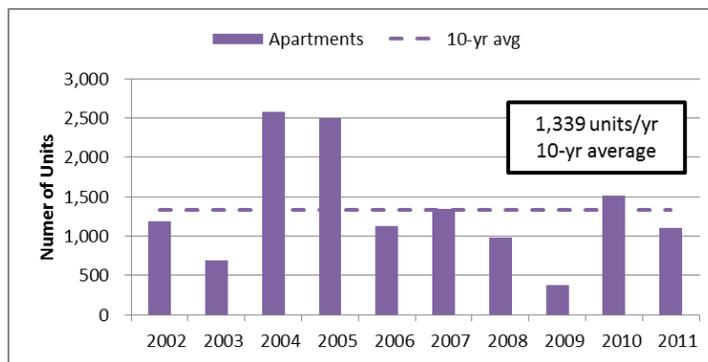
The forecast for residential new construction is based on past construction activity. Statewide construction for the ten years of 2002 through 2011 is listed in Table 11 and plotted in Figure 4 and Figure 5. These data show a ten-year average of 3,827 single-family units per year and 1,339 apartments per year. The data also show a significant decline in construction since 2005.

**Table 11. Residential Construction History, Number of Dwelling Units (Source: Dodge data provided by Mary Blewitt, DBEDT)**

Year	Single-family	Apartments
2002	4,191	1,186
2003	5,131	687
2004	4,967	2,581
2005	6,413	2,490
2006	5,191	1,126
2007	4,370	1,342
2008	2,653	987
2009	2,145	381
2010	1,702	1,513
2011	1,504	1,100
<b>5-yr average</b>	<b>2,475</b>	<b>1,065</b>
<b>10-yr average</b>	<b>3,827</b>	<b>1,339</b>

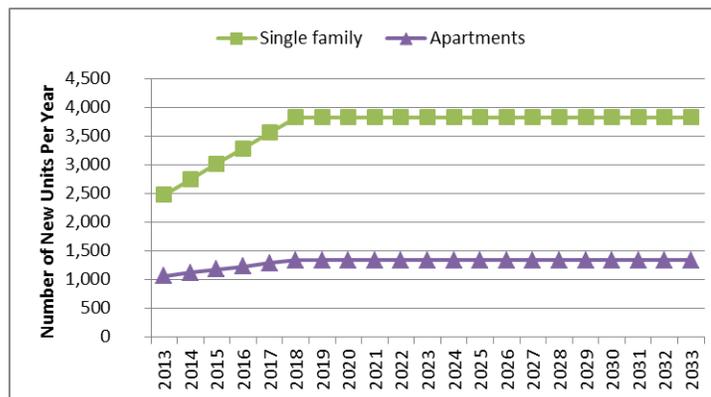


**Figure 4. Residential Construction History, Single-Family (Source: Dodge data provided by Mary Blewitt, DBEDT)**



**Figure 5. Residential Construction History, Apartments (Source: Dodge data provided by Mary Blewitt, DBEDT)**

The residential construction forecast used in this analysis is illustrated in Figure 6 and Figure 7. The construction activity for 2013 is assumed to be equal to the 5-year average, which is 2,475 single-family units per year and 1,065 apartment units per year. Then activity is assumed to increase until 2018 when it would reach the 10-year average. Figure 6 shows the assumption for number of units constructed in each year. Figure 7 shows the cumulative number of new units constructed over 20 years. The cumulative total for single-family units reaches 38,038 in the year 2023, 64,825 in 2030 and 76,305 in the year 2033. The cumulative total for apartment units reaches 13,908 in 2023, 23,283 in 2030 and 27,301 in 2033.



**Figure 6. Residential Construction Forecast, Units per Year**

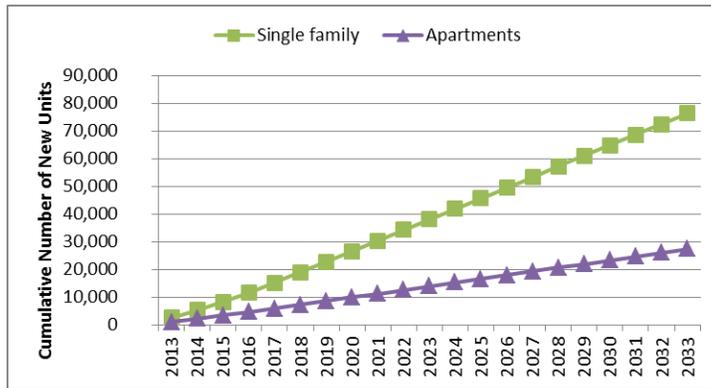


Figure 7. Residential Construction Forecast, Cumulative Number of Units

### Nonresidential Construction Forecast

Nonresidential construction is estimated to include 430,000 ft<sup>2</sup>/yr of hotels and 1.49 million ft<sup>2</sup>/yr of other nonresidential buildings. This is a rough estimate based on Dodge data for permit value and the assumption that average permit value is \$200 per square foot of floor area. The resulting historical estimate of floor area is shown in Figure 8 for hotels and Figure 9 for other nonresidential buildings. The cumulative construction forecasts for 2023, 2030 and 2033 are summarized in Table 12.

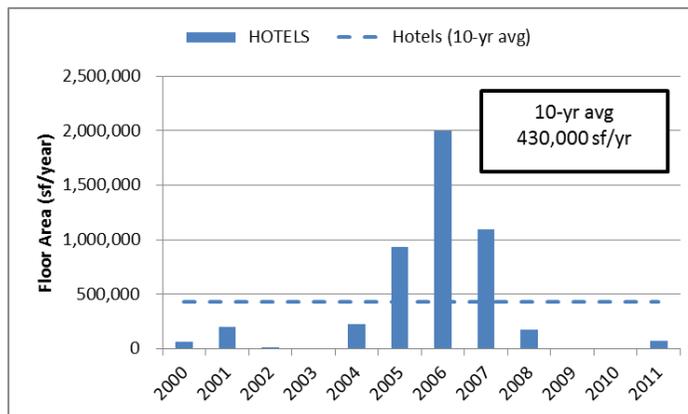
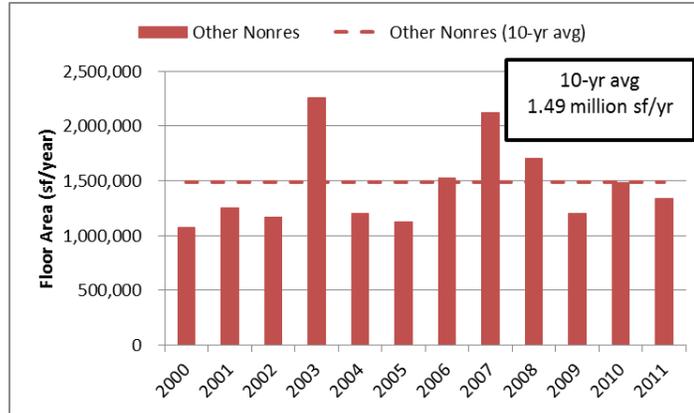


Figure 8. Hotel Construction History  
(Source: Dodge data provided by Mary Blewitt, DBEDT)



**Figure 9. Other Nonresidential Construction History**  
 (Source: Dodge data provided by Mary Blewitt, DBEDT)

**Table 12. Nonresidential Construction Forecast, Square Feet of Floor Area**

	2013	2023	2030	2033
Hotels	430,000	4,300,000	7,310,000	8,600,000
Other nonresidential	1,490,000	14,900,000	25,330,000	29,800,000
Total	1,920,000	19,200,000	32,640,000	38,400,000

### Residential Energy Impact Forecast

The estimated impact of the Hawaii Code on residential energy is an increase of 609 MWh/yr in 2013 (year 1) compared to the 2009 IECC. The cumulative total increases to 9,107 MWh/yr in 2023 (year 10), 15,477 MWh/yr in 2030 and 18,208 MWh/yr in 2033 (year 20). Calculations are summarized in Table 13. These estimates are based on the residential construction forecast described on page 19 and the residential energy calculation described on page 9. The forecast for energy impact was determined as follows:

- The increase of 381 kWh/yr in electricity for air conditioning described in Table 6 is appropriate for a 2,400 ft<sup>2</sup> single-family home with seasonally-varying air conditioning operation.
- The typical single-family home size<sup>7</sup> is assumed to be 1,700 ft<sup>2</sup> rather than 2,400 ft<sup>2</sup>. The impact is assumed to reduce proportionately from 381 to 270 kWh/yr.
- As a rough assumption, 75% of new homes statewide have air conditioning, reducing the average impact to 202 kWh/yr.
- For apartments, the impact is assumed to be 50% of the value calculated for single-family homes, equal to 101 kWh/yr per apartment.

<sup>7</sup> *Hawaii Housing Planning Study, 2011 Inventory Report*, SMS Research & Marketing Services, November 2011. This report notes that the median single-family home size is 1,700 ft<sup>2</sup> on Oahu and 1,400 to 1,500 ft<sup>2</sup> on other islands. The Oahu value is used in this analysis based on the assumption that average new homes would be larger than average existing homes.

**Table 13. Residential Energy Forecast  
(Positive value indicates increase in electricity consumption)**

		2013	2023	2030	2033
Single-family	# units	2,475	38,038	64,825	76,305
	kWh/yr-unit	202	202	202	202
	MWh/yr	501	7,699	13,121	15,445
Apartment	# units	1,065	13,908	23,283	27,301
	kWh/yr-unit	101	101	101	101
	MWh/yr	108	1,408	2,356	2,763
Total	# units	3,539	51,946	88,108	103,606
	<b>MWh/yr</b>	<b>609</b>	<b>9,107</b>	<b>15,477</b>	<b>18,208</b>

### Nonresidential Energy Impact Forecast

The estimated savings for the nonresidential buildings under the Hawaii Code is 1,250 MWh/yr in 2013 compared to ASHRAE Standard 90.1-2007. The cumulative total increases to 12,504 MWh/yr in 2023, 21,257 MWh/yr in 2030 and 25,008 MWh/yr in 2033. These savings estimates are summarized in Table 14. This estimate combines the construction forecast described on page 21 with the savings estimate described on page 18.

**Table 14. Nonresidential Energy Forecast  
(Negative value indicates decrease in electricity consumption)**

		2013	2023	2030	2033
Hotel	ft <sup>2</sup>	430,000	4,300,000	7,310,000	8,600,000
	kWh/ ft <sup>2</sup>	(1.21)	(1.21)	(1.21)	(1.21)
	MWh/yr	(520)	(5,203)	(8,845)	(10,406)
Other	ft <sup>2</sup>	1,490,000	14,900,000	25,330,000	29,800,000
	kWh/ ft <sup>2</sup>	(0.49)	(0.49)	(0.49)	(0.49)
	MWh/yr	(730)	(7,301)	(12,412)	(14,602)
Total	ft <sup>2</sup>	1,920,000	19,200,000	32,640,000	38,400,000
	<b>MWh/yr</b>	<b>(1,250)</b>	<b>(12,504)</b>	<b>(21,257)</b>	<b>(25,008)</b>

### Net Energy Impact Forecast

The net overall impact of the Hawaii Code is estimated to be savings of 642 MWh/yr in 2013, 3,397 MWh/yr in the year 2023, 5,779 MWh/yr in 2030 and 6,800 MWh/yr in the year 2033. These estimates are summarized in Table 15 which shows that the expected increase in residential energy consumption is offset by the estimated savings in nonresidential energy consumption.

**Table 15. Combined Residential and Nonresidential Energy Forecast**

	2013	2023	2030	2033
Residential (see also Table 13)	609	9,107	15,477	18,208
Nonresidential (see also Table 14)	(1,250)	(12,504)	(21,257)	(25,008)
<b>Total</b>	<b>(642)</b>	<b>(3,397)</b>	<b>(5,779)</b>	<b>(6,800)</b>

## Appendix 1 - Residential Prototype Simulation Model

### Residential Model Starting Point

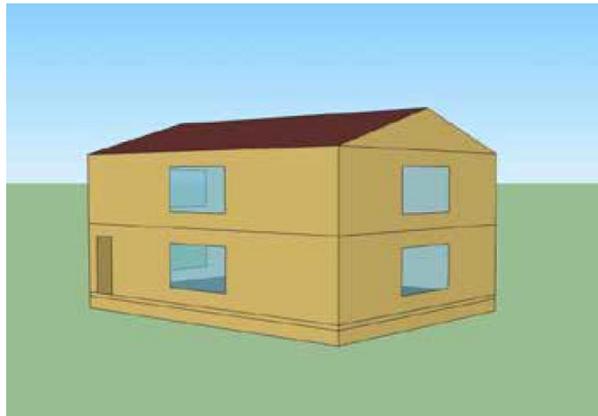
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The starting point for the residential prototype simulation model is a single-family model developed by Pacific Northwest National Laboratory (PNNL) for evaluating energy code savings. The selected EnergyPlus input file includes the following characteristics:

- Single family, two-story, 2,400 ft<sup>2</sup> floor area.
- Slab-on-grade floor
- Air conditioning and heat pump heating, with 24 hour-per-day conditioning and 75°F cooling setpoint
- 2009 IECC minimum equipment efficiency, including SEER 13 air conditioner
- Electric water heating (no solar water heating)
- Honolulu Airport weather data
- IECC 2009 compliance

The file was downloaded from [www.energycodes.gov/development/residential/iecc\\_models](http://www.energycodes.gov/development/residential/iecc_models).

More details of model characteristics are documented in PNNL's report *Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes*, April 2012, available at <http://www.energycodes.gov/development/residential/methodology/>.



**Figure 10. Residential Prototype Model**

(Source: *Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes*, PNNL, April 2012)

### Residential Model Modifications and Assumptions

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The following updates were made to the prototype model obtained from PNNL:

- The file was updated to run on EnergyPlus v7.1, the latest version at the time of this study.
- Attic vent area was increased in the baseline model. Output from the original baseline model showed an average attic ventilation rate of 1.4 air changes per hour (ach) based on an EnergyPlus effective leakage area (ELA) input of 57.4 in<sup>2</sup>. Based on a survey of literature on measured attic ventilation rates

it appears that an average ventilation rate of about 2.7 ach is typical<sup>8</sup>. Therefore, the baseline attic ELA was increased to 114.7 in<sup>2</sup>, which results in an average attic ventilation rate of 2.7 ach, ranging from about 1 ach to 5 ach depending on wind speed and temperature.

Two additional baseline models were developed in order to evaluate the wall insulation tradeoffs in the Hawaii Code: 1) metal-framed wall baseline and 2) mass wall baseline. The baseline metal wall construction has U-factor of 0.082(2009 IECC requirement) and solar absorptance of 70%. The baseline mass wall consists of concrete masonry units with insulation and drywall on the interior and with U-factor of 0.197 (2009 IECC requirement). The mass wall solar absorptance is 70%.

Roof construction options were modeled in EnergyPlus as follows:

- Radiant barrier. A material layer was added under the roof (at the top of the attic) with minimal “thermal resistance” but with “thermal absorptance” of 0.05 rather than 0.90 used for other materials.
- Cool roof. The “solar absorptance” of the roof membrane was changed from a baseline of 70% to 45%, which represents an aged reflectance of 55%.
- Extra ventilation. The “Effective Leakage Area” input was doubled from 114.7 in<sup>2</sup> to 229.4 in<sup>2</sup>, to represent the doubling of minimum vent area required for this option. The result in EnergyPlus is to roughly double the attic ventilation air change rate.

Two of the wall insulation exceptions apply for residences where high efficacy lighting is used for a minimum of 90% of permanently installed lighting fixtures. The baseline requirement is 50%. To represent this change from 50% to 90% the lighting power density is decreased from 0.138 W/ft<sup>2</sup> of hardwired lighting in the baseline model to 0.083 W/ft<sup>2</sup>, which is a reduction of 40%. This reduction is based on an assumption that the average efficacy of the high efficacy lighting is 45 lumens/watt and the efficacy of standard lighting is 15 lumens/watt. The average efficacy in the baseline case is 22.5 lumens/watt, and the average efficacy in the improved case is 37.5 lumens/watt, which results in a 40% drop in lighting power.

Another wall insulation exception applies where the visible light reflectance of the exterior wall surface is at least 64%. This requirement is expressed in visible reflectance rather than solar reflectance because the solar reflectance performance data is not commonly available for wall paint. In the EnergyPlus model it is assumed that the two values are equal.

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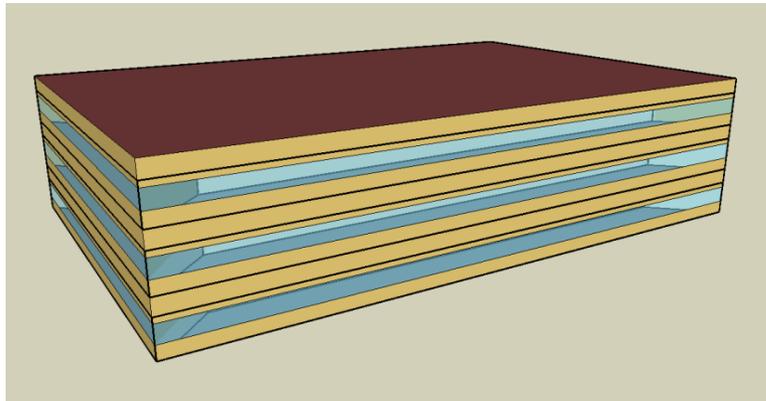
<sup>8</sup> Parker, Danny, “A Stratified Air Model for Simulation of Attic Thermal Performance”, Florida Solar Energy Center, <http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-226-91/>

## Appendix 2 - Nonresidential Prototype Simulation Model

An EnergyPlus simulation model was used in this analysis to evaluate the impact of the cool roof insulation exception for nonresidential roofs. A prototype medium-sized office building model developed by Pacific Northwest National Laboratory was used as the baseline. That model has the following characteristics.

- Three stories
- 53,600 ft<sup>2</sup> floor area
- 33% window-wall ratio
- Packaged VAV air conditioning system
- 90.1-2007 compliant envelope, lighting and HVAC for ASHRAE climate zone 1 (which includes Hawaii)

More details of the prototype model are included in the report, “Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010”. That report, along with the EnergyPlus model, is available at [http://www.energycodes.gov/development/commercial/90.1\\_models](http://www.energycodes.gov/development/commercial/90.1_models).



**Figure 11. Nonresidential Prototype Model**  
(Source: [www.energycodes.gov](http://www.energycodes.gov))

For this analysis the prototype model was updated with climate and location data for Honolulu and was converted to run on EnergyPlus version 7.1. Changes to the roof insulation and the roof surface “solar absorptance” were made to evaluate the energy impact of replacing the baseline roof with an uninsulated cool roof. Results are presented earlier on page 17 and in Table 9.

## Appendix 3 – Hawaii Code Amendments

Amendments adopted by the Hawaii State Building Code Council in February 2012 are attached for reference.

DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

Adoption of Chapter 3-181  
Hawaii Administrative Rules

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SUMMARY

1. Chapter 181 of Title 3, Hawaii Administrative Rules, entitled "State Energy Conservation Code" adopting and amending the "International Energy Conservation Code, 2006 Edition", is repealed.
  2. Chapter 181 of Title 3, Hawaii Administrative Rules, entitled "State Energy Conservation Code", amending the "International Energy Conservation Code, 2009 Edition" to include amendments applicable to the state, is adopted.
-

## HAWAII ADMINISTRATIVE RULES

## TITLE 3

## DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

## SUBTITLE 14

## STATE BUILDING CODE COUNCIL

## CHAPTER 181

## STATE ENERGY CONSERVATION CODE

## Subchapter 1 Rules of General Applicability

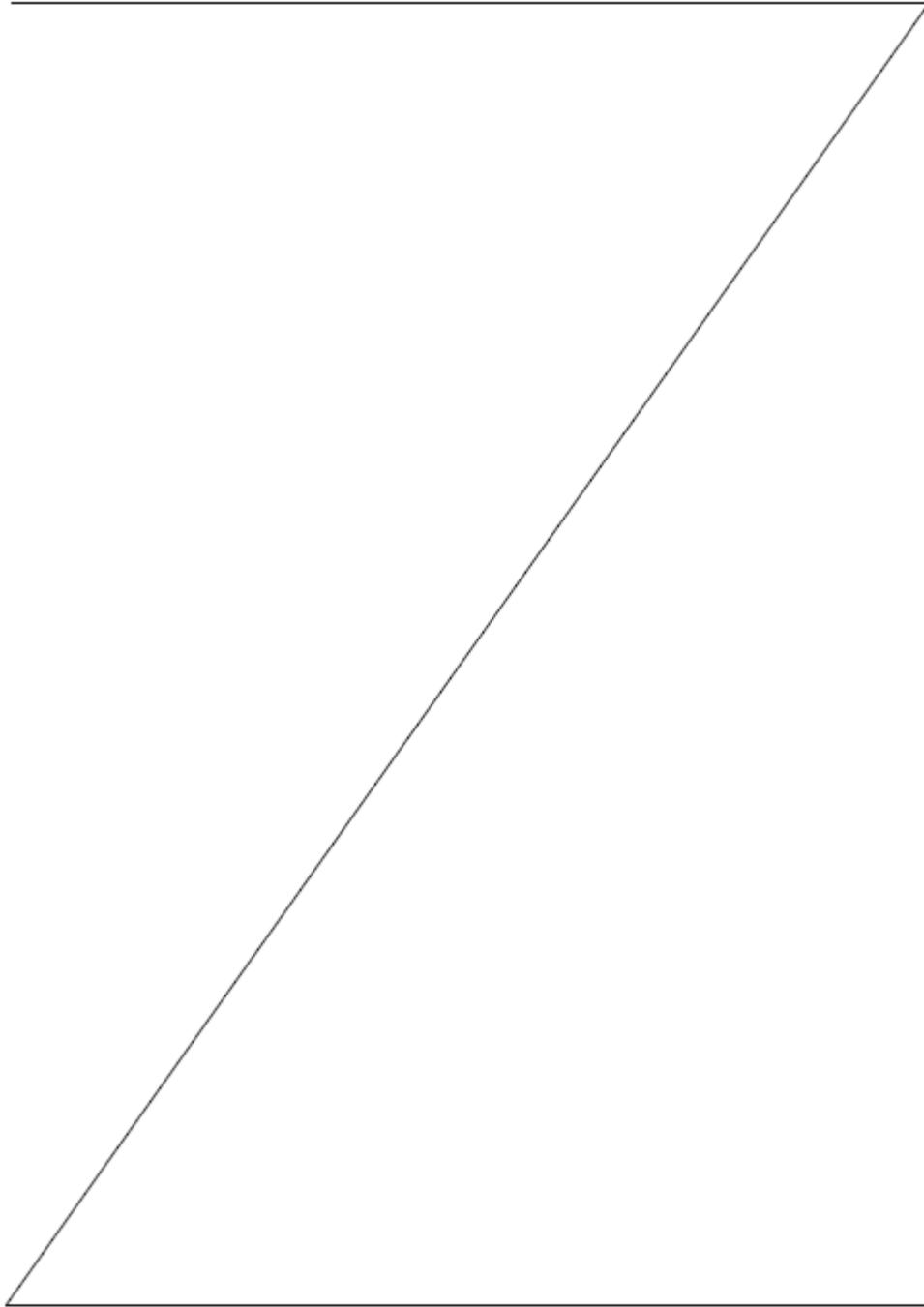
§3-181-1	Purpose
§3-181-2	Scope
§3-181-3	Definitions
§3-181-4	Adoption of the International Energy Conservation Code
§3-181-5	Permit authorization

Subchapter 2 Amendments to the 2009 ICC  
International Energy  
Conservation Code

§3-181-6	Title
§3-181-7	Low energy buildings
§3-181-8	General
§3-181-9	Inspections
§3-181-10	Certificate
§3-181-11	Insulation and fenestration requirements by component
§3-181-12	Wall insulation alternative
§3-181-13	Ceiling insulation alternatives
§3-181-14	Equivalent U-factors
§3-181-15	Steel-frame ceilings, walls and floors
§3-181-16	<u>U-factor</u>
§3-181-17	Glazed fenestration exemption
§3-181-18	Unconditioned building exemption
§3-181-19	Fenestration air leakage
§3-181-20	Residential pools
§3-181-21	<u>Roof assembly</u>
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## §3-181-1

## SUBCHAPTER 1

## RULES OF GENERAL APPLICABILITY

**§3-181-1 Purpose.** The purpose of this chapter is to adopt the state energy conservation code as required by section 107-25, Hawaii Revised Statutes (HRS).  
 [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-2 Scope.** This chapter sets forth minimum requirements for the design and construction of buildings for the effective use of energy and is intended to provide flexibility to allow the use of innovative approaches and techniques to achieve the effective use of energy.  
 [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-3 Definitions.** In this chapter, unless the context otherwise requires:

"ICC" means the International Code Council.

"IECC Section" means a section of a chapter of the International Energy Conservation Code.

"IECC" means the ICC, International Energy Conservation Code, [~~2006~~] 2009 edition, as copyrighted by the International Code Council. [Eff ]  
 (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-4 Adoption of the International Energy Conservation Code.** The "International Energy Conservation Code, [~~2006~~] 2009 Edition" as copyrighted and published in [~~2006~~] 2009 by International Code Council, Incorporated, 500 New Jersey Avenue, 6<sup>th</sup> Floor, Washington, DC 20001, is adopted by reference and made a part of this chapter. This incorporation by reference includes all parts of the International Energy Conservation Code subject to the amendments hereinafter set forth. The appendices of the ICC, IECC are not adopted except as provided in this chapter. [Eff ] (Auth: HRS §107-29)  
 (Imp: HRS §§107-24, 107-25)

**§3-181-5**

**§3-181-5 Permit authorization.** Each county may, by ordinance, require that a permit be obtained from the building official for any area regulated by this chapter. [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**SUBCHAPTER 2****AMENDMENTS TO THE 2009 ICC INTERNATIONAL ENERGY CONSERVATION CODE**

**§3-181-6 Title.** IECC section 101.1 is amended to read as follows:

**"101.1 Title.** This code shall be known as the [~~International~~] Energy Conservation Code of the State of Hawaii, and shall be cited as such. It is referred to herein as "this code"." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-7 Low energy buildings.** IECC section 101.5.2 is amended to read as follows:

**"101.5.2 Low energy buildings.** The following buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this code shall be exempt from the building thermal envelope provisions of this code:

1. Conditioned spaces with a peak design rate of energy usage less than 3.4 Btu/h•ft<sup>2</sup> (10.7 W/m<sup>2</sup>) or 1.0 watt/ft<sup>2</sup> (10.7 W/m<sup>2</sup>) of floor area for space conditioning purposes.
2. Unconditioned spaces that are non-habitable spaces."

[Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-8 General.** IECC section 103.1 is amended to read as follows:

**"103.1 General.** When the requirements in this code apply to a building as specified in Section 101.4, plans, specifications or other construction documents submitted for a building, electrical or plumbing permit required by the jurisdiction shall comply with this code and shall be prepared, designed, approved and observed by a design professional. The responsible design professional shall

**§3-181-9**

provide on the plans a signed statement certifying that the project is in compliance with this code.

**Exception:** Any building, electrical or plumbing work that is not required to be prepared, designed, approved or observed by a licensed professional architect or engineer pursuant to chapter 464 Hawaii Revised Statutes." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-9 Inspections.** IECC section 104 is deleted in its entirety. [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-10 Certificate.** IECC section 401.3 is amended to read as follows:

**"401.3 Certificate.** When required by the code official, a permanent certificate shall be posted on or in the electrical distribution panel. The certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. The certificate shall be completed by the builder or registered design professional. The certificate shall list the predominant R-values of insulation installed in or on ceiling/roof, walls, foundation (slab, basement wall, crawlspace wall and/or floor) and ducts outside conditioned spaces; U-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types and efficiencies of heating, cooling and service water heating equipment. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall list "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be listed for gas-fired unvented room heaters, electric furnaces or electric baseboard heaters." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-11 Insulation and fenestration requirements by component.** IECC Table 402.1.1 is amended to read as follows:

## §3-181-11

**Table 402.1.1  
Insulation and Fenestration Requirements by Component<sup>a</sup>**

Climate Zone	Fenestration U-Factor	Skylight <sup>b</sup> U-Factor	Glazed Fenestration SHGC <sup>b,e</sup>	Ceiling R-Value	Wood Frame Wall R-Value <sup>k</sup>	Mass Wall R-Value <sup>k</sup>	Floor R-Value	Basement Wall R-Value <sup>c</sup>	Slab <sup>d</sup> R-Value & Depth	Crawl Space <sup>e</sup> Wall R-Value
1	1.20	0.75	0.30	See Section (402.1.1.1) 402.1.6	13	3/4	NR	NR	NR	NR
2	0.75	0.75	0.30	30	13	4/6	13	0	0	0
3	0.65	0.65	0.30	30	13	5/8	19	0	0	5 / 13
4 except Marine	0.40	0.60	NR	38	13	5/10	19	10 / 13	10, 2 ft	10 / 13
5 and Marine 4	0.35	0.60	NR	38	20 or 13+5 <sup>h</sup>	13/17	30 <sup>g</sup>	10 / 13	10, 2 ft	10 / 13
6	0.35	0.60	NR	49	20 or 13+5 <sup>h</sup>	15/19	30 <sup>g</sup>	10 / 13	10, 4 ft	10 / 13
7 and 8	0.35	0.60	NR	49	21	19/21	30 <sup>g</sup>	10 / 13	10, 4 ft	10 / 13

For SI: 1 foot = 304.8 mm.

NR = No requirement.

- a. R-values are minimums. U-factors and SHGC are maximums. R-19 batts compressed into a nominal 2 × 6 framing cavity such that the R-value is reduced by R-1 or more shall be marked with the compressed batt R-value in addition to the full thickness R-value.
- b. The fenestration U-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
- c. "15/19" means R-15 continuous insulated sheathing on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulated sheathing on the interior or exterior of the home. "10/13" means R-10 continuous insulated sheathing on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.
- d. R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Zones 1 through 3 for heated slabs.
- e. There are no SHGC requirements in the Marine zone.
- f. Basement wall insulation is not required in warm-humid locations as defined by Figure 301.1 and Table 301.1.
- g. Or insulation sufficient to fill the framing cavity, R-19 minimum.
- h. "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2."
- i. The second R-value applies when more than half the insulation is on the interior of the mass wall.

## §3-181-12

- j. For impact rated fenestration complying with Section R301.2.1.2 of the Residential Code of the State of Hawaii or Section 1608.1.2 of the Building Code of the State of Hawaii, the maximum *U*-factor shall be 0.75 in Zone 2 and 0.65 in Zone 3.
- k. A reduction of *R*-5 for interior walls or *R*-4 for exterior walls shall be permitted in buildings that meet one of the following criteria:
1. Exterior walls are finished with a paint or surface with an average light reflectance value  $\geq 0.64$  (garages, trim and other non-wall components are exempt).
  2. High efficacy lamps in a minimum of 90 percent of permanently installed lighting fixtures.
  3. The building has a wall projection factor, in accordance with Equation 4-1, of not less than 0.30 for all walls that face more than 22.5 degrees from true north."
- [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-181-12 Wall insulation alternative. Section 402.1.5 is added to the IECC to read as follows:

"402.1.5 Wall insulation alternative. Insulation requirements for walls in buildings are permitted to be reduced in accordance with Footnote k of Table 402.1.1, where the following conditions are met:

1. The building is located in climate zone 1, and
2. The wall projection factor is not less than 0.30 for all walls that face more than 22.5 degrees from true north.

The wall projection factor shall be determined in accordance with Equation 4-1.

(Equation 4-1)

$$WPF = A/B$$

where:

WPF = Wall projection factor (decimal)

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the wall

B = Distance measured vertically from the bottom of the wall to the underside of the overhang, eave, or permanently attached shading device. The distance B does not need to extend below the bottom of the floor assembly of the lowest occupied floor level

[Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-181-13

§3-181-13 Ceiling insulation alternatives. Sections [402.1.1.1] 402.1.6 to [402.1.1.8.1] 402.1.6.8.1 are added to the IECC to read as follows:

[402.1.1.1] 402.1.6 Ceiling insulation alternatives.  
[Insulation requirements for ceilings of buildings constructed in climate zone 1 shall meet one of the design options in Table 402.1.1.1.] Insulation requirements for ceilings of buildings are permitted to be modified in accordance with Sections 402.1.6.1 through 402.1.6.8.1 for buildings:

1. Located in climate zone 1, and
2. Located at elevations below 2,400-foot (731.5 m).

402.1.6.1 Design options. Ceiling insulation requirements shall meet at least one of the design options in Table 402.1.6.1. Construction documents required in accordance with Section 402.1.6.3 shall be provided for any design option utilized.

Table [402.1.1.1] 402.1.6.1  
 Ceiling Insulation for Buildings in Climate Zone 1

Design Option	Design and Construction Components				
	Roof Insulation (Section [402.1.1.4] 402.1.6.4)	Attic Ventilation (Section [402.1.1.5] 402.1.6.5)	Radiant Barrier (Section [402.1.1.6] 402.1.6.6)	Cool Roof (Section [402.1.1.7] 402.1.6.7)	Roof Heat Gain Factor below 0.05 (Section [402.1.1.8] 402.1.6.8)
1	R				
[2 <sup>a</sup> ] 2		R	R		
[3 <sup>a</sup> ] 3			R	R	
[4 <sup>a</sup> ] 4					R

R = Required

[a. Design Option is not allowed at building sites above a 2,400 foot (731.5 m) elevation.]

[402.1.1.2] 402.1.6.2 Definitions. For the purpose of this section, the following terms shall be defined as follows:

**GROSS AREA OF OPAQUE ROOF SURFACES.** Gross area of opaque roof surfaces means the total surface of the roof assembly exposed to outside air or unconditioned spaces. The opaque roof assembly shall exclude skylight surfaces, service openings, and overhangs.

**NET FREE VENT AREA.** Net free vent area means the total area through which air can pass in a screen, grille face or register.

## §3-181-13

**ROOF AREA.** Roof area means attic floor area; or, if there is no attic, "roof area" means the horizontal projection of roof area measured from the outside surface of the exterior walls.

~~[402.1.1.3]~~ **402.1.6.3 Construction documents.** Plans shall be submitted which indicate insulation type, thickness, and location; ventilation opening types, sizes and locations; radiant barrier location; and roof surface type as appropriate, depending on the option selected from Table ~~[402.1.1.1]~~ **402.1.6.1.**

~~[402.1.1.4]~~ **402.1.6.4 Roof insulation.** Roof insulation shall be provided as follows:

1. In buildings with an attic space provide either:
  - 1.1. R-30 insulation installed above the ceiling level, or
  - 1.2. R-19 insulation installed at the roof level between the roof framing members.
2. In buildings without an attic space provide either:
  - 2.1. R-19 insulation installed at the roof level between the roof framing members, or
  - 2.2. R-15 entirely above the roof deck.

~~[402.1.1.5]~~ **402.1.6.5 Attic Ventilation.** Ventilation shall be provided by at least one of the following:

1. A baffled ridge vent installed in accordance with the manufacturer's instructions in addition to lower inlet openings to provide a total of no less than one square foot of net free vent area for each 300 square feet of roof area. No less than 30 per cent of the total vent area shall be in either the ridge vent or the lower half of the ventilated space.
2. A solar-powered exhaust fan that provides at least one cubic foot per minute of airflow for each square foot of roof area.
3. Upper and lower vents with total net free vent area of at least one square foot for each 150 square feet of roof area. At least 30 percent of the total vent area shall be in the upper half of the ventilated space and at least 30 percent of the total vent area shall be in the lower half of the ventilated space.

~~[402.1.1.6]~~ **402.1.6.6 Radiant barrier.** A radiant barrier shall have an emissivity of no greater than 0.05 as tested in accordance with ASTM E-408. The radiant barrier shall be installed with the shiny side facing down and with a minimum air gap thickness of ¼ inch below. The radiant barrier may be securely attached to the roof framing or may be laminated to the bottom of the roof sheathing.

## §3-181-13

**Exception:** The radiant barrier is not required within 24 inches (610 mm) of the face of the exterior wall when Table 402.1.6.1 Option 2 or 3 is selected and the unprotected portion of the roof is insulated to a value of R-19 with continuous insulation to the exterior wall.

~~[402.1.1.7]~~ **402.1.6.7 Cool roof.** A cool roof rated in compliance with the Cool Roof Rating Council, Product Rating Program Manual, shall have an infrared emittance of no ~~[more]~~ less than 0.75 when tested in accordance with ASTM E-408 and ~~[a high solar reflectance]~~ an initial reflectance of no less than 0.70 and an extended reflectance of no less than 0.55. ~~[The manufacturer's test results shall be acceptable for compliance.]~~

~~[402.1.1.8]~~ **402.1.6.8 Roof Heat Gain Factor.** The Roof Heat Gain Factor (RHGF) shall not exceed 0.05 when calculated as described in Equation ~~[402.1.1.1]~~ 4-2.

**Equation ~~[402.1.1.1]~~ 4-2**

$$RHGF = U_r \times \alpha \times RB$$

Where:

RHGF = Roof Heat Gain Factor [Btu/ft<sup>2</sup>•h•°F]

$U_r$  = overall thermal transmittance value for the gross area of opaque roof surfaces [Btu/ft<sup>2</sup>•h•F]

$\alpha$  = roof surface absorptivity. Between 0.3 and 1.0 [unitless]

RB = Radiant Barrier credit. Equals 0.33 if a radiant barrier is installed and 1.00 otherwise [unitless]. Radiant barrier installation must comply with Section ~~[402.1.1.7.1]~~ 402.1.6.8.1 to qualify for Radiant Barrier credit.

~~[402.1.1.8.1]~~ **402.1.6.8.1 Radiant barrier credit.** To qualify for the radiant barrier credit (RB) described in Section ~~[402.1.1.8.7]~~ 402.1.6.8, the installation of the radiant barrier must meet the following criteria:

1. The emissivity of the radiant barrier must be 0.10 or less. The manufacturer must provide test data or documentation of the emissivity as tested in accordance with ASTM E-408.
2. The radiant barrier must be securely installed in a permanent manner using one of the following installation methods:
  - 2.1. The radiant barrier shall be draped with the shiny side facing down over the top cord of the truss before the roof deck is installed. A minimum air gap of ¼ inch must be provided between the radiant barrier and the roof deck



## §3-181-14

§3-181-14 **Equivalent U-factors.** IECC Table 402.1.3 is amended to read as follows:

**"Table 402.1.3  
Equivalent U-Factors<sup>a</sup>**

Climate Zone	Fenestration U-Factor	Skylight U-Factor	Ceiling U-Factor	Frame Wall U-Factor	Mass Wall U-Factor <sup>b</sup>	Floor U-Factor	Basement Wall U-Factor	Crawl Space Wall U-Factor <sup>c</sup>
1	1.2	0.75	0.035	0.082	0.197	NR	NR	NR
2	0.65	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.50	0.65	0.035	0.082	0.141	0.047	0.091 <sup>c</sup>	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.065

NR = No requirement.

- Nonfenestration U-factors shall be obtained from measurement, calculation or an approved source.
- When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.10 in Zone 4 except Marine, and the same as the frame wall U-factor in Marine Zone 4 and Zones 5 through 8.
- Basement wall U-factor of 0.360 in warm-humid locations as defined by Figure 301.1 and Table 301.1." [Eff \_\_\_\_\_ ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-15 Steel-frame ceilings, walls and floors.**

IECC section 402.2.5 is amended to read as follows:

**"402.2.5 Steel-frame ceilings, walls, and floors.**

Steel-frame ceilings, walls and floors shall meet the insulation requirements of Table 402.2.5 or shall meet the U-factor requirements in Table 402.1.3. The calculation of the U-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

**Exception:** Buildings located at elevations below 2,400 feet (731.5 m) do not need to comply with the continuous R-value requirement where one of the following apply:

- In Climate Zones 1 and 2, the continuous insulation requirements in Table 402.2.5 shall be permitted to be reduced to R-3 for steel frame wall assemblies with studs spaced at 24 inches

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- (610 mm) on center.
2. In Climate Zones 1 and 2, the continuous insulation requirements in Table 402.2.5 shall be permitted to be reduced to R-0 for steel frame wall assemblies of buildings that meet one of the following criteria:
- 2.1. Exterior walls are finished with a paint or surface with an average light reflectance value  $\geq 0.64$  (garages, trim and other non-wall components are exempt),
- 2.2. High efficacy lamps in a minimum of 90 percent of permanently installed lighting fixtures, or
- 2.3. A wall projection factor, in accordance with Equation 4-1, of not less than 0.30 of all walls that face more than 22.5 degrees from true north.
- 2.4. The building is equipped with central air conditioning with a minimum efficiency rating of 14 SEER.
3. The building has a steep slope roof with an initial reflectance of 0.25 or higher."  
 [Eff ] (Auth: HRS §107-29)  
 (Imp: HRS §§107-24, 107-25)

§3-181-16 **U-factor.** IECC section 402.3.1 is amended to read as follows:

"402.3.1 **U-factor.** An area-weighted average of fenestration products shall be permitted to satisfy the U-factor and SHGC requirements." [Eff ]  
 (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-181-17 **Glazed fenestration exemption.** IECC section 402.3.3 is amended to read as follows:

"402.3.3 **Glazed fenestration exemption.** Up to 15 square feet (1.4 m<sup>2</sup>) of glazed fenestration per dwelling unit shall be permitted to be exempt from U-factor and SHGC requirements in Section 402.1.1. This exemption shall not apply to the U-factor alternative approach in Section 402.1.3 and the Total UA alternative in Section 402.1.4. North-facing windows and windows with a projection factor of 1.0 or more shall be permitted to be exempt from SHGC requirements in Section 402.1.1." [Eff ]  
 (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

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§3-181-18 Unconditioned building exemption. Section 402.4.1.1 is added to the IECC to read as follows:

**"402.4.1.1 Unconditioned building exemption.**

Unconditioned residential buildings are exempt from compliance with Section 402.4. The free-vent fenestration area of unconditioned buildings shall be no less than 14 per cent of the floor area. All interior doors shall be capable of being secured in the open position and ceiling fan stub-ins shall be provided to living areas and bedrooms." [Eff ] (Auth: HRS §107-29)  
(Imp: HRS §§107-24, 107-25)

§3-181-19 Fenestration air leakage. IECC section 402.4.4 is amended to read as follows:

**"402.4.4 Fenestration air leakage.** Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m<sup>2</sup>), and swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m<sup>2</sup>), when tested according to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and listed and labeled by the manufacturer.

**Exceptions:**

1. Site-built windows, skylights and doors.
  2. Jalousie windows shall not exceed 1.2 cfm per square foot (6.1 L/s/m<sup>2</sup>)."
- [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

§3-181-20 Residential pools. IECC section 403.9 is amended to read as follows:

**"403.9 Residential pools.** Residential pools shall be provided with energy-conserving measures in accordance with Sections 403.9.1 through 403.9.3.

**403.9.1 Pool heaters.** All pool heaters shall be equipped with a readily accessible on-off switch to allow shutting off the heater without adjusting the thermostat setting. [~~Pool heaters fired by natural gas~~] Gas-fired pool heaters shall not have continuously burning pilot lights.

**403.9.2 Time switches.** Time switches that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on swimming pool heaters and pumps.

**Exceptions:**

1. Where public health standards require 24-hour pump operation.

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2. Where pumps are required to operate solar- and waste-heat-recovery pool heating systems.

**403.9.3 Pool covers.** Heated pools shall be equipped with a vapor retardant pool cover on or at the water surface. Pools heated to more than 90°F (32°C) shall have a pool cover with a minimum insulation value of R-12.

**Exception:** Pools deriving over 60 percent of the energy for heating from site-recovered energy or solar energy source." [Eff ]  
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-21 Roof assembly.** IECC section 502.2.1 is amended to read as follows:

**"502.2.1 Roof assembly.** The minimum thermal resistance (R-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 502.2(1), based on construction materials used in the roof assembly.

**Exception:** Buildings located at elevations below 2,400 feet (731.5 m) do not need to comply where one of the following apply:

1. Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted U-factor is equivalent to the same assembly with the R-value specified in Table 502.2(1).
2. Roofs in compliance with the Cool Roof Rating Council, Product Rating Program Manual, meeting initial reflectance values of 0.70 and extended reflectance values of 0.55.

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation."

[Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-22 Area-weighted average - commercial.** Section 502.3.3 is added to the IECC to read as follows:

**"502.3.3 Area-weighted average - commercial.** In commercial buildings, an area-weighted average of fenestration products shall be permitted to satisfy SHGC requirements." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-23**

**§3-181-23 Wall insulation reduction.** Section 502.2.3.1 is added to the IECC to read as follows:

**"502.2.3.1 Wall insulation reduction.** A reduction of R-5 for interior walls or R-4 for exterior walls shall be permitted in buildings that meet the following criteria:

1. The building is located at an elevation below 2,400-foot (731.5 m) above sea level,
2. The building is located in climate zone 1, and
3. The building has a wall projection factor, in accordance with Equation 4-1, of not less than 0.30 for all walls that face more than 22.5 degrees from true north." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-24 Mechanical systems commissioning and completion requirements.** IECC sections 503.2.9 to 503.2.9.3 are retitled and amended to read as follows:

**"503.2.9 Mechanical systems commissioning and completion requirements.** Prior to the issuance of a certificate of occupancy, the design professional shall provide a written statement of system completion in accordance with Sections 503.2.9.1 through 503.2.9.3.

**503.2.9.1 System commissioning.** Commissioning is a process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner's project requirements and construction documents. Drawing notes shall require commissioning and completion requirements in accordance with this section. Drawing notes may refer to specifications for further requirements. Copies of all documentation shall be given to the owner.

**503.2.9.2 Commissioning plan.** A commissioning plan shall include as a minimum the following items:

1. A detailed explanation of the original owner's project requirements,
2. A narrative describing the activities that will be accomplished during each phase of commissioning, including guidance on who accomplishes the activities and how they are completed,
3. Equipment and systems to be tested, including the extent of tests,
4. Functions to be tested (for example calibration, economizer control, etc.),
5. Conditions under which the test shall be performed

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(for example winter and summer design conditions, full outside air, etc.), and

6. Measurable criteria for acceptable performance.

**503.2.9.3 Systems adjusting and balancing.** All HVAC systems shall be balanced in accordance with generally accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within 10 per cent of design rates. Test and balance activities shall include as a minimum the following items:

1. Air systems balancing: Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the International Mechanical Code. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp, fan speed shall be adjusted to meet design flow conditions.

**Exception:** Fan with fan motors of 1 hp or less.

2. Hydronic systems balancing: Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the ability to measure pressure across the pump, or test ports at each side of each pump.

**Exceptions:**

1. Pumps with pump motors of 5 hp or less.
2. When throttling results in no greater than 5% of the nameplate horsepower draw above that required if the impeller were trimmed." [Eff ]  
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-25 Sleeping unit controls.** IECC section 505.2.3 is amended to read as follows:

~~"505.2.3 Sleeping unit controls. [Sleeping units in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired luminaires and switched receptacles, except those in the bathroom(s). Suites shall~~

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~~have a control meeting these requirements at the entry to each room or at the primary entry to the suite.] Sleeping units in Group R-1 occupancies shall be equipped with a method of adjusting thermostat set points and turning off all permanently installed light fixtures and all outlets powering portable light fixtures and entertainment devices when the unit is unoccupied.~~

Exception: Bathroom night lights, not exceeding three watts.

Each sleeping unit in Group R-1 occupancies shall be equipped with one or more of the following devices or systems:

1. A master switch at the main entry door activated by a room card that must be inserted upon entry,
2. A sensor capable of detecting when the room is occupied, or
3. An electronic control system capable of detecting when the room is occupied.

Operable doors leading from a conditioned space to a balcony or patio in sleeping units of Group R-1 occupancies shall be provided with interlock controls to disable heating and cooling of the space while the door is open."

[Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

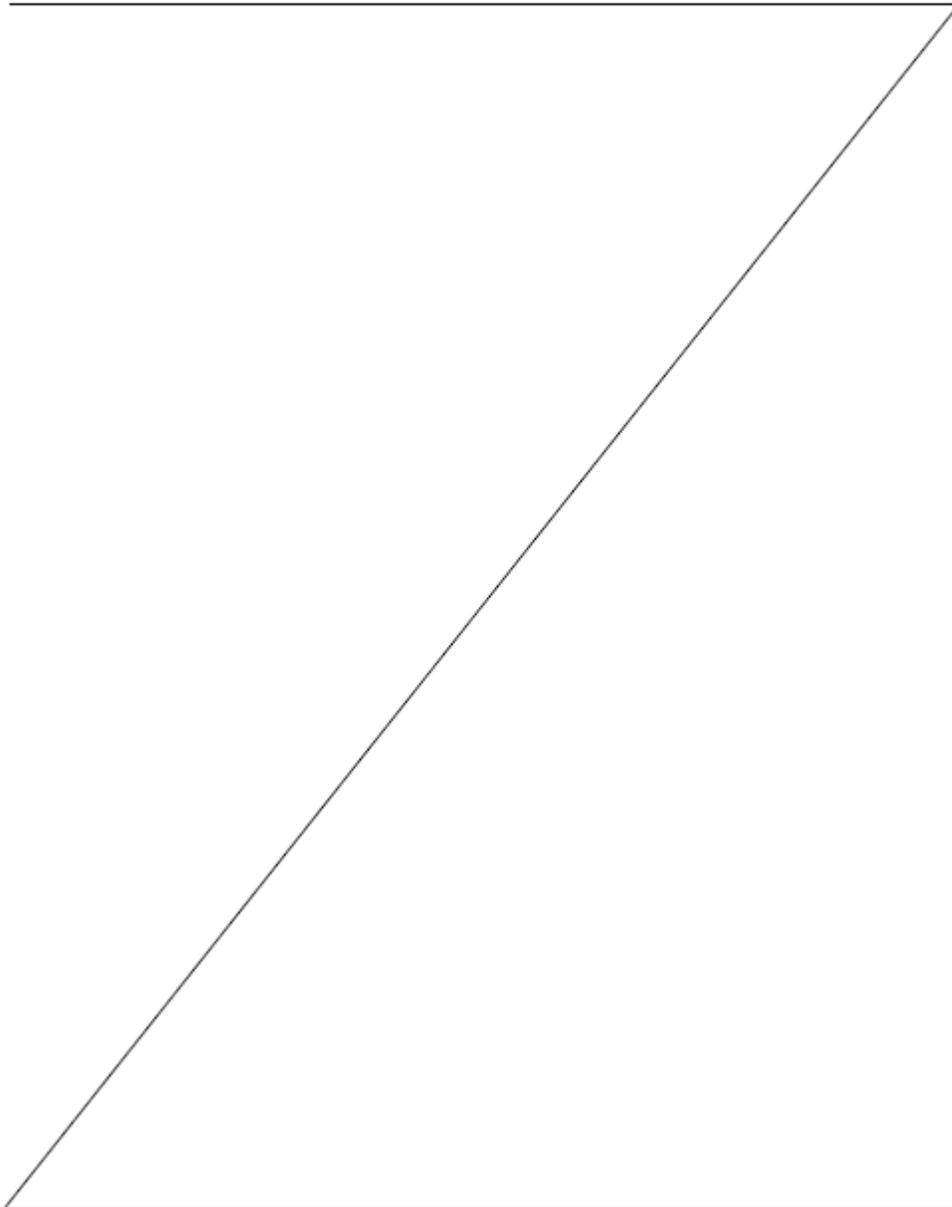
**§3-181-26 Electrical energy consumption. (Mandatory).** IECC section 505.7 is amended to read as follows:

**"505.7 Electrical energy consumption. (Mandatory).** [~~In buildings having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each tenant by separately metering individual dwelling units.~~] In new buildings with tenants, metering shall be collected for the entire building and individually for each tenant occupying 1,000 square feet (93 m<sup>2</sup>) or more. Tenants shall have access to all data collected for their space. A tenant is defined as "one who rents or leases from a landlord." [Eff ] (Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)

**§3-181-27 Referenced standards.** The following standard is added to IECC chapter 6 - Referenced Standards to read as follows:

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"ASTM E 408-2008, Standard Test Methods for Total Normal  
Emittance of Surfaces Using Inspection Meter  
Techniques.....[~~402.1.1.6, 402.1.1.7, 402.1.1.8.1~~]  
402.1.6.6, 402.1.6.7, 402.1.6.8.1" [Eff ]  
(Auth: HRS §107-29) (Imp: HRS §§107-24, 107-25)



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DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES

Chapter 3-181, Hawaii Administrative Rules, on the Summary Page dated \_\_\_\_\_, was adopted on \_\_\_\_\_, following a public hearing held on \_\_\_\_\_, after public notice was given in the Honolulu Star-Advertiser on \_\_\_\_\_.

The adoption of chapter 3-181 shall take effect ten days after filing with the Office of the Lieutenant Governor.

\_\_\_\_\_  
BRUCE COPPA  
State Comptroller and  
Chairperson, State Building Code  
Council

APPROVED:

\_\_\_\_\_  
NEIL ABERCROMBIE  
GOVERNOR  
STATE OF HAWAII

Dated: \_\_\_\_\_

APPROVED AS TO FORM:

\_\_\_\_\_  
Deputy Attorney General

\_\_\_\_\_  
Filed

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