

REPORT

2018 Hawaii Energy Codes Compliance Study

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

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828 Fort Street Mall, Ste 500
Honolulu, HI 96813
(808) 521-3773



704 Tennessee Street
San Francisco, CA 94107
(415) 531-5198

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Table of Contents

Executive Summary.....	1
County Building Energy Codes.....	1
Compliance Study Method.....	1
Summary of Compliance Review Results – Non-residential and High-rise Residential.....	1
Summary of Compliance Review Results – Low-rise Residential	5
Summary of Energy Impact	7
Summary of Recommendations	8
Introduction.....	10
Current Energy Codes.....	10
IECC Overview	10
County Code Amendments	12
Energy Code Enforcement Process	14
County of Hawaii Enforcement	14
County of Honolulu Enforcement.....	14
County of Maui Enforcement	14
County of Kauai Enforcement	14
Compliance Review Method	14
Sampling Method – Non-residential and High-rise Residential	14
Sampling Method – Low-rise Residential	17
Plan Review Method – Non-residential and High-rise Residential.....	17
Plan Review Method – Low-rise Residential	18
Compliance Review Results – Non-residential and High-rise Residential.....	20
Summary of Reviewed Projects.....	20
Summary of Compliance Level Results.....	22
Compliance Certification Results.....	28
Interior Lighting Results	29
Exterior Lighting Results	32
Envelope Results	35
HVAC Results	42
Water Heating Results.....	45
Compliance Review Results – Low-rise Residential	46
Summary of Reviewed Projects.....	46
Summary of Compliance Level Results vs 2006 IECC	48
Summary of Compliance Level Results vs 2015 IECC	55
Compliance Certification Results.....	62
Envelope Results	63
HVAC System Results.....	66
Water Heating System Results	66
Electrical System Results	67

Energy Impact – Non-residential and High-rise Residential	67
Construction Forecast	68
Energy Impact – Interior Lighting	69
Energy Impact – Fenestration	71
Energy Impact – Energy Recovery	73
Energy Impact – HVAC Commissioning	74
Total Energy Impact	74
Energy Impact – Low-rise Residential	75
Recommendations	76
Non-residential and High-rise Residential	76
Low-rise Residential	78
Appendix 1 – Summary of Selected Code Requirements – 2006 IECC – Non-residential and High-rise Residential	79
Opaque Envelope Requirements – 2006	79
Fenestration Requirements – 2006	80
Interior Lighting Power Allowances – 2006	81
Exterior Lighting Power Allowances – 2006	82
Unitary Air Conditioner Efficiency Requirements – 2006	83
Appendix 2 – Summary of Selected Code Requirements – 2015 IECC Non-residential and High-rise Residential	84
Envelope Requirements – 2015	84
Interior Lighting Power Allowances – 2015	85
Exterior Lighting Power Allowances – 2015	86
Unitary Air Conditioner Efficiency Requirements – 2015	87
Appendix 3 – Summary of Selected Code Requirements – 2006 IECC Low-rise Residential	89
Appendix 4 – Summary of Selected Code Requirements – 2015 IECC Low-rise Residential	89
Appendix 5 - Project Review Checklist	92
Checklist for Non-residential and High-rise Residential	92
Checklist for Low-rise Residential	94
Appendix 6 – Fenestration Modeling – Non-residential and High-rise Residential	97
Appendix 7 – Fenestration Modeling – Low-rise Residential	101
Residential Model Starting Point	101
Residential Model Modifications and Assumptions	101
Appendix 8 – Suggested Designer Compliance Certification Block – Low-rise Residential	103
Appendix 9 – Suggested Designer Compliance Certification Block – Non-residential and High-rise Residential	104

Executive Summary

This report describes the results of a building energy code compliance study for the State of Hawaii.

County Building Energy Codes

The current building energy code in Hawaii, Maui and Honolulu Counties as of June 2018 is the 2006 International Energy Conservation Code (2006 IECC) adopted with several amendments. In Kauai County the 2009 IECC with amendments is the current code. Kauai's 2015 IECC, with amendments, passed second reading in the Kauai County Council as of mid-June 2018. The amendments extend the building envelope requirements to some unconditioned buildings, require designers to provide a signed compliance certification on their plans, require a commissioning plan for mechanical systems, and in some cases require tenant electricity sub-metering.

Compliance Study Method

A sample of recently permitted projects were selected in each county. The sampling method is described starting on page 14. The goal of the sampling was to provide a reasonably representative range of building types. The sampling method varied by County due to different formats of information available from each building department.

For non-residential and high-rise residential buildings, the sample size was 10 in Hawaii, 10 in Maui, 20 in Honolulu and 10 in Kauai. In Hawaii County those plans were reviewed on-site in the building department offices. For Maui and Kauai Counties electronic plans were downloaded and reviewed remotely. For Honolulu County, a sample was selected from a publicly accessible database, and then the scanned plans were provided by the building department. The projects were selected to provide a mix of large and small projects and new construction and renovation projects. The review of each project took an average of two hours and covered the buildings' interior lighting, exterior lighting, envelope, HVAC and water heating systems.

For low-rise residential buildings, the sample size was 18 in Hawaii, 15 in Maui, 39 in Honolulu and 22 in Kauai. Electronic plans were available for Maui and Kauai. Paper plans were reviewed on site in Hawaii and Honolulu Counties.

Summary of Compliance Review Results – Non-residential and High-rise Residential

Designer Compliance Certification

A signed certification of energy code compliance is required on the plans. The review of 50 non-residential projects found signed compliance statements on the plans as follows:

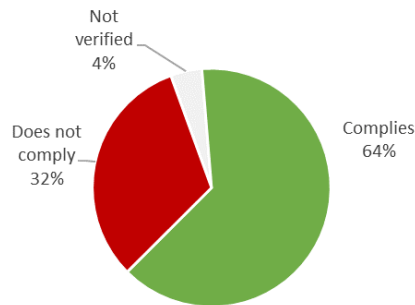
- Envelope: 34 of 43 applicable projects, 79% compliance
- Lighting: 43 of 49 applicable projects, 85% compliance
- Mechanical: 41 of 47 applicable projects, 87% compliance

Interior Lighting Power

Interior lighting power is the code requirement with one of the higher rates of non-compliance, equal to 32% of the projects. Small retail projects account for most of the non-complying projects. Improperly

accounting for track lighting power is a common compliance problem. Specifications for lighting fixture input power were missing from most projects.

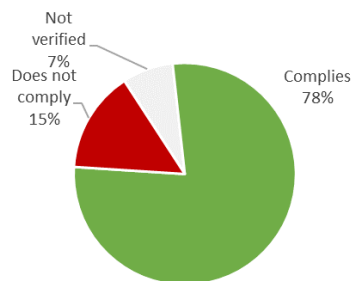
- Complies: 30 of 47 (64%)
- Does not comply: 15 of 47 (32%)
- Not verified: 2 of 47 (4%)
(information missing)



Exterior Lighting Power

Exterior lighting power compliance was generally good, and the designed power was often 50% to 80% below the allowed lighting power. One problem occurring in a few projects was improper accounting for lighting power of screw-base fixtures, where designers take credit for compact fluorescent lamps while the code requires use of the maximum rated fixture power in compliance calculations.

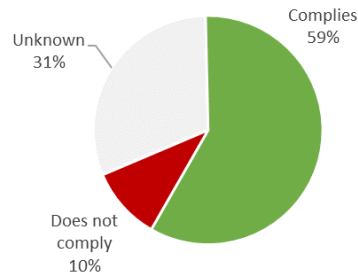
- Complies: 21 of 27 (78%)
- Does not comply: 4 of 27 (15%)
- Not verified: 2 of 27 (7%)
(information missing)



Roof Insulation

Roof insulation R-value specifications were missing from 31% of the reviewed projects. The code requires that information such as insulation R-value be included on the construction documents that are submitted for permit. Due to this lack of information, the compliance for many of the projects could not be verified. However, it is expected that the actual compliance rate is fairly good. Two non-compliance cases identified in this study specified R-19 insulation where the requirement was R-30 for insulation installed under the roof deck. Another non-compliance case was a high-rise affordable-housing project with a concrete roof with no roof insulation shown on the plans

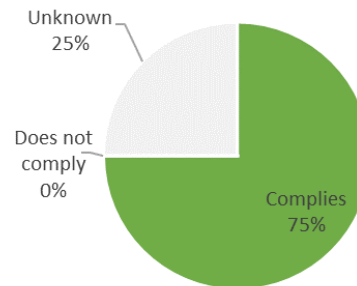
- Unknown: 9 of 29 (31%)
(information missing)
- Complies: 17 of 29 (59%)
- Does not comply: 3 of 29 (10%)



Wall Insulation

Wall insulation compliance rates were good. Just as with roof insulation, the R-value information was often missing from the plans, but in the case of walls there is no insulation required for concrete walls. Therefore, a greater fraction of projects could be verified to comply.

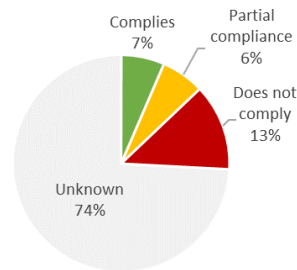
- Unknown: 7 of 28 (25%)
(information missing)
- Complies: 21 of 28 (75%)
- Does not comply: 0 of 28 (0%)



Fenestration

Window solar heat gain coefficient (SHGC) requirements could not be verified for most of the reviewed projects because window specifications were not often included on the construction documents submitted to the building department. While it is likely that a significant fraction of these projects do in reality comply with the SHGC limits, there is also a reasonable chance that some do not. Several projects show single-pane glazing, which would require very dark tint or reflective coatings in order to meet the code requirements.

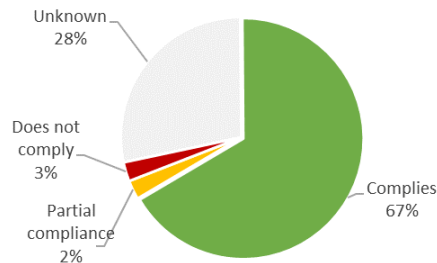
- Unknown: 23 of 31 (74%)
(information missing)
- Complies: 2 of 31 (7%)
- Partial compliance: 2 of 31 (6%)
- Does not comply: 4 of 31 (13%)



HVAC Cooling Efficiency

Nearly all of the reviewed projects comply with the code's cooling equipment efficiency requirements. Performance specifications were missing from 28% of the projects, but most equipment that is currently available on the market will meet the minimum efficiency requirements of the 2006 IECC. One case that does not comply includes a water-source heat pump with efficiency of EER 11.2, while the minimum requirement is EER 12.0.

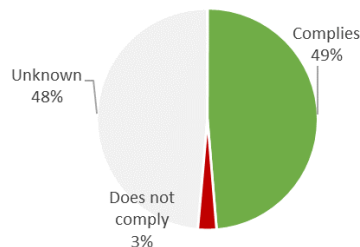
- Unknown: 11 of 39 (28%)
(information missing)
- Complies: 26 of 39 (67%)
- Partial compliance: 1 of 39 (3%)
- Does not comply: 1 of 39 (3%)



HVAC Insulation

Duct insulation specifications were missing from 49% of the reviewed projects.

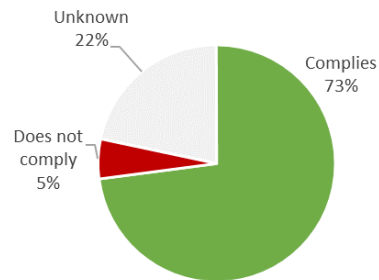
- Unknown: 18 of 37 (49%)
(information missing)
- Complies: 18 of 37 (48%)
- Does not comply: 1 of 37 (3%)



HVAC Controls

Compliance was generally good, but 22% of projects did not include HVAC control information on the plans.

- Unknown: 8 of 37 (22%)
(Information missing)
- Complies: 27 of 37 (73%)
- Does not comply: 2 of 37 (5%)



Other HVAC Requirements

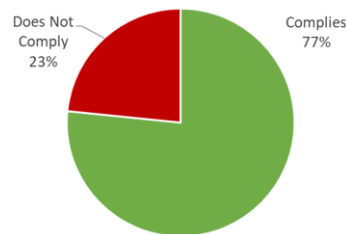
HVAC commissioning notes were missing from the plans in all but 4 cases. Energy recovery ventilation was missing from two projects.

Summary of Compliance Review Results – Low-rise Residential

Designer Compliance Certification

Of the 94 low-rise residential projects, most included designer compliance certification for envelope compliance.

- Unknown: 0 of 94 (0%)
(information missing)
- Complies: 72 of 94 (77%)
- Does Not Comply: 22 of 94 (23%)

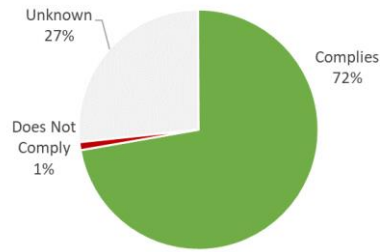


Most plans did not have energy code stamps related to HVAC and lighting systems because HVAC and electrical plans are not submitted to the building department.

Roof Insulation

Compliance was verified in 72 percent of the projects, but in 27 percent of the projects the insulation R-value was missing from the plans and compliance was uncertain. Only one project clearly had no insulation and did not comply.

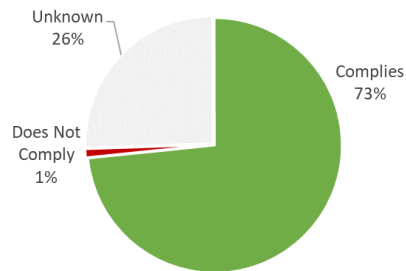
- Unknown: 25 of 94 (27%)
(information missing)
- Complies: 68 of 94 (72%)
- Does Not Comply: 1 of 94 (1%)



Wall Insulation

Compliance results were very similar to roof insulation; 73 percent were found to comply and compliance was uncertain in 26 percent.

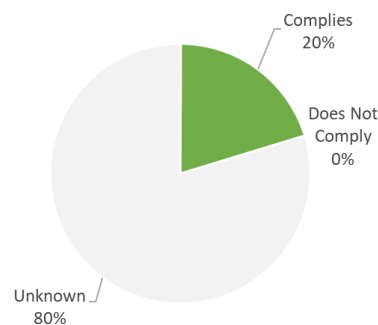
- Unknown: 24 of 94 (26%)
(information missing)
- Complies: 69 of 94 (73%)
- Does Not Comply: 1 of 94 (1%)



Fenestration

Of the 94 applicable projects only 19 projects had information available related to SHGC. Compliance could not be verified for 80 percent of the projects. The SHGC data was seldom found on the plans. In most of the 19 cases, the window specifications were obtained by contacting the project architects.

- Unknown: 75 of 94 (80%)
(information missing)
- Complies: 19 of 94 (20%)
- Does Not Comply: 0 of 94 (0%)



HVAC Systems

HVAC compliance was unclear for most of the projects that were reviewed. Plans submitted to the building departments rarely show air conditioning systems, though it is likely that some of homes do get air conditioning installed. For the small number that did include HVAC on the plans, only 5 of 94 projects, the air conditioners complied with the efficiency requirements with designed SEER ranging from 16.5 to 18.0. The federally mandated minimum SEER for residences in Hawaii is 14.0.

Water Heating Systems

The 2006 IECC does not include requirements for water heating system efficiency.

The Hawaii amendments to the 2015 IECC reference the Hawaii state requirements for solar water heating, which also allow instantaneous gas water heaters under specific circumstances. Figure 1 shows the breakdown of water heater system type for the relevant new construction projects in the sample. In some cases, the plans did not include information about water heating, and they are indicated as “unknown”.

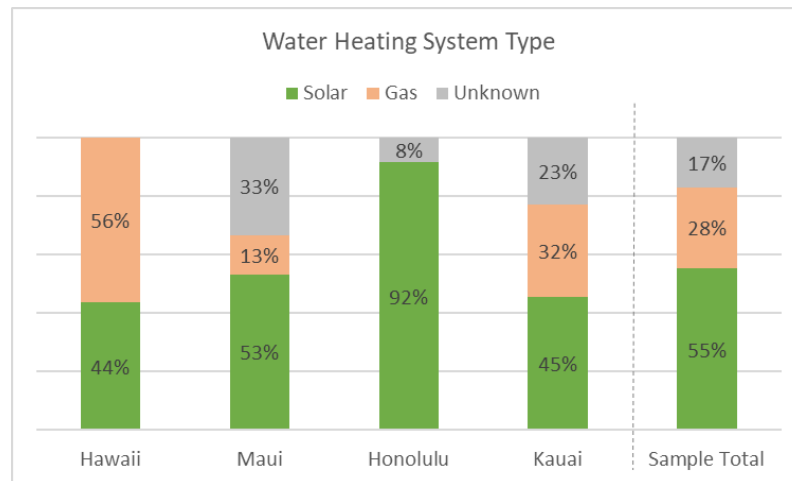


Figure 1. Low-rise Residential Water Heating System Type

Electrical Systems

The 2006 code does not include lighting efficiency requirements, but the 2009 code that applies in Kauai does require that at least 50 percent of permanently installed lights be high-efficacy. None of the Kauai plans included information about lighting systems, therefore the rate of compliance with the existing code is unknown.

In the other three counties, only one project included information about lighting. That case complies with the 2015 high-efficacy requirement, but none of the other projects can be verified for compliance.

Summary of Energy Impact

The total impact of non-compliance is estimated to be roughly 7.1%. Table 1 lists the four areas identified in this review that are likely to have an impact. When applied to the construction forecast of 2,700,000 square feet per year, the total lost energy savings are roughly 4,800,000 kWh per year.

Table 1. Energy Impact of Non-Compliance

	Electricity Consumption Impact (%)	Electricity Consumption (kWh/sf-yr)	Construction Forecast (sf/yr)	Electricity Consumption (kWh/yr)
Baseline	--	25.1	2,700,000	67,770,000
Interior lighting impact	0.28%	0.070		189,756
Fenestration impact	0.62%	0.156		420,174
Energy recovery ventilation impact	1.18%	0.296		799,686
Commissioning impact	5.00%	1.255		3,388,500
Total	7.08%	26.9		72,568,116
Lost Savings		1.78		4,798,116

Summary of Recommendations

Recommendations are provided as follows. More details are provided within the body of the report.

Non-residential and High-rise Residential

- Promote the use of the proposed compliance certifications that are included in Appendix 9, with the goal to improve compliance with requirements that performance information be included on plans and to inform plan reviewers of the compliance path used by the designers.
- Improve awareness of the County code amendments, such as the commissioning-plan requirement, perhaps by encouraging use of code compliance checklists.
- Provide additional mechanical plan review for large projects to ensure important measures such as energy recovery ventilation are implemented.
- Develop simple compliance guidance and/or incentive programs for small retail projects, especially to focus on lighting power compliance.
- Develop guidance for improving window compliance for projects in general.
- Develop guidance for mechanical system commissioning. Awareness of the requirement appears to be low, and the potential impact is significant.
- Develop guidance on envelope requirements for unconditioned buildings. This was a request from a building official.
- Prepare guidance information to support compliance with the 2015 IECC. There are several areas where the new code will be significantly more stringent than the existing code, such as insulation of concrete walls, continuous insulation of steel-frame walls, and installation and commissioning of automatic daylighting controls.

Low-rise Residential

- Promote the use of the proposed compliance certification that is included in Appendix 8.
- Work with the building departments, design professionals and builders to develop a process where designers or contractors are required to submit documentation showing compliance with HVAC, water heating and electrical requirements. The current permit process does not require the submission of electrical or mechanical plans in many cases.

- Develop guidance for the 2015 IECC requirements for envelope air leakage testing and duct leakage testing.

Introduction

The Hawaii State Energy Office commissioned this study as a follow-on to a study performed for Hawaii Energy in 2015. That study evaluated the level of compliance of non-residential and high-rise residential projects with building energy codes in the Counties of Hawaii, Honolulu, and Maui as of early 2015. This study expands the previous study to add the following:

- Low-rise residential projects in Hawaii, Kauai, Maui and Honolulu Counties
- Non-residential projects in Kauai
- Evaluation of compliance with the 2015 IECC as well as the 2006 IECC

A primary goal of this work was to identify whether there are compliance problem areas and whether there were corresponding savings opportunities available from improving the compliance rates.

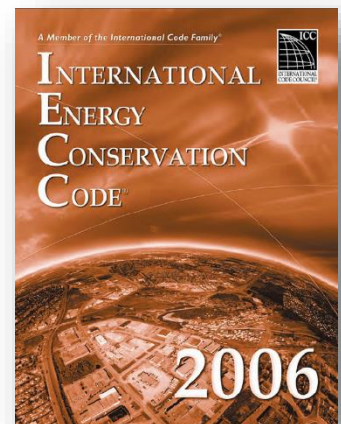
Part of the inspiration for this work was a 1998 study that looked at compliance rates in Honolulu and Hawaii Counties for the energy codes that they had adopted in 1995 and 1994 respectively.¹ The current study follows similar methods to the 1998 study.

The work described in this report took place in the period September 2017 through May 2018. The work was performed by Erik Kolderup of Kolderup Consulting and Srinivas Vemuri of Insynergy Engineering. Gail Suzuki-Jones and Howard Wiig of the Hawaii State Energy Office served as project managers.

Current Energy Codes

The energy code in effect at the time of this study in Hawaii, Maui and Honolulu counties is the 2006 International Energy Conservation Code (2006 IECC) with several amendments specific to Hawaii. The code in Kauai is the 2009 IECC. Kauai's 2015 IECC, with amendments, passed second reading in the Kauai County Council as of mid-June 2018. Most of the amendments currently in effect are same for each county. However, there are a few differences which are highlighted in the sections below.

In March of 2017, the Governor signed Chapter 3-181.1 Hawaii Administrative Rules to codify amendments to the 2015 IECC, which was in the process of being adopted by each County at the time of the publication of this report.



IECC Overview

Non-residential and High-rise Residential Summary

The scope of the IECC covers the following building design elements for non-residential buildings

- Envelope
- Interior lighting
- Exterior lighting

¹ Eley Associates, *Energy Code Compliance Study: Honolulu and Hawaii Counties*, 1999. Available at <http://energycodesocean.org/resource/energy-code-compliance-study-honolulu-and-hawaii-counties>.

- HVAC
- Service water heating

Table 2 compares some of the requirements of the 2006 and 2015 versions of the IECC. See also Appendix 1 and Appendix 2 for more details.

Table 2. Highlights of IECC Requirements – Non-residential and High-rise Residential

	2006 IECC	2015 IECC
Roof – insulation above deck	R-15	R-25 (group R) R-20 (others)
Roof – metal building	R-19 + R-10	R-19 + R-11
Roof – attic or other	R-30	R-38
Wall – mass (CMU or concrete)	R-0	R-5.7
Wall – metal building	R-13	R-13 + R6.5
Wall – metal frame	R-13	R-13 + R-5 *
Wall – wood frame and other	R-13	R-13 + R3.8 or R-20 *
Low-slope roof membrane	No requirement	Aged reflectance ≥ 0.55 + aged emittance ≥ 0.75 , or aged reflectance ≥ 0.64 (exceptions available)
Windows – maximum area	40%	30% of gross wall area (40% with daylighting control)
Windows – solar heat gain coefficient (SHGC)	≤ 0.25 if projection factor < 0.25 . ≤ 0.33 if projection factor 0.25-0.5. ≤ 0.40 if projection factor ≥ 0.5 .	≤ 0.25 if projection factor < 0.2 . ≤ 0.30 if projection factor 0.2-0.5. ≤ 0.40 if projection factor ≥ 0.5 .
Windows – U-factor	1.20	0.50 fixed fenestration 0.65 operable fenestration 1.10 entrance doors
Skylights – minimum area	No requirement	Skylights and daylight responsive controls required for certain spaces $\geq 2,500$ ft ² with ceiling height ≥ 15 ft.
Skylights – maximum area	3%	3% (5% with daylighting controls)
Skylights – solar heat gain coefficient (SHGC)	0.40 glass, 0.35 plastic	0.35 (0.60 with daylighting control)
Skylights – U-factor	1.60 glass, 1.90 plastic	0.75 (0.90 with daylighting control)

* See County code amendments below.

In addition to the performance requirements, the IECC requires that performance information be included in the construction documents so that compliance with the code may be verified. Section 104.2 states, “Details shall include, but are not limited to, insulation materials and their R-values; fenestration U-factors and SHGCs; system and equipment efficiencies, types, sizes and controls; duct sealing, insulation and location; and air sealing details.”

The 2006 IECC allows two compliance paths for non-residential buildings: prescriptive and total building performance. The total building performance path requires building energy simulation models of the proposed design and a standard design, and this path allows tradeoffs between the performance of different systems. A primary reason for using the total building performance path is to show compliance for projects with window area greater than 40%.

ASHRAE Standard 90.1-2004 is allowed as an alternative compliance path for non-residential and high-rise residential buildings in the 2006 IECC.

Low-rise Residential Summary

For low-rise residential buildings, the IECC covers the following building design elements for non-residential buildings.

- Envelope
- Interior lighting
- HVAC
- Service water heating

Table 3 highlights some differences between the 2006 and 2015 IECC. There are few changes to the prescriptive envelope requirements for low-rise residential buildings. The most significant changes are the addition of air leakage testing requirements for the overall house and for air conditioning ducts. A requirement for high-efficacy lighting is also new in 2015.

Table 3. Highlights of IECC Requirements – Low-rise Residential

	2006 IECC	2015 IECC
Roof – wood frame	R-30*	R-30*
Roof – metal frame	R-38*	R-38*
Wall – mass (CMU or concrete)	R-3	R-3 ext. or R-4 int.
Wall – metal frame	R-13 + R-5 *	R-13 + R-4.2 *
Wall – wood frame and other	R-13	R-13
Floor – wood frame	R-13	R-13
Floor – metal frame	R-19	R-19
Windows – max. SHGC	0.25	0.25
Skylights – max. SHGC	0.30	0.30
Skylights – U-factor	0.75	0.75
Air leakage testing	None	Blower door test required
Duct leakage testing	None	Duct blaster test required
Lighting	None	> 75% high-efficacy

* See County code amendments below.

County Code Amendments

Each of the counties has adopted amendments to their current version of the IECC, which are very similar with only a few exceptions. The amendments are summarized in Table 4.

- **Hawaii.** Chapter 5, Article 5, Section 5-84. Adopted October 2010
- **Honolulu.** Chapter 32 Building Energy Conservation Code. Adopted November 2009
- **Maui.** Chapter 16.16A. Adopted October 2009
- **Kauai.** Chapter 12, Article 6. Energy Code. Adopted January 2010

Table 4. Summary of County Code Amendments – Current Codes

Amendment	Hawaii	Honolulu	Maui	Kauai
Habitable unconditioned spaces must meet the envelope requirements.		✓	✓	✓
The responsible design professional shall provide a signed statement of compliance on the plans.	✓	✓	✓	✓
Section 105 covering inspection requirements is deleted	✓	✓	✓	✓
Non-residential and high-rise residential				
Mechanical system commissioning plan is required.	✓	✓	✓	✓
Tenant electricity sub-metering required.	✓		✓	
Low-rise residential				
R-0 floor insulation	✓	✓	✓	✓
Roof insulation alternatives	✓	✓	✓	✓
Pool covers	✓	✓	✓	✓

While the 2015 IECC had not yet been adopted by any of the counties at the time of this report, the State adopted a set of amendments in March 2017. The following are highlights of the state amendments, which are being considered by the counties.

Non-residential and High-rise residential amendments:

- Habitable unconditioned spaces must meet the envelope requirements.
- The responsible design professional shall provide a signed statement of compliance on the plans.
- Framed walls do not require continuous insulation if reflectance ≥ 0.64 or shading $PF \geq 0.3$
- Tenant submetering requirement

Low-rise residential amendments:

- Habitable unconditioned spaces must meet the envelope requirements.
- The responsible design professional shall provide a signed statement of compliance on the plans.
- Tropical zone option window SHGC credit for overhangs
- Tropical zone roof options, credit for cool roof
- Added Points Option for walls and roof
- Solar water heating requirement references state law
- Ceiling fan requirement

Energy Code Enforcement Process

County of Hawaii Enforcement

Some energy code plan review is performed. Plan reviewers check that the designers have provided a certificate of compliance on the plans. In addition, designers are typically asked for an energy code analysis. Some designers provide Comcheck software reports to demonstrate compliance. Some plan reviewers check to make sure results are reasonable and that inputs match plans.

Typically, separate certifications are included on the plans for envelope, lighting, mechanical and water heating. Plan review takes place in two offices: Hilo and Kailua-Kona.

County of Honolulu Enforcement

The County of Honolulu relies on the designer's certification on the plans for energy code compliance.

County of Maui Enforcement

Plan reviewers check for a designer certification on the plans but otherwise perform minimal review of energy code requirements, especially on commercial buildings. The plan review office is in Wailuku.

County of Kauai Enforcement

The County of Honolulu relies on the designer's certification on the plans for energy code compliance and requires a note related to mechanical system commissioning.

Compliance Review Method

Sampling Method – Non-residential and High-rise Residential

The target was set at 50 projects to be reviewed in this study, with a breakdown as is listed in Table 5. These targets were set based on judgment, with the goal being to provide reasonably representative and useful results with a reasonable level of effort. This target is also similar to the number of projects reviewed for the previous compliance study in 1998. The actual number of projects reviewed is listed in Table 6. The total number of projects reviewed for each county matches the target, but the breakdown of project types varies from the target due to project availability.

Table 5. Sampling Targets, Number of Projects for Review

Project Type	Hawaii	Honolulu	Maui	Kauai	Total
New construction – small <25k ft ²	2	4	2	2	10
New construction – medium/large	2	4	2	2	10
Renovation – small <25k ft ²	2	4	2	2	10
Renovation – medium/large	2	4	2	2	10
High-rise residential	2	4	2	2	10
Totals	10	20	10	10	50

Table 6. Sampling Actual, Number of Projects for Review

Project Type	Hawaii	Honolulu	Maui	Kauai	Total
New construction – small <25k ft ²	3	7	1	4	15
New construction – medium/large	2	2	4	0	8
Renovation – small <25k ft ²	5	8	3	5	21
Renovation – medium/large	0	2	1	0	3
High-rise residential	0	1	1	1	3
Totals	10	20	10	10	50

An additional goal was to review a mix of non-residential building types, in such as office, retail, restaurant, and lodging.

As a point of reference regarding sample size, the US Department of Energy provides an online “State Sample Generator”, developed for energy code compliance studies. The recommended sample sizes are shown in Figure 2 for new construction projects and Figure 3 for renovation projects. The methodology behind these samples is described in a report available at <https://www.energycodes.gov/compliance/evaluation>. These results call for a total new-construction sample of 33. That total is slightly higher than the proposed sample size of 30 new-construction projects. For renovation projects the recommended sample size is 40 projects, which is larger than the planned sample of 20 renovation projects.

Commercial New Construction
Construction starts represent an annual average from 2008-2010 data.

Location	Construction Starts	Sample Size ⓘ				
		Small	Medium	Large	X-Large	XX-Large
State Totals	107	11	11	11	2	1
Climate Zone 1 Totals	107	11	11	11		
Hawaii County	37	4	5	2		
Honolulu County	48	6	5	4		
Kauai County	6	1	-	1		
Maui County	15	-	1	4		

Figure 2. State Sample Generator Results – Commercial New Construction

US Department of Energy Building Energy Codes Program,
<https://www.energycodes.gov/compliance/evaluation>

Commercial Renovations
Construction starts represent an annual average from 2008-2010 data.

Location	Construction Starts	Sample Size
State Totals	371	40
Climate Zone 1 Totals	371	40
Hawaii County	69	5
Honolulu County	249	29
Kauai County	13	1
Maui County	39	5

Figure 3. State Sample Generator Results – Commercial Renovations

US Department of Energy Building Energy Codes Program,
<https://www.energycodes.gov/compliance/evaluation>

Hawaii County Sampling

Projects were selected from among the recently permitted project plans stored on shelves at the building permitting offices in Hilo and Kailua-Kona. The selection of specific projects was based on judgment of the reviewer, with the goal of providing a mix of project sizes and types from among recently permitted projects. Four projects were reviewed in Kailua-Kona and six in Hilo.

Honolulu County Sampling

Projects to be reviewed were identified from an online database listing all permitted projects in the County.² That large database was downloaded and filtered to identify projects permitted 2013 or later and to exclude low-rise residential projects. The list was also filtered to include only projects that had completed construction because a sample would be later reviewed in the field. Some additional information for individual projects was obtained at another website.³ That information was used to help judge whether the project was a type that falls under the scope of the energy code. A list of 20 projects was then selected that appeared to represent the desired mix of project size and type. The building department provided a DVD disk with scanned plans.

Maui County Sampling

Internet access to electronic plans is available in Maui.⁴ The building department provided a list of 10 recent projects that matched the project-type categories listed above in Table 5. Plans were downloaded for review.

Kauai County Sampling

The county provided a list of recently permitted projects, and a short-list of about 20 projects were selected. The projects were selected based on judgment of the reviewer to provide a representative mix

²<https://data.honolulu.gov/>

³ <http://dppweb.honolulu.gov/DPPWeb/default.aspx?PossePresentation=BuildingPermitSearch>

⁴ <http://public.co.maui.hi.us/records/index.aspx>

of building type and project size. Plans for those projects were accessed online through the county's plan review system.

Sampling Method – Low-rise Residential

For each county, a sample size for low-rise residential projects was set based on judgment, with the goal being to provide reasonably representative and useful results with a reasonable level of effort. The targeted sample size for each county is listed in Table 7. The actual number of reviewed projects is also listed in the table. In each case, the specific individual projects were selected by the reviewer based on judgment, with the goals of selecting recent projects and reviewing a mix of residence type and size.

Table 7. Sampling Targets and Actual, Number of Projects for Review – Low-Rise Residential

	Hawaii	Honolulu	Maui	Kauai	Total
Target number of projects	5	20	10	5	40
Actual sample - multi-family	1	18	7	6	62
Actual sample - single family	17	21	8	16	32
Total reviewed	18	39	15	22	94

Hawaii County Sampling

Projects were selected from among the recently permitted project plans stored on shelves at the building permitting offices in the Hilo and Kailua-Kona.

Honolulu County Sampling

Projects were selected from among the recently permitted project plans stored on shelves in the Honolulu building permitting office.

Maui County Sampling

Projects were selected from among the recently permitted project plans, remote online access was available to electronic plans.

Kauai County Sampling

Projects were selected from among the recently permitted project plans, remote online access was available to electronic plans.

Plan Review Method – Non-residential and High-rise Residential

Each project was reviewed for one to two hours and information was recorded in a spreadsheet checklist. See Appendix 2 for a list of information collected in the checklist. The review process included the following steps.

- Collect project information. Building type, size, and location.
- Note designer compliance certifications
- Review envelope compliance. Check roof and wall construction types and insulation levels, window area, glazing specifications, skylight area, and skylight specifications.
- Review interior lighting compliance. Calculate interior lighting power based on count of fixtures and fixture input power. Determine allowed lighting power based on floor area and space types. Check for lighting controls.

- Review exterior lighting power compliance. Calculate exterior lighting power based on count of fixtures and fixture input power. Determine allowed lighting power based on illuminated area and lighting application. Check for exterior lighting controls.
- Review mechanical compliance. Check cooling equipment efficiency. Check duct and pipe insulation. Check off-hour controls. Check for commissioning plan notes. Check for adjusting and balancing notes. Check for additional requirements for complex HVAC systems.
- Review water heating compliance. Check equipment efficiency, pipe insulation and controls.

Following each review, a subjective assessment of compliance level per the 2006 IECC was recorded. This same method was used in the previous study and is repeated in this study for consistency. Each compliance category, such as roof compliance or interior lighting power compliance, was assessed on the following scale:

- **Exceeds code.** Performance level is significantly better than required by the code. For example, lighting power is more than about 25% lower than required.
- **Meets code.** Performance level equal to or better than required.
- **Minor non-compliance.** Close to compliance, but not quite. Within roughly 10% of required performance, or a small element of a system is not in compliance or is not documented on the plans.
- **Moderate non-compliance.** This includes cases when non-compliance is significant but not complete. For example, lighting power is 10% to 50% higher than allowed, or envelope insulation is not adequate.
- **Major non-compliance.** This category includes things like no roof insulation and installed lighting power 50% to 100% greater than allowed. These cases will have significant energy impacts.
- **Not applicable**

In some cases, compliance could not be verified because information was missing from the plans. In each of those cases, one of the compliance levels listed above was assigned based on subjective assessment of the severity of the impact of the omission. These cases are described as “unknown” in the discussion later in this report. It is possible that some of those cases comply, but compliance cannot be verified based on information submitted to the building department.

Plan Review Method – Low-rise Residential

Each project was reviewed for one to two hours and information was recorded in a spreadsheet checklist. See Appendix 2 for a list of information collected in the checklist. The review process included the following steps.

- Collect project information. Building type, size, and location.
- Note designer compliance certifications
- Review envelope compliance. Check roof and wall construction types and insulation levels, window area, glazing specifications.
- Review interior lighting compliance. Check for count of fixtures and fixture input power.
- Review mechanical compliance. Check cooling equipment efficiency and controls. Check duct and pipe insulation.
- Review water heating compliance. Check equipment efficiency, pipe insulation and controls.
- Review notes and specifications for building envelope air leakage.
- Review ceiling fan compliance.

- Review solar hot water compliance.

Following each review, a subjective assessment of compliance level was recorded. Compliance was assessed versus both the 2006 IECC and the 2015 IECC. Each compliance category, such as roof or wall insulation compliance, was assessed on the following scale:

- **Exceeds code.** Performance level is significantly better than required by the code.
- **Meets code.** Performance level equal to or better than required.
- **Minor non-compliance.** Close to compliance, but not quite.
- **Moderate non-compliance.** This includes cases when non-compliance is significant but not complete.
- **Major non-compliance.** This category includes things like no roof or wall insulation. These cases will have significant energy impacts.
- **Not applicable**

In some cases where compliance could not be verified because information was missing from the plans, a compliance level was assigned based on subjective assessment of the severity of the impact of the omission. These cases are described as “unknown” in the discussion later in this report. It is possible that some of those cases comply, but compliance cannot be verified based on information submitted to the building department.

Compliance Review Results – Non-residential and High-rise Residential

Summary of Reviewed Projects

The tables in this section provide an overview of the type and size of non-residential and high-rise residential projects reviewed for each county.

Table 8. List of Projects– Hawaii County

ID	Building type	Construction phase	Plan date	Stories	Floor area
1	Mixed use, office/retail, warehouse	New	May-14	2	11,932
2	Medical office building	New	Jul-13	2	29,600
3	Lounge/food service	Renovation	Sep-14	1	815
4	Retail	Renovation	Jul-14	1	4,382
5	Gymnasium	New	Jan-12	1	4,489
6	Retail	Renovation	Jan-13	1	1,620
7	Bank	Renovation	Feb-14	1	6,000
8	Gymnasium, Multipurpose	New	Jun-12	1	42,182
9	Warehouse	New	Apr-14	1	10,800
10	Hotel	Renovation	Oct-14	2	17,708
				Total	129,528
				Average	12,953
				Median	8,400

Table 9. List of Projects – Maui County

ID	Building type	Construction phase	Plan date	Stories	Floor area
11	Retail	New	Jun-13	1	137,462
12	Warehouse	New	Jun-13	1	46,475
13	Retail	New	Feb-14	1	26,092
14	Bank	New	Oct-13	2	11,700
15	Retail	Renovation	Apr-14	1	4,000
16	Retail	Renovation	Dec-13	1	1,475
17	Retail	Renovation	Jul-14	1	13,897
18	Hotel	New	May-11	4	75,891
19	High-rise residential	New	Aug-11	12	237,000
20	Hotel	Renovation	Aug-11	7	294,000
				Total	847,992
				Average	84,799
				Median	36,284

Table 10. List of Projects – Honolulu County

ID	Building type	Construction phase	Plan date	Stories	Floor area
21	Hotel	Renovation	Dec-13	1	2,750
22	Hotel	Renovation	Oct-11	14	217,000
23	Retail	Renovation	Dec-14	1	5,072
24	Retail	Renovation	Nov-14	1	2,270
25	Retail	Renovation	Nov-14	3	n/a
26	Retail	Renovation	Nov-14	1	1,965
27	Office	Renovation	Oct-14	31	5,422
28	Office	Renovation	Oct-14	2	15,527
29	Office	Renovation	Dec-13	6	8,036
30	Office	Renovation	Aug-13	3	41,809
31	Bank	New	Oct-12	1	6,100
32	Office	New	Jun-12	1	15,585
33	Retail	New	Dec-13	1	867
34	Retail	New	Mar-14	1	978
35	Retail	New	May-13	1	1,983
36	Retail	New	May-13	3	35,576
37	High-rise residential	New	Jan-12	43	485,745
38	Educational	New	Feb-12	4	43,793
39	Library	New	Feb-12	1	17,135
40	High-rise residential	New	Oct-11	7	66,290
				Total	973,903
				Average	51,258
				Median	8,036

Table 11. List of Projects – Kauai County

ID	Building type	Construction phase	Plan date	Stories	Floor area
41	Residential	New	Jun-14	4	48,089
42	Retail	New	Apr-13	1	14,820
43	Retail	New	Jun-17	1	2,484
44	Multipurpose	New	Nov-13	1	2,500
45	Retail and Office	New	May-14	1	3,000
46	Office	Renovation	Apr-14	1 + bsmt	21,900
47	Bank branch	Renovation	Apr-16	1	5,137
48	Retail	Renovation	Aug-16	1	21,630
49	Outpatient healthcare	Renovation	Aug-13	1	3,951
50	Restaurant	Renovation	May-16	1	4,000
				Total	127,511
				Average	12,751
				Median	4,569

Summary of Compliance Level Results

The following set of tables summarizes the level of compliance using the categories described earlier that indicate whether the project exceeds the code, meets the code, or does not comply with the code. In cases where information is missing from the plans, such as missing window SHGC, a non-compliance level was assigned based on subjective assessment. These summaries are presented in two ways: 1) a count of projects at each compliance level and 2) the percentage of projects at each compliance level. The final summary in Table 20 lists the compliance level results for each of the reviewed projects. Please see the following sections for discussion of compliance findings.

Table 12. Number of Projects at Each Compliance Level – Hawaii County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	3	1	1	4	0	1
Lighting power - exterior	2	3	1	0	0	4
Lighting controls - interior	0	5	4	0	0	1
Lighting controls - exterior	0	4	2	0	0	4
Envelope - roof	0	2	3	0	0	5
Envelope - wall	0	4	1	0	0	5
Envelope - windows	0	1	3	2	0	4
Envelope - skylights	0	0	1	0	0	9
HVAC - efficiency	0	4	2	0	0	4
HVAC - insulation	0	3	2	0	0	5
HVAC - other	0	3	3	0	0	4
HVAC commissioning	0	0	0	6	0	4
HVAC adjusting and balancing	0	3	0	3	0	4
WH - efficiency	1	5	1	0	0	3
WH - insulation	0	4	3	0	0	3
WH - controls	0	2	0	0	0	8
Tenant electrical submetering	0	3	1	0	0	6

Table 13. Percent of Projects at Each Compliance Level – Hawaii County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	9	33%	11%	11%	44%	0%
Lighting power - exterior	6	33%	50%	17%	0%	0%
Lighting controls - interior	9	0%	56%	44%	0%	0%
Lighting controls - exterior	6	0%	67%	33%	0%	0%
Envelope - roof	5	0%	40%	60%	0%	0%
Envelope - wall	5	0%	80%	20%	0%	0%
Envelope - windows	6	0%	17%	50%	33%	0%
Envelope - skylights	1	0%	0%	100%	0%	0%
HVAC - efficiency	6	0%	67%	33%	0%	0%
HVAC - insulation	5	0%	60%	40%	0%	0%
HVAC - other	6	0%	50%	50%	0%	0%
HVAC commissioning	6	0%	0%	0%	100%	0%
HVAC adjusting and balancing	6	0%	50%	0%	50%	0%
WH - efficiency	7	14%	71%	14%	0%	0%
WH - insulation	7	0%	57%	43%	0%	0%
WH - controls	2	0%	100%	0%	0%	0%
Tenant electrical submetering	4	0%	75%	25%	0%	0%

Table 14. Number of Projects at Each Compliance Level – Maui County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	2	4	3	1	0	0
Lighting power - exterior	0	5	1	0	0	4
Lighting controls - interior	0	6	4	0	0	0
Lighting controls - exterior	0	4	2	0	0	4
Envelope - roof	0	5	2	0	0	3
Envelope - wall	0	6	1	0	0	3
Envelope - windows	0	0	7	0	0	3
Envelope - skylights	0	0	1	1	0	8
HVAC - efficiency	0	7	2	0	0	1
HVAC - insulation	0	3	6	0	0	1
HVAC - other	0	6	3	0	0	1
HVAC commissioning	0	0	0	9	0	1
HVAC adjusting and balancing	0	4	0	5	0	1
WH - efficiency	0	6	3	0	0	1
WH - insulation	0	2	6	0	0	2
WH - controls	0	1	4	0	0	5
Tenant electrical submetering	0	0	0	0	0	10

Table 15. Percent of Projects at Each Compliance Level – Maui County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	10	20%	40%	30%	10%	0%
Lighting power - exterior	6	0%	83%	17%	0%	0%
Lighting controls - interior	10	0%	60%	40%	0%	0%
Lighting controls - exterior	6	0%	67%	33%	0%	0%
Envelope - roof	7	0%	71%	29%	0%	0%
Envelope - wall	7	0%	86%	14%	0%	0%
Envelope - windows	7	0%	0%	100%	0%	0%
Envelope - skylights	2	0%	0%	50%	50%	0%
HVAC - efficiency	9	0%	78%	22%	0%	0%
HVAC - insulation	9	0%	33%	67%	0%	0%
HVAC - other	9	0%	67%	33%	0%	0%
HVAC commissioning	9	0%	0%	0%	100%	0%
HVAC adjusting and balancing	9	0%	44%	0%	56%	0%
WH - efficiency	9	0%	67%	33%	0%	0%
WH - insulation	8	0%	25%	75%	0%	0%
WH - controls	5	0%	20%	80%	0%	0%
Tenant electrical submetering	0	n/a	n/a	n/a	n/a	n/a

Table 16. Number of Projects at Each Compliance Level – Honolulu County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	2	12	3	1	0	2
Lighting power - exterior	0	7	2	1	0	10
Lighting controls - interior	0	12	6	0	0	2
Lighting controls - exterior	0	8	2	0	0	10
Envelope - roof	0	8	1	1	0	10
Envelope - wall	1	6	3	0	0	10
Envelope - windows	0	0	11	1	0	8
Envelope - skylights	0	0	1	0	0	19
HVAC - efficiency	1	8	5	0	0	6
HVAC - insulation	0	6	9	0	0	5
HVAC - other	0	10	3	0	0	7
HVAC commissioning	0	1	0	15	0	4
HVAC adjusting and balancing	0	9	0	5	0	6
WH - efficiency	0	2	7	0	0	11
WH - insulation	0	3	3	0	0	14
WH - controls	0	1	1	0	0	18
Tenant electrical submetering	0	0	0	0	0	20

Table 17. Percent of Projects at Each Compliance Level – Honolulu County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	18	11%	67%	17%	6%	0%
Lighting power - exterior	10	0%	70%	20%	10%	0%
Lighting controls - interior	18	0%	67%	33%	0%	0%
Lighting controls - exterior	10	0%	80%	20%	0%	0%
Envelope - roof	10	0%	80%	10%	10%	0%
Envelope - wall	10	10%	60%	30%	0%	0%
Envelope - windows	12	0%	0%	92%	8%	0%
Envelope - skylights	1	0%	0%	100%	0%	0%
HVAC - efficiency	14	7%	57%	36%	0%	0%
HVAC - insulation	15	0%	40%	60%	0%	0%
HVAC - other	13	0%	77%	23%	0%	0%
HVAC commissioning	16	0%	6%	0%	94%	0%
HVAC adjusting and balancing	14	0%	64%	0%	36%	0%
WH - efficiency	9	0%	22%	78%	0%	0%
WH - insulation	6	0%	50%	50%	0%	0%
WH - controls	2	0%	50%	50%	0%	0%
Tenant electrical submetering	0	n/a	n/a	n/a	n/a	n/a

Table 18. Number of Projects at Each Compliance Level – Kauai County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	1	7	2	0	0	0
Lighting power - exterior	1	4	0	0	0	5
Lighting controls - interior	0	10	0	0	0	0
Lighting controls - exterior	0	5	0	0	0	5
Envelope - roof	0	5	2	0	0	3
Envelope - wall	0	4	2	0	0	4
Envelope - windows	0	1	2	3	0	4
Envelope - skylights	0	0	0	0	0	10
HVAC - efficiency	0	6	4	0	0	0
HVAC - insulation	0	6	2	0	0	2
HVAC - other	0	8	1	0	0	1
HVAC commissioning	0	3	0	7	0	0
HVAC adjusting and balancing	0	7	0	2	0	1
WH - efficiency	0	5	3	1	0	1
WH - insulation	0	4	1	0	0	5
WH - controls	0	2	2	0	0	6
Tenant electrical submetering	0	0	0	0	0	10

Table 19. Percent of Projects at Each Compliance Level – Kauai County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	10	10%	70%	20%	0%	0%
Lighting power - exterior	5	20%	80%	0%	0%	0%
Lighting controls - interior	10	0%	100%	0%	0%	0%
Lighting controls - exterior	5	0%	100%	0%	0%	0%
Envelope - roof	7	0%	71%	29%	0%	0%
Envelope - wall	6	0%	67%	33%	0%	0%
Envelope - windows	6	0%	17%	33%	50%	0%
Envelope - skylights	0	n/a	n/a	n/a	n/a	n/a
HVAC - efficiency	10	0%	60%	40%	0%	0%
HVAC - insulation	8	0%	75%	25%	0%	0%
HVAC - other	9	0%	89%	11%	0%	0%
HVAC commissioning	10	0%	30%	0%	70%	0%
HVAC adjusting and balancing	9	0%	78%	0%	22%	0%
WH - efficiency	9	0%	56%	33%	11%	0%
WH - insulation	5	0%	80%	20%	0%	0%
WH - controls	4	0%	50%	50%	0%	0%
Tenant electrical submetering	0	n/a	n/a	n/a	n/a	n/a

Table 20. Compliance Level by Project

ID	Building Type	County	Phase	Floor Area (ft ²)	Lighting power - interior	Lighting power - exterior	Lighting controls - interior	Lighting controls - exterior	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	HVAC - other	HVAC commissioning	HVAC adjusting and balancing	WH - efficiency	WH - insulation	WH - controls	Tenant electrical submetering
1	Mixed use	Hawaii	New	11,932	0	-1	0	1	2	2	2	0	0	0	0	0	0	0	0	0	1
2	Medical office building	Hawaii	New	29,600	-1	-1	1	2	2	1	1	0	1	2	1	3	3	-1	2	1	0
3	Lounge/food service	Hawaii	Renovation	815	3	0	1	0	0	0	0	0	0	0	0	0	0	1	2	0	1
4	Retail	Hawaii	Renovation	4,382	3	0	1	0	0	0	3	0	1	1	1	3	1	1	1	1	1
5	Gymnasium	Hawaii	New	4,489	3	1	2	1	1	1	2	0	0	0	0	0	0	0	0	0	0
6	Retail	Hawaii	Renovation	1,620	3	0	1	0	0	0	0	0	2	1	1	3	1	1	1	0	2
7	Bank	Hawaii	Renovation	6,000	-1	1	1	2	2	1	3	2	2	1	2	3	3	2	1	0	0
8	Gymnasium, Multipurpose	Hawaii	New	42,182	1	1	2	1	1	1	2	0	1	2	2	3	3	1	2	0	0
9	Warehouse	Hawaii	New	10,800	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Hotel	Hawaii	Renovation	17,708	-1	0	2	0	0	0	0	0	1	0	2	3	1	1	1	0	0
11	Retail	Maui	New	137,462	-1	0	1	0	1	1	2	0	1	2	1	3	3	1	2	1	0
12	Warehouse	Maui	New	46,475	-1	1	2	2	1	1	2	0	1	2	1	3	3	1	2	0	0
13	Retail	Maui	New	26,092	1	1	1	1	2	1	2	0	2	1	1	3	1	1	1	0	0
14	Bank	Maui	New	11,700	1	1	1	1	1	2	2	3	1	2	1	3	1	1	2	0	0
15	Retail	Maui	Renovation	4,000	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Retail	Maui	Renovation	1,475	2	0	1	0	0	0	0	0	1	1	1	3	3	1	0	0	0
17	Retail	Maui	Renovation	13,897	2	0	2	0	0	0	0	0	1	2	2	3	1	2	1	2	0
18	Hotel	Maui	New	75,891	1	1	1	1	1	1	2	0	1	1	2	3	1	2	2	2	0
19	High rise residential	Maui	New	237,000	1	1	1	1	2	1	2	0	1	2	2	3	3	1	2	2	0
20	Hotel	Maui	Renovation	294,000	2	2	2	2	1	1	2	2	2	2	1	3	3	2	2	2	0
21	Hotel	Honolulu	Renovation	2,750	-1	0	1	0	0	0	0	0	0	2	0	3	1	0	0	0	0
22	Hotel	Honolulu	Renovation	217,000	1	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
23	Retail	Honolulu	Renovation	5,072	1	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
24	Retail	Honolulu	Renovation	2,270	2	0	1	0	0	0	2	0	2	2	1	3	1	0	0	0	0
25	Retail	Honolulu	Renovation	n/a	0	0	0	0	0	0	0	0	-1	0	1	3	0	0	0	0	0
26	Retail	Honolulu	Renovation	1,965	-1	0	2	0	0	0	0	0	0	1	0	3	1	2	1	0	0
27	Office	Honolulu	Renovation	5,422	1	0	1	0	0	0	0	0	0	2	1	3	1	0	0	0	0
28	Office	Honolulu	Renovation	15,527	2	0	1	0	0	0	0	0	2	1	1	3	1	0	0	0	0
29	Office	Honolulu	Renovation	8,036	1	0	1	0	0	0	0	0	2	2	1	3	3	0	0	0	0
30	Office	Honolulu	Renovation	41,809	1	0	2	0	0	0	0	0	1	2	0	1	1	1	1	0	0
31	Bank	Honolulu	New	6,100	1	1	1	1	1	1	2	0	1	1	2	3	3	2	0	0	0
32	Office	Honolulu	New	15,585	1	1	2	2	1	1	2	0	1	0	0	0	0	0	0	0	0
33	Retail	Honolulu	New	867	0	2	0	1	1	2	2	0	1	0	0	0	0	0	0	0	0
34	Retail	Honolulu	New	978	1	1	1	1	2	2	2	0	1	1	1	3	1	2	0	0	0
35	Retail	Honolulu	New	1,983	3	3	2	1	1	1	2	0	1	1	1	3	1	2	0	0	0
36	Retail	Honolulu	New	35,576	1	1	1	1	1	1	2	0	2	1	1	3	3	2	2	2	0
37	Highrise residential	Honolulu	New	485,745	2	2	2	2	1	1	2	0	2	2	2	3	3	1	2	0	0
38	Educational	Honolulu	New	43,793	1	1	1	1	1	2	2	0	0	2	1	3	3	2	2	1	0
39	Library	Honolulu	New	17,135	1	1	1	1	1	-1	2	2	1	2	1	3	1	0	0	0	0
40	Highrise residential	Honolulu	New	66,290	1	1	1	1	3	1	3	0	0	1	0	2	3	0	2	1	0
41	Residential	Kauai	New	48,089	1	0	1	0	2	2	2	0	1	2	1	3	3	2	2	1	0
42	Retail	Kauai	New	14,820	1	1	1	1	1	1	1	0	1	1	1	1	1	2	1	1	0
43	Retail	Kauai	New	2,484	-1	-1	1	1	1	2	2	0	2	0	1	1	1	2	0	0	0
44	Multipurpose	Kauai	New	2,500	1	1	1	1	1	1	3	0	1	0	1	3	0	3	0	0	0
45	Retail and Office	Kauai	New	3,000	2	1	1	1	1	1	3	0	1	1	1	3	1	1	0	0	0
46	Office	Kauai	Renovation	21,900	1	1	1	1	1	0	0	0	2	2	2	3	3	1	0	0	0
47	Bank branch	Kauai	Renovation	5,137	1	0	1	0	0	0	0	0	2	1	0	1	1	0	0	0	0
48	Retail	Kauai	Renovation	21,630	1	0	1	0	2	1	3	0	1	1	1	3	1	1	1	2	0
49	Outpatient healthcare	Kauai	Renovation	3,951	1	0	1	0	0	0	0	0	1	1	1	3	1	1	1	2	0
50	Restaurant	Kauai	Renovation	4,000	2	0	1	0	0	0	0	0	2	1	1	3	1	1	1	0	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Compliance Certification Results

The code amendments adopted in each county require that the responsible designer include a signed statement on the plans indicating compliance with the energy code. An example certification block is shown in Figure 4. Typically, there are separate certifications provided by designers of the building envelope, HVAC and lighting systems.

The figure displays two separate compliance certification forms. The top form is from the County of Maui, Chapter 16.16A Energy Code. It includes a statement of conformity, checkboxes for Building, Electrical, and Mechanical Component Systems (with 'X' marked for Building), signature and date lines, and fields for Name, Title (Registered Professional Architect), and License No. The bottom form is from the City and County of Honolulu, Revised Ordinance Chapter 32, Honolulu County Code 1990, As Amended. It includes a similar statement of conformity, checkboxes for Building, Electrical, and Mechanical Component Systems (with 'X' marked for Electrical), signature and date lines, and fields for Name, Title, and License No. Both forms have redacted signature and name areas.

Figure 4. Example Compliance Certifications

Of the 50 projects in the review sample there was only one case where no certification block was found. However, that one case did have a separate compliance report produced by the software Comcheck.

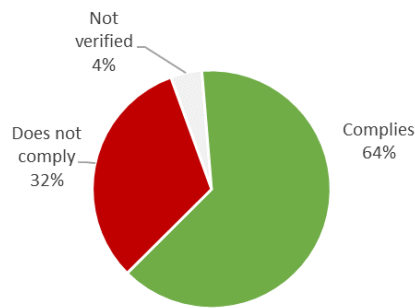
In several cases compliance blocks were not found for one or more relevant sections. For example, in one case the lighting and mechanical designers had provided compliance blocks, but the envelope certification was missing. The following are the findings for compliance certifications in the 50 projects:

- Envelope: 34 of 43 applicable projects, 79% compliance
- Lighting: 43 of 49 applicable projects, 85% compliance
- Mechanical: 41 of 47 applicable projects, 87% compliance

Interior Lighting Results

Of the 50 projects in the sample, 30 comply with the lighting power requirements, meaning that the designed lighting power was equal to or lower than the allowed interior lighting power. Fifteen projects do not comply and have designed power higher than the allowed limit. Of the final five projects, three did not include interior lighting in the design and two did not have enough information on the plans to confirm interior lighting compliance and are described as “not verified” in the chart below. Table 21 lists the results for installed and allowed interior lighting power for each project.

- Complies: 30 of 47 (64%)
- Does not comply: 15 of 47 (32%)
- Not verified: 2 of 47 (4%)
(information missing)



The difference between installed lighting power and allowed lighting power is illustrated Figure 5. A compliance margin greater than zero indicates a non-complying project; installed power is greater than allowed. A negative margin indicates that installed power is below the limit.

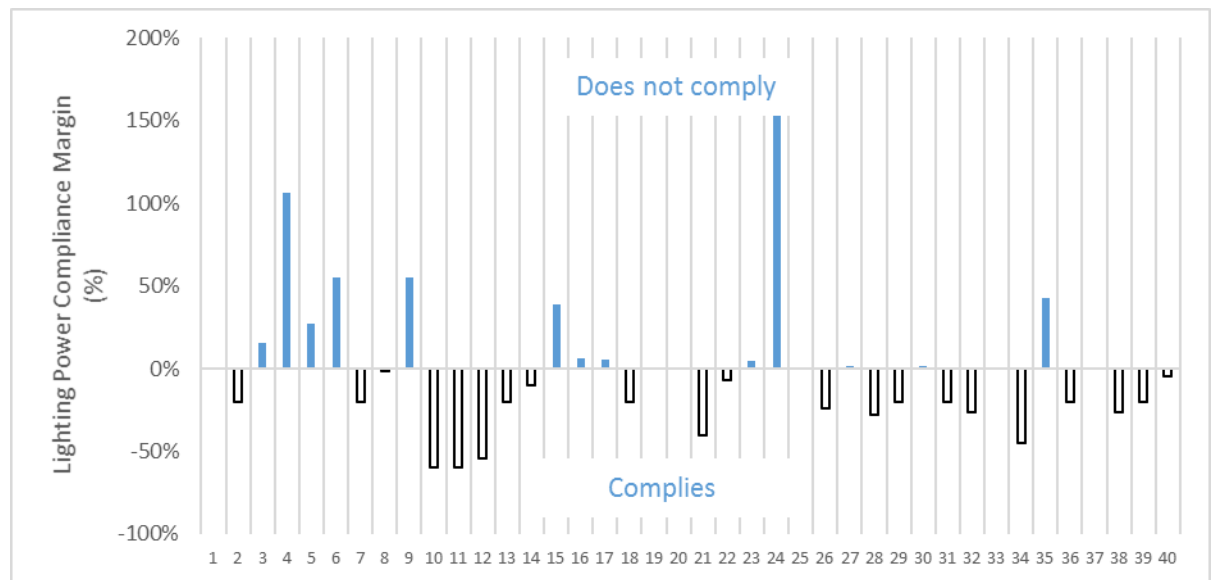


Figure 5. Interior Lighting Power Compliance Margins

Table 21. Interior Lighting Power Results by Project, Sorted by Compliance Margin

ID	Building Type	Floor Area	Installed interior lighting power (W/sf)	Allowed interior lighting power (W/sf)	Diff. (W/sf)	Diff. (%)
43	Retail	2,484	0.38	1.5	-1.12	-75%
10	Hotel	17,708	0.4	1.0	-0.60	-60%
11	Retail	137,462	0.6	1.5	-0.90	-60%
12	Warehouse	46,475	0.4	0.9	-0.48	-55%
48	Retail	21,630	0.82	1.5	-0.68	-45%
34	Retail	978	0.83	1.5	-0.67	-45%
47	Bank branch	5,137	0.89	1.5	-0.61	-41%
21	Hotel	2,750	0.6	1	-0.40	-40%
44	Multipurpose	2,500	0.8	1.2	-0.40	-33%
42	Retail	14,820	1.03	1.5	-0.47	-31%
41	Residential	48,089	0.5	0.7	-0.20	-29%
28	Office	15,527	0.72	1	-0.28	-28%
32	Office	15,585	0.22	0.3	-0.08	-27%
38	Educational	43,793	0.88	1.2	-0.32	-27%
26	Retail	1,965	1.06	1.4	-0.34	-24%
49	Outpatient healthcare	3,951	0.78	1	-0.22	-22%
31	Bank	6,100	1.13	1.42	-0.29	-20%
13	Retail	26,092	1.2	1.5	-0.30	-20%
39	Library	17,135	1.04	1.3	-0.26	-20%
2	Medical office building	29,600	0.8	1.0	-0.20	-20%
7	Bank	6,000	0.8	1.0	-0.20	-20%
18	Hotel	75,891	0.8	1.0	-0.20	-20%
29	Office	8,036	0.8	1	-0.20	-20%
36	Retail	35,576	1.6	2	-0.40	-20%
14	Bank	11,700	0.9	1.0	-0.10	-10%
22	Hotel	217,000	0.93	1	-0.07	-7%
46	Office	21,900	0.95	1	-0.05	-5%
40	Highrise residential	66,290	0.67	0.7	-0.03	-4%
8	Gymnasium, Multipurpose	42,182	1.1	1.1	-0.02	-2%
19	High rise residential	237,000	1.0	1.0	0.00	0%
27	Office	5,422	1.02	1	0.02	2%
30	Office	41,809	1.02	1	0.02	2%
23	Retail	5,072	1.57	1.5	0.07	5%
17	Retail	13,897	2.0	1.9	0.10	5%
16	Retail	1,475	1.6	1.5	0.10	7%
50	Restaurant	4,000	1.48	1.3	0.18	14%
3	Lounge/food service	815	1.5	1.3	0.20	15%
45	Retail and Office	3,000	1.18	1	0.18	18%
5	Gymnasium	4,489	1.4	1.1	0.30	27%
15	Retail	4,000	3.2	2.3	0.90	39%
35	Retail	1,983	2	1.4	0.60	43%
6	Retail	1,620	3.1	2.0	1.10	55%
9	Warehouse	10,800	1.4	0.9	0.50	56%
4	Retail	4,382	3.1	1.5	1.60	107%
24	Retail	2,270	5.1	1.9	3.20	168%
1	Mixed use, office/retail, warehouse	11,932	n/a	n/a	n/a	n/a
20	Hotel	294,000	unknown	1.0	unknown	unknown
25	Retail	n/a	n/a	n/a	n/a	n/a
33	Retail	867	n/a	n/a	n/a	n/a
37	Highrise residential	485,745	unknown	0.7	unknown	unknown

Total and average results for interior lighting power compliance are listed in Table 22. These results show that the floor area of complying buildings in the sample is much greater than non-complying buildings, 1,181,356 sf vs. 105,034 sf. In addition, the non-complying projects tend to be smaller. The median size of non-complying buildings is 4,000 sf while the median for complying projects is 17,422 sf. Table 21 shows that many of the non-complying cases are retail projects.

For the complying buildings, interior lighting power is 20% lower than the allowance on an area-weighted average basis. For the non-complying buildings, the lighting power is 21% higher than the allowance on average. Considering the entire sample of buildings, the area-weighted average interior lighting power is 17% below (better than) the allowed limit.

Table 22. Interior Lighting Power Results Summary

		Complying Projects	Non- Complying Projects	All Projects
Number of Projects (2 unknown, 3 not applicable)		30	15	45
Floor Area (sf)	Average	39,379	7,002	28,586
	Median	17,422	4,000	10,800
	Total	1,181,356	105,034	1,286,390
Allowed Power (W/sf)	Average	1.16	1.44	1.25
	Median	1.00	1.40	1.20
	Area Weighted Avg.	1.09	1.27	1.11
Installed Power (W/sf)	Average	0.82	2.04	1.23
	Median	0.81	1.54	1.00
	Area Weighted Avg.	0.85	1.57	0.91
Compliance Margin (W/sf)	Average	-0.34	0.60	-0.02
	Median	-0.29	0.20	-0.20
	Area Weighted Avg.	-0.25	0.30	-0.20
Compliance Margin (%)	Average	-28%	38%	-6%
	Median	-23%	17%	-20%
	Area Weighted Avg.	-20%	21%	-17%

This table includes 45 projects because of the 50 total projects there were three that did not include lighting and two that were missing information and were not verified.

Interior Lighting Observations

These results show that most projects are complying with the interior lighting power requirements, but there are several important observations and some potential areas for improved compliance.

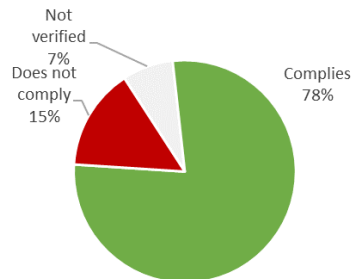
- Small retail projects comprise 9 of 15 of the non-complying cases and present an opportunity for savings. Table 21 shows that the five largest non-compliance margins are retail projects. On the other hand, there are many retail projects that comply with lighting power significantly lower than the code allowance.
- Use of track lighting is a common compliance problem in retail projects. The code requires that input power for line-voltage track lighting be counted at 30 watts per linear foot. It appears that some designers are not heeding this requirement in their compliance calculations.
- For most projects, the luminaire input power is missing from the plans. The code requires that the plans include information that allows compliance to be verified. Therefore, input power should be included in the lighting fixture schedule. For this review, the information on lamp type and quantity was used to estimate the likely actual input power.

- In a few cases in Hawaii County a designer showed lighting power compliance calculations on the plans but was using the allowed values from the previous version of the Hawaii County code that applied prior to October 2010.
- Office projects all comply or exceed code limits only slightly.
- Compliance could not be verified for two large projects, one hotel and one high-rise residential project, because lighting fixture information was not included on the plans. In these cases, it is likely that the designer's lighting fixture specifications were included in a separate document that was not submitted to the building department.

Exterior Lighting Results

Of the 50 projects in the review sample, 27 included exterior lighting. Of those 27 projects only four showed designed exterior lighting power exceeding the code allowance, and 21 of the 27 showed exterior lighting power lower than the allowance, often by a significant margin. Two projects could not be verified because the plans did not include lighting fixture specifications. Table 23 lists the review results for each project, showing designed exterior power and allowed exterior power. Figure 6 illustrates the results, showing the compliance margin in percentage terms. In Figure 6 negative values indicate that designed exterior lighting power is lower than the allowed limit. The graph shows that in many cases the designed power is 50% to 80% lower than the maximum allowance.

- Complies: 21 of 27 (78%)
- Does not comply: 4 of 27 (15%)
- Not verified: 2 of 27 (7%)
(information missing)



There were only four non-complying cases:

- Project #9 is a small warehouse using exterior lighting fixtures with a medium screw base. The code requires that the assumed input power for screw-base fixtures be the maximum rated power of the luminaire. For this review the maximum power was assumed to be 75 watts. The designer had stated that 13-watt self-ballasted compact-fluorescent lamps would be used. That may be true, however for purposes of code compliance it would be necessary to use dedicated pin-base fixtures in order to take credit for the lower lighting power of a compact fluorescent.
- Project #12 is a warehouse using metal-halide parking-lot lighting, and the installed power is only slightly higher than the calculated allowance.
- Projects #33 and #35 are both quick service restaurants. The first has 415 W of installed exterior lighting and 275 W allowance. The second has 2,070 W installed and 1,110 W allowance. In both cases a significant amount of the exterior lighting was used for façade illumination. Compliance calculation results were shown on the plans in both cases. However, review showed that the calculations undercount installed luminaires and overestimate the allowed lighting power.

Table 23. Exterior Lighting Power Results by Project, Sorted by Compliance Margin

ID	Building Type	Designed exterior lighting power (W)	Allowed exterior lighting power (W)	Diff. (W/sf)	Diff. (%)
44	Multipurpose	104	850	-746	-88%
36	Retail	4140	22058	-17918	-81%
43	Retail	136	589	-453	-77%
8	Gymnasium, Multipurpose	4,496	16,120	-11,624	-72%
19	High rise residential	5,000	15,000	-10,000	-67%
32	Office	364	1038	-674	-65%
2	Medical office building	2,640	7,400	-4,760	-64%
34	Retail	2953	7790	-4837	-62%
45	Retail and Office	593	1415	-822	-58%
7	Bank	254	600	-346	-58%
5	Gymnasium	1,195	2,773	-1,578	-57%
39	Library	3,570	7,400	-3,830	-52%
14	Bank	2,160	4,400	-2,240	-51%
31	Bank	1892	3750	-1858	-50%
1	Mixed use, office/retail, warehouse	2,925	5,063	-2,138	-42%
38	Educational	6672	10853	-4181	-39%
40	Highrise residential	2,120	2,780	-660	-24%
42	Retail	1851	2415	-564	-23%
18	Hotel	10,567	13,516	-2,949	-22%
46	Office	520	658	-138	-21%
13	Retail	26,050	30,500	-4,450	-15%
12	Warehouse	3,080	3,000	80	3%
9	Warehouse	450	360	90	25%
33	Retail	415	275	140	51%
35	Retail	2070	1110	960	86%
3	Lounge/food service	n/a	n/a	n/a	n/a
4	Retail	n/a	n/a	n/a	n/a
6	Retail	n/a	n/a	n/a	n/a
10	Hotel	n/a	n/a	n/a	n/a
11	Retail	n/a	n/a	n/a	n/a
15	Retail	n/a	n/a	n/a	n/a
16	Retail	n/a	n/a	n/a	n/a
17	Retail	n/a	n/a	n/a	n/a
21	Hotel	n/a	n/a	n/a	n/a
22	Hotel	n/a	n/a	n/a	n/a
23	Retail	n/a	n/a	n/a	n/a
24	Retail	n/a	n/a	n/a	n/a
25	Retail	n/a	n/a	n/a	n/a
26	Retail	n/a	n/a	n/a	n/a
27	Office	n/a	n/a	n/a	n/a
28	Office	n/a	n/a	n/a	n/a
29	Office	n/a	n/a	n/a	n/a
30	Office	n/a	n/a	n/a	n/a
41	Residential	n/a	n/a	n/a	n/a
47	Bank branch	n/a	n/a	n/a	n/a
48	Retail	n/a	n/a	n/a	n/a
49	Outpatient healthcare	n/a	n/a	n/a	n/a
50	Restaurant	n/a	n/a	n/a	n/a
20	Hotel	unknown	unknown	unknown	unknown
37	Highrise residential	unknown	unknown	unknown	unknown

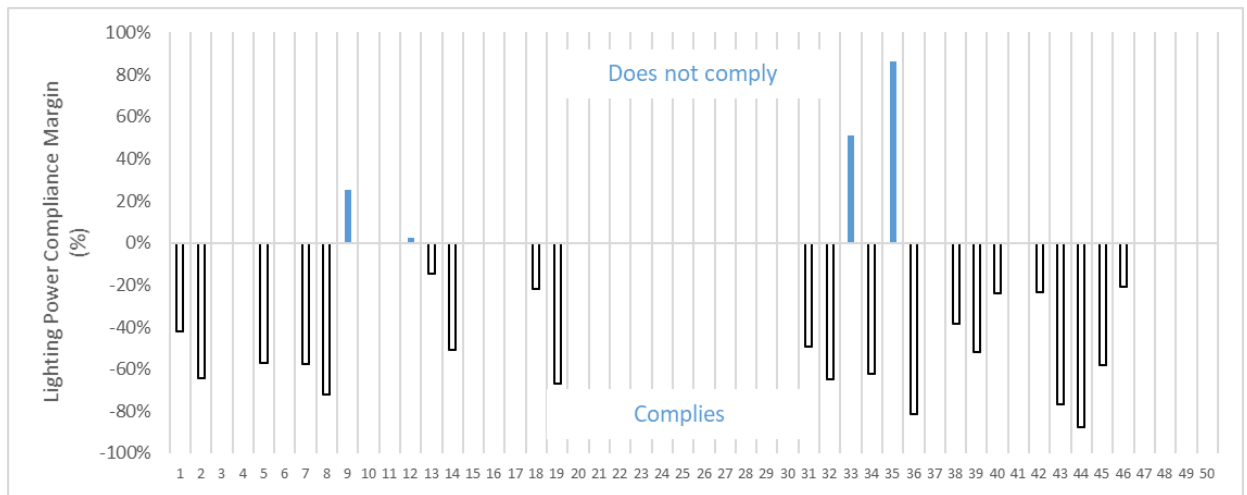


Figure 6. Exterior Lighting Power Compliance Margins

Table 24. Exterior Lighting Power Results Summary

		Complying Projects	Non-Complying Projects	All Projects
Number of Projects (2 unknown, 23 not applicable)		21	4	25
Exterior lighting power (W)	Average	3,819	1,504	3,449
	Median	2,160	1,260	2,120
	Total	80,202	6,015	86,217
Allowed Power (W)	Average	7,475	1,186	6,469
	Median	4,400	735	3,000
	Total	156,968	4,745	161,713
Compliance Margin (W)	Average	-3,656	318	-3,020
	Total	-76,766	1,270	-75,496

This table includes 25 projects because of the 50 total projects there were 23 that did not include exterior lighting and two that were missing information and were not verified.

Exterior Lighting Observations

Most projects are complying with the exterior lighting power limits. However, there are a few observations:

- Installed power is more than 50% lower than the allowance in one-half of the projects with exterior lighting, indicating that most projects do not have problems meeting the requirements.
- Some designers are using medium screw-base fixtures for exterior lighting. Per the code, the installed power for those fixtures must be counted as the maximum rated power for the fixture. In a few projects designers were taking credit for self-ballasted compact fluorescent lamps or screw-in LED lamps.
- Many designers are neglecting to include the luminaire input power in the plans. This information should be included in the luminaire schedule. This is the same problem mentioned earlier for interior lighting luminaires.

- While in some cases the plans show lighting power compliance calculation results, e.g. allowed and installed exterior lighting power, those results are significantly different in some cases than the results obtained from a review of plans performed for this study.

Envelope Results

Roof Insulation

Table 25 lists the designed roof insulation R-value for each project along with the minimum required R-value. The required R-value varies depending on the type of roof construction. For many of the projects the roof insulation requirements are not applicable because they are renovations or tenant improvements within an existing shell.

Unfortunately, in about one-third of the projects the designed R-value for roof insulation is not indicated on the plans and compliance cannot be verified. Of the 29 applicable projects:

- Unknown: 9 of 29 (31%)
(information missing)
- Complies: 17 of 29 (59%)
- Does not comply: 3 of 29 (10%)

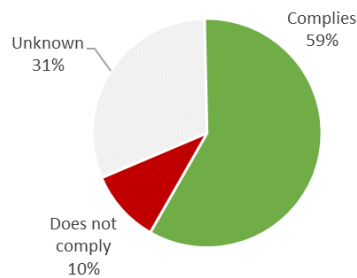


Table 25. Roof Insulation Results by Project

ID	Building Type	Designed Roof Insulation R-value	Required Roof Insulation R-value	Complies?
1	Mixed use, office/retail, warehouse	Missing	R-19+R-10	Unknown
2	Medical office building	Missing	R-15	Unknown
3	Lounge/food service	n/a	n/a	n/a
4	Retail	n/a	n/a	n/a
5	Gymnasium	R-30	R-30	Yes
6	Retail	n/a	n/a	n/a
7	Bank	Missing	R-15	Unknown
8	Gymnasium, Multipurpose	R-19	R-30	No
9	Warehouse	n/a	n/a	n/a
10	Hotel	n/a	n/a	n/a
11	Retail	Missing	R-15	Unknown
12	Warehouse	R-17.5	R-15	Yes
13	Retail	Missing	R-15	Unknown
14	Bank	R-19	R-15	Yes
15	Retail	n/a	n/a	n/a
16	Retail	n/a	n/a	n/a
17	Retail	n/a	n/a	n/a
18	Hotel	Missing	R-30	Unknown
19	High rise residential	Missing	R-30	Unknown
20	Hotel	R-19	R-15	Yes
21	Hotel	n/a	n/a	n/a
22	Hotel	n/a	n/a	n/a
23	Retail	n/a	n/a	n/a
24	Retail	n/a	n/a	n/a
25	Retail	n/a	n/a	n/a
26	Retail	n/a	n/a	n/a
27	Office	n/a	n/a	n/a
28	Office	n/a	n/a	n/a
29	Office	n/a	n/a	n/a
30	Office	n/a	n/a	n/a
31	Bank	R-30	R-30	Yes
32	Office	R-19	R-15	Yes
33	Retail	R-15	R-15	Yes
34	Retail	Missing	R-30	Unknown
35	Retail	R-16	R-15	Yes
36	Retail	R-15	R-15	Yes
37	Highrise residential	R-15	R-15	Yes
38	Educational	R-15	R-15	Yes
39	Library	R-20	R-15	Yes
40	Highrise residential	R-0	R-19	No
41	Residential	Missing	R-30	Unknown
42	Retail	R-18	R-15	Yes
43	Retail	R-30	R-30	Yes
44	Multipurpose	R-30	R-30	Yes
45	Retail and Office	R-30	R-30	Yes
46	Office	R-30	R-30	Yes
47	Bank branch	n/a	n/a	n/a
48	Retail	R-19	R-30	No
49	Outpatient healthcare	n/a	n/a	n/a
50	Restaurant	n/a	n/a	n/a

Wall Insulation

Table 26 lists the designed wall insulation R-value along with the corresponding required R-value. R-13 is required for framed wall constructions and no insulation is required for concrete walls. As was the case for roof insulation, the designed R-value for wall insulation is missing from the plans in several cases. However, the R-value of insulation could be inferred in a few cases from the thickness of the framing cavity. Therefore, wall insulation compliance could be verified for most of the projects. There are no clear cases of noncompliance.

- Unknown: 7 of 28 (25%)
(information missing)
- Complies: 21 of 28 (75%)
- Does not comply: 0 of 28 (0%)

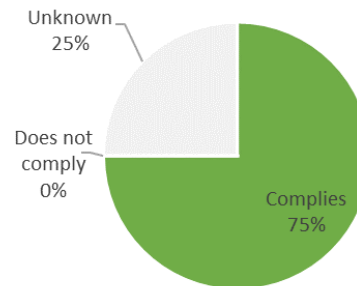


Table 26. Wall Insulation Results by Project

ID	Building Type	Designed Wall Insulation R-value	Required Wall Insulation R-value	Complies?
1	Mixed use, office/retail, warehouse	Missing	R-13	Unknown
2	Medical office building	R-13	R-13	Yes
3	Lounge/food service	n/a	n/a	n/a
4	Retail	n/a	n/a	n/a
5	Gymnasium	R-13	R-13	Yes
6	Retail	n/a	n/a	n/a
7	Bank	Missing	None	Yes
8	Gymnasium, Multipurpose	Missing	R-13	Unknown
9	Warehouse	n/a	n/a	n/a
10	Hotel	n/a	n/a	n/a
11	Retail	R-6	None	Yes
12	Warehouse	R-20	R-13	Yes
13	Retail	R-6	None	Yes
14	Bank	R-13	R-13	Yes
15	Retail	n/a	n/a	n/a
16	Retail	n/a	n/a	n/a
17	Retail	n/a	n/a	n/a
18	Hotel	R-13+R-10	R-13	Yes
19	High rise residential	R-13+R-6	R-13	Yes
20	Hotel	None	None	Yes
21	Hotel	n/a	n/a	n/a
22	Hotel	n/a	n/a	n/a
23	Retail	n/a	n/a	n/a
24	Retail	n/a	n/a	n/a
25	Retail	n/a	n/a	n/a
26	Retail	n/a	n/a	n/a
27	Office	n/a	n/a	n/a
28	Office	n/a	n/a	n/a
29	Office	n/a	n/a	n/a
30	Office	n/a	n/a	n/a
31	Bank	Missing	R-0	Yes
32	Office	R-13+R-5	R-13	Yes
33	Retail	Missing	R-13	Unknown
34	Retail	Missing	R-13	Unknown
35	Retail	R-19	R-13	Yes
36	Retail	Missing	R-0	Yes
37	Highrise residential	R-0	R-0	Yes
38	Educational	Missing	R-0 & R-13	Unknown
39	Library	R-13	R-0	Yes
40	Highrise residential	R-0	R-0	Yes
41	Residential	Missing	R-13	Unknown
42	Retail	R-15	R-0	Yes
43	Retail	Missing	R-13	Unknown
44	Multipurpose	R-13	R-13	Yes
45	Retail and Office	R-19	R-13	Yes
46	Office	n/a	n/a	n/a
47	Bank branch	n/a	n/a	n/a
48	Retail	R-19	R-13	Yes
49	Outpatient healthcare	n/a	n/a	n/a
50	Restaurant	n/a	n/a	n/a

Fenestration

Table 27 shows the designed solar heat gain coefficient (SHGC) for each project along with the corresponding maximum SHGC allowed by code based on the size of the overhangs in the specific project. The primary code requirement for windows is a maximum limit on SHGC. The SHGC limit increases if a window is shaded by an overhang. The allowed maximum varies from 0.25 to 0.40. Window U-factor is not reported here because the 2006 IECC allows single-pane glazing and all windows will meet that requirement.

The designed SHGC was indicated on the plans in only 4 of the 31 applicable projects. In another 4 of the 25 the SHGC could be inferred from glazing descriptions on the plans. Therefore, window compliance could not be verified for 23 of the 31 projects. In one project a note on the plans referred to a separate report for window performance information, but that report was not part of the permit submittal. It is likely that in some cases there is a separate set of specifications that includes the designer's window performance requirements, but those specifications have not been provided to the building department.

In the eight cases where SHGC information was available, two comply and in the others, most of the windows comply except for a few that have smaller overhangs.

- Unknown: 23 of 31 (74%)
(information missing)
- Complies: 2 of 31 (7%)
- Partial compliance: 2 of 31 (6%)
- Does not comply: 4 of 31 (13%)

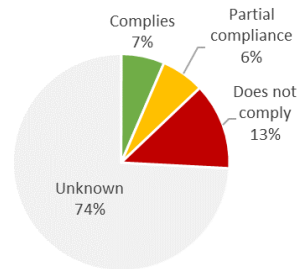


Table 27. Window SHGC Results by Project

ID	Building Type	Designed Window SHGC	Required Max. Window SHGC	Complies?
1	Mixed use, office/retail, warehouse	Missing	0.4	Unknown
2	Medical office building	0.27	0.33	Yes
3	Lounge/food service	n/a	n/a	n/a
4	Retail	Missing	0.33	Unknown
5	Gymnasium	0.3	0.25-0.40	Partial
6	Retail	n/a	n/a	n/a
7	Bank	Missing	0.33	Unknown
8	Gymnasium, Multipurpose	Missing	0.4	Unknown
9	Warehouse	n/a	n/a	n/a
10	Hotel	n/a	n/a	n/a
11	Retail	Missing	0.33	Unknown
12	Warehouse	Missing	0.25	Unknown
13	Retail	Missing	0.4	Unknown
14	Bank	Missing	0.25-0.40	Unknown
15	Retail	n/a	n/a	n/a
16	Retail	n/a	n/a	n/a
17	Retail	n/a	n/a	n/a
18	Hotel	Missing	0.25-0.33	Unknown
19	High rise residential	Missing	0.4	Unknown
20	Hotel	Missing	0.4	Unknown
21	Hotel	n/a	n/a	n/a
22	Hotel	n/a	n/a	n/a
23	Retail	0.82	0.4	No
24	Retail	0.82	0.4	No
25	Retail	n/a	n/a	n/a
26	Retail	n/a	n/a	n/a
27	Office	n/a	n/a	n/a
28	Office	n/a	n/a	n/a
29	Office	n/a	n/a	n/a
30	Office	n/a	n/a	n/a
31	Bank	Missing	0.33-0.40	Unknown
32	Office	Missing	0.33-0.40	Unknown
33	Retail	0.4	0.25-0.40	No
34	Retail	0.19 and 0.32	0.25	Partial
35	Retail	Missing	0.33	Unknown
36	Retail	Missing	0.25-0.33	Unknown
37	Highrise residential	Missing	0.25-0.33	Unknown
38	Educational	Missing	0.25-0.33	Unknown
39	Library	Missing	0.25-0.40	Unknown
40	Highrise residential	0.82	0.4	No
41	Residential	Missing	0.25-0.40	Unknown
42	Retail	0.27	0.33	Yes
43	Retail	Missing	0.4	Unknown
44	Multipurpose	Missing	0.33-0.40	Unknown
45	Retail and Office	Missing	0.33	Unknown
46	Office	n/a	n/a	n/a
47	Bank branch	n/a	n/a	n/a
48	Retail	Missing	0.33	Unknown
49	Outpatient healthcare	n/a	n/a	n/a
50	Restaurant	n/a	n/a	n/a

Envelope Observations

The primary issue with envelope compliance is that performance information is missing from the permit submittal in many cases. This problem is most prevalent for window SHGC specifications and roof insulation R-value, but it also applies to wall insulation R-value. As noted earlier, the 2006 IECC states the following requirement for construction documents:

Details shall include, but are not limited to, insulation materials and their R-values; fenestration U-factors and SHGCs; system and equipment efficiencies, types, sizes and controls; duct sealing, insulation and location; and air sealing details. (Section 104.2)

While envelope compliance could not be verified for all cases, there are several useful observations:

- While insulation R-value information was often missing, the actual roof insulation compliance rates are likely good. In most cases the plans indicate that there is some insulation even if the specific R-value and/or insulation thickness is not specified on the plans. For projects with roof insulation above deck it is likely that the minimum requirement of R-15 is met in most cases. It is less clear whether all projects with insulation installed below the roof deck are complying because the requirement is R-30. Two of the reviewed projects indicated R-19 is to be installed, but R-30 was required. It appears that some designers believe that R-19 is the requirement for all roofs, which is not correct for the 2006 IECC. In one case, a high-rise affordable housing project with a concrete roof, no roof insulation was shown on the plans.
- Wall insulation compliance rates appear to be good. In many cases, plans show more wall insulation than required.
- Window SHGC compliance rates are uncertain. It seems likely that some of the “unknown” cases listed above will comply because it is indicated on the plans that dual-pane, low-e will be used. But not all dual-pane, low-e windows will meet the SHGC requirements. And in a few cases single-pane glazing is shown on the plans, and there is a good chance that it would not meet the low SHGC requirements in the code. Therefore, it is likely that there is a moderate fraction of projects that are not meeting the window SHGC requirements.
- Window performance is a good candidate for improved plan review and enforcement. SHGC values for all windows should be required on the plans.

HVAC Results

Cooling Efficiency

Compliance with the cooling efficiency requirements of the code was generally good. Table 28 shows that of the 39 applicable projects 11 were missing efficiency specifications on the plans, and it is likely that in those cases the equipment would meet the code's requirements as well. National manufacturers build equipment to meet more recent requirements. Therefore, most of the cooling equipment available on the market will meet the minimum requirements in the 2006 IECC.

The one case of non-compliance was a small retail store in a shopping mall with a new water-source heat pump. The efficiency was not listed on the plans, but a manufacturer's brochure for the specified unit showed efficiency of EER 11.2, while the requirement is 12.0. In the one case of partial compliance, efficiency was provided for chillers but was missing for packaged cooling units.

- Unknown: 11 of 39 (28%)
(information missing)
- Complies: 26 of 39 (67%)
- Partial compliance: 1 of 39 (3%)
- Does not comply: 1 of 39 (3%)

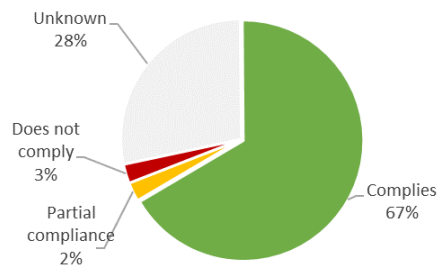


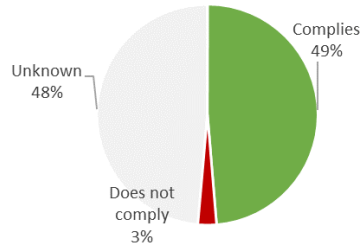
Table 28. Cooling Efficiency Results by Project

ID	Building Type	Designed Cooling Efficiency	Required Cooling Efficiency	Complies?
1	Mixed use, office/retail, warehouse	n/a	n/a	n/a
2	Medical office building	EER 10.3 & 12.1	EER 9.2 & 9.7	Yes
3	Lounge/food service	n/a	n/a	n/a
4	Retail	EER 11.5	EER 10.3	Yes
5	Gymnasium	n/a	n/a	n/a
6	Retail	Missing	EER 10.3	Unknown
7	Bank	Missing	EER 10.3	Unknown
8	Gymnasium, Multipurpose	EER 11.0	EER 9.5	Yes
9	Warehouse	n/a	n/a	n/a
10	Hotel	SEER 16.7	SEER 10.0	Yes
11	Retail	EER 11.4 to 12.4	EER 9.5-10.3	Yes
12	Warehouse	EER 11, 12.3, 12.7	EER 9.7-10.3	Yes
13	Retail	Missing	EER 9.7-10.3	Unknown
14	Bank	EER 11.2 & 12.0	EER 9.7	Yes
15	Retail	n/a	n/a	n/a
16	Retail	SEER 13.0	SEER 10.0	Yes
17	Retail	EER 11.0 & 11.2	EER 10.3	Yes
18	Hotel	EER 12.0-12.7	EER 9.3-10.3	Yes
19	High rise residential	0.673 kW/ton	0.79 kW/ton	Yes
20	Hotel	0.65 kW/ton	0.72 kW/ton	Partial
21	Hotel	n/a	n/a	n/a
22	Hotel	n/a	n/a	n/a
23	Retail	n/a	n/a	n/a
24	Retail	11.2 EER	12.0 EER	No
25	Retail	1.12 kW/ton	1.26 kW/ton	Yes
26	Retail	n/a	n/a	n/a
27	Office	n/a	n/a	n/a
28	Office	Missing	9.7 SEER	Unknown
29	Office	Missing	9.7 EER	Unknown
30	Office	10.0 EER	9.7 SEER	Yes
31	Bank	11.2 and 11.0 EER	10.2 and 9.7 EER	Yes
32	Office	12.2, 11.5, and 10.4 EER	10.3, 9.7, and 9.5 EER	Yes
33	Retail	12 EER	10.3 EER	Yes
34	Retail	15.2 SEER	13.0 SEER	Yes
35	Retail	11.0 EER	10.3 EER	Yes
36	Retail	Missing	9.5 EER	Unknown
37	Highrise residential	Missing	WSHP: 11.2 EER. AC: 11.0 EER.	Unknown
38	Educational	n/a	n/a	n/a
39	Library	2.84 COP	2.8 COP	Yes
40	Highrise residential	9.7 EER	9.3 EER	Yes
41	Residential	12.0, 16.5, & 19.1 EER	11.2 & 12.0 EER	Yes
42	Retail	SEER 17+, EER 12+	10.0 SEER, 9.7 EER	Yes
43	Retail	Missing	10 SEER	Unknown
44	Multipurpose	13 SEER	10 SEER	Yes
45	Retail and Office	11.0 EER	10 SEER	Yes
46	Office	Missing	9.7 EER	Unknown
47	Bank branch	Missing	10 SEER	Unknown
48	Retail	17.0 SEER, 12.0 EER	10 SEER, 9.7 EER	Yes
49	Outpatient healthcare	12.8, 13.2, 13.6 EER	12.0 EER	Yes
50	Restaurant	Missing	10 SEER	Unknown

HVAC Insulation

The required duct insulation was often not indicated on the plans. In only one case did the specified insulation not meet the code-required R-value. The code requires R-5 insulation for ducts in unconditioned spaces and R-8 insulation for ducts located outdoors.

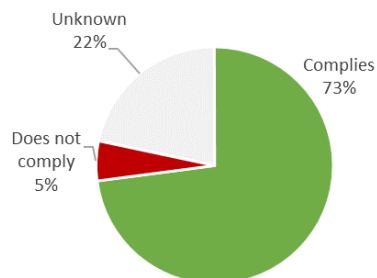
- Unknown: 18 of 37 (49%)
(Information missing)
- Complies: 18 of 37 (48%)
- Does not comply: 1 of 37 (3%)



HVAC Controls

Of the HVAC requirements grouped into the category “HVAC Other” in the earlier compliance-level tables, the most commonly applicable requirement is off-hour controls. The code requires, at a minimum, automatic off-hour controls such as a programmable thermostat. Twenty-two percent of projects did not include HVAC control information. However most of those projects are likely to have complying controls because time-clock controls are relatively standard practice. Only 2 projects were clearly not complying. One has only manual on/off control of the HVAC system, and the other has window air conditioners that do not have setback control capability.

- Unknown: 8 of 37 (22%)
(Information missing)
- Complies: 27 of 37 (73%)
- Does not comply: 2 of 37 (5%)



Energy Recovery

Two projects did not comply with the code’s energy recovery requirement. The energy recovery requirements apply to large air handlers (>5,000 cfm) with a high outdoor airflow requirement (>70%). This requirement applies to only three of the 50 reviewed projects. One of those projects complied by employing a “wrap-around” heat pipe for energy recovery. However, the other two projects did not show any form of heat recovery and therefore are not in compliance.

Heat Recovery for Water Heating

This requirement applies to projects with both large cooling systems and large hot water demand, such as a hotel or a high-rise residential building. The requirement applies to only 2 of the 50 reviewed projects, and both of those projects meet the requirements. One does so by using solar water heating, which is a permitted exception to the heat recovery requirement. The other uses heat pump water heaters to recovery heat from the cooling tower water to use for domestic hot water and pool heating.

HVAC Commissioning

HVAC commissioning notes were missing from the plans in every case except for four. Three of those cases were in Kauai, where the building department emphasizes the commissioning requirement. As noted earlier, each County's adopted 2006 IECC amendments require that a commissioning plan be developed for the HVAC system and that "drawing notes shall require commissioning and completion requirements...". It appears that designers are not aware of this requirement. The complying projects mentioned commissioning in a note on the plans.

HVAC Adjusting and Balancing

HVAC system adjusting and balancing requirements were also missing in about one-half of the reviewed projects. There is also low awareness of this requirement.

HVAC Observations

Compliance with the HVAC requirements is generally good. However, performance information was missing from the submittals in some cases. Areas for improvement include the following:

- Include cooling efficiency specifications on the plan in all cases.
- Indicate duct insulation on the plans.
- Indicate HVAC controls on the plans.
- Include commissioning requirements note on the plans.
- Include system adjusting and balancing requirements note on the plans.

Water Heating Results

For water-heating systems, as for the HVAC systems discussed above, compliance appeared to be generally good except that performance specifications were often missing from the plans.

The majority of systems are electric water heaters that are likely to meet the efficiency requirements for those systems, but the efficiency ratings were missing in every case. Nine of the projects included gas water heaters and those cases were also missing rated efficiency for the selected water heaters in most cases. Again, it is likely that they meet the minimum efficiency requirements in the code.

Hot water pipe insulation information is missing from 14 of the 27 applicable projects (52%).

Controls for hot water circulation systems are missing from 9 of 13 applicable projects (69%).

Compliance Review Results – Low-rise Residential

Summary of Reviewed Projects

The following tables provides an overview of the projects reviewed for each county.

Table 29. List of Projects– Hawaii County

ID	Building type	County	Construction phase	Plan date	Stories	Floor area
1	Single Family	Hawaii	New	May-15	2	2,290
2	Single Family	Hawaii	New	Mar-16	2	1,600
3	Single Family	Hawaii	Renovation	Jul-16	2	1,827
4	Single Family	Hawaii	Renovation	Mar-16	2	2,292
5	Duplex	Hawaii	New	Mar-16	2	2,242
6	Single Family	Hawaii	New	Apr-17	1	1,665
7	Single Family	Hawaii	New	Apr-15	2	2,332
8	Single Family	Hawaii	New	Jan-17	1	3,407
9	Single Family	Hawaii	New	Jan-17	2	2,404
10	Single Family	Hawaii	New	Jun-15	2	2,105
11	Single Family	Hawaii	New	Mar-17	1	1,536
12	Single Family	Hawaii	New	Jan-17	1	2,786
13	Single Family	Hawaii	New	Jun-17	2	3,422
14	Single Family	Hawaii	New	Mar-17	2	2,186
15	Single Family	Hawaii	New	Jun-17	1	2,381
16	Single Family	Hawaii	New	Apr-17	1	2,496
17	Single Family	Hawaii	New	Jun-17	1	1,614
18	Single Family	Hawaii	New	Aug-16	2	2,341
Total						40,926
Average						2,274
Median						2,291

Table 30. List of Projects – Maui County

ID	Building type	County	Construction phase	Plan date	Stories	Floor area
19	Single Family	Maui	New	Apr-17	2	3,665
20	Single Family	Maui	New	Nov-16	2	3,869
21	Single Family	Maui	New	Nov-16	1	2,850
22	Single Family	Maui	New	Jun-17	2	2,421
23	Single Family	Maui	New	Sep-17	1	2,324
24	Single Family	Maui	New	Mar-17	1	1,170
25	Single Family	Maui	New	Apr-17	1	5,778
26	Single Family	Maui	New	Dec-16	2	3,541
27	Multi Family	Maui	New	Oct-17	3	1,035
28	Multi Family	Maui	New	May-16	3	1,350
29	Multi Family	Maui	New	Jan-16	2	776
30	Multi Family	Maui	New	Mar-17	2	1,111
31	Multi Family	Maui	New	May-17	2	1,125
32	Multi Family	Maui	New	Aug-17	2	2,199
33	Multi Family	Maui	New	Aug-17	2	2,199
Total						35,413
Average						2,361
Median						2,199

Table 31. List of Projects – Honolulu County

ID	Building type	County	Construction phase	Plan date	Stories	Floor area
34	Single Family	Honolulu	New	Apr-15	3	5,081
35	Single Family	Honolulu	New	Aug-15	3	2,213
36	Single Family	Honolulu	Renovation	Jul-15	1	1,095
37	Single Family	Honolulu	Renovation	Oct-15	2	1,505
38	Single Family	Honolulu	New	Feb-15	1	2,083
39	Single Family	Honolulu	Renovation	Aug-15	1	1,800
40	Multi Family	Honolulu	New	Feb-15	2	5,227
41	Multi Family	Honolulu	Renovation	Jun-15	2	2,829
42	Multi Family	Honolulu	Renovation	Aug-15	2	5,015
43	Apartment houses	Honolulu	Renovation	Jan-15	2	NA
44	Single Family	Honolulu	New	May-17	2	2,925
45	Multi Family	Honolulu	Renovation	May-17	1	2,369
46	Single Family	Honolulu	Renovation	Mar-17	2	2,974
47	Single Family	Honolulu	Renovation	Dec-16	1	2,179
48	Multi Family	Honolulu	New	Dec-16	2	5,789
49	Multi Family	Honolulu	Renovation	Nov-16	2	5,517
50	Multi Family	Honolulu	Renovation	Oct-16	1	792
51	Multi Family	Honolulu	Renovation	Jun-16	2	2,892
52	Single Family	Honolulu	Renovation	May-16	2	3,624
53	Single Family	Honolulu	Renovation	Mar-16	2	2,270
54	Single Family	Honolulu	Renovation	Jan-16	2	2,760
55	Multi Family	Honolulu	Renovation	Jan-16	2	2,010
56	Single Family	Honolulu	Renovation	Oct-15	2	3,968
57	Single Family	Honolulu	New	Mar-16	1	2,171
58	Multi Family	Honolulu	Renovation	Jan-17	1	1,179
59	Multi Family	Honolulu	New	Apr-16	3	5,730
60	Multi Family	Honolulu	New	Sep-16	2	4,438
61	Multi Family	Honolulu	Renovation	Feb-17	2	3,416
62	Single Family	Honolulu	Renovation	Jun-16	2	5,169
63	Multi Family	Honolulu	New	Apr-16	2	4,377
64	Single Family	Honolulu	Renovation	Feb-16	3	4,296
65	Single Family	Honolulu	Renovation	Nov-15	1	1,904
66	Multi Family	Honolulu	Renovation	May-17	2	3,416
67	Multi Family	Honolulu	Renovation	Oct-16	2	3,629
68	Single Family	Honolulu	Renovation	Sep-17	2	3,219
69	Single Family	Honolulu	Renovation	Jan-17	2	3,225
70	Single Family	Honolulu	Renovation	Dec-15	2	2,448
71	Single Family	Honolulu	Renovation	Jan-16	2	2,978
72	Apartment	Honolulu	Renovation	N/A	3	N/A
					Total	118,512
					Average	3,203
					Median	2,974

Table 32. List of Projects – Kauai County

ID	Building type	County	Construction phase	Plan date	Stories	Floor area
73	Multifamily	Kauai	New	Apr-14	2	1,047
74	Duplex	Kauai	New	Jun-14	2	1,945
75	Single Family	Kauai	New	Jun-14	2	2,967
76	Single Family	Kauai	New	Jul-14	2	3,150
77	Single Family	Kauai	New	Aug-14	2	2,733
78	Single Family	Kauai	New	Jan-15	2	2,723
79	Multifamily	Kauai	New	Jul-15	3	814
80	Single Family	Kauai	New	Jul-15	2	5,868
81	Single Family	Kauai	New	Feb-15	2	2,080
82	Duplex	Kauai	New	Jul-15	1	1,257
83	Single Family	Kauai	New	Apr-16	1	2,028
84	Single Family	Kauai	New	May-16	1	1,820
85	Single Family	Kauai	New	Nov-16	1	2,160
86	Single Family	Kauai	New	Mar-17	1	1,404
87	Single Family	Kauai	New	Feb-17	1	1,404
88	Single Family	Kauai	New	Mar-17	1	2,060
89	Single Family	Kauai	New	Mar-17	2	2,060
90	Duplex	Kauai	New	Apr-17	2	3,853
91	Single Family	Kauai	New	Apr-17	2	2,826
92	Duplex	Kauai	New	May-17	2	3,874
93	Single Family	Kauai	New	May-17	2	3,066
94	Single Family	Kauai	New	Jun-17	1	1,755
					Total	52,894
					Average	2,404
					Median	2,070

Summary of Compliance Level Results vs 2006 IECC

The following set of tables summarizes the level of compliance using the categories described earlier that indicate whether the project exceeds the code, meets the code, or does not comply with the code. In cases where information is missing from the plans, such as missing window SHGC, a non-compliance level was assigned based on subjective assessment. These summaries are presented in three ways: 1) a count of projects at each compliance level, 2) the percentage of projects at each compliance level, and 3) the compliance level results for each of the reviewed projects. Please see the following sections for discussion of compliance findings. This section covers compliance vs. the 2006 IECC. A following section covers compliance for the same projects vs. the 2015 IECC.

Hawaii County

Table 33. Number of Projects at Each Compliance Level vs. 2006 IECC – Hawaii County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Envelope - roof	0	2	0	0	16	0
Envelope - wall	1	2	0	0	15	0
Envelope - windows	0	0	0	0	18	0
Envelope - skylights	0	0	0	0	0	18
HVAC - efficiency	1	0	0	0	0	17
HVAC - insulation	0	1	0	0	0	17
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	18	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	18
Air Leakage - Swinging Doors	0	0	0	18	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	18

Table 34. Percent of Projects at Each Compliance Level vs. 2006 IECC – Hawaii County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non- compliance	Moderate non- compliance	Major non- compliance
Envelope - roof	18	0%	11%	0%	0%	89%
Envelope - wall	18	6%	11%	0%	0%	83%
Envelope - windows	18	0%	0%	0%	0%	100%
Envelope - skylights	0					
HVAC - efficiency	1	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Air Leakage - Windows/Skylights/Sliding Door	18	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	18	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 35. Compliance Level by Project vs. 2006 IECC – Hawaii County

ID	Building Type	County	Phase	Floor Area (ft ²)	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
1	Residential - Single Family	Hawaii	New	2,290	4	4	4	0	0	0	3	0	3	0
2	Residential - Single Family	Hawaii	New	1,600	4	1	4	0	0	0	3	0	3	0
3	Residential - Single Family	Hawaii	Renovation	1,827	4	4	4	0	0	0	3	0	3	0
4	Residential - Single Family	Hawaii	Renovation	2,292	4	4	4	0	0	0	3	0	3	0
5	Residential - Duplex	Hawaii	New	2,242	4	4	4	0	0	0	3	0	3	0
6	Residential - Single Family	Hawaii	New	1,665	4	4	4	0	0	0	3	0	3	0
7	Residential - Single Family	Hawaii	New	2,332	4	4	4	0	0	0	3	0	3	0
8	Residential - Single Family	Hawaii	New	3,407	4	4	4	0	0	0	3	0	3	0
9	Residential - Single Family	Hawaii	New	2,404	4	4	4	0	0	0	3	0	3	0
10	Residential - Single Family	Hawaii	New	2,105	1	-1	4	0	0	0	3	0	3	0
11	Residential - Single Family	Hawaii	New	1,536	4	4	4	0	0	0	3	0	3	0
12	Residential - Single Family	Hawaii	New	2,786	4	4	4	0	0	0	3	0	3	0
13	Residential - Single Family	Hawaii	New	3,422	4	4	4	0	0	0	3	0	3	0
14	Residential - Single Family	Hawaii	New	2,186	4	4	4	0	0	0	3	0	3	0
15	Residential - Single Family	Hawaii	New	2,381	4	4	4	0	0	0	3	0	3	0
16	Residential - Single Family	Hawaii	New	2,496	4	4	4	0	0	0	3	0	3	0
17	Residential - Single Family	Hawaii	New	1,614	4	4	4	0	0	0	3	0	3	0
18	Residential - Single Family	Hawaii	New	2,341	1	1	4	0	-1	1	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance.
Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Maui County

Table 36. Number of Projects at Each Compliance Level vs. 2006 IECC – Maui County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Envelope - roof	0	15	0	0	0	0
Envelope - wall	0	15	0	0	0	0
Envelope - windows	0	7	0	0	8	0
Envelope - skylights	0	0	0	0	0	15
HVAC - efficiency	3	0	0	0	0	12
HVAC - insulation	0	1	0	0	0	14
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	15	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	15
Air Leakage - Swinging Doors	0	0	0	15	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	15

Table 37. Percent of Projects at Each Compliance Level vs. 2006 IECC – Maui County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Envelope - roof	15	0%	100%	0%	0%	0%
Envelope - wall	15	0%	100%	0%	0%	0%
Envelope - windows	15	0%	47%	0%	0%	53%
Envelope - skylights	0					
HVAC - efficiency	3	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Air Leakage - Windows/Skylights/Sliding Door	15	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	15	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 38. Compliance Level by Project vs. 2006 IECC – Maui County

ID	Building Type	County	Phase	Floor Area (ft ²)	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
19	Residential - Single Family	Maui	New	3,665	1	1	1	0	0	0	3	0	3	0
20	Residential - Single Family	Maui	New	3,869	1	1	4	0	0	0	3	0	3	0
21	Residential - Single Family	Maui	New	2,850	1	1	1	0	0	0	3	0	3	0
22	Residential - Single Family	Maui	New	2,421	1	1	4	0	0	0	3	0	3	0
23	Residential - Single Family	Maui	New	2,324	1	1	4	0	0	0	3	0	3	0
24	Residential - Single Family	Maui	New	1,170	1	1	4	0	0	0	3	0	3	0
25	Residential - Single Family	Maui	New	5,778	1	1	4	0	0	0	3	0	3	0
26	Residential - Single Family	Maui	New	3,541	1	1	4	0	-1	1	3	0	3	0
27	Residential - Multi Family	Maui	New	1,035	1	1	1	0	-1	0	3	0	3	0
28	Residential - Multi Family	Maui	New	1,350	1	1	4	0	-1	0	3	0	3	0
29	Residential - Multi Family	Maui	New	776	1	1	4	0	0	0	3	0	3	0
30	Residential - Multi Family	Maui	New	1,111	1	1	1	0	0	0	3	0	3	0
31	Residential - Multi Family	Maui	New	1,125	1	1	1	0	0	0	3	0	3	0
32	Residential - Multi Family	Maui	New	2,199	1	1	1	0	0	0	3	0	3	0
33	Residential - Multi Family	Maui	New	2,199	1	1	1	0	0	0	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Honolulu County

Table 39. Number of Projects at Each Compliance Level vs. 2006 IECC – Honolulu County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Envelope - roof	0	38	0	0	1	0
Envelope - wall	1	36	0	0	2	0
Envelope - windows	0	2	0	0	37	0
Envelope - skylights	0	0	0	0	0	39
HVAC - efficiency	1	0	0	0	0	38
HVAC - insulation	0	1	0	0	0	38
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	39	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	39
Air Leakage - Swinging Doors	0	0	0	39	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	39

Table 40. Percent of Projects at Each Compliance Level vs. 2006 IECC – Honolulu County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Envelope - roof	39	0%	97%	0%	0%	3%
Envelope - wall	39	3%	92%	0%	0%	5%
Envelope - windows	39	0%	5%	0%	0%	95%
Envelope - skylights	0					
HVAC - efficiency	1	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Air Leakage - Windows/Skylights/Sliding Door	39	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	39	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 41. Compliance Level by Project vs. 2006 IECC – Honolulu County

ID	Building Type	County	Phase	Floor Area (ft2)	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
34	Residential - Single Family	Honolulu	New	5,081	1	1	4	0	-1	1	3	0	3	0
35	Residential - Single Family	Honolulu	New	2,213	1	1	4	0	0	0	3	0	3	0
36	Residential - Single Family	Honolulu	Renovation	1,095	1	1	4	0	0	0	3	0	3	0
37	Residential - Single Family	Honolulu	Renovation	1,505	1	1	4	0	0	0	3	0	3	0
38	Residential - Single Family	Honolulu	New	2,083	1	1	4	0	0	0	3	0	3	0
39	Residential - Single Family	Honolulu	Renovation	1,800	1	1	4	0	0	0	3	0	3	0
40	Residential - Multi Family	Honolulu	New	5,227	1	1	4	0	0	0	3	0	3	0
41	Residential - Multi Family	Honolulu	Renovation	2,829	1	1	4	0	0	0	3	0	3	0
42	Residential - Multi Family	Honolulu	Renovation	5,015	1	1	1	0	0	0	3	0	3	0
43	Apartment houses	Honolulu	Renovation	NA	1	1	4	0	0	0	3	0	3	0
44	Residential - Single Family	Honolulu	New	2,925	4	4	4	0	0	0	3	0	3	0
45	Residential - Multi Family	Honolulu	Renovation	2,369	1	1	4	0	0	0	3	0	3	0
46	Residential - Single Family	Honolulu	Renovation	2,974	1	1	4	0	0	0	3	0	3	0
47	Residential - Single Family	Honolulu	Renovation	2,179	1	1	4	0	0	0	3	0	3	0
48	Residential - Multi Family	Honolulu	New	5,789	1	1	4	0	0	0	3	0	3	0
49	Residential - Multi Family	Honolulu	Renovation	5,517	1	1	4	0	0	0	3	0	3	0
50	Residential - Multi Family	Honolulu	Renovation	792	1	1	4	0	0	0	3	0	3	0
51	Residential - Multi Family	Honolulu	Renovation	2,892	1	1	4	0	0	0	3	0	3	0
52	Residential - Single Family	Honolulu	Renovation	3,624	1	1	4	0	0	0	3	0	3	0
53	Residential - Single Family	Honolulu	Renovation	2,270	1	1	4	0	0	0	3	0	3	0
54	Residential - Single Family	Honolulu	Renovation	2,760	1	1	4	0	0	0	3	0	3	0
55	Residential - Multi Family	Honolulu	Renovation	2,010	1	1	4	0	0	0	3	0	3	0
56	Residential - Single Family	Honolulu	Renovation	3,968	1	1	1	0	0	0	3	0	3	0
57	Residential - Single Family	Honolulu	New	2,171	1	-1	4	0	0	0	3	0	3	0
58	Residential - Multi Family	Honolulu	Renovation	1,179	1	1	4	0	0	0	3	0	3	0
59	Residential - Multi Family	Honolulu	New	5,730	1	1	4	0	0	0	3	0	3	0
60	Residential - Multi Family	Honolulu	New	4,438	1	1	4	0	0	0	3	0	3	0
61	Residential - Multi Family	Honolulu	Renovation	3,416	1	1	4	0	0	0	3	0	3	0
62	Residential - Single Family	Honolulu	Renovation	5,169	1	1	4	0	0	0	3	0	3	0
63	Residential - Multi Family	Honolulu	New	4,377	1	1	4	0	0	0	3	0	3	0
64	Residential - Single Family	Honolulu	Renovation	4,296	1	1	4	0	0	0	3	0	3	0
65	Residential - Single Family	Honolulu	Renovation	1,904	1	1	4	0	0	0	3	0	3	0
66	Residential - Multi Family	Honolulu	Renovation	3,416	1	1	4	0	0	0	3	0	3	0
67	Residential - Multi Family	Honolulu	Renovation	3,629	1	1	4	0	0	0	3	0	3	0
68	Residential - Single Family	Honolulu	Renovation	3,219	1	1	4	0	0	0	3	0	3	0
69	Residential - Single Family	Honolulu	Renovation	3,225	1	1	4	0	0	0	3	0	3	0
70	Residential - Single Family	Honolulu	Renovation	2,448	1	1	4	0	0	0	3	0	3	0
71	Residential - Single Family	Honolulu	Renovation	2,978	1	1	4	0	0	0	3	0	3	0
72	Apartment	Honolulu	Renovation	N/A	1	4	4	0	0	0	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Kauai County

Table 42. Number of Projects at Each Compliance Level vs. 2006 IECC – Kauai County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	0	0	0	22	0	0
Envelope - roof	0	14	0	0	8	0
Envelope - wall	0	14	0	0	8	0
Envelope - windows	0	10	0	0	12	0
Envelope - skylights	0	0	0	0	0	22
HVAC - efficiency	0	0	0	0	0	22
HVAC - insulation	0	0	0	0	0	22
Air Leakage - Overall Dwelling Unit	0	0	0	22	0	0
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	22	0	0
Air Leakage - Jalousie Windows	0	0	0	5	0	16
Air Leakage - Swinging Doors	0	0	0	22	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	22

Table 43. Percent of Projects at Each Compliance Level vs. 2006 IECC – Kauai County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	22	0%	0%	0%	100%	0%
Envelope - roof	22	0%	64%	0%	0%	36%
Envelope - wall	22	0%	64%	0%	0%	36%
Envelope - windows	22	0%	45%	0%	0%	55%
Envelope - skylights	0					
HVAC - efficiency	0					
HVAC - insulation	0					
Air Leakage - Overall Dwelling Unit	22	0%	0%	0%	100%	0%
Air Leakage - Windows/Skylights/Sliding Door	22	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	5	0%	0%	0%	100%	0%
Air Leakage - Swinging Doors	22	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 44. Compliance Level by Project vs. 2006 IECC – Kauai County

ID	Building Type	County	Phase	Floor Area (ft2)	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
73	Residential - Multifamily	Kauai	New	1,047	1	1	1	0	0	0	3	3	3	0
74	Residential - Duplex	Kauai	New	1,945	1	1	4	0	0	0	3	3	3	0
75	Residential - Single Family	Kauai	New	2,967	4	4	4	0	0	0	3	0	3	0
76	Residential - Single Family	Kauai	New	3,150	1	1	1	0	0	0	3	0	3	0
77	Residential - Single Family	Kauai	New	2,733	1	1	4	0	0	0	3	0	3	0
78	Residential - Single Family	Kauai	New	2,723	1	1	1	0	0	0	3	0	3	0
79	Residential - Multifamily	Kauai	New	814	1	1	4	0	0	0	3	3	3	0
80	Residential - Single Family	Kauai	New	5,868	4	4	4	0	0	0	3	3	3	0
81	Residential - Single Family	Kauai	New	2,080	4	4	4	0	0	0	3	0	3	0
82	Residential - Duplex	Kauai	New	1,257	1	1	4	0	0	0	3	0	3	0
83	Residential - Single Family	Kauai	New	2,028	1	1	1	0	0	0	3		3	0
84	Residential - Single Family	Kauai	New	1,820	1	1	4	0	0	0	3	3	3	0
85	Residential - Single Family	Kauai	New	2,160	4	4	4	0	0	0	3	0	3	0
86	Residential - Single Family	Kauai	New	1,404	4	4	1	0	0	0	3	0	3	0
87	Residential - Single Family	Kauai	New	1,404	4	4	1	0	0	0	3	0	3	0
88	Residential - Single Family	Kauai	New	2,060	4	4	4	0	0	0	3	0	3	0
89	Residential - Single Family	Kauai	New	2,060	1	1	1	0	0	0	3	0	3	0
90	Residential - Duplex	Kauai	New	3,853	1	1	1	0	0	0	3	0	3	0
91	Residential - Single Family	Kauai	New	2,826	4	4	4	0	0	0	3	0	3	0
92	Residential - Duplex	Kauai	New	3,874	1	1	1	0	0	0	3	0	3	0
93	Residential - Single Family	Kauai	New	3,066	1	1	4	0	0	0	3	0	3	0
94	Residential - Single Family	Kauai	New	1,755	1	1	1	0	0	0	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Summary of Compliance Level Results vs 2015 IECC

This section covers compliance levels vs. the 2015 IECC for the same projects that were covered in the previous section for 2006 IECC compliance. Each project was evaluated vs. both versions of the code. In cases where information is missing from the plans, such as missing window SHGC, a non-compliance level was assigned based on subjective assessment. The following set of tables summarize the level of compliance using the categories described earlier that indicate whether the project exceeds the code, meets the code, or does not comply with the code. These summaries are presented in three ways: 1) a count of projects at each compliance level, 2) the percentage of projects at each compliance level, and 3) the compliance level results for each of the reviewed projects. Please see the following sections for discussion of compliance findings.

Hawaii County

Table 45. Number of Projects at Each Compliance Level vs. 2015 IECC – Hawaii County

Code Requirement	Exceeds Code	Meets Code	Minor non- compliance	Moderate non- compliance	Major non- compliance	Not Applicable
Lighting power - interior	0	0	0	18	0	0
Envelope - roof	0	2	0	0	16	0
Envelope - wall	1	2	0	0	15	0
Envelope - windows	0	0	0	0	18	0
Envelope - skylights	0	0	0	0	0	18
HVAC - efficiency	1	0	0	0	0	17
HVAC - insulation	0	1	0	0	0	17
Ceiling Fans	0	8	10	0	0	0
Solar Hot Water	0	7	0	0	9	2
Air Leakage - Overall Dwelling Unit	0	0	0	18	0	0
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	18	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	18
Air Leakage - Swinging Doors	0	0	0	18	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	18

Table 46. Percent of Projects at Each Compliance Level vs. 2015 IECC – Hawaii County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non- compliance	Moderate non- compliance	Major non- compliance
Lighting power - interior	18	0%	0%	0%	100%	0%
Envelope - roof	18	0%	11%	0%	0%	89%
Envelope - wall	18	6%	11%	0%	0%	83%
Envelope - windows	18	0%	0%	0%	0%	100%
Envelope - skylights	0					
HVAC - efficiency	1	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Ceiling Fans	18	0%	44%	56%	0%	0%
Solar Hot Water	16	0%	44%	0%	0%	56%
Air Leakage - Overall Dwelling Unit	18	0%	0%	0%	100%	0%
Air Leakage - Windows/Skylights/Sliding Door	18	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	18	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 47. Compliance Level by Project vs. 2015 IECC – Hawaii County

ID	Building Type	County	Phase	Floor Area (ft ²)	Lighting power - interior	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Ceiling Fans	Solar Hot Water	Air Leakage - Overall	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
1	Residential - Single Family	Hawaii	New	2,290	3	4	4	4	0	0	0	2	1	3	3	0	3	0
2	Residential - Single Family	Hawaii	New	1,600	3	4	1	4	0	0	0	1	1	3	3	0	3	0
3	Residential - Single Family	Hawaii	Renovation	1,827	3	4	4	4	0	0	0	2	0	3	3	0	3	0
4	Residential - Single Family	Hawaii	Renovation	2,292	3	4	4	4	0	0	0	2	0	3	3	0	3	0
5	Residential - Duplex	Hawaii	New	2,242	3	4	4	4	0	0	0	2	1	3	3	0	3	0
6	Residential - Single Family	Hawaii	New	1,665	3	4	4	4	0	0	0	2	4	3	3	0	3	0
7	Residential - Single Family	Hawaii	New	2,332	3	4	4	4	0	0	0	2	4	3	3	0	3	0
8	Residential - Single Family	Hawaii	New	3,407	3	4	4	4	0	0	0	1	1	3	3	0	3	0
9	Residential - Single Family	Hawaii	New	2,404	3	4	4	4	0	0	0	1	4	3	3	0	3	0
10	Residential - Single Family	Hawaii	New	2,105	3	1	-1	4	0	0	0	1	1	3	3	0	3	0
11	Residential - Single Family	Hawaii	New	1,536	3	4	4	4	0	0	0	2	1	3	3	0	3	0
12	Residential - Single Family	Hawaii	New	2,786	3	4	4	4	0	0	0	1	4	3	3	0	3	0
13	Residential - Single Family	Hawaii	New	3,422	3	4	4	4	0	0	0	2	4	3	3	0	3	0
14	Residential - Single Family	Hawaii	New	2,186	3	4	4	4	0	0	0	1	4	3	3	0	3	0
15	Residential - Single Family	Hawaii	New	2,381	3	4	4	4	0	0	0	2	4	3	3	0	3	0
16	Residential - Single Family	Hawaii	New	2,496	3	4	4	4	0	0	0	2	1	3	3	0	3	0
17	Residential - Single Family	Hawaii	New	1,614	3	4	4	4	0	0	0	1	4	3	3	0	3	0
18	Residential - Single Family	Hawaii	New	2,341	3	1	1	4	0	-1	1	1	4	3	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Maui County

Table 48. Number of Projects at Each Compliance Level vs. 2015 IECC – Maui County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	0	1	0	14	0	0
Envelope - roof	0	15	0	0	0	0
Envelope - wall	0	15	0	0	0	0
Envelope - windows	0	7	0	0	8	0
Envelope - skylights	0	0	0	0	0	15
HVAC - efficiency	3	0	0	0	0	12
HVAC - insulation	0	1	0	0	0	14
Ceiling Fans	0	15	0	0	0	0
Solar Hot Water	0	8	0	0	7	0
Air Leakage - Overall Dwelling Unit	0	0	0	15	0	0
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	15	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	15
Air Leakage - Swinging Doors	0	0	0	15	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	15

Table 49. Percent of Projects at Each Compliance Level vs. 2015 IECC – Maui County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non- compliance	Moderate non- compliance	Major non- compliance
Lighting power - interior	15	0%	7%	0%	93%	0%
Envelope - roof	15	0%	100%	0%	0%	0%
Envelope - wall	15	0%	100%	0%	0%	0%
Envelope - windows	15	0%	47%	0%	0%	53%
Envelope - skylights	0					
HVAC - efficiency	3	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Ceiling Fans	15	0%	100%	0%	0%	0%
Solar Hot Water	15	0%	53%	0%	0%	47%
Air Leakage - Overall Dwelling Unit	15	0%	0%	0%	100%	0%
Air Leakage - Windows/Skylights/Sliding Door	15	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	15	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 50. Compliance Level by Project vs. 2015 IECC – Maui County

ID	Building Type	County	Phase	Floor Area (ft ²)	Lighting power - interior	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Ceiling Fans	Solar Hot Water	Air Leakage - Overall	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
19	Residential - Single Family	Maui	New	3,665	3	1	1	1	0	0	0	1	1	3	3	0	3	0
20	Residential - Single Family	Maui	New	3,869	3	1	1	4	0	0	0	1	1	3	3	0	3	0
21	Residential - Single Family	Maui	New	2,850	3	1	1	1	0	0	0	1	1	3	3	0	3	0
22	Residential - Single Family	Maui	New	2,421	3	1	1	4	0	0	0	1	4	3	3	0	3	0
23	Residential - Single Family	Maui	New	2,324	3	1	1	4	0	0	0	1	1	3	3	0	3	0
24	Residential - Single Family	Maui	New	1,170	3	1	1	4	0	0	0	1	1	3	3	0	3	0
25	Residential - Single Family	Maui	New	5,778	3	1	1	4	0	0	0	1	4	3	3	0	3	0
26	Residential - Single Family	Maui	New	3,541	1	1	1	4	0	-1	1	1	4	3	3	0	3	0
27	Residential - Multi Family	Maui	New	1,035	3	1	1	1	0	-1	0	1	4	3	3	0	3	0
28	Residential - Multi Family	Maui	New	1,350	3	1	1	4	0	-1	0	1	4	3	3	0	3	0
29	Residential - Multi Family	Maui	New	776	3	1	1	4	0	0	0	1	4	3	3	0	3	0
30	Residential - Multi Family	Maui	New	1,111	3	1	1	1	0	0	0	1	4	3	3	0	3	0
31	Residential - Multi Family	Maui	New	1,125	3	1	1	1	0	0	0	1	1	3	3	0	3	0
32	Residential - Multi Family	Maui	New	2,199	3	1	1	1	0	0	0	1	1	3	3	0	3	0
33	Residential - Multi Family	Maui	New	2,199	3	1	1	1	0	0	0	1	1	3	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance.
Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Honolulu County

Table 51. Number of Projects at Each Compliance Level vs. 2015 IECC – Honolulu County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	0	0	0	39	0	0
Envelope - roof	0	38	0	0	1	0
Envelope - wall	1	36	0	0	2	0
Envelope - windows	0	2	0	0	37	0
Envelope - skylights	0	0	0	0	0	39
HVAC - efficiency	1	0	0	0	0	38
HVAC - insulation	0	1	0	0	0	38
Ceiling Fans	0	17	22	0	0	0
Solar Hot Water	0	11	0	1	0	27
Air Leakage - Overall Dwelling Unit	0	0	0	39	0	0
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	39	0	0
Air Leakage - Jalousie Windows	0	0	0	0	0	39
Air Leakage - Swinging Doors	0	0	0	39	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	39

Table 52. Percent of Projects at Each Compliance Level vs. 2015 IECC – Honolulu County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	39	0%	0%	0%	100%	0%
Envelope - roof	39	0%	97%	0%	0%	3%
Envelope - wall	39	3%	92%	0%	0%	5%
Envelope - windows	39	0%	5%	0%	0%	95%
Envelope - skylights	0	N/A	N/A	N/A	N/A	N/A
HVAC - efficiency	1	100%	0%	0%	0%	0%
HVAC - insulation	1	0%	100%	0%	0%	0%
Ceiling Fans	39	0%	44%	56%	0%	0%
Solar Hot Water	12	0%	92%	0%	8%	0%
Air Leakage - Overall Dwelling Unit	39	0%	0%	0%	100%	0%
Air Leakage - Windows/Skylights/Sliding Door	39	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	0					
Air Leakage - Swinging Doors	39	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

Table 53. Compliance Level by Project vs. 2015 IECC – Honolulu County

ID	Building Type	County	Phase	Floor Area (ft ²)	Lighting power - interior	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Ceiling Fans	Solar Hot Water	Air Leakage - Overall	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
34	Residential - Single Family	Honolulu	New	5,081	3	1	1	4	0	-1	1	1	1	3	3	0	3	0
35	Residential - Single Family	Honolulu	New	2,213	3	1	1	4	0	0	0	1	1	3	3	0	3	0
36	Residential - Single Family	Honolulu	Renovation	1,095	3	1	1	4	0	0	0	2	0	3	3	0	3	0
37	Residential - Single Family	Honolulu	Renovation	1,505	3	1	1	4	0	0	0	2	0	3	3	0	3	0
38	Residential - Single Family	Honolulu	New	2,083	3	1	1	4	0	0	0	1	1	3	3	0	3	0
39	Residential - Single Family	Honolulu	Renovation	1,800	3	1	1	4	0	0	0	2	0	3	3	0	3	0
40	Residential - Multi Family	Honolulu	New	5,227	3	1	1	4	0	0	0	1	1	3	3	0	3	0
41	Residential - Multi Family	Honolulu	Renovation	2,829	3	1	1	4	0	0	0	1	0	3	3	0	3	0
42	Residential - Multi Family	Honolulu	Renovation	5,015	3	1	1	1	0	0	0	2	0	3	3	0	3	0
43	Apartment houses	Honolulu	Renovation	NA	3	1	1	4	0	0	0	2	0	3	3	0	3	0
44	Residential - Single Family	Honolulu	New	2,925	3	4	4	4	0	0	0	2	3	3	3	0	3	0
45	Residential - Multi Family	Honolulu	Renovation	2,369	3	1	1	4	0	0	0	1	0	3	3	0	3	0
46	Residential - Single Family	Honolulu	Renovation	2,974	3	1	1	4	0	0	0	1	0	3	3	0	3	0
47	Residential - Single Family	Honolulu	Renovation	2,179	3	1	1	4	0	0	0	2	0	3	3	0	3	0
48	Residential - Multi Family	Honolulu	New	5,789	3	1	1	4	0	0	0	1	1	3	3	0	3	0
49	Residential - Multi Family	Honolulu	Renovation	5,517	3	1	1	4	0	0	0	2	0	3	3	0	3	0
50	Residential - Multi Family	Honolulu	Renovation	792	3	1	1	4	0	0	0	2	0	3	3	0	3	0
51	Residential - Multi Family	Honolulu	Renovation	2,892	3	1	1	4	0	0	0	2	0	3	3	0	3	0
52	Residential - Single Family	Honolulu	Renovation	3,624	3	1	1	4	0	0	0	2	0	3	3	0	3	0
53	Residential - Single Family	Honolulu	Renovation	2,270	3	1	1	4	0	0	0	2	0	3	3	0	3	0
54	Residential - Single Family	Honolulu	Renovation	2,760	3	1	1	4	0	0	0	2	0	3	3	0	3	0
55	Residential - Multi Family	Honolulu	Renovation	2,010	3	1	1	4	0	0	0	2	1	3	3	0	3	0
56	Residential - Single Family	Honolulu	Renovation	3,968	3	1	1	1	0	0	0	2	0	3	3	0	3	0
57	Residential - Single Family	Honolulu	New	2,171	3	1	-1	4	0	0	0	2	1	3	3	0	3	0
58	Residential - Multi Family	Honolulu	Renovation	1,179	3	1	1	4	0	0	0	1	0	3	3	0	3	0
59	Residential - Multi Family	Honolulu	New	5,730	3	1	1	4	0	0	0	1	1	3	3	0	3	0
60	Residential - Multi Family	Honolulu	New	4,438	3	1	1	4	0	0	0	2	1	3	3	0	3	0
61	Residential - Multi Family	Honolulu	Renovation	3,416	3	1	1	4	0	0	0	1	0	3	3	0	3	0
62	Residential - Single Family	Honolulu	Renovation	5,169	3	1	1	4	0	0	0	1	0	3	3	0	3	0
63	Residential - Multi Family	Honolulu	New	4,377	3	1	1	4	0	0	0	1	1	3	3	0	3	0
64	Residential - Single Family	Honolulu	Renovation	4,296	3	1	1	4	0	0	0	2	0	3	3	0	3	0
65	Residential - Single Family	Honolulu	Renovation	1,904	3	1	1	4	0	0	0	1	0	3	3	0	3	0
66	Residential - Multi Family	Honolulu	Renovation	3,416	3	1	1	4	0	0	0	2	1	3	3	0	3	0
67	Residential - Multi Family	Honolulu	Renovation	3,629	3	1	1	4	0	0	0	1	0	3	3	0	3	0
68	Residential - Single Family	Honolulu	Renovation	3,219	3	1	1	4	0	0	0	2	0	3	3	0	3	0
69	Residential - Single Family	Honolulu	Renovation	3,225	3	1	1	4	0	0	0	2	0	3	3	0	3	0
70	Residential - Single Family	Honolulu	Renovation	2,448	3	1	1	4	0	0	0	1	0	3	3	0	3	0
71	Residential - Single Family	Honolulu	Renovation	2,978	3	1	1	4	0	0	0	1	0	3	3	0	3	0
72	Apartment	Honolulu	Renovation	N/A	3	1	4	4	0	0	0	2	0	3	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Kauai County

Table 54. Number of Projects at Each Compliance Level vs. 2015 IECC – Kauai County

Code Requirement	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance	Not Applicable
Lighting power - interior	0	0	0	22	0	0
Envelope - roof	0	14	0	0	8	0
Envelope - wall	0	14	0	0	8	0
Envelope - windows	0	10	0	0	12	0
Envelope - skylights	0	0	0	0	0	22
HVAC - efficiency	0	0	0	0	0	22
HVAC - insulation	0	0	0	0	0	22
Ceiling Fans	0	22	0	0	0	0
Solar Hot Water	0	10	0	0	12	0
Air Leakage - Overall Dwelling Unit	0	0	0	22	0	0
Air Leakage - Windows/Skylights/Sliding Door	0	0	0	22	0	0
Air Leakage - Jalousie Windows	0	0	0	5	0	16
Air Leakage - Swinging Doors	0	0	0	22	0	0
Air Leakage - Recessed Lighting	0	0	0	0	0	22

Table 55. Percent of Projects at Each Compliance Level vs. 2015 IECC – Kauai County

Code Requirement	Number of Applicable Projects	Exceeds Code	Meets Code	Minor non-compliance	Moderate non-compliance	Major non-compliance
Lighting power - interior	22	0%	0%	0%	100%	0%
Envelope - roof	22	0%	64%	0%	0%	36%
Envelope - wall	22	0%	64%	0%	0%	36%
Envelope - windows	22	0%	45%	0%	0%	55%
Envelope - skylights	0					
HVAC - efficiency	0					
HVAC - insulation	0					
Ceiling Fans	22	0%	100%	0%	0%	0%
Solar Hot Water	22	0%	45%	0%	0%	55%
Air Leakage - Overall Dwelling Unit	22	0%	0%	0%	100%	0%
Air Leakage - Windows/Skylights/Sliding Door	22	0%	0%	0%	100%	0%
Air Leakage - Jalousie Windows	5	0%	0%	0%	100%	0%
Air Leakage - Swinging Doors	22	0%	0%	0%	100%	0%
Air Leakage - Recessed Lighting	0					

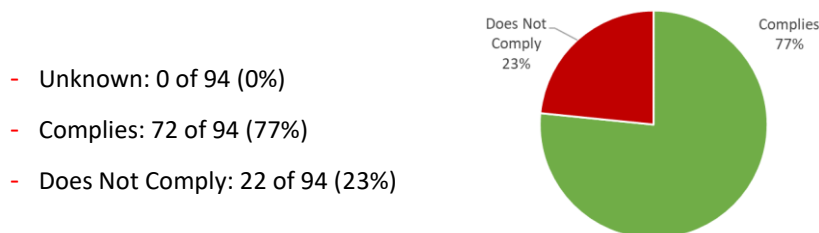
Table 56. Compliance Level by Project vs. 2015 IECC – Kauai County

ID	Building Type	County	Phase	Floor Area (ft ²)	Lighting power - interior	Envelope - roof	Envelope - wall	Envelope - windows	Envelope - skylights	HVAC - efficiency	HVAC - insulation	Ceiling Fans	Solar Hot Water	Air Leakage - Overall	Air Leakage - Fenestration	Air Leakage - Jalousies	Air Leakage - Doors	Air Leakage - Recessed Ltg
73	Residential - Multifamily	Kauai	New	1,047	3	1	1	1	0	0	0	1	1	3	3	3	3	0
74	Residential - Duplex	Kauai	New	1,945	3	1	1	4	0	0	0	1	4	3	3	3	3	0
75	Residential - Single Family	Kauai	New	2,967	3	4	4	4	0	0	0	1	1	3	3	0	3	0
76	Residential - Single Family	Kauai	New	3,150	3	1	1	1	0	0	0	1	4	3	3	0	3	0
77	Residential - Single Family	Kauai	New	2,733	3	1	1	4	0	0	0	1	1	3	3	0	3	0
78	Residential - Single Family	Kauai	New	2,723	3	1	1	1	0	0	0	1	4	3	3	0	3	0
79	Residential - Multifamily	Kauai	New	814	3	1	1	4	0	0	0	1	4	3	3	3	3	0
80	Residential - Single Family	Kauai	New	5,868	3	4	4	4	0	0	0	1	4	3	3	3	3	0
81	Residential - Single Family	Kauai	New	2,080	3	4	4	4	0	0	0	1	4	3	3	0	3	0
82	Residential - Duplex	Kauai	New	1,257	3	1	1	4	0	0	0	1	4	3	3	0	3	0
83	Residential - Single Family	Kauai	New	2,028	3	1	1	1	0	0	0	1	1	3	3	3	3	0
84	Residential - Single Family	Kauai	New	1,820	3	1	1	4	0	0	0	1	4	3	3	0	3	0
85	Residential - Single Family	Kauai	New	2,160	3	4	4	4	0	0	0	1	4	3	3	0	3	0
86	Residential - Single Family	Kauai	New	1,404	3	4	4	1	0	0	0	1	4	3	3	0	3	0
87	Residential - Single Family	Kauai	New	1,404	3	4	4	1	0	0	0	1	4	3	3	0	3	0
88	Residential - Single Family	Kauai	New	2,060	3	4	4	4	0	0	0	1	4	3	3	0	3	0
89	Residential - Single Family	Kauai	New	2,060	3	1	1	1	0	0	0	1	1	3	3	0	3	0
90	Residential - Duplex	Kauai	New	3,853	3	1	1	1	0	0	0	1	1	3	3	0	3	0
91	Residential - Single Family	Kauai	New	2,826	3	4	4	4	0	0	0	1	1	3	3	0	3	0
92	Residential - Duplex	Kauai	New	3,874	3	1	1	1	0	0	0	1	1	3	3	0	3	0
93	Residential - Single Family	Kauai	New	3,066	3	1	1	4	0	0	0	1	1	3	3	0	3	0
94	Residential - Single Family	Kauai	New	1,755	3	1	1	1	0	0	0	1	1	3	3	0	3	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance. Cases where performance information was missing on the plans, such as missing window SHGC, are assigned a minor, moderate or major non-compliance level based on subjective judgment of the reviewer.

Compliance Certification Results

Of the 94 low-rise residential projects, most included designer compliance certification for envelope compliance.



Most plans did not have energy code stamps related to HVAC and lighting systems because HVAC and electrical plans are not submitted to the building department.

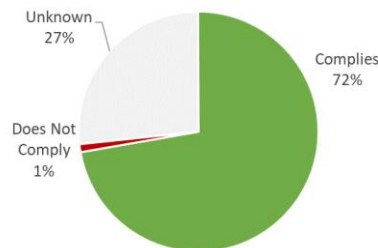
Envelope Results

The stringency of low-rise residential requirements for roof insulation, wall insulation and window SHGC is the same for both the 2006 and 2015 IECC in Hawaii's climate. Therefore, the following pie charts illustrate envelope compliance levels for both versions for the code.

Roof Insulation

Table 57 through Table 60 list the designed roof insulation R-value for each project along with the minimum required R-value. Compliance was verified in 72 percent of the projects, but in 27 percent of the projects the insulation R-value was missing from the plans and compliance was uncertain. Only one project clearly had no insulation and did not comply. Of the 94 applicable projects:

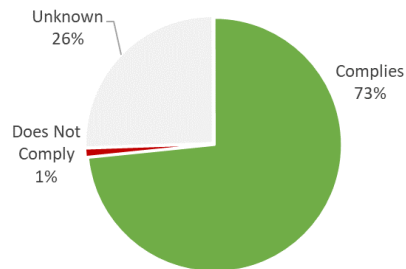
- Unknown: 25 of 94 (27%)
(Information missing)
- Complies: 68 of 94 (72%)
- Does Not Comply: 1 of 94 (1%)



Wall Insulation

Table 57 through Table 60 list the designed wall insulation R-value for each project along with the minimum required R-value. Compliance results are very similar to roofs. Of the 94 applicable projects:

- Unknown: 24 of 94 (26%)
(Information missing)
- Complies: 69 of 94 (73%)
- Does Not Comply: 1 of 94 (1%)



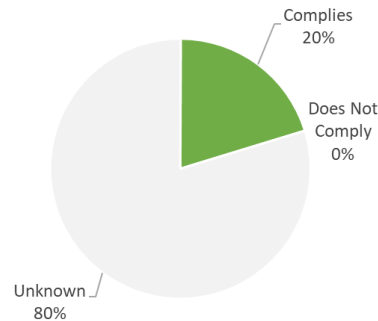
Fenestration

Table 57 through Table 60 show the designed solar heat gain coefficient (SHGC) for each project along with the corresponding maximum SHGC allowed by code based on the size of the overhang. The primary code requirement for windows is a maximum limit on SHGC. The SHGC limit increases if a window is shaded by an overhang. The allowed maximum varies from 0.25 to 0.40. The designed SHGC information was gathered both by reviewing the plans and by contacting the corresponding architect. Of the 94 applicable projects only 19 projects had information available related to SHGC. Compliance could not be verified for 80 percent of the projects.

The SHGC data was seldom found on the plans. In most of the 19 complying cases, the window specifications were obtained by contacting the project architects.

The majority of the 94 applicable projects had window overhangs.

- Unknown: 75 of 94 (80%)
(Information missing)
- Complies: 19 of 94 (20%)
- Does Not Comply: 0 of 94 (0%)



Envelope Observations

- Roof and wall insulation compliance rates appeared to be good in Honolulu, Kauai and Maui counties. The compliance level in Hawaii county was less certain due to information missing on the plans. See Table 57 for details of Hawaii County.
- Window SHGC compliance rates were uncertain. Most of the reviewed projects have no information on the plans related to SHGC.
- Window performance is a good candidate for improved plan review and enforcement. SHGC values for all windows should be required on the plans.

Table 57. Roof, Wall and Window Results by Project – Hawaii County

ID	Building Type	ROOF			WALL			WINDOWS		
		Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?
1	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
2	Single Family	Missing	R-19 or Greater	No	Missing	R-13	Yes	Missing	0.4	Unknown
3	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
4	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
5	Duplex	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
6	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
7	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
8	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
9	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
10	Single Family	R-19	R-19 or Greater	Yes	R-19	R-13	Yes	Missing	0.4	Unknown
11	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
12	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
13	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
14	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
15	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
16	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
17	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
18	Single Family	6 inch	R-19 or Greater	Yes	4 inch	R-13	Yes	Missing	0.4	Unknown

Table 58. Roof, Wall and Window Results by Project – Maui County

ID	Building Type	ROOF			WALL			WINDOWS		
		Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?
19	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.3	0.4	Yes
20	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
21	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
22	Single Family	R-19	R-19 or Greater	Yes	R-19	R-13	Yes	Missing	0.4	Unknown
23	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
24	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
25	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
26	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
27	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
28	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
29	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
30	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.29	0.4	Yes
31	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
32	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
33	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes

Table 59. Roof, Wall and Window Results by Project – Honolulu County

ID	Building Type	ROOF			WALL			WINDOWS		
		Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?
34	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
35	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
36	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
37	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
38	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
39	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
40	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
41	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
42	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	0.23	0.4	Yes
43	Apartments	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
44	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
45	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
46	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
47	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
48	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
49	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
50	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
51	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
52	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
53	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
54	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
55	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
56	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
57	Single Family	R-30	R-19 or Greater	Yes	R-19	R-13	Yes	Missing	0.4	Unknown
58	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
59	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
60	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
61	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
62	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
63	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
64	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
65	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
66	Multi Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
67	Multi Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
68	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
69	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
70	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
71	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
72	Apartment	None	R-19 or Greater	No	CMU - None	R-13	No	Missing	0.4	Unknown

Table 60. Roof, Wall and Window Results by Project – Kauai County

ID	Building Type	ROOF			WALL			WINDOWS		
		Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?	Design	Required (2006 & 2015)	Complies?
73	Multifamily	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.3	0.4	Yes
74	Duplex	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
75	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
76	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
77	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
78	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
79	Multifamily	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
80	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
81	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
82	Duplex	R-19	R-19 or Greater	Yes	R-19	R-13	Yes	Missing	0.4	Unknown
83	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
84	Single Family	R-30	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
85	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
86	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	0.21	0.4	Yes
87	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	0.21	0.4	Yes
88	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
89	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
90	Duplex	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
91	Single Family	Missing	R-19 or Greater	No	Missing	R-13	No	Missing	0.4	Unknown
92	Duplex	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes
93	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	Missing	0.4	Unknown
94	Single Family	R-19	R-19 or Greater	Yes	R-13	R-13	Yes	0.4	0.4	Yes

HVAC System Results

HVAC compliance was unclear for most of the projects that were reviewed. Plans submitted to the building departments rarely show air conditioning systems, though it is likely that some of homes do get air conditioning installed. For the small number that did include HVAC on the plans, only 5 of 94 projects, the air conditioners complied with the efficiency requirements with designed SEER ranging from 16.5 to 18.0.

Under the 2015 IECC, duct leakage testing will also be required. None of the reviewed projects included information about duct testing, which is not a current requirement.

Water Heating System Results

The 2006 IECC does not include requirements for water heating system efficiency.

The Hawaii amendments to the 2015 IECC reference the Hawaii state requirements for solar water heating, which also allow instantaneous gas water heaters under specific circumstances. Of all projects reviewed, the number showing solar water heating was 36 out of 65 relevant new construction projects (55 percent). The number of projects with gas water heaters were 18 of 65 (28 percent). System type was not indicated in 11 cases (17 percent). Table 61 shows the count of system types for each county, and Figure 7 shows the percent represented by each system type in each county.

Table 61. Low-rise Residential Water Heating System Type

County	Solar	Gas	Unknown	Total
Hawaii	7	9	0	16
Maui	8	2	5	15
Honolulu	11	0	1	12
Kauai	10	7	5	22
Total	36	18	11	65

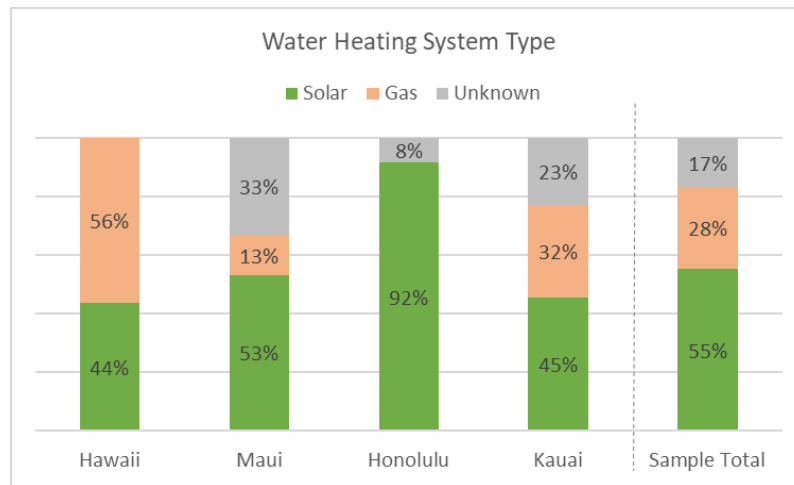


Figure 7. Low-rise Residential Water Heating System Type

Electrical System Results

The 2006 code does not include lighting efficiency requirements.

The 2009 code that applies in Kauai does require that at least 50 percent of permanently installed lights be high-efficacy. The 2015 code will require 75 percent high-efficacy lamps. None of the Kauai plans included information about lighting systems, therefore the rate of compliance with the existing code is unknown. In this study, those are considered cases of moderate non-compliance.

In the other three counties, only one project included information about lighting. That case complies with the 2015 high-efficacy requirement, but none of the other projects can be verified for compliance.

The 2015 code with Hawaii amendments will also require rough-ins for ceiling fans. The number of projects indicating rough ins for ceiling fans are 62 of 94 projects (66 percent). Results by county are:

- Hawaii: 8 of 18, 44%
- Maui: 15 of 15, 100%
- Honolulu: 17 of 39, 44%
- Kauai: 22 of 22, 100%

Energy Impact – Non-residential and High-rise Residential

Based on the plan review results discussed earlier, there are a few areas of non-compliance that are likely to have an energy impact. These areas are discussed in the following sections

- Interior lighting
- Fenestration

- Energy recovery
- HVAC commissioning

In other cases, the energy impact of non-compliance was expected to be small. Many of those cases are identified as “unknown” in the review above because required information was not included on the plans. For example, in some cases the roof insulation R-value was not indicated. There is a chance that in some of those cases the installed R-value was less than required, but in many cases the actual project likely complies. Therefore, it would be unreasonable to assume that there is an energy impact to non-compliance in all projects with missing information on the plans. The following are areas where the review identified little energy impact related to code compliance.

- Exterior lighting. The extra exterior lighting power total for the four projects that exceed the allowance totals to only 1.27kW, as shown in Table 24. While there would be some savings for bringing them into compliance, the amount would be small. For most projects the installed exterior lighting power is significantly lower than the allowance.
- Roof insulation. There may be a small impact. However, all but one of the projects showed roof insulation on the plans. The problem was that the insulation R-value was not indicated.
- Wall insulation. Compliance is likely in the “unknown” cases because the 2006 IECC requires only R-13 in framed walls and does not require insulation for mass walls.
- Cooling system efficiency. Only one project had efficiency slightly below the requirement. The “unknown” cases are very likely to meet the efficiency requirements because most cooling equipment sold in the U.S. is built to at least these standards.
- HVAC insulation. There is potentially some loss of efficiency due to insufficiently insulated ducts, but standard practice in Hawaii is likely to include adequate insulation to reduce chances of condensation.
- HVAC controls. Most projects comply, and the “unknown” cases are likely to have programmable thermostats or similar controls and comply. The field assessment verified that controls were present in all five project that were visited.
- Water heating. Impact of non-compliance is small. Most projects have small electric water heaters.

Construction Forecast

The estimate construction activity is based on historical data for total building permit value. Past construction activity in terms of floor area is estimated by dividing the historical permit value by a rough estimate of construction cost in terms of dollars per square foot.

The average annual private building permit value over the period 2006 through 2015 is used as the forecast for this analysis. The results shown in Figure 8 include Hawaii, Maui, and Honolulu Counties. Kauai commercial construction data were not available but are likely to be small relative to the other counties. The ten-year average is \$458 million/yr for commercial and industrial building permits and \$1,235 million/yr for additions and alterations.

The floor area estimate for commercial and industrial projects is 2.29 million square feet per year, based on a very rough assumption of \$200/sf of permit value. The estimate for additions and alterations is 6.18 million square feet. It is not possible to know with certainty how many of these projects include work subject to the energy code, but a rough assumption is made for this analysis. The assumption is that 50% of the commercial and industrial projects are applicable and 25% of the additions and alterations are applicable. The resulting rough construction forecast is 2.7 million square feet per year.

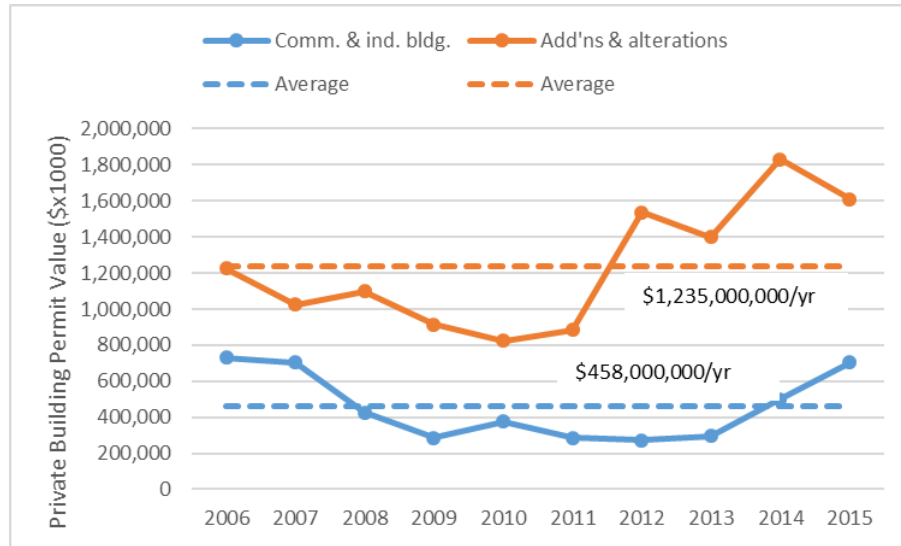


Figure 8. Historical Building Permit Value – Hawaii, Honolulu, & Maui Counties
 (source: DBEDT, <http://dbedt.hawaii.gov/economic/databook>)

Energy Impact – Interior Lighting

As noted earlier on page 29, the designed lighting power exceeded the code allowance in 15 of the 50 reviewed projects. The net effect on electricity consumption for the group of 50 projects is a 0.28% increase in electricity consumption. Table 62 summarizes the analysis results. Column B shows the approximate baseline annual electricity consumption intensity (per square foot), based on either prototype simulation models (Appendix 4) or benchmark data (Appendix 5) for each building type. Column C lists the approximate portion of that electricity that is expected to be due to interior lighting. Column D lists the code compliance review results from Table 21 for each of the 15 non-complying projects. Then column D shows adjusted electricity consumption intensity, accounting for the increased lighting power above code.

Table 63 shows the same results for the retail project alone, showing a 1.7% increase in total electricity consumption due to non-compliance. Retail projects comprised most of interior-lighting compliance issues.

Table 62. Energy Impact of Non-Compliance – Interior Lighting

ID	Building Type	A Floor Area (sf)	B Baseline Total Electricity Consumption Intensity* (kWh/sf-yr)	C Interior Lighting Portion of Baseline Electricity Consumption Intensity** (kWh/sf-yr)	D Percent lighting power increase due to non- compliance *** (%)	E Adjusted Electricity Consumption Intensity (B+C*D) (kWh/sf-yr)	F Baseline Electricity Consumption Intensity (A*B) (kWh/yr)	G Adjusted for Non- Compliance Electricity Consumption (A*E) (kWh/yr)	H Percent Increase (G vs. F) (%)
1	Mixed use, office/retail	11,932	15			15.0	178,980	178,980	
2	Medical office building	29,600	25			25.0	740,000	740,000	
3	Lounge/food service	815	23	8	15%	24.2	18,745	19,748	5.4%
4	Retail	4,382	23	8	107%	31.5	100,786	138,179	37.1%
5	Gymnasium	4,489	15	3	27%	15.8	67,335	71,008	5.5%
6	Retail	1,620	23	8	55%	27.4	37,260	44,388	19.1%
7	Bank	6,000	15			15.0	90,000	90,000	
8	Gymnasium, Multipurpose	42,182	15			15.0	632,730	632,730	
9	Warehouse	10,800	7	4	56%	9.2	75,600	99,792	32.0%
10	Hotel	17,708	28			28.0	495,824	495,824	
11	Retail	137,462	23			23.0	3,161,626	3,161,626	
12	Warehouse	46,475	7			7.0	325,325	325,325	
13	Retail	26,092	23			23.0	600,116	600,116	
14	Bank	11,700	15			15.0	175,500	175,500	
15	Retail	4,000	23	8	39%	26.1	92,000	104,522	13.6%
16	Retail	1,475	23	8	7%	23.5	33,925	34,712	2.3%
17	Retail	13,897	23	8	5%	23.4	319,631	325,482	1.8%
18	Hotel	75,891	28			28.0	2,124,948	2,124,948	
19	High rise residential	237,000	28			28.0	6,636,000	6,636,000	
20	Hotel	294,000	28			28.0	8,232,000	8,232,000	
21	Hotel	2,750	28			28.0	77,000	77,000	
22	Hotel	217,000	28			28.0	6,076,000	6,076,000	
23	Retail	5,072	23	8	5%	23.4	116,656	118,550	1.6%
24	Retail	2,270	23	8	168%	36.5	52,210	82,795	58.6%
25	Retail (central plant)	n/a							
26	Retail	1,965	23			23.0	45,195	45,195	
27	Office	5,422	15	3	2%	15.1	81,330	81,655	0.4%
28	Office	15,527	15			15.0	232,905	232,905	
29	Office	8,036	15			15.0	120,540	120,540	
30	Office	41,809	15	3	2%	15.1	627,135	629,644	0.4%
31	Bank	6,100	15			15.0	91,500	91,500	
32	Office	15,585	15			15.0	233,775	233,775	
33	Retail	867	23			23.0	19,941	19,941	
34	Retail	978	23			23.0	22,494	22,494	
35	Retail	1,983	23	8	43%	26.4	45,609	52,408	14.9%
36	Retail	35,576	23			23.0	818,248	818,248	
37	Highrise residential	485,745	28			28.0	13,600,860	13,600,860	
38	Educational	43,793	15			15.0	656,895	656,895	
39	Library	17,135	15			15.0	257,025	257,025	
40	Highrise residential	66,290	28			28.0	1,856,120	1,856,120	
41	Residential	48,089	28			28.0	1,346,492	1,346,492	
42	Retail	14,820	23			23.0	340,860	340,860	
43	Retail	2,484	23			23.0	57,132	57,132	
44	Multipurpose	2,500	15			15.0	37,500	37,500	
45	Retail and Office	3,000	23	8	18%	24.4	69,000	73,320	6.3%
46	Office	21,900	15			15.0	328,500	328,500	
47	Bank branch	5,137	15			15.0	77,055	77,055	
48	Retail	21,630	23			23.0	497,490	497,490	
49	Outpatient healthcare	3,951	25			25.0	98,775	98,775	
50	Restaurant	4,000	23	8	14%	24.1	92,000	96,480	4.9%
Totals		2,078,934	25.07			25.14	52,114,573	52,258,033	0.28%

* Baseline kWh/sf-yr based on prototype models and benchmark data.

** Baseline lighting energy fraction is based on prototype simulation results. See Appendix 4.

*** Percent increase in lighting power for each project reported in Table 21.

Table 63. Energy Impact of Non-Compliance – Interior Lighting – Retail Only

ID	Building Type	A Floor Area	B Baseline Total Electricity Consumption Intensity* (kWh/sf-yr)	C Interior Lighting Portion of Baseline Electricity Consumption Intensity** (kWh/sf-yr)	D Percent lighting power increase due to non- compliance*** (%)	E Adjusted Electricity Consumption Intensity (B+C*D) (kWh/sf-yr)	F Baseline Electricity Consumption (A*B) (kWh/yr)	G Adjusted for Non- Compliance Electricity Consumption (A*E) (kWh/yr)	H Percent Increase (G vs. F) (%)
4	Retail	4,382	23	8	107%	31.5	100,786	138,179	37.1%
6	Retail	1,620	23	8	55%	27.4	37,260	44,388	19.1%
11	Retail	137,462	23			23.0	3,161,626	3,161,626	
13	Retail	26,092	23			23.0	600,116	600,116	
15	Retail	4,000	23	8	39%	26.1	92,000	104,522	13.6%
16	Retail	1,475	23	8	7%	23.5	33,925	34,712	2.3%
17	Retail	13,897	23	8	5%	23.4	319,631	325,482	1.8%
23	Retail	5,072	23	8	5%	23.4	116,656	118,550	1.6%
24	Retail	2,270	23	8	168%	36.5	52,210	82,795	58.6%
26	Retail	1,965	23			23.0	45,195	45,195	
33	Retail	867	23			23.0	19,941	19,941	
34	Retail	978	23			23.0	22,494	22,494	
35	Retail	1,983	23	8	43%	26.4	45,609	52,408	14.9%
36	Retail	35,576	23			23.0	818,248	818,248	
42	Retail	14,820	23			23.0	340,860	340,860	
43	Retail	2,484	23			23.0	57,132	57,132	
45	Retail and Office	3,000	23	8	18%	24.4	69,000	73,320	6.3%
48	Retail	21,630	23			23.0	497,490	497,490	
Totals		279,573	23			23.4	6,430,179	6,537,458	1.7%

* Baseline kWh/sf-yr based on prototype models and benchmark data.

** Baseline lighting energy fraction is based on prototype simulation results. See Appendix 4.

*** Percent increase in lighting power for each project reported in Table 21.

Energy Impact – Fenestration

As noted earlier on page 39, there were 31 reviewed projects requiring fenestration compliance but only one of them could be confirmed to comply. In 23 cases, the glazing specifications were not provided on the plans. The remaining eight cases either did not comply either in whole or in part.

Due to the lack of information about actual window performance specifications, an assumption is required in each case about the likely solar heat gain coefficient (SHGC) for the windows. Table 64 shows those assumptions and indicates the 12 projects where there is likely to be some energy impact. The expected impact is an increase in cooling energy. In the remaining cases, the judgment is that there is likely to be little energy impact.

In most cases, the assumed SHGC listed in Table 64 is based on the type of window shown on the plans: either single-pane or double-pane. Sometimes notes on the plans indicate “low-e” or “tinted”, which is not enough information to know the exact SHGC but points to a likely range.

The overhang projection factor is indicated in Table 64 for those cases that seem likely to be non-compliant. These PF values are based on review of the building plans.

The estimated energy impact for fenestration non-compliance is shown in Table 65. The estimated baseline electricity consumption for each of the 31 projects is the same as described above in the interior lighting analysis. Those values are based on either prototype simulation models or benchmark values based on building type. The adjusted electricity consumption is based on simulation analysis using prototype models, which provide estimates of electricity consumption with varying SHGC and overhang PF. Those model results are described in Appendix 4.

Table 65 shows that the overall impact on electricity consumption for these 31 buildings is an increase of 0.62%. The impact on individual buildings ranges from 0 to 6.8%. According to these results, the relative impact of window non-compliance is greater in office, bank and hotel type buildings than it is for retail type buildings.

Table 64. Fenestration Impact Assumptions

ID	Building Type	Max. Allowed Window SHGC	Designed Window SHGC	Assumed Window SHGC	Assumed Overhang Projection Factor	Notes
1	Mixed use, office/retail	0.4	Missing	Likely complies		Likely dual-pane low-e, SHGC<0.4.
2	Medical office building	0.33	0.27	Complies		
4	Retail	0.33	Missing	0.82	0.32	Strip mall store, new single-pane windows in existing building, likely clear glass.
5	Gymnasium	0.25-0.40	0.3	Likely complies		Notes indicate dual-pane, low-e.
7	Bank	0.33	Missing	0.60	0.17	Single-pane. Assume typical SHGC for 6mm gray tint
8	Gymnasium, Multipurpose	0.4	Missing	Likely complies		
11	Retail	0.33	Missing	0.60	0.33	Large retail, single-pane, but mostly vestibule
12	Warehouse	0.25	Missing	Likely complies		Small north-facing windows
13	Retail	0.4	Missing	0.82	>1.0	Shaded single-pane windows, likely clear glass.
14	Bank	0.25-0.40	Missing	Likely complies		Notes indicate dual-pane, low-e.
18	Hotel	0.25-0.33	Missing	Likely complies		Notes indicate dual-pane, vinyl-frame sliding doors.
19	High rise residential	0.4	Missing	Likely complies		Dual-pane sliding doors.
20	Hotel	0.4	Missing	0.60	0.5	Single-pane sliding doors. Assume typical SHGC for tinted glass.
23	Retail	0.4	0.82	0.82	>1.0	Clear glass with large overhang.
24	Retail	0.4	0.82	0.82	0.5	Clear glass with modest overhang.
31	Bank	0.33-0.40	Missing	0.60 (part)	1	Mostly double-pane low-e (ok), some single-pane with large overhang.
32	Office	0.33-0.40	Missing	0.60	0.35 & 0.5	Plans seem to indicate single-pane, with overhang.
33	Retail	0.25-0.40	0.4	0.40	varies	
34	Retail	0.25	0.19 and 0.32	0.19 and 0.32	small	
35	Retail	0.33	Missing	Likely complies		Notes indicate dual-pane, low-e.
36	Retail	0.25-0.33	Missing	Likely complies		Notes indicate dual-pane, low-e, tinted.
37	Highrise residential	0.25-0.33	Missing	Likely complies		OK based on specs obtained in site visit.
38	Educational	0.25-0.33	Missing	Likely complies		Likely ok based on observed glazing at site visit.
39	Library	0.25-0.40	Missing	Likely complies		Likely ok based on observed glazing at site visit.
40	Highrise residential	0.4	0.82	0.82	0.56	Single-pane clear glass.
41	Residential	Missing	0.25-0.40	Likely complies		Dual pane on plans; lanai shading
42	Retail	0.27	0.33	Likely complies		
43	Retail	Missing	0.4	Likely complies		Dual pane vinyl frame
44	Multipurpose	Missing	0.33-0.40	Likely complies		Most windows enclose unconditioned space, so little energy impact.
45	Retail and Office	Missing	0.33	Likely complies		
48	Retail	Missing	0.33	Likely complies		Small area of shaded windows.

Table 65. Energy Impact of Non-Compliance – Fenestration

ID	Building Type	A	B	C	D	E	F	G	H
		Floor Area (sf)	Baseline Total Electricity Consumption Intensity (kWh/sf-yr)	Assumed Window SHGC*	Assumed Overhang Projection Factor*	Adjusted Electricity Consumption Intensity** (kWh/sf-yr)	Baseline Electricity Consumption (A*B) (kWh/yr)	Adjusted for Non- Compliance Electricity Consumption (A*E) (kWh/yr)	Percent Increase (G vs. F)
1	Mixed use, office/retail	11,932	15.00	Likely complies		15.00	178,980	178,980	
2	Medical office building	29,600	25.00	Complies		25.00	740,000	740,000	
4	Retail	4,382	22.83	0.82	0.32	23.20	100,041	101,670	1.6%
5	Gymnasium	4,489	15.00	Likely complies		15.00	67,335	67,335	
7	Bank	6,000	14.55	0.60	0.17	15.54	87,300	93,259	6.8%
8	Gymnasium, Multipurpose	42,182	15.00	Likely complies		15.00	632,730	632,730	
11	Retail	137,462	22.83	0.60	0.33	23.00	3,138,257	3,161,934	0.8%
12	Warehouse	46,475	7.00	Likely complies		7.00	325,325	325,325	
13	Retail	26,092	22.83	0.82	>1.0	22.83	595,680	595,680	
14	Bank	11,700	15.00	Likely complies		15.00	175,500	175,500	
18	Hotel	75,891	28.00	Likely complies		28.00	2,124,948	2,124,948	
19	High rise residential	237,000	28.00	Likely complies		28.00	6,636,000	6,636,000	
20	Hotel	294,000	28.43	0.60	0.5	28.96	8,358,420	8,514,599	1.9%
23	Retail	5,072	22.83	0.82	>1.0	22.83	115,794	115,794	
24	Retail	2,270	22.83	0.82	0.5	23.06	51,824	52,356	1.0%
31	Bank	6,100	14.55	0.6	1	14.55	88,755	88,755	
32	Office	15,585	14.55	0.60	0.35	15.24	226,762	237,552	4.8%
33	Retail	867	22.83	0.40	0.33	22.83	19,794	19,792	
34	Retail	978	22.83	0.32	0.10	22.89	22,328	22,384	0.2%
35	Retail	1,983	23.00	Likely complies		23.00	45,609	45,609	
36	Retail	35,576	23.00	Likely complies		23.00	818,248	818,248	
37	Highrise residential	485,745	28.00	Likely complies		28.00	13,600,860	13,600,860	
38	Educational	43,793	15.00	Likely complies		15.00	656,895	656,895	
39	Library	17,135	15.00	Likely complies		15.00	257,025	257,025	
40	Highrise residential	66,290	28.43	0.82	0.56	29.48	1,884,625	1,954,165	3.7%
41	Residential	48,089	28.00	Likely complies		28.00	1,346,492	1,346,492	
42	Retail	14,820	23.00	Likely complies		23.00	340,860	340,860	
43	Retail	2,484	23.00	Likely complies		23.00	57,132	57,132	
44	Multipurpose	2,500	15.00	Likely complies		15.00	37,500	37,500	
45	Retail and Office	3,000	23.00	Likely complies		23.00	69,000	69,000	
48	Retail	21,630	23.00	Likely complies		23.00	497,490	497,490	
Totals		1,701,122	25.45			25.61	43,297,509	43,565,868	0.62%

* See notes in Table 64.

** Adjusted electricity consumption intensity is based on prototype model simulations, accounting for SHGC and overhang PF.

Energy Impact – Energy Recovery

As noted on page 44, two projects did not comply with the code's requirement for energy recovery. The energy recovery ventilation system requirements (Section 503.2.6) apply to large air handlers (>5,000 cfm) with a high outdoor airflow requirement (>70%) and require heat recovery with minimum of 50% effectiveness.

One of the projects is a hotel, and the other is a high-rise residential building. Both buildings have large air handlers that provide conditioned 100% outdoor air to the dwelling units for ventilation. If energy recovery were included, then the systems would precool and dehumidify the incoming outdoor air in part by capturing cooling from the exhaust air.

The energy impact of the missing energy recovery is summarized in Table 66, which is estimated to be 3.2% for the hotel and 2.5% for the high-rise residential building. The table shows the design outdoor air ventilation rate for each project. The outdoor air cooling load was estimated using an annual hourly set of outdoor air temperature and humidity data for Honolulu Airport. The electricity consumption corresponding to that load is approximated using an average cooling efficiency of EER 10. In the non-

compliance case, one half of that energy is added to the baseline whole-building electricity consumption to account for missing energy recovery.

This compliance issue occurred in only two of the 50 projects, but the overall impact is 1.18% because these were two of the largest projects. The total increase is 614,000 kWh/yr (total from Table 66) compared to total baseline electricity consumption of 52,114,600 kWh/yr (for all 50 projects in Table 62).

Table 66. Energy Impact of Non-Compliance – Energy Recovery Ventilation

Project ID		20	37
A	Building Type	Hotel	Highrise residential
B	Floor Area (sf)	294,000	485,745
C	Outdoor airflow from plans (cfm)	26,600	35,000
D	Outdoor Air Cooling Load* (kBtu/yr)	5,305,271	6,980,620
E	Cooling efficiency (kBtu/kWh)	10	10
F	Cooling Electricity Consumption due to Ventilation, (D/E) (kWh/yr)	530,527	698,062
G	Cooling Electricity Intensity due to Ventilation, (F/B) (kWh/sf-yr)	1.80	1.44
H	Lost Electricity savings due to missing heat recovery, (G*50%) (kWh/sf-yr)	0.90	0.72
I	Baseline Total Electricity Consumption Intensity** (kWh/sf-yr)	28.43	28.43
J	Adjusted Electricity Consumption Intensity, (H+I) (kWh/sf-yr)	29.33	29.15
K	Baseline Electricity Consumption, (B*I) (kWh/yr)	8,358,420	13,809,730
L	Adjusted for Non-Compliance Electricity Consumption, (B*J) (kWh/yr)	8,623,684	14,158,761
M	Percent Increase (L vs. K) (%)	3.2%	2.5%

* Outdoor air cooling load is calculated based on airflow, annual hourly outdoor air enthalpy for Honolulu Airport, and assumed return air conditions of 75F/50%RH.

** Baseline electricity consumption intensity is based on prototype simulation model results. See Appendix 4.

Energy Impact – HVAC 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.⁵ It is reasonable to expect energy savings of at least an average of 5% percent due to the Hawaii Code's requirement for commissioning. Only four of the 50 projects in this review included commissioning requirements listed on the plans.

Total Energy Impact

Combining the impact of interior lighting, fenestration, heat recovery, and commissioning; the total electricity consumption impact is roughly 7.1% for the projects in the sample, as shown in Table 67. The average electricity use intensity increases from a baseline of 25.1 to 26.9kWh/sf-yr.

It is important to note that this impact estimate is based on many assumptions and that the selected sample of review projects may not be representative of the whole population. However, the relative magnitude of results may be useful for informing efforts to improve compliance.

⁵ Mills, Evan, "Building Commissioning, A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions", LBNL, July 21. 2009.

Table 67. Energy Impact of Non-Compliance – Total for Reviewed Projects

	Electricity Consumption Impact (%)	Electricity Consumption (kWh/sf-yr)	Electricity Consumption (kWh/yr)
Baseline	--	25.1	52,114,600
Interior lighting impact	0.28%	0.070	145,921
Fenestration impact	0.62%	0.156	323,111
Energy recovery ventilation impact	1.18%	0.296	614,952
Commissioning impact	5.00%	1.255	2,605,730
Total	7.08%	26.9	55,804,314

When applied to the construction forecast for Hawaii, Honolulu and Maui Counties, the estimated lost savings due to energy code non-compliance is roughly 4.8 million kWh/yr, as shown in Table 68.

Table 68. Energy Impact of Non-Compliance – Forecast Total

	Electricity Consumption Impact (%)	Electricity Consumption (kWh/sf-yr)	Construction Forecast (sf/yr)	Electricity Consumption (kWh/yr)
Baseline	--	25.1	2,700,000	67,770,000
Interior lighting impact	0.28%	0.070		189,756
Fenestration impact	0.62%	0.156		420,174
Energy recovery ventilation impact	1.18%	0.296		799,686
Commissioning impact	5.00%	1.255		3,388,500
Total	7.08%	26.9		72,568,116
Lost Savings		1.78		4,798,116

Energy Impact – Low-rise Residential

The most significant potential energy impact of non-compliance with the current code is for low-rise residential windows and their impact on air conditioning energy. As shown earlier in the section on compliance review results, compliance rates are generally good for opaque envelope components. Compliance rates for windows are very uncertain due to a lack of performance information on plans submitted to the building departments.

An energy simulation model of a typical home was used for a rough estimate of the potential energy impact of non-compliance with the window SHGC requirements. A description of the prototype home model is included in Appendix 7.

Figure 9 shows how annual electricity consumption varies with window SHGC. A complying window has an SHGC of 0.40, and total electricity consumption is about 15,400 kWh per year. Consumption for a home with single-pane clear windows would be between 16,500 and 17,000 kWh per year, an increase of 8 to

10 percent. On the other hand, electricity consumption for a home with windows meeting the 2015 IECC, with an SHGC of 0.25, would consume about 3% less electricity.

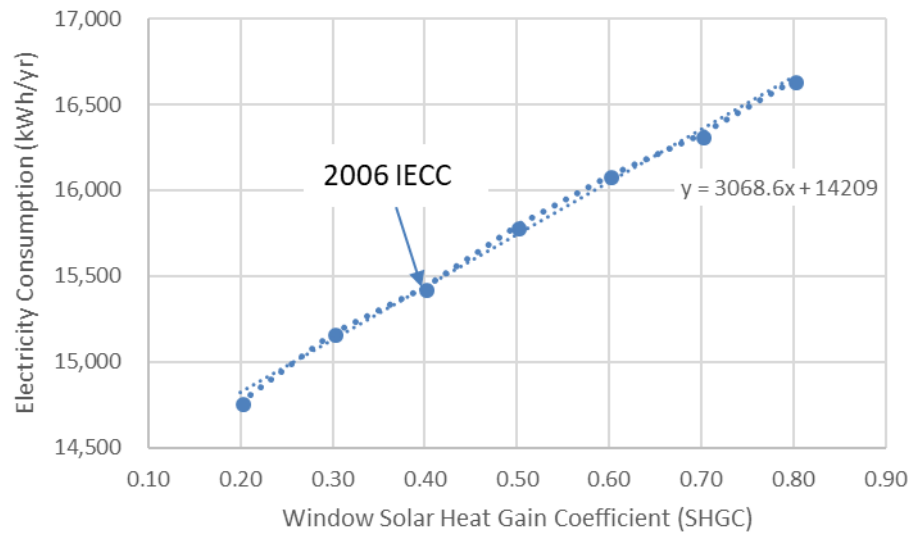


Figure 9. Simulation Results with Varying Window SHGC – Low-rise Residential Dwelling

This analysis shows that window performance has potentially significant impact on annual electricity consumption. It is not possible to make a specific estimate due to the uncertainty of the actual window performance in the reviewed projects, but the results indicate that it is likely there are some significant savings available through efforts to require window performance to be listed on building plans.

Recommendations

Non-residential and High-rise Residential

Performance Information on Plans and Updated Compliance Certifications

Develop simple guidelines that show minimum performance information that needs to be included on the plans for permit submittal. This information is often missing from the plans but is required by code. Promote used of proposed compliance certification blocks included in Appendix 9.

Key items:

- Lighting-fixture input power
- Window solar heat gain coefficient (SHGC)
- Roof insulation R-value

Other items:

- Wall insulation R-value
- Cooling equipment efficiency
- Duct insulation R-value

- Water heating equipment efficiency

Identify Code Version and Compliance Path on Plans

Ask that designers include a statement on the plans indicating which set of energy code requirements they are using for compliance. See the compliance blocks in Appendix 8 for an example.

Awareness of County Amendments

Improve awareness of the requirements in the County amendments, perhaps by encouraging the use of code compliance checklists that include requirements in the County amendments. It appears that designers are not aware of some of the code's requirements, especially the County amendments that require HVAC system commissioning and HVAC system adjusting and balancing.

Mechanical Plan Review for Large Projects

A significant portion of the lost savings found in this analysis was due to the lack of energy recovery in two large projects. This experience suggests that extra review of buildings with large HVAC systems may help capture future savings.

Guidance for Small Retail Compliance

Develop simple compliance information and/or incentive programs for small retail projects, including both new construction and renovations. Focus on lighting code compliance, including the compliance implications of track lighting. In this study, small retail projects are the type of project with the greatest lighting compliance issues.

Guidance for Fenestration Compliance

As noted earlier, window performance information is not shown on the plans for most of the reviewed projects. Due to the potentially significant impact on cooling loads and cooling energy consumption, efforts to improve window compliance are recommended.

Guidance for Mechanical System Commissioning

A brief document or webpage would be helpful. Useful information would include a description of the information that needs to be included on the plans, a sample scope of work for code-complying commissioning activities, and a list of resources for more information about the commissioning process.

Guidance on Envelope Requirements for Unconditioned Buildings

This is a problem for building officials. Ideally a simple guide on compliance options for unconditioned buildings, with information on the motivations for the requirements, such as occupant comfort.

Preparation for Adoption of 2015 IECC with Amendments

The upcoming code is significantly more stringent in many areas. Additional compliance guidance will likely be helpful in the following areas.

- Insulation of concrete and concrete masonry walls. This is not currently required.
- Continuous insulation on framed walls.
- Window U-factor requirements, which will require dual-pane, low-e glazing in most cases.
- Design, installation and commissioning of automatic daylighting controls.

Low-rise Residential

Performance Information on Plans

Promote the use of updated compliance certification blocks that include basic information about compliance path and information required on plans. Promote the concept to both building departments and designers. In addition, work to increase awareness among contractors of the low-rise residential requirements and the additional information that should be included on plans. See Appendix 8 for an example.

The highest priority information:

- Window SHGC
- Roof insulation R-value
- Wall insulation R-value
- Lighting fixture efficacy (lumens/watt)

HVAC Compliance Information Submitted to Building Department

Under the current permitting process, HVAC plans are not typically submitted for plan review. Therefore, building departments do not receive the information that would allow someone to verify that systems meet energy code requirements.

The recommendation is to work with the building departments, design professionals and builders to develop a process where designers or contractors are required to submit documentation showing compliance. This documentation could be similar in detail to the compliance certification block described above.

Electrical Compliance Information Submitted to Building Department

Building departments do not currently receive electrical plans for most low-rise residential projects. The recommendation here is like the previous recommendation for HVAC systems. It is important to work with building departments, design professionals and builders to let them know that the new code includes requirements related to high-efficacy lighting and ceiling fans. Some documentation will be necessary so that the building department or a third party could verify compliance.

Water Heating Information Submitted to Building Department

Consider a similar documentation requirement related to water heating systems, unless this documentation is already handled via enforcement of the state water heating regulation.

Guidance on Envelope Air Leakage Testing

Envelope air leakage testing using a blower door will be a new process to most Hawaii designers and builders. Some form of support will be helpful in improving compliance with the new code. That support could include flyers, a web page, and presentations to professional organizations.

Guidance on Duct Air Leakage Testing

Duct leakage testing is a new requirement for all air-conditioned residences. Therefore, it is recommended that support information be developed.

Appendix 1 – Summary of Selected Code Requirements – 2006 IECC – Non-residential and High-rise Residential

This section includes excerpts from the 2006 IECC for non-residential and high-rise residential projects.

Opaque Envelope Requirements – 2006

TABLE 502.2(1)
BUILDING ENVELOPE REQUIREMENTS – OPAQUE ASSEMBLIES

CLIMATE ZONE	1	2	3	4 except Marine	5 and Marine 4	6
Roofs						
Insulation entirely above deck	R-15 ci	R-15 ci	R-15 ci	R-15 ci	R-20 ci	R-20
Metal buildings (with R-5 thermal blocks ^{a)} ^b	R-19 + R-10	R-19	R-19	R-19	R-19	R-1
Attic and other	R-30	R-30	R-30	R-30	R-30	R-3
Walls, Above Grade						
Mass	NR	NR	R-5.7 ci ^{c, e}	R-5.7 ci ^c	R-7.6 ci	R-9.5
Metal building ^b	R-13	R-13	R-13	R-13	R-13 + R-13	R-13 R-1
Metal framed	R-13	R-13	R-13	R-13	R-13 + R-3.8 ci	R-13 R-3.8
Wood framed and other	R-13	R-13	R-13	R-13	R-13	R-1
Walls, Below Grade						
Below grade wall ^d	NR	NR	NR	NR	NR	NR
Floors						
Mass	NR	R-5 ci	R-5 ci	R-10 ci	R-10 ci	R-10
Joist/Framing	NR	R-19	R-19	R-19	R-19	R-3
Slab-on-Grade Floors						
Unheated slabs	NR	NR	NR	NR	NR	NR
Heated slabs	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 24 in. below	R-1 for 36 in. below
Opaque Doors						
Swinging	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0
Roll-up or sliding	U – 1.45	U – 1.45	U – 1.45	U – 1.45	U – 1.45	U – 0

Fenestration Requirements – 2006

**TABLE 502.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION**

Climate Zone	1	2	3	4 except Marine	5 and Marine 4
Vertical Fenestration (40% maximum of above-grade wall)					
<i>U</i> -Factor					
Framing materials other than metal with or without metal reinforcement or cladding					
<i>U</i> -Factor	1.20	0.75	0.65	0.40	0.35
Metal framing with or without thermal break					
Curtain Wall/Storefront <i>U</i> -Factor	1.20	0.70	0.60	0.50	0.45
Entrance Door <i>U</i> -Factor	1.20	1.10	0.90	0.85	0.80
All Other <i>U</i> -Factor ^a	1.20	0.75	0.65	0.55	0.55
SHGC-All Frame Types					
SHGC: PF < 0.25	0.25	0.25	0.25	0.40	0.40
SHGC: 0.25 ≤ PF < 0.5	0.33	0.33	0.33	NR	NR
SHGC: PF ≥ 0.5	0.40	0.40	0.40	NR	NR
Skylights (3% maximum)					
Glass					
<i>U</i> -Factor	1.60	1.05	0.90	0.60	0.60
SHGC	0.40	0.40	0.40	0.40	0.40
Plastic					
<i>U</i> -Factor	1.90	1.90	1.30	1.30	1.30
SHGC	0.35	0.35	0.35	0.62	0.62

NR = No requirement.

PF = Projection factor (See Section 502.3.2)

a. All others includes operable windows, fixed windows and non-entrance doors.

Interior Lighting Power Allowances – 2006

**TABLE 505.5.2
INTERIOR LIGHTING POWER ALLOWANCES**

LIGHTING POWER DENSITY	
Building Area Type ^a	(W/ft ²)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare-Clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multi-Family	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail ^b	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

- a. In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.
- b. Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or 1.6 W/ft² times the area of the specific display but not to exceed 50% of the floor area, or 3.9 W/ft² times the actual case or shelf area for displaying and selling jewelry, china or silver, shall be added to the interior lighting power determined in accordance with this line item.

Exterior Lighting Power Allowances – 2006

**TABLE 505.6.2
LIGHTING POWER DENSITIES FOR BUILDING EXTERIORS**

APPLICATIONS	LIGHTING POWER DENSITIES
Tradable Surfaces (Lighting Power Densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded.)	
Uncovered Parking Areas	
Parking Lots and drives	0.15 W/ft ²
Building Grounds	
Walkways less than 10 feet wide	1.0 watts/linear foot
Walkways 10 feet wide or greater, plaza areas and special feature areas	0.2 W/ft ²
Stairways	1.0 W/ft ²
Building Entrances and Exits	
Main entries	30 watts/linear foot of door width
Other doors	20 watts/linear foot of door width
Canopies and Overhangs	
Canopies (free standing & attached and overhangs)	1.25 W/ft ²
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft ²
Street frontage for vehicle sales lots in addition to "open area" allowance	20 watts/linear foot
Nontradable Surfaces (Lighting Power Density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the Tradable Surfaces section of this table.)	
Building facades	0.2 W/ft ² for each illuminated wall or surface or 5.0 Watts/linear foot for each illuminated wall or surface length
Automated teller machines and night depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Drive-up windows at fast food restaurants	400 watts per drive-through
Parking near 24-hour retail entrances	800 watts per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

Unitary Air Conditioner Efficiency Requirements – 2006

TABLE 503.2.3(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS,
ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY ^b	TEST PROCEDURE ^a
Air conditioners, Air cooled	< 65,000 Btu/h ^d	Split system	10.0 SEER	ARI 210/240
		Single package	9.7 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.3 EER ^c	ARI 340/360
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.7 EER ^c	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.5 EER ^c 9.7 IPLV ^c	
Air conditioners, Water and evaporatively cooled	≥ 760,000 Btu/h	Split system and single package	9.2 EER ^c 9.4 IPLV ^c	ARI 210/240
	< 65,000 Btu/h	Split system and single package	12.1 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER ^c	ARI 340/360
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER ^c	
	≥ 240,000 Btu/h	Split system and single package	11.0 EER ^c 10.3 IPLV ^c	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER values are those set by NAECA.

Appendix 2 – Summary of Selected Code Requirements – 2015 IECC Non-residential and High-rise Residential

This section includes excerpts from the 2015 IECC.

Envelope Requirements – 2015

Roof – insulation above deck	R-25 or U-0.039 (group R) R-20 or U-0.048 (others)	C402.1, C402.2
Roof – metal building	R-19 + R-11 or U-0.044 (with thermal block and liner system)	C402.1, C402.2
Roof – attic or other	R-38 or U-0.027	C402.1, C402.2
Wall – mass (CMU or concrete)	R-5.7 or U-0.151	C402.1, C402.2
Wall – metal building	R-13 + R6.5 or U-0.079	C402.1, C402.2
Wall – metal frame	R-13 + R-5 or U-0.077 (R-5 not required with reflectance ≥ 0.64 or shading $PF \geq 0.3$)*	C402.1, C402.2*
Wall – wood frame and other	R-13 + R3.8 or R-20 or U-0.064 (R-3.8 not required with reflectance ≥ 0.64 or shading $PF \geq 0.3$)*	C402.1, C402.2*
Door – swinging	U-0.61	C402.1
Door – non-swinging	R-4.75	C402.1
Low-slope roof membrane	Aged reflectance ≥ 0.55 + aged emittance ≥ 0.75, or aged reflectance ≥ 0.64 (exceptions available)	C402.3
Windows – maximum area	$\leq 30\%$ of gross wall area ($\leq 40\%$ when meeting daylighting requirements)	C402.4.1
Windows – solar heat gain coefficient (SHGC)	≤ 0.25 if projection factor < 0.2 . ≤ 0.30 if projection factor $0.2-0.5$. ≤ 0.40 if projection factor ≥ 0.5 .	C402.4.3
Windows – U-factor	≤ 0.50 fixed fenestration ≤ 0.65 operable fenestration ≤ 1.10 entrance doors	C402.4.3
Skylights – minimum area	Skylights and daylight responsive controls required for certain spaces $\geq 2,500$ ft ² with ceiling height ≥ 15 ft.	C402.4.2
Skylights – maximum area	$\leq 3\%$ of gross roof area ($\leq 5\%$ when meeting daylighting requirements)	C402.4.1.2
Skylights – solar heat gain coefficient (SHGC)	≤ 0.35 (≤ 0.60 with daylighting control)	C402.4.3
Skylights – U-factor	≤ 0.75 (≤ 0.90 with daylighting control)	C402.4.3
Air leakage	▪ Continuous air barrier ▪ Fenestration air leakage ▪ Openings to shafts, chutes, stairways and elevator lobbies ▪ Air intakes, exhaust openings, stairways, and shafts. ▪ Loading-dock weatherseals ▪ Recessed lighting	C402.5

Interior Lighting Power Allowances – 2015

TABLE C405.4.2(1)
INTERIOR LIGHTING POWER ALLOWANCES:
BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (w/ft ²)
Automotive facility	0.80
Convention center	1.01
Courthouse	1.01
Dining: bar lounge/leisure	1.01
Dining: cafeteria/fast food	0.9
Dining: family	0.95
Dormitory	0.57
Exercise center	0.84
Fire station	0.67
Gymnasium	0.94
Health care clinic	0.90
Hospital	1.05
Hotel/Motel	0.87
Library	1.19
Manufacturing facility	1.17
Motion picture theater	0.76
Multifamily	0.51
Museum	1.02
Office	0.82
Parking garage	0.21
Penitentiary	0.81
Performing arts theater	1.39
Police station	0.87
Post office	0.87
Religious building	1.0
Retail	1.26
School/university	0.87
Sports arena	0.91
Town hall	0.89
Transportation	0.70
Warehouse	0.66
Workshop	1.19

Exterior Lighting Power Allowances – 2015

TABLE C405.5.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

		LIGHTING ZONES			
		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)		500 W	600 W	750 W	1300 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas are tradable.)	Uncovered Parking Areas				
	Parking areas and drives	0.04 W/ft ²	0.06 W/ft ²	0.10 W/ft ²	0.13 W/ft ²
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft ²	0.14 W/ft ²	0.16 W/ft ²	0.2 W/ft ²
	Stairways	0.75 W/ft ²	1.0 W/ft ²	1.0 W/ft ²	1.0 W/ft ²
	Pedestrian tunnels	0.15 W/ft ²	0.15 W/ft ²	0.2 W/ft ²	0.3 W/ft ²
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft ²	0.25 W/ft ²	0.4 W/ft ²	0.4 W/ft ²
	Sales Canopies				
	Free-standing and attached	0.6 W/ft ²	0.6 W/ft ²	0.8 W/ft ²	1.0 W/ft ²
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft ²	0.25 W/ft ²	0.5 W/ft ²	0.7 W/ft ²
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.075 W/ft ² of gross above-grade wall area	0.113 W/ft ² of gross above-grade wall area	0.15 W/ft ² of gross above-grade wall area
	Automated teller machines (ATM) and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area	0.75 W/ft ² of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area	0.5 W/ft ² of covered and uncovered area
	Drive-up windows/doors	400 W per drive-through	400 W per drive-through	400 W per drive-through	400 W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W per main entry

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m².

W = watts.

Unitary Air Conditioner Efficiency Requirements – 2015

TABLE C403.2.3(1)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE ^a
				Before 1/1/2016	As of 1/1/2016	
Air conditioners, air cooled	< 65,000 Btu/h ^b	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
			Single Package	13.0 SEER	14.0 SEER ^c	
Through-the-wall (air cooled)	≤ 30,000 Btu/h ^b	All	Split system	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h ^b	All	Split System	11.0 SEER	11.0 SEER	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 12.8 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 12.2 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 11.6 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 11.2 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 11.0 IEER	
Air conditioners, water cooled	< 65,000 Btu/h ^b	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 13.9 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.5 EER 12.5 IEER	12.5 EER 13.9 IEER	
		All other	Split System and Single Package	12.3 EER 12.5 IEER	12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.4 EER 12.6 IEER	12.4 EER 13.6 IEER	
		All other	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 12.4 IEER	12.2 EER 13.5 IEER	
		All other	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 13.3 IEER	

(continued)

TABLE C403.2.3(1)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE ^a
				Before 1/1/2016	As of 1/1/2016	
Air conditioners, evaporatively cooled	< 65,000 Btu/h ^b	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.0 EER 12.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	11.8 EER 12.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.9 EER 12.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 11.9 IEER	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	11.5 EER 11.7 IEER	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.5 EER 11.8 IEER	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.5 EER 14.0 IEER	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

c. Minimum efficiency as of January 1, 2015.

Appendix 3 – Summary of Selected Code Requirements – 2006 IECC Low-rise Residential

Table 69. Summary of 2006 IECC Requirements – Low-rise Residential

	2006 IECC
Roof – wood frame	R-30*
Roof – metal frame	R-38*
Wall – mass (CMU or concrete)	R-3
Wall – metal frame	R-13 + R-5 *
Wall – wood frame and other	R-13
Floor – wood frame	R-13
Floor – metal frame	R-19
Windows – max. SHGC	0.25
Skylights – max. SHGC	0.30
Skylights – U-factor	0.75
Air leakage testing	None
Duct leakage testing	None
Lighting	None

* Hawaii amendments apply.

Appendix 4 – Summary of Selected Code Requirements – 2015 IECC Low-rise Residential

The following table lists the prescriptive requirements for low-rise residential buildings in the 2015 IECC

Component/System	Requirement	Code Section
Certification	Responsible design professional certification on plans	R103.1*
Construction documents	Include: - Insulation R-values - Fenestration U-factors and solar heat gain coefficients (SHGCs)	R103.2
Roof – wood frame	☐ R-30 or U-0.035 , ☐ Total UA alternative, or ☐ Points option	R402.1, R402.1.5, R407*
Roof – metal truss	☐ R-38 or U-0.035 , ☐ R-30 + R-3 , or ☐ R-26 + R-5 , ☐ Total UA alternative, or ☐ Points option	R402.1, R402.2, R402.1.5, R407*
Roof – metal joist	☐ R-30 in 2x4, 2x6 or 2x8 framing, or ☐ R-49 in any framing ☐ Total UA alternative, or ☐ Points option	R402.1, R402.2, R402.1.5, R407*
Wall – wood frame	☐ R-13 or U-0.084 ☐ Total UA alternative, or ☐ Points option	R402.1, R402.1.5, R407*

Component/System	Requirement	Code Section
Wall – metal frame	Framing 16 in. on center: ☐ R-13 + R-4.2 ☐ R-19 + R-2.1 ☐ R-21 + R-2.8 Framing 24 in. on center: ☐ R-13 + R-3.0 ☐ R-15 + R-2.4 ☐ <i>Total UA alternative, or</i> ☐ <i>Points option</i>	R402.1, R402.2, R402.1.5, R407*
Wall – mass (CMU or concrete)	☐ R-3 exterior, R-4 interior or U-0.197 ☐ <i>Total UA alternative, or</i> ☐ <i>Points option</i>	R402.1
Raised floor – wood or concrete	☐ R-13 or U-0.064 ☐ <i>Total UA alternative, or</i> ☐ <i>Points option</i>	R402.1
Raised floor – metal frame	☐ R-19 in 2x6 framing ☐ R-19 + R-6 in 2x8 or 2x10 framing ☐ <i>Total UA alternative, or</i> ☐ <i>Points option</i>	R402.1
Slab-on-grade floor	No requirement	
Windows & skylights	SHGC ≤ 0.25 Area-weighted average permitted as long as no window or skylight has SHGC > 0.50. Up to 15 ft ² exempt.	R402.3
Air leakage – installation	▪ Continuous air barrier ▪ Breaks or joints are sealed ▪ Recessed lighting ▪ Fenestration air leakage	R402.4
Air leakage - testing	Leakage ≤ 5 air changes per hour tested at pressure of 0.2 in. w.g. (50 Pascals)	R402.4.1.2
AC controls	Programmable thermostat	R403.1.1
Duct insulation	In unconditioned attic: R-8 for ducts ≥ 3 in. diameter R-6 for ducts < 3 in. diameter Other locations: R-6 for ducts ≥ 3 in. diameter R-4.2 for ducts < 3 in. diameter Within building thermal envelope: No requirements	R403.3.1
Duct testing	Rough-in before air handler installed: $\leq 3 \text{ cfm}/100 \text{ ft}^2$ at 0.1 in. w.g. (25 Pa) Rough-in after air handler installed: $\leq 4 \text{ cfm}/100 \text{ ft}^2$ at 0.1 in. w.g. (25 Pa) Postconstruction: $\leq 4 \text{ cfm}/100 \text{ ft}^2$ at 0.1 in. w.g. (25 Pa) (No testing required if ducts are located completely within the thermal envelope.)	R403.3.3, R403.3.4
Water heating – circulation systems	Pump required. Automatic controls required.	R403.5.1.1
Water heating – heat trace systems	Automatic controls required	R403.5.1.2
Water heating – demand recirculation systems	Control requirements	R403.5.2

Component/System	Requirement	Code Section
Water heating – pipe insulation	R-3 insulation for all the following pipe conditions: - diameter $\geq \frac{3}{4}$ in. diameter - serves more than one dwelling - outside conditioned space - from water heater to manifold - under floor slab - buried - circulation systems	R403.5.3
Water heating – solar systems	Required for new single-family	R403.5.5*
Pools and permanent spas	Heaters. Electric power switch required. No gas pilot. Automatic time switches on heater and pumps. Covers required (except with solar heating) Comply with APSP-15 standard.	R403.10 R403.12
Lighting	$\geq 75\%$ of lamps or fixtures are high-efficacy	R404.1
Ceiling fans	A ceiling fan or ceiling fan rough-in is provided for bedrooms and the largest space that is not used as bedroom.	R404.2*

* Code section added or modified by Hawaii amendment

Appendix 5 - Project Review Checklist

The information listed in the following table was recorded for each project in a spreadsheet.

Checklist for Non-residential and High-rise Residential

IDENTIFICATION
Review date
Review location
Review time
Project Name
County
Address
County ID number
Architect
Plan date
Sample group
Construction phase
DESCRIPTION
General description
Building type
Floor area
Number of stories
Compliance method
Software used
Notes
CERTIFICATION
Certification - envelope
Certification - lighting
Certification - mechanical
Certification - water heating
Other compliance information
LIGHTING
Notes
Lighting luminaire description(s)
Installed interior lighting power
Allowed interior lighting power
Designed interior lighting power (for report)
Allowed interior lighting power (for report)
Light reduction controls.
Automatic lighting shutoff
Exterior efficiency sources (if >100W, then >60 lumens/W)
Exterior lighting power
Allowed exterior lighting power
Designed exterior lighting power (for report)
Allowed exterior lighting power (for report)
Exterior lighting controls
Screw lamp, low-voltage, track luminaires
ENVELOPE - OPAQUE
Notes
Roof type (above deck, metal bldg., attic/other)

Insulation type
Insulation R-value
Roof insulation R-value (for report)
Required roof insulation R-value
Membrane (cool roof)
Wall type (mass, metal, steel frame, wood)
Insulation type
Insulation R-value
Wall insulation R-value (for report)
Required wall insulation R-value
ENVELOPE - FENESTRATION
Notes
Window area/WWR
Glazing type
Frame type
Window U-factor
Window SHGC north
Window SHGC non-north
Window shading type
Window overhang projection factor
Skylight area
Skylight-roof area ratio
Skylight glazing type
Skylight frame type
Skylight U-factor
Skylight SHGC
HVAC
Notes
Cooling equipment type
Cooling equipment capacity
Cooling equipment efficiency
Fan system efficiency (not in IECC)
Off-hour controls
Energy recovery (if >5000 cfm & >70% OA)
Duct insulation (R-5 in unconditioned, R-8 outdoors)
VAV fan control
Hydronic system controls
Heat rejection equipment fan speed control
Multiple-zone system control (min flow)
Heat recovery for water heating (if >500 tons & 24 hr.)
Commissioning (drawing notes required)
Systems adjusting and balancing (drawing notes required)
SERVICE WATER HEATING
Notes
Water heater efficiency
Pipe insulation
Manual or auto shutoff for circulating controls
ELECTRICAL
Tenant sub metering (Hawaii only)

In addition to the information above, the following information is collected for the purpose of checking compliance with the 2015 IECC.

Allowed interior lighting power
Allowed interior lighting power (for report)
Daylight responsive controls
Allowed exterior lighting power
Allowed exterior lighting power (for report)
Required roof insulation R-value
- Roof replacement requires compliance
Required wall insulation R-value
- Continuous insulation not required for framed walls with $\text{refl} \geq 0.64$, $\text{PF} \geq 0.3$
Window max. Ufactor requirement
Window max. SHGC requirement
Cooling equipment efficiency requirement
Demand control ventilation, >500 sf, >25 p/1000sf,
Garage ventilation control
Energy recovery
- hotel door switches
Refrigeration with remote condensers
Kitchen exhaust
Transformers
Electric motors
Submetering
Commissioning - mechanical
Commissioning - service water heating
Commissioning - preliminary report
Commissioning - lighting controls (OS, time switch, daylight)

Checklist for Low-rise Residential

IDENTIFICATION
Review date
Review location
Review time
Project Name
County
Address

Location On Island
County ID number
Architect
Plan date
Sample group
Construction phase
DESCRIPTION
General description
Building type
Floor area (sf)
Number of stories
Other
CERTIFICATION
Certification - envelope
Certification - lighting
Certification - mechanical
Certification - water heating
Certification - energy code
REQUIREMENTS
Fenestration U-Factor
Fenestration U-Factor (Assembly)
Skylight U-Factor
Skylight U-Factor (Assembly)
Glazed Fenestration SHGC
Ceiling R-Value
Ceiling U-Factor
Wood Frame Wall R-Value
Frame Wall U-Factor (Assembly)
Mass Wall R-Value
Mass Wall U-Factor (Assembly)
Floor R-Value
Floor U-Factor (Assembly)
Basement Wall R-Value
Basement Wall U-Factor (Assembly)
Slab R-Value & Depth
Crawl Space Wall R-Value
Crawl Space Wall U-Factor (Assembly)
Air Leakage - Overall Dwelling Unit
Air Leakage - Windows/Skylights/Sliding Door
Air Leakage - Swinging Doors
Air Leakage - Jalousie Windows
Air Leakage - Recessed Lighting

Cooling/Heating Systems - Controls
Duct - Insulation
Duct - Leak Test (Post Construction)
Mechanical System Piping - Insulation
Mechanical Ventilation System Fan Efficacy
Cooling Equipment Efficiency Rating
Ceiling Fans
Solar Water Heating
Electric Water Heater
Lighting

Appendix 6 – Fenestration Modeling – Non-residential and High-rise Residential

Simulations were used to estimate the energy impact of fenestration shading non-compliance. Prototype models developed by Pacific Northwest National Laboratory were run using Honolulu weather data with varying window performance and overhang sizes. The prototype buildings otherwise meet requirements of the 2006 IECC. Detailed modeling assumptions are included in documentation developed by PNNL⁶.

Three building types were selected for this analysis because the most closely matched the buildings in this study where windows did not meet minimum code requirements. Those three buildings are 1) medium office, 2) large hotel, and 3) retail strip mall.

EnergyPlus version 8.1 was used for these simulations. The weather data TMY3 data for Honolulu Airport (file name: USA_HI_Honolulu.Intl.AP.911820_TMY3.epw).

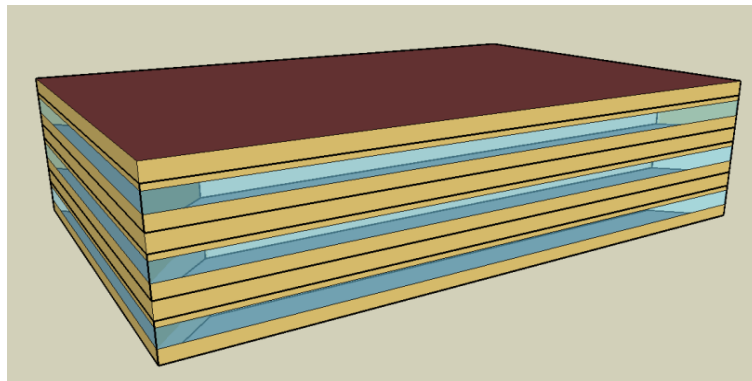


Figure 10. Prototype Simulation Model – Medium Office Building

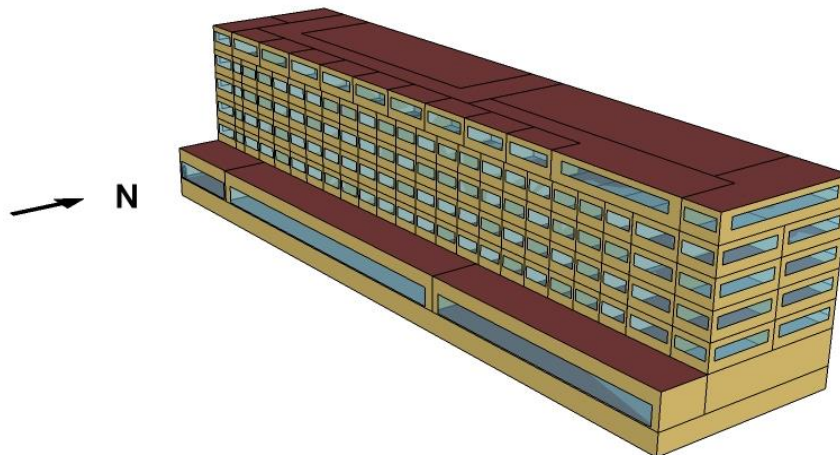


Figure 11. Prototype Simulation Model – Large Hotel

⁶ https://www.energycodes.gov/development/commercial/prototype_models

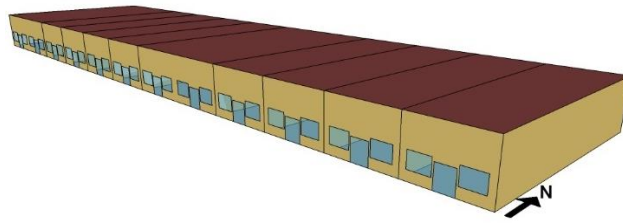


Figure 12. Prototype Simulation Model – Retail Strip Mall

The electricity end-use results for the three buildings are shown in the following three figures. Results cover seven glass types, ranging in solar heat gain coefficient (SHGC) from 0.25 to 0.80. As expected, cooling energy increases as SHGC increases. Fan energy also increases a modest amount.

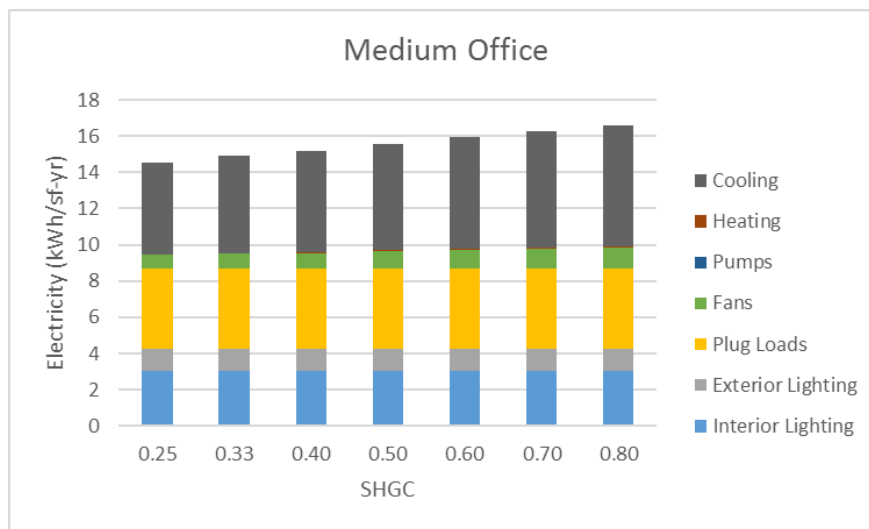


Figure 13. Simulation Results with Varying Window SHGC – Medium Office

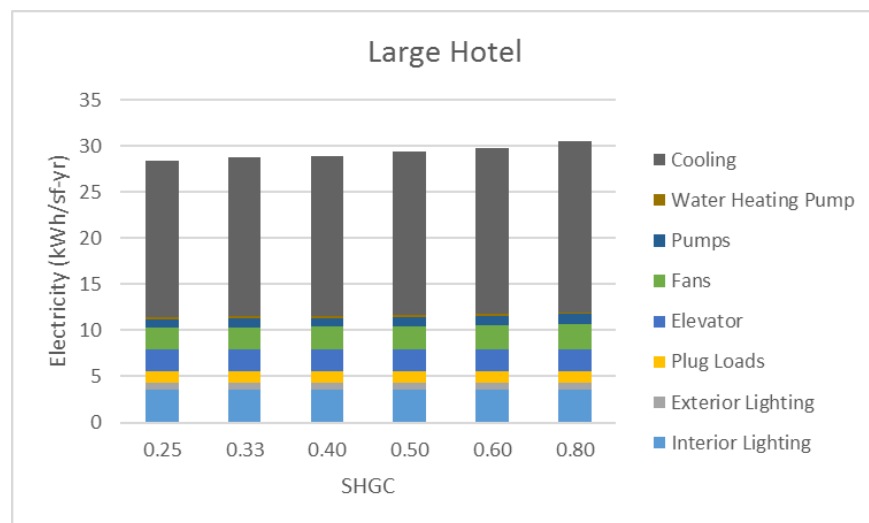


Figure 14. Simulation Results with Varying Window SHGC – Large Hotel

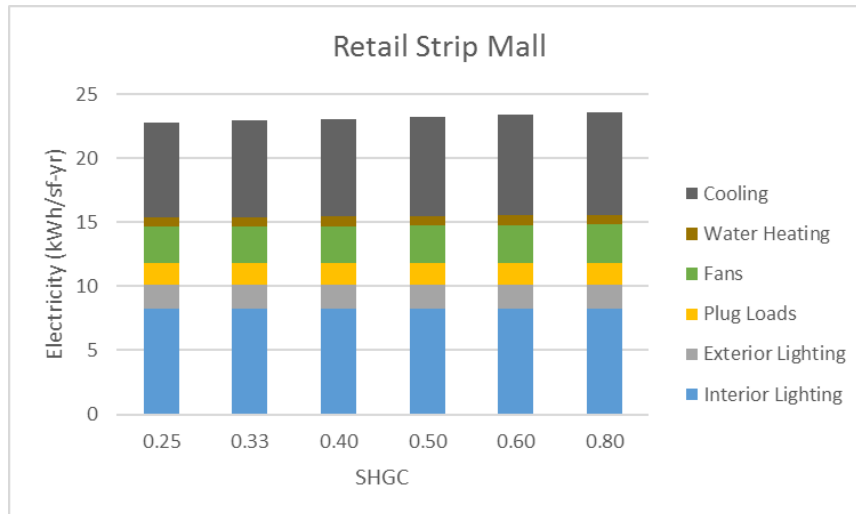


Figure 15. Simulation Results with Varying Window SHGC – Retail Strip Mall

The 2006 IECC allows use of overhangs for compliance with the window requirements, and the following three figures show the impact of both SHGC and overhang projection factor (PF). The results show that the result is similar for each of the three compliance options: 1) SHGC 0.25 with no overhang, 2) SHGC 0.33 with 0.25 projection factor, and 3) SHGC 0.40 with 0.50 projection factor. The results shown in these plots can be used to estimate the energy impact of glazing and overhang conditions that do not meet code requirements.

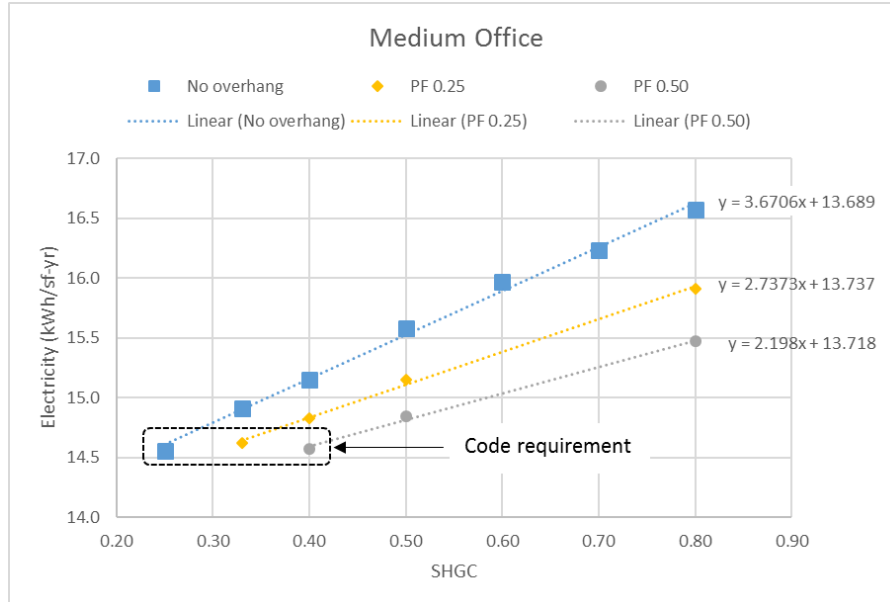


Figure 16. Impact of Window SHGC and Overhang Shading – Medium Office

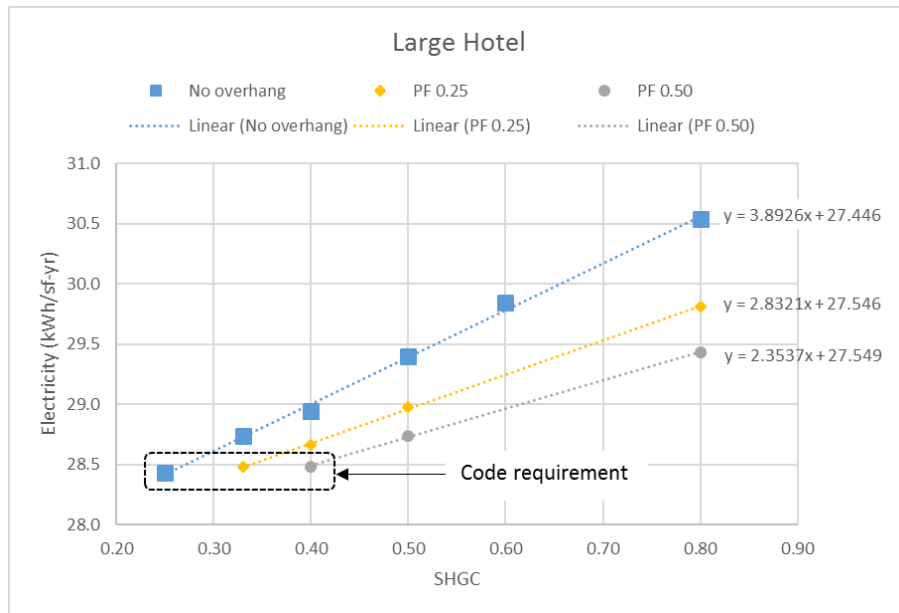


Figure 17. Impact of Window SHGC and Overhang Shading – Large Hotel

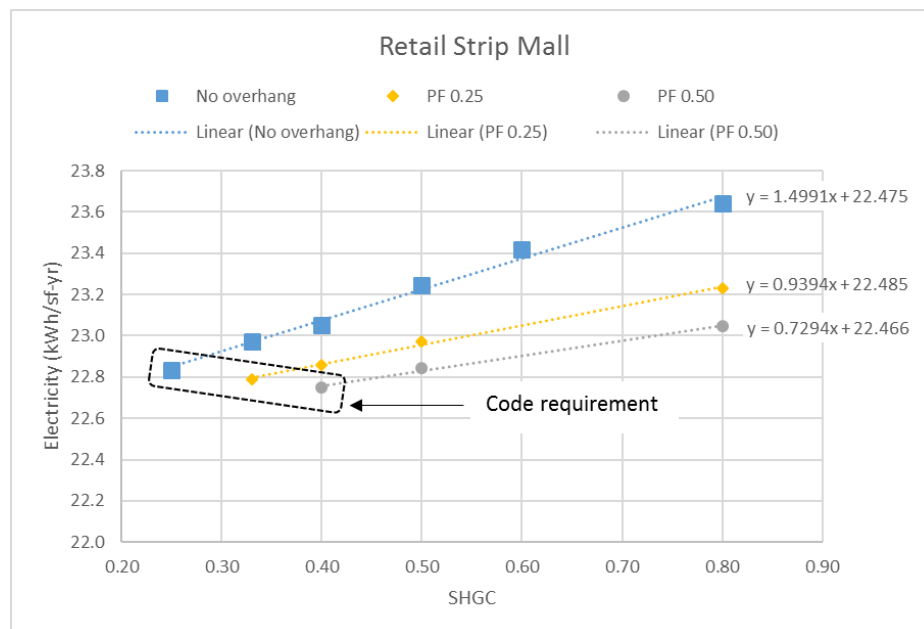


Figure 18. Impact of Window SHGC and Overhang Shading – Retail Strip Mall

Appendix 7 – Fenestration Modeling – Low-rise Residential

Residential Model Starting Point

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 ft² floor area.
- Slab-on-grade floor
- Air conditioning and heat pump heating, with 24 hour-per-day conditioning and 75°F cooling setpoint
- 2006 IECC minimum equipment efficiency, including SEER 13 air conditioner
- Electric water heating (no solar water heating)
- Honolulu Airport weather data
- IECC 2006 compliance

The file was downloaded from 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/>.

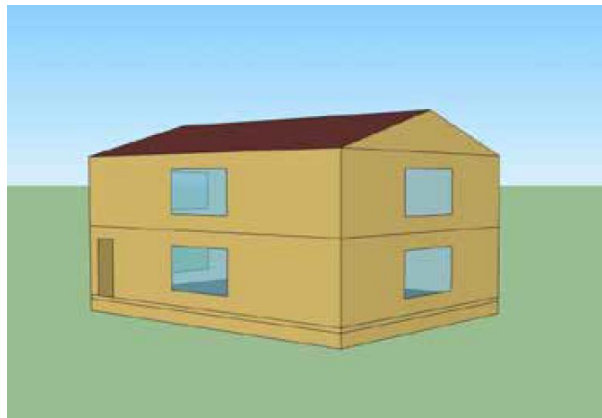


Figure 19. Residential Prototype Model

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

Residential Model Modifications and Assumptions

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

- The file was updated to run on EnergyPlus v8.6.
- 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 in². Based on a survey of literature on measured attic ventilation rates it appears that an average ventilation rate of about 2.7 ach is typical⁷. Therefore, the baseline attic ELA was increased to 114.7 in², 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.

⁷ 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 8 – Suggested Designer Compliance Certification Block – Low-rise Residential

COUNTY OF [REDACTED] [COUNTY'S ENERGY CODE NAME]		
To the best of my knowledge, this project's design substantially conforms to the Residential Provisions of [COUNTY'S ENERGY CODE NAME] (2015 IECC as amended).		
COMPLIANCE METHOD		
☐ Tropical Zone. R401.2.1 ☐ Prescriptive. R402		
Roof and Wall		
☐ Insulation R-value. Table R401.1.2 ☐ Construction U-factor. Table R402.1.4 ☐ Total UA. R402.1.5 ☐ Points Option. R407		
☐ Simulated Performance Alternative. R405 ☐ Energy Rating Index Compliance Alternative. R406		
INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Envelope		
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window and skylight SHGC	☐	☐
Air leakage testing requirement	☐	☐
Air Conditioning		
Air conditioning equipment capacity and efficiency	☐	☐
Programmable thermostat	☐	☐
Duct insulation R-value	☐	☐
Duct leakage testing requirement	☐	☐
Electrical		
Lighting fixture locations	☐	☐
Lamp type	☐	☐
Ceiling fans	☐	☐
Whole-house fan	☐	☐
NOTES		
SIGNATURE:		
DATE:		
NAME:		
TITLE:		
LICENSE NO.:		

Appendix 9 – Suggested Designer Compliance Certification Block – Non-residential and High-rise Residential

COUNTY OF [REDACTED] [COUNTY'S ENERGY CODE NAME]		
To the best of my knowledge, this project's design substantially conforms to the [CODE NAME] (2015 IECC as amended) for building envelope components (Section C402).		
COMPLIANCE METHOD		
☐ 2015 IECC as amended. Mandatory & Prescriptive ☐ 2015 IECC as amended. Mandatory & Total Building Performance ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget Method		
INFORMATION IN CONSTRUCTION DOCUMENTS	Yes	N/A
Roof insulation R-value	☐	☐
Roof insulation type and location	☐	☐
Roof membrane solar reflectance and thermal emittance	☐	☐
Wall insulation R-value	☐	☐
Wall insulation type and location	☐	☐
Window SHGC	☐	☐
Window U-factor	☐	☐
Skylight SHGC	☐	☐
Skylight U-factor	☐	☐
NOTES		
SIGNATURE:		
DATE:		
NAME:		
TITLE:		
LICENSE NO.:		

COUNTY OF [COUNTY'S ENERGY CODE NAME]		
To the best of my knowledge, this project's design substantially conforms to the [CODE NAME] (2015 IECC as amended) for mechanical systems (Sections C403, C404 and C408).		
COMPLIANCE METHOD ☐ 2015 IECC as amended. Mandatory & Prescriptive ☐ 2015 IECC as amended. Mandatory & Total Building Performance ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget		
INFORMATION IN CONSTRUCTION DOCUMENTS HVAC Systems Equipment capacity and efficiency. C403.2.3 Thermostatic controls C403.2.4 Guest room door switches. C403.2.4.2.4 Ventilation rate C403.2.6 Demand control ventilation controls C403.2.6.1 Enclosed parking garage ventilation control. C403.2.6.2 Energy recovery ventilation system. C403.2.7 Kitchen exhaust systems. C403.2.8 Duct and plenum insulation thickness/R-value. C403.2.9 Duct and plenum sealing requirements. C403.2.9 Pipe insulation thickness/R-value. C403.2.10 Fan motor horsepower. C403.2.12 Fan efficiency. C403.2.12 Fan motor efficiency. C405.8 Pump motor efficiency. C405.8 Variable-flow fan control. C403.4.1 Static pressure sensor location. C403.4.1.2 Static pressure reset control. C403.4.1.3 Chilled water variable flow control. C403.4.2.4 Chiller isolation. C403.4.2.6 Cooling tower fan control. C403.4.3 Terminal unit minimum and maximum airflow. C403.4.4 Commissioning requirements. C408.2 Refrigeration Refrigeration equipment efficiency. C403.2.14 Walk-in coolers and freezers. C403.2.15, C403.2.16 & C403.5 Refrigerated warehouses. C403.2.15 & C403.5 Refrigerated display cases. C403.2.17 & C403.5 Service Water Heating Heat recovery for service water heating. C403.4.5 Equipment capacity and efficiency. C404.2 Pipe insulation. C404.4 Hot water pipe length/volume. C404.5 Hot water circulation controls. C404.6 Heated pool and spa covers. C404.9.3 Commissioning requirements. C408.2	Yes	N/A
NOTES		
SIGNATURE:		
DATE:		
NAME:		
TITLE:		
LICENSE NO.:		

COUNTY OF [REDACTED]
[COUNTY'S ENERGY CODE NAME]

To the best of my knowledge, this project's design substantially conforms to the [CODE NAME] (2015 IECC as amended) for **electrical and lighting systems** (Section C405 and C408).

COMPLIANCE METHOD

- ☐ 2015 IECC as amended. Mandatory & Prescriptive
- ☐ 2015 IECC as amended. Mandatory & Total Building Performance
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Prescriptive
- ☐ ASHRAE Standard 90.1-2013. Mandatory & Energy Cost Budget

INFORMATION IN CONSTRUCTION DOCUMENTS

	Yes	N/A
Interior Lighting		
Occupant sensor controls. C405.2.1	☐	☐
Time switch controls. C405.2.2	☐	☐
Daylight responsive controls. C405.2.3	☐	☐
Daylight zones on plans. C405.2.3.2 & C405.2.3.3	☐	☐
Guest room controls. C405.2.4	☐	☐
Interior lighting fixture schedule	☐	☐
Input power for interior lighting fixtures. C405.4.1	☐	☐
Interior lighting fixture locations	☐	☐
Lighting control functional performance testing requirement. C408.3	☐	☐
Exterior Lighting		
Exterior lighting controls. C405.2.5	☐	☐
Exterior lighting fixture schedule	☐	☐
Input power for exterior lighting fixtures	☐	☐
Exterior lighting fixture locations	☐	☐
Electrical		
Electrical transformer efficiency. C405.7	☐	☐
Tenant submetering. C405.10	☐	☐

NOTES

SIGNATURE:

DATE:

NAME:

TITLE:

LICENSE NO.: