Energy Code Compliance Study

Honolulu and Hawaii Counties

January 15, 1999

State of Hawaii
Department of Business, Economic Development, and Tourism
Energy, Resources, and Technology Division

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1. Executive Summary

This report describes results of a study to check levels of energy code compliance on the islands of Oahu and Hawaii. This study reviews 32 building plans for projects that received permits after the revised building codes were adopted. These 32 include 21 in Honolulu and 11 in Hawaii County. Eighteen are new construction, and 14 are renovations or tenant improvements. Field inspections were not performed in this study.

Construction levels

Construction levels in 1994 through 1997 are close to those predicted in the Impact Report for the Hawaii Model Energy Code (December 1993). New construction was predicted to be 2.2 million ft^2 per year for nonresidential buildings, and the actual values range from 1.6 to 2.7 million ft^2. Renovations of retail and office spaces was predicted to be just over 1.2 million ft^2, and the and actual annual construction was between 1.2 and 1.6 million ft^2 per year.

Lighting power compliance

Out of 32 total buildings, 22 meet or exceed the lighting power requirements, 9 do not comply, and 1 is not applicable. Floor area of complying buildings adds up to 355,000 ft^2 (87%) and non-complying buildings equal 53,000 ft^2 (13%). Unrealized savings due to non-compliance are about 5% of total lighting power in new buildings and renovations.

Lighting controls compliance

Fourteen buildings meet all the lighting control requirements, 12 have minor compliance problems, and 5 show moderate problems. Potential lighting energy savings due to improved controls compliance is between 1.4% and 2.8% of all new projects. The most common problem was too few controls in small rooms like offices, conference rooms, and classrooms.

Envelope compliance

Slightly more than half of the plans required envelope compliance (the others were lighting and/or HVAC only). Compliance rates were 14 of 18 for roofs and 14 of 17 for walls and windows. The energy impact of the envelope non-compliance cases is not large because most of the significant problems were in buildings without air conditioning.

HVAC compliance

Of the 26 plans with some HVAC components, 11 met all relevant requirements and 15 failed to meet at least one requirement. Most HVAC non-compliance cases are due to information missing from the plans. Excessive cooling capacity is installed in many retail and restaurant spaces. Potential HVAC energy savings for full compliance are roughly 1% of HVAC energy in new buildings.

Water heating compliance

Of 23 plans with water heating systems, 9 met all requirements and 14 were missing some elements. Controls for circulating hot water systems and hot water pipe insulation are often missing from plans. Heat recovery for water heating was missing in several applicable cases. Total unrealized savings is roughly 5% of water heating energy.

Building official reports

Building officials reported track-lighting wattage to be a compliance problem area. Cooling of unenclosed spaces is also described as a problem area.

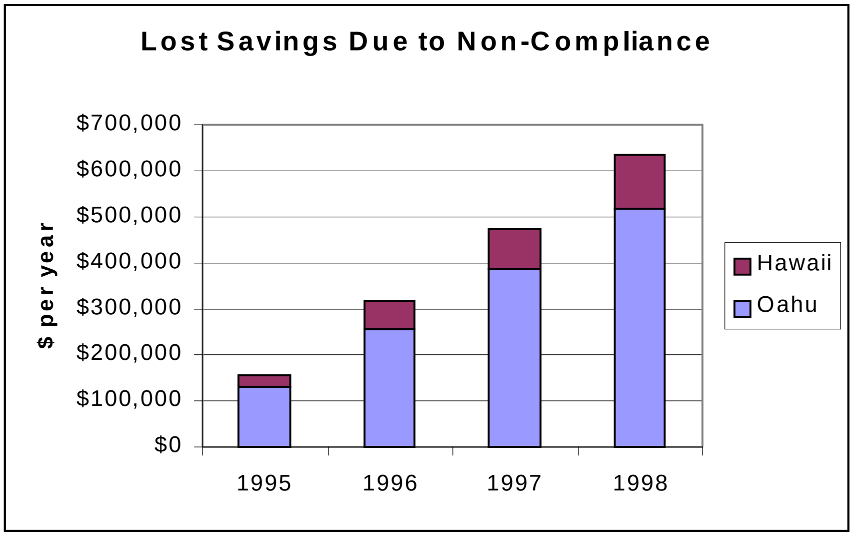
Design professional reports

Design professionals reported that the lighting power limits have the biggest impact on their designs. HVAC designs are not changed much by the code except for cooling of unenclosed spaces (however, one designer expressed favor for the requirement). Designers report receiving few comments from building officials regarding the energy code.

Impact of non-compliance

The impact of non-compliance on energy costs is estimated to be roughly $160,000 per year for each year's projects. By the end of 1998, the cumulative annual impact is about $630,000 per year of lost energy savings. These unrealized savings equal 13% of the predictions in the original impact analysis. About 50% of the lost savings are due to lighting power non-compliance and another 20% are from lighting controls.

Figure 1
Cumulative Lost Energy Savings Since Code Adoption ($/yr) (same as Figure 10)



Recommendations

Recommendations include:

- training tailored to building officials
- on-call engineer for energy code support to building departments
- checklist for building officials highlighting critical points
- sample specifications for designers to include on plans
- support topics on a website
- code modifications for track lighting, exterior lighting, and swimming pools
- require designer compliance certification specifically for each code division
- review plans for at least a few critical energy-code related items.

2. Introduction

This report describes results of a study to check levels of energy code compliance on the islands of Oahu and Hawaii. The primary purposes of the study are to identify whether energy savings expected from the code are occurring and whether measures to improve compliance are necessary.

The energy code was adopted on Hawaii in late 1994 and Oahu in early 1995 (also in 1995 in Kauai, which is not included in this study). The scope of the code includes nonresidential and high-rise residential buildings, with some exceptions for industrial and other building types. On Hawaii, air-conditioned low-rise residential buildings are also covered. The areas of building design addressed by the code are lighting, envelope, HVAC and water heating.

This study includes review of a sample of building plans for projects that received permits since the revised building codes were adopted. Information was also obtained through interviews with building officials and design professionals. The work was performed in February and March of 1998. The purpose of the study is the following:

- Determine the level of compliance with the Model Energy Code.
- Identify compliance problem areas with specific code requirements, geographic regions, or building types.
- Identify measures to improve compliance, if necessary.
- Identify areas where the code is less stringent than standard practice and where increased stringency may provide additional cost effective energy savings.
- Identify trends in compliance level over time.
- Estimate approximate energy impact of non-compliance if it is discovered.

This work was commissioned by the State of Hawaii, Department of Economic Development and Tourism, Energy Division, project manager Howard Wiig and Branch Chief Carilyn Shon. The U.S. Department of Energy provided funds. Erik Kolderup of Eley Associates, San Francisco, California, performed the work.

3. Current Enforcement Procedures

3.1 Oahu

The primary responsibility for energy code compliance lies with the architect and engineer, and they are required to include a note on their plans certifying that the design complies. However, while the building department does not perform a thorough review of all plans, some items are checked in potential problem cases and are called to the designers' attention when it appears that a design may not be in compliance. Examples of these cases include a check of HVAC capacity for small projects (especially when an engineer's stamp is not required), cooling capacity for unenclosed spaces, roof insulation for unconditioned buildings, and swimming pool heating systems.

Calculations are not required on the plans (under the previous code the OTTV calculations were required).

Up to five different groups are involved in the permit approval and building inspection process. The steps in the building permit process are outlined below:

1. Plans are submitted to a building examiner in the *Building Division* who checks zoning, setbacks, parking and similar issues.
2. Plans are sent to the *Electrical Division* for their approval. Here the plans may be reviewed by an electrical engineer.
3. Plans continue to the *Plumbing Division* for plumbing and mechanical review. Again, an engineer may review the plans.
4. The *Department of Health* may also review the plans for outdoor air ventilation and air conditioning capacity requirements.
5. Approved plans are microfilmed and archived.
6. Plans are sent to the *Building Inspection Division* where they are assigned to an inspector based on geographic region and building type.
7. Buildings are inspected during and after construction by the building inspector as well as inspectors from the electrical and plumbing divisions. Inspectors do not check energy code items.
8. Buildings receive an occupancy permit or notice of violation.

In addition to the two division heads, the electrical division consists of 2 engineers that check plans and 14 inspectors, and the plumbing division has three engineers and ten inspectors. The engineers have professional engineer certification and the inspectors must be licensed electricians or licensed plumbers. The staff of the building inspection division consists of about 30 inspectors.

Permit fees depend on the value of the project, ranging from 1.7% at $1,000 to 1% at $100,000.

3.2 Hawaii

The energy code compliance review process on the Big Island is slightly different from Oahu. Primary responsibility for compliance still rests with the designers, but more energy code documentation is required on the plans. For mechanical systems, a copy of the air conditioning load calculations must be included if the system is larger than 65,000 Btu/hr (a bit larger than 5 tons). Evidence of envelope calculations is also required, and most plans include ENV1 software reports. Lighting power compliance calculations are typically included as well.

The Building Division is part of the Department of Public Works in Hawaii County, and the division has two offices: one in Hilo and the other in Kailua, Kona. The Hilo office staff consists of one structural engineer, three plan reviewers (building, electrical and plumbing) and eight inspectors (four building, two electrical and two plumbing).

In Kona, the staff is lead by one civil engineer and has nine inspectors, including one inspector each to review building, electrical and plumbing plans.

The level of energy code compliance review depends on the experience of the inspector and the current workload. Due to current staff shortage, energy code review in Kona is limited. In Hilo, most lighting calculations are reviewed and a sample of lighting fixtures and controls are verified in the field. Mechanical plans receive a cursory review, limited by the fact that the building division does not have a mechanical engineer on staff – mechanical reviews are the responsibility of the plumbing inspector. Building insulation is not always checked during construction.

In Hawaii, building permit fees depend on the value of the project, starting at $10 for project up to $500 and ranging up to $355 for projects up to $50,000 plus $3 for each additional $1,000 value. In terms of percent of project value, the permit charge is 2% at $500 and 0.5% at $100,000.

The general permit approval process in Hawaii is similar to Oahu, but some steps occur in a different order. In Hawaii, the energy code review takes place at the end of the process after the Department of Health review.

1. *Building Division.* Checks that plans are complete and are stamped by design professionals.
2. *Planning Division.* Zoning and land-use issues.
3. *Engineering Division.* Flood zone and excavation requirements.
4. *State Department of Health.* Checks outside air ventilation and air conditioning capacity.
5. *Fire Department.* Fire safety codes.
6. *Wastewater/Solid Waste.*
7. *Building Division.* The plans return to the building division for a check of compliance with the building, electrical, plumbing, and energy codes. Hawaii County has not adopted the Uniform Mechanical Code.

4. Construction Activity

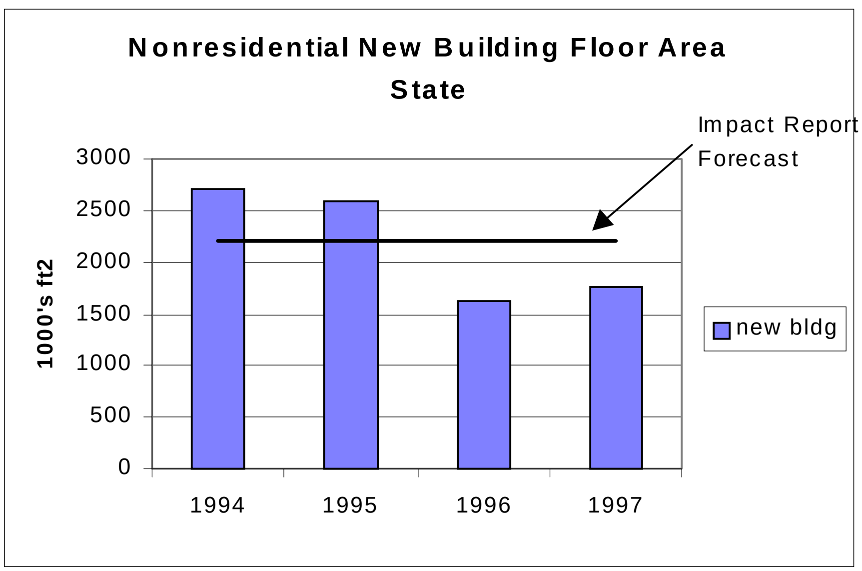
This section reports the number and value of building permits during the period since adoption of the energy code. The focus is on nonresidential buildings because they are the only buildings covered by the Honolulu code, and most homes in Hawaii County are not affected.

In Honolulu the number of building permits is currently 1,000 to 1,200 per month, and the permit value is around $40 million per month. At the peak of construction activity several years ago, the value of permits was two to three times the current level.

In Hawaii County, the number of permits is lower: about 1,800 per year in Hilo and 1,000 to 1,200 each year in Kona. The past peak in Hilo was around 3,000 per year.

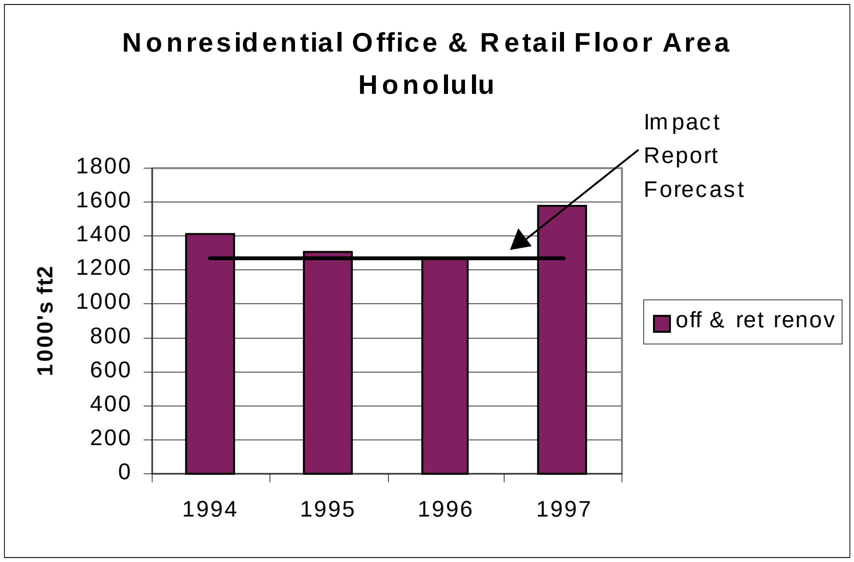
The construction levels are close to those predicted in the Impact Report for the Hawaii Model Energy Code (December 1993). For example, new construction was predicted to be 2,210,000 ft2 per year for nonresidential buildings. Corresponding Bank of Hawaii data for the period is shown in Figure 2. The same information for additions and alterations is in Figure 3.

Figure 2
Comparison of Predicted to Actual New Building Construction



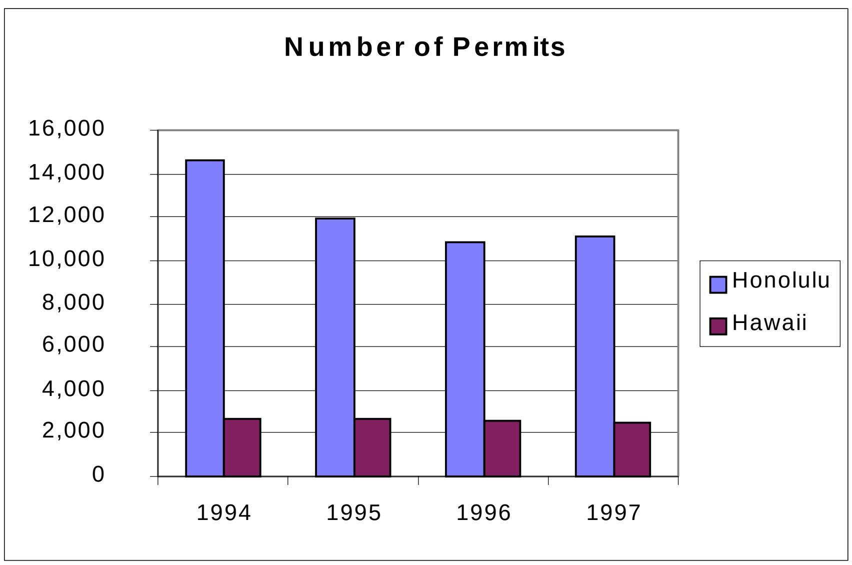
Source: calculations of floor area based on permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

Figure 3
Comparison of Predicted to Actual Additions and Alterations



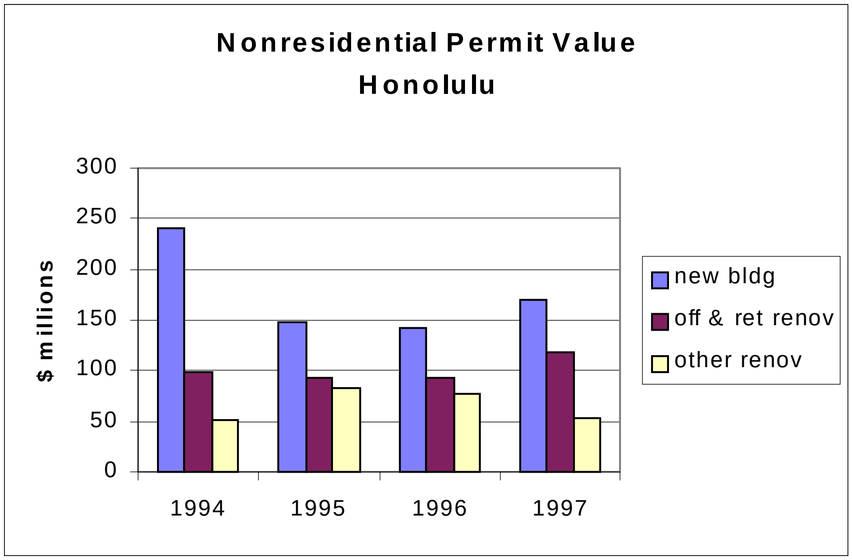
Source: calculations of floor area based on permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

Figure 4
Number of Total Building Permits, Both Residential and Nonresidential



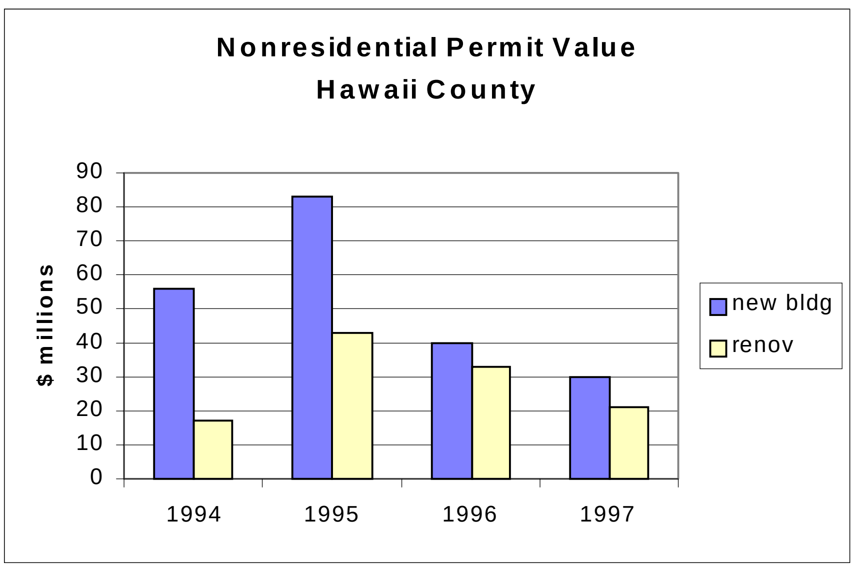
Source: Hawaii State Department of Business, Economic Development & Tourism.

Figure 5
Permit Value, Honolulu



Source: permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

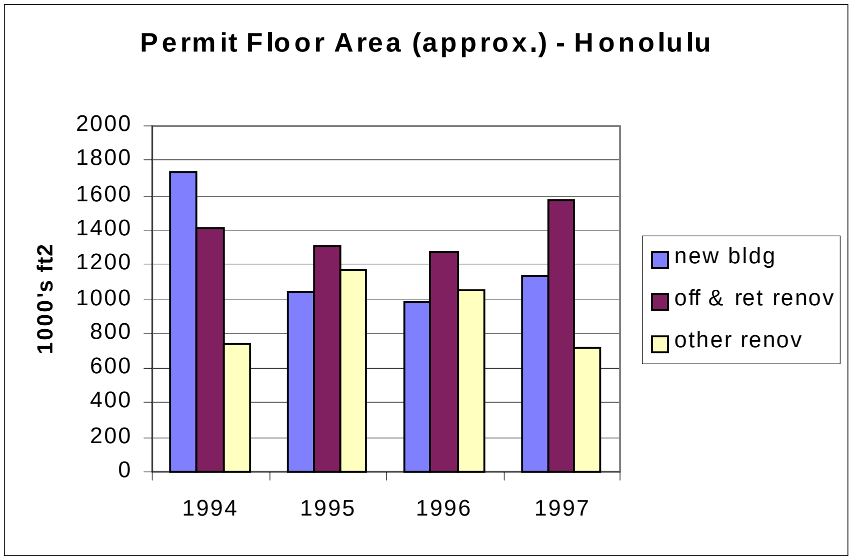
Figure 6
Permit Value, Hawaii



Source: permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

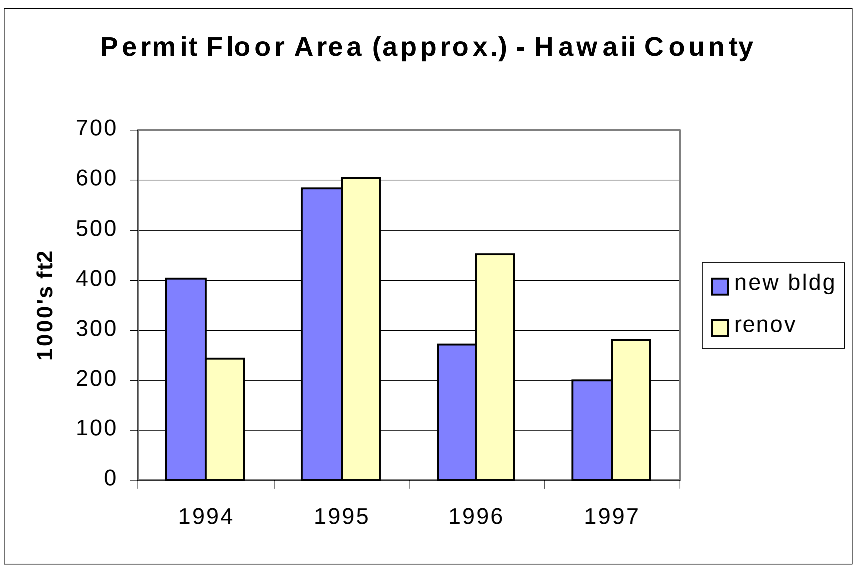
Floor area estimates are shown in the following two charts. These are approximate estimates based on the permit value illustrated in the previous graphs. Construction cost is assumed to be about $150/ft2 for new buildings and $75/ft2 for renovations.

Figure 7
Floor Area Estimates, Honolulu



Source: calculations of floor area based on permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

Figure 8
Floor Area Estimates, Hawaii County



Source: calculations of floor area based on permit value reported in *Construction in Hawaii 1998*, Bank of Hawaii.

5. Plan Review Sample

The following tables list the buildings that were part of the survey. The total number of plans reviewed is 32, including 21on Oahu and 11 on Hawaii. New construction accounts for 18, and there are 14 renovations and tenant improvements. These projects were chosen from those in storage at the building department offices. These projects are approved and are in the construction process or recently completed. The choice is not entirely random because selections were made to provide a range of building types and sizes. However, no plans were included or rejected because they appeared to more or less likely than others to comply with the code. Therefore, the sample should be a fair representation of recent design practice.

Table 1
List of Buildings in Survey – Oahu

	Building Type	Construction Phase	Plan Date	Stories	Total Floor Area
1	High rise residential	New	Apr-96	41	529,487
2	Food processing	New	Mar-97	2	93,000
3	Bank	New	Apr-97	2	17,040
4	Medical office	New	Jul-96	1	15,604
5	School	New	Jul-97	2	12,009
6	Assembly/service	New	Oct-95	2	6,900
7	School	New	Nov-95	2	2,800
8	Retail	New	Oct-96	1	2,544
9	Church	New	Oct-95	1	1,860
10	Grocery	Renovation	Jun-96	1	31,176
11	Office & warehouse	Renovation	Feb-97	1	15,915
12	Restaurant	Renovation	Feb-97	1	10,068
13	Office	Renovation	Jun-97	1	5,898
14	Retail	Renovation	Dec-96	2	5,840
15	Medical office	Renovation	Dec-96	1	5,179
16	Retail	Renovation	Jul-96	1	4,082
17	Retail	Renovation	Oct-96	1	3,791
18	Retail	Renovation	Oct-96	2	1,800
19	Retail	Renovation	Apr-97	1	750
20	High rise office	Tenant improvement	Sep-97	1	16,732
21	Office	Tenant improvement	Apr-95	1	6,200
				Total	788,675
				Mean	37,556
				Median	6,200

Table 2
List of Buildings in Survey – Hawaii

	Building Type	Construction Phase	Plan Date	Stories	Total Floor Area
1	Office	New	Mar-97	2	50,020
2	Medical office	New	Aug-96	2	36,000
3	School/multipurpose	New	Jun-96	1	9,093
4	Restaurant	New	Jul-97	2	6,100
5	Auto sales	New	May-97	2	5,894
6	Single family residential	New	Sep-97	1	2,878
7	Fast food restaurant	New	Jan-97	1	2,679
8	Grocery	New	Apr-97	1	1,930
9	Laundromat	New	Jun-96	1	1,836
10	Bank	Renovation	Aug-97	2	2,500
11	Medical office	Tenant improvement	Feb-97	1	7,250
				Total	126,180
				Mean	11,471

Median	5,894

6. Level of Code Compliance

6.1 Summary Tables

Three sets of results are presented in the following tables: 1) Oahu and Hawaii, 2) Oahu only and 3) Hawaii only. The level of compliance is described qualitatively using the categories listed below.

The following tables summarize the qualitative survey results

Exceeds. Performance level is significantly better than required by the code. For example, lighting power is more than about 25% lower than required.

Meets. 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. This category includes the case when a few spaces within a large project do not meet lighting control requirements.

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 a significant fraction of spaces do not have complying lighting controls, 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.

Table 3
Number of Plans at Each Compliance Level (Oahu & Hawaii)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance	Not Applicable
Lighting Controls	0	14	12	5	0	1
Lighting Power	3	19	3	3	3	1
Roof	1	13	1	1	2	14
Wall	1	13	1	2	0	15
Window	1	13	2	1	0	15
HVAC Controls	0	15	8	0	0	9
Fans	0	8	1	0	0	23
Pumps	0	2	0	0	0	30
Cooling Equipment	0	14	6	0	0	12
HVAC Insulation	0	16	6	2	0	8
SWH Controls	0	5	2	1	0	24
SWH Equipment	0	18	2	0	0	12
SWH Insulation	0	10	6	3	0	13
Heat Recovery	0	2	1	2	0	27
TOTAL	4	164	51	20	5	204

Table 4
Percent of Plans at Each Compliance Level (Oahu & Hawaii)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance
Lighting Controls	0%	45%	39%	16%	0%
Lighting Power	10%	61%	10%	10%	10%
Roof	6%	72%	6%	6%	11%
Wall	6%	76%	6%	12%	0%
Window	6%	76%	12%	6%	0%
HVAC Controls	0%	65%	35%	0%	0%
Fans	0%	89%	11%	0%	0%
Pumps	0%	100%	0%	0%	0%
Cooling Equipment	0%	70%	30%	0%	0%
HVAC Insulation	0%	67%	25%	8%	0%
SWH Controls	0%	63%	25%	13%	0%
SWH Equipment	0%	90%	10%	0%	0%
SWH Insulation	0%	53%	32%	16%	0%
Heat Recovery	0%	40%	20%	40%	0%

Table 5
Number of Plans at Each Compliance Level (Oahu only)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance	Not Applicable
Lighting Controls	0	9	8	4	0	0
Lighting Power	1	13	1	3	3	0
Roof	0	6	1	1	2	11
Wall	0	9	0	1	0	11
Window	0	7	2	0	0	12
HVAC Controls	0	11	5	0	0	5
Fans	0	7	1	0	0	13
Pumps	0	2	0	0	0	19
Cooling Equipment	0	8	5	0	0	8
HVAC Insulation	0	11	4	2	0	4
SWH Controls	0	4	2	1	0	14
SWH Equipment	0	10	1	0	0	10
SWH Insulation	0	3	3	3	0	12
Heat Recovery	0	2	0	0	0	19
TOTAL	1	102	33	15	5	138

Table 6
Percent of Plans at Each Compliance Level (Oahu only)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance
Lighting Controls	0%	43%	38%	19%	0%
Lighting Power	5%	62%	5%	14%	14%
Roof	0%	60%	10%	10%	20%
Wall	0%	90%	0%	10%	0%
Window	0%	78%	22%	0%	0%
HVAC Controls	0%	69%	31%	0%	0%
Fans	0%	88%	13%	0%	0%
Pumps	0%	100%	0%	0%	0%
Cooling Equipment	0%	62%	38%	0%	0%
HVAC Insulation	0%	65%	24%	12%	0%
SWH Controls	0%	57%	29%	14%	0%
SWH Equipment	0%	91%	9%	0%	0%
SWH Insulation	0%	33%	33%	33%	0%
Heat Recovery	0%	100%	0%	0%	0%

Table 7
Number of Plans at Each Compliance Level (Hawaii only)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance	Not Applicable
Lighting Controls	0	5	4	1	0	1
Lighting Power	2	6	2	0	0	1
Roof	1	7	0	0	0	3
Wall	1	4	1	1	0	4
Window	1	6	0	1	0	3
HVAC Controls	0	4	3	0	0	4
Fans	0	1	0	0	0	10
Pumps	0	0	0	0	0	11
Cooling Equipment	0	6	1	0	0	4
HVAC Insulation	0	5	2	0	0	4
SWH Controls	0	1	0	0	0	10
SWH Equipment	0	8	1	0	0	2
SWH Insulation	0	7	3	0	0	1
Heat Recovery	0	0	1	2	0	8
TOTAL	3	62	18	5	0	66

Table 8
Percent of Plans at Each Compliance Level (Hawaii only)

Code Requirement	Exceeds	Meets	Minor Non-Compliance	Moderate Non-Compliance	Major Non-Compliance
Lighting Controls	0%	50%	40%	10%	0%
Lighting Power	20%	60%	20%	0%	0%
Roof	13%	88%	0%	0%	0%
Wall	14%	57%	14%	14%	0%
Window	13%	75%	0%	13%	0%
HVAC Controls	0%	57%	43%	0%	0%
Fans	0%	100%	0%	0%	0%
Pumps	0%	0%	0%	0%	0%
Cooling Equipment	0%	86%	14%	0%	0%
HVAC Insulation	0%	71%	29%	0%	0%
SWH Controls	0%	100%	0%	0%	0%
SWH Equipment	0%	89%	11%	0%	0%
SWH Insulation	0%	70%	30%	0%	0%
Heat Recovery	0%	0%	33%	67%	0%

Table 9
Compliance Level by Building

	Bldg Type	County	Const Phase	Total Floor Area	Cond Floor Area	Lighting Controls	Lighting Power	Roof	Wall	Window	HVAC Controls	Fans	Pumps	Cooling Equipment	HVAC Insulation	SWH Controls	SWH Equipment	SWH Insulation	Heat Recovery
1	high rise residential	Honolulu	new	529,487	359,207	1	-1	1	1	2	1	0	1	1	0	1	1	0	1
2	medical office	Honolulu	renovation	5,179	5,179	1	1	0	0	0	0	0	0	0	1	2	0	1	0
3	high rise office	Honolulu	tenant improvement	16,732	16,732	2	1	0	0	0	1	0	0	0	1	0	0	1	0
4	grocery	Honolulu	renovation	31,176	31,176	2	1	0	0	0	0	0	0	1	0	0	0	0	0
5	retail	Honolulu	new	2,544	2,544	2	1	1	1	1	2	0	0	1	2	1	1	3	0
6	school	Honolulu	new	12,009	-	3	1	4	1	1	0	0	0	0	0	0	1	0	0
7	retail	Honolulu	renovation	4,082	4,082	2	1	0	0	0	1	0	0	0	1	0	0	0	0
8	bank	Honolulu	new	17,040	17,040	2	1	1	1	1	1	1	1	1	3	1	1	3	0
9	medical office	Honolulu	new	15,604	15,604	1	2	1	3	1	1	1	0	1	3	1	1	3	1
10	restaurant	Honolulu	renovation	10,068	10,068	2	4	0	0	0	1	1	0	2	2	3	2	2	0
11	retail	Honolulu	renovation	5,840	5,840	1	4	0	0	0	1	0	0	0	1	0	0	0	0
12	church	Honolulu	new	1,860	-	2	3	4	1	1	0	0	0	0	0	0	0	0	0
13	assembly/service	Honolulu	new	6,900	6,900	2	1	1	1	1	2	1	0	1	1	2	1	1	0
14	food processing	Honolulu	new	93,000	14,000	3	1	3	1	1	1	0	0	2	2	0	0	0	0
15	office	Honolulu	renovation	5,898	5,898	3	1	0	0	0	2	0	0	1	1	0	1	0	0
16	office & warehouse	Honolulu	renovation	15,915	8,000	1	1	2	1	0	1	2	0	2	1	0	1	2	0
17	retail	Honolulu	renovation	3,791	3,791	1	4	0	0	0	0	0	0	0	1	0	1	0	0
18	retail	Honolulu	renovation	750	750	1	3	0	0	0	2	1	0	2	1	0	0	0	0
19	Office	Honolulu	tenant improvement	6,200	6,200	1	3	0	0	0	1	1	0	0	1	0	0	0	0
20	retail	Honolulu	renovation	1,800	1,800	1	1	0	0	0	2	1	0	2	1	0	0	0	0
21	school	Honolulu	new	2,800	2,800	3	1	1	1	2	1	0	0	1	2	0	1	2	0
22	bank	Hawaii	renovation	2,500	2,500	1	2	0	0	0	2	0	0	1	1	0	1	1	0
23	medical office	Hawaii	new	36,000	28,100	1	1	1	1	1	0	0	0	0	0	0	0	0	0
24	school/multipurpose	Hawaii	new	9,093	-	1	1	1	0	1	0	0	0	0	0	0	2	1	0
25	fast food restaurant	Hawaii	new	2,679	2,348	2	1	1	3	3	1	0	0	1	1	0	0	1	3
26	laundromat	Hawaii	new	1,836	-	2	-1	1	1	1	0	0	0	0	0	0	1	2	0
27	restaurant	Hawaii	new	6,100	4,000	2	1	1	2	1	2	0	0	2	2	0	1	1	3
28	medical office	Hawaii	tenant improvement	7,250	7,250	3	1	0	0	0	1	0	0	1	1	1	1	2	2
29	grocery	Hawaii	new	1,930	1,930	1	-1	-1	-1	1	2	0	0	1	1	0	1	1	0
30	single family residential	Hawaii	new	2,878	2,878	0	0	1	1	1	1	0	0	1	2	0	1	2	0
31	auto sales	Hawaii	new	5,894	5,894	2	2	0	0	0	1	1	0	1	1	0	1	1	0
32	office	Hawaii	new	50,020	32,902	1	1	1	1	-1	0	0	0	0	0	0	1	1	0

Note: -1 = exceeds code, 0 = not applicable, 1 = meets code, 2 = minor non-compliance, 3 = moderate non-compliance, 4 = major non-compliance.

These plan reviews took place at the building departments and were performed by a single reviewer. Time spent on each plan averaged 1½ hours. The applicable energy code requirements were determined for each of the categories listed in the tables above (e.g. lighting control, lighting power, roof…). Those requirements depend on characteristics like the building type, floor area, window area, and HVAC system type. Therefore, the following information was collected from each of the plans where applicable.

- floor, window, and wall area
- window specifications (calculate relative solar heat gain)
- wall and roof construction insulation levels (review ENV1 calculations if applicable)
- lighting fixture count, lighting fixture schedules, lighting controls (switches, occupant sensors, timeclocks…), calculate installed lighting power, review computer calculations (LTGSTD or HiLight)

- mechanical equipment specifications for complying efficiency
- HVAC controls, insulation, fan system design, pumping system design
- electric motor efficiency
- water heating system and equipment specifications and controls

Finally, the information from the plans was compared to the code's requirements to determine the compliance level. For example, lighting plans were checked for controls such as manual switches, occupant sensors or timeclocks that would comply with the control point requirements. For lighting power, the fixtures were counted and approximate lighting power was determined.

Table 10
Table of Performance Characteristics by Building

	Building Type	County	Installed Lighting Power Density, W/sf	Allowed Lighting Power Density, W/sf	Roof Insulation R-value *	Wall Insulation R-value	Window RSHG North	Window RSHG East/South/West	Window Wall Ratio North	Window Wall Ratio East/South/West	Cooling Equipment Efficiency, EER	Fan System Efficiency, W/cfm
1	high rise residential	Honolulu	0.6	1.0	15	13	0.36	0.43	0.43	0.41	10.5	-
2	medical office	Honolulu	1.8	1.9	-	-	-	-	-	-	-	-
3	high rise office	Honolulu	1.2	1.3	-	-	-	-	-	-	-	-
4	grocery	Honolulu	1.7	2.0	-	-	-	-	-	-	11	-
5	retail	Honolulu	1.4	2.5	19	0	0	0.53	0	0.29	10.5	-
6	school	Honolulu	1.3	1.3	0	0	0	0	0	0	-	-
7	retail	Honolulu	2.0	2.5	-	-	-	-	-	-	-	-
8	bank	Honolulu	1.3	1.3	19	0	0.5	0.44	0.5	0.26	9.4	0.7
9	medical office	Honolulu	1.4	1.3	12	0	0.76	0.62	0.097	0.16	9.4	1.22
10	restaurant	Honolulu	2.3	1.5	-	-	-	-	-	-	0	0.9
11	retail	Honolulu	5.4	3.3	-	-	-	-	-	-	-	-
12	church	Honolulu	2.7	2.2	0	0	0.64	0.64	0.12	0.16	-	-
13	assembly/service	Honolulu	1.6	2.0	11	11	0.5	0.55	0.1	0.16	10	0.63
14	food processing	Honolulu	1.0	1.2	10	0	0	0	0	0	0	-
15	office	Honolulu	1.2	1.9	-	-	-	-	-	-	11.2	-
16	office & warehouse	Honolulu	1.2	1.3	4	0	-	-	-	-	0	0.86
17	retail	Honolulu	3.6	2.5	-	-	-	-	-	-	-	-
18	retail	Honolulu	4.1	3.5	-	-	-	-	-	-	11	0.4
19	Office	Honolulu	1.9	1.3	-	-	-	-	-	-	-	0.54
20	retail	Honolulu	2.7	2.7	-	-	-	-	-	-	0	0.7
21	school	Honolulu	1.6	2.1	19	0	0.9	0.63	0.09	0.12	0	-
22	bank	Hawaii	1.5	1.4	-	-	-	-	-	-	9	-
23	medical office	Hawaii	0.4	0.5	1	11	0.47	0.38	0.25	0.27	-	-
24	school/multipurpose	Hawaii	1.5	1.5	19	-	0.62	0.4	0.11	0.08	-	-
25	fast food restaurant	Hawaii	1.1	1.1	19	0	0.8	0.8	0.6	0.14	9.7	-
26	laundromat	Hawaii	1.2	1.9	19	11	0	0	0	0	-	-
27	restaurant	Hawaii	1.7	1.7	15	0	0	0	0.05	0.08	0	-
28	medical office	Hawaii	1.3	1.5	-	-	-	-	-	-	10	-
29	grocery	Hawaii	1.7	2.7	30	19	0	0.35	0	0.13	10	-
30	single family residential	Hawaii	0.0	0.0	13	7	0.34	0.27	0.3	0.55	0	-
31	auto sales	Hawaii	1.8	1.7	-	-	-	-	-	-	9.9	0.4
32	office	Hawaii	0.3	0.4	19	11	0.4	0.31	0.14	0.17	-	-

* Roofs with less than R-19 insulation may comply by using a light-colored surface and/or radiant barrier.

6.2 General Observations

In one case plans claimed incorrectly that the building was exempt from the code. It is not clear from the sample of plans reviewed whether this is common. This building includes office space, food preparation and storage.

At least one design professional certification appeared on all but two of the plans. One of the exceptions was the facility described above where the designer mistakenly assumed that compliance was not required. The other case was a renovation of a small high-end retail shop.

Architect compliance certifications were not too common, appearing on 10 of the 32 plans. Mechanical engineers certified 21 plans, but certifications were missing on five or six plans where they should have been present. Electrical engineer certifications appeared on 28 plans and were missing in only one or two cases.

6.3 Lighting Power Results

Table 10 shows lighting power densities, both installed power and allowed power, for each building. Those results are summarized in Table 11 below which shows that non-complying buildings exceed allowed lighting power by 23% to 30% on average. Complying buildings beat the code by 15% to 16%, and the overall average building does somewhere between 2% and 10% better than code. Figure 9 illustrates the percent compliance margin for each building. Out of 32 total buildings, 22 meet or exceed the lighting power requirements, 9 do not comply, and 1 is not applicable. Floor area of complying buildings adds up to 355,000 ft^2 (87%) and non-complying buildings equal 53,000 ft^2 (13%).

Potential lighting demand savings from improved compliance is about 5%

Lighting power in non-complying buildings is about 0.6 W/ft^2 higher on average than the allowed limit (see Table 11). Assuming that 13% of construction floor area does not comply, then the potential savings for bringing these projects into compliance is about 0.08 W/ft^2 of new lighting projects. These savings are equal to about 5% of total lighting power in new buildings and renovations. See page 25 for more discussion of the energy and demand impact.

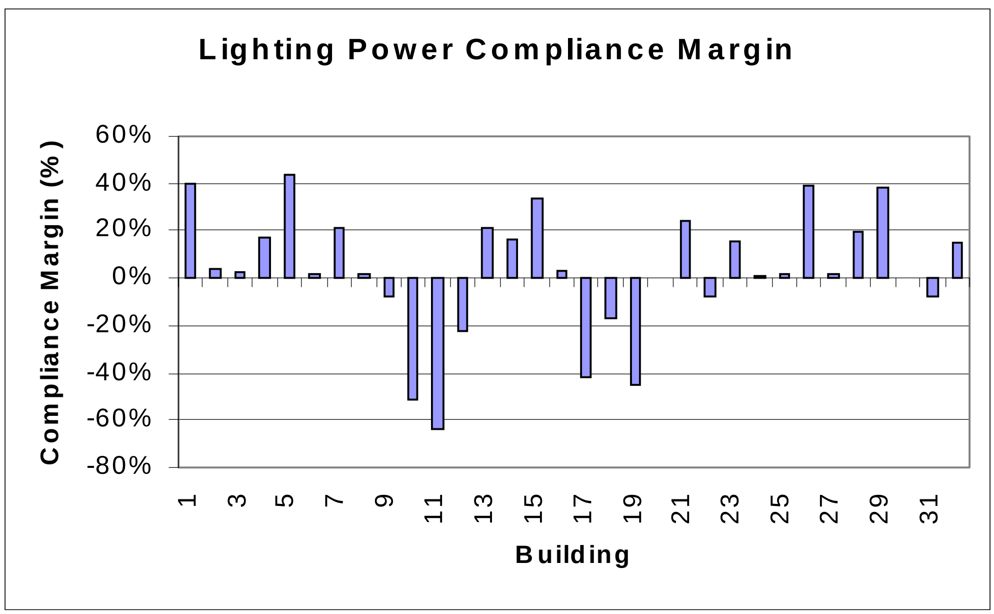
Note that these statistics are approximate because they are based on a relatively small sample.

Restaurant and small retail buildings comprise the majority of non-complying cases. The reasons for non-compliance varied. In a few cases the designer used lighting power allowances from the old Honolulu code. In another case, the "pre-1993" model energy code limits were used. The largest non-compliance margin was due to use of the "Jewelry Merchandising" allowance (6.0 W/ft^2) when the "Fine Merchandising" category (3.5 W/ft^2) was appropriate. Others made incorrect assumptions in calculations. Regardless of the reason, there seems to be pressure on high-end retail and restaurant facilities to exceed code lighting limits. Note, however, that several small retail and most large retail spaces met the code.

Table 11
Quantitative Lighting Power Survey Results

		Complying Buildings	Non Complying Buildings	Total
Floor Area	Average	16,136	5,834	13,145
(sf)	Median	7,075	5,840	6,100
	Total	354,983	52,507	407,490
Allowed Power	Average	1.65	2.08	1.77
(W/sf)	Median	1.63	1.69	1.69
	Area Weighted Avg.	1.20	1.76	1.27
Installed Power	Average	1.35	2.74	1.75
(W/sf)	Median	1.28	2.30	1.50
	Area Weighted Avg.	1.01	2.36	1.19
Compliance	Average	0.30	-0.66	0.02
Margin (W/sf)	Median	0.14	-0.58	0.03
	Area Weighted Avg.	0.19	-0.60	0.09
Compliance	Average	16%	-29%	3%
Margin (%)	Median	16%	-23%	2%
	Area Weighted Avg.	15%	-30%	10%

Figure 9
Percent Lighting Power Compliance Margin for Each Building



6.4 Lighting Controls Results

Only 45% of the plans complied with all the lighting control requirements. Minor non-compliance was found in 39% of the plans, which means that up to about 20% of the spaces in those buildings do not meet the code's control point requirements. Moderate non-compliance was found in the remaining 16%. In those cases, a significant fraction of spaces did not have adequate controls.

The most common problem was too few controls in small rooms like offices, conference rooms, and classrooms. To satisfy the code in most of those cases multi-level switching or occupancy sensors are required. This problem occurred most often in schools and office buildings.

Potential lighting energy savings due to improved controls compliance is between 1.4% and 2.8% of all new projects

The impact of the missing controls is difficult to estimate. As a very rough calculation, assume that non-complying floor area accounts for 15% in minor non-complying buildings and 50% in moderate non-complying facilities. Then the average fraction of non-complying floor space is 14% of new lighting systems (39% * 15% + 16% * 50% = 14%). With a second assumption that the missing controls would have saved between 10% and 20% of lighting energy, then the overall impact of non-compliance is 1.4% to 2.8% of lighting energy for all new projects.

6.4.1 Other Lighting Observations

Lighting power adjustment factors (PAF) appear to be seldom used. The PAF allows credit for using automatic controls and increases the allowed lighting power. The main reason is that automatic controls are used infrequently (especially in Hawaii County). Other likely reasons are a lack of awareness and a desire to avoid extra calculation complexity.

The lighting system performance method is frequently applied incorrectly. This method requires the lighting power allowance to be calculated space-by-space. Rooms such as toilets and corridors have different limits from other spaces like offices and waiting rooms. One common problem is that different types of spaces are grouped together under one space type. Usually this leads to an overestimation of the allowed power, because spaces like storage rooms are combined with spaces that have higher allowances such as offices.

Another misuse of the system performance method is that the area-factor multipliers are not applied. The result is that the allowed power is lower than it should be. The area factor accounts for the shape of the space and permits more lighting power in smaller rooms.

The old Honolulu lighting energy code was used for several of the plans. At least one of these cases was designed by a mainland engineer who may not have been aware of the code update. Another was a tenant improvement submitted after the adoption date of the new code, in a new building that had been permitted before the new energy code.

Lighting compliance results and calculations are usually shown on the plans

Lighting power calculation results are almost always on the plans. The calculations themselves are often on the plans in Oahu and almost always included in Hawaii. In many cases, lighting compliance software reports were attached to the plans in Hawaii. None of the plans in Oahu included software reports.

Lighting power compliance is slightly better in Hawaii County than in Honolulu. While this difference may be due to the requirement for documentation in Hawaii County, it might be explained by the presence of more high-end retail and restaurant projects in Honolulu.

One electrical engineer created a spreadsheet to perform lighting compliance calculations, but the power allowances for some spaces are incorrect. The review shows, however, that the difference did not have a significant impact on compliance.

6.5 Envelope Results

Envelope compliance was fairly good -- 78% for roofs, 82% for walls, and 82% for windows.

Compliance with the roof requirements was fairly good, with 78% complying out of the 18 plans that include roofs. There were two cases of plans showing no roof insulation, a school and a church, and both did not have air conditioning. Two other buildings had insulation, but it was less than required. One was a food processing facility and the other was a combined office and warehouse. It is likely that in these cases the designer did not realize that portions of the building are within the scope of the energy code.

Table 10 shows that the most commonly specified insulation is R-19, but in one case a grocery store showed R-30. Lower insulation levels were used in 6 buildings (ranging from R-11 to R-15), and most complied base on roof color. Fiberglass batt insulation and rigid foam insulation were about equally common.

The energy impact of non-compliance is very small in the case of roofs because the two uninsulated buildings (the school and church) are not air-conditioned.

Most of the plans (82%) complied with the wall insulation requirements. Only 2 of the 17 plans with wall construction did not show wall insulation when it would be required. Another 7 projects did not have insulation, but it was not required because the building was not air-conditioned or the wall had high thermal mass. Table 10 lists the wall insulation level for each building.

Window shading compliance was also fairly good, and 82% of the plans met or exceeded the code requirements. The compliance problems were one high-rise residential building where not quite enough shading was provided, a school where clear glass did not receive adequate shading, and a fast food restaurant with large area of clear, west-facing glass.

Table 10 lists the window wall ratio determined from the plans for each building, with the north side separated from the others. The relative solar heat gain (RSHG) is also listed for these two cases. RSHG is a function of glass type, overhangs, sidefins, and interior shades.

Found no significant energy impact from envelope non-compliance

The energy impact of the envelope non-compliance cases is not large because most of the significant problems were in buildings without air conditioning.

6.5.1 Other Envelope Observations

Envelope software compliance reports were found only once in Oahu, while they were often either attached to the plans or included on the plans in Hawaii.

Closer checks and tougher documentation requirements lead to better compliance in some cases. For example, roof insulation compliance appears better in Hawaii County where plans were checked more closely.

One set of plans by a mainland architect included a compliance report with OTTV calculations according to the old energy code. A review of the plans showed that the envelope design also complies with the current code.

Roughly 10% to 20% of single-family home plans in Kona show ceiling insulation

A brief review of roughly 20 single family home plans in Kona showed that 10% to 20% include ceiling and wall insulation while only one of them was air conditioned. It is not clear if these ratios are typical.

6.6 HVAC Results

Most HVAC non-compliance cases are due to information missing from the plans. In several cases duct or pipe insulation is not shown, or if it is shown then the thickness is not listed. Other common cases are plans without air conditioner efficiency (EER) or type of thermostat specified. Many of these systems may actual meet code when they are installed, because these elements of the design might be described in the specifications rather than the plans. However, the specifications are seldom saved at the building department and were not available for review.

Table 4 shows that the fraction of plans meeting HVAC requirement varies from 65% for control requirements to 100% for pumping requirements (only two pumping system were reviewed, however). Almost all of the problem cases are minor non-compliance issues. Table 10 lists two HVAC system characteristics: cooling EER and fan system efficiency.

Potential HVAC energy savings for full compliance are roughly 1%

The energy impact of HVAC non-compliance is very difficult to estimate. The most significant problem in these plans was excessive cooling capacity in several retail and restaurant spaces, probably to allow entry doors to remain open. These five spaces account for about 21,000 ft^2 of the total 900,000 ft^2 of surveyed floor area, equal to 2.4%. A very rough assumption is that these buildings use 30% more cooling energy than if they had properly sized cooling equipment. Therefore, potential HVAC energy savings are around 0.8% on average for all buildings.

6.6.1 Other HVAC Observations

Cooling load calculations are never listed on the plans in Oahu, while they are almost always on the plans or attached to the plans in Hawaii.

Excessive cooling capacity is installed in many retail and restaurant spaces

Oversizing of cooling systems was observed in many designs. In an extreme case, the cooling capacity for a retail store was 75 ft2/ton, which is at least three or four times what should be necessary, and another store and a fast food restaurant each had 130 ft2/ton of capacity. It is possible that the systems are oversized in anticipation that the doors will remain open. Two restaurant kitchens had cooling capacity between 60 and 80 ft2/ton.

Motor efficiency was not listed on any of the plans. However, most of the air conditioning systems are packaged units and their motor energy is included in the overall efficiency rating.

Pipe insulation for chilled water systems is usually installed regardless of the code requirement because it reduces condensation.

Hawaii County staff members stamp notes on the plans in red ink to highlight some requirements. The only stamp related to the energy code was a note regarding pipe insulation on the first eight feet from the water heater.

Of the plans reviewed, only 4 had no air conditioning: two schools, a chapel, and a laundromat.

The most common air conditioning type is a split system with outdoor condensing unit and indoor constant volume fan coil. Packaged rooftop units are the next most popular, followed by water loop air conditioners with cooling tower. The only two variable air volume systems were installed as part of a tenant improvement in a high-rise office building and in a bank branch office.

Reheat for zone temperature control appears to be uncommon. The only case was in a medical office for an isolation room.

6.7 Water Heating Results

Compliance levels with water heating requirements were mixed. Most relevant plans met the equipment requirements (90%), but only 63% complied with all the control requirements, 53% with the insulation requirements and 40% with the heat recovery requirements (see Table 4 for details).

Controls for circulating hot water systems and hot water pipe insulation are often missing from plans

The problems with the control requirements were for circulating systems and "heat trace" systems (a heat tape that keeps water warm in the pipe). The code requires automatic control for the circulating pump or heat trace system. Of the five plans with these system types, only two indicated controls.

Pipe insulation was missing from plans in 9 of 19 cases. The code requires insulation on the first 8 feet of pipe in a non-circulating system and insulation on all pipes in a circulating system.

Heat recovery is required when the water-heating load is greater than 12 kW and the air conditioning load is greater than 10 tons. Of the five plans meeting these criteria, only two included heat recovery systems to preheat water. One is a high-rise residential building that recovers heat from the condenser water loop that serves a water-cooled heat pump in each unit. The other heat recovery system employs a desuperheater to reclaim heat from the refrigerant in a packaged rooftop air conditioner in a medical office building. Awareness of the heat recovery requirement is low.

The average water heating energy consumption for nonresidential buildings is roughly 0.4 kWh/ft^2/yr. The savings to bring all water heating systems into compliance is hard to determine, but due to the large number of non-complying plans, 5% savings potential seems like a conservative estimate. Therefore, the potential savings are about 0.02 kWh/ft^2/yr.

6.7.1 Other Water Heating Observations

All water heating systems on these plans are electric resistance water heaters. However, the one single family home reviewed had a solar water heater as its primary system. In addition, two systems used heat recovery from the cooling system to preheat water.

7. Building Official Survey

County building officials were asked to identify compliance and enforcement problems they had encountered with the energy code.

- Sometimes designers are not aware of the fact that non-residential buildings must comply with the code even if they are not air-conditioned. They do not learn until they come for plan check.
- In one case there was a disagreement about lighting requirements for a hotel guestroom renovation. The contractor claimed some of the existing equipment was being reused, including some conduit and wiring, and that it was not a new system. The code does not define a "new" lighting system.

Track lighting

- Track lights cause a plan review problem because the number of fixtures shown on the plan is sometimes fewer than gets installed in the field.
- A major retail project shell is being constructed without envelope compliance calculations. The developer is not installing walls and is leaving them for the tenant improvements. Therefore, envelope compliance is left as the responsibility of each tenant. This project was not one of those reviewed, but it was reported by a building official.

Cooling of unenclosed spaces

- Cooling of unenclosed spaces is reported as a problem in Honolulu. Designers have told the building officials that the cooling capacity allowance is not large enough. The building department reportedly has allowed some flexibility in the definition of unenclosed space.
- Pool heating requirements are a problem for pools used for competition that are remote from other buildings. The code requires either solar heating or a heat pump, while designers may want to use gas heating. The competition pools reportedly have temperature control requirements that do not permit the use of solar heating, and heat recovery for the heat pump is not possible if air conditioned buildings are not nearby.
- Get to know which contractors are more likely to cut corners. The inspectors tend to check their work more closely.

8. Design Professional Survey

A phone survey of three electrical and three mechanical engineers provided the following information.

8.1 Lighting

Impact on design. Two out of three said that the code has a significant impact on design due to tighter lighting power limits. The third felt that the change was primarily due to improved technologies rather than the code. The consensus was that the limits are not too difficult to meet, but are more restrictive than the earlier code. One reported impact was that it is necessary to think about fixture selections earlier in the design process and that requires more design time.

Compliance calculation method. Each of the designers used the system performance method of lighting compliance. Two used the HiLight software and the third used a spreadsheet developed from the tables in the code.

Plan review. None of the designers receives many comments from the building department on energy code issues.

Compliance problem areas. Sometimes there is a conflict between IES required illumination levels and the code power limits, but this is not a big problem. Classrooms lighting power limits are difficult to meet. Controls compliance is a little difficult.

Other comments:

- Don't have any specific recommendations. "Code works pretty well for us"
- Liked old code because it was very simple. The current code is a waste of time, because the people who cheated before still cheat.
- Not aware of any difficult compliance areas. Controls and efficient fixtures are generally very cost effective in Hawaii.

8.2 Envelope

Responsibilities. The mechanical engineers report that they usually end up helping the architects with the envelope compliance calculations, but they all feel it should not be their responsibility. One designer reported that envelope compliance was a problem because envelope designers usually don't consider the energy code requirements early in their designs and material changes (such as glass type) are necessary late in the process.

Compliance method. Two use the ENV1 software although they said it was primitive and would appreciate an upgrade. The third uses the prescriptive tables in the code, and reported that he had problems with the software.

8.3 Mechanical

Impact on design. The main area of impact has been in retail and hotel spaces where owners want doors to be left open. One designer is glad for the open space cooling restriction because it gives him an argument with the owner. Some owners and contractors are surprised by the requirement.

Otherwise, engineers reported that the designs are not changed too much by the code. Timers on air conditioners is the main impact (one designer felt it doesn't always make sense to have a timer on each little 2-to-3 ton unit).

Equipment selection was reported to be a little tighter than before (a few manufacturers reportedly don't meet the code requirements). And cooling load calculations are slightly affected; safety factor assumptions are tightened.

Plan review. When the code was first adopted they would get some comments from the building department and were required to submit some calculations. However, they aren't asked for calculations anymore. However, Hawaii County asks for a letter certifying compliance.

Compliance problem areas. None of these designers reported a problem with the limit on cooling capacity in open spaces, but code officials listed this as a common concern.

One requirement that is sometimes difficult to meet is the limit on use of reheat with constant volume systems. It is used for a simple method of humidity control, although it is known to be energy intensive and not the optimal control method. However, contractors understand how to install it and it is likely to work. Complicated humidity controls may not be installed correctly, and VAV is not always appropriate. (Doesn't have a good answer to the problem).

Other comments:

- A general design problem in open spaces is condensation on the diffusers, which also leads to water damage. Where spot cooling is provided there will usually be some condensation, causing mildew and corrosion problems.
- Usually takes a few years for code officials and designers to get up to speed on the code.
- Has not received an increase in design fee since the code was adopted.

9. Impact of Non Compliance

On average, the buildings in these plans are more efficient than the minimum code complying building. For example, the results listed earlier in Table 11 show that the average lighting power is somewhere between 2% and 10% better than code. However, there are savings available in bringing the non-complying elements of some buildings "up to code". In the case of lighting, this means reducing the lighting power in the non-complying buildings to the point where it just meets the requirements.

The potential savings summarized in Table 12 could also be considered lost savings opportunities over the nearly four years since the code was adopted. Figure 10 illustrates the cumulative effect and shows that the losses add up to about $630,000 per year by the end of 1998. The total impact over these four years adds up to about $1.6 million.

Lost savings equal 13% of original impact report savings estimates

By comparison, the energy code savings predicted in the Impact Analysis (1993) were for annual savings of $4.7 million per year by the end of the fourth year and cumulative savings at that point of $12 million. Therefore, the lost savings are equal to 13% of the original savings estimate.

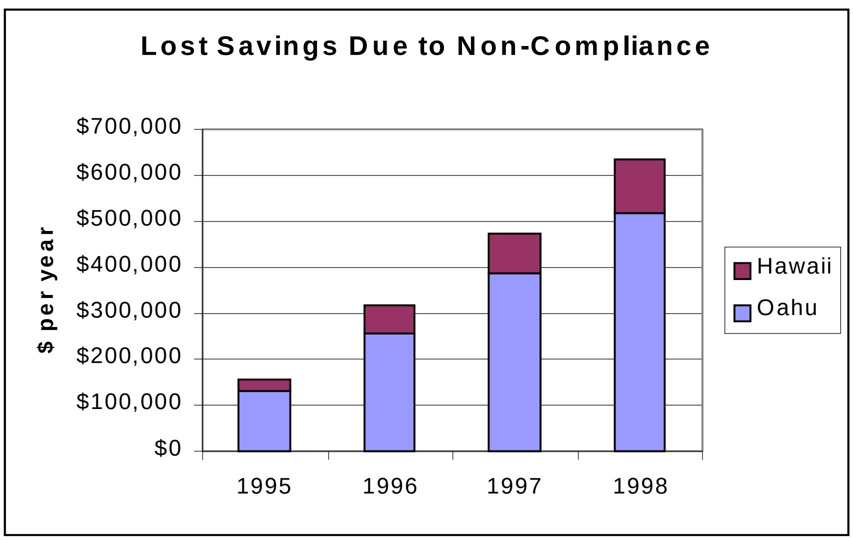
Remember that these calculations are based on many assumptions and a relatively small sample of buildings. The results are most useful to show the order of magnitude of the potential benefit to improving energy code compliance.

Although the potential savings are a relatively small part of the energy use of buildings constructed each year (around 2%), the cumulative impact gets large over the life of these buildings.

Table 12 Lost Energy Savings Due to Non-Compliance ($/yr)

Code Requirement	Oahu	Hawaii	Total
Lighting Power	$68,642	$15,814	$84,456
Lighting Controls	$28,830	$6,642	$35,472
HVAC	$26,149	$6,024	$32,174
Water Heating	$5,241	$1,208	$6,449
Total	$128,862	$29,688	$158,550

Figure 10 Cumulative Lost Energy Savings Since Code Adoption ($/yr)



The savings estimates reported here are based on average construction estimates of 2.6 million square feet per year in Oahu and 600,000 square feet per year in Hawaii. These are averages for the past four years and include new construction and retail and office renovations.

Lighting power savings (5%) are discussed in section 6.3, and lighting control savings (2.1%) in section 6.4. HVAC energy impacts (1%) are covered in section 6.6, and water-heating estimates (5%) in section 6.7. Observed envelope non-compliance (discussed in section 6.5) does not cause a significant energy loss.

10. Recommendations

10.1 Training

Training tailored to building officials would be helpful if it focused on elements of the code that are most important to review. Some of the building officials contacted during this study were interested in learning more. Topics that might be covered are:

- retail and restaurant lighting requirements and examples
- typical cooling capacities and definition of unenclosed spaces
- lighting control requirements in small spaces (such as a private office)
- system performance method for lighting compliance (specifically, the fact that each space type must be listed separately)
- envelope requirements for unconditioned space
- controls for circulating hot water heating systems
- Heat recovery requirements for water heating

10.2 Staffing

Hawaii County does not have a mechanical engineer or electrical engineer on staff so it is difficult for them to judge compliance. While Honolulu does have several engineers in the building department, they do not have the time to focus on energy code issues. It would be helpful to have one or more engineers on call to either county who could provide interpretations or could be assigned the task of reviewing questionable or critical projects.

Similarly, a contact for design professionals is helpful to answer energy code questions. Some states maintain a hotline for designers and building officials to call with energy code questions.

10.3 Informational Materials & Compliance Tools

A checklist for building officials that highlights the critical points of the code would help them to catch some compliance errors.

Sample specifications and notes that can be added to plans would help improve documentation of features like pipe insulation, glass type, EER, motor efficiency, and HVAC controls. Perhaps these could be distributed to designers via DBEDT's website.

Additional support topics could be added to the website. These might include: discussion of lighting control requirements, lighting power requirements in retails and restaurant spaces, water heating insulation requirements, heat recovery requirements and examples, and issues regarding cooling of unenclosed spaces. (The advantage to distributing information on the website is that production costs are low and the material can easily be updated and augmented. The information would also be easily available to mainland designers, who were found to be using the old energy code in a few cases.)

10.4 Code Modifications

Add a statement regarding track lighting such as that included in ASHRAE 90.1R:

> "The wattage of lighting track, plug-in busway and flexible-lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the luminaires included in the system with a minimum of 45 W/lin ft. Systems with integral overload protection such as fuses or circuit breakers shall be rated at 100% of the maximum rated load of the limiting device."

A statement could be added to address exterior lighting applications that are not specifically addressed by the code.

> Fixtures used for exterior lighting for applications not covered in Table 6.1 and not otherwise exempt shall contain lamps having a minimum efficacy of 45 lm/W unless a motion sensor controls the luminaire.

A swimming pool heating exception could be added to allow gas heat for pools used for athletic events that must meet temperature specifications.

10.5 Plan Review Process Modifications

Require that the designer's compliance certification state which articles (or divisions) of the code are covered by the certification, and check that each section (lighting, envelope, mechanical) is covered. In a few of the reviewed plans, a mechanical engineer certified compliance with the mechanical sections of the code, but there was no clear certification for the envelope requirements.

Check plans for a few critical items such as insulation R-value (should be on plans), glass type (often in specs, but good idea to put on plans), air conditioner EER, and motor efficiency. Perhaps create a few red ink stamps like the one used in Hawaii County for water heating pipe insulation.