Commercial Building Energy Code Compliance in Oregon

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Executive Summary

In April 1991, Ecotope, Inc. and Clark's Energy Services began an evaluation of the non-residential energy code in the states of Washinton and Oregon. These codes are meant to increase energy efficiency in commercial buildings by regulating components which affect energy use. This volume reports on the findings from the review of 71 buildings in the State of Oregon.

This study had four purposes: 1) to characterize building activity and current construction practices by developing a random sample of new commercial buildings, 2) to assess compliance in this sample, 3) to interview design professionals and building code officials to determine attitudes toward the code and 4) to recommend changes which might enhance the code's effectiveness.

We used data from a private database service to develop a sampling frame of all new commercial buildings permitted in Oregon between April 1990 and April 1991. The sampling frame contained 213 new commercial buildings which cost over $200,000 to construct. Because half of the total square footage was found in large buildings which were only 6% of the buildings in the sample, we stratified the buildings by size so we could insure that large buildings were adequately represented in the final sample. Buildings were drawn at random and recruited to participate in the study. The final sample contained 71 buildings and was representative of the square footage of the total population of new commercial buildings.

We reviewed the building documents, did detailed take-offs of the building envelope and mechanical and lighting systems, and compared the results with the code requirements to determine compliance. We also coducted an audit of each building, verifying aspects of construction and mechanical and electrical equipment. We assessed compliance for each of the major building systems--envelope, mechanical and lighting, totaling nine separate items--and categorized reasons for non-compliance. Overall compliance meant a building complied with all code requirements reviewed.

Compliance levels for lighting and envelope provisions ranged from 70% to 80% while the compliance level for HVAC systems was 96%. 54% of the buildings surveyed complied with all aspects of the energy code reviewed. Most of the non-compliance occurred in larger counties. Buildings supported under various utility assistance programs achieved 44% compliance overall. The use of code compliance forms had little effect on compliance but they had just been introduced at the time of the study.

On average, building practices exceeded the code requirements. This suggests that the code represents most current building practice. In some areas (i.e., HVAC equipment efficiency), current practice noticeably improved on the code.

We interviewed 149 architects, engineers and installers who were involved in the design and constuction of these buildings. Most felt there was little code enforcement; only 5% had received any feedback from code officials on their buildings. Engineers took most of the responsibility for the code. We also interviewed building officials from ten Oregon building departments and the state BCA. The majority (75%) of building officials expressed frustration with the lack of resources and training for energy code enforcement. Both groups were interested in additional training and noted specific problems with various code provisions.

One premise of the energy code is that complying buildings are more energy efficient than non-complying buildings. This is not necessarily the case. It is quite possible that an efficient building which fails to comply with one aspect of the code, e.g., exterior lighting, be listed as non-complying. We found that the more typical situation, however, was a pattern of design and specification which ignored the provisions of the energy code. Futhermore, there was relatively little evidence that code compliance was, in turn, compelled by the enforcement process of plan review and inspection.

Code compliance could be improved by requiring more systematic documentation, better inspection procedures, and a simplified code.

1 Introduction

Beginning in April 1991, Ecotope, Inc. and Clark's Energy Services began an evaluation of the non-residential energy code in the states of Washington and Oregon. These codes are meant to increase energy efficiency in commercial buildings by regulating components which affect energy use. This volume reports on the findings from the review of 71 buildings in the State of Oregon.

The purpose of this study was four-fold:

1. To characterize building activity and current construction practices.
2. To assess code compliance in this sample by reviewing building documents, conducting site visits and comparing the results with code requirements.
3. To determine attitudes toward the energy code and perceived training needs among building design professionals and building code officials.
4. To review the energy code and suggest changes which might enhance compliance.

We did not review code enforcement procedures directly. Interviews with building code officials touched on enforcement proceedures, but this study focused on building professionals and current building practices. Thus, the building as planned and built was deemed the arbiter of code compliance.

The evaluation was conducted from August 1991 through December 1991. The final sample contained 71 Oregon buildings, chosen at random from new commercial buildings permitted between April 1990 and April 1991.

1.1 Energy Code

Although other building codes are designed to provide public health and safety by setting a minimum standard and limits of liability, the energy code is different. It is essentially a design standard seeking to codify energy efficient design practices. That was the intent of the original ASHRAE 90 standard, which was adopted by various jurisdictions across the country as a model energy code. It gave mechanical engineers and designers some guidelines for designing an energy-efficient building. Revisions of the ASHRAE 90 standard have become increasingly sophisticated and more like code. Nonetheless, they are still design standards, not health or safety standards.

In Oregon, these design standards have become a statewide code first adopted twelve years ago and currently enforced by the approximately 80 building departments in the state. The state Building Official delegates authority to enforce this code to each jurisdiction.

Compliance is only one index of the impact of energy codes. Another index is the degree to which building practice has responded to these codified design standards. Section Three discusses compliance levels while Section Four describes the impact of the code on building practices.

It is important to remember that the energy code has the force of law and represents a public acknowledgement of the minimum energy efficiency standard to be built into all Oregon buildings. Thus, design guidelines which represent good design practice could be assumed to exceed code requirements. In some buildings where economics or other conditions dictate a less careful approach, the code must be the final word in the public's interest in an energy efficient building stock. In this sense, full compliance, though difficult to attain, is the legitimate goal of the energy code.

1.2 Code Compliance

We evaluated code compliance for three major building systems:

Envelope

- Envelope compliance is based on target heatloss rate values for walls, roofs and floors. These values are given in Table 53-A for over 90 different Oregon cities.
- Section 5303-b allows trade-offs by component, as long as overall heatloss rate for the envelope is within code guidelines.
- The code sets envelope standards for cooled buildings. The heat loss of the envelope component is adjusted for component mass, local design temperatures, and solar transmission characteristics of the glazing and must meet the target overall thermal transmissivity values (OTTV) in Table 53-A, calculated in accordance with Section 5303(d).

HVAC

- The code establishes minimum equipment efficiencies. For cooling equipment, efficiency is expressed as EER or SEER. Heating equipment efficiency ratings (EERs) depend on the fuel source and equipment configuration and may be rated as AFUE, COP or HSPF. The requirements are shown in Table 53-E through 53-J.
- Economizers, or outside air cooling capacity, are required on systems using more than 5,000 cfm. Some types of equipment are exempted from this requirement. (Section 5304 (a)).

Lighting

- The code establishes a lighting budget for each building by establishing allowable lighting watts per square foot (lighting power density or LPD) by occupancy types within buildings. These lighting levels are given in Table 53-M.
- Section 5310-(f) regulates exterior lighting of the building perimeter only to 7.5 W/ft. This system cannot be combined with interior lighting to determine compliance.
- Section 5310-(f) also mandates certain switching strategies, including dual-level switching in larger spaces or near windows and automatic controls (e.g., timers) on exterior lights.
- Overall LPDs may be increased by specific percentages (power adjustment factors) if certain switching strategies (such as programmable controls or timers) are used. Table 53-N lists LPD adjustment factors.

1.3 Methodology

The evaluation took place in three stages.

Using data from the F.W. Dodge database service, we developed a sampling frame of all new commercial buildings permitted in Oregon between April 1990 and April 1991. From this group, we recruited buildings to participate in this study. Buildings were selected for the final sample if we could obtain copies of the building documents, permission for a site visit and an interview with at least one member of the design team.

During the second phase of the evaluation, we reviewed the plans, did detailed take-offs of the building envelope and mechanical and lighting systems, and compared the results with the code requirements for these major building systems. We also conducted site visit and review of each building, verifying aspects of construction and mechanical and electrical equipment where possible. Since the buildings were in various stages of construction not all aspects of energy code compliance could be verified. When we could not verify installation, we assumed the equipment and fixtures shown on the building plans would be installed and based compliance on these specifications.

Finally, we used a structured telephone interview format to ask architects and engineers involved in the design of these buildings about the specific building's design process and the code in general. We also interviewed building officials from jurisdictions which were significant in terms of construction activity and asked them for general comments about the energy code and the code compliance process.

1.4 Report Organization

Section Two describes the sample selection and construction practices observed. Section Three summarizes compliance levels for all buildings, including data weighted for area and sample biases. Section Four describes the impact of the code on current building practices. Section Five summarizes the interview responses of building professionals and code enforcement officials. Section Six contains the project team's conclusions and recommendations.

2 Sample Development

The sample of Oregon buildings was drawn from the F.W. Dodge Dataline service, a private database which tracks commercial construction throughout the country. We reviewed one year's worth of data between April 1990 and April 1991. We eliminated buildings that cost less than $200,000 to construct, tenant improvements, remodels, renovations, industrial process buildings, parking lots, parking garages and other non-building projects. A total of 213 buildings, representing 8.3 million square feet, met these criteria. This was considered representative of all the new commercial buildings built in the state of Oregon during this time period.

2.1 Geographic Distribution

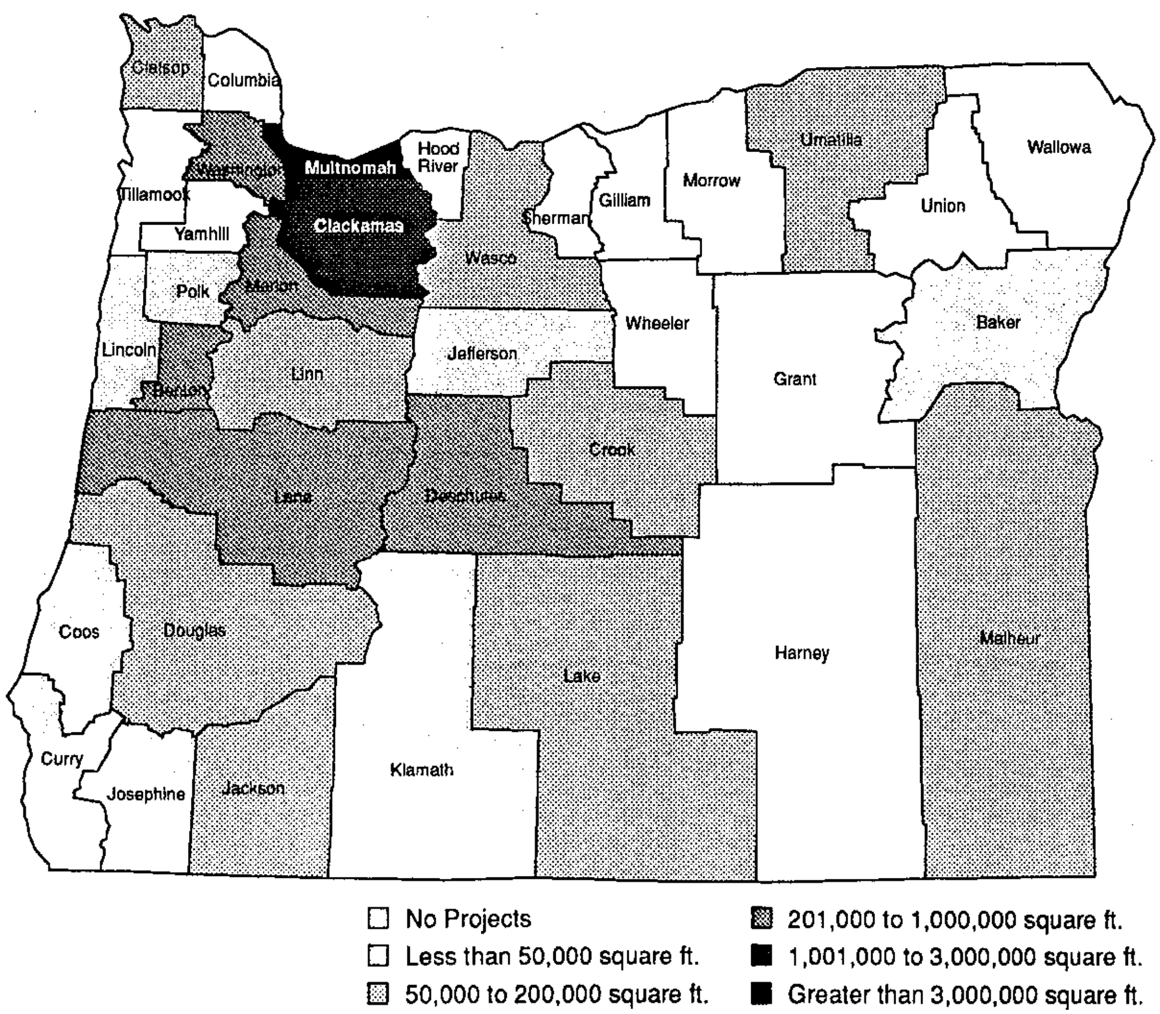


Figure 2.1
This map shows the distribution of square footage of new commercial construction through Oregon counties from April 1990 to April 1991.

Most new commercial construction occurs in the four counties immediately around Portland. These counties contain 57% of all new commercial buildings built and 78% of all the new commercial building square footage built in the state during this year. In a random sample of buildings, these counties could be expected to dominate the compliance review.

2.2 Building Types and Size

Commercial buildings were divided into ten building types.

Office buildings dominate the sample, representing almost a third of total construction. About one quarter of the total square footage is represented by a wide variety of end uses, including health care facilities, grocery stores, assemblies, public institutions (fire stations and maintenance facilities), restaurants and other uses not easily categorized.

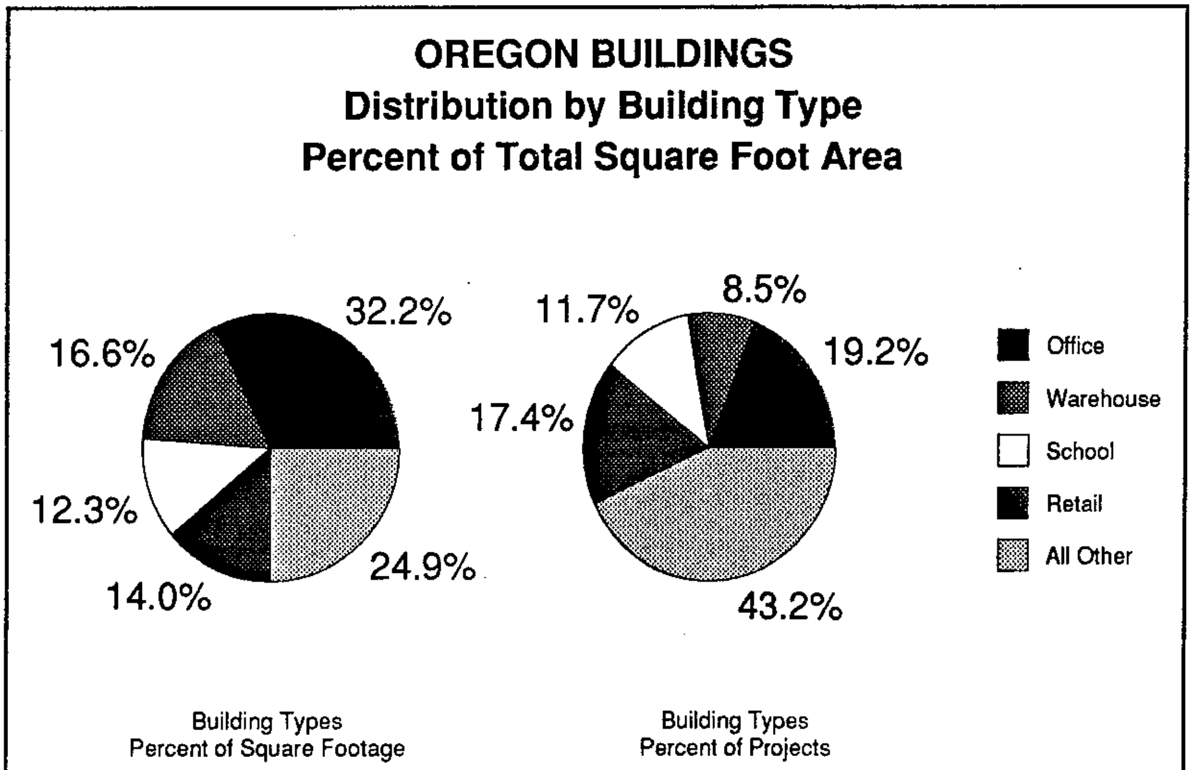


Figure 2.2
This figure illustrates the distribution of buildings and square footage by end use type in Oregon. "Other" includes assembly, grocery, public institutions, health, restaurant and miscellaneous.

The average building size for the state of Oregon is 39,000 ft^2. However, 50% of all the square footage was in buildings over 104,000 ft^2 or 6% of all the buildings built in Oregon. Because of this very skewed distribution, we stratified the random sample of buildings to insure that large buildings were adequately represented in the final review of code compliance. Biases associated with stratification were removed by assigning case weights proportional to the increased probability of a building being selected due to its size.

Buildings were recruited for participation through phone calls to the persons, generally architects, listed as the principal contacts in the Dodge database. We asked them to supply us with copies of the building plans and specifications and grant permission for a field visit. In some cases, where we could not obtain documents directly from the building professional, we were able to use SCAN films of the bid documents submitted to Dodge by the architects.

Table 2.1 illustrates the distribution of buildings by area.

Table 2.2 details the final distribution of the Oregon sample. It shows that the final sample was reasonably representative of the building population as a whole.

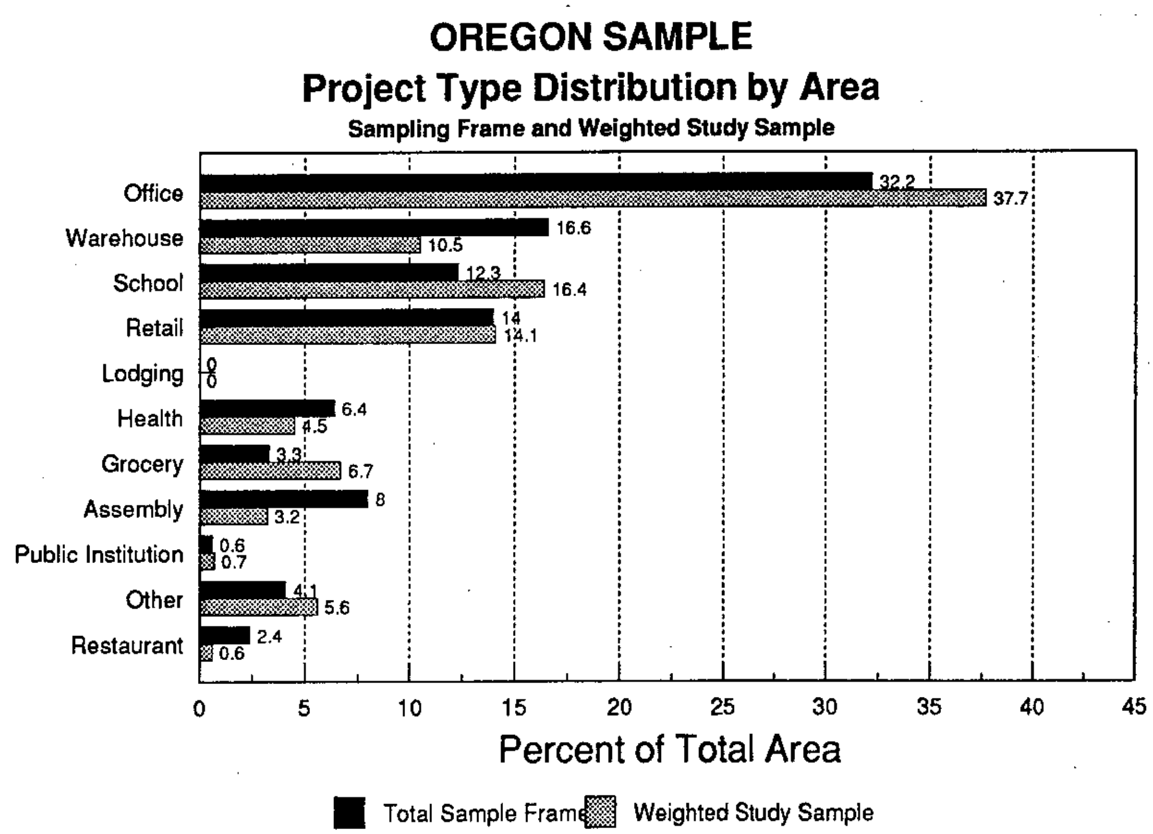


Figure 2.3 This figure illustrates the distribution of square footage by end use category for the total population and the final sample. The principal difference is explained by the over-sampling of large buildings which resulted in an increased percentage of square footage being assigned to schools and offices. But again the sample is reasonably consistent with the distribution of the square footage for the total population. This final sample was used to evaluate building characteristics and code compliance for Oregon.

Table 2.1 Oregon Building Size Distribution						
Size Bin (ft^2/bldg) (000)	**#**	**%**	**Cum %**	**Area (000,000)**	**%**	**Cum %**
> 320	4	1.9	1.9	1.83	22.1	22.1
160 - 320	7	3.3	5.2	1.52	18.3	40.4
80 - 160	13	6.1	11.3	1.44	17.4	57.8
40 - 80	22	10.3	21.6	1.21	14.6	72.4
20 - 40	45	21.1	42.7	1.35	16.3	88.7
10 - 20	29	13.6	56.3	.43	5.1	93.8
< 10	93	43.7	100.0	.57	6.2	100.0
Median:14,475 ft^2 Midpoint:104,000 ft^2 Mean:39,000 ft^2						

Table 2.2 Oregon Sample Development						
	Total population		**Recruitment pool**		**Final sample**	
Building Type	**#**	**%**	**#**	**%**	**#**	**%**
Office	41	32.22	25	36.27	14	35.68
Retail	37	14.04	21	12.34	14	17.93
Grocery	7	3.34	6	3.52	4	3.84
Restaurant	22	2.41	11	1.23	6	1.36
Warehouse	18	16.62	10	18.18	6	10.75
School	25	12.25	14	12.79	11	15.34
Assembly	28	8.03	14	6.78	6	8.81
Public Institution	6	0.59	4	0.21	4	0.37
Health	20	6.36	7	4.98	4	5.17
Other	9	4.14	4	3.69	2	0.74
Total	213	100.00	116	100.00	71	100.00

3 Overall Compliance

Of the 71 Oregon buildings sampled, 38 buildings (54%) met the code. Large buildings were less likely to comply than small buildings: 44% of the large buildings and 59% of the small buildings met the code. Large buildings represent a much higher percentage of overall square footage, both in the sample and in overall building activity. Therefore, when the sample is weighted for area and sampling bias, the level of compliance in large buildings decreases to 45%.

3.1 Compliance By Building Type

Table 3.1 shows the results of the evaluation of the 71 Oregon commercial buildings.

Table 3.1
Oregon Compliance by Building Type

		# of Buildings		
Size	**Building Type**	**Studied**	**Complied**	**Percent**
Large ($>40{,}000ft^2$)	Office	5	1	20%
	Retail	4	2	50%
	Grocery	4	1	25%
	School	6	5	83%
	Warehouse	5	1	20%
	Assembly	1	1	100%
	Health	1	0	0%
	Other	1	1	100%
	Total	27	12	44%
Small ($<40{,}000ft^2$)	Office	12	7	58%
	Retail	11	5	45%
	Grocery	1	1	100%
	School	4	4	100%
	Restaurant	5	1	20%
	Institution	4	2	50%
	Assembly	4	4	100%
	Health	1	1	100%
	Other	2	1	50%
	Total	44	26	59%
Total		71	38	54%

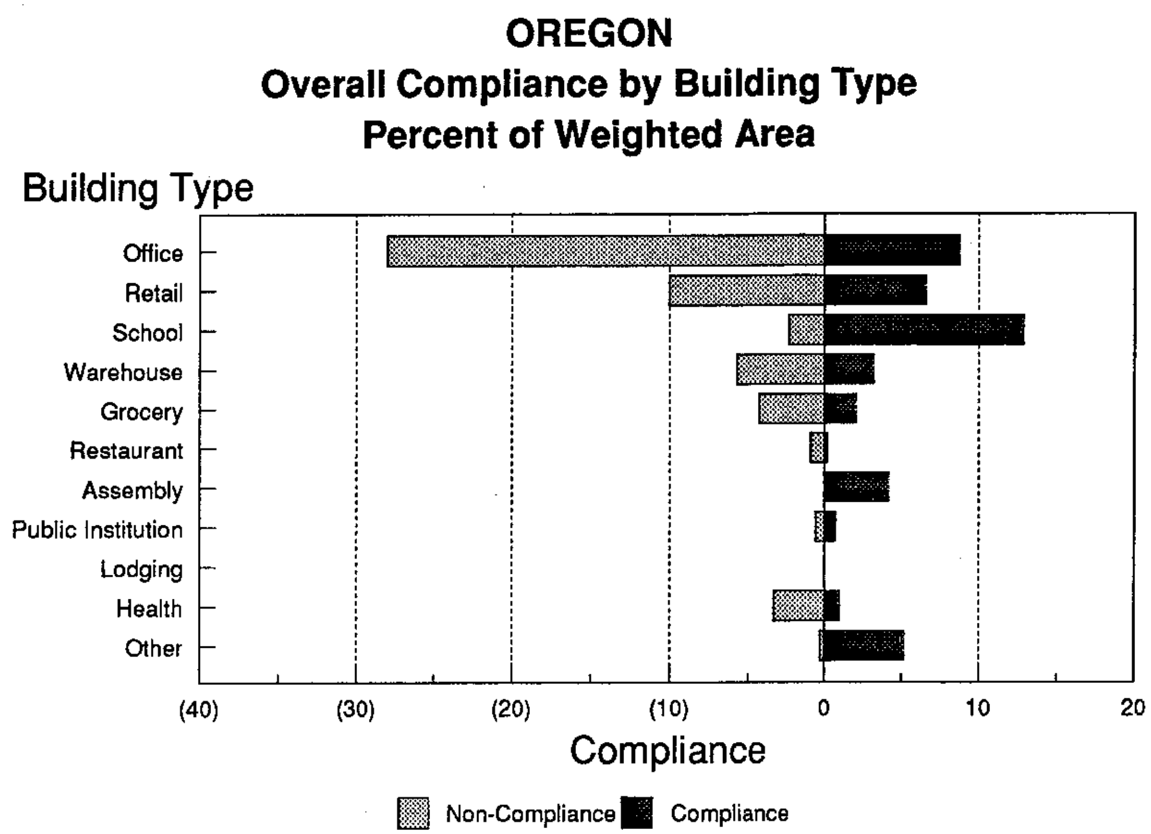


Figure 3.1
This figure illustrates compliance in commercial buildings by building type. Each bar represents the percent of total floor area of the sample, weighted for sample bias. The most significant problems with compliance occur in the office sector which unfortunately is also the dominant end use among Oregon commercial buildings.

3.2 Compliance By Building System

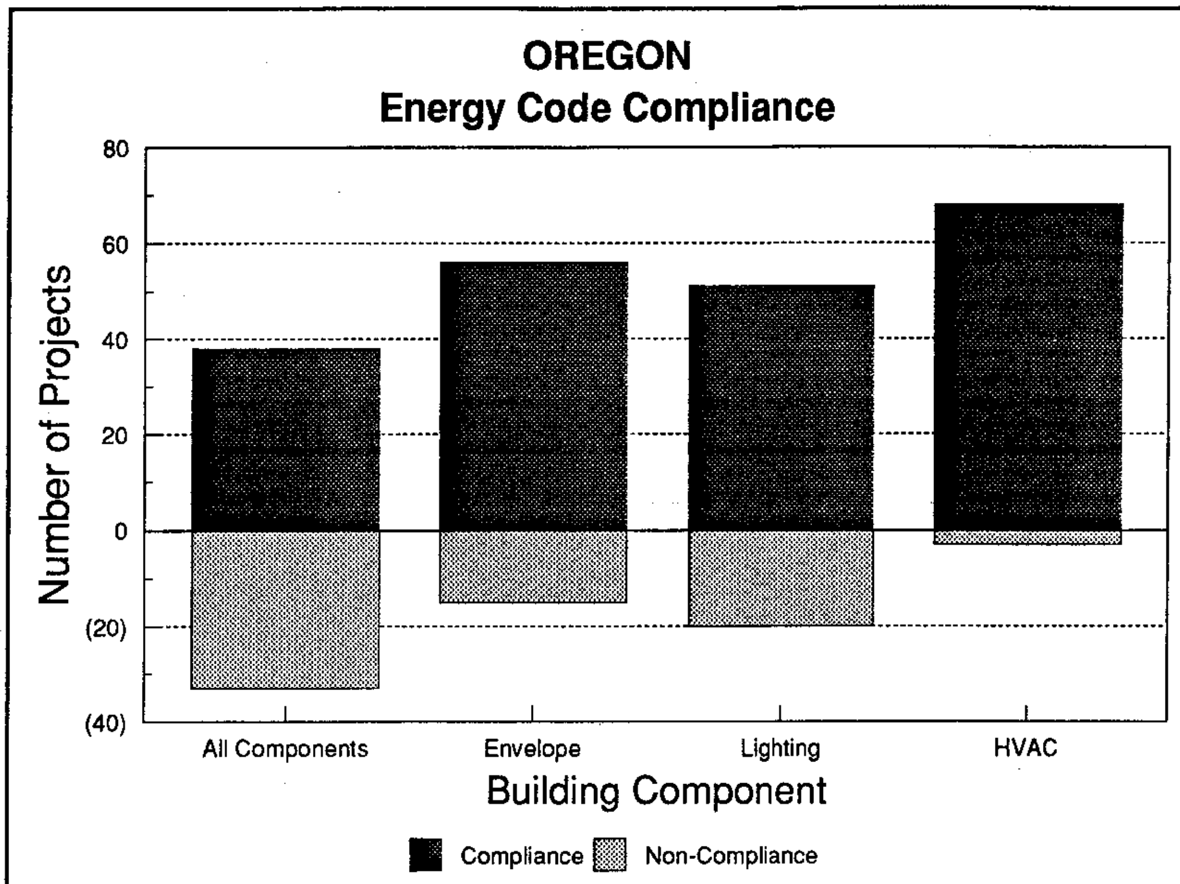


Figure 3.2
This figure shows levels of compliance for each major building system.

Compliance levels ranged from 70% to 80% for lighting system and envelope, while HVAC system compliance was over 95%. This is partly due to the relative simplicity of the HVAC requirements in the Oregon code. HVAC systems were evaluated based on two criteria: the efficiency of the heating and cooling equipment and the presence of economizers in large equipment. For the most part, Oregon designers and installers were easily able to meet these requirements. However, they had much more trouble complying with envelope and lighting requirements.

Envelope

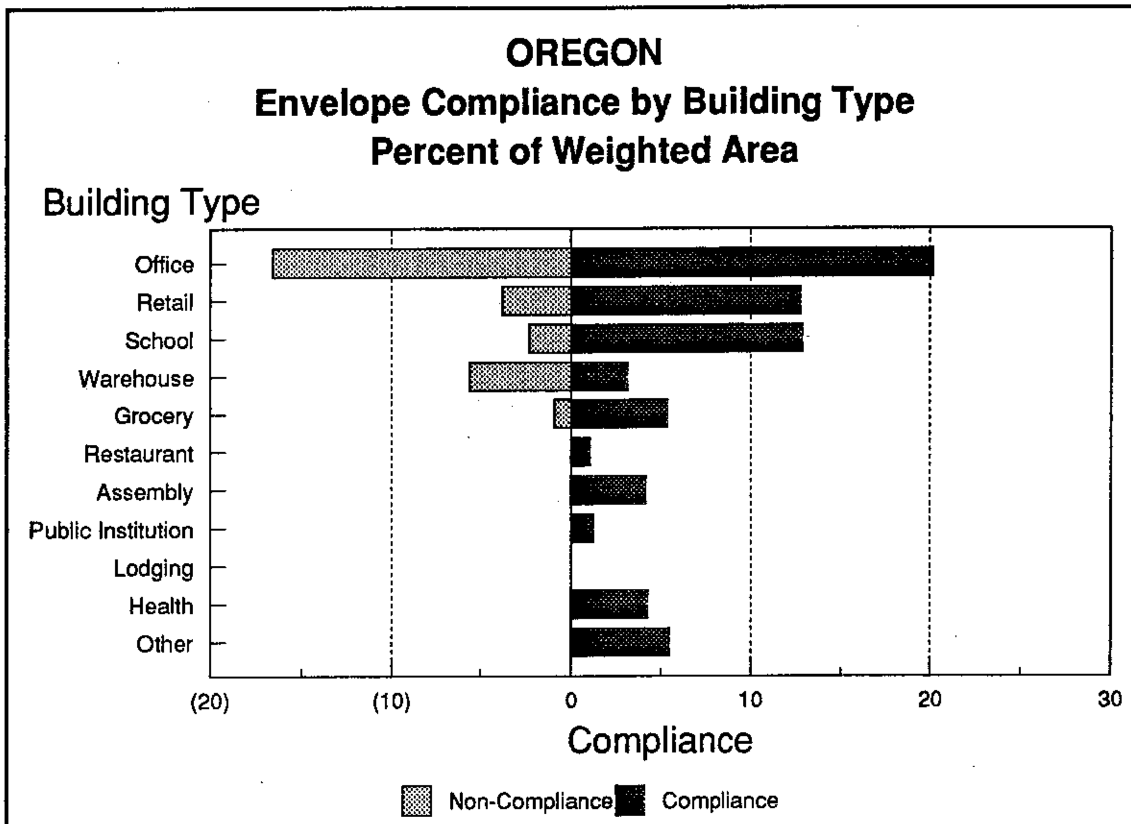


Figure 3.3
This figure illustrates the level of compliance with envelope requirements. Most buildings complied although significant levels of non-compliance were noted in three building types--warehouses, offices and retail.

To achieve compliance with the building envelope, the thermal performance of the building must satisfy both the heating criteria and the cooling criteria. In addition, the building must satisfy the air infiltration and moisture barrier requirements. Our review checked compliance with the heating and cooling criteria, but not the infiltration or moisture barrier requirements.

Table 3.2 Oregon Envelope Non-Compliance (71 Building Sample)			
	Building Size		
Component	**Large**	**Small**	**Total**
Heating Criteria (UA)	9	2	**11**
Wall (U_o)	7	2	
Ceiling (U_o)	2	0	
Cooling Criteria (OTTV)	2	6	**8**
Window Shading Coefficient	1	6	
Insulation	1	0	
Field Changes*	2	2	**4**
Total	**9**	**6**	**15**

*Field changes refer to discrepancies between the plans reviewed and the field observation which resulted in non-compliance with envelope provisions of the code.

Table 3.2 summarizes the reasons for non-compliance in the sample.

Fifteen of the buildings surveyed (21%) did not comply with the building envelope requirements. Small buildings generally failed when the designer used excessive amount of clear glazing. Two-thirds of the non-complying small buildings had glazing areas in excess of 25% of the wall area. Large buildings had similar problems but about half of their non-compliance was due to low levels of insulation in walls and ceilings.

The area of the glazing, the shading coefficient of the glass and the amount of wall insulation are the controlling factors affecting the level of compliance. However, one building type is unique. A warehouse usually complies if it has uninsulated CMU block walls and an insulated roof because of low glazing levels and the "mass credits" allowed in the Oregon code (Section 5303-d).

Seven percent of the total sample failed because of changes to the envelope made in the field. Most field changes involved reducing the amount of insulation or omitting it altogether. Apparently, contractors believe that building inspectors will not challenge such changes. One contractor said that insulation would be added during tenant improvements. We inspected this building long after the tenants had moved in and found no insulation in the walls although it was shown on the code submittals. This problem occurs in both large and small buildings. When field changes reduce the thermal performance of the building envelope, some buildings still comply. In an additional 3% of the buildings, field changes reduced the levels of insulation but did not cause non-compliance. For 3% of the sample, field changes improved the performance of the envelope.

HVAC Systems

The Oregon sample achieved a high level of compliance with HVAC requirements. Only three buildings in the sample failed to comply, largely due to poor equipment selection. In this section, the code is a prescriptive code with a few HVAC requirements that are easily understood and enforced. Furthermore, most new equipment offered by manufacturers meets the applicable code standards so compliance is nearly assured. One of the buildings out of compliance on these provisions used reconditioned equipment which did not meet the efficiency standards.

We did not review the simultaneous heating and cooling requirements or duct and pipe insulation requirements.

Lighting

Lighting system compliance was based on three criteria: interior lighting budget established by occupancy type, exterior perimeter lighting (the same for all building types) and control systems (such as switching by windows and in smaller rooms within a building).

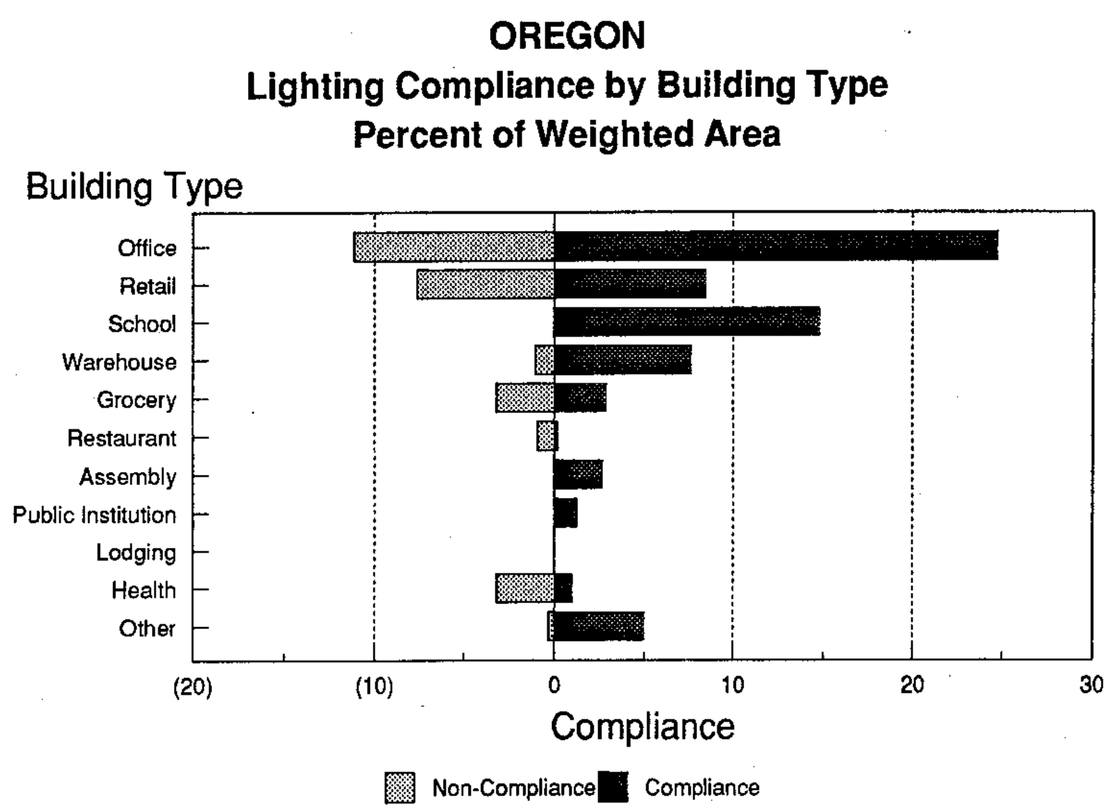


Figure 3.4
This figure summarizes compliance with the lighting requirements of the code. More buildings failed (28%) based on lighting than on any other system. Offices, retail stores and restaurants had the most problems complying with lighting requirements.

Our review checked compliance with the interior and exterior lighting requirements. We compromised on the switching requirements. We ignored the requirement for switches for luminaires next to windows--most designers ignore this requirement and the 1992 code deletes it. We only failed a building for the dual level switching requirements if the lights for a whole floor were operated by a single switch.

Table 3.3
Oregon Lighting Non-Compliance
(71 Building Sample)

Lighting Provision	Large	Small	Total
Interior Power	3	8	**11**
Exterior Power	5	5	**10**
Switching/Controls	0	1	**1**
Field Changes*	2	2	4
Total	**7**	**13**	**20**

*Field changes refer to discrepancies between the plans reviewed and the field observation which resulted in non-compliance with lighting provisions of the code.

Table 3.3 indicates the reasons for non-compliance with lighting code requirements.

Twenty buildings failed to comply with the lighting code. Restaurants and small offices most often failed to meet the interior lighting power budget. Retail stores and restaurants most often failed to meet the exterior lighting power budget.

As with the envelope, field changes had an impact on code compliance. Of the 12 buildings that failed because of interior LPD, four (or 33%) failed because of field changes. An additional five projects included changes which reduced the efficiency of the lighting system but did not lead to non-compliance. Subcontractors substituted less efficient ballasts, fixtures and lamps for those specified because of time and budget constraints. For instance, subcontractors had trouble locating "octic" fixtures so they used other, less efficient fixtures. They also commonly installed 40 W lamps where 34 W lamps were specified. Fortunately, these changes are quite obvious. Unfortunately, in at least four cases, code officials did not review the final lighting installation.

3.3 Compliance By County

The level of compliance is uneven and not easily explained by size of county or location. For this purpose, all jurisdiction, city or county, within a particular county is aggregated. Nevertheless, several points should be noted. The largest county, Multnomah, had a 33% compliance rate. This is somewhat distressing since this county contains the largest number of buildings and 40% of the total square footage in the sample. In addition, this county contains 43% of all new commercial building square footage constructed in the state in 1990.

Four counties--Washington, Clackamas, Marion and Multnomah--contained the majority of the buildings in the sample and the vast majority of square footage built in the state of Oregon. These counties achieved code compliance rates under 50%, lower than the rest of the state. The other large county, Lane, had compliance similar to the rest of the state.

In these five counties, most of the failures were due to lighting. A third of the compliance failures in these counties occurred as a result of field changes in envelope or lighting. Thus, the lack of code review during the inspection process contributed to the overall poor performance.

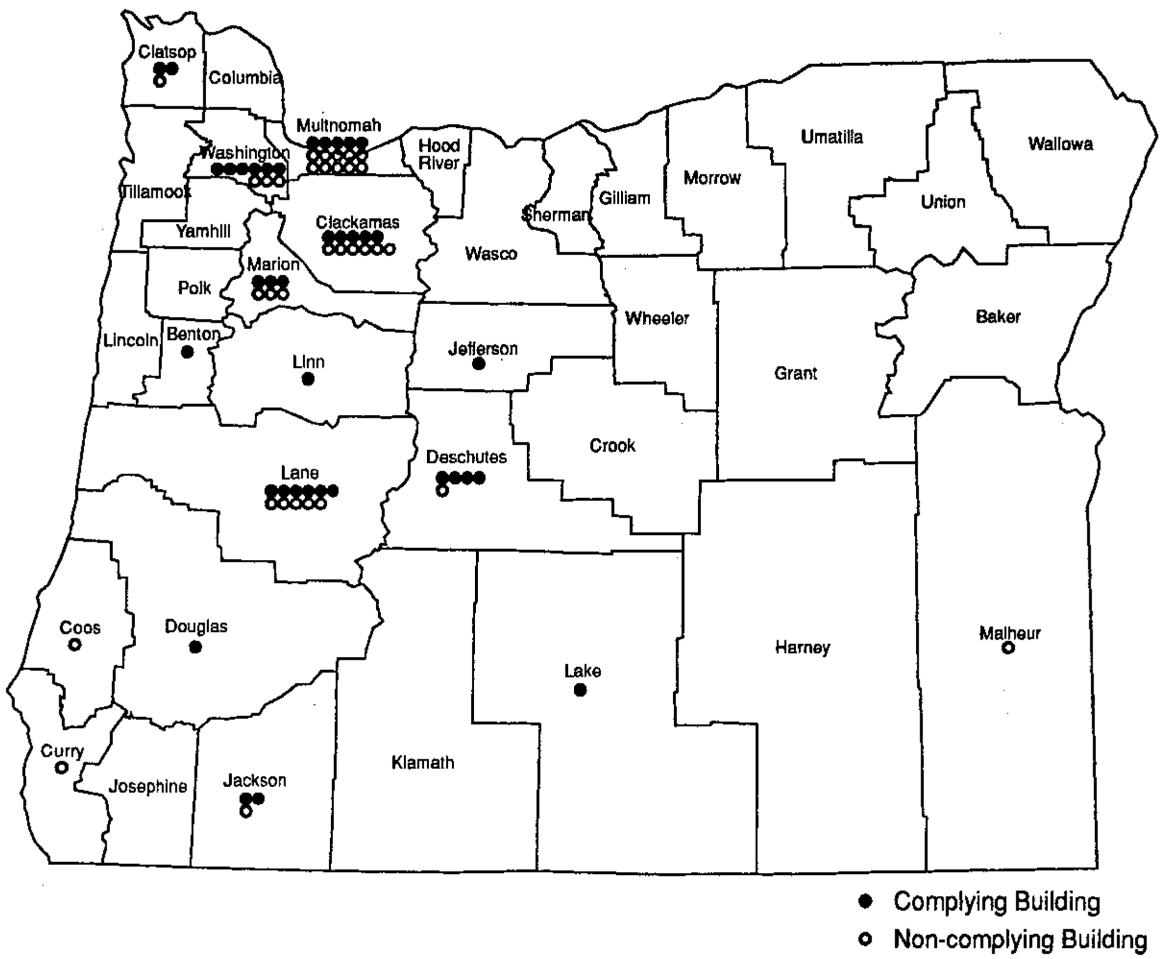


Figure 3.5
This map illustrates the distribution of our sample and the level of compliance by county.

3.4 Code Compliance in Utility Support Programs

During the interview process, we asked architects and engineers if they received support from a utility program. Nine buildings in Oregon received such support. Unfortunately, many of these buildings did not comply with code. In fact, measures which were supposedly added as a result of the utility program were often absent from the buildings during the field review. When we asked architects and designers about this, they usually blamed the changes on problems obtaining equipment during construction.

While it is laudable that utilities are actively supporting conservation investment in the commercial sector, they do not seem to follow through to make sure the measures are installed. In at least two cases, the utility specified electronic ballasts but the subcontractors had difficulty obtaining them, so they were never installed. Lack of review and enforcement can reduce or nullify the energy savings purchased by these programs.

Table 3.4
Oregon Utility Program Participation & Compliance

	Number	Complying	Percent
Envelope	9	8	88%
HVAC	9	9	100%
Lighting	9	5	55%
Total	9	4	44%

3.5 Code Compliance Forms

The state of Oregon developed a set of code compliance forms to aid understanding the code and documenting compliance. Many jurisdictions, particularly the larger ones, started requiring the use of these forms in code submittals around May of 1990. When interviewing designers, we asked them if they used the forms. We looked at the results to determine if the use of the forms affected compliance.

In five or six cases in which designers said they submitted code compliance forms, the drawings which we reviewed showed that the insulation levels did not meet the code. In several cases, the required level of insulation was installed; in others, it was not and the buildings were uninsulated. In other words, the correspondence between the plans and the code compliance forms was not exact. Both the drawings and the forms need to be reviewed to insure compliance.

In a few cases, both the forms and the drawings demonstrated compliance, but the buildings did not comply as a result of field changes. Again, the code compliance form needs to be available on-site so field inspectors can check for the presence of insulation or particular lighting fixtures.

Buildings which used the code compliance forms had the same level of code compliance as other buildings in this sample. However, many engineers and architects told us during interviews that the forms helped them understand the code better, which indicates the possibility of their having a future beneficial effect on code compliance.

3.6 Comparison with 1985 Study

In 1985, the State of Oregon contracted Church/Davis Architects to review code compliance in the state [Davis et al., 1985]. Church/Davis staff inspected 65 buildings and queried architects and engineers about the code. A comparison between this study and the results of our more detailed and comprehensive study is informative.

The Church/Davis study noted a higher incidence of code compliance in large buildings and large jurisdictions. This study did not find higher levels of compliance in either. In fact, large jurisdictions and large buildings had lower levels of compliance than small jurisdictions and small buildings.

The Church/Davis report did not report directly on compliance by building system. The rough comparison that can be made suggests that compliance has improved since 1985. About half of the 1985 buildings complied with lighting requirements. In our study, compliance increased to approximately 78%. Slightly under two-thirds of the 1985 buildings failed to comply with the HVAC requirements. In our study, this level rose to about 96%. Envelope compliance was the exception: 87% in 1985 and 72% in our study.

However, overall compliance does not seem to have improved appreciably. The 1985 study reports that somewhat more than 50% of the buildings failed to meet some aspect of the code, which is similar to our findings. While the extremes noted in the 1985 study are gone, the overall performance has improved only marginally.

4 Energy Code Impacts

Compliance is only one dimension of the impact of the energy code on building practices. In our evaluation, buildings which failed to meet any one of the nine criteria evaluated for the Oregon energy code were considered non-complying. Theoretically, a well-constructed and relatively efficient building could fail to meet the energy code because it failed to meet one criterion.

If the code is viewed as a design standard, on the other hand, then the important criteria are the overall energy efficiency of the building stock and the degree to which building practices have been changed by the code during the twelve years it has been used in Oregon.

Comparing the Oregon results with the results from the companion sample of 70 Washington buildings studied at the same time gives us some insight into the impact of the energy code on overall building practice since the two states have similar codes which differ in enough specifics to make comparison instructive.

In tables comparing the two states we have included a separate summary for buildings said to have received utility design assistance and/or utility rebate for energy conservation measures. As can be seen, these buildings on average did not vary significantly from the rest of the sample in either state.

This section contains several graphics comparing the Oregon and Washington samples using box plots. The median (the mid point of the data) is the line in the center of the box, and the box represents the amount of scatter in each building type. The height of the box represents the middle 50% of the data. The width of the box is proportional to the square root of the number of buildings in each category. The "whiskers" show the outer 50% of the data but must not exceed 150% of the height of the box. Outliers beyond this point are shown as individual points above or below the "whiskers."

4.1 Building Practice

Building Envelope

The Oregon energy code regulates both the heating and the cooling conditions of the building envelope. Glazing area, U-factor and shading coefficient all affect compliance. The new code compliance forms clarified these factors for architects and engineers. Nearly 80% of the buildings met all aspects of the envelope code.

Table 4.1 summarizes and compares the performance of Oregon buildings on two main indices of compliance: overall heat loss rate (UA/ft^2) and overall thermal transmission value (OTTV). This table shows that, in general, building envelopes performed much better than the code, particularly in small buildings. When weighted by area, the overall heat loss rate is about 15% better than the building code. For cooling, most buildings showed a 40% improvement over the code criteria. Only a few buildings failed the cooling criteria, almost always because of high glazing percentages.

Figure 4.1 compares the Washington and Oregon buildings. While both states have similar levels of compliance with the envelope provisions of the code, the Washington code has more stringent insulation requirements for low-rise buildings and about a 10% lower U_o for wall and window systems.

Table 4.1
Oregon Envelope Performance

	Heat Loss Rate (UA/ft^2)				Cooling Budget (OTTV)			
	Sample		Code		Sample		Code	
Size	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Small (< $40,000ft^2$)	.219	.073	.315	.086	23.3	13.6	35.0	-
Large (> $40,000ft^2$)	.180	.088	.200	.059	20.0	9.4	35.0	-
Total (weighted)	.172	.069	.206	.075	21.8	11.1	35.0	-
Utility	.189	.052	.255	.092	20.9	7.2	35.0	-

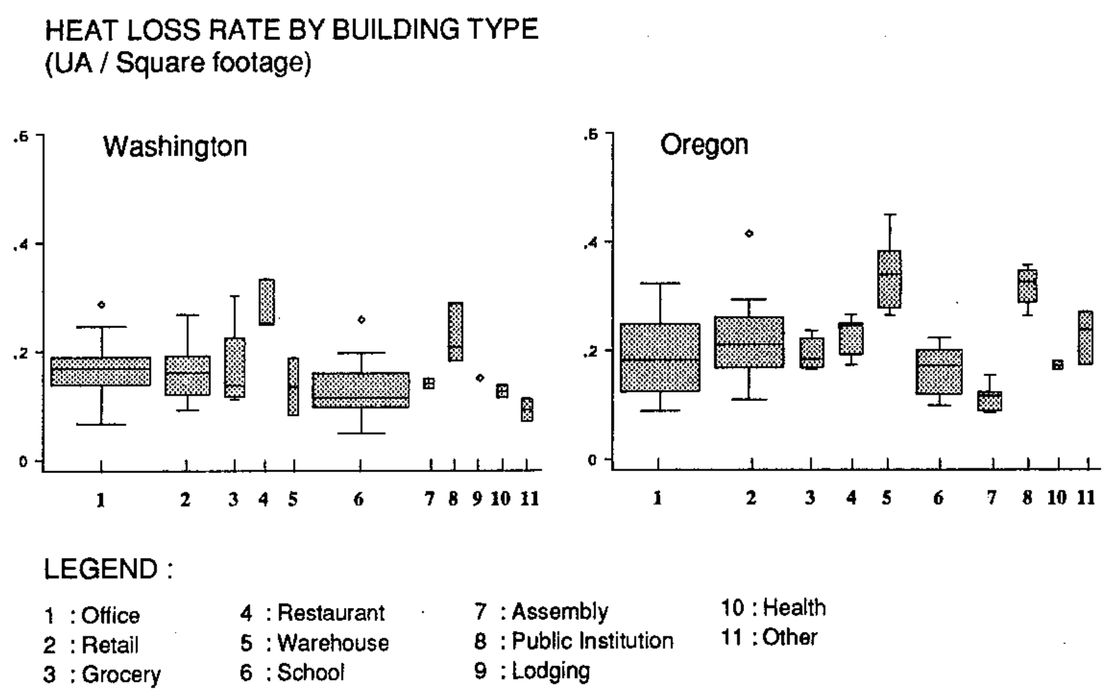


Figure 4.1

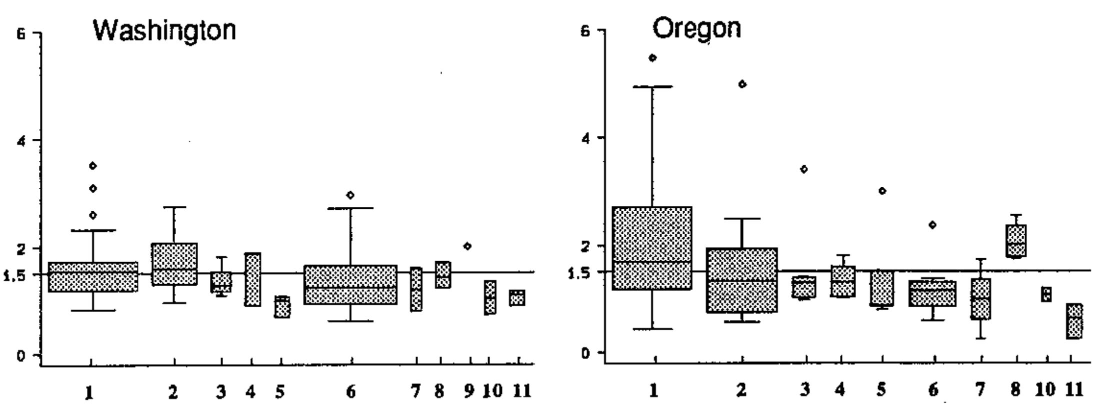
This figure shows that the Washington sample has a 20% lower normalized heat loss rate. At the higher end of performance, the Washington and Oregon buildings are similar but the less stringent Oregon code has resulted in buildings which tend to spread towards higher heat loss rates. This is not explained by lower levels of code compliance. It is best explained by a tightening in building practice fostered by the more stringent Washington code.

HVAC

The HVAC code for Oregon buildings does not regulate certain features. 26% of the Washington buildings failed to comply with HVAC requirements while only 4% of the Oregon buildings failed. The principal difference is the sizing requirement in the Washington code which stipulates that HVAC systems cannot exceed 1.5 times the calculated heating or cooling load. Figure 4.2 compares heating system sizing in Washington and Oregon buildings.

HEATING SYSTEM SIZING BY BUILDING TYPE

Heating Capacity / Heating Load



LEGEND :

1 : Office
2 : Retail
3 : Grocery
4 : Restaurant
5 : Warehouse
6 : School
7 : Assembly
8 : Public Institution
9 : Lodging
10 : Health
11 : Other

Figure 4.2

This figure compares the heating system sizing of Oregon and Washington buildings. There is no requirement for sizing in Oregon while in Washington heating or cooling equipment cannot exceed 1.5 times the calculated load. Even though much of the Washington sample does not comply with the requirements, there is much less spread in the Washington data. This illustrates a major effect of code requirements: even where compliance is a problem, the requirement reduces the variation in design practice substantially.

Both states regulate equipment efficiency by setting a lower limit or floor on efficiency. Figure 4.3 shows how this affects code compliance. This is an ideal situation, showing how all code provisions should work.

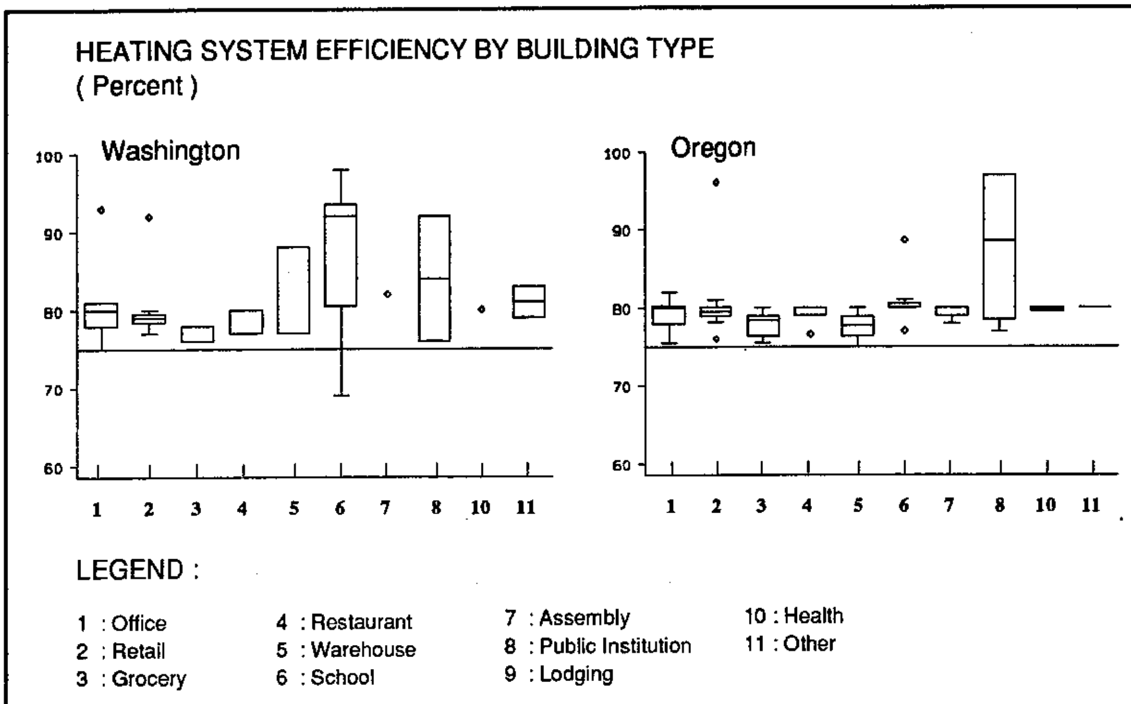


Figure 4.3
This figure compares the two states on heating system efficiency for fossil fueled devices. The Oregon sample has much less scatter than Washington but both are well above the average code requirements. We believe this is due to manufacturers developing more efficient equipment. Most of the more efficient equipment in Washington buildings is in schools, apparently a result of the state-mandated lifecycle cost purchasing process. The 75% efficiency line is included to provide a visual reference; code provisions vary from this standard.

Lighting

Table 4.2 summarizes interior LPD in Oregon buildings.

Table 4.2
Oregon Interior LPD

	LPD		Code LPD	
Size	**Mean**	**SD**	**Mean**	**SD**
Small (< 40,000ft^2)	1.70	.39	2.09	.72
Large (> 40,000ft^2)	1.38	.46	1.76	.52
Total (weighted)	1.44	.47	1.81	.47
Utility	1.61	.55	1.84	.53

As with the heat loss rate, the average building shows a 20% improvement over the code standard. This compares to the Washington sample in a way that illustrates the value of straightforward code provisions.

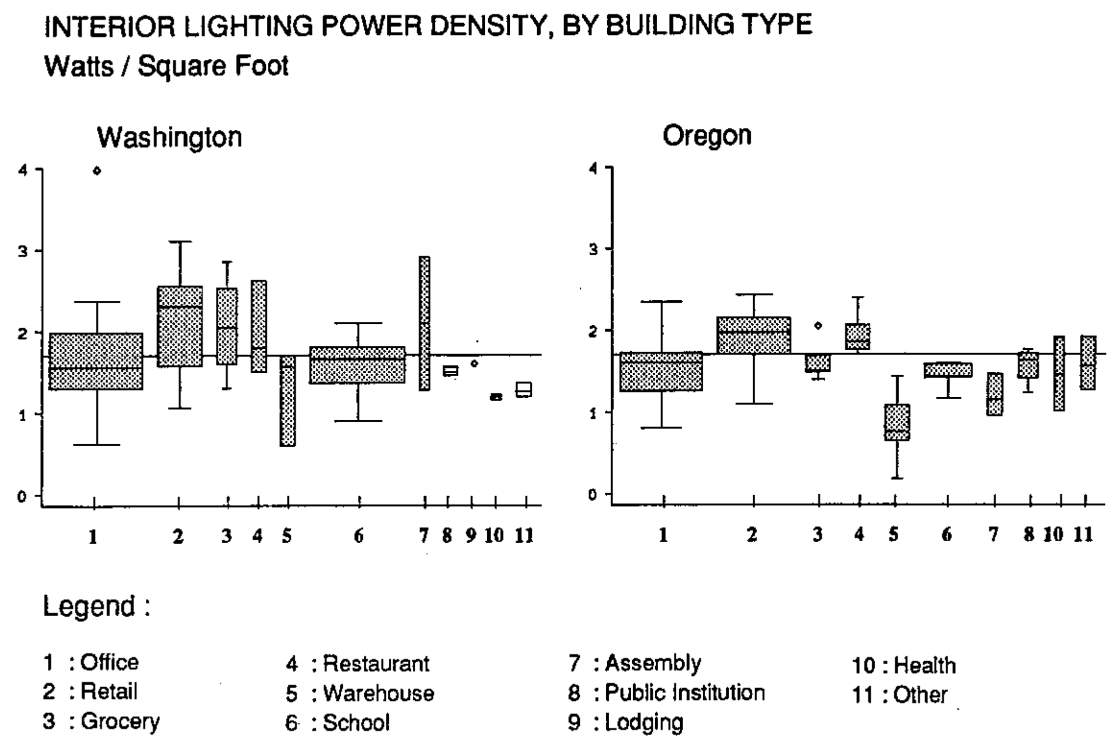


Figure 4.4
This figure compares Washington and Oregon LPDs. Even though Washington code requires a lower LPD in the retail sector, the average Washington building has a somewhat higher interior LPD than the average Oregon building and there is more scatter. Washington code permits designers to combine interior and exterior lighting budgets into an overall lighting budget. In many Washington buildings, particularly schools and offices, where exterior lighting of parking lots and building perimeters is not required, this allows designers to increase the interior LPD. Thus, even though the code-required interior LPD for Washington is lower and the levels of compliance higher, this loophole reduces the code's effectiveness compared to the Oregon code's more straightforward interior LPD budget.

In 1985, Church/Davis Architects conducted a survey of code compliance in 58 Oregon buildings [Davis et al., 1985]. During this study, they collected data on lighting levels. The average LPD was 42% higher than the LPD for 52 buildings with the same end use in our sample. The reduced LPDs were consistent across building types (from 25% to 70%) and school LPDs showed a dramatic improvement. This can be attributed partly to improved code language and clarity but largely to spectacular improvements in cost-effective high-efficiency lighting technologies over the past seven years.

4.2 Utility Programs

According to the architects and engineers interviewed, only nine Oregon buildings received utility incentives for participating in the Energy Smart Design (ESD) program. It was not clear whether these incentives were meant to subsidize specific energy improvements or were paid to the designers to develop recommended measures. The performance of these buildings was disappointing. When compared to the weighted average of all buildings, these buildings were about 10% less efficient than the sample as a whole for envelope and lighting efficiency.

There are several possible explanations for this. First, the building was reviewed for possible measures but none were incorporated into the design. Second, though ESD measures were incorporated into the design, they were not installed due to decisions made during the bidding or construction process. Third, the ESD measures did not directly impact the code levels. For example, a building may have received an energy efficient lighting package, identified in the ESD program, but failed to comply with the code in building envelope. Fourth, ESD measures, though identified and given incentives, were not verified by utilities and thus specifications deteriorated during the installation process.

4.3 Code Compliance Forms

The buildings in the Oregon sample were permitted between April 1990 and April 1991. During this period, Oregon was adopting code compliance forms as standard compliance methods for jurisdictions throughout the state. Of the sample, 53% of the buildings used these forms for code compliance submittals. These buildings had compliance rates of 56%, only marginally better than the overall sample. While we expected using these forms would help building designers understand code requirements and allow building inspectors to verify code compliance, this did not seem to be the case.

There are two possible explanations. First, the energy code compliance forms were filled out during the permit process and were not directly related to the building plans and specifications. Thus, the contractor's bidding documents did not contain the same information as the compliance forms. Second, changes made in the field affected the building's compliance and were not corrected due to lack of inspection for energy code issues.

This is a transition period. We noted higher levels of insulation and compliance in buildings, particularly in strip retail buildings, permitted towards the end of the sample period. Increasing familiarity with and use of the code compliance forms might explain this improved compliance.

4.4 Summary

Most buildings comply with the energy code on most measures. On average, construction practices in the Oregon sample are as good or better than the code demands. One can conclude that the code has improved building practices or, at a minimum, that building practices are well represented by the current code.

5 Interviews

5.1 Design Professionals

We attempted to interview at least one design professional or owner's representative for each building evaluated. Of the 71 buildings in Oregon, we interviewed at least one person associated with 67 of the buildings. For the remaining four buildings, either the designers refused to cooperate or we could not schedule an interview. Table 5.1 illustrates the distribution of interviews for the Oregon sample.

Table 5.1
Oregon Building Professionals Interviewed

Architect	61
Mechanical Engineer	43
Lighting Engineer	30
Owner's Representative	2
Contractor	4
Mechanical Installer	1
Lighting Installer	3
Other	5
Total	**149**

We used a structured interview format which focused on the specific building being evaluated and design decisions made to meet the energy code. Many of those interviewed responded with general answers based on their experience with the code overall. Although we collected a great deal of information, it tended to be anecdotal or impressionistic. It was impossible to systematically categorize most of these responses.

Overall Enforcement

Many designers cited inconsistent enforcement as the most time consuming and frustrating aspect of the energy code. Because they did not believe the code was enforced, many designers submitted drawings which did not comply with the energy code even though they submitted code compliance forms. Very few designers could remember an instance where feedback was received from code officials on any energy code issue. Only 5 of the Oregon respondents indicated that they had received any feedback on the particular building reviewed. In the absence of feedback, the designers assumed their projects complied. Lack of feedback almost certainly leads to neglect of energy code requirements. Feedback provided by building officials often led to increased incorporation of energy saving measures, although these buildings still might not comply with other code requirements. Some designers noted that feedback from code officials gave them a better understanding of energy code requirements.

Table 5.2
Frequency of Code Enforcement in Oregon
Cited by Building Designers

Enforcement Response	Yes	No
Comments or Feedback from Code Officials	5	86
Enforcement Affected Design	3	121
Revisions to Project Required	6	117

Enforcement Problems

Building professionals repeatedly mentioned certain problems. Usually these were due to confusion about the code requirements or inconsistent interpretations. These are summarized below by building system.

Envelope

- Thermal values for building components are not standardized. Some jurisdictions require ASTM tests (window and doors). Some require ASHRAE references. Some don't require any documentation at all.
- Slab insulation and thermal breaks are required but are not enforced and, even when noted on drawings, are not usually included in the building.
- Some mechanical engineers questioned the levels of insulation required by the code given the extensive internal heat gains in their buildings.
- The OTTV provision does not allow external shading to be considered. Some architects thought this was unfair.

HVAC Systems

- Because of lack of enforcement, some installers routinely omit economizers for small packaged equipment. Apparently, neither the design engineers or inspectors verify this provision.
- The prescriptive requirements in the code tables are often difficult to interpret and cause confusion in equipment selection (although most buildings easily complied with these provisions).
- Contractors installed used or refurbished equipment without documenting the efficiency of this equipment. This was rare, occurring twice in this sample.

Lighting

- Designers thought that most jurisdictions did not review lighting compliance and saw no reason to include LPD calculations on their drawings.
- In several instances, lighting installers substituted less efficient fixtures for those specified. In four cases, this resulted in non-compliance. The designers were typically unaware that field changes had affected energy code compliance, if they were aware of the changes at all.
- Several lighting designers said that table 53-M (which shows the LPD requirements) was difficult to interpret. Its ambiguities would cause many enforcement problems if the lighting requirements were enforced.
- Lights are often added in the final stages of construction, as part of tenant improvements, for display lighting or at the behest of the owner. These additions are not reviewed for code compliance.

Code Responsibilities

At the outset of this project we assumed that the architects serve as owner's representative and project manager on most building projects. However, a surprisingly small number of architects take responsibility for any part of the energy code. Table 5.3 shows who was responsible for code compliance according to the design professionals we interviewed.

Table 5.3
Oregon Code Responsibility
By Profession and Building System

Building System	Architect	Consulting Engineer	Contractor/ Installer	Other
Envelope	29	30	0	7
HVAC	1	35	6	8
Lighting	4	34	5	7

In only 40% of the cases did the architect or primary building designer take responsibility for any decisions involving the energy code. When the architect did take responsibility for code compliance, this usually involved only the building envelope.

In actuality, consulting engineers dominate the design and energy code compliance of all building systems. In most cases, they work for the architect or owner's representative; sometimes they work for the mechanical or electrical subcontractor.

Owner's representatives, or consultants hired by them, were responsible for code compliance in about 7 of the Oregon buildings. These were generally employees of chain stores or other large organizations who provided overall project management and to whom the architect was directly responsible.

The overall picture is one of minimal effort toward code compliance throughout the building professions.

- Architects routinely expected engineers to be responsible for energy code compliance. Even those who took responsibility for code compliance typically used calculations submitted by the mechanical engineer to decide the levels of insulation and window areas in the final building design.
- Relatively few architects understood much about the calculations and evaluation procedures used to establish envelope performance in the energy code.
- Most architects and some engineers appeared to believe that the jurisdictions are responsible for their understanding of the code. The architects consistently noted difficulties with consistent interpretation from one jurisdiction or official to another.
- Lack of consistent enforcement was cited as a corrosive effect, since buildings which evade code provisions are less expensive to build.
- The code itself was noted as a source of substantial problems because of inconsistent wording which seems to allow a variety of interpretations and causes confusion.

While many architects commented on code problems, few of them have any grasp of the code provisions. Many of their comments about envelope provisions did not reflect the actual code language and seemed to be based on hearsay from other building professionals. The engineers interviewed were somewhat critical of specific provisions. But most agreed that the code was not difficult to understand or incorporate into their designs. This was particularly true for lighting designers. About 75% of the architects and 50% of the engineers requested more training about energy code specifics.

5.2 Interviews with Code Officials

The purpose of this study was to review code compliance and current building practices. The review and interviews with code officials were considered of secondary importance, largely because we assumed in the time between the permitting of these individual buildings and our interviews, up to two years had elapsed and direct information about individual building enforcement would be difficult to access. As a result, the interview with the code officials focused on the general patterns of code review and enforcement and the nature and extent of training and understanding of the energy code.

We interviewed ten building departments in Oregon. These departments were for the most part selected to insure that the major jurisdictions with large amounts of commercial construction were reviewed and that some sampling of smaller jurisdictions with minimal activity were also surveyed.

In larger jurisdictions these interviews usually included at least two and sometimes three individuals involved in various aspects of building inspection and plan checking in the commercial sector and often included the person primarily responsible for energy code review.

Because of the general nature of these interviews, most of the information was anecdotal, although a structured interview was conducted and certain information was collected from all people interviewed. The responses are summarized under three headings:

Training and Resources

- Most Oregon code officials had participated in state-sponsored training programs. They frequently cited the Oregon Building Officials Association (OBOA) Short School and the OBOA Circuit Rider programs.

- Code officials frequently mentioned the inadequate amount of time allowed for reviewing energy code provisions and the need for more funding or manpower.

- Some jurisdictions had recently increased their enforcement of energy code provisions. Often this represented their first attempt at such enforcement. While they expressed frustration with both the code and the expectation that their office had the time and resources to enforce it, most of those interviewed believed their jurisdiction was able to enforce the code successfully.

- A recent statewide emphasis on energy code enforcement corresponds with the introduction of the Oregon Energy Code Compliance Manual and related forms. Most jurisdictions seem to use the forms for code compliance documentation, although some jurisdictions require them only for larger buildings. Although most jurisdictions gave the manual high marks, many complained that they had run out of the manuals and were unable to obtain more. They felt that this lack of support led to less effective code implementation.

- The amount of training or experience in energy code issues seemed closely related to a code official's sense of the value and enforceability of the energy code.

Compliance and Enforcement

- Almost unanimously, those interviewed described energy code compliance within their jurisdictions as 'good'. This applied to jurisdictions of any size, regardless of whether projects were reviewed for compliance with all aspects of the energy code.

- Jurisdictions with limited manpower or limited understanding of the energy code often did not review certain aspects of many projects for energy code compliance, relying instead on the mechanical or electrical engineer's stamp to verify compliance.

- Building officials were consistently frustrated by a lack of information on submitted plans. This led to an increase in the time required to review submittals, making manpower limitations even more acute. In some cases, lack of information made it impossible to verify compliance.

Building Systems

Envelope

- Half of the jurisdictions surveyed indicated that slab insulation and thermal breaks were consistently a problem area for energy code enforcement. Designers tended to ignore or misinterpret slab insulation requirements.
- Six of the ten jurisdictions surveyed mentioned consistent problems with wall insulation requirements. Windows and other aspects of the building envelope were also mentioned.
- More than half of the building officials interviewed felt that the definition of 'unheated' spaces was unclear and often manipulated by designers.
- Envelope compliance with energy code provisions was rated as good to excellent by all jurisdictions surveyed.

HVAC Systems

- Several jurisdictions indicated that mechanical system compliance was not reviewed, or that they relied on the engineer's stamp for energy code compliance. Most requested additional training in this area.

Lighting

- Most jurisdictions felt that compliance with the energy code was weakest in the area of lighting requirements. They mentioned consistent lack of documentation, despite requirements in many jurisdictions that lighting levels be indicated on plan submittals. LPD requirements were consistently misinterpreted or ignored. Changes in the lighting design during the project were particularly difficult to monitor.
- Tenant improvement projects consistently fail to meet LPD limits. Various reasons for this were given, including code ambiguities, inadvertent or intentional misinterpretation of the code by designers, and lack of a formal review process for lighting in these projects.

5.3 Comparison with 1985 Study

In a study of compliance in 1985, Church/Davis staff interviewed architects and engineers about the energy code. Comparing the earlier comments with those from our interviews underscores certain themes.

Architects and engineers seem more knowledgeable about the code in 1991 than in 1985. Still they have the same complaints. Architects say they need more information and must rely on engineers to provide code submittal information. The codes now are very similar to those used in 1985 except the lighting code which is now integral to Chapter 53 and therefore a bit more accessible.

The 1985 study noted that building department officials did not have the time or resources to adequately review the energy code and answer questions from architects and engineers about code compliance issues.

While overall compliance has improved since 1985, the conclusions of the earlier study are similar to ours. The Church/Davis report recommended simplifying the code for ease of use, requiring HVAC manufacturers to demonstrate code compliance and actively enforcing the code.

6 Conclusions and Recommendations

The 54% level of full compliance in this sample and the casual attitude of building design professionals towards the code suggest the need for substantial changes in enforcement. The similarity of our findings and recommendations with those from the 1985 study of code compliance reinforces the message. There are several ways to enhance enforcement.

6.1 Documentation

The current code requires minimal documentation. Only one jurisdiction required architects and engineers to note LPDs, equipment efficiency ratings (EER's) and equipment sizing on the drawings where they could be readily reviewed. Although Oregon compliance forms require references to equipment on drawings and specifications, we rarely saw these references.

Requiring documentation on plans would facilitate code reviews and inspections. Specifications are reviewed sparingly in building departments and virtually unused for on-site inspections. Information which must be reviewed in the field should be on the drawings.

We recommend requiring that the following key information be noted on drawings and bid documents, and checked during inspection.

Envelope

- Insulation values for walls, ceilings and floors on typical sections or in notes.
- Window U-values and shading coefficients on window schedules.

HVAC

- Equipment efficiency rating (EER) or other efficiency information on equipment schedules.
- Economizers specified on equipment schedules.
- Equipment capacity, fan size and horsepower on mechanical schedules.

Lighting

- Lighting watts and fixtures noted on lighting schedules.
- Control credits, when applied, noted on drawings.

6.2 Code Provisions -- Prescriptive Approach

Enforcement problems are compounded by the complexity of the code. The code as written demands a level of understanding of mechanical systems and, to a lesser extent, lighting systems and controls, that is usually associated with trained engineers, not building officials. Furthermore, building officials do not have sufficient time to check or inspect most provisions of the energy code due to lack of resources. Code enforcement would improve if the code was viewed, not as an engineering design standard, but as a set of straightforward provisions used to insure a minimum standard of efficiency in all buildings.

If the energy code were simplified, it would reduce the time required to review and enforce it. While simplifying and focusing the energy code would insure that certain measures be included in all buildings, doing so would require that the potential energy conservation delivered by the code be reduced. A new prescriptive code might include the following provisions:

Envelope

- Use a prescriptive approach to regulate the envelope: require that all walls be .07, all windows .60 and all ceilings and floors .05. Remove restrictions on glazing area.
- Drop the requirement for building floor slab insulation for large unheated slabs (over 3,000 ft^2).
- Require a shading coefficient of .75 for exposed glazing in a building with cooling.
- Eliminate the "unheated" designation except in limited situations (e.g., greenhouses) and require that all buildings meet minimum U-values for all components.

HVAC

- Retain the existing efficiency requirements which seem to be working well. Upgrade large cooling equipment efficiencies.
- Mandate economizers for air handlers over 2,000 cfm; this would include all single zone rooftop and related packaged units.

Lighting

- Retain the existing LPD format but require notations on fixture wattage on code submittal documents.
- Insure that lighting inspections be conducted as part of the field inspection for code compliance.
- Eliminate exterior lighting budgets.
- Retain requirements for automatic switching on exterior lights.
- Eliminate control credits.

6.3 Code Design Standard Approach

The alternative to the prescriptive approach described above is to continue with the current design standard approach and provide the additional resources and documentation necessary for enforcement.

In general, design professionals have not yet accepted the code as a mandatory set of provisions to be followed as part of the permit process nor have they accepted the necessity for detailed documentation of energy code provisions on drawings and specifications. This can only change if building departments demand this level of compliance and documentation before issuing a building permit. This would require additional resources in terms of time and trained personnel.

Most code provisions can be easily verified during a plan review. However, during our evaluation of 141 buildings in Washington and Oregon, we spent from four to six hours a building conducting detailed reviews of plans and specifications for a limited number of provisions. Each field inspection took at least four hours, and we only inspected each building once and often could not review all components regulated by the energy code. To insure energy code compliance, building officials should spend at least eight and perhaps twelve hours reviewing plans and specifications and inspecting to insure compliance. This is comparable to the total time building officials are now able to devote to the entire code enforcement process, including enforcing structural, fire, life and safety. Continuing to view the energy code as a design standard and allocating the time necessary to enforce it would cost between $500 and $800 for new commercial buildings, and somewhat less for tenant improvements and remodels.

In large jurisdictions, trained staff members are available to review details of mechanical and electrical submissions. In smaller jurisdictions, staff members may not be trained to deal with this level of complexity. It seems essential to develop a cadre of code officials who could be called upon to enforce the energy code throughout the state, in lieu of or in cooperation with local building officials. In this way, engineers and other specialists could be devoted directly to energy code compliance.

6.4 Utility Programs

Utility programs should be much more effective than they are. The utility is responsible for insuring that the rate-payer's money is actually producing energy savings. We noted two problems with utility programs.

1) There is no definition of current construction practice which can be used as a baseline to insure that the utility is financing improvements over current building practices. Quite often engineers commented that they would have added the conservation measures funded by the utility even in the absence of a utility program. In cases where the energy code requirements are actually below current design standards, the utility pays for the owner to build a "current practice" building. For example, the typical chillers used in large buildings have EERs of about 16, almost double the code minimum. In an energy budget submittal, this normal level of performance can look like energy conservation and can compensate for poor performance of the building envelope or a poorly designed distribution system.

2) Simply offering cash for the development of better designs is not enough. As with the code, enforcement is necessary to insure that energy efficiency is implemented. Utilities must inspect and verify the installation of items subsidized under the ESD program. There was evidence in this sample that some ESD measures identified in the specifications were not implemented during construction.

Addressing the problems encountered in ESD and utility incentive programs is beyond the scope of this project. But it is important to remember that the delivery of energy efficiency in the commercial sector is not strictly a responsibility of the code. For certain sorts of improvements, especially in mechanical systems, lighting and controls, utilities must take the lead. It is the utility benefits associated with conservation that gave us the commercial energy code in the first place.

6.5 Efficiency vs Compliance

It is taken as axiomatic that energy code compliance is equivalent to some level of energy efficiency. Conversely, buildings that do not comply with the code are inherently less efficient than buildings that do. In actuality, this may not be the case.

Some provisions of the code have little or no relationship to actual energy use. Other provisions may under some conditions actually increase energy use (such as the use of lighting control credits, which result in higher lighting budgets but not necessarily reduced lighting duty cycles). Our findings indicate that while about half of the sample fails to comply with all aspects of the code, the average building complies.

It is wise to consider the impact of complex codes which require some technical understanding and detailed calculations. Many design professionals argue that the code is unnecessary interference in their business. Our findings indicate that in some cases this interference has not been productive. It is appropriate to identify the limitations of energy codes and concentrate efforts on strengthening and simplifying those provisions which do indeed deliver improved energy efficiency and can be easily enforced.

The level of non-compliance found in this sample is unacceptable because it sends the message that the level of efficiency mandated by the code is optional. We should either enforce these standards by allocating appropriate resources to the task, or choose standards that can be enforced and gain further savings through well-designed incentive programs.

7 Acknowledgements

Dennis Oberto, Erin McMahon and Jonathan Heller did most of the evaluations of the individual buildings. Their competence and dedication were essential in the completion of this report. Andy Eckman of the Bonneville Power Administration and Jeff Harris of the Northwest Power Planning Council provided review and support which made this project possible. Finally, Alan Boner and John Perry of the Oregon Department of Energy provided review and project management for the State of Oregon.

8 References

Davis, William et al., *Commercial Building Code Compliance in Oregon*, 1985. For Oregon Department of Energy, Salem, OR.

Companion Reports

This report is one of a series. *Energy Code Compliance in Commercial Buildings, Washington and Oregon* is the full report on the study. It contains more detailed and comprehensive information on the methodology, sample development, building evaluations and interviews.

We also wrote a parallel summary on code compliance in Washington.

There are seven appendices which provide back-up documentation. These include energy code tables, data collection forms, the Dodge database building list, and building summaries for each sample. This compendium of documentation is available for those seeking further details.

Baylon, David, Mark Frankel and Curtis Clark, *Energy Code Compliance in Commercial Buildings, Washington and Oregon*, 1992. For the Washington State Energy Office, Olympia, WA and the Oregon Department of Energy, Salem, OR.

Baylon, David, Mark Frankel and Curtis Clark, *Commercial Building Energy Code Compliance in Washington, 1992*. For the Washington State Energy Office, Salem, OR.

9 Appendices

Oregon Code Compliance Data Sheet Legend

Oregon Code Compliance Data

OREGON CODE COMPLIANCE

Data Sheet Legend

Reference

BUILDING TYPE:	Building type by end use category.
COUNTY:	County in which building is located.
SQ. FT:	Square feet of heated building area, in thousands.

Envelope

WALL UO:	Overall average thermal value of walls, including glazing and doors.
CEIL. UO:	Overall average thermal value of roof, including skylights.
TOTAL UA:	Building heatloss: Sum of component areas multiplied by installed thermal value of each component, in BtuH/ft.^{2}.
CODE UA:	Code allowed heat loss: Sum of component areas multiplied by allowed thermal value of each component, in BtuH/ft^2.
OTTV:	Overall Thermal Transfer Value.
CODE OTTV:	Maximum OTTV allowed by code.
GLAZE %:	Glazing percent of floor area.

HVAC

COOL EER:	Equipment Efficiency Rating of installed cooling equipment, in Btu/w.
HEAT EFF:	Efficiency of installed heating equipment.
HEAT FUEL:	Heating system fuel source: E: Electric G: Gas HP: Heat Pump STM: Steam

Lighting

LIGHTING LPD:	Lighting Power Density; installed watts per square foot.
CODE LPD:	Lighting Power Density; allowed watts per square foot, based on building type.
EXTERIOR KW:	Installed exterior lighting, in kilowatts.
EXTERIOR CODE:	Allowed exterior lighting, in kilowatts, based on building perimeter.
CONTROL CREDITS:	Installation of lighting controls used to justify installation of lighting levels above regular code allowances, as allowed by code. '1': Yes '0': No

Compliance

'1': Yes '0': No