Baseline Commercial Construction Practices in the Pacific Northwest

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ABSTRACT

This baseline study was conducted to describe the current building practices and standards in the four states represented by the Northwest Energy Efficiency Alliance (Idaho, Montana, Oregon and Washington). The goal was to provide baseline data which the Alliance could use to develop and evaluate a variety of initiatives that focus on transforming the consumer market in new non-residential buildings and to provide a snapshot of compliance with energy code standards in these states.

In general, non-residential buildings were found to be relatively efficient across all four states. Certain efficient components tended to dominate in local markets, while largely absent from others. While energy codes appear to be the dominant influence on construction practices, factors ranging from climate to national HVAC equipment standards appear to have positively impacted particular markets.

The success of non-code factors in increasing the efficiency of specific components in some markets indicate the importance of other factors. While it is outside of the scope of this study to identify the market forces responsible, it is clear that persuading a few key decision-makers to adopt specific energy efficient strategies in any particular market leads rapidly to a wide-spread response from competitors, and ultimately, a complete market transformation.

Introduction

The Northwest Energy Efficiency Alliance (the Alliance) is a consortium of electric utilities, state agencies and regulators founded to develop and administer a regional approach to market transformation in energy efficient building practices. This baseline study was designed to describe the current building practices and standards in the four states represented by the Alliance (Idaho, Montana, Oregon and Washington). The purpose of the baseline was to provide a basis for evaluating a variety of initiatives that focus on transforming building practices and energy efficiency in new non-residential buildings, specifically:

- Characterize the distribution of building types and building sizes across the region.
- Describe the applicability of, and compliance with, existing energy standards in each state.
- Provide a measurement of the efficiency of major building components (envelope, HVAC and lighting), analyzed separately for each state against a local and regional performance standard.
- Provide a characterization of the market penetration of particular technologies where sufficient information might be collected.

The general approach was to develop a representative sample of buildings in each state using a statewide database. Buildings were recruited and a plan review of the as-built or permits was conducted. This was followed by a field audit evaluating the major building components and interviews with the building architect and engineer.

Sample Frame and Sample Design

The field review was conducted in Idaho, Montana and Oregon using non-residential construction permitted in 1998 as the sample frame. The Washington baseline used the review conducted in 1996 using buildings permitted in 1995 (Baylon et al. 1997). In this survey, the main goal was to assess the energy compliance, but the field protocol was essentially identical to this evaluation. In addition, a code compliance baseline was conducted in Washington and Oregon in 1990-91 (Baylon et al. 1992). This used a similar field methodology. The dataset from 1995 Washington buildings has been used to complete this baseline for the region. The 1990 buildings have been included for comparison.

Each state sample and the samples from previous studies were all constructed from a commercial database purchased from F.W. Dodge®. Although this data source is somewhat problematic (particularly with respect to reporting dates and ambiguity between new projects and remodels), it offers the most complete basis for sampling and evaluating state-wide non-residential construction. To prepare the sample frame, building projects of less than $200,000 construction valuation and buildings that were said to be remodels were removed. Table 1 shows the resulting sample frame for each state for the 1998 building year (including Washington) and the distribution of building types. For the reasons stated above, the Washington sample has not been included in the total column in this table and no field review was conducted on this sample (interviews were conducted).

Table 1: Sample Frame, 1998 (by state and end use)

	Idaho		Montana		Oregon		Total	Washington	
	N	% sf	N	% sf	N	% sf	% sf	N	% sf
Assembly	37	6.3	20	11.9	53	5.2	6.1	87	7.7
Education	27	12.5	21	18.0	51	8.7	10.3	89	10.1
Grocery	8	1.8	8	5.8	18	2.8	2.9	32	2.7
Health	24	4.0	16	8.4	48	3.8	4.3	54	5.1
Institution	8	2.3	8	10.5	17	0.9	2.1	28	1.6
Lodging	7	5.8	6	5.9	35	8.6	7.8	36	8.1
Manufacturing	0	0.0	0	0.0	00	0.0	0.0	0	0.0
Office	89	15.7	26	7.2	125	20.5	18.2	207	18.8
Other	48	15.1	13	6.1	99	17.3	15.8	129	14.8
Restaurant	27	2.1	3	0.7	34	0.9	1.1	57	1.1
Retail	42	22.9	29	19.7	67	8.5	12.5	156	13.4
Warehouse	39	11.5	18	5.8	108	22.8	18.8	145	16.6
Total	356	100	168	100	655	100	100	1,020	100

This sample design resulted in a three-stratum design, unique to each state, owing to the differences between states and between years. The design generally broke the sample frame into three building sizes: large, medium and small. The sample was randomized within each strata. Buildings were recruited through direct phone contact with architects and owners. Overall, about half of the contacts resulted in successful recruitment. Non-participants were replaced with randomly selected candidates within each stratum until a target number was achieved. The final samples are shown in Table 2. Each sample underwent a similar recruitment regimen.

Overall summaries of each state were developed using case and area weights, and were designed to provide an estimate of population behavior within each state. In total, almost 30% of the total construction activity occurring in these four states was evaluated.

Table 2: Non-residential Baseline Samples by State

State	Year	Sample Frame		Sample		
		N	SF	N	SF	Percent
Idaho	98	356	5,568	48	2,037	36.6
Montana	98	168	2,581	32	1,160	44.9
Oregon	98	655	18,814	64	5,021	26.7
Washington	98	1,020	25,804	88	9,771	37.9
Washington	95	792	25,128	88	6,092	24.2
Oregon	90	213	8,290	71	3,817	46.0
Washington	90	468	17,360	70	4,296	24.7

Characteristics

The results of this review indicate that, while the energy efficiency of typical building stock is impacted by the minimum standards set by energy codes, other factors also produce significant impacts. Idaho and Montana have adopted the MEC '95 as "statewide" codes. In Idaho, enforcement is voluntary in each jurisdiction. For the most part, major Idaho jurisdictions do not enforce a non-residential energy code. In Montana, all statewide building codes are assigned to the State Architect's office. These are in turn passed to individual building jurisdictions. In Montana, this includes only a few "urban" areas. The rural areas remain the responsibility of the state. Permits and code enforcement for these areas are very problematic, and only public buildings actually experience significant enforcement. For purposes of evaluating Montana and Idaho, the ASHRAE 90.1-89 standard was used. This is the performance standard for these two states. Oregon and Washington have similar and fairly stringent energy codes. The Washington energy code was revised in 1994; the Oregon energy code, in 1996.

Despite these differences in regulatory environments, buildings in both Montana and Idaho tend to be consistent with the efficiency levels of buildings in Oregon, even exceeding Oregon's requirements on some components. Other factors that impact actual practice appear to be consumer demand and professional practices. An additional important factor is indirectly related to regional and national code requirements: equipment manufacturers and suppliers tend to use the highest regional standard as their minimum guideline when designing product lines. This increases the efficiency and reduces the availability of less efficient alternatives.

Building Envelope

The analysis of envelope characteristics in the non-residential sector is complicated by differences within and between end uses within the sample. For example, the retail sector in Idaho and Montana is largely comprised of big box outlets and small stand-alone convenience stores, while urban retail malls dominate the retail sector in Oregon. While the range of values across states for particular end uses can appear quite large, close inspection of the individual buildings both in the current and in the 1995 Washington sample reveals that this is largely an artifact of the particular sample itself.

Table 3 examines the overall heat loss rate of the envelopes for buildings in the study sample and for other recent work.

Table 3: Envelope Heat Loss Rate

Sample	Pop #	Sample Heat Loss Rate (UA/ft^2)		Code Heat Loss Rate (UA/ft^2)	
		Mean	Std. Dev.	Mean	Std. Dev.
1998 Oregon	64	.20	.085	.19	.083
1998 Idaho	48	.17	.119	.15	.096
1998 Montana	32	.12	.050	.14	.064
1998 All	144	.18	.076	.15	.086
1995 Washington	84	.17	.111	.19	.115
1990 Washington	70	.13	.076	.15	.045
1990 Oregon	71	.18	.070	.21	.071

In the current sample, the envelope U-values for Oregon were higher than those of other states. While this is partly due to climate, the primary cause is the allowance of trade-offs in the Oregon Energy Code between the building shell and the lighting and equipment efficiency using a simulation methodology. (Washington also allows these trade-offs but they are rarely employed). This is largely an artifact of the buildings in the Oregon sample. There are three large office/retail projects in Oregon with large glazing areas. They dominate the Oregon sample. The Idaho heat loss rates are almost as large as that of Oregon and Washington in spite of the smaller building sizes and lesser glass area (roughly 30% less glazing across the sample). This is largely the result of much lower-performing windows in that state.

The 1990 Washington sample has a noticeably lower heat loss rate than the other samples, except Montana's. This is largely because the Washington code regarding non-residential building envelopes was relaxed significantly in 1994 and made consistent with the ASHRAE standard.

Windows. Window performance under most codes and standards, residential or non-residential, focuses on both normalized window area (in non-residential codes, usually window area as a percent of wall area) and actual window U-value performance. In non-residential construction, particularly in buildings with installed cooling, this also includes the shade coefficient (SC) or tint of the windows. Both the Oregon and Washington codes address the SC.

Table 4 describes the actual window performance by window class. In this case, "class" refers to the two-digit whole number that represents the actual U-value of the window and, in general, describes the thermal performance/heat conductivity of the window.

Table 4: Window Thermal Integrity by State

State	Average U-value	Percent Area in Window Class (U-factor x 100)			
		30-40	41-50	51-60	>60
Idaho	0.557	3.9	42.4	13.0	40.7
Montana	0.453	21.2	70.7	5.7	2.4
Oregon	0.583	5.9	20.6	41.2	32.3
Region	0.557	8.1	32.5	30.6	28.7
Washington 1995	0.673	0.4	15.4	46.3	37.9

The Montana windows have noticeable lower U-values than those seen in Idaho or Oregon. Montana builders tend to treat windows as a major response to their relatively cold climate. The lower window area of the Idaho sample largely cancels out the performance difference between the Idaho and Montana samples. The overall window heat loss between the two states is very comparable. The Oregon sample, on the other hand, has a much higher overall heat loss rate. This is principally caused by a few large urban developments (especially Office and Retail) that use trade-offs to allow more glass.

The contrast with the 1995 Washington sample is notable. The principle difference in the current samples is the presence of low-ε coatings in windows manufactured and installed since 1995. An added issue is the nature of the Default tables in the Washington code. Table 5 shows the distribution of various performance-enhancing window components.

Table 5: Window Characteristics by State (percent of area)

State	Low-e	Tint	Reflective	Argon
Idaho	38.9	48.9	6.7	7.0
Montana	93.2	46.8	2.2	7.3
Oregon	63.7	83.7	6.4	9.6
Region	64.7	73.8	5.9	8.6
Washington 1995	27.0	22.4	----	0.3

Low-ε coatings have become dominant in non-residential windows in both the Montana and Oregon markets. In fact, in the Montana market they have become standard practice. The use of shading tints has become extremely dominant in Oregon. This can largely be attributed to the requirements in Oregon for shade coefficient as a component in building envelope design. By contrast, Idaho does not use low-ε coatings to any major degree. Reflective coatings and argon remain fairly rare throughout the region.

The Washington sample was drawn in 1995 and involved window specifications done somewhat prior to this date. The addition of regional manufacturing facilities made low-ε coatings more available after 1995. Clearly, this market change has (at least in Oregon and Montana) been reflected in a major increase in the non-residential use of low-ε coatings. Since the presence of coatings was far lower in the Washington sample, a contemporary sample would probably resemble the Oregon results.

When comparing the envelope practices across the four states—even when window performance is taken into account—the patterns of building insulation and glazing selection are reasonably similar (with the possible exception of Idaho). In Montana, the attention to building shell seems to dominate the market, and is clearly an area of focus for designers and builders in the non-residential sector.

HVAC Systems

A complete review of the HVAC equipment of each building was made. System and equipment type, rating, and size information was collected. Where possible, name plate information was gathered so that capacity and efficiency data could be determined.

The vast majority of sample buildings used packaged constant- or variable-volume air handlers. A small number of buildings had separate systems to meet the different loads, all serving the same space. Heating is sometimes supplied by radiant floor or perimeter fin-tube radiators, while ventilation and cooling are supplied with a central air system. Table 6 shows the distribution of space conditioning by state.

Cooling strategies vary widely across the region. A majority of commercial floor area in the region is cooled. However, most warehouse and manufacturing space, as well as 40% of school floor area, is not. Traditional compressor-driven cooling is predominant in Oregon. Montana has significantly less cooling than the other states, due to the use of free cooling in many building types. Several Montana buildings employ chiller-less cooling towers and airside economizers to meet cooling loads.

Table 6: Degree of Heating and Cooling (percent of floor area)

State	Heated	Semi-heat	Unheated	Unknown	Total
Idaho	98.30	1.70	0.00	0.00	100.00
Montana	98.76	1.24	0.00	0.00	100.00
Oregon	83.63	6.80	1.56	8.01	100.00
Total	89.47	4.73	0.95	4.85	100.00
State		Cooled	Uncooled	Unknown	Total
Idaho		83.3	15.8	0.9	100.0
Montana		66.3	33.6	0.1	100.0
Oregon		75.3	15.7	8.9	100.0
Total		76.2	18.2	5.6	100.0

System Types. Commercial HVAC systems come in a wide variety of combinations, and many of the audited facilities have a mixture of equipment and system types. Table 7 summarizes the system configurations found. Single and multi-zone/complex equipment systems have been grouped. Package single zone equipment and package VAV serve 80% of the floor area.

A summary of the 1990 and 1995 distribution from the Washington study has been provided for comparison. In 1995, 72% of the buildings used simple systems. Even in large buildings, simple systems were used where single-zone packaged rooftop units were employed. In the 1999 sample, 75% of buildings used simple systems. Over the last decade there has been an increasing trend toward package single-zone systems

Table 7: System Configuration by State (percent of floor area)

System Type	Idaho	Montana	Oregon	Total	WA 1995	WA 1990
Single-Zone					72	66
Package Single Zone	77.5	43.3	72.3	69.5		
Built-up Single Zone	7.2	24.2	2.0	6.6		
Multizone/Complex						
Package VAV	0.8	2.6	15.6	9.8	11	15
Built-up VAV	4.8	12.9	5.7	6.5		
Package Other	0.0	0.0	1.4	0.8	7	6
Built-up Other	9.7	17.0	3.0	6.8	10	12
Total	100.0	100.0	100.0	100.0	100	100

Fuel Selection. System data is described by fuel type in Table 8. The saturation of electric heat is somewhat overstated because the fuel type for VAV systems used the reheat fuel. In these cases, the primary coils are often gas fired with electric reheat. The almost 30% saturation of gas heat (with boilers and hot water coils) in VAV reheat is a marked departure from previous regional work where reheat fuel was almost universally electric. Other fuels include central steam and geothermal. About 93% of the boilers used hot water, with the remainder being steam.

Table 8: Equipment Type by Fuel (percent of floor area)

	Primary Heating Fuel					
Equipment Type	Electric	Heat Pump	Natural Gas	Propane	Other	Total
Package Single Zone						
FRN-Furnace/AC	0.9	0.8	16.9	1.0	1.9	21.5
PTAC/HP	2.0	3.0	0.0	0.0	0.0	5.0
Rooftop CV	1.6	0.0	26.6	0.0	1.1	29.2
Radiant Heaters	0.0	0.0	4.8	0.0	0.0	4.8
Zone/Unit Heater	0.3	0.0	8.9	0.0	0.1	9.3
Sub-total	4.8	3.8	57.2	1.0	3.1	69.8
Complex Systems - Built-up and/or Multi-zone						
HP Loop	0.2	0.0	2.5	0.0	0.0	2.6
Misc. Complex	0.0	0.0	1.4	0.5	0.0	1.8
VAV	11.1	0.0	4.4	0.7	0.5	16.7
Unit Ventilator	0.0	0.0	2.9	0.0	0.2	3.0
Sub-Total	11.4	0.0	16.9	1.2	0.8	30.2
Total – All Systems	16.1	3.8	74.1	2.2	3.8	100.0

Efficiency. Where available, equipment efficiency data was collected. Efficiency is regulated by the ASHRAE 90.1 and federal standards in Idaho and Montana. These standards also form the basis of the Oregon energy code efficiency requirements. National standards and distribution have made it difficult to purchase new equipment that does not meet code efficiency levels, even in unregulated areas. On average, Montana has significantly better equipment than Idaho or Oregon. This is mainly due to a much higher saturation of condensing furnaces (gas) in Montana. Table 9 describes the average system efficiency of the HVAC equipment in the sample.

Table 9: HVAC System Equipment Efficient (by state)

Equipment	Idaho		Montana		Oregon	
	Avg. Eff.	% not compliant	Avg. Eff.	% not compliant	Avg. Eff.	% not compliant
Combustion heat	81.2	13.7	83.2	3.8	81.4	8.1
Boilers (steady state)	83.5	0.0	83.1	0.0	80.9	0.0
Cooling	9.9	1.2	10.5	1.5	10.0	3.7

Compliance levels are very high for all equipment types except large furnaces. However, even in sample buildings with non-complying equipment, efficiency was very close to the mandated levels. Other regulated features (such as economizers) were found to be compliant in about 90% of the cases where verification was possible. All boilers in the sample were found to meet or exceed ASHRAE-mandated efficiency levels. Package cooling equipment efficiencies were near or better than code in almost all cases. Package terminal AC and heat pumps, and large unitary equipment, were often significantly better than code.

Motors and Controls. With the predominance of package equipment, a vast majority of the motor horsepower is installed by equipment manufacturers and is regulated as part of the system efficiency. Motor size, drive and control information were gathered for site-installed fan and pump motors, and are shown in Table 10.

Forty-six percent of HVAC fan motors are controlled with adjustable speed drives, representing 77% of the total HVAC fan horsepower. Significantly, no other variable flow controls (inlet vanes) were identified in site-installed or packaged VAV systems. Pump motor modulation was typically accomplished with staging or adjustable speed drives. Motor staging was the primary modulation technique in large applications.

Table 10: Fan Motors – Controls Summary

Controller type	Percent of Motors			Percent of Horsepower		
	Other	HVAC	All	Other	HVAC	All
ASD	4.2	46.0	28.6	11.6	76.7	54.1
Multispeed	5.3	5.1	5.2	0.7	6.3	4.3
Constant	90.5	49.0	66.2	87.7	17.1	41.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

Lighting

Extensive data on lighting systems was collected. Fixture, lamp and ballast type information was derived from plans and in the field. Lighting power includes the lamp, ballast and transformer energy for each fixture based on observed characteristics. Lighting power densities were calculated from the resulting fixture energy use. Ballast type was sometimes difficult to determine from the plans. The main fixtures in most buildings were checked with a "flicker checker," which detects the lower frequency of magnetic ballasts.

Montana does not regulate lighting power outside of the public sector, while Oregon enforces lighting as part of the Oregon Energy Code. In the Montana public sector, the state architect enforces the ASHRAE 90.1-89 energy codes. Lighting control adjustments were applied to the lighting budgets.

ASHRAE 90.1 interior lighting levels were established using the prescriptive Unit Lighting Power Allowance (ULPA). The ASHRAE code makes extensive modifications to the installed Calculated Lighting Power (CLP) for various kinds of lighting controls, which complicates comparisons. Since the adjustment is essentially an artifact of the code, we have applied the adjustment to the ULPA rather than the CLP. This allows a direct comparison of the sample with both standards.

Efficient lighting systems were found to dominate the public and private sectors in all three states, with the average lighting power density in all states lower than local requirements. The availability and cost of efficient fixtures and lamps has apparently allowed standard building practices to exceed code requirements.

Lighting Power Density (LPD). Table 11 presents the average lighting power density for each state and the sample as a whole. The differences between states were not found to be statistically significant. Despite sample differences, comparing these results with the previous Washington samples is instructive. The 1990 sample has a significantly higher LPD than the 1995 Washington sample or the 1998 regional sample. A persistent, dramatic reduction in lighting power has occurred over the last eight years.

Table 11: Lighting Power Density by State (watts per ft^2)

State	N	Sample LPD	Std Dev	Oregon Code		ASHRAE Std	
				LPD	Result[1]	LPD	Result[1]
Idaho	48	1.21	0.33	1.36	1.15	1.58	1.18
Montana	32	1.25	0.32	1.23	1.12	1.42	1.16
Oregon	63	1.13	0.43	1.29	1.07	1.66	1.10
Region	143	1.17	0.39	1.30	1.10	1.60	1.13
Washington 1995	88	1.15	0.59	1.28	1.05	-----	-----
Washington 1990	70	1.58	0.53	1.74	1.31	-----	-----

[1] The result column is the average LPD that results from bringing non-complying buildings into code compliance. Full compliance with either the Oregon state code or the ASHRAE code would reduce lighting load by 4% region-wide.

End use changes the average LPD. For example, removing warehouse and manufacturing spaces results in state LPD's that are nearly identical to one another. Differences between the building types were not found to be statistically significant. There is a great deal of similarity between this sample and the 1995 Washington sample. It is notable that between 1990 and the current sample, there has been a 25% reduction in LPD in Washington and Oregon. This can be traced to a similar reduction in code requirements, although the performance of the Idaho and Montana samples suggests that lighting technology improvements are also very important in this reduction.

Fixture Selection. While LPD levels are similar across the states, lighting technology does provide some variation. Fewer T12 fixtures were found in Oregon (6% of the total T8 and T12 watts), while Idaho buildings account for 16%. A higher saturation of HID lighting in Oregon results from the greater number of warehouses in the Oregon sample. Ballast type showed a strong correlation with state. Idaho and Montana buildings used fewer electronic ballasts, although more than 80% of ballasts were electronic. In Oregon, more than 90% of ballasts were electronic. Table 12 details the lamp and ballast types observed.

Table 12: Lamp & Ballast Type by State (percent of watts)

Lamp Type	Percent of watts			
	Idaho	Montana	Oregon	Region
Fluorescent	66.5	71.1	50.1	57.9
T8	55.8	61.8	46.6	51.5
T12	10.7	9.4	3.5	6.3
CFL	3.3	4.5	5.1	4.5
HID	21.8	16.7	34.0	27.9
Incandescent	8.1	7.5	9.1	8.6
Low Volt (24V)	0.2	0.1	1.5	0.9
Exit	0.2	0.2	0.1	0.1
Total	100.0	100.0	100.0	100.0
Ballast Type				
Dim Electronic	0.00	0.5	3.3	1.8
Magnetic	20.0	18.4	10.0	14.4
Electronic	80.0	81.1	86.7	83.8
Total	100.00	100.00	100.00	100.00

Standard 4' fluorescent fixtures are used in the vast majority of the region's floor area. Where ballasts were present, T8 lamps and electronic ballasts were the dominant combination in all states, though magnetic ballasts were found in a minority of cases. T12 lamps typically were installed with magnetic ballasts. An estimated one-third of the magnetically ballasted T12 lamps were used in situations where electronic ballasts and T8 lamps are not commonly employed (including cold start and high output fixtures in loading docks, warehouses and manufacturing). HID lighting was the dominant lighting source in facilities with high ceilings. Metal halide lamps were the primary fixture.

Incandescent fixtures account for 9% of the connected lighting load. In 21 buildings, incandescent fixtures represented 20% or more of the total connected load. Eight of these were in the residential/lodging category. Retail and grocery also had greater levels of incandescent lighting.

Lighting Controls. Advanced lighting controls were present only in the larger projects, and multiple strategies were often employed in the same project. Table 13 describes the distribution by state.

The two largest buildings in the sample (both Oregon office buildings) accounted for one-third of the advanced controls found in Oregon and 25% of the total found throughout the region. Oregon had significantly better lighting controls than the other states, largely due to the larger buildings in the Oregon sample. Offices, assembly, education, and retail were the main sectors with advanced controls. In the assembly and retail sectors, advanced controls are most often used in large open spaces (such as exhibition halls and big box retail facilities). Daylighting controls were installed in six buildings and were generally associated with very large amounts of glass. Two of the six buildings were offices utilizing perimeter lighting control. These projects were the two largest buildings in the sample.

Table 13: Automatic Lighting Controls by State (percent of watts)

State	Lighting controls			Total
	Daylight	Occupant	Sweep	
Idaho	3.42	0.13	0.00	3.55
Montana	1.46	0.41	6.30	8.17
Oregon	5.01	8.58	13.23	17.90
Region	4.12	5.31	8.91	12.91

Interviews

Interviews were conducted with design professionals in all four states. The majority of the respondents were architects (64%), and mechanical engineers comprised another 16%. The remainder of the sample included owners, owners' representatives, developers, contractors, and other design professionals. No other group comprised more than 5% of the sample.

The interview responses suggest that decisions affecting energy efficiency are made by the individual design professional for each major building component, with the architect and/or owner communicating general goals and retaining final authority. However, the impact of the owners and architects varies widely by state. Mechanical engineers select equipment and designs in 87% of the Montana sample, while energy efficiency decisions are made by these professionals in only 27% of the Idaho sample. Table 14 describes the decision-making chain for the three major components examined in this study.

Table 14: Energy Efficiency Decision-Makers (by percent)

	Envelope				Mechanical				Lighting			
	ID	MT	OR	WA	ID	MT	OR	WA	ID	MT	OR	WA
Architect/Design	45	94	67	67	23	13	4	2	23	31	13	8
Owner	36	6	8	10	34	0	11	12	34	0	10	17
Mechanical	0	0	0	0	27	87	63	60	0	0	0	0
Electrical	0	0	0	0	0	0	0	0	25	56	52	47
Contractor	2	0	2	6	5	0	16	17	2	0	15	12
Other	17	0	23	17	11	0	6	9	16	13	10	16
Total	100	100	100	100	100	100	100	100	100	100	100	100

The Washington and Oregon professionals typically said they were governed by their state's Nonresidential Energy Code. In Montana, 93% of the respondents said they designed to MEC standards, with the remainder citing ASHRAE Standard 90.1. Responses from the

Idaho respondents, on the other hand, were surprising. Fully 38% of the Idaho sample said they did not design to any of these standards, while 27% said they were governed by ASHRAE Standard 90.1. About 18% said they designed to Oregon or Washington Energy Code standards, 7% said they use the MEC as a guideline, and almost 5% said they use the Idaho *Residential* standard.

This was reflected in responses to questions about code official intervention and code acceptance. When asked if any feedback from code officials had been received, only one Idaho respondent said yes, and only two from Montana. About half of the respondents In Washington and Oregon had received feedback on energy code compliance.

The majority of respondents said they design their buildings in accordance with applicable energy codes; however, the number claiming to exceed energy code requirements varied substantially by state. About a third of Oregon and Washington respondents said they exceeded code requirements while about 10 percent of Idaho and Montana respondents made this claim.

When questioned about the overall attitudes of their peers and clients toward energy efficiency, the results were somewhat contradictory. About 45% of respondents from Oregon and 35% from Washington said the design team (including the owner) would rate energy efficiency "important" or "very important". No one interviewed in Idaho or Montana so indicated. Two-thirds of the Idaho respondents and half of the Montana respondents rated the overall design team interest at "moderate", while the rest said it was of little or no importance.

Interestingly, when asked whether the owner had ever mentioned energy efficiency as an important design element, far more Idaho and Montana respondents answered "yes" (65% and 44%, respectively) than in either Oregon (37%) or Washington (36%). Additional comments recorded during the interviews indicate that owners are interested in energy efficiency until less efficient cost-saving measures are discussed.

Cost was seen as the major barrier to increased energy efficiency in all four states, cited by 75% of the overall sample. Although it was more frequently mentioned in Idaho than any other state, the Idaho buildings typically exhibit the least effort to provide energy efficiency of any state. No other barrier was mentioned by more than 5% of the respondents. These results are presented in Table 15.

Table 15: Barriers to Increased Energy Efficiency (by percent)

Barrier	ID	MT	OR	WA	Total
Cost	91	73	62	77	77
Lighting	0	0	6	0	1
Design criteria	2	0	6	6	5
System complexity	2	0	6	1	3
Owner disinterest	2	18	6	3	5
Other	3	9	14	13	9
Total	100	100	100	100	100

Conclusions

While energy codes appear to be the dominant influence on construction practices in Washington and Oregon, factors ranging from climate to national HVAC equipment standards appear to have positively impacted the Montana market. However, this is not true in Idaho (except regarding lighting), despite the similarity in freedom from regulation and climate between Idaho and Montana. Even so, more similarities than differences were noted in standard practices in the four states.

Two findings from the interviews may provide some insight into this situation. Since more than 90% of the Idaho respondents cited cost as the primary barrier to increased efficiency (especially to the owner), and energy efficiency decisions are far more likely to be made by the owner in Idaho than in any other state, a marketing effort aimed at educating the Idaho consumer about cost effectiveness issues might prove beneficial. It appears that engineers and designers are relatively educated about, and supportive of, increasing efficiency wherever possible. In general, architects and owners appear to be less supportive and less knowledgeable about the costs and benefits of energy efficiency issues.

The success of non-code factors in increasing the efficiency of lighting in Idaho and windows in Montana indicate the importance of other market factors. While it is outside of the scope of this study to identify the market forces responsible, it is clear that persuading a few key decision-makers to adopt specific energy efficient strategies in any particular market leads rapidly to a wide-spread response from competitors, and ultimately, a complete market transformation.

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