Market Research Report

Baseline Characteristics of the Multi-Family Sector

Oregon and Washington

NORTHWEST ENERGY EFFICIENCY ALLIANCE
www.nwalliance.org

BASELINE CHARACTERISTICS OF THE MULTI-FAMILY SECTOR:

OREGON AND WASHINGTON

For the

Northwest Energy Efficiency Alliance

ECOTOPE
Consulting
Research
Design

4056 9th Avenue NE Seattle, WA 98105
(206) 322-3753 FAX: (206) 325-7270

David Baylon
Alison Roberts
Shelly Borrelli
Michael Kennedy

Table of Contents

Table of Tables

Table of Figures

Executive Summary to Multi-Family Baseline Study

The Northwest Energy Efficiency Alliance (the Alliance), as a regional utility consortium, commissioned this study to establish the current practices and attitudes that characterize the energy efficiency of new multi-family residential construction as the basis for developing and evaluating regional market transformation programs targeting this sector. This sector differs from other building sectors in that no previous baseline has been collected. In the late 1980s, the single- and multi-family sectors began to diverge in characteristics, particularly along the lines of heating system selection, so that the multi-family sector could no longer be described by studies of the single-family sector.

The specific goals of this study were to:

- Establish a representative sample of multi-family buildings in Washington and Oregon.
- Develop a picture of the building characteristics in these buildings, distinguishing between states.
- Establish heating fuel selection and HVAC system practices in these buildings to contrast the performance and building characteristics with findings in the single-family sector.
- Assess attitudes toward energy efficient buildings and building practices among decision-makers involved in the multi-family market.

A detailed review was conducted for each of 50 buildings sampled. This included a review of architectural and engineering drawings supplemented with field visits to verify key component data and collect data unavailable from the plan sets. A performance simulation was conducted using the *Sunday*^{Ò} program based on the observed building heat loss characteristics. A comparison run was also made with a "reference" building characterized using local energy code requirements to compare performance goals and actual construction practice. Interviews with 50 architects and developers associated with the projects were conducted and summarized to identify goals and attitudes towards energy conservation in each building project.

The individual states each regulate multi-family occupancies differently under the applicable energy codes. In Washington, all multi-family residences, regardless of size, are regulated as residential (Group R) occupancies and have the same requirements as single-family residences. In Oregon, multi-family residential buildings are regulated under both the residential code and the non-residential code depending on the height of the building. If the complex is less than three stories high, the single-family residential code generally applies. If the building is greater than three stories, the nonresidential code applies.

Population and Sample Design

Multi-family dwellings have become increasingly important, representing 30% of all new housing starts in the region as a whole and considerably more in the more populous

counties (60 percent of the housing starts in the Seattle and Portland area counties were multi-family units). Table 1 summarizes the multi-family sector and shows the single-family building activity as a comparison.

Table 1: Census Bureau Residential Construction (1998 Housing Starts)

State	Buildings				Total Multi-Family Units	Total Residential Units
	Single-Family	Duplex	3-4 Units	5+ Units		
Idaho	8,460	91	45	66	1,106	9,566
Montana	3,865	87	48	54	994	4,856
Oregon	16,920	517	254	553	8,640	25,560
Washington	27,849	665	422	873	16,180	44,029
Total	56,917	1,360	769	1,546	26,920	83,837

This review was confined to Oregon and Washington, because 92% of all units being built in the region are in these two states. The sample was drawn to characterize this sector from F.W. Dodge® reports. Owing to resource limitations, a relatively small random sample (25 buildings in each state) was drawn from Washington and Oregon.

In Oregon, the smaller building strata had a very low rate of participation and some buildings that were recruited were misclassified, resulting in an under sampling of small buildings. Despite these sampling problems, about half of all Oregon multi-family units were included in this sample. Coverage was less effective in Washington, but the distribution of projects across the range of building types and sizes is far better than in Oregon, so the final sample is more representative of the population.

Table 2 summarizes the results of the sampling and recruiting.

Table 2: Sample Development (F.W. Dodge® Database)

State	Number of Projects	Number of Units	Projects in Sample	Units in Sample
Oregon	215	7,769	24	4,024
Washington	228	10,252	25	1,745
Total	443	18,021	49	5,769

Characteristics

Heating Fuel and Heating System

Traditionally, the multi-family sector in the Pacific Northwest has been dominated by electric heating systems, usually zoned electric wall heaters or baseboards. Part of this field review assessed the impacts that various initiatives from gas utilities and other market forces have had on heating system selection in the multi-family sector. Table 3 summarizes heating fuel selection by unit size.

Table 3: Heating Fuel Selection

Unit Area (ft^2)	Percent of Units			
	Oregon		Washington	
	Electric	Gas	Electric	Gas
<800	100.0	0.0	100.0	0.0
800 – 1,000	100.0	0.0	66.9	33.1
1,000 – 1,400	89.5	10.5	2.8	97.1
>1,400	0.0	100.0	0.0	100.0
All Units	93.6	6.3	45.5	54.5

This table shows the saturation of gas heating in the two states. As a fraction of units, the Oregon sample is more than 90% electrically-heated, while the Washington sample indicates that 50% of the multi-family units are gas-heated. However, larger units (over 1,400 ft^2) in both Oregon and Washington are invariably gas-heated. Gas heat is a significant option in medium sized units in Washington, but almost unknown outside of larger units in Oregon.

In Washington, the use of gas heat is partly the result of a slightly more lenient energy code, which can lead to 2x4 wall construction in lower-rise buildings, and somewhat relaxed ceiling and floor insulation standards. The shift to gas heating in Washington can also be seen as corresponding with the shift away from zonal heating to either radiant floor or fan coil systems using oversized domestic water heaters and potable water loops as the basis for heating systems. In addition, using a gas-fired "heating rated" fireplace, which is allowed by the Washington code with a small amount of supplemental electric heating seems to be a relatively inexpensive way to heat smaller, lower rent units.

The Oregon code is fuel blind, so that one should not expect differences in building construction based on fuel selection. In Oregon, the use of gas heat is confined to forced-air furnaces installed in larger apartments. Also in Oregon, air conditioning is installed in nearly 20% of the units, three times the saturation observed in the Washington market.

There is a clear and growing trend toward gas heat in the multi-family market, and it seems likely, at least within Washington, that this trend will not only continue but accelerate. As the technologies associated with gas heating multi-family buildings become proven, an increased saturation of the Oregon market can also be expected.

Building Envelope

Wall construction was somewhat different between the two states. The differences in thermal integrity and construction techniques between Washington and Oregon can be traced to the differences in the energy codes, particularly with respect to fuel choice. The Washington State Energy Code (WSEC) permits the use of 2x4 walls if traded off against window glazing performance and window area. The net result is an overall wall U-value that is approximately 9 percent higher on average in Washington.

Roof construction was consistent across all buildings in the sample. Virtually all of the multi-family developments observed in this sample use truss roof detailing of one kind or another, with approximately R-30 to R-38 insulation. Only a small percentage of buildings sampled in either state uses cut-roof structures of any sort.

Floor construction in both Washington and Oregon buildings is dominated by slab construction. In more urbanized areas, the slab is located on top of parking or other occupancy. About half of the buildings surveyed were constructed with slab-on-grade floor systems on the ground floor. Insulation values for these systems were generally lower than other alternative floor construction.

Window performance in the two states is also impacted by the energy code. When submitted under the residential code, the windows of the Oregon multi-family buildings must be U=0.4, regardless of fuel type. If the building is permitted under the non-residential code then the window requirement is U=0.54.

In Washington, window performance and window area are linked in the component performance path, thus window area is traded off against window performance. Furthermore, in Washington windows in multi-family buildings submitted under gas code are allowed to perform 20% worse than any window used in the state (U=0.65). Despite these lower standards, the allowance of trade-offs in the Washington code determines that there are only rather minor differences between Washington and Oregon in overall window U-value. The bulk of the trade-offs are implemented through better window U-values in order to reduce overall wall thickness and thus framing costs.

Vinyl windows dominate both the Washington and Oregon markets and have U-values of 0.50 or better. Forty percent of the windows in Washington and 60% of the windows in Oregon achieve a rating of Class 40 or better.

Domestic hot water (DHW) in the multi-family sector is handled in different ways between the two states. Table 4 summarizes DHW fuel selection. In Washington, DHW fuel selection mirrors the selection of heating fuel. In Oregon, on the other hand, a substantial fraction of electrically-heated apartments are supplied with gas-fired hot water. This is because 20% of the DWH systems in Oregon are central systems that supply the entire building with a single central hot water tank. These central systems are always fueled with gas, regardless of the space heating fuel selection. In Washington very few of the units (3%) are supplied with central DHW systems.

Table 4: Domestic Hot Water and Heating Fuel Selection (Percent of Units)

Heat Fuel	Oregon		Washington	
	Elect DHW	**Gas DHW**	**Elect DHW**	**Gas DHW**
Electric Heat	70.9	22.3	39.5	4.3
Gas Heat	0.0	6.8	2.0	54.1
Total	70.9	29.1	41.6	58.4

Building Performance

Heat Loss Rate and Code Compliance

Washington buildings have 12% greater heat loss than Oregon buildings because of the more lenient gas code and, taken as a whole, they comply with the code to an even greater degree than the single-family buildings reviewed. Table 5 summarizes the heat loss rates by state.

A relatively low level of code compliance among Oregon buildings was noted in spite of the lower heat loss rate in the Oregon buildings as a whole. The nature of this non-compliance is complicated, since some of the multi-family buildings are regulated under the Oregon non-residential energy code. Washington buildings have much higher compliance rates largely because of the lenient nature of the Washington code.

Table 5: Heat Loss Summary

	Oregon			Washington		
	Electric	**Gas**	**Total**	**Electric**	**Gas**	**Total**
Sample UA/ft^2	0.161	0.196	0.164	0.169	0.190	0.183
Code UA/ft^2	0.164	0.199	0.168	0.176	0.215	0.200
% Compliance	80.2	77.9	79.9	93.9	100.0	97.7

Using the overall heat loss rates and other characteristics derived from the field review, the performance of the audited buildings was developed using the *Sunday*® energy simulation program. This program predicts space heating load from the UA, climate, window characteristics, and other factors. Additional runs were made to provide a comparison with the same population of buildings had they been built exactly to local code requirements.

Each building location was matched to a climate and all runs characterizing these buildings used the most applicable climate data available for their locations. Table 6 summarizes the results of the *Sunday*® runs.

Table 6: Heat Required per Unit (Building Only)

Heat Fuel	Oregon			Washington		
	Electric	**Gas**	**Total**	**Electric**	**Gas**	**Total**
Building Sample						
KBTU/ft^2	5.5	10.2	5.9	7.8	10.0	9.2
Code Requirements						
KBTU/ft^2	5.7	10.5	6.2	8.5	12.7	11.1

The Washington sample uses 55% more heating than the Oregon sample. When the electric-only codes are compared, most of the performance difference is the result of climate. Approximately two-thirds of the overall difference is due to the colder climates in Washington; the remaining distinction reflects the difference between the two codes and resulting building practices.

When these heating requirements are compared with single-family homes in the two states, there is a fairly consistent improvement in efficiency between multi-family and single-family units. On average, this suggests that there is a 25% improvement in heat loss rate and a reduced heating energy requirement of over 60% per square foot of dwelling in the multi-family sector. This is true even in Oregon, where code compliance in the multi-family sector is much less consistent than among single-family residences.

Interviews

Fifty architects, engineers, and subcontractors involved in multi-family projects were interviewed using a structured format focused on attitudes regarding energy conservation, energy efficiency, and energy codes as applied to multi-family buildings. Principal findings on all topics were:

- The role of general contractors and developers is more significant in multi-family projects than in other large projects. Decisions about fuel type and equipment selection are usually the responsibility of the contractor.
- Often design decisions are made outside of the design process during the bidding and construction phase of the project.
- Two-thirds of all buildings received direct code feedback.
- Detailing around slab insulation (both at grade and above grade) was a dominant issue in Oregon code compliance.
- In Washington, difficulty in code enforcement was noted most often in regard to glazing specifications and the application of the Washington ventilation code.
- The primary sources for energy efficiency information (for both designers and builders) is the code, engineers and consultants, and manufacturers' sales representatives.
- Direct presentation of energy efficiency measures and opportunities to the architect or the owner during the early stages of the *design* process was thought to be the best opportunity for improving energy efficiency.

Conclusions

Even though the energy codes and building standards for the multi-family sector are similar or identical to the single-family sector in both states, decisions made in the multi-family sector for space heating and insulation levels are substantially different. This review identified several important characteristics of the multi-family sector in these two states:

- Compared to single-family construction, there is a much higher fraction of electric heat in multi-family units: 90% in Oregon and 50% in Washington. In the single-family sector, electric heat of all types accounts for only about 15% of the homes in both states.
- Gas-fired space heating has penetrated the multi-family market in the Seattle area but not in Portland nor any other area in either Washington or Oregon. This accounts for virtually all of the gas heating in the multi-family sector and seems to be attributable to the marketing program of the local gas utility.
- Compliance with the energy code is problematic in the Oregon multi-family market. About 20% non-compliance was observed. In the single-family Oregon homes, compliance was essentially 100%. In Washington, both sectors had similar levels of compliance at greater than 90%. This is largely explained by the code structure which forces different size buildings in Oregon to use different codes, while in Washington the same code applies to all multi-family buildings.
- Washington buildings have 12% greater heat loss than Oregon buildings because of the more lenient gas code.
- Because the design of multi-family buildings is confined to a narrow group of architects and builders, the ability to impact this sector with utility programs or other energy efficiency programs is much more straight-forward than in the rest of the residential sector.
- Finally, the overall performance of multi-family buildings is much more efficient than the single-family counterpart. This is partly due to a lower window-area-to-floor-area ratio and a lower overall heat loss rate. The large difference in dwelling unit size between single family and multi-family housing compounds this effect.

This study suggests that multi-family units should be more carefully reviewed, considering that they comprise about a third of all new residential dwellings in the region, and an even larger fraction of the dwellings in the more populated areas of western Washington and western Oregon.

1. Introduction

In 1996 the Northwest Energy Efficiency Alliance (NEEA) was established to consolidate a regional effort aimed at developing energy efficiency program alternatives using market-based approaches. These approaches were to build on the successes and learn from the failures of the almost two-decade regional effort to develop and promulgate energy conservation and energy efficiency in the building industry.

In the single-family and multi-family residential new construction sector, this effort had been a combination of utility incentives for high-performance insulation and heating systems with energy codes that mandated energy-efficient components in residential construction. These two programs complemented one another: as utility incentives introduced concepts of efficiency into the building community, they were proposed into code as the building community became accustomed to the approaches. These standards were first developed in the late 1970s under various auspices in Washington, Oregon, Idaho, and Montana, where they established construction practices regarding insulation levels and the thermal performance of residential buildings.

Most of the programs aimed at multi-family construction were based on the use of electricity as the dominant heating source in apartment developments. Indeed, a 1984 review of multi-family buildings in the region showed that 94% of units constructed in the five years ending in 1980 were heated with electricity (BPA, 1985).

Several electric utilities developed programs to influence the efficiency of electrically-heated multi-family buildings. Because of these construction trends, virtually all new multi-family construction was electrically-heated by the end of the 1980s. The gas utilities of the region largely avoided this sector because of the difficulties of providing a gas-based heating system that was cost competitive to the very simple electric zone heating that had become a standard in the region.

Most of the electric utility programs were phased out in 1996. At the same time, Seattle-based Washington Natural Gas began a marketing program to sell gas into the multi-family market. This effort, which was confined to the Puget Sound area, was well received. In other markets, no effort was made by either electric or gas utilities to impact either fuel choice or building efficiency. Furthermore, the multi-family market attached no premium to gas heating systems, though fuel costs were much lower.

In the last decade, the multi-family sector has been in transition as more emphasis on urban density in the Portland and Seattle areas have increased the demand for multi-family units. The challenge has been to establish energy efficiency as a factor in the planning and marketing of this sector. From the perspective of developing market-based approaches, it is important first to understand what characteristics and components were actually used in multi-family residential construction, and second to know the attitudes and marketing efforts currently employed in new multi-family developments. The purpose of this multi-family baseline review is to establish the current practices and attitudes of building professionals. Moreover, the review aims to provide an

understanding of the current market so that future Alliance programs can be targeted efficiently and effectively. It should also serve as the basis for measuring the impacts of future programs.

The multi-family sector differs from other building sectors in that no previous regional characteristics baseline has been collected. Historically, multi-family buildings could be adequately described by studies of the residential sector. In the late 1980s, however, the single- and multi-family sectors began to diverge, particularly along the lines of heating system selection.

During the early 1990s, gas forced-air heating came to dominate the single-family residential market while electric zone heating pervaded the multi-family sector. The degree to which other residential characteristics (insulation, window type, etc.) adequately describe this sector is currently unknown. Consequently, this review was conducted to survey both construction practices and unit and building characterizations in the multi-family sector. A broad range of buildings across all multi-family types was sampled to represent the vast majority of all multi-family construction in the region.

1.1. Goals and Objectives

The goals of the study are to:

- Establish a representative sample of multi-family buildings in Washington and Oregon.
- Develop a picture of the characteristics of these buildings, distinguishing between states.
- Establish heating fuel selection practices and HVAC system information in these buildings to contrast the performance and building characteristics with findings in the single-family sector.
- Assess attitudes toward energy efficient buildings among decision-makers involved in the multi-family market, including their attitudes toward actual or perceived barriers to energy efficient construction within the multi-family markets.

1.2. Objectives and Methodology

As with other portions of this baseline study, the basis for this review is a field review performed upon a sample of multi-family buildings. The sample was drawn from F.W. Dodge® Dataline reports. The net result of this review, then, is a relatively small random sample of multi-family projects in Washington and Oregon drawn but stratified by overall project budget. The project was limited to the states of Washington and Oregon since these two states had over 92% of all multi-family construction. The sample was designed to be representative of the multi-family industry in each state and to provide a basis for understanding construction practices in this industry.

For purposes of this review, a "multi-family building" could be any building with more than a single unit. This definition was selected to ensure that all residential units were covered by a regional baseline review. As a practical matter, duplexes, triplexes and 4-plexes represent about 20% of the multi-family units. In the urbanized areas, these are most often part of larger complexes with multiple buildings. In the more rural areas these buildings represent 70% of the multi-family buildings and almost 40% of all multi-family units. Traditionally, the utility programs that target multi-family buildings have been focused on buildings of five units or greater. This is a more narrow definition than used here, although some effort has been made to separate larger buildings where such summaries are possible.

A detailed plan review was conducted for each building in the final sample, supplemented with field visits to verify key component data and collect data unavailable from the plan set. This study focused on components with significant impact on energy use that could be verified through the plan/field review process. Specifically, we analyzed:

- Building size and configuration
- Envelope
- HVAC equipment and selection

The evaluation was conducted on a building-by-building basis so that component performance could be compared by state and across states. A performance simulation was conducted using the *Sunday*® program based on the observed heat loss characteristics and window characteristics. A second *Sunday*® run was performed based on local energy codes. This allowed a comparison between the performance goals of the individual energy standards and actual construction practice.

Interviews were conducted with architects and developers associated with these projects. There was an attempt to secure at least one interview for each project and identify goals and attitudes towards energy conservation as they related to the multi-family population. The complete responses are summarized in Appendix B.

2. Sample

2.1. Sample Frame

Multi-family dwellings (using the broadest definition) have become increasingly important, representing 30% of all new housing starts in the region as a whole and considerably more in the more populous counties (e.g., 60% of the housing starts in the Seattle and Portland counties were multi-family units). As shown in Figure 1, the vast majority of this activity is in Oregon and Washington, accounting for 92% of the total regional units (including duplexes and triplexes). If only larger multi-family buildings (i.e., greater than 4 units) are included, Washington and Oregon represents about 94% of all new multi-family construction. Therefore, we confined our review to these two states.
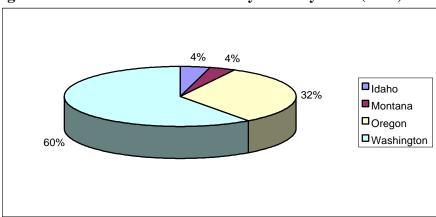
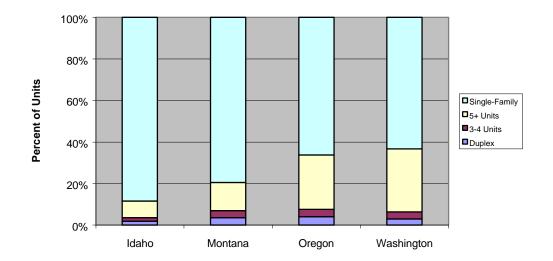**Figure 1: Distribution of Multi-Family Units by State (1998)**

The multi-family sector has a distribution of units that is highly skewed towards larger buildings. About 40% of the buildings are greater than 5 units while more than 80% of the total multi-family units are located in these buildings. Table 2.1 summarizes the multi-family sector and shows the single-family building activity as a comparison. This type of distribution suggests the need for a stratified random sample to characterize this sort of population with a minimum sample size.

Table 2.1: Census Bureau Residential Construction (1998 Housing Starts)

State	Buildings				Total Multi-Family Units	Total Residential Units
	Single-Family	Duplex	3-4 Units	5+ Units		
Idaho	8,460	91	45	66	1,106	9,566
Montana	3,865	87	48	54	994	4,856
Oregon	16,920	517	254	553	8,640	25,560
Washington	27,849	665	422	873	16,180	44,029
Total:	56,917	1,360	769	1,546	26,920	83,837

The percentage of residential units represented by multi-family construction differs greatly between the four states. Multi-family units represent roughly 15% of the new residential units in Idaho and Montana, but a full third of all units built in Washington and Oregon. The distribution of residential units is shown in Figure 2.

Figure 2: Distribution of Residential Units

The sample frame for this review was drawn from the F.W. Dodge® data set. This represented buildings that received permits and began construction in 1998 for construction in 1998-99. The sample frame was selected to represent sectors in a manner which could characterize the overall population. In addition to the sample frame, a separate assessment was developed from US Census Bureau's housing start data, which gives total number of residential units permitted in each state.

This had certain disadvantages, since the F.W. Dodge® system focuses on larger projects and non-residential projects. The US Census Bureau's housing start permit data was used to compare the F.W. Dodge® data, but the housing start data did not identify particular buildings, thus it cannot be used as a sample frame.

While using the F.W. Dodge® database as the sample frame may have introduced some biases, it allowed a direct recruitment call to builders and/or architects of multi-family buildings to solicit their participation. It was thought that the complexity of field visits to large multi-family projects would require a significant amount of cooperation on the part of architects and builders. Furthermore, making these contacts in advance allowed a full set of construction documents to be secured as part of the recruitment frame. This allowed take offs on building areas, levels of insulation, window specifications, etc. to be collected prior to field visits.

While the U.S. Census data could not be used directly to sample buildings since there was no tracking information that would allow the individual buildings to be identified, it provided a means to evaluate the completeness of the F.W. Dodge® database itself. The coverage of the multi-family sector within the F.W. Dodge® database is reasonably sound (see Table 2.2), and captures about 75% of the multi-family units in the two states.

Table 2.2: F.W. Dodge® Sample Frame

State	Multi-Family Buildings	Multi-Family Units	Census Units	Percent F.W. Dodge®
Oregon	215	7,700	8,640	89.1%
Washington	228	10,300	16,180	63.7%

*Inferred from reported area and valuation

The census data set is not directly comparable because F.W. Dodge® reports on the basis of projects and permits. This has the effect of aggregating buildings in individual projects in an inconsistent way. For example, one project within the F.W. Dodge® data set had approximately 16 entries, representing approximately 150 units. The project was selected in the sample and the actual size was approximately 50 buildings and 400 units. The permit data listed the project as a combination of triplexes and four-plexes rather than a single large multi-family development. This type of variability was common.

2.2. Sampling and Recruiting

A stratified random sample was drawn from this sample frame. The stratification was developed using the Neyman allocation and the Delanius-Hodges stratification design (Cochran, 1977), in which the largest buildings are drawn as a census stratum and the remaining buildings are divided into two smaller strata that represent the vast majority of the buildings but only a fraction of the total units. This sample was then used as a recruiting base by field reviewers to recruit buildings into the sample.

Since the sample was randomized with respect to the individual buildings, recruiters were instructed to attempt recruitment of all buildings in their sample. The sample delivered was approximately 45 multi-family homes in each state; however, due to budget constraints, only 25 of these buildings could be used as part of the field review. In both states, recruitment was successful within the initial sample, and no additional buildings were drawn from the remaining population.

The strategy worked fairly well in Washington, where participation was fairly well distributed among the strata of the sample. In Oregon, however, the smaller building strata had a significantly lower rate of participation. Worse yet, some of

those buildings that were recruited were misclassified by F.W. Dodge®, and should actually have been classed as Stratum 2 projects. Thus, the lowest stratum in the F.W. Dodge® database is not well represented in the field sample in Oregon. This stratum represents 72% of the buildings in the F.W. Dodge® sample, but only 14% of the reported valuation. It is impossible to determine whether the sample as represented by the final recruited sample actually addresses these smaller units, since even though there are large numbers of buildings in this scale, they are part of larger complexes with multiple buildings with relatively few units in each building.

It should be pointed out that, in spite of sampling only 25 projects out of 215 F.W. Dodge® entries, about half of all Oregon multi-family units were included in this sample. In the Washington sample, the coverage was only about 10% of all units identified in the census appeared in the sample project. On the other hand, the distribution of these projects across the range of building types and sizes is far better than in Oregon. It is also much more likely that this sample represents all building sizes and strata across the state. Tables 2.3 and 2.4 summarize the results of the sampling and recruiting from the F.W. Dodge® database. These tables represent the final sample used. Because of resource limitations, the precision used to draw this sample assumed an 80% confidence interval on a sampling variable of project valuation.

Table 2.3: Sample Development (Oregon)

Stratum	Construction		Sample	
	Number of Projects	Number of Units	Project Sample	Number of Units
1	156	1,234	2	154
2	44	2,755	10	762
3	15	3,780	12	3,108
Total	215	7,769	24	4,024

Table 2.4: Sample Development (Washington)

Stratum	Construction		Sample	
	Number of Projects	Number of Units	Project Sample	Number of Units
1	150	2,099	8	163
2	58	3,962	9	502
3	20	4,191	8	1,080
Total	228	10,252	25	1,745

Tables 2.5 and 2.6 show the distribution of permitted multi-family buildings by county in the two states when compared to the recruited sample. These tables illustrate the counties with the greatest amount of multi-family construction. These populations represent in excess of 90% of the units constructed in each state. The F.W. Dodge® sample roughly corresponds to this distribution although,

because of the random nature of the design, the precise representation of smaller counties is not very uniform.

Table 2.5: Multi-Family Distribution (Oregon Counties)

County	Number of Buildings	Percent of State	Number of Units	Percent of State	Sample Number	Number of Units
Multnomah	266	20.4	2,602	30.1	13	2,457
Washington	245	18.8	2,090	24.2	4	479
Clackamas	105	8.1	749	8.7	3	432
Lane	120	9.2	661	7.7	3	630
Marion	111	8.5	629	7.3	0	0
Deschutes	80	6.1	352	4.1	0	0
Linn	66	5.1	301	3.5	0	0
Yamhill	50	3.8	198	2.3	0	0
Jackson	55	4.2	192	2.2	0	0
Other	204	15.7	866	10.0	1	22
Total	1,302		8,640		24	4,025

Table 2.6: Multi-Family Distribution (Washington Counties)

County	Number of Buildings	Percent of State	Number of Units	Percent of State	Sample Number	Number of Units
King	694	35.4	8,132	50.3	14	921
Snohomish	479	24.4	3,553	22.0	5	296
Pierce	217	11.1	1,302	8.0	1	250
Clark	172	8.8	1,024	6.3	0	0
Spokane	103	5.3	918	5.7	1	104
Yakima	76	3.9	275	1.7	1	24
Thurston	58	3.0	239	1.5	0	0
Whatcom	51	2.6	176	1.1	2	59
Skagit	20	1.0	125	0.8	0	0
Other	90	4.6	436	2.7	1	96
Total:	1,960		16,180		25	1,750

2.3. Case Weights

The difficulties in the small-building stratum in Oregon pre-empted any efforts to provide this stratum with case weights. Consequently, when summarizing the Oregon results, only Strata 2 and 3 could be used; bias associated with the smaller projects cannot be assessed. Table 2.7 summarizes the case weights as applied in the project. These case weights were used in weighting various statistical summaries of both characteristics and unit populations in the summary of characteristic results.

Table 2.7: Case Weights Sample

State	Stratum		
	1	**2**	**3**
Oregon	NA	0.057	0.021
Washington	0.073	0.028	0.013

3. Characteristics

This study gathered information on construction practices, insulation levels and heat loss performance of the individual building components. Each major building component was individually analyzed by state. The results have been presented below; however, caution should be used when making cross-state comparisons. The contrasts reflect differences between the states in market conditions and building practices as well as energy code provisions. In multi-family buildings, these differences reflect the perceptions of the developers and builders as much as the market perceptions.

3.1. State Energy Codes

The individual states each regulate multi-family occupancies differently under the applicable energy codes. In Washington, all multi-family residences, regardless of size, are regulated as residential (Group R) occupancies and have the same requirements as single-family residences. In Oregon, multi-family residential buildings are regulated under both the residential code and the non-residential code depending on the height of the building. If the complex is less than three stories high, the single-family residential code generally applies. If the building is greater than three stories, the nonresidential code applies (State of Oregon, 1996).

The Washington residential code regulates the envelope requirements based on climate zone and fuel type (Washington State Energy Code, 1997). There are different envelope requirements depending on the combination of these two factors for particular buildings. For the most part, the buildings evaluated here are permitted in "Climate Zone I" in western and southeastern Washington. A more significant distinction is based on "Fuel Type." In the Washington code, residential buildings with electric resistance space heat must meet a more stringent envelope standard. This standard results in a decrease of about 30% in the regulated heat loss rate for these buildings. In order to be eligible for the lesser standard, the building must be heated with "Other Fuels." This is defined as any fuel other than electric resistance heat, including heat pumps. Furthermore, buildings can have up to 1,000 watts of electric heat per dwelling unit and still be considered as heated with Other Fuels as long as another heating system is installed.

The Oregon code has different provisions depending on building height. If a multi-family building is more than three stories, the envelope insulation and glazing performance requirements are much less that the residential code used for low-rise buildings. These provisions would result in a 30 to 40% reduction in regulated envelope heat loss rate depending only on the height of the multi-family building. The difficulty with this involves the interpretation of this provision in cases where there are mixed-use buildings with one or more stories of non-residential occupancy. There appears to be some latitude that allows the building official to rule on this point. Consequently, a developer might see a separate set of requirements in particular jurisdictions for similar buildings. It is quite

apparent that there is some confusion among builders and developers as to the applicable code for these types of buildings. This is the source of most of the non-compliance in the Oregon sample that we observed (Section 4.1).

3.2. Project Size and Unit Area

Table 3.1 summarizes the results of this sample when applied to overall building and project characteristics. This summary is the result of the un-weighted characteristics of the buildings surveyed. This summary allows a comparison of the samples and indicates the nature of the relative biases in the Oregon sample.

Table 3.1: Multi-family Projects Characterization

State	Buildings / Project	Units / Project	Units / Building	Unit Size (ft^2)
Oregon	9.7	167	39.6	1002
Washington	7.8	70	22.0	1004

Substantial differences can be noted between Washington and Oregon, particularly in terms of the recorded number of units per project and per building. In both cases, the Oregon results are highly suspect, since the number of smaller projects actually surveyed is, in essence, none. Only the Washington sample is likely to represent an adequate characterization of smaller projects. Nevertheless, when these results are viewed as a function of overall unit area, no bias is evident.

Across the Oregon and Washington samples and stratification design, there is remarkable homogeneity in average unit size (about 1,000 ft2/unit). Bias in the Oregon sample (as judged by the Washington sample) appears to have little effect on unit size. Table 3.2 summarizes the distribution of unit sizes in each state.

Table 3.2: Unit Size Distribution (Percent of Units)

State	Area (ft^2)					
	>800	800 – 1,000	1,000 – 1,400	<1,400	Median	Mean
Oregon	28.7	34.0	34.6	2.7	961	977
Washington	25.9	27.5	42.5	4.1	899	1,024

This table has been constructed using project size and case weights. The weighting scheme should give a good picture of average unit size across the population. However, this summary suggests that average unit size in the region is about 1,000 ft^2/unit in both states, with a slight skew downward suggested by median unit size around 900 ft^2/unit for the region.

The principal picture from this sample is one of relatively large complexes with average project sizes of roughly 84 units across both states. This may be slightly biased by the lack of smaller projects in the Oregon sample but, even when this bias is corrected, average project size remains well above 50 units. In Portland

itself, the average size of each building is more than twice that in the rest of the region. While this observation may be partly due to bias in the Oregon sample, it seems unlikely that such biases alone could cause such a significant difference.

3.3. Heating System and Heating Fuel Selection

One impetus for reviewing the multi-family sector separately is to establish differences in construction techniques and equipment specification decisions between the multi-family and single-family residential sectors. When compared to site-built homes, there have been long-standing differences in heating system selection in multi-family buildings. This is largely caused by the difficulties in delivering cost-effective space heating with relatively modest first cost to the multi-family sector. In recent years, this trend has been subject to considerable marketing effort, particularly in the Seattle area, as the gas utility attempted to increase their market share of this sector. In addition, owner-occupied condominiums comprise an increasing proportion of the multi-family sector, with lower-density row-house type developments or multi-story apartment units catering to higher income multi-family tenants. All these trends seem to support a greater level of gas heating.

3.3.1. Heating Fuel

Traditionally, the multi-family sector has been dominated by electric heating systems, usually zoned electric wall heaters or baseboards. This trend has cuts across virtually all types of apartment units in virtually all markets (cf. Baylon, et al, 1987; BPA, 1985). These studies suggest a saturation of electric heat in the existing sectors of about 75% and much higher in new construction. A significant effort of this field review is to assess the degree to which this trend has diminished and the impacts of various initiatives from gas utilities and other market forces on fuel and heating system selection in the current multi-family sector. Table 3.3 summarizes heating fuel selection by unit size.

Table 3.3: Heating Fuel Selection

Area (ft^2)	Percent of Units			
	Oregon		Washington	
	Electric	Gas	Electric	Gas
<800	100.0	0.0	100.0	0.0
800 – 1,000	100.0	0.0	66.9	33.1
1,000 – 1,400	89.5	10.5	2.8	97.1
>1,400	0.0	100.0	0.0	100.0
All Units	93.6	6.3	45.5	54.5

This table shows the saturation of gas heating in the two states. The difference is rather striking: as a fraction of units, the Oregon sample is more

than 90% electrically-heated, while the Washington sample indicates that 50% of the multi-family units are gas-heated.

A more important issue is the tendency of gas heat to be installed in larger units. In both Oregon and Washington, multi-family units over 1,400 ft^2 are invariably gas heated. In the Oregon market, virtually no other units are heated with gas; in Washington, only small units (<800 ft^2) are electrically-heated to the exclusion of gas. The penetration into medium and even small size units is substantial.

This trend is dominated by projects with large numbers of units per site. When the same summary is conducted on a *project* basis (assuming that these decisions are made independently by project and not by unit), saturation of gas heat in the Washington market falls to about 36%, while the same rises to 14% in the Oregon market. Nevertheless, the Oregon market remains, on the whole, electrically-heated. Gas heat has penetrated only the higher end of the multi-family market in both owner-occupied condominiums and larger rental units.

In Washington, the use of gas heat is partly the result of a more lenient energy code, which can lead to 2x4 wall construction in lower-rise buildings, and somewhat relaxed ceiling and floor insulation standards. The Oregon code is fuel blind, so that one should not expect differences in building construction based on fuel selection. Electric use has benefited from advances in small-scale radiant coils as an alternative to zone electric baseboard heat. Typically, this strategy has not been available to units using gas heat, although the advent of small hydronic fan coils, similar radiant systems, and more flexible gas plumbing options has widened the availability of gas.

Table 3.4 summarizes the selection of heating system by state and percent construction.

Table 3.4: Heating Systems (Percent of Units)

State	Fuel	Equipment Type					
		Furnace	**PTHP***	**Zonal**	**Hydronic**	**Fireplace**	**Cooling**
OR	All	12.3	5.9	76.8	5.0	0.0	17.7
	Electric	21.0	100.0	100.0	100.0	0.0	2.1
	Gas	79.0	0.0	0.0	0.0	0.0	15.6
WA	All	8.2	0.0	37.8	42.74	11.24	5.2
	Electric	0.0	0.0	100.0	0.0	0.0	5.2
	Gas	100.0	0.0	0.0	100.0	100.0	0.0

  *Packaged terminal heat pumps

As evident, the shift to gas heating in Washington corresponds with a shift away from zonal heating, especially electric. The advent of hydronic systems—either radiant floor or fan coil using oversized domestic water

heaters and potable water loops as the basis for heating systems—has made serious in-roads in the Washington market, in contrast to its modest success in the Oregon market.

A further aspect of the Washington market is the use of gas-fireplaces for heating systems. This system has been introduced in King County for lower-end apartments, and is based on a provision of the Washington energy code which allows the projects to be submitted as gas-heated but allows a small amount of supplemental electric heat for outlying bedrooms etc. The fireplace uses a higher-end "heating rated" fireplace, with a thermostat, controlling fans and enhanced heat exchangers. Since these are listed as space heaters rather than furnaces, requirements for efficiency are significantly lower than with conventional forced-air furnaces (AFUE = 62). This system has, to date, penetrated only slightly into the Washington market, although the sort of developments that use it are the lower-end rental projects with smaller units. This suggests that, if and when this technique becomes popular, it will provide a relatively inexpensive way to heat smaller units with gas.

In Oregon, the use of gas heat is confined to forced-air furnaces installed in individual apartments. This configuration is considerably more complicated to install, since the furnaces themselves need to be ducted within the apartments. In Oregon, about 20% of the ducted furnace systems use electric heat. In contrast, all of the furnace systems installed in Washington are gas fired.

One trend in the Oregon market that seems uncommon in Washington is the use of cooling equipment. In the single-family Oregon market, cooling appeared in about 20% of homes surveyed. Table 3.4 also presents the fraction of multi-family construction that uses some degree of cooling. In the Oregon market, this takes the form of packaged terminal heat pumps (PTHP) or packaged terminal air conditioners (PTAC). In the latter case, heating is provided by electric-resistance zone heat; through-the-wall air conditioning units are then provided in some zones of the unit. In about a third of the cases, this unit is a heat pump, which provides both heating and cooling to those zones, usually with additional electric resistance heating in other outlying zones. Gas-heated buildings in the Oregon market are about three times more likely to use cooling than electrically-heated projects. This generally takes the form of additional air conditioning (AC) coils in a furnace/air handler with a separate outdoor compressor, an option used in both electric and gas furnace heating systems in the Oregon market.

The Washington market includes permanently installed AC in only about 5% of the units surveyed. In all cases, these appeared in eastern Washington, and used a through-the-wall (PTAC) or through-the-window air conditioning unit. By contrast, the Oregon buildings which use AC are located within the

immediate area of Portland and reflect an approach to the high end of the Portland multi-family residential market.

3.3.2. Supplemental Sample

In the Washington market, the distinct possibility that the sample tends to be dominated by large projects increases the apparent saturation of gas heat. To ascertain whether this was true, a second level of study was conducted by reviewing current multi-family projects in building departments in two urbanized counties (King County in the Seattle area; Pierce County in the Tacoma area). The results of this review are shown in Table 3.5.

Table 3.5: Washington Multi-Family "Cover" Review

Fuel Choice	N (Buildings)	Percent
Gas	21	47.72
Electric	22	50.00
Heat Pump	1	2.28
Total	44	100

Although this sample is hardly as geographically comprehensive as the field survey, it confirms the trend indicated by the field samples when compared between Oregon and Washington, even if it is impossible to set the exact level of gas saturation within the Washington multi-family market. There is a clear and growing trend toward gas heat in this market, and it seems likely, at least within Washington, that this trend will not only continue but accelerate. As the technologies associated with gas heating multi-family buildings become proven, an increased saturation of the Oregon market can also be expected.

3.4. Building Components

The building components present in the Oregon and Washington market are somewhat different. This can be traced to differences in the energy codes that lead to differences in thermal integrity and construction techniques between the two states. This difference is actually larger (in percentage terms) than the difference observed in single-family homes over the same period. Furthermore, the Oregon residential sector is essentially prescriptive, so the components don't vary with building configuration. The Washington code is essentially a heat loss performance code with trade-offs allowed between the specifications for all of the building envelope components.

3.4.1. Walls

The primary difference between states in wall construction is the prevalence of 2x4 construction in low-rise multi-family buildings in Washington. This construction type is permitted under the Washington State Energy Code

(WSEC) if traded off against window glazing performance and window area. About a quarter of the total wall area in the Washington sample is 2x4 construction, and this group is completely gas-heated. The net result is an overall wall U-value that is approximately 9% higher in Washington across the entire sector than in Oregon. Table 3.6 summarizes wall construction types for this sector.

Table 3.6: Wall Characteristics

Type	Oregon		Washington	
	% Wall	U-value	% Wall	U-value
2x4 Above Grade	1.8	0.079	25.0	0.080
2x6 Above Grade	95.8	0.057	71.0	0.062
Above Grade Concrete	0.5	0.076	1.2	0.068
Below Grade	1.9	0.062	2.8	0.062
Total	100.0	0.059	100.0	0.064

In both states, wood-frame construction dominates, with only a small fraction of wall area being assigned to above-grade concrete or below-grade wall. No steel framing was observed in this sample. The bulk of the above-grade concrete wall is post-tension slab serving as a base for mid-rise wood-frame apartments in both Washington and Oregon. The impact of energy codes on wall heat loss rates is quite substantial.

3.4.2. Windows

Window performance in the two states is also impacted by the energy code. Table 3.7 summarizes characteristics of windows in the two states.

Table 3.7: Window Characteristics by State

Windows	Oregon			Washington		
	Electric	Gas	All	Electric	Gas	All
U-Value	0.41	0.39	0.41	0.38	0.47	0.43
% Window	11.6	16.6	12.1	12.2	14.1	13.4

In Oregon, 19 of the 24 buildings surveyed were permitted under the residential energy code. Five were taller than three stories and permitted under the Oregon non-residential energy code. Though these codes differ in window prescription, the overall impact of the current residential construction standards in Oregon seems to lead to a common and accepted window specification: approximately $U = 0.4$.

Window area in Oregon is not regulated under either code, but the overall glazing-to-floor-area ratio is about 12 percent. In Washington, window performance and window area are linked in the component performance path, thus window area is traded off against window performance. Furthermore, a

different criteria exists for buildings constructed under the gas code than for those built under the electric code. The base standard for gas is a U = 0.65 window, which would perform at least 20% worse than any window actually used in the state. The net result is a trade-off between window area (with greater percentages allowed for higher-performance windows) and wall performance.

As reviewed in the previous section, the bulk of these trade-offs are made to reduce overall wall thickness and thus framing cost. When the totals of the two states are compared, while Washington has noticeably lower energy code standards, the net result is a rather minor increase in overall window U-value. As with window area (although this may be partly due to biases in the Oregon sample) actual window selection in Washington and Oregon is greatly dominated by the window codes themselves. Table 3.8 summarizes the windows by class. ("Window class" refers to a two-digit integer that reflects the window U-value.)

Table 3.8: Window Type by State (Percent of Units)

Window	Oregon			Washington		
Class	Electric	Gas	Total	Electric	Gas	Total
30-37	17.1	18.9	18.3	67.5	8.9	29.1
38-40	50.3	12.6	49.9	11.1	8.1	9.1
40-45	17.0	0.0	14.8	11.7	3.3	6.2
46-50	11.7	24.3	13.4	9.6	74.2	51.9
51-60	1.1	0.0	0.9	0.0	0.4	0.2
60 +	2.7	1.9	2.6	0.0	5.1	3.4

The classes of windows in Table 3.8 are categorized to reflect overall glazing performance. The first category (Class 30-37) reflects windows with high-quality, low-e coatings and at least one additional glazing feature (e.g., argon gas, warm edge spacers, higher-performance low- coating). These windows usually comply with the Energy Star® rating, although very few labels were observed. It is almost 50% more likely that such windows are placed in Washington multi-family buildings, but this could be easily explained by the fact that windows can be traded-off against other features of the building (e.g., wall U-value or window area), whereas Oregon provides no particular trade-off advantages to these decisions.

The Oregon code generally requires a window U-value of 0.40 or less (Class 40). Predictably, the Oregon multi-family market is dominated by this type of window. Buildings greater than three stories in Oregon are permitted under the non-residential code. This code allows windows with U = 0.54 capped at 30% window-to-wall ratio. This code applied to about 25% of the Oregon sample. In most cases, the individual buildings seem to be built to a standard similar to the low rise multi-family buildings. The next category (Class 40-45) can, in Oregon, be used to trade-off against lower window area

(less than 13%) and, to some extent, this seems to happen in the Oregon market.

Both the Class 40 and the Class 40-45 windows are used less in Washington and are largely present in electrically-heated buildings. The Washington code requires 0.4 glazing U-value as a standard for electrically-heated buildings with 15% overall glazing. Since the glazing areas are noticeably less than 15% in this sector, trade-offs to window U-values higher than 0.4 are used among electrically-heated buildings. Windows in gas-heated buildings, on the other hand, use no separate code in the Oregon market, although they have a separate code in the Washington market of U-value=0.65.

The most striking feature of the window packages in either state is the use of vinyl windows. Only about 6% of the windows in Oregon and 12% of the windows in Washington use aluminum frames with thermal breaks. This is largely independent of most factors other than higher-rise buildings, which presumably have alternate structural requirements and sometimes select commercial-grade aluminum windows. Only these windows come anywhere close to a Class 65 rating. For the most part, the vinyl windows that represent the remaining 90% of the apartment sector are approximately Class 50 or better. Thus, window selection in Washington defaults to around Class 50 when gas is used, and about Class 35 in electrically-heated apartments.

3.4.3. Ceilings

There is relatively little difference in ceiling practices across the two states, either by construction type or insulation level. Most of the multi-family developments observed in this sample use truss roof detailing of one kind or another, with approximately R-30 to R-38 insulation. Only a small percentage of buildings sampled in either state use cut-roof structures of any sort. Table 3.9 summarizes ceiling construction in the two states.

Table 3.9: Ceiling Construction (Percent of Ceilings)

Ceiling Type		Oregon		Washington	
		% Ceiling	U-value	% Ceiling	U-value
Truss	Flat	85.5	0.032	88.7	0.033
	Scissors	7.2	0.036	10.9	0.035
Rafter	All	7.2	0.033	0.4	0.032
Total		100.0	0.032	100.0	0.033

3.4.4. Floor Systems

By and large, the floor systems in both states are characterized by one of three conditions: concrete slab-on-grade, post-tension concrete slab above grade, or wooden floor over a crawlspace.

1. The first is a slab-on-grade or slab slightly below-grade, forming a ground floor level of the apartments. In these cases, some or all of the units have some portion of the slab associated with the living spaces, with the rest of the slab area being associated with parking. Firewalls (both in ceilings and walls) typically separate the living spaces from the parking areas. In other developments, the ground floor units are essentially slab-on-grade. This is typically seen in lower density developments in suburban areas with adjacent surface parking available.

2. The principal alternative to this is a slab-above-grade, in which a post-tension slab is used to separate the residential units from parking or other non-residential areas on the ground floor. This serves as both a thermal and a fire separation, and is usually associated with developments in more heavily populated areas, chiefly Seattle and Portland.

3. The other major floor system used throughout the multi-family sector is wood-frame floor over crawlspaces. This is almost invariably used in lower-density developments. These lower densities are mainly associated with suburban or rural multi-family buildings, where parking can be located in adjacent lots or other areas.

The floor U-values associated with these construction types are summarized in Table 3.10. These U-values are calculated using a combination of conventional floor U-values, framing, and perimeter-slab loss normalized to slab area, thereby allowing an effective comparison between floors.

Table 3.10: Floor Construction

Floor Type	Oregon		Washington	
	% Floors	**U-Value**	**% Floors**	**U-Value**
Slab above Grade	11.3	0.052	8.8	0.040
Slab on/below Grade	61.9	0.089	47.8	0.056
Frame above Grade	0.0	NA	6.1	0.059
Crawlspace	26.8	0.033	37.3	0.033
Total	100.0	0.069	100.0	0.046

For the most part, wood-framed floors use insulation levels ranging from R-19 to R-30, depending on the state and application. In slabs, however, this is more problematic. Slab-on-grade detailing in Oregon has not historically

included thermal breaks and/or perimeter insulation. This causes the overall heat loss rates of the slabs to be higher than in Washington. Since the verification of thermally broken perimeter slab insulation is quite difficult in the field, the field auditors relied on plans and specifications. This may have magnified the differences between Washington and Oregon, since they could not verify the level of enforcement in slab and perimeter insulation in Washington. Nevertheless, the Oregon sample typically did not include a description of thermally broken perimeter insulation in the slabs, while the Washington sample typically did include such information.

A common problem with multi-family buildings using above-grade slabs was found in both states. In almost all cases, fiberglass batt insulation with a plastic cover is used on the undersides of slabs, usually insulated to R-20 or R-30. However, this insulation is often diminished to some degree, depending on treatment of the slab edge. Usually, the slab edge itself penetrates to the outside and is left as an uninsulated heat loss. Depending on the slab design, this could result in a 0-20% reduction in the overall performance of the slab.

The difference between the two states largely reflects the differences in slab edge insulation treatment in above-grade slabs, and the relative difficulty of applying insulation to these details. Since the detailing is specific to architect and builder, it cannot be easily generalized to a larger population. In the residential energy codes of both states, details are treated with ambiguity, and neither building inspectors nor architects use a consistent strategy for these situations. Indeed, in discussing energy issues with architects, the problem of slab insulation—both at and above grade—were most often mentioned as areas of the code in need of improvement and/or clarification (Section 5).

3.4.5. Domestic Hot Water

Domestic hot water in the multi-family sector is handled in different ways between the two states. In fact, the difference in equipment selections between Oregon and Washington suggests more divergent attitudes regarding this characteristic than almost any other. Table 3.11 illustrates the equipment selections in both states.

Table 3.11: Domestic Hot Water Systems (Percent of Units)

Tank Type	Oregon			Washington		
	Electric	**Gas**	**Total**	**Electric**	**Gas**	**Total**
Individual Unit	100.0	32.0	80.2	100.0	94.7	96.9
Central	0.0	68.0	19.8	0.0	5.3	3.1

The Washington sample is characterized by individual hot water tanks placed in individual units (seen in almost 97% of the sample). This does not seem to vary with size of project, building height or size, or any other factor. The

remaining 3% use central water tanks and circulating water loops to supply the entire project.

In Oregon, on the other hand, about 20% of multi-family units use a central water heating system. This system seems to be used chiefly in the metropolitan Portland area. Some of this distinction between urban Portland and the rest of the state may result from the large size of the urban Portland projects (although this trend does not appear in larger projects in Washington).

Another interesting feature of Oregon domestic hot water selection is that, unlike in Washington, the fuel used for domestic water heating often differs from the space-heating fuel. All of the central water heaters in the Washington and Oregon samples used gas to fire the central boiler or water heater. In Washington, whenever this decision is made, the remainder of the building is gas-heated by one means or another. In Oregon, the building remains electrically-heated at least two-thirds of the time, though the domestic water heating system is fired with a gas boiler. With this distinction, almost 30% of the Oregon sample uses gas for either domestic hot water or space heating, with only a small percent of these being gas space-heating systems.

Table 3.12 shows the distinction between gas and electric space heating and water heating fuels. Each cell in Table 3.12 represents the fraction of units in the overall sample, so that the four cells in each state total 100 percent.

Table 3.12: Domestic Hot Water and Heating Fuel Selection (% of Units)

Heat Fuel	Oregon		Washington	
	Elect DHW	**Gas DHW**	**Elect DHW**	**Gas DHW**
Electric Heat	70.9	22.3	39.5	4.3
Gas Heat	0.0	6.8	2.0	54.1
Total	70.9	29.1	41.6	58.4

4. Code Compliance and Performance

The overall impact of these characteristics and decisions results in some distinctions in building performance and heat loss rate. These distinctions largely parallel the energy code requirements in each state; furthermore, the overall impact of these decisions results in appreciable differences in space heating performance between the two states. These can be partially explained by the colder climate of Washington, but its principal causes are the differences in building components in response to the code requirements.

4.1. Energy Code Compliance

Table 4.1 summarizes the results of the characteristics review in terms of UA/ft^2. These values are weighted by number of units surveyed.

Table 4.1: Heat Loss Summary (By Unit)

	Oregon			Washington		
	Electric	**Gas**	**Total**	**Electric**	**Gas**	**Total**
Sample UA/ft^2	0.161	0.196	0.164	0.169	0.190	0.183
Code UA/ft^2	0.164	0.199	0.168	0.176	0.215	0.200
% Compliance	80.2	77.9	79.9	93.9	100.0	97.7

The most striking feature of this table is the relatively low level of compliance among Oregon buildings, in spite of the lower heat loss rate in the Oregon buildings as a whole. The nature of this non-compliance is complicated by the fact that whether multi-family buildings are regulated under the residential or non-residential energy code depends on the number of building stories in Oregon. These classifications can be ambiguous for buildings that have mixed uses, even if this mixed use is minimal.

For this code review, we assumed that the number of residential levels in the individual buildings would determine which code was used. This is significant in that the non-residential code is dramatically less stringent than the residential code, especially regarding window standards. The non-residential default U-value is approximately 0.54, resulting in almost 35% more heat loss than in the residential energy code requirement. While none of the non-complying buildings in our Oregon sample were subject to, or permitted under, the non-residential code, some of the low-rise buildings appeared to be designed under these provisions. It is not at all clear what the explanation for this is, particularly since energy code compliance in the single-family residential sector in Oregon is nearly 100 percent.

The primary code deficiency between non-complying Oregon multi-family buildings lies in the use of glazing with U-values above code requirements. It is important to note that "compliance" in this evaluation was defined as the expected heat loss rate (UA) of buildings in which every component meets prescriptive standard. We did not ascribe non-compliance to buildings that failed to meet the

energy code provisions for one component but compensated with the improvement of another component. Of the six non-complying buildings, five failed to meet the window compliance and lacked compensating features.

Washington multi-family buildings, taken as a whole, comply with the code to an even greater degree than the single-family buildings reviewed. In spite of this compliance, Washington buildings incur noticeably greater heat loss per square foot than Oregon buildings. This is almost exclusively due to the use of the gas heating code among the Washington sample. This code is considerably more lenient than the electric heating code and allows 2x4 walls as a matter of course. The net result is that Washington buildings have approximately 12% greater heat loss than Oregon buildings. This is presumably offset by the fact that Washington buildings are roughly three times more likely to be heated with gas and, since gas is a far cheaper heating fuel than electricity in virtually all markets in both states, the operating costs should be lower.

4.2. Performance

Using the overall heat loss rates and other characteristics derived from the field review, the performance of the audited buildings was analyzed using the *Sunday*® thermal simulation program. This program predicts space heating load from the UA, climate, window characteristics, and other factors. For this analysis, internal gains and thermostat set point were assumed. Since these factors were not directly measured in the protocol, assumptions were assigned in common to all buildings in both samples. These assumptions included an infiltration rate of 0.35 air changes per hour (ACH), a thermostat set point of 65° (24 hrs/day), and internal gain of 2,000 BTU's per unit per day. These assumptions were derived from earlier reviews of the multi-family sector (Heller, 1992; Kennedy, 1991). In these cases, direct measurements of infiltration and other sub-metered information were used to calculate average values for multi-family construction taken in the early 1990s under the Residential Construction Demonstration Project (RCDP) Cycle III protocols.

To implement *Sunday*®, each site was assigned to a weather site. Table 4.2 summarizes the weather sites used in this evaluation, including the base 65 degree days associated with the sites.

Table 4.2: Weather Sites

State/Region	N	Degree Days
Oregon		
- Eugene	3	4,628
- Portland	17	4,461
- Redmond	1	6,701
- Salem	3	4,868
Total	24	4,558
Washington		
- Bellingham (TMY1)*	2	5,769
- Seattle	20	4,867
- Spokane	1	6,888
- Yakima	2	6,059
Total	25	5,070

*Temperature adjusted from nearby TMY1 file.

These weather sites were directly adapted from the TMY1 and TMY2 weather sites produced by the National Oceanic and Atmospheric Administration (NOAA). TMY2 data was used for every site except Bellingham, Washington, where only TMY1 data was available.

4.2.1. Whole Building Analysis

The *Sunday*® runs were conducted on building characteristics and heat loss rates for each building as observed in the field and as it would have performed were it built exactly to local code requirements. Table 4.3 summarizes the results of the *Sunday*® runs. This table is constructed using *Sunday*® heating calculations for the building shell alone—no equipment efficiency or distribution efficiency was included (these effects are shown in Section 4.2.2 below).

Table 4.3: Heat Required per Unit (Building Only)

Heat Fuel	Oregon			Washington		
	Electric	Gas	Total	Electric	Gas	Total
Building Sample						
KBTU/Unit	5,171	16,148	5,867	6,943	13,823	10,692
KBTU/ft^2	5.5	10.2	5.9	7.8	10.0	9.2
Code Requirements						
KBTU/Unit	5,426	16,643	6,137	7,603	17,557	13,028
KBTU/ft^2	5.7	10.5	6.2	8.5	12.7	11.1

This table shows the striking contrast between the performance of buildings in Oregon versus Washington. The Washington units use 55% more space heat than the Oregon units. Furthermore, when the code buildings are compared with the space heat predictions for these buildings (built to comply

exactly to the relevant code) the Washington buildings use almost 80% more space heat.

Part of this difference is due to the colder climates in Washington. This accounts for almost two-thirds of the difference between the two states. The balance can be attributed to two causes: (1) the Oregon buildings are built to a more stringent heat loss standard and (2) the larger unit sizes in the gas-heated buildings have a much larger impact on the overall Washington average since these buildings also have the largest normalized heat loss. Of course, this difference would have been greater if Washington builders had actually constructed their buildings to the code requirement. As is, they exceeded code by about 20%.

The gas buildings in Oregon appear to be roughly half as efficient as the electric buildings. The principal distinction between these two sets of buildings is that the Oregon gas-heated buildings are almost all high-end larger units with high glazing levels. Furthermore, the gas-heated units represent a very small percentage of the Oregon sample. This distinction does not really occur in Washington, since the state's gas-heated buildings are more evenly distributed among all buildings and unit sizes. Since the Oregon code does not regulate glazing area, units with large amounts of glazing comply readily with the Oregon energy code.

4.2.2. Heating Fuel and System Requirements

After the *Sunday*® runs were completed, individual heating system types were reviewed. Heating system efficiency was assigned to every unit. Electrically-heated units were typically assigned an efficiency of 1.0 for the zonal electric heating. Gas furnaces were assigned their rated AFUE as determined in the field review. Heat pumps were assigned a rated COP from manufacturers' test data (ARI). There are only two such heat pumps in the sample, and both were through-the-wall packaged terminal units, to which a COP of 1.8 was assigned. These units were summarized with the other electric heating units. Once heating system efficiency was added, the summaries in Table 4.3 were recalculated for the appropriate fuel in each unit. This result is summarized in Table 4.4.

Table 4.4: Heat Energy with Equipment Efficiency

	Gas			Electric		
	N	Therms	Therms/ft^2	N	KWH	KWH/ft^2
Oregon	3	196	0.13	21	1,472	1.6
Washington	11	177	0.13	14	2,034	2.3

In gas-heated buildings, the distinction between states is almost nil, particularly when unit size is taken into account. With electric, however, the heating energy requirements of the Washington buildings are about 45%

greater than the Oregon buildings. The Washington buildings do not include heat pumps, and thus the equipment efficiency of the few heat pumps in Oregon increase this apparent difference.

In Washington, when units with gas heating are compared with electrically-heated units, there is a 60% increase in required heating BTUs. This is the result of two factors: heating system efficiency (including the impact of furnace combustion efficiency and units) and increased heat loss rates due to the relaxed standards for gas-heated units in Washington. However, when the cost of the fuel to consumers is added, the cost of heating gas apartments in Washington is about 55% of the cost of electrically-heated units. It is this component of the gas-heating system that has served as a marketing advantage to medium- and upper-end apartments, especially in the Seattle market.

In Oregon, this pattern is not as pronounced, though the costs of gas and electricity are similar to those in Washington. Other building features (e.g., unit size, glazing area, etc.), together with heating system efficiency, offset some of the cost advantages of gas heating.

It should be noted that the gas-heated units in the Oregon market are dramatically different from the electric units, so that a comparison, even when normalized for square feet, probably does not indicate the true state of affairs regarding the potential for gas heating in Oregon. The most significant issue here could be the addition of gas heat in markets for low- and moderate-end units, which did not occur in this sample of Oregon buildings. Given the differences in overall heat loss and the milder climate of Oregon, the selection of gas heat results in an approximately 25% decrease in heating cost per square foot of heated space for the consumer. This difference is not apparent because gas-heated units tend to be larger.

4.2.3. Comparison with Single-Family Buildings

When heating loads are compared between the single-family buildings and multi-family buildings in the individual states, a large difference in space heating requirements is apparent. Table 4.5 compares the field evaluation results with the single-family construction reviewed in both states. The assumptions for the *Sunday*® runs in the two samples were comparable, and the methods for compiling heat loss rates and window performance were the same.

Table 4.5: Single-Family/ Multi-Family Heating Comparison

State	Fuel Type			
	Gas (Therms/ft^2)		Electric (KWH/ft^2)	
	Single-Family	Multi-Family	Single-Family	Multi-Family
Oregon	0.19	0.13	2.7	1.6
Washington	0.23	0.13	2.9	2.3

In general, single-family residential buildings use much more heating energy per square foot than multi-family units. Furthermore, the size of single-family units in these samples is more than twice as large as the multi-family units, compounding this effect. In Oregon electric buildings and Washington gas buildings, the difference between multi-family and single-family is about a factor of two; in Oregon gas buildings and Washington electric buildings, this distinction is somewhat reduced. The principal difference between Washington's electrically-heated single-family homes and electrically-heated multi-family homes is that 70% of Washington's single-family electrically-heated homes use heat pumps, which are virtually never used in the multi-family sector. This reduces most of the difference between the two groups.

The Oregon gas comparison has less meaning than the other three cells, since only three Oregon multi-family buildings had gas heat, and these were far and away the largest units in the sample. The units in these buildings are much more like the single-family sector than any other subset of the multi-family sample.

The overall performance of multi-family buildings use about 60% as much space heat per square foot of heated floor space compared to the single-family counterparts. In addition to the reduced heat loss, the size of these multi-family units results in a further overall reduction heating requirements for the dwelling units.

5. Interviews

As part of the review of the multi-family sector in Washington and Oregon, architects and engineers involved in multi-family projects were targeted using a structured interview format focused on attitudes regarding energy conservation, energy efficiency, and energy codes as applied to multi-family buildings. To administer this interview, architects and engineers were telephoned and asked to participate. The interview was designed to take 10-15 minutes. In general, participation levels were high. Table 5.1 shows the distribution of interviews in the multi-family sector.

Table 5.1: Interviews

Interviewee	Oregon	Washington	Total
Architect	20	17	37
Developer	1	3	4
General Contractor	1	7	8
Mechanical Engineer	1	0	1
Total	23	27	50

The 50 interviews conducted represent 40 unique projects in the multi-family sector out of the 49 buildings surveyed. More than 75% of the interviews were conducted with the architects primarily responsible for the design of these multi-family complexes. Appendix B details the responses to the questions in the interview. This section summarizes certain areas of inquiry.

5.1. Design Responsibility

As detailed below, architects are the primary decision makers in specifying the building shell. They are often important in areas of HVAC and lighting, though the role of general contractor and developer in these areas can be more significant than in other large projects. This role can extend to taking responsibility for the design of much, if not all, of the mechanical system in buildings. By and large, the mechanism for this is a design-build format which requires that a subcontractor provides both the design and installation of the heating/cooling systems. In many cases (especially in low-rise, multi-family construction), a mechanical engineer, electrical engineer, or other engineering technician is not involved except through the installation contractor.

Those interviewed were asked which professional was responsible for decisions affecting energy code compliance and energy efficiency in various components of the building. Table 5.2 summarizes the results of this question.

Table 5.2: Design Responsibility (Percent of Interviewees)

Component/Decision Maker	Oregon	Washington	Total
Building Shell			
Architect	18	20	38
Contractor	1	1	2
Owner/Developer	4	6	10
HVAC			
Architect	3	6	9
Mechanical Engineer	6	3	9
Contractor/Subcontractor	5	5	10
Owner/Developer	7	11	18
Consultant/Other	2	2	4
Lighting			
Architect	6	11	17
Electrical Engineer	6	1	7
Contractor/Subcontractor	4	5	9
Owner/Developer	6	8	14
Consultant/Other	1	2	3

As Table 5.2 illustrates, decisions regarding building shell design are largely handled by the architect, although owner/developers have this decision power in 20% of the cases. However, less than one-third of HVAC and lighting design decisions are made by architects. In half the projects, decisions affecting these components are made by owners, general contractors or subcontractors. The distinction between general contractor and owner is often ambiguous in these projects, since large complexes are often owned, developed, and constructed by one firm.

In many cases, the subcontractor was responsible for energy-related decision making for these components as part of the design-build bidding process. The most important aspect of this finding is that these decisions are made outside of the design process during the bidding and construction phase of the project.

5.2. Code Compliance

A portion of the interviews focused on the mechanics of meeting energy code standards for multi-family projects. In general, the interview questions were designed to determine whether the architects or building developers were required to make changes in insulation or building equipment as a result of their interaction with building officials over the issue of energy code. Table 5.3 shows the percent of respondents who received direct feedback on energy code issues during the permitting process.

Table 5.3: Code Feedback from Building Officials

Feedback	Oregon				Washington			
	Yes		No		Yes		No	
	N	%	N	%	N	%	N	%
Permit	11	65	6	35	12	48	13	52
Inspections	4	22	14	78	11	50	11	50
Total	15	43	20	57	23	49	24	51

Oregon and Washington are fairly similar in this regard: about one half of all buildings received direct code feedback during either the permit or inspection process (or both). The distinction between the states lies largely in the difference between feedback at the inspection stage versus feedback at the permit process. In Oregon, this feedback took the form of clarifications during permit review about 40% of the time, and resulted in few or no changes. In Washington, the inspection process seemed to focus more on the energy code, at least in this sector, and result in direct enforcement of the code provisions.

Another discussion during the permitting process was the detailing around slab edge insulation, a recurring theme in the Oregon interviews. In Washington, slab insulation also played a role, but changes and discussions focused on documentation both on the plans and in the field, and these seemed to be the dominant source of feedback and discussion between design teams and building departments.

In Washington, the difficulties with code enforcement were dominated by glazing specifications, which presumably reflects the fact that specific glazing performance is determined not by a prescriptive code (as in Oregon), but by a component performance calculation, requiring considerably more documentation in the permitting process.

While discussing the interactions between the design teams and the building officials over the energy code issue, the interviewers asked the architect or contractor to describe any difficulties they had with the code or with code compliance. Table 5.4 details the major results of these discussions.

Table 5.4: Energy Code Difficulties (By Percent)

Comment	Oregon	Washington
None	50	46
Ventilation Requirements	9	19
Slab Insulation	27	4
Too Confusing/Inconsistent	5	19
Glazing Requirements	0	4
Other Requirements	9	9

Roughly half of the respondents had no comments or compelling difficulties with the code. The remaining half seemed (in Oregon, at least) to focus on slab

insulation and, in both states, on ventilation requirements and confusion over such requirements. It should be pointed out that the ventilation code in Washington is not a part of the energy code and there is no specific ventilation code or requirement in Oregon. Confusion over code provisions was much more significant in the Washington sample. This is presumably an artifact of the component performance and trade-off calculations that are part of the Washington State Energy Code.

5.3. Energy Efficiency Information

Interviewees were asked several questions concerning their source of information for use in building design and building specification. Each respondent was given the opportunity to list three sources. These queries produced little consistency among the interviewees. About a third mentioned other design professionals, while another 10% mentioned various utility programs, especially the Seattle Lighting Design Lab, the Seattle City Light Energy Smart® program, and the Puget Sound Energy gas marketing program.

The most commonly mentioned resource, however, was the code itself. Roughly 40% of the respondents mentioned the energy code, energy code manuals, energy code training, etc. as the primary source for energy efficiency information. Product literature and product representatives comprised an important resource for information regarding specific products. Almost 40% of the respondents mentioned manufacturers' literature and representatives as an information source. Another source (mentioned by about 37% of the respondents) was periodicals, especially professional magazines and journals, which seem to provide a great deal of basic information.

In addition to these sources, respondents noted the importance of experience and common sense as well as the information provided by subcontractors and installers. These were not usually mentioned without some other information sources, usually the code documents and available literature.

5.4. Utility Programs

Utility programs were mentioned as substantial influences on building design in roughly 15% of the cases in both states. There were three main programs mentioned: the Eugene Water and Electric Board (EWEB) energy design incentives (a direct incentive utility program aimed at high efficiency residential buildings), Seattle City Light Build Smart® program (a high efficiency insulation program targeted at Seattle area electrically-heated multi-family buildings), and Puget Sound Energy (PSE) programs (which market gas to the Puget Sound region).

Interestingly enough, the two electric utilities provide direct incentives as part of their programs, thus marketing high-efficiency electrically-heated buildings

within their service territories. The gas company uses a marketing program with almost no incentives, although it does provide some technical assistance, product information and service bulletins. This program seems to account for the major differences between Oregon and Washington in the use of gas heating as a part of the building design process. The fact that the PSE program was mentioned by about 25% of the Washington interviewees suggests that the program had a major impact on the overall decisions in these projects. This may also help to explain the great difference between the saturation of gas heating systems in Washington as opposed to Oregon. In Oregon, these gas systems are almost all forced-air furnaces installed in larger, presumably high-end, apartments and condominiums. In Washington, the gas heating extends across all but the smallest multi-family units.

One other interesting point is that in no case where the utility incentive was used or mentioned as important in the use of energy efficiency measures did the respondent mention the utility as an information source. Even in well established multi-family programs such as EWEB and Seattle City Light, the utility does not seem to be considered a source for information in this industry.

5.5. Marketing

Virtually all respondents suggested that the best and most straightforward opportunity for delivering energy efficiency into the multi-family sector lies in direct contact with architects, providing specific information such as cost-effectiveness data, model designs and projects, and direct assistance during the design process. While there was no consensus on how this information should be delivered in the multi-family sector, there was a strong view that direct presentation to the architect or to the owner during the early stages of the design process would have a substantial impact. Almost two thirds of the respondents noted the importance of integrating energy efficiency at a very early stage of the design process. Furthermore, the importance of the early design process in this sector was shared by the architects, building owners, and general contractors. No other response indicated this kind of consensus.

When asked how this information could best be provided for architects, most architects and contractors suggested direct mailings and brochures together with continuing education classes, workshops, and training sessions. A few architects did mention specific programs which they found useful. The two most common of these were the Seattle Lighting Design Lab (together with the workshops it conducts) and the Portland General Electric Earth Smart® program, which provides some marketing and direct contact with architects and building design professionals. In response to many of these questions, most architects argued for the need for additional information delivered in seminars, literature targeted at designers, or some other form.

6. Conclusions

The multi-family sector as described in this sample is quite different from the rest of the residential sector. Decisions made in the multi-family sector for space-heating and insulation levels are different from those made for the single-family sector, and seem to require completely different mechanisms for addressing and changing standard building practices.

6.1. Space-Heating

The most striking feature of this sample is the large amount of gas heating in the Washington sample as compared to the Oregon sample. When compared to single-family residential construction, both states have rather small gas heat saturations in the multi-family sector relative to the 80-90% levels seen in single-family houses throughout the region. What is most interesting about this trend is that, for one reason or another, gas heating has penetrated the multi-family market in the Seattle area but not in Portland or any other area in either Washington or Oregon.

This seems to be associated with the marketing efforts of the gas company that, to some extent, have been counterbalanced by electric utility marketing programs for electric heat. These programs have addressed the vital questions of implementing heating systems in multi-family units and providing architects and engineers with alternatives that have made the implementation effective. These steps have been taken in the Seattle market and change has occurred; they have not been undertaken in Portland, and gas saturation there remains low.

The heating systems selected in the multi-family sector do not include very extensive use of ducted forced air systems. Only in the larger condominium-type developments of Oregon were any significant fraction of the homes heated with forced air furnaces; throughout the Washington sample, the advent of zoned hot water heat seems to have made significant in-roads on heating system selection. Architects and designers maintain that this is a response to current market conditions and to the demand of developers and future tenants of these apartments to provide a gas heating alternative to the traditional multi-family zoned heating. Again, this type of heating is quite rare in single-family construction in the region.

6.2. Code Compliance

Another striking feature of Oregon multi-family buildings is the relative difficulty with code compliance. This may be partially explained by the somewhat complicated nature of the Oregon code as it applies to these buildings. In Oregon, multi-family buildings of three stories or less are regulated under the single-family residential code, requiring 2x6 walls and Class 40 windows. Multi-family buildings of 4 or more stories are regulated under the non-residential energy code,

which includes an envelope code approximately 40% less stringent than the residential sector, Class 54 windows and roughly R-13 walls.

This distinction seems straightforward, but, in reviewing code compliance difficulties within the multi-family sector, it appears that the most common problem is the development of code compliance strategies around the non-residential code for buildings which ought to be permitted under the residential code. From our perspectives, it is difficult to determine which of these codes was used by local building officials and thus which buildings are in absolute compliance with the Oregon code. Nonetheless, it is certain that the vagueness of Oregon multi-family building classification deteriorates the performance of Oregon multi-family building, especially in contrast to Oregon single-family buildings, which are almost universally compliant with the Oregon residential code.

Compliance levels in the Washington multi-family sector are considerably higher, though the impact of this compliance does not correspond to increased efficiency in the building shells   This is largely due to the nature of the Washington code, which allows significantly less effective shells for gas-heated buildings. The Washington code for gas-heated buildings is roughly equivalent to the Oregon code for non-residential buildings. This explains why, although Washington's compliance is considerably better than Oregon's, its performance is not. Most of this can be traced to the use of an aluminum window standard in the Washington code, which dates from about 1986 and is seriously outdated in terms of both multi-family window technology and overall availability of advanced glazing and frame designs. The multi-family sector has availed itself of these more effective window technologies, and these technologies form the basis of compliance to the Washington energy code. It is the distinction between the gas code and the electric code which explains most of the difference between the performance of Washington and Oregon buildings.

6.3. Other Observations

The sample reviewed here is relatively small and is designed around the F.W. Dodge® database, which makes it possible that some bias is present. This problem is most worrisome in Oregon, where relatively small projects (presumably in outlying areas) are not included, but one must also note the possibility of bias in Washington as a result of small sample size. While we believe that the characteristics determined here are well-represented in the population, further efforts to focus on particular issues, such as the transition between gas heat and electric heat in the multi-family sector, would be useful.

This study suggests that multi-family units should be more carefully reviewed, considering that they comprise about a third of all new residential dwellings in the region, and an even larger fraction of the dwellings in the more populated areas of western Washington and western Oregon.

Overall, the multi-family sector does not have the same characteristics, either in building type or code compliance, as the single-family residential buildings. Heating systems are far more likely to be electric, even in the Washington market (use of electric zone heating having almost completely vanished from single-family residences). The other significant issue is the treatment of slab edges: both above-grade and slabs-on-grade are problematic for multi-family developments. This difficulty is fairly severe in high-rise multi-family buildings in Washington. Architects and builders in both states found these requirements problematic, both in the treatment of thermally broken slab edges and the treatment of above-grade exposed slab edges.

The overall performance of multi-family buildings is almost 40% more efficient per square foot of heated floor space than its single-family counterpart. This is partly due to the geometry of building design: apartments units share many surfaces with other heated areas and buffer spaces. It is also due to a lower window-area-to-floor-area ratio and somewhat more consistent use of coatings and gas fills in installed windows, especially in Washington. In addition to the reduced heat loss, the size of these multi-family units results in an overall reduction of 60% in overall heating requirements for the dwelling units.

Designers of multi-family buildings are more like those of the non-residential sector. The buildings are typically designed by architects with a complex of builders, suppliers and installers that deliver the projects. This mechanism can be accessed through the network of architects that provide design and project management services to this industry. The interviews with this group suggest that they are supportive of energy efficiency if it can be made a part of the design process. Unlike the single-family residential sector, this is not a diverse group that relies on information from the utilities. They have many channels that provide them with detailed information, and they rely on these channels.

It is apparent that considerable strides could be made in the efficiency of these buildings and in the selection of heating systems. These strides can be based on a credible marketing approach that focuses on specific information and provides detailed alternatives that can be readily and cost-effectively applied to the multi-family sector. The experience of Washington Natural Gas in the Seattle market is very illustrative. This was a small utility marketing program, consisting of two salesmen with some technical back-up and some detailed information. The program succeeded in increasing the saturation of gas heating in the Seattle market by threefold in less than five years.

7. References

Baylon, D., M. Kennedy, M.J. DeLaHunt, 1987, *Conservation Potential for the Multi-family Sector*, Seattle City Light, Seattle, WA.

Bonneville Power Administration, 1985, *Multi-Family Database, BPA Region,* Bonneville Power Administration, Portland, OR.

Cochran, W. 1977. *Sampling Techniques.* John Wiley & Sons, Inc. New York, NY.

Heller, J. 1992. *Residential Construction Demonstration Project: Cycle III: Analysis of Innovative Ventilation Systems in Multi-family Buildings.* For the Washington State Energy Office, Olympia, WA.

Kennedy, M. 1991. *Documentation for Simplified Heating System Equipment Model.* For the Washington State Energy Office, Olympia, WA.

State of Oregon, 1996, *Structural Specialty Code*, Oregon Building Codes Division, Salem, OR.

Washington Natural Gas, 1997, *Natural Gas for Multi-family Projects*, Seattle, WA

Washington State Energy Code, 1997, Washington State Building Code Council, Olympia, WA.

8. Acknowledgements

Appendix A

Multi-Family File/Field Review Protocol
Cover Review Protocol

NEEA Multi-Family Protocol

Project Information

_____   Project ID

_____   Dodge Number

_____   Date of plan review   Date of Field Review   _____
_____   Plan Reviewer Name   Field Reviewer Name   _____

_____   Jurisdiction Name

Building name: _____
Address: _____
_____

Contact name at building: _____
Phone: _____

Configuration

Whole Residential Development
_____   Number of buildings in development
_____   Total number of residential units in this development
        Approximate average HFA of residential units: _____
        Approximate average ceiling ht. of residential units: _____
Describe type and size of any accessory buildings that are part of this development:
_____

Target Building
_____   Number of residential units in this building
        Approximate average number of bedrooms/unit: _____
        Approximate average number of bathrooms/unit: _____
_____   Number of stories (total)

  [y]   [n]   Lower floors are non-residential (mixed-use building)
                Characterize **street level** use:
                  [ ] retail   [ ] office   [ ] parking   [ ] other: _____
  [y]   [n]   Retail/Office; number of levels: _____
  [y]   [n]   Parking; number of levels: _____

_____   Total number of **residential** levels

Residential Units

        Check all characteristics that apply:

           [ ]   apartments
           [ ]   elderly housing
           [ ]   low income housing
           [ ]   dormitory
           [ ]   row housing
           [ ]   condominiums

        Each residential unit is:

           [ ]   single level
           [ ]   multiple level
           [ ]   some of each

        Characterize unit access:

           [ ]   primary access to each unit is from outside
           [ ]   primary access to each unit is from common area:

Common Areas

  [y]   [n]   Are there enclosed common areas? (not including mixed use or parking)

        Characterize common areas:

           [ ]   common area is heated by its own heating equipment:
               [ ] yes   [ ] no   [ ] unknown
           [ ]   wall/ceiling/floor between living units and common areas is insulated:
               [ ] yes   [ ] no   [ ] unknown
           [ ]   wall/ceiling/floor between common areas and outside is insulated:
               [ ] yes   [ ] no   [ ] unknown

Mixed Use

           [ ]   Is the wall/ceiling/etc between living units and commercial areas insulated?
               [ ] yes   [ ] no   [ ] unknown

Building takeoffs

List total **floor area** by category for this building:

    [ ] Residential (combine units): _____
    [ ] Common area: _____
    [ ] Non-Residential (heated):
       list HFA by use type: HFA: _____   use type: _____
                                 HFA: _____   use type: _____
                                 HFA: _____   use type: _____

List the approximate **volume** by category for this building (very rough calculation only):

    [ ] Residential (combine units): _____
    [ ] Common area: _____
    [ ] Non-Residential (heated):   _____

Takeoffs

Except for questions about individual unit floor areas and heating capacities, all residential component areas should be combined for the target building. Common areas that are part of the residential areas should be included in the residential building calculation. In the take-offs, assume that the common area is a heated space, but answer the specific questions about systems and insulation in this form. Complete takeoffs of common area components regardless of heating strategy.

For mixed-use buildings, do not calculate the area of walls or other components between residential and non-residential uses (adiabatic). Non-residential areas will be described in the mixed use section.

Lighting takeoffs will include residential common areas, all of the building exterior, and some specific questions about the residential areas.

FLOORS
Fill out a separate MULTIFAMILY FLOOR TYPE form for each type listed. Count the following as separate floor types:
- Floors over unheated space
- Slab vs. frame floors. For structural slabs above unheated space, count the area over unheated space; **note:** the exposed perimeter length should also be calculated as a rim joist wall type. For structural slabs between two residential levels, count the perimeter of **each level** as a rim joist wall type. Also answer the characterization questions in the structural slab section on the component forms.

_____ Number of **residential** floor types (including common areas)

Floor Type #	Description/location	Floor Area (linear ft. for slabs)	Verified
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]

WALLS

Fill out a separate MULTIFAMILY WALL TYPE form for each type listed. All wall areas should indicate gross wall area; do not subtract windows and doors. Count the following as separate wall types:

- Walls of different construction or thickness
- Rim joists or exposed above grade slab edges

_____ Number of **residential** wall types (including common areas)

Wall Type #	Description/location (i.e. typical exterior wall, attic sidewall, above grade slab, etc.)	Wall Area	Verified
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]

CEILINGS

Fill out a MULTIFAMILY CEILING TYPE form for each ceiling type in the project.

_____ Number of **residential** ceiling types (including common areas)

Ceiling Type #	Description/location	Ceiling Area	Verified
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]
_____	_____	_____	[ ]

DOORS

Describe doors in the table below. Include a description of door construction, area, and location. Multiple doors with the same characteristics can be combined, but separate doors located in different wall types. Doors which are half or fully glazed should be described in the window section. Doors with small view windows can be described here. There are no other component description forms for doors. All door areas should be calculated based on rough opening size.

Door Location (ie: main entry, typical exterior, etc)	Construction (ie: wood panel door, insulated door, etc.)	Located in wall type #	Door area (ft^2)

WINDOWS

Windows

_____ Number of Window Types
Each of the following should be counted as a separate window type:

- Windows with different frame materials
- Windows with different types of glazing
- Custom 'stopped-in' glazing
- Glazed 'swing' doors
- Skylights
- Single glazing
- Sliding glass doors can be counted with other windows with similar frame construction.

For each window type, fill out a window type description form (blue). **If the same window type occurs in two different wall types list the window type twice with the appropriate areas and orientations for each wall type in which it is located.** All window areas should be calculated based on rough opening size.

Check here if no direction indicated on plan set: [   ]
(Describe revised orientation in field:_____**)**

Window Type #	In Wall (ceiling) Type #	Description (i.e.: main windows, skylight, etc.) Label skylights clearly!	Area by Orientation (for skylights, use **Total** column only)				Total Area
			North	**South**	**East**	**West**	
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____

HVAC

Information about mixed use portions of projects should be indicated in the mixed use section of this form. If the mixed use HVAC system is integrated with the residential HVAC system, or if the residential units are served by a central heating system, the non-residential mechanical system forms should be used to characterize the system.

Characterize the residential and residential common area systems below. Then fill out a multifamily HVAC system worksheet for the heating, cooling, and hot water systems.

Is gas available in this area?
     [ ] yes   [ ] no   [ ] unknown

Does the building have gas service?
     [ ] yes   [ ] no   [ ] not indicated on plans   [ ] not present in field
     If gas is indicated/present:
     Does it serve each unit (for stoves, hot water, heat, or etc)?
          [ ] yes   [ ] no   [ ] unknown
     Is it individually metered (for each unit)
          [ ] yes   [ ] no   [ ] unknown

Indicate the type of HVAC system in the residential units:
     [ ] Individual heating(cooling) equipment installed in each residential unit: Fill out
          MULTIFAMILY HVAC SYSTEM sheet
     [ ] Multiple residential units served by the a single piece of equipment: Fill out the
          COMPLEX HVAC SYSTEM sheets.

Common Areas:
Check here if no common areas: [   ]

What information is provided on the plans regarding common area heating:
[ ] no information   [   ] indicated as heated, no other info
[ ] system and capacity information given

What is determined in the field about the heating system in the common area:
[ ] heated by independent system   [   ] not heated by specific system
[ ] unknown   [   ] not applicable

Which of the following best characterizes the ventilation system in the common area:
[ ] no information on plans   [   ] fan system only ([ ] supply [ ] return)
[ ] no ventilation system installed   [   ] fan system with heat ([ ] supply[ ] return)

Indicate common area heating system and capacity information:

Distribution code	Capacity	Capacity Units	Model	Manufacturer
_____	_____	_____	_____	_____

Describe common area mechanical system:

_____

MULTIFAMILY HVAC SYSTEMS

Fill out the form below describing the heating systems in the residential units. Indicate equipment manufacturer and capacity for three 'typical' residential units for heating and cooling where indicated. Describe the common area heating system at bottom of page.

System includes: [ ] heating   [ ] cooling   [ ] combined system (heat pumps)
Heating Fuel Type: [ ] electric   [ ] natural gas [ ] heat pumps
                        [ ] other: _____   [ ] n/a

Is cooling provided to some or all of the residential units?
    [ ] yes   [ ] no   [ ] not indicated on plans   [ ] not present in field

Use these codes for the equipment type column:
   HR hydronic radiator   **RF** radiant floor heat   **FC** fan coils
   ER electric radiator   **FP** "heat-rated" fireplace **HP** split heat pump
  FRN forced air furnace   **PTAC** Package Terminal Heat Pump
 EVAP evaporative cooling   **O** other, describe: _____

Fill out the following table for three "typical" residential units. Fill out a separate line for heating and cooling in each unit if they are separate appliances:

Resid. Unit HFA	Equip. Type	Capacity	Capacity Units	Efficiency (elec:100%)	Manufact.	Model	Heat	Cool
_____	_____	_____	_____	_____	_____	_____	[ ]	[ ]
_____	_____	_____	_____	_____	_____	_____	[ ]	[ ]
_____	_____	_____	_____	_____	_____	_____	[ ]	[ ]
_____	_____	_____	_____	_____	_____	_____	[ ]	[ ]
_____	_____	_____	_____	_____	_____	_____	[ ]	[ ]

Typical t-stat type:

[ ] programmable   [ ] single set-point   [ ] multiple t-stats   [ ] unknown

Hot Water

If hot water is provided to the units by **individual water heaters**, fill out the information below.
If hot water is provided by a **central boiler**, fill out the non-residential system forms.
If heating appliance is **combined** with domestic hot water, check here: [ ]

Fill out the following information about a typical **domestic hot water appliance** in a residence:
              Fuel: _____   Tank Capacity (gals):   _____
    Capacity (Btu/kw):   _____   Manufacturer: _____
    Efficiency Rating: _____   Model: _____

Are typical heating systems ducted? [Yes] [No] [Unknown]
     Location
     [ ] Interior Space   [Some] [All] [None] [NA] [Unknown]
     [ ] Buffer Area   [Some] [All] [None] [NA] [Unknown]

[ ] Roof	[Some] [All] [None] [NA] [Unknown]
[ ] Crawlspace	[Some] [All] [None] [NA] [Unknown]
[ ] Insulation	[Some] [All] [None] [NA] [Unknown]

Residential Ventilation and Combustion

Check all boxes in the following categories which describe the **ventilation systems** installed in the residential units:

General
    [ ] not indicated on plans
    [ ] not yet installed in field (can't tell yet)
    [ ] no ventilation installed in field (it ain't going in)

Exhaust
    [ ] spot exhaust fans only
    [ ] central house fan other than spot fan provides exhaust
    [ ] at least one fan is controlled by a 24-hour timer
    [ ] fully ducted ventilation (AAHX, HPWH, central ducted fan per unit)
    [ ] central building exhaust (serves multiple units)

Supply
    [ ] no fresh air intakes
    [ ] window slot vents provide fresh air
    [ ] through wall ports provide fresh air
    [ ] ducted fresh air supply in heating system

Check all boxes below which describe the **combustion exhaust** for combustion appliances in the individual units (hot water or furnace). Do not characterize fireplaces here.
    [ ] no combustion appliances
    [ ] not indicated on plans
    [ ] natural draft vented
          [ ] high/low intake   [ ] single intake
    [ ] forced draft vent
    [ ] sealed combustion vent

Check all boxes below which describe **fireplaces** in the individual units.
    [ ] no fireplaces indicated on plans
    [ ] no fireplaces installed in field (check this box only if complete enough to know)
    [ ] fireplaces are gas-fired

    [ ] fireplaces vent to vertical chimneys
    [ ] fireplaces vent out a sidewall
    [ ] fireplaces vent directly into living space
    [ ] fireplaces are heat-rated

    [ ] outside combustion air source installed

Lighting

Residential Area
Answer the following questions about typical lighting in the residential units:

[y] [n] [unk] Are there any compact fluorescent lamps permanently installed in the units?
     If so, how many: [_____]
[y] [n] [unk] Are there recessed can lights installed through the building envelope?
     If so, how many: _____

Common Areas and Exterior
Complete lighting take-offs for the **common areas and exterior areas** of the project using the forms below:

Floor Area (see take-offs section):   _____
Ceiling Height::   _____

Fixture Schedule:

Fixture Type ID	Fixture Type	Lamp Type	# of Lamps	Watts/ Lamp	Ballast Type	# of Ballst	Plan Watts/ Fixture	Field Verif	Notes

Common Area Installed Fixtures:

Fixture ID	Watts/fixture	Plans		Actual		Exmpt
		# of fixtures	Watts	# of fixtures	Watts	(y/n)
Totals						

Exterior Lighting:

Parking Area:_____

Outdoor Area: _____

Building Facade Area:_____

Building Perimeter (linear foot):_____

Notes: _____

Fixtures:

Fixture Type ID	Notes	Plans # of fixtures	Field # of fixtures	Control Type[1]	Exmpt (y/n) [2]
Totals					

[1]Photocell, timer, switched, 24hour
[2]Explain in notes

Materials

Indicate what materials are used on the project in the check-boxes below.

Exterior Walls

[ ] wood lap siding   [ ] cementious lap siding
[ ] wood vertical siding   [ ] aluminum siding
[ ] stucco   [ ] vinyl siding
[ ] synthetic stucco   [ ] composite/manufactured 'wood' siding
[ ] T-111 siding   [ ] other: _____

Roof

[ ] wood shingles   [ ] cementious shingles

A-11

[　]　asphalt shingles　　　　　[　]　other: _____
[　]　metal roofing

Miscellaneous Materials

[　]　'Tyvek'-type building wrap　[　]　structural insulating panels
[　]　plastic lumber　　　　　　　[　]
[　]　insulating concrete forms　　[　]　other: _____

Structural System

Briefly describe the configuration of the building with regard to structure and configuration:
(i.e., five story structural concrete structure; four story wood frame construction over concrete parking garage, etc.):

_____
_____

Walls

MULTIFAMILY Component Description Form

_____ Wall Type
                 Location/description:_____

Check location:
      [ ]   Above Grade
      [ ]   Buffer;   to space type (describe):   _____
      [ ]   Below Grade;   average depth at base (ft.): _____
      [ ]   Slab Edge exposed above grade or Rim joist

Insulation   Overall installed R-_____(plans) _____(field)
                 [ ] indicated as this or better on plans
      [ ]   fiberglass   R- _____
      [ ]   rigid   R- _____   thickness (in.) _____ location: _____
      [ ]   loose fill
      [ ]   insulated cores: type: _____
      [ ]   other (panels, foam forms, etc.): _____
      [ ]   unknown

Structure
      [ ]   studs   [wood] [metal] [unknown]   [other]: _____
               [ ] thickness [2x4]   [2x6]   [other]: _____
               Stud spacing   [16"]   [24"]   [n/a]   [unknown]

               Headers insulated   [y]   [n]   [n/a]   [unknown]
               Insulated corners   [y]   [n]   [n/a]   [unknown]

      [ ]   concrete   [6"]   [8"]   [other]: _____
      [ ]   concrete block [6"]   [8"]   [other]: _____
      [ ]   other (panels, foam forms, etc.)   describe: _____

Slab Edge characteristics
      [ ]   flush to wall   slab thickness: _____
      [ ]   exposed fin   thickness: _____
      [ ]   beam at wall edge: beam ht: _____

+---+
| Field Review: |
| This component was checked in the field   [y]   [n] |
| Modifications were made in the field   [y]   [n] |
| |
| Please describe all changes: |
| |
| |
+---+

FLOORS

MULTIFAMILY Component Description Form

_____ Floor Type
                Location (i.e. main floor, basement, etc): _____

[ ]   indicated as this or better on plans

[ ]   Frame
          [ ]   over crawlspace
          [ ]   over garage
          [ ]   to outside
          [ ]   over basement
          [ ]   other: _____
[ ]   Slab on Grade
[ ]   Structural slab above grade
[ ]   Below Grade Slab; depth: [2 ft]   [3.5 ft]   [7 ft]

Frame Floor Insulation   R- _____(plans) _____(field)
          [ ]   fiberglass
          [ ]   other: _____

Frame Floor Structure
          [ ]   joist spacing   [12"]   [16"]   [24"]   [ ] other: _____
          [ ]   wood joists   [lumber] [I-joists] depth (in.): _____
          [ ]   1-1/2" 'car decking' w/ beams & girders
          [ ]   metal joists   depth: _____
          [ ]   other (panels, etc.) describe: _____

Slab Insulation
          [ ]   none
          [ ]   thermal break? [y]   [n]   describe: _____
          [ ]   perimeter: R- _____(plans) _____(field) describe: _____
          [ ]   fully insulated: R- _____(plans) _____(field) thickness: ____
          [ ]   unknown

┌───┐
│ Field Review: │
│   This component was checked in the field   [y]   [n] │
│   Modifications were made in the field   [y]   [n] │
│ Please describe all changes: │
│   │
│   │
└───┘

CEILINGS

MULTIFAMILY Component Description Form

_____ Ceiling Type   Location: _____

    [ ]   Attic
    [ ]   Vault-Scissor
    [ ]   Vault-Rafter
    [ ]   Structural Slab

Roof slope: _____ in 12

Are there skylights in this roof type? [y]   [n]   [unknown]

Insulation   R-value: _____(plans) _____(field)
            [ ] indicated as this or better on plans
    [ ]   batts
    [ ]   loose fill   [cellulose] [fiberglass] [rockwool]   [unknown]
            depth:_____
    [ ]   rigid   thickness (in.) _____
    [ ]   other: _____
    [ ]   unknown

Structure
    [ ]   manufactured trusses
            [ ]   heel height (in.): _____
            [ ]   describe perimeter insulation: _____

    [ ]   stick framed
            [ ]   structural depth (in.): _____
                 [ ]   I-joists
                 [ ]   dimensional lumber
                 [ ]   metal framing

    [ ]   structural slab

    [ ]   other framing, describe: _____

Field Review:
    This component was checked in the field   [y]   [n]
    Modifications were made in the field   [y]   [n]
Please describe all changes:

WINDOWS

Component Description Form (BLUE FORM)

_____   Window Type   Description: _____

        [ ]   Windows, Sliding Glass Doors
        [ ]   Skylight
        [ ]   Glazed 'Swing' Door   [half-lite]   [full-lite]

Frame Material
        [ ]   vinyl
        [ ]   wood   [wood finish]   [clad]
        [ ]   aluminum   [thermal break]   [no thermal break]
        [ ]   "stopped in"
        [ ]   other: _____
        [ ]   unknown

Glazing
    Number of glazing layers:[1]   [2]   [2+film]   [3]
    Low-ε coating: [y]   [n]   [unknown]
    Tinted: [y]   [n]   [unknown]
    "Warm-edge"   [y]   [n]   [unknown]
    Gas filled (rivets visible): [y]   [n]   [unknown]

    Spacing: [   ] thin (3/8"-)   [   ] thick (1/2"+)   [unknown]

    Manufacturer: _____

      Is there a window schedule on the plans?   [y]   [n]
      If so, which of the following are indicated:
    [ ]   window areas
    [ ]   U-values
    [ ]   manufacturer

      Are labels present on windows?   [y]   [n]
    [ ]   NFRC
    [ ]   small manufacturer default
    [ ]   other: _____

  Window U-value:_____(plans) _____(field)
             [   ] indicated as this U or better on plans

    ┌───┐
    │ Field Review: │
    │   This component was checked in the field   [y]   [n]│
    │   Modifications were made in the field   [y]   [n]│
    │ Please describe all changes: │
    │   │
    └───┘

COMPLEX HVAC SYSTEMS
MultiUse and Built Up Systems

Delivery System # ___: This system provides ___heat ___cool ___vent
       Space ID Served: SPACE-

       From Plans?   Y / N   Field Verified?   Y / N

       Description:

       System Type: _____
       Configuration [package]   [built-up] [unknown]
       Total CFM _____   MinOA_____
       Economizer   [Yes]   [No]   [NA]   [Unknown]
       Sub-Zone Reheat   [Yes]   [No]   [NA]   [Unknown]   Reheat Fuel
Type:_____
       Heat Source(reference to boiler, or none):   _____   _____
       Cool Source (reference to chiller or none):   _____   _____
       Fans Serving (reference to fan number):   _____ _____ _____ _____
       Package Eq Number (ref to pkg number):   _____ _____ _____ _____

       Control Strategies *(this system)*
              Description:

              Specific items:
              [ ]   OA control   [economizer]   [CO2]   [n/a]   [unknown] [Other] _____
              [ ]   Deck Temp. Reset   [Y]   [N]   [n/a]   [unknown]
              [ ]   Deck Pressure Reset   [Y]   [N]   [n/a]   [unknown]
              [ ]   Night Time "setback" [Y]   [N]   [n/a]   [unknown]
                     Setback Duration_____

SYSTEM TYPE CODES		FUEL TYPE CODES	
CV	CONSTANT VOLUME (REHEAT)	E	ELECTRICITY
VAV	VARIABLE AIR VOLUME	NG	NATURAL GAS
HPLP	HEAT PUMP LOOP	OIL	FUEL OIL / DIESEL
VVT	VARIABLE VOLUME-TEMPERATURE	HW	HOT WATER FROM BOILER
2PFC	TWO PIPE FAN COIL	OTHER *(SPECIFY)*	
4PFC	FOUR PIPE FAN COIL		
SPECIFY OTHER SYSTEMS			

Boilers

Unit Dsg	Qty	Fuel	Load Type	Boiler Type	Burner Type	Cap	Cap Units	Eff.	Eff Units	Control Type[1]

Make, Model:

Make, Model:

Make, Model:

[1] include all applicable control strategies

FUEL TYPE CODES	**BURNER TYPE**
E ELECTRICITY NG NATURAL GAS OIL FUEL OIL / DIESEL GO GAS/OIL (DUEL FUEL) P PROPANE / BUTANE WH WASTE ST STEAM *(purchased from outside)* OTHER *(SPECIFY)*	NAT = NATURAL DRAFT PWR = POWER DRAFT **CAPACITY UNITS** KBTU MMBTU HP*(horsepower)* KW OTHER *(SPECIFY)*_____
LOAD TYPES	**CONTROL TYPE CODES**
S SPACE HEAT ONLY SW SPACE HEAT AND WATER HEAT W WATER HEAT ONLY P PROCESS HOT WATER HEATING OTHER *(SPECIFY)*	B1 CYCLING B2 TEMPERATURE RESET B3 TRIM CONTROL B4 MODULATING B5 STAGED
BOILER TYPES	
HW HOT WATER S STEAM	

Chillers

Unit Dsg	Qty	Cap	Cap Units	Compressor Type	Eff	Eff Units	Heat Recovery (y/n)	Staged	Control Type[1]

Make, Model:

_____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Make, Model:

_____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Make, Model:

_____ _____ _____ _____ _____ _____ _____ _____ _____ _____

[1] include all applicable control strategies

<table>
<tr><td>

COMPRESSOR TYPE
CENT CENTRIFIGAL
RECIP RECIPROCATING
SCRO SCROLL
ABO   ABSORPTION FROM OIL
ABG   ABSORPTION FROM GAS
ABW   ABSORPTION FROM WASTE HEAT
ABS   ABSORPTION FROM STEAM
OTHER *(SPECIFY)*

</td><td>

CAPACITY UNIT CODES
KBTU
MMBTU
HP*(horsepower)*
TON
OTHER *(SPECIFY)*_____

CONTROL TYPE CODES
C1 TEMPERATURE RESET
C2 MODULATING
C3 MODULATING –VFD
C4 STAGED

</td></tr>
</table>

COOLING TOWER

Natural draft: ☐ Yes ☐ No

Capacity control: ☐ Single speed ☐ Two speed ☐ Variable speed ☐ Fluid bypass

Heat exchanger loop : ☐ Yes ☐ No

Temperature control : ☐ Fixed ☐ Wetbulb reset ☐ Other

Unit No	Manufacturer/Model	GPM	EWT	LWT	Fan HP	Fan BHP	Fan Eff

Fans (except fans in package units)

Unit Dsg	Qty	HP	BHP	Work Type	Control	------Motor------ Eff (plans)	Eff (fld)	Dsgn Flow	Dsgn dP	Motor Speed	Open/ Closed
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——

WORK TYPE	**CONTROL TYPE CODES**
AHU = SUPPLY&RETURN FAN	F1 = CONSTANT
SF = SUPPLY FAN	F2 = MULTI-SPEED MOTOR
RF = RETURN FAN	F3 = INLET VANES
EF = EXHAUST FAN	F4 = CONE
EFGR = GARAGE EXHAUST	F5 = ASD–VFD
CT= COOLING TOWER	F6 = DISCHARGE DAMPER
INTR = OTHER INTERMITTENT FAN	F7 = BYPASS DAMPER
CONT= OTHER CONTINUOUS FAN (>1000 HRS)	F8 = CYCLING ON THERMOSTAT
	F9 = CYCLING ON AIR QUALITY
	F10 = VANE AXIAL VARIABLE PITCH
	F11= VANE AXIAL VARIABLE PITCH,.ASD

Pumps

Unit Dsg	Qty	HP	BHP	Work Type	Control	Eff (plans)	Eff (fld)	Dsgn Flow	Dsgn dP	Motor Speed	Open/ Closed
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——
——	——	——	——	——	——	——	——	——	——	——	——

WORK TYPE	**CONTROL TYPE CODES**
CC= CHILLED WATER CIRCULATION	P1 = CONSTANT
HC= HOT WATER CIRCULATION	P2 = CYCLING ON DEMAND
CN=CONDENSOR WATER	P3 = DISCHARGE VALVE
HP=WATER SOURCE HEAT PUMP CIRCULATION	P4 = ASD-VFD
INTR = OTHER INTERMITTENT PUMP	P5 = STAGED WITH OTHER PUMPS
CONT= OTHER CONTINUOUS PUMP (>1000 HRS)	P6 = SPEEDS STAGED
	P7 = BYPASS VALVE

Multi-Family Cover Sheet Review

Date: _____   **Field Reviewer Name:**_____

Building I.D.: _____   **Jurisdiction:**_____

County: _____

Project Name:_____

Project Address: _____

_____

Contact Name: _____

Phone: _____

Permit#: _____   **Permit Date:** _____

Target Building

Configuration: **Construction:**

    [ ] *Town House / Condos*   [ ] *Wood Frame*
    [ ] *Multi-Story Apartments*   [ ] *Struct. Slabs / Concrete*
    [ ] *Multi-Building*   [ ] *Steel Frame*

    Number of Units _____**Number of Stories** _____

Primary Heating Fuel Type (check one)

    [ ] *Unknown*
    [ ] *Electric*
    [ ] *Non Electric* (check one if indicated)
        [ ] **Natural Gas**
        [ ] **Heat Pump**
        [ ] **Fuel Oil**
        [ ] **Propane**
        [ ] **Wood**
        [ ] **Other:** _____

Valuation: _____

Heated Floor Area:_____

_____

Building Designer Introduction

Project Number: _____

Building Name: _____

Square Footage: _____

Address: _____

_____

Firm: _____

Contact: _____

Contact Address: _____

_____

Telephone: (___)_____

Good (Afternoon), my name is _____ from Ecotope Inc., an energy research firm based in Seattle. We may have talked to you before about the project we are working on for The Northwest Energy Efficiency Alliance. The project is aimed at evaluating the standard building practices regarding energy efficiency. They hired us to look at 240 randomly selected commercial buildings and 500 residential buildings across the Pacific Northwest to determine the ways in which energy conservation has impacted the design and construction process.

One of the buildings that appeared in our sample was the_____
(building name) which I believe you were involved with. As part of a follow-up study, I would like to ask you a few questions about the design decisions and permitting process for this building.

Were you involved with decisions relating to the building shell, HVAC system, lighting design or energy code submittal on this building? (If not, can you put us in touch with the correct person?)

Do you have a few minutes for the interview? (If not, arrange a suitable time).

_____

Building Designer/Engineer Interview

(Draft)

Project Name: _____

Check one:

_____ Architect/Envelope Designer
_____ Mechanical Engineer
_____ Mechanical Contractor
_____ Lighting Designer
_____ Lighting Contractor
_____ Building Owner
_____ Corporate Headquarters
_____ General Contractor
_____ Other _____

First, we would like to obtain some general information on your firm.

1. How many employees are at your company?

        1-5   [ ]
        6-10   [ ]
        11-25   [ ]
        26-100   [ ]
        over 100   [ ]

2. What is the primary business of your company?

        Architecture   [ ]
        Engineering   [ ]   _____(specify type)
        Other Design Professional   [ ]   _____ (specify type)
        General Contractor   [ ]
        Specialty Contractor   [ ]   _____(specify type)
        Supplier   [ ]
        Manufacturer   [ ]
        Developer   [ ]
        Other   [ ]   _____(specify)

3. How many projects do you estimate your firm completes annually?
        What (estimated) square footage does this represent?

4. Do you use the energy code as the minimal design criteria?
        If no: Did you use any references to establish the minimum energy efficiency design
        criteria for this building? _____

_____

5. Which energy code applies to you most often?

        Washington State Energy Code   [ ]
        Oregon State Energy Code   [ ]
        Model Energy Code (MEC)   [ ]
        ASHRAE Standard 90.1   [ ]
        Other Non-residential Code, specify _____   [ ]
        Idaho Residential Energy Standard (IRES)   [ ]
        No energy codes apply   [ ]
        Other _____   [ ]

6. Are there any elements of the energy code that you feel are not cost-effective or poorly thought out? Why do you feel that way?

 Do you still implement them into your design?

7. Do the building departments usually enforce the applicable energy codes?

 Are there any aspects of the energy codes that are not typically enforced?

8. Do provisions of the energy code or code enforcement typically have an impact on your design?

        No   [ ]
        Yes (describe below)   [ ]

9. In general, did you incorporate any energy efficiency measure(s) beyond what is minimally required? (If yes, please describe)

10. For this project, was energy efficiency a particularly challenging problem for any aspect of the building (envelope/mechanical/mechanical) system? If so, why?

11. What barriers to integrating energy efficiency into your designs or including high efficiency equipment do you perceive?

12 Did this project participate in a utility energy efficiency incentive program? Which program? Which utility?

   If yes:

        12 a. What energy efficiency measures were added as a result of this program or incentive? (Envelope, Mechanical, Lighting)

   If yes:

        12 b. Were any changes made during construction to the design or equipment which would effect energy efficiency?

            No   [ ]
            Yes (describe below)   [ ]

13. In buildings where energy efficiency changes have not been adopted, what are the most usual reasons for not making changes?

     [   ] Not required by code
     [   ] Lack of information on energy efficiency
     [   ] Client chose not to include
     [   ] Too expensive
     [   ] Did not consider
     [   ] Technology unreliable
     [   ] Other_____
     [   ] Don't know

14. In your opinion, has consumer demand for an energy efficient design changed your building practices?

_____

15. Beyond code requirements and consumer demand, what other factors have caused you to increase the energy efficiency of your designs?

16. Roughly what percentage of your clients/customers would you say consider energy efficiency to be important?

17. Are there any building types (such as warehouse/retail) where the costs are too cost inhibitive and are therefore not used (for example; insulation, efficient lighting products, etc.)? Do you argue otherwise or do you agree that these measures are not cost-effective?

18. Do you "commission" a building after the project is completed?

    If yes:
          18 a. What steps do you go through when commissioning a building?

    If yes:
          18 b. Which systems are commissioned?

                HVAC   [ ]
                Lighting   [ ]

19. Do you or other staff members from your office attend conferences on energy efficiency?

20. Did you receive any training in energy efficiency building practices?

    If yes:
          20 a. From where?

_____

21. Where do you obtain most of your energy and energy efficiency information: (Check the first three mentioned)

     [   ] Seminars/Conferences
     [   ] Trade Journal or Other Periodical
     [   ] Trade or Professional Association
     [   ] Advertising
     [   ] Electric Utility
     [   ] Gas Utility
     [   ] Colleagues/Peers
     [   ] Government Agency: (list) _____
     [   ] Consultants
     [   ] Contractors
     [   ] Manufacturers or Dealers/distributors
     [   ] Other _____

22. With whom do you normally share energy efficiency information?

     [   ] No one
     [   ] Staff
     [   ] Colleagues
     [   ] Clients
     [   ] Other ____

23. How often have you ever made changes to your business practices as a result of energy efficiency information you have received?

     [   ] Never
     [   ] Once or twice
     [   ] A few times
     [   ] Often
     [   ] Very often

          23a. What were the main reasons?

             [   ] Reduced O&M
             [   ] Cost Savings
             [   ] Lower capital investment
             [   ] Client request
             [   ] Client satisfaction
             [   ] Other_____

_____

24. What is the best way to market energy efficiency information/products to professions such as yours? (Record top three responses.)

[   ]   _____   [   ] _____   [   ] _____

25. Who serves as the key decision maker in making energy and energy efficiency related decisions?

        [   ] Owner
        [   ] Architect
        [   ] Engineer
        [   ] Contractor
        [   ] Consultant
        [   ] Code
        [   ] Corporate management
        [   ] Local management
        [   ] Other_____

26. Does *your organization* place high value, medium value, low value, or no value on:

	1 High	2 Medium	3 Low	4 No Value
Reducing energy use?				
Continuing education or training programs?				
Environmental issues?				
Recycling?				
Innovation?				
Adoption of "cutting edge" technologies?				

27. Do *you personally* place high value, medium value, low value, or no value on:

	1 High	2 Medium	3 Low	4 No Value
Reducing energy use?				
Continuing education or training programs?				
Environmental issues?				
Recycling?				
Innovation?				
Adoption of "cutting edge" technologies?				

_____

28. What trade or professional magazine do you value the most? _____

29. Have you heard of Energy Star products? Yes_____   No_____

(If yes)

> *29a. What Energy Star products and services have you heard of and have you installed/used/specified them? (Check all those mentioned below)*

	Heard of	Installed/used/specified
Fixtures	_____	_____
Windows	_____	_____
Washers	_____	_____
Dishwashers	_____	_____
Refrigerators	_____	_____
Room air conditioner	_____	_____
Central heating	_____	_____
Central cooling	_____	_____
The whole manufactured home	_____	_____
Bulk purchases	_____	_____
Personal computers	_____	_____
Other office equipment	_____	_____
Green Lights Program	_____	_____
Other_____	_____	_____

30. What do you feel is the best way to promote energy efficiency?

31. Do you have any general comments or observations regarding the energy efficiency, or comments on this project specifically?

32. What suggestions do you have for improving the energy efficiency of our buildings?

Appendix B

Builder Interview- Annotated Protocol

Building Designer Introduction

Dodge Number: _____

Ecotope ID Number: _____

Building Name: _____

Square Footage: _____

Address: _____

_____

City: _____ State: _____

Firm: _____

Contact First Name _____ Last Name:_____

Contact Address:_____

_____

City: _____ State: _____

Telephone: (___)_____

Good (Afternoon), my name is _____ from Ecotope Inc., an energy research firm based in Seattle. We may have talked to you before about the project we are working on for The Northwest Energy Efficiency Alliance. The project is aimed at evaluating the standard building practices regarding energy efficiency. They hired us to look at 240 randomly selected commercial buildings and 500 residential buildings across the Pacific Northwest to determine the ways in which energy conservation has impacted the design and construction process.

One of the buildings that appeared in our sample was the_____ (building name) which I believe you were involved with. As part of a follow-up study, I would like to ask you a few questions about the design decisions and permitting process for this building.

Were you involved with decisions relating to the building shell, HVAC system, lighting design or energy code submittal on this building? (If not, can you put us in touch with the correct person?)

Do you have a few minutes for the interview? (If not, arrange a suitable time).

Building Designer/Engineer Interview

(Draft)

Project Name: _____

Check one:

_____ Architect/Envelope Designer
_____ Mechanical Engineer
_____ Mechanical Contractor
_____ Lighting Designer
_____ Lighting Contractor
_____ Building Owner
_____ Corporate Headquarters
_____ General Contractor
_____ Other _____

Design Role	Oregon		Washington		Total	
	N	%	N	%	N	%
Architect/Env Designer	20	86.96	17	62.96	37	74.00
Building Owner	2	8.70	2	7.41	4	8.00
General Contractor	0	0.00	7	25.93	7	14.00
Mechanical Contractor	1	4.35	0	0.00	1	2.00
Owner's Representative	0	0.00	1	3.70	1	2.00
Total	23	100.00	27	100.00	50	100.00

General Questions

First, we would like to obtain some general information on your firm.

1.1 How many employees are at your company?

1-5	[ ]
6-10	[ ]
11-25	[ ]
26-100	[ ]
over 100	[ ]

Number of Employees	Oregon		Washington		Total	
	N	%	N	%	N	%
1-5	6	26.09	8	29.63	14	28.00
6-10	3	13.04	7	25.93	10	20.00
11-25	9	39.13	4	14.81	13	26.00
26-100	3	13.04	5	18.52	8	16.00
> 100	2	8.70	3	11.11	5	10.00
Total	23	100.00	27	100.00		100.00

1.2 What is your company's primary business?

Architecture	[ ]	
Engineering	[ ]	_____(specify type)
Other Design Professional	[ ]	_____ (specify type)
General Contractor	[ ]	
Specialty Contractor	[ ]	_____(specify type)
Supplier	[ ]	
Manufacturer	[ ]	
Developer	[ ]	
Other	[ ]	_____(specify)

Primary Business	Oregon		Washington		Total	
	N	%	N	%	N	%
Architecture	20	86.96	17	62.93	37	74.00
Developer	1	4.35	3	11.11	4	8.00
General Contractor	1	4.35	7	25.93	8	16.00
Mechanical Engineer	1	4.35	0	0.00	1	2.00
Total	23	100.00	27	100.00	50	100.00

1.3 How many projects do you estimate your firm completes annually?_____
     What (estimated) square footage does this represent? _____

Number of Projects	Oregon		Washington		Total	
	N	%	N	%	N	%
1 to 10	7	31.82	7	29.17	14	30.43
11 to 25	2	9.09	6	25.00	8	17.39
26 to 50	6	27.27	7	29.17	13	28.26
51 to 150	6	27.27	3	12.50	9	19.57
> 150	1	4.55	1	4.17	2	4.35
Total	22	100.00	24	100.00	46	100.00

Annual Square Footage	Oregon		Washington		Total	
	N	%	N	%	N	%
0 to 100,000	1	11.11	4	36.36	5	25.00
100,000 to 250,000	1	11.11	2	18.18	3	15.00
250,001 to 1,000,000	5	55.56	5	45.45	10	50.00
1,000,001 to 25,000,000	2	22.22	0	0.00	2	10.00
Total	9	100.00	11	100.00	20	100.00

1.4 Who is the primary decision-maker responsible for energy code and energy efficiency decisions for the following components?

1.4A - Building Shell:
Structural Engineer   [ ]
Owner   [ ]
Architect   [ ]
General Contractor   [ ]
Consultant   [ ]
Code   [ ]
Corporate Manager   [ ]
Local Management   [ ]
Other   [ ]

Decision Maker: Building Shell	Oregon		Washington		Total	
	N	%	N	%	N	%
Architect	17	73.91	18	66.67	35	70.00
Code	0	0.00	2	7.41	2	4.00
General Contractor	1	4.35	1	3.70	2	4.00
Owner	4	17.39	6	22.22	10	20.00
Structural Engineer	1	4.35	0	0.00	1	2.00
Total	23	100.00	27	100.00	50	100.00

1.4B - Mechanical System
Mechanical Engineer [ ]
Owner   [ ]
Architect   [ ]
HVAC Contractor   [ ]
Structural Engineer   [ ]
General Contractor   [ ]
Consultant   [ ]
Code   [ ]
Corporate Manager   [ ]
Local Management   [ ]
Other   [ ]

Decision Maker:	Oregon		Washington		Total	
Mechanical System	N	%	N	%	N	%
Architect	3	13.04	6	22.22	9	18.00
Code	0	0.00	1	3.70	1	2.00
Consultant	1	4.35	0	0.00	1	2.00
General Contractor	1	4.35	4	14.81	5	10.00
HVAC Contractor	4	17.39	1	3.70	5	10.00
Mechanical Engineer	6	26.09	3	11.11	9	18.00
Other	0	0.00	1	3.70	1	2.00
Owner	7	30.43	11	40.74	18	36.00
Structural Engineer	1	4.35	0	0.00	1	2.00
Total	23	100.00	27	100.00	50	100.00

1.4C - Lighting System
      Electrical Engineer   [ ]
      Owner   [ ]
      Architect   [ ]
      Lighting Contractor   [ ]
      Structural Engineer   [ ]
      General Contractor   [ ]
      Consultant   [ ]
      Code   [ ]
      Corporate Manager   [ ]
      Local Management   [ ]
      Other   [ ]

Decision Maker:	Oregon		Washington		Total	
Lighting System	N	%	N	%	N	%
Architect	5	21.74	10	37.04	15	30.00
Code	0	0.00	1	3.70	1	2.00
Consultant	1	4.35	0	0.00	1	2.00
Electrical Engineer	6	26.09	1	3.70	7	14.00
General Contractor	1	4.35	4	14.81	5	10.00
Lighting Contractor	3	13.04	1	3.70	4	8.00
Other	0	0.00	2	7.41	2	4.00
Owner	6	26.09	8	29.63	14	28.00
Structural Engineer	1	4.35	0	0.00	1	2.00
Total	23	100.00	27	100.00	50	100.00

Practices and Attitudes Related To The Energy Code

2.1 Does the WA State Energy Code apply to you? Any others?

Washington State Energy Code   [ ]
Oregon State Energy Code [ ]
Model Energy Code (MEC) [ ]
ASHRAE Standard 90.1 [ ]
Other Non-residential Code, specify _____ [ ]
Idaho Residential Energy Standard (IRES) [ ]
No energy codes apply [ ]
Other _____ [ ]

Applicable Code	Oregon		Washington		Total	
	N	%	N	%	N	%
Model Energy Code	1	4.35	0	0.00	1	2.00
Oregon State Energy Code	19	82.61	0	0.00	19	38.00
Washington State Energy Code	3	13.04	27	100.00	30	60.00
Total	23	100.00	27	100.00	50	100.00

2.2 Were energy codes or standards mentioned as part of the building department review
of the project (e.g. energy forms, direct notes on plans, questions at counter, etc.)?

Yes [ ]   No [ ]

Standards Mentioned	Oregon		Washington		Total	
	N	%	N	%	N	%
No	6	27.27	0	0.00	6	12.50
Yes	16	72.73	26	100.00	42	87.50
Total	22	100.00	26	100.00	48	100.00

If yes:

  2.2 a Did you receive feedback from building officials on energy code compliance
      for this project at plan examination?
          Yes [ ]   No [ ]

Received Feedback at Examination	Oregon		Washington		Total	
	N	%	N	%	N	%
No	6	35.29	13	52.00	19	45.24
Yes	11	64.71	12	48.00	23	54.76
Total	17	100.00	25	100.00	42	100.00

At inspections?

Yes [ ]   No [ ]

Received Feedback	Oregon		Washington		Total	
at Inspection	N	%	N	%	N	%
No	14	77.78	11	50.00	25	62.50
Yes	4	22.22	11	50.00	15	37.50
Total	18	100.00	22	100.00	40	100.00

If yes: What changes were made as a result of this feedback?

	Oregon		Washington		Total	
	N	%	N	%	N	%
No Change	2	40.00	4	40.00	6	40.00
Perimeter Slab Insulation	2	40.00	0	10.00	2	13.33
Glazing	1	20.00	1	10.00	2	13.33
Insulation	0	0.00	1	10.00	1	6.67
Minor (Unspecified)	0	0.00	1	10.00	1	6.67
Ventilation	0	0.00	1	10.00	1	6.67
Documentation	0	0.00	2	20.00	2	13.33
Total	5	100.00	10	100.00	15	100.00

2.3 Would you hire a consultant to help specifically with energy code or energy
efficiency issues?

Yes [ ]   No [ ]

Would Hire Energy	Oregon		Washington		Total	
Efficiency Consultant	N	%	N	%	N	%
No	11	47.83	8	33.33	19	40.43
Yes	12	52.17	16	66.67	28	59.37
Total	23	100.00	24	100.00	47	100.00

2.3a Did such a person participate in this project?

Yes [ ]   No [ ]

Hired Energy Efficiency	Oregon		Washington		Total	
Consultant	N	%	N	%	N	%
No	20	86.96	17	70.83	37	78.72
Yes	3	13.04	7	29.17	10	21.28
Total	23	100.00	24	100.00	47	100.00

2.4 Did you use the energy code as the minimal design criteria for the following
components in this building?

Building shell?   Yes [ ]   No [ ]

Building Shell	Oregon		Washington		Total	
	N	%	N	%	N	%
No	1	4.35	1	3.70	2	4.00
Yes	22	95.65	26	96.30	48	96.00
Total	23	100.00	24	100.00	50	100.00

Mechanical system?   Yes [ ]   No [ ]

Mechanical System	Oregon		Washington		Total	
	N	%	N	%	N	%
No	6	26.09	8	29.63	14	28.00
Yes	17	73.91	19	70.37	36	72.00
Total	23	100.00	27	100.00	50	100.00

Lighting system?   Yes [ ]   No [ ]

Lighting System	Oregon		Washington		Total	
	N	%	N	%	N	%
No	5	21.74	10	37.04	15	30.00
Yes	18	78.26	17	62.96	35	70.00
Total	23	100.00	27	100.00	50	100.00

2.5 **For Retail Buildings Only**: Which compliance path did you use for this project?
Retail A   [ ]   Retail B   [ ]

Compliance Path	Oregon		Washington		Total	
	N	%	N	%	N	%
A	1	100.00	0	NA	1	100.00
B	0	0.00	0	NA	0	0.00
Total	1	100.00	0	NA	1	100.00

2.6 Are there any elements of the energy code that you feel are not cost-effective or
are poorly thought out?
Yes [ ]   No [ ]

If yes: What are they?

Problems with Energy Code	Oregon		Washington		Total	
	N	%	N	%	N	%
No	11	50.00	12	46.15	23	47.92
Yes	11	50.00	14	53.85	25	52.08
Total	22	100.00	26	100.00	48	100.00
Ventilation Requirements	2	18.18	5	29.41	7	25.00
More Consistent Enforcement	0	0.00	1	5.88	1	3.57
Slab Insulation	6	54.55	1	5.88	7	25.00
Too Confusing	1	9.09	1	5.88	2	7.14
Glazing Levels Too Restrictive	0	0.00	1	5.88	1	3.57
Lighting Too Restrictive	1	9.09		0.00	1	3.57
Conflicts between UBC and Energy Code	0	0.00	3	17.65	3	10.71
Insulating/Framing/ Envelope	1	9.09	3	17.65	4	14.29
Orientation	0	0.00	1	5.88	1	3.57
Remodel/TI Restrictions	0	0.00	1	5.88	1	3.57
Total	11	100.00	17	100.00	28	100.00

2.5 a. Did you still implement them into your design? Yes [ ]   No [ ]

Still Implemented	Oregon		Washington		Total	
	N	%	N	%	N	%
No	1	11.11	0	0.00	1	5.56
Yes	8	88.89	9	100.00	17	94.44
Total	9	100.00	9	100.00	18	100.00

2.7 Do you use any software package (such as WattSun or DOE2®) to demonstrate
    compliance with energy codes?
        Yes [ ]   No [ ]

        If yes: What is your opinion on its use and outcome?

Use Software	Oregon		Washington		Total	
	N	%	N	%	N	%
No	20	90.91	15	57.69	35	72.92
Yes	2	9.09	11	42.31	13	27.08
Total	22	100.00	26	100.00	48	100.00
WattSun	0	NA	5	71.43	5	71.43
DOE2®	0	NA	1	14.29	1	14.29
CodeComp	0	NA	1	14.29	1	14.29
Total	0	NA	7	100.00	7	100.00
Favorable Opinion	0	NA	5	100.00	5	100.00

2.8 Have additional requirements or procedures been imposed on you as a result of recent
    revisions in the energy code?

Additional Requirements	Oregon		Washington		Total	
	N	%	N	%	N	%
No	13	86.67	2	40.00	15	75.00
Insulation Approach Changed	2	13.33	2	40.00	4	20.00
Overall Approach Changed	0	0.00	1	20.00	1	5.00
Total	15	100.00	5	100.00	20	100.00

Energy Efficient Design Criteria

3.1 Did you incorporate any energy efficiency measure(s) in this project beyond what
   is minimally required by an energy code? (If yes, please describe).

        Lighting: Yes [ ]   No [ ]
        HVAC: Yes [ ]   No [ ]
        Envelope: Yes [ ]   No [ ]

Energy Efficiency Measures	Oregon		Washington		Total	
	N	%	N	%	N	%
Lighting	6	46.15	7	30.43	13	36.11
HVAC	3	23.08	9	39.13	12	33.33
Envelope	4	30.77	7	30.43	11	30.56
Total	13	100.00	23	100.00	36	100.00

3.1 a. What were the main reasons?

Reasons	Oregon		Washington		Total	
	N	%	N	%	N	%
Utility Incentive	3	37.50	5	31.25	8	33.33
Better Design	3	37.50	2	12.50	5	20.83
Maintenance Benefit	2	25.00	0	0.00	2	8.33
Occupant Request	0	0.00	3	18.75	3	12.50
Cost Savings	0	0.00	3	18.75	3	12.50
Increased Lighting	0	0.00	3	18.75	3	12.50
Total	8	100.00	16	100.00	24	100.00

3.1 b. How important was incorporating energy efficient features to other
members of the design team?

Importance	Oregon		Washington		Total	
	N	%	N	%	N	%
No Importance	1	6.67	2	9.09	3	8.11
Not Very Important	3	20.00	7	31.82	10	27.03
Medium Importance	6	40.00	5	22.73	11	29.73
Important	4	26.67	5	22.73	9	24.32
Very Important	1	6.67	3	13.64	4	10.81
Total	15	100.00	22	100.00	37	100.00

3.2 Did the building owner request energy efficiency in the building design?
Yes [ ]   No [ ]

Owner Requested Energy Efficiency	Oregon		Washington		Total	
	N	%	N	%	N	%
No	18	81.82	17	70.83	35	76.09
Yes	4	18.18	7	29.17	11	23.91
Total	22	100.00	24	100.00	46	100.00

If yes: What measures?

Requested Measures	Oregon		Washington		Total	
	N	%	N	%	N	%
Windows and Doors	1	20.00	1	14.29	2	16.67
Incentive Requirements	3	60.00	2	28.57	5	41.67
HVAC Equipment / Ducts	0	0.00	2	28.57	2	16.67
Lighting	0	0.00	1	14.29	1	8.33
Insulation	1	20.00	1	14.29	2	16.67
Total	5	100.00	7	100.00	12	100.00

3.3 What is the most dominant lighting fixture type used in this project?

Dominant Lighting Fixture	Oregon		Washington		Total	
	N	%	N	%	N	%
Fluorescent	4	21.05	4	18.18	8	19.51
HID	2	10.53	0	0.00	2	4.88
Incandescent	13	68.42	18	81.82	31	75.61
Total	19	100.00	22	100.00	41	100.00

3.4 Was a performance analysis of the energy requirements of this building done as
part of the design or code compliance process?
Yes [ ]   No [ ]

Performance Analysis	Oregon		Washington		Total	
	N	%	N	%	N	%
No	18	81.82	12	50.00	30	65.22
Yes	4	18.18	12	50.00	16	34.78
Total	22	100.00	24	100.00	46	100.00

3.4 Do you "commission" a building after the project is completed?
Yes [ ]   No [ ]

"Commission" Completed	Oregon		Washington		Total	
	N	%	N	%	N	%
No	18	85.71	23	92.00	41	89.13
Yes	3	14.29	2	8.00	5	10.87
Total	21	100.00	25	100.00	46	100.00

If yes:
3.4 a. What steps do you go through when commissioning a building?

3.4 b. Was training or an operating manual provided for the building
operator?
Yes [ ]   No [ ]

Training or Manual Provided	Oregon		Washington		Total	
	N	%	N	%	N	%
No	3	100.00	3	100.00	6	100.00
Yes	0	0.00	0	0.00	0	0.00
Total	3	100.00	3	100.00	6	100.00

3.5 What were the main barriers to including energy efficiency in the design of this
   project?

Main Barriers	Oregon		Washington		Total	
	N	%	N	%	N	%
None	9	40.91	1	4.55	10	22.73
Site Planning	1	4.55	0	0.00	1	2.27
Costs	7	31.82	14	63.64	21	47.73
Education	3	13.64	2	9.09	5	11.36
Slab Edge Insulation	1	4.55	0	0.00	1	2.27
Envelope Requirements	1	4.55	4	18.18	5	11.36
Window Requirements	0	0.00	1	4.55	1	2.27
Total	22	100.00	22	100.00	44	100.00

Support and Information Requirements

4.1 What 2 or 3 sources do you use to obtain information on energy efficiency designs
   and technology in new building construction?

Oregon Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Code / code training	3	14.3	5	29.4	1	10.0
Journals, Magazines	5	23.8	4	23.5	3	30.0
Professionals/Consultants	3	14.3	3	17.7	5	50.0
Manufacturers, Rep./Lit.	6	28.6	4	23.5	0	0.0
Contractors	3	14.3	0	0.0	0	0.0
Utility	0	0.0	1	5.9	0	0.0
Experience/Other	1	4.8	0	0.0	1	10.0
Total	21	100.0	17	100.0	10	100.0

Washington Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Code / code training	7	31.8	4	25.0	1	16.7
Journals, Magazines	2	9.1	2	12.5	2	33.3
Professionals/Consultants	3	13.6	1	6.3	1	16.7
Manufacturers, Rep./Lit.	4	18.2	4	25.0	2	33.3
Contractors	3	13.6	2	12.5	0	0.0
Utility	1	4.5	3	18.8	0	0.0
Experience/Other	2	9.1	0	0.0	0	0.00
Total	22	100.0	16	100.0	6	100.0

Total

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Code / code training	10	23.3	9	27.3	2	12.5
Journals, Magazines	7	16.3	6	18.2	5	31.2
Professionals/Consultants	6	13.9	4	12.1	6	37.5
Manufacturers, Rep./Lit.	10	23.3	8	24.2	2	12.5
Contractors	6	13.9	2	6.1	0	0.0
Utility	1	2.3	4	12.1	0	0.0
Experience/Other	3	7.0	0	0.00	1	6.3
Total	43	100.0	33	100.0	16	100.0

4.2 Do you believe you had enough information to implement energy efficiency into
this project?
Yes [ ]   No [ ]

Sufficient Information on Energy Efficiency	Oregon		Washington		Total	
	N	%	N	%	N	%
No	3	13.04	0	0.00	3	6.25
Yes	20	86.96	25	100.00	45	93.75
Total	23	100.00	25	100.00	48	100.00

4.3 Do you believe you had enough information on the energy code as it applied to
this project?
Yes [ ]   No [ ]

Sufficient Information on Energy Code	Oregon		Washington		Total	
	N	%	N	%	N	%
No	0	0.00	1	4.00	1	2.08
Yes	23	100.00	24	96.00	47	97.92
Total	23	100.00	25	100.00	48	100.00

If no: What information would have aided in the design?

Information Type	Oregon		Washington		Total	
	N	%	N	%	N	%
Example Projects	1	25.00	0	NA	1	25.00
State-Provided Technical / Cost Information	3	75.00	0	NA	3	75.00
Total	4	100.00	0	NA	4	100.00

Who would you expect to provide this information?

[No significant responses.]

General Attitudes and Suggestions for Improvement

5.1 In your opinion, has client demand for an energy efficient design changed your
design practices in general?
Yes [ ]   No [ ]

Client Demand Changed Practices	Oregon		Washington		Total	
	N	%	N	%	N	%
No	20	86.96	22	4.00	42	85.71
Yes	3	13.04	4	96.00	7	14.29
Total	23	100.00	26	100.00	49	100.00

If yes, what design elements?

5.2 Roughly what percentage of your clients/customers would you say consider
energy efficiency to be important? _____

What Percent Clients	Oregon		Washington		Total	
	N	%	N	%	N	%
0 to 10	3	13.64	9	40.91	12	27.27
11 to 25	5	22.73	4	18.18	9	20.45
26 to 50	6	27.27	5	22.73	11	25.00
51 to 75	0	0.00	2	9.09	2	4.55
76 to 100	8	36.36	2	9.09	10	22.73
Total	22	100.00	22	100.00	44	100.00

5.3 Where in the design/construction process in multi-family buildings would you say
the best opportunities to improve energy efficiency exist?

Opportunity to Improve	Oregon		Washington		Total	
	N	%	N	%	N	%
Educate Architects	0	46.15	1	4.55	1	2.22
Consider Early in Design Process	18	23.08	11	50.00	29	64.44
Educate Owners / Contractors	1	30.77	2	9.09	3	6.67
Improve Siting	2		0	0.00	2	4.44
Improve Code	2		6	27.27	8	17.78
Reduce Costs	0		2	9.09	2	4.44
Total	23	100.00	22	100.00	45	100.00

5.4 What do you feel is the best way to promote energy efficiency and to convey new
technology to architects, designers and engineers?

Way to Promote	Oregon		Washington		Total	
	N	%	N	%	N	%
Architect Education	0	0.00	4	17.39	4	8.89
Articles / Seminars / Workshop	15	68.18	5	21.74	20	44.44
Demonstration Projects	0	0.00	1	4.35	1	2.22
Literature	3	13.64	5	21.74	8	17.78
Cost / Benefit Data	4	18.18	4	17.37	8	17.78
Incentives	0		3	13.04	3	6.67
Improve Code	0		1	4.35	1	2.22
Total	22	100.00	23	100.00	45	100.00