BASELINE CHARACTERISTICS OF THE MULTI-FAMILY SECTORS OREGON AND WASHINGTON

For the

Northwest Energy Efficiency Alliance

ECOTOPE

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1. Introduction

The purpose of the baseline review is to establish the current practices and attitudes of building professionals in particular building sectors, in this case, multi-family residential construction. The goal is to provide an understanding of the current market so that future Alliance programs can be targeted efficiently and effectively, as well as to serve as the basis for measuring the impacts of future program.

The multi-family sector differs from other building sectors in that no previous 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 diverge, particularly along the lines of heating system selection. Throughout 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 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 were sampled to represent the vast majority of all multi-family construction in the region.

Multi-family dwellings (using the broadest definition) have become increasingly popular, represents 30% of all new housing starts in the region as a whole and considerably more in the more populous counties. The majority of this activity is in Oregon and Washington, which account 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, it represents almost 94% of all multi-family construction. Therefore, we confined our review to these two states. Table 1.1 illustrates the distribution of multi-family construction activity by state.

Table 1.1: Residential and Multifamily Activity (1998)

	Idaho		Montana		Oregon		Washington		Total
	N	%	N	%	N	%	N	%	%
Single-Family	8,460	88.44	3,865	79.54	16,920	66.20	27,849	63.25	67.89
Multi-Family Units	1,106	11.56	994	20.46	8,640	33.80	16,180	36.75	32.11
Total Units	9,566	100	4,859	100	25,560	100	44,029		100

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 building characteristics in these buildings, distinguishing between states.
- Establish heating fuel selection practices and HVAC system information in these building to contrast the performance and building characteristics with findings in the single-family sector.

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. 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.

The net result of this review, then, is a relatively small random sample of multi-family projects in Washington and Oregon drawn without regard for individual buildings but stratified by overall project budget from F.W. Dodge®. This enabled a relatively large project to be included in the sample and allowed a much larger coverage of the units constructed in the individual states.

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 those components which have a significant impact on energy use and can 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. Sampling and Recruiting

The sample designed to provide a 90% confidence interval would have required 34 cases in each state; however, budget considerations limited our review to 25 sites. Due to concerns about non-response rates, every building in the sample frame was recruited though only 25 were analyzed for this study.

2.1. Sample Frame

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 (Table 2.1).

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

While this assessment 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 between 75-90% 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 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 (accounting for about 92% of all regional multi-family activity).

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 four-plexes and five-plexes rather than an a single large multi-family development. This type of variability was common. Efforts were taken to carefully conduct the sample in a way that did not introduce any additional bias from these types of entries.

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 seemed to have 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 of relatively small size.

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 far less effective, with only about 10% of all units constructed appearing 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. Table 2.3 and 2.4 summarize the results of the sampling and recruiting from the F.W. Dodge® database.

Table 2.3: Sample Development (Oregon)

Stratum	Number of Projects	Number of Units	Number 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	Number of Projects	Number of Units	Number 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,

owing to 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
Clackmas	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

2.2. 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.

Table 2.7: Case Weights Sample

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

These case weights were used in weighting various statistical summaries of both characteristics and unit populations in the summary of characteristic results.

3. Characteristics

Table 3.1 summarizes the results of this sample when applied to overall building and project characteristics.

Table 3.1: Multifamily 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 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-Washington sample and stratification design there is remarkable homogeneity in average unit size (about 1,000 ft^2/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 (in 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 by weighting the summary in accordance with the case weights developed for the sample design and in accordance with the number of units-per-project sampled. 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 building size around 900 ft^2/unit for the region.

The principle 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 biased is corrected for, average project size remains above 50 units. With the exception of Portland, there seem to be no clear-cut distinctions among jurisdictions and counties. 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.

3.1. Heating System and Heating Fuel Selection

The principle 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 increasingly larger 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.

3.1.1. Heating Fuel

Traditionally, the multi-family sector has been dominated by electric heating systems, usually zoned electric wall heaters or base boards. This trend cuts across virtually all types of apartment units in virtually all markets. 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 multi-family sector. Table 3.3 summarizes heating fuel selection by unit size.

Table 3.3: Heating Fuel Selection

Area (in 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 feet are invariably gas heated. In the Oregon market, virtually no other units are heated with gas; in Washington, only small units (<800ft^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 into the Washington market falls to about 36%, while it rises to 14% in the Oregon market. Nevertheless, it remains clear that the Oregon market remains, on the whole, electric heat. Gas heat has penetrated only the higher end of the multi-family market, either in owner-occupied condominiums or larger rental units.

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 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 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 zonal heating. 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, the EPAC requirement for efficiency is significantly lower than with conventional forced-air furnaces (AFUE = 0.62). This system has, to date, penetrated only slightly into the Washington market, although the sort of development that uses 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 gas-heat smaller units.

In Oregon, the use of gas heat is confined to forced-air furnaces installed in 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.

The use of packaged terminal heat pumps (PTHP) in the Oregon market provides an interesting counterpoint. One trend in the Oregon market that seems not to be common 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 or packaged terminal air conditioners. In the latter case, heating is provided by electric-resistance zone heat; through-the-wall coolers are also 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. Buildings using gas heating in the Oregon market are about three times more likely to use cooling than electrically-heated projects. This generally takes the form of additional 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 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.

3.1.2. Supplemental Sample

In the Washington market, there is a distinct possibility that the tendency of this sample 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 polling 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)	%
Gas	21	47.72
Electric	22	50.00
Heat Pump	1	2.28
Total	44	100

It should be noted that the gas buildings in this sample are somewhat smaller and, consequently, even this summary many overstate the saturation of gas in these markets.

Although this sample is hardly as geographically comprehensively as the field survey, it confirms the trend indicated by the fields sample 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 could also be expected.

3.2. 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 (particularly with respect to fuel choice), leading to differences in thermal integrity and construction techniques between the two states. This difference is actually larger than the difference observed in single-family homes over the same period.

3.2.1. 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 13% higher on average across the entire sector between Washington and 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. 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 the wall heat loss rates are quite substantial, with an increase of almost 10% in average wall U-values between the two states.

3.2.2. 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 and five under the 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%. 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 and 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. Similarly with window area (although this may be partly due to biases in the Oregon sample) actual window selection in Washington and Oregon are greatly dominated by the window codes themselves. Table 3.8 summarizes the windows by class. ("Window class" essentially refers to a two-digit integer that reflects the window U-value.)

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

Window Class	Oregon			Washington		
	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-ε coating). These windows usually comply with the Energy Star® rating, although few labels testifying to this were observed. Strikingly enough, 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 Class 40 window or better, or a window U-value of 0.40 or less. Unsurprisingly, the Oregon multi-family market is dominated by Class 40 windows. This is the code requirement, and most Oregon buildings adhere to it. 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, but had only modest impacts on actual building components.

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 dominated by 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 0.40 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 alternative structural systems and sometimes select commercial-grade aluminum windows. Only these windows come anywhere close to a 0.65 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, with a small number of windows exceeding this level.

3.2.3. 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 uses cut-roof structures of any sort. Table 3.9 summarizes the 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

3.2.4. Floor Systems

By and large, the floor systems in both states are characterized by one of three conditions - concrete slab 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. This serves as both a thermal and a fire separation, and is usually associated with developments in more heavily populated areas, chiefly in 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, although 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 caused 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 we 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 plastic coating 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).

3.2.5. Domestic Hot Water

Domestic hot water in the multi-family sector is handled in different ways between the two states. In fact, the differences 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 a central water tank and circulating water loop 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 space heating fuel. All of the central water heaters in both 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 that appear in the overall sample, so that the four cells in each state total 100%.

Table 3.12: Fuel Selection—Domestic Hot Water and Heating (By Unit)

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 changes in performance in terms of heating requirements between the two states. These can be partially explained by the colder climate of Washington, but its principal causes are the differences in building UA caused by various sections of the energy code.

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	0.101	0.133	0.104	0.109	0.128	0.120
Code UA/ft^2	0.110	0.147	0.114	0.121	0.161	0.146
% 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 multifamily 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 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 row-rise buildings appeared to be designed under those 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 was nearly 100%.

The primary code deficiency among 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 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 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 15% greater heat loss than Oregon buildings. This is presumably off-set 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 developed using the *Sunday*® energy 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 ACH, a thermostat set point 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 (cf. 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 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 those 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	4	4,868
Total	24	4,553
Washington		
- Bellingham (TMY1)*	2	5,769
- Seattle	20	4,867
- Spokane	1	6,888
- Yakima	2	6,059
Total	25	5,035

*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 were used except in Bellingham, Washington, where no data were available and TMY1 was used. With one notable exception, these study results are consistent with other study results throughout the region. The Seattle weather site is significantly altered by the use of the TMY2 summary. When compared with TMY1, which was used for virtually all the Seattle-based *Sunday*® runs during the development of the Bonneville Power Administration (BPA) conservation supply curves, TMY2 are almost 10% warmer. This substantial shift reflects inconsistencies in the long-term Seattle weather record during the TMY1 period, which were corrected when TMY2 information was assembled. Only minor changes were observed at other sites.

4.2.1. Whole Building Analysis

The *Sunday*® runs were conducted on building characteristics and heat loss rates for both 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 in this summary.

Table 4.3: Heat Required per Unit (Building Only)

	Oregon			Washington		
	Electric	**Gas**	**Total**	**Electric**	**Gas**	**Total**
Building						
KBTU/Unit	5,093	15,495	5,752	6,943	13,783	10,670
KBTU/ft^2	5.4	9.8	5.8	7.8	10.0	9.2
Code						
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

As evident, the overall impact of the climate and building shell performance between the two states is almost 50% in space heating requirements. The difference between the code requirement is almost twice as large. Approximately 20% of this difference is due to the colder climates in Washington; the remaining distinction reflects the difference between the two codes and subsequent building practices.

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. This distinction does not really occur in Washington, since the state's gas heated buildings are more evenly distributed among all building 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. Furnace efficiency or zone-heated efficiency were 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 efficiencies of 1.8 were 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	189	0.12	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 difference in consumption between Oregon and Washington buildings is about 50%. The Washington buildings do not include heat pumps, and thus the equipment efficiency of the few heat pumps in Oregon tend to increase this apparent difference.

When these fuel use values are taken into account, the distinction between gas and electric heating requirements on a strictly BTU basis suggests a 20-30% increase in heating requirement and an almost 40% increase in heating requirements when the efficiency of heating systems are taken into account. However, when the cost of the fuel to consumers is added, the cost of heating gas apartments in Washington is reduced by about 25%. It is this component of the gas heating system that has served as a marketing advantage to median- and upper-end apartments, especially in the Seattle market.

In Oregon, this pattern does not exist, though the costs of gas and electricity are close to those in Washington. Other features of the building (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 does not occur in this sample of Oregon buildings. Given the performance advantage of the Oregon building practice and code, there is less impact on the ultimate consumers of the fuel selection. Whether this offsets or explains the relatively low saturation of gas heat in Oregon is a matter for further study.

4.2.3. Comparison with Single-Family Buildings

It should also be pointed out that when heating loads are compared between the single-family buildings in the individual states and multi-family buildings, a large difference appears in space heating requirements. Table

4.5 compares the field evaluation results with the single-family construction reviewed in both states.

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	0.12	2.7	1.6
Washington	0.23	0.13	2.9	2.3

In Oregon electric buildings and in 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.

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.

As detailed below, though the architects vary somewhat in the development of energy efficiency and the selection of heating/cooling equipment, etc. in the multi-family sector, quite often the role of general contractor and developer is 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-built format which requires that a subcontractor ultimately bids both for the design of the heating/cooling systems and the cost of installation. 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

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	1	1	2
Lighting			
Architect	6	11	16
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, fewer than one-third of HVAC and lighting design decisions are made by architects. In half the sample, 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 in 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.

5.1. 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 which received direct feedback on energy code issues during the permitting process.

Table 5.3: Code Feedback from Building Officials (Percent of Respondents)

Feedback	Oregon				Washington			
	Yes		No		Yes		No	
	N	%	N	%	N	%	N	%
Permit	11	73.33	6	30.00	12	52.17	13	54.17
Inspections	4	26.67	14	70.00	11	47.83	11	45.83
Total	15	100.00	20	100.00	23	100.00	24	100.00

Oregon and Washington are fairly similar in this regard, in that about two-thirds of all buildings received direct code feedback either during the permit or inspection process. The distinction between the two states lies largely in the difference between the feedback at the building stage versus the feedback at the permit/inspection phase. In Oregon, this feedback took the form of clarifications during documentation review about 40% of the time, and resulted in few or no changes.

The other principle discussion during the permitting process was the detailing around slab edge insulation, a recurring theme in the Oregon interviews. In Washington, slab insulations 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. As with Oregon slab insulation, this resulted in some discussion during the permit process but, unlike in Oregon, unit ventilation (under the Washington ventilation code) was a factor in such discussion. Washington maintains a ventilation code for the residential sector; Oregon does not.

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

Table 5.4: Energy Code Difficulties (By Percent)

Comment	Oregon	Washington
None	50.0	46.2
Ventilation Requirements	9.1	19.2
Slab Insulation	27.3	3.8
Too Confusing/Inconsistent	4.6	19.2
Glazing Requirements	0.0	3.8
Other Requirements	9.1	8.6

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 those requirements.

5.2. Energy Efficiency Information

Interviewees were asked several questions concerning their source of information for use in building design and building specification. These queries produced little consistency among the interviewees. About 10% 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 a third of the respondents mentioned the energy code, energy code manuals, energy code training, etc. as the primary source for energy efficiency information.

Another source (mentioned by about 20% of the respondents) was periodicals, especially professional magazines and journals, which seem to provide a great deal of basic information. Finally, product literature and product representatives comprised an important resource for information regarding specific products.

5.3. 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 nature 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.

5.4. Marketing

Virtually all respondents suggested that the best and most straightforward opportunity for delivering energy efficiency into the multi-family sector lay 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 design process would have a substantial impact.

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. These were not dominant in either the Portland or Seattle market but, in response to most of these questions, most architects argued for the need for additional information delivered in seminars, literature targeted at designers, or some other form. These two utility programs offer seminars and literature.

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 both different from those made for the single-family sector and seem to require completely different mechanisms for addressing and changing standard building practices.

The most striking feature of this sample is the large amount of gas heating in the Washington sample as compared to the Oregon sample. More importantly, when compared to single-family residential construction, both states have rather small gas heat saturations relative to the 80-90% levels seen in other 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 nor 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 this implementation highly 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.

Another striking feature of the 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.

The sample reviewed here is relatively small and is designed around the FW 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.

Overall, the multi-family sector does not have the same characteristics, either in building type or code compliance, as the single-family 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. Neither of these problems are apparent in the single-family residences, where slab floors are almost unheard of, especially in Washington and Oregon.

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.

Finally, the overall performance of multi-family buildings, in spite of thermal issues, is about 50% 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 fills in installed windows, especially in Washington.

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.

7. References

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 Multifamily 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.

Appendix A

Multi-Family File/Field Review Protocol
Cover Review 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:

		Plans	Field		
Fixture Type ID	**Notes**	**# of fixtures**	**# 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
[ ] wood vertical siding
[ ] stucco
[ ] synthetic stucco
[ ] T-111 siding
[ ] cementious lap siding
[ ] aluminum siding
[ ] vinyl siding
[ ] composite/manufactured ‘wood’ siding
[ ] other: ____________

Roof

[ ] wood shingles
[ ] cementious shingles

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

Miscellaneous Materials

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

- 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)*

LOAD TYPES

- S SPACE HEAT ONLY
- SW SPACE HEAT AND WATER HEAT
- W WATER HEAT ONLY
- P PROCESS HOT WATER HEATING
- OTHER (*SPECIFY*)

BOILER TYPES

- HW HOT WATER
- S STEAM

BURNER TYPE

- NAT = NATURAL DRAFT
- PWR = POWER DRAFT

CAPACITY UNITS

- KBTU
- MMBTU
- HP(*horsepower)*
- KW
- OTHER *(SPECIFY)*________________________

CONTROL TYPE CODES

- B1 CYCLING
- B2 TEMPERATURE RESET
- B3 TRIM CONTROL
- B4 MODULATING
- B5 STAGED

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

COMPRESSOR TYPE	CAPACITY UNIT CODES
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)*	KBTU MMBTU HP(*horsepower)* TON OTHER *(SPECIFY)*______________________ **CONTROL TYPE CODES** C1 TEMPERATURE RESET C2 MODULATING C3 MODULATING –VFD C4 STAGED

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:** ____

<u>Target Building</u>

Configuration:

[ ] ***Town House / Condos***
[ ] ***Multi-Story Apartments***
[ ] ***Multi-Building***

Construction:

[ ] ***Wood Frame***
[ ] ***Struct. Slabs / Concrete***
[ ] ***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 ID # ______________

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 ID # ______________

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: Mechanical System	Oregon		Washington		Total	
	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: Lighting System	Oregon		Washington		Total	
	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 at Inspection	Oregon		Washington		Total	
	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 Efficiency Consultant	Oregon		Washington		Total	
	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 Consultant	Oregon		Washington		Total	
	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	%
	3	14.29	4	23.53	1	10.00
	5	23.81	5	29.41	3	30.00
	1	4.76	1	5.88	0	0.00
	3	14.29	0	0.00	2	20.00
	6	28.57	4	23.53	0	0.00
	3	14.29	3	17.65	4	40.00
	0	0.00	0	0.00	0	0.00
Total	21	100.00	17	100.00	10	100.00

Washington Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
	7	31.82	6	37.50	1	16.67
	2	9.09	2	12.50	2	33.33
	0	0.00	1	6.25	0	0.00
	3	13.64	0	0.00	0	0.00
	6	27.27	6	37.50	2	33.33
	3	13.64	1	6.25	1	16.67
	1	4.55	0	0.00	0	0.00
Total	22	100.00	16	100.00	6	100.00

Total

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
	10	23.26	10	30.30	2	12.50
	7	16.28	7	21.21	5	31.25
	1	2.33	2	6.06	0	0.00
	6	13.95	0	0.00	2	12.50
	12	27.91	10	30.30	2	12.50
	6	13.95	4	12.12	5	31.25
	1	2.33	0	0.00	0	0.00
Total	43	100.00	33	100.00	16	100.00

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