Market Research Report

Baseline Characteristics of the Residential Sector

Idaho, Montana, Oregon and Washington

prepared by

Ecotope

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BASELINE CHARACTERISTICS OF THE RESIDENTIAL SECTOR: IDAHO, MONTANA, OREGON AND WASHINGTON

For the

Northwest Energy Efficiency Alliance

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Executive Summary to Residential Baseline Study

This report is supported by the Northwest Energy Efficiency Alliance for the purpose of developing a baseline description of residential construction practices with respect to energy use and efficiency in the Pacific Northwest region. The study focused on a direct field review of buildings under construction in all four Pacific Northwest states: Washington, Oregon, Idaho, and Montana.

The goals of the study were:

1. To develop and provide a statistically representative sample that could be used to characterize building practices in each state and combined to develop a picture of the overall range of building practices in the region.
2. To assess the degree to which local energy codes and standards are being followed in the building industry and enforced by relevant code jurisdictions.
3. To provide a basis for comparing building practices across states.
4. To identify attitudes toward energy efficiency and energy codes and building standards through interviews with builders and others.

Sample Development and Methodology

The sample for each state was drawn from individual building department permit records. Table 1 shows the distribution of single-family residences in the four states using the 1998 building year and the actual field sample used in this survey. The samples drawn from each jurisdiction were taken at random and the distribution of each sample was proportional to the housing starts in that jurisdiction. This resulted in a representative random sample that could characterize regional residential construction.

Table 1: Residential Single Family Housing Starts (1998)

State	Houses		Sample	
	Units	Percent	Units	Percent
Idaho	8,460	14.9	104	1.22
Montana	3,865	6.8	61	1.58
Oregon	16,743	29.4	44*	0.26
Washington	27,849	48.9	157	0.56
Total	56,917	100.0	366	0.64

*Oregon results supplemented with 283 homes studied in 1994

Single urban areas dominate Idaho, Oregon, and Washington. In Idaho, the counties immediately around Boise account for 69% of residential construction. In Oregon, the Portland area accounts for 53%; in Washington, the Seattle area accounts for 63 percent. Only Montana lacks a single urban area accounting for more than 20% of residential construction.

In this study, a combination of plan reviews, on-site inspections and computer simulations were used to identify the pertinent characteristics of the homes under construction. The energy use associated with the characteristics was simulated using *Sunday*® and local climate data.

Throughout the report, construction characteristics are compared to "code." In Idaho, this refers to the 1996 Idaho Residential Energy Standard (IRES), which is required by local ordinance in many Idaho jurisdictions. In Montana, the standard of comparison is the 1997 federal Model Energy Code (MEC) and a Montana prescriptive option used by many builders. In most of Montana, particularly outside municipal jurisdictions, no energy code or building code is enforced. About 60% of the state's residential construction is built outside any code jurisdiction. The Oregon Residential Energy Code (OREC) that was adopted in 1993 is mandated for all jurisdictions, and is essentially a prescriptive standard for all building components. In Washington, the 1997 Washington State Energy Code (WSEC) is used as the basis of comparison.

Characteristics

Size

Table 2 summarizes home sizes in each state. Included is a summary of the much larger 1994 Oregon sample, which was used as the surrogate for Oregon characteristics, given the relatively small sample in this state studied in 1999. This sample suggests substantial increases in the size of Oregon housing (15% in the five years between 1994 and 1999) and the regional house size (22% floor area increase when compared to previous regional studies, most notably the 1986 sample done for the NORIS study reflecting homes built between 1980 and 1986).

Table 2: House Size by State (square feet)

State	N	Floor Area		Basement Fraction
		Mean	Median	
Idaho	104	1,941	1,678	0.173
Montana	61	2,504	2,420	0.623
Oregon (1999)	80	2,370	2,242	0.068
Oregon (1994)	283	2,056	1,877	0.067
Washington	157	2,259	2,111	0.146
Total	366	2,223	2,003	0.244

Walls

The most common type of wall construction is 2x6 framing with R-21 insulation. The two primary exceptions are the Boise and Seattle areas, which commonly use 2x4 framing with R-13 insulation. The IRES calls for 15% greater insulation than is installed in these cases, while the WSEC makes allowances for this 2x4 construction if other building components (typically windows) exceed the standard.

Floors

The most dominant type of floor construction is framing over a crawlspace. Basements are prevalent in the coldest areas, but crawlspaces are the typical practice in western Washington, western Oregon, and the Boise region. R-19 floor insulation is the most common, with the exception of Oregon (which requires R-25). A striking lack of under-floor, perimeter, and basement wall insulation is found in Idaho and Montana.

Windows

Table 3 reveals that windows in the sample vary substantially from state to state, and code requirements differ as well. Windows that meet or exceed the Class 40 standard (U=0.40) represent more than 90% of the windows installed in Oregon and about 80% of the windows installed in Montana. In Washington and Idaho, where window standards are much lower, these windows represent something less than 30% of the construction practice. In Washington, the code requirement for most of these homes is for Class 65 windows, but common practice far exceeds this. The difference is generally used to offset reduced insulation values in wall framing or ceiling and floor insulation.

In the Washington sample, windows average almost 40% better than code requirements, largely because code requirements are based on a 1986 code provision assuming the use of thermally-improved aluminum windows, which have almost totally been replaced by vinyl windows.

Table 3: Window U-value Distribution by State (Percent of Window Area)

Window class	Idaho	Montana	Oregon	Washington
< Class 38	21.0	54.2	43.3	25.3
Class 38-40	2.2	25.4	50.7	6.6
Class 41-46	4.9	5.6	3.8	4.8
Class 47-50	47.8	13.5	1.4	47.1
Class 51-60	24.2	0.0	0.8	16.1
>Class 60	0.0	1.3	0.0	0.1
Total	100.0	100.0	100.0	100.0

Heating and Cooling

Across the region, gas heating using forced-air furnaces has become a standard in virtually all markets. Table 4 shows the distribution of gas versus electric heating. Generally speaking, homes use the same fuel for domestic hot water that they do for heating.

Table 4: Heating Fuel Selection (Percent by State)

State	Fuel Type (Percent of Floor Area)				
	Gas	Electric		Other	Cooling
		Resistance	Heat Pump		
Idaho	93.5	5.7	0.9	0.0	72.1
Montana	91.3	6.5	1.8	0.4	18.0
Oregon (1999)	90.3	0.8	4.7	4.2	18.2
Oregon (1994)	72.0	23.6	3.0	1.4	23.9
Washington	77.7	6.5	14.6	1.3	21.0

The primary exception is the use of heat pumps in parts of the Spokane and Tri-Cities markets, where cooling loads have always been significant, and the outlying communities in the Seattle area with relatively larger high-end homes, where air conditioning is becoming more common.

Generally speaking, cooling appears in about 20% of new single-family construction in virtually every state except Idaho. Cooling equipment is pervasive (95% saturation) in the Boise market; this results in a total cooling saturation of over 70% in Idaho. In the other states, the cooling equipment is concentrated in hotter, more extreme climates such as in eastern Oregon and Washington. On the eastside, approximately 50% of homes have cooling, while in the Seattle and Portland markets only about 10% of homes are built with central cooling.

Performance

Heat Loss Rates

Washington, Montana, and the parts of Idaho that are not in the Boise market have approximately the same overall heat loss rate. The only significant deviations from these averages are in the Oregon market, which typically has about a 10% lower overall heat loss rate, and the Boise market, where heat loss is about 20% higher. Table 5 summarizes the overall heat loss rate per square foot, and compares these values to the standards defined for each state.

Table 5: Overall Heat Loss Rates (by State)

State	UA/FT^2		Percent Compliance
	Buildings	Code	
Idaho	0.267	0.261	51.9
Boise	0.285	0.270	31.7
Other	0.240	0.247	82.9
Montana	0.245	0.251	86.8
Oregon	0.220	0.230	100.0
Washington	0.242	0.264	93.6

Most Northwest markets have construction which meets the associated standard for the area, even in areas where enforcement is marginal. In Montana, for example, more than two-thirds of the homes surveyed did not require a building permit and had no building inspection or code review whatsoever. Even so, energy code compliance throughout the state was about 86 percent.

Heating Energy

The heating energy impacts of these building characteristics are summarized in Table 6.

Table 6: Overall Heating Fuel Use

State	Gas			Electric			Heat Pump		
	N	Th	Th/ft^2	N	KWH	KWH/ft^2	N	KWH	KWH/ft^2
Idaho	99	683	0.37	4	15,675	6.9	1	9271	5.1
Montana	52	931	0.38	5*	15,885	9.1	1	6337	2.3
Oregon	39	462	0.19	1	8,436	5.5	3	4670	2.2
Washington	119	524	0.23	12	6,006	3.5	22	6446	2.6

*single large outlier removed

Table 5 shows that the overall heat loss rate is fairly similar across the region. However, Table 6 shows that Idaho and Montana homes use significantly more energy. This is due to the more severe climate, and suggests that Idaho and Montana would find additional insulation measures to be cost-effective.

Interviews

Interviews were conducted with builders identified during the sampling process. Because a very small percentage of the builders contacted in Idaho consented to an interview, Idaho is not represented in the survey results. A total of 226 interviews were conducted in the remaining states; 87% of those interviews were with builders.

Approximately three-fourths of the builders interviewed in each state said that they often exceed energy codes. While this may be true is some sense, the data from the characteristics survey suggests that very few components exceed the code, and most components were selected to meet the minimum code requirements. Even when more efficient components are selected, they are traded against less efficient components elsewhere in the home. This is particularly true in the Washington and Montana samples.

About three quarters of the builders interviewed said they accepted the local energy code as part of their building practice. For the remaining one quarter, problems with ventilation and moisture control were the most significant. This was true even in areas where no energy code was directly enforced (e.g. Montana).

Somewhat less than half the builders suggested that there was any interest in energy efficiency among residential homebuyers. Accordingly, fewer than a third of the builders interviewed said that they used the energy efficiency as part of marketing their homes.

Conclusions

The dominant conclusion of this report is that energy codes, even when they are only marginally enforced, are generally the basis for building standards used by single-family residential builders. Only in the Boise area of Idaho are homes built to a consistently lower standard than contained in the local energy codes.

Of all the markets reviewed, the Oregon market seems to be the most homogenous across virtually every county throughout the state. The Oregon code is based on a single prescriptive standard that is followed by virtually all builders. Interestingly enough, these builders also maintain that they often exceed the code. In the case of Oregon and all other states, there is very little evidence of any practices exceeding code.

Although climate plays a large role in the overall energy use of buildings, particularly in Idaho and Montana, this is not reflected in the selection of building materials, insulation levels, or even window performance. Montana building practice appears quite similar to that of Washington and Oregon, though the amount of heating required in Montana is more than double that of western Oregon and Washington.

The results of this study have been compared to several prior regional residential studies to identify the following trends:

- Electric resistance heat in new single-family site-built construction has almost been eliminated, with less than 10% of the homes in any state being heated with electric resistance (and most of these being supplement by wood heat). Fifteen years ago, electric heat (including electric heat pumps) was used in 60% of new homes. By contrast, multifamily units in Oregon use primarily electric heat and hot water, while in Washington they primarily use gas.
- The incidence of cooling equipment in the region has risen to about 30%, including a saturation in cooling equipment of about 20% in the Washington and Oregon markets. About 95% of the homes constructed in the Boise market had central cooling installed.
- Homes have been increasing in size over the last 15 years. Most strikingly, the regional average between the 1980s and 1999 increased by about 22 percent.
- The performance of windows has been steadily increasing, especially between 1990 and 1995, with the acceptance of vinyl window frames and low-e coatings in residential construction. This trend corresponded with the increasing window standards in the Oregon and Washington codes.
- The Washington code is more lenient than the Oregon code for homes heated with fuels other than electric resistance heat. This results in an overall increase of about 10% in the heat loss rates in Washington homes in spite of comparable compliance rates.
- The combination of steadily decreasing the heat loss rate and increasing house size over the last two decades has the net effect that today's larger homes use about 12% less energy than homes built in 1980 but are 35% more efficient with insulation and

window performance. If house size had remained steady, the energy use of homes would have dropped almost 50 percent.
- Site built construction is clearly the dominant type of residential new construction that occurs in this region. About 57,000 site built homes were built in the base year for this sample (1998); there were approximately 27,000 multifamily units built (concentrated in the Seattle and Portland areas), and 6,000 manufactured homes in the region (concentrated in more rural areas). Thus single-family construction represented 63% of new homes sited in this region.

The most prominent opportunities identified through this characteristics study include:

- Help builders and homeowners understand the techniques that would deliver energy efficient homes.
- Energy codes provide a consistent standard used by builders. These standards should be supported and set to an acceptable base level throughout the region.
- In Idaho, improve the crawl space insulation and the windows; in Montana, increase the crawl space and basement insulation; in Washington, update the window standard in the state energy code to reflect current practice.

1. Introduction

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

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

From the perspective of developing market-based approaches, it is important first to understand what characteristics and components were actually used in residential construction, and second to know the attitudes and marketing efforts currently employed in new residential construction. This study establishes a baseline against which any future effort or program can be judged or evaluated.

The purpose of this study is to review residential building practices in each of the four states as a basis for comparing overall residential construction. While this baseline survey of the region is not intended as an assessment of compliance with the existing codes and standards, standards have been found to be a major factor in the design and building practices in the residential sector. In some jurisdictions (notably Washington and Oregon) these standards have been enforced or debated among building professionals and utilities throughout the past 20 years. This process has had a substantial impact on the construction techniques and overall performance of new residential construction.

1.1. Previous Studies

The region has embarked on several surveys and characterizations that have addressed the nature and practice of residential practice in the Pacific Northwest. The period from 1985 to 1990 was characterized by utility incentive programs that targeted specific geographic areas and/or utility service territories. These studies provided some characteristic data, but largely avoided a systematic sample of new construction practice. The Northwest Residential Infiltration Survey (NORIS) was a regional sample of new construction, but it focused on air infiltration and ventilation issues and did not explore other aspects of construction practice (Palmiter, et al, 1989). This study did result in certain characterizations, such as home size and heating fuel selection, which are discussed in this study where applicable. Several other studies were conducted that addressed specific practices such as glazing and insulation specification and code compliance. These were not generally regional samples, but rather evaluations of particular utility programs that were applied to some specific jurisdictions (e.g. Brown, et al, 1991; Palmiter, et al, 1990).

By 1990, only Washington and Oregon consistently supported a residential energy code that was enforced in most jurisdictions. In 1993 and 1994, two separate compliance reviews were conducted to assess the impact of, and compliance with, codes and standards in Washington and Oregon. The 1993 Washington review assessed the degree to which individual components were built to meet the prescriptive standard (Warwick, et al, 1993). This analysis suggested that 95% of the components met the standard, although the overall number of houses that actually complied with the code was not directly assessed. The 1994 Oregon review (Frankel & Baylon, 1994) identified about 95% code compliance on a building basis.

Both of these bodies of work have been referred to here. The 1994 Oregon review has been quoted extensively as a supplement to the Oregon sample drawn for this study.

1.2. Project Goals

The baseline review for the residential sector is designed to provide a regional overview of the principal building characteristics used to establish new residential energy efficiency in the four states. The specific goals of this review are to:

1. Develop and provide a statistically representative sample that can be used to characterize building practices in each state and combined to develop a picture of the overall range of building practices in the region.
2. Assess the degree to which local energy codes and standards are being followed in the building industry and enforced by relevant code jurisdictions.
3. Provide a basis for comparing building practices across states.
4. Identify attitudes toward energy efficiency, energy codes, and building standards through interviews with builders and others.

1.3. Objectives and Methodologies

1.3.1. Field Review

The data collection for this project was conducted from the early spring through December of 1999. The methodology was based on the use of a field review for a representative random sample of homes in each state. The field review was designed as an extensive review of homes in the latter stages of construction. At the outset, it was assumed that plans available at building departments would provide some guidance to the code compliance components of the individual homes. This was not the case in any of the states. On-site efforts were made to resolve these issues; however, components could not be assessed in some sites in relatively early stages of construction. This was particularly problematic in Montana, where the sampling methodology did not allow homes to be screened based on their current state of construction. Field auditors were instructed to collect as much area and component information from plans at the site or building department as possible and to verify component characteristics and areas during the field visit. Appendix A includes the protocol for both plan and field reviews.

The sample was intended to be collected at the building departments, selecting a target number of buildings at random from current permit records and visiting these sites. To facilitate this, a larger sample of buildings than needed was drawn and a random sample of this group taken. In this larger group, a cover review was conducted where practical. The cover review collected information on building area, fuel type, and compliance path together with general information on builder and home location. In some jurisdictions, particularly Washington, the cover review included overall window area and information that would help characterize the residential population.

It was difficult to apply this methodology in Idaho and Montana. In Idaho, homes available for review were identified and reviewed, and any sampling was based on the random nature of the visit. In Montana, building departments were not used at all because the great bulk of Montana residential construction was conducted without a building permit. In the case of Montana, a secondary private database from Western Construction Monitor® was used to generate a sample for the overall assessment of building practices.

1.3.2. Energy Analysis

The analysis of the data collected focused on three factors:

- An assessment of the characteristics and distribution of characteristics among buildings in each state.
- A comparison between these values and the values contained in the energy standards for each state.
- Overall space-heating energy performance in new homes in the four states.

In all cases, these standards were compared on a building-by-building basis so the overall impact of the standards, or failure to meet these standards, was assessed. Both the characteristics and impacts of the standards are summarized for each state across all homes.

A performance simulation was conducted using the *Sunday*® program. This performance run was conducted on each home based on the observed heat loss characteristics and window characteristics. A second *Sunday*® run was performed based on the standards in each region. This allowed a comparison between the performance goals of the individual energy standards and between actual construction types based on climate differences. This comparison allowed the construction characteristics practiced in the relatively harsh climates of Idaho and Montana to be compared to the much milder climates in western Oregon and Washington.

A review of heating equipment specifications and system performance was also attempted. In the original protocol, a Duct Blaster® and blower door test was to be conducted in each home. This approach was abandoned early on in the field work, when it became clear that a significant fraction of homes were not adequately completed and difficulties of builder cooperation were to be expected. Consequently, ventilation, air infiltration, and duct efficiency were fixed by assumptions based on previous studies and not compared among the various states.

Duct efficiency assumptions were generated using characterization data gathered during the plan review. Location, insulation and furnace type were all used to assess overall efficiency. These allowed comparisons of overall home performance based on the use of particular types of heating systems in the various localities.

1.3.3. Interviews

In order to assess the attitudes toward energy conservation in the residential building sector, the builders were asked to participate in a brief interview. The interview protocol is contained in Appendix B along with a summary of the responses. In this industry the decisions on most components of the building are made by builders in the context of market perceptions in their locality. The interviews were designed to acquire some information on these perceptions. The response to the interviews was reasonably good in Washington, Oregon and Montana, with about half of the builders consenting to an interview. In Idaho, only about one in ten builders actually participated in a structured interview. As a result, the Idaho interviews were largely ignored in the summaries of the interview results. Overall, 231 interviews were conducted in the region, focusing on attitudes toward energy efficiency in the home building industry.

1.4. State Energy Codes

While energy codes have been used in every state in the region, there remains a large difference between the energy codes both in specific provisions and enforcement. Over the last ten years, there has been considerable divergence as different states have implemented various codes while reducing funding and emphasis on enforcement. In the residential sector, there are different energy codes in each state and numerous different enforcements and interpretations of the provisions in the various jurisdictions in each state. For this effort, the individual states were taken into account, but the practices and interpretations of the individual jurisdiction were largely ignored.

1.4.1. Idaho

The state of Idaho does not have a state building code of any sort (energy, plumbing, mechanical, etc.). Individual jurisdictions have the ability to assemble building departments, issue building permits, and charge fees. The state legislature issues guidelines, but local jurisdictions have the option to enforce or not enforce any or all of these guidelines. Nevertheless, virtually all the residential stock in Idaho is subject to building permit and inspection requirements from one jurisdiction or another.

In 1996, Idaho adopted the Idaho Residential Energy Standards (IRES), a set of guidelines that were enforced at the option of local building jurisdictions. The IRES was designed to be mandated and enforced by adoption in local jurisdictions. Each jurisdiction, in turn, has the option to adopt the IRES, more stringent codes, or to enforce no energy code at all. Finally, the jurisdictions can and do interpret this code based on the needs and conditions of the local housing market. An overall assessment of compliance patterns or building characteristics for Idaho's residential sector has never been conducted.

The Idaho legislature has also adopted the 1993 Model Energy Code (MEC) by reference. This code has been deemed equivalent to IRES, although there are several significant differences. Our observations in Idaho suggest that only limited portions of the MEC or IRES are actually enforced. For purposes of assessing energy code compliance in this study, the IRES standard was used.

1.4.2. Montana

The Montana situation is less easily articulated. As in Idaho, the MEC forms the state-recommended standards (endorsed by the legislature), which are advisory to the local jurisdictions. However, in Montana only a few of the larger cities and towns have building departments, and they regulate nonresidential construction only within a 4.5 mile radius of city limits. The remainder of the state (about 60% of the new housing starts) is divided into six jurisdictions, which are regulated by the Building Codes Division of the State Department of Commerce. Outside the main urban jurisdiction, there is a blanket exemption for single-family homes. Only compliance with the electrical code is required, and the permits and inspections are handled by the state jurisdictions.

In 1997, Montana adopted the federal Model Energy Code (MEC) by reference. This became part of the Montana building code. At the same time, a prescriptive path was established that developed a "deemed to comply" set of standards for each residential building component. Builders and jurisdictions were given the option of enforcing the full MEC or a prescriptive component compliance table that had the effect of setting the expected U-value performance of the Montana residential buildings. For the most part, this standard would result in homes with about 20-30% greater heat loss (and thus more heat load) than the MEC for the Montana climates. For purposes of this study, the Montana prescriptive standard was used to assess compliance rather than the MEC.

1.4.3. Oregon

In Oregon, a state energy code is mandated for all jurisdictions. In addition, the state mandates fee structures, permit procedures and provides technical assistance to building departments throughout the state. The state also qualifies building inspectors and prescribes the limits of their inspections and authority.

The Oregon code was adopted in its current form in 1993. As a residential code it is somewhat unique. The basic design is to provide a simple prescriptive set of requirements that mandate the performance of all the components regardless of heating fuel or component area. This is common to almost all residential codes. The difference in the Oregon case is that there are no glazing area restrictions. This removes the principle reason for trading-off specific performance provisions to develop enough credits to allow higher levels of glazing. The impact of this approach is to reduce code complexity and improve enforcement.

A review of the Oregon residential energy code (Frankel, et al. 1994) was conducted a year or so after this major revision was put in place. This study suggested compliance levels of more than 95% on homes permitted under this code.

1.4.4. Washington

The state of Washington is similar to the state of Oregon in that the residential energy code has evolved over a period of 20 years and is based on both national standards and local public processes to develop the code as currently practiced. The energy code was originally passed by the legislature as both a minimum and a maximum; consequently, the individual jurisdictions do not have any flexibility in the nature of the residential energy codes adopted. The State Building Code Council, which reviews the code every three years, has control over all revisions.

Unlike Oregon, the Washington building code fees and fee structures are set by local ordinance. Individual jurisdictions can set the fees, in part as a revenue source. In this regard, virtually every jurisdiction in the state maintains a building department.

The Washington code remains based on a component performance standard which emphasizes flexibility by allowing the performance of building elements to be traded-off: increasing the performance of one component is allowed to compensate for the reduced performance of another component. The code was designed to provide different standards depending on heating system, thus creating different standards for homes heated with natural gas or electric heat pumps ("other fuels") than for homes heated with electric resistance heat ("electric"). Window standards for electrically heated buildings were set quite high (comparable to those of the Oregon code) while window standards for homes heated with gas or heat pumps were lowered. This provided builders with substantial leverage in designing and developing homes where electric resistance heat was not used, and resulted in a more performance-based standard. When coupled with the development of the WATTSUN® program, this standard focused on estimated component performance to document code compliance.

2. Sampling and Recruitment

The review of the residential sector in this project was based on simple random samples. Each state had a different sample design based on the actual conditions from which the sample was drawn. Idaho, Oregon, and Washington samples were drawn using records from building departments. In Montana, the samples were drawn completely outside of the building departments via secondary sources (a private database from the Western Construction Monitor®).   In Oregon and Washington, plans were available from the building departments, and these were examined as the samples were constructed. In Montana and Idaho, plan sets were reviewed on site with the cooperation of the builder. The building officials were not generally involved in any of the sample development. Sample sizes were established using a 95% confidence interval in Washington, Idaho, and Montana. In Oregon the criteria was relaxed to 90% as explained in Section 2.1.3.

2.1. Sample Frame

A sample frame was developed for each state based on building permit activity in the 1998 building year. This represented the last full year for which data was available when the project began, and it allowed for an assessment of the distribution of homes throughout the individual states and region. Population weights and sample sizes were based on this information.

Figure 1 shows the distribution of new single-family housing starts in the region. The two main urban areas, Seattle and Portland, dominate distribution. These two areas account for half of all the single family homes built in the region.

In addition to these two areas, substantial construction is distributed throughout the western parts of Washington and Oregon around the major population centers. There are substantial housing starts in two areas in the eastern part of the region: Spokane and Boise. The housing starts in Boise and the surrounding areas are comparable to the larger counties around Seattle and Portland. Approximately 60% of all the new housing in Idaho was built in the Ada County and Canyon County areas surrounding Boise.

Counties in Montana have relatively limited housing starts. Four counties (Missoula, Flathead, Gallatin and Yellowstone) have the highest residential construction activity; there is no truly dominant county. The overall housing starts in Montana were only about 7% of the region.

Figure 1 and Table 2.1 show the distribution between states for residential housing starts. Also included in Table 2.1 is the distribution of multi-family housing starts, including duplexes, tri-plexes and four-plexes.

Figure 1: 1998 Residential Housing Starts for the Pacific Northwest

Table 2.1: Residential Housing Starts (1998)

State	Single		Multi-Family	
	Units	Percent	Units	Percent
Idaho	8,460	14.9	1,106	4.1
Montana	3,865	6.8	994	3.7
Oregon	16,743	29.4	8,640	32.1
Washington	27,849	48.9	16,180	60.1
Total	56,917	100.0	26,920	100.0

The distribution of multi-family housing shows the relatively minor impact of multi-family construction outside of the main urbanized states. This sector was not addressed in this study.

Since a different sampling strategy and modeling approach was used in every state, the principal goal in this stage was to develop a representative random sample of each state to allow for comparison between the states.

2.1.1. Idaho

The Idaho sample was drawn using the 1998 permit records filed with the U.S. Department of Congress. The distribution of permits for the largest counties is shown in Table 2.2. This represents all 39 Idaho counties and approximately 82 independent jurisdictions.

Table 2.2: Idaho Residential Construction (1998)

County	Single-Family	Percent	Sample	Percent	Cover Sample	Percent
Ada	3,438	40.6	43	41.3	246	45.8
Canyon	1,759	20.8	27	26.0	126	23.5
Kootenai	1,084	12.8	16	15.4	76	14.2
Bonneville	522	6.2	7	6.7	36	6.7
Twin Falls	209	2.5	3	2.9	14	2.6
Blaine	171	2.0	2	1.9	11	2.0
Jefferson	146	1.7	0	0.0	0	0.0
Bannock	125	1.5	2	1.9	9	1.7
Boise	109	1.3	0	0.0	0	0.0
Valley	104	1.2	1	1.0	4	0.7
Elmore	100	1.2	0	0.0	0	0.0
Fremont	88	1.0	1	1.0	6	1.1
Madison	85	1.0	0	0	0	0.0
Bingham	77	0.9	1	1.0	5	0.9
Gem	76	0.9	0	0.0	0	0.0
Bonner	69	0.8	1	1.0	4	0.7
Bear Lake	62	0.7	0	0.0	0	0.0
Other	236	2.8	0	0.0	0	0.0
Total	8,460	100.0	104	100.0	537	100.0

Some of these jurisdictions appear under-represented in the sample frame. This is because either the building jurisdictions did not report their results or no explicit building permits were issued in the more rural jurisdictions. This problem is intractable in Idaho. Since jurisdictions do not report housing starts—these homes are built with no permit at all. This appears to be a fairly minor problem confined to a few rural counties.

Surveys conducted by a secondary source (Western Construction Monitor®) indicate that this represents about 6% of state-wide single-family residential activity. This suggests that the great bulk of Idaho homes are located in jurisdictions which use building permits and report permit data, and that the total residential construction in Idaho is adequately represented.

Our sampling methodology focused on the larger jurisdictions within the counties listed in Table 2.2. The general approach was to identify jurisdictions with sufficient activity and send a field reviewer to those areas. Based on the activity in these jurisdictions in 1998, a target number of cases to be sampled were identified. This meant that the random sample was constrained to those jurisdictions with high levels of construction in the 1998 program year. This provided a random sample that is representative of large jurisdictions across the states. This methodology excludes some fraction of the residential construction. In the case of Idaho, this amounts to approximately 10% of the single-family residential population.

In Idaho, field reviewers were instructed to gather plans at the building department, review these plans, and sample a fraction of the homes in the field. This proved impractical in several larger jurisdictions (e.g., Ada County and City of Boise) since plans were kept on site rather than at the building department, meaning that no information about the building itself, beyond permit paperwork, was available at the building department. The sample was redesigned so all resources were expended on field reviews.

A target sample of 115 buildings was identified, representing approximately 1.5% of the total residential activity in the target jurisdictions. This sample size was assumed to represent the building characteristics of Idaho with an approximately 95% confidence interval and a 5% significance level. These estimates were based on anticipated variance in floor area and normalized heat loss rates observed in previous residential sector samples (Frankel, et al, 1994; Palmiter & Brown, 1989). The sample size actually achieved was 104 homes.

With minor variations, this strategy was also used in Washington and Oregon. The Idaho sample frame included more than 500 permit cover applications for these field reviews. The distribution of the cover evaluation is included in Table 2.2.

2.1.2. Montana

The Montana sample frame was originally designed to utilize building jurisdiction data, as in Idaho. However, the unique nature of Montana's building permit policies made this impractical. Urban jurisdictions are only allowed to enforce the building code within a 4.5 mile radius of city limits; homes outside this boundary are not required to obtain a building permit or receive inspections. Fortunately, the State of Montana requires that every building receive an electrical permit and a plumbing permit. If no local jurisdiction is providing the permit and inspection services for these areas, the builders are required to secure an electrical permit from the State. These permits are, in principal, examined by an electrical inspector whose jurisdiction includes a large portion of the entire state.

Sampling at the State Buildings Codes Division (in Helena) where these permits are issued is not practical, since it is impossible to learn the status of construction from the electrical permits filed there. Furthermore, a private sector database (Western Construction Monitor®) has been developed using the results of the electrical permits and developing a list of home builders, locations, and home sizes for purposes of reporting to potential contractors and subcontractors throughout the state. This database appears to be relatively complete for the areas it covers. Table 2.3 summarizes the sample frame in Montana.

Table 2.3: Montana Residential Construction (1998)

County	Single-Family	Percent	Sample	Percent	Cover Sample	Percent
Gallatin	563	14.6	14	23.0	26	18.1
Flathead	514	13.3	8	13.1	28	19.4
Yellowstone	427	11.0	9	14.8	25	17.4
Missoula	404	10.5	9	14.8	15	10.4
Ravalli	320	8.3	5	8.2	11	7.6
Lewis&Clark	245	6.3	3	4.9	12	8.3
Lake	190	4.9	6	9.8	9	6.3
Lincoln	160	4.1	1	1.6	3	2.1
Jefferson	96	2.5	2	3.3	5	3.5
Madison	96	2.5	0	0.0	3	2.1
Cascade	95	2.5	1	1.6	3	2.1
Carbon	91	2.4	0	0.0	0	0.0
Silver Bow	91	2.4	2	3.3	3	2.1
Park	90	2.3	1	1.6	1	0.7
Sanders	69	1.8	0	0.0	0	0.0
Other	414	10.7	0	0.0	0	0.0
Total	3865	100.0	61	100.0	144	100.0

An effort was made to characterize the sample frame using the same building year as the permit data used in the other three states. The private database was supplemented by data from the Building Code Division from the selected year to assess counties not covered in Western Construction Monitor®. The disadvantage of this method was that homes in areas where electrical permits are issued by a city were not covered, although this is rare enough in most rural counties that it has a negligible impact on the sample frame. We believe the sample frame assessed in this manner is representative of overall Montana housing (even though some areas may have more homes than represented here, particularly in eastern Montana).

Following this effort, a sample was drawn from the Construction Monitor® database. This random sample was drawn from building permit data assembled from homes permitted after January 1999. The actual sample design used the permit and construction data from 1998 combined with the Construction Monitor® and the electrical permit information from the state. Counties with fewer than 50 housing starts in the entire 1998 year were eliminated from consideration, focusing the sample on the areas with most activity. This resulted in approximately 10% of the population being excluded from the sample.

The resulting sample frame represents the 15 largest counties in Montana. A random sample was drawn from the Construction Monitor® information on those counties. Since this was a random sample, not targeted by jurisdiction or county, the distribution was different from the actual permit data which the sample was designed from.

The sample size for Montana was 61 homes, representing a 90% confidence interval. The variance for calculating the sample size was based on the variance in the reported square footage in the Construction Monitor® database. This suggested a higher uniformity of homes constructed in Montana, thus rendering the smaller sample size appropriate. Since the sample had to be recruited by contacting the builders, a larger recruiting sample was drawn. This sample is shown as the "cover sample" in Table 2.3 and represents the homes contacted in order to secure the final sample.

2.1.3. Oregon

The Oregon sample was appreciably different from that of the other states. In 1994, about a year after the adoption of the current residential code, an extensive code compliance and residential characteristics review was conducted. This review involved a large sample (283 homes), and was designed to assess the differences between jurisdictions. The methodology was also intended to provide a highly accurate assessment of builder and code official response to the newly implemented Oregon energy code.

Since no energy code revisions have been adopted since this review was conducted, it was assumed for this study that a smaller supplemental sample would allow the assertion that construction practices observed in 1994 were still representative of Oregon in 1999. The results of this review suggest that this assumption was correct. The sample size was reduced dramatically, and the sample frame focused on the most active counties and jurisdictions. This included jurisdictions in Washington County, and the Portland, Salem, Eugene and Bend areas. The sample frame for this review included about 85% of all new residential construction activity in the state.

A sample size of approximately 44 homes was selected. These home were distributed in the larger jurisdictions and included most of the large counties in western Oregon, as well as Deschutes County in eastern Oregon. Table 2.4 shows the distribution of this sample as well as the distribution of construction activity in the state for the largest counties.

Table 2.4: Oregon Residential Construction (1998)

County	Single-Family	Percent	Sample	Percent	Cover Sample	Percent
Washington	3,672	21.9	9	20.5	95	25.5
Clackamas	1,791	10.7	6	13.6	39	10.5
Multnomah	1,710	10.2	6	13.6	49	13.2
Deschutes	1,640	9.8	6	13.6	48	12.9
Marion	1,377	8.2	5	11.4	37	9.9
Lane	1,334	8.0	3	6.8	39	10.5
Jackson	1,166	7.0	4	9.1	25	6.7
Yamhill	555	3.3	2	4.5	15	4.0
Linn	501	3.0	1	2.3	8	2.2
Josephine	326	1.9	1	2.3	6	1.6
Polk	287	1.7	0	0.0	0	0.0
Douglas	283	1.7	0	0.0	0	0.0
Columbia	253	1.5	0	0.0	0	0.0
Jefferson	232	1.4	1	2.3	7	1.9
Benton	222	1.3	0	0.0	0	0.0
Other	1,394	8.3	0	0.0	4	1.1
Total	16,743	100.0	44	100.0	372	100.0

Summaries using this sample have been compared directly to the characteristics data collected in 1994. In addition to the 44 homes examined in the field, approximately 372 cover sheet reviews were conducted in these same jurisdictions. An additional 36 plan reviews allowed a larger sample on such issues as fuel choice and house size. This larger sample is adequate to represent these limited variables without reference to the 1994 sample, allowing for trends in fuel choice and house size to be observed.

2.1.4. Washington

The Washington sample is designed to be a representative sample using roughly the same criteria as used in Idaho. In Washington, the code divides the state into two regions (Zone I represents western jurisdictions, and Zone II represents eastern). An effort was made to inflate the sample sufficiently so that comparisons between the two separate standards in Washington would be possible. Total sample size for the state of Washington was 157 homes, representing 23 of the 39 Washington counties and the 80 most active jurisdictions in the state. Table 2.5 describes the distribution of homes in the Washington sample.

Table 2.5: Washington Residential Construction (1998)

County	Single-Family	Percent	Sample	Percent	Cover Sample	Percent
King	5,320	19.1	31	19.7	182	19.6%
Pierce	4,389	15.8	26	16.6	139	15.0
Snohomish	4,314	15.5	24	15.3	149	16.1
Clark	3,327	11.9	19	12.1	98	10.6
Spokane	1,588	5.7	10	6.4	59	6.4
Thurston	1,415	5.1	8	5.1	57	6.1
Kitsap	1,100	3.9	6	3.8	43	4.6
Whatcom	916	3.3	5	3.2	26	2.8
Island	642	2.3	4	2.5	27	2.9
Skagit	493	1.8	2	1.3	17	1.8
Benton	455	1.6	3	1.9	21	2.3
Mason	361	1.3	2	1.3	16	1.7
Clallam	356	1.3	2	1.3	8	0.9
Yakima	346	1.2	2	1.3	13	1.4
Cowlitz	335	1.2	2	1.3	9	0.9
Chelan	269	1.0	1	0.6	7	0.8
San Juan	269	1.0	2	1.3	9	0.9
Franklin	267	1.0	2	1.3	6	0.6
Jefferson	251	0.9	1	0.6	5	0.5
Kittitas	221	0.8	1	0.6	8	0.9
Lewis	198	0.7	1	0.6	8	0.9
Grays Harbor	149	0.5	0	0.0	0	0.0
Grant	138	0.5	1	0.6	6	0.6
Okanogan	138	0.5	1	0.6	6	0.6
Stevens	135	0.5	1	0.6	5	0.5
Other	457	1.6	0	0.0	2	0.2
Total	27,849	100.0	157	100.0	928	100.0

In addition to the field sample, a cover sample was drawn in every jurisdiction. In some cases, this cover sample included a plan review, but it was largely designed to collect data on house size and location. The information was used in a method for partially randomizing the sample in individual jurisdictions. Data on house size was collected on 928 homes during this process. This study suggested compliance levels of more than 95% on homes permitted in 1998 under the code. The Washington summaries are limited to the 157 homes with detailed field reviews.

The Washington sample was drawn from the most active jurisdictions rather than by county, making a substantial distribution possible. Two jurisdictions refused to cooperate (Spokane and Vancouver); to compensate, a supplemental sample was drawn for these jurisdictions outside of the building permit process. The sample frames for Spokane and Vancouver were derived from Western Construction Monitor® data. The field auditors contacted builders from homes drawn and asked for permission to review the homes directly. While this limited our field review to six homes in the two jurisdictions, it allowed coverage in these important jurisdictions to be included in the sample.

2.2. Recruitment

Once the sample was drawn, the process of recruiting houses into the study was fairly straightforward (except in areas where building permits were not used or where permitting jurisdictions did not cooperate). This accounted for all of the jurisdictions in Idaho, Oregon and Washington, except the two Washington jurisdictions mentioned above.

In cooperating jurisdictions, the field staff selected the target number of sites randomly from the available permits, including any homes that had received at least a "cover" inspection. By screening in this way, it was assumed that homes would be near enough completion that a field inspection could verify such important components of the building as insulation levels, windows specifications, and other details and components.

In the Washington and Oregon jurisdictions, this worked fairly well. Homes were selected, the permit records were pulled for the homes, and plan take-offs were done in the building department office. Once this was complete, the inspectors were instructed to go to the homes and conduct field reviews after receiving permission from the construction foreman or contractor (on site). In many cases, an attempt was made to contact the building inspector involved so that the home could be reviewed when the building inspector would be conducting an inspection review. Very few homes were dropped because of non-cooperation at the site, even though no effort was made to recruit the homes in advance.

In Idaho, the field review had to include a review of the plan set, since plan sets were not generally available at the building departments. As a result, the field process was more time-consuming and the status of the homes was not clear from the building permit record. In several cases, homes had to be dropped from the sample because the data that could be collected was inadequate to assess the relevant characteristics of the homes. As a result, the target sample of 115 homes was not met; only 104 homes were sampled.

In Montana, building permits and building jurisdictions were not used at all because they covered only a third of all the new residential construction. Since the sample was drawn from a public database, builders were contacted directly and invited to participate in the study. There was no indication in the database as to the level of completion in the homes recruited, homes had to be assessed to determine whether a field review could even be conducted. Recruiters were instructed to bypass homes which were already occupied.

In order to accommodate this, an initial sample of 61 homes was drawn for recruitment, followed by a second sample of approximately 90 homes. This second sample was meant to be a prioritized list of backups that could be used to replace homes that did not qualify or cooperate for one reason or another. Since this was a random sample of all homes in the state, some counties were under-sampled as part of the random chance associated with the sampling. Nevertheless, 12 of the 13 counties in the original sample were represented in the final sample, although the distribution was somewhat different.

This sample represents the fraction of the residential population sited in the sampled counties (about 90%). The more rural counties in eastern and southern Montana are not represented here, although we have no reason to believe that building practices are appreciably different in those areas. Many rural areas are represented here in areas where the state also handled the inspection.

There is some bias associated with this sample. We believe that the fraction of homes that were actually issued building permits in this sample was approximately 50%, while the fraction of homes in the entire state of Montana is slightly over 30 percent. Because of the methodology used, the only cover sample was the homes that were selected to be recruited but which did not participate. No larger sample of Montana homes was available.

2.3. Sample Weighting

Sampling in each state was assumed to be random with respect to the target population, thus no weight has been assigned to statewide characteristics data. In Oregon, the comparison with the larger sample done in 1994 provides the basis for verifying or modifying the characteristics assessed in that study. Overall sampling weights for that region are derived from the relevant portion of new residential construction for each of the states. In Washington, an effort was made to divide findings beyond the state level (with a separate summary in the eastern Washington area, where a different code is enforced).

In some other specific cases, comparisons were made on specific characteristics between particular subsets of the sample and the state as a whole. These comparisons were ad hoc, but were limited to situations where the sub-samples compared were large enough to provide meaningful insights. The comparison among states uses these weights to assemble regional averages throughout this study.

Table 2.6: Regional Sample Weights

State	Field		Plan	
	Weight	**N**	**Weight**	**N**
Idaho	0.0014	104	0.0014	108
Montana	0.0011	61	0.0011	61
Oregon	0.0067	44	0.0037	80
Washington	0.0031	157	0.0020	245

Table 2.6 summarizes population weights used in the regional characterizations. Since the methodology utilized simple random samples for each state, no additional weighting was applied. Information from the "plan reviews" was not generally summarized, although some details could be inferred from this sample. The field reviews appear adequate for the analysis purposes of this study.

3. Residential Construction Characteristics

This study gathered information on construction practices, insulation levels, and heat loss performance of the individual building components. Separate, independent samples were drawn for each state. Each major building component was individually analyzed by state. The results have been presented below; however, caution should be used when making cross-state comparisons. Each component is regulated under one or another building standard, but fairly significant differences exist among the states on the enforcement and acceptance of these standards, as well as the actual requirements.

3.1. Home Characteristics and Building Size

The study sample suggests fairly substantial differences in home design and size among the four states. Table 3.1 summarizes home size and the use of basements across the sample. The fraction of the average house size comprised of finished basements is delineated because the presence of basements is responsible for the large difference in house size between Montana and the other states.

Table 3.1: House Size by State

State	N	Floor Area	Std. Dev	(Med)	Basement Fraction
Idaho	104	1,941	761	1678	0.173
Boise	63	1,810	629		0.064
Other	41	2,143	900		0.341
Montana	61	2,504	1,419	2420	0.623
Oregon (1999)	80	2,370	1,022	2242	0.068
Oregon (1994)	283	2,056	776	1877	0.067
Washington	157	2,259	770	2111	0.146
Western	133	2,254	715		0.098
Eastern	24	2,284	1,040		0.414
Total	366	2,261	917	2,003	0.244

An interesting counterpoint to this are the construction practices in Idaho, and in the Boise area in particular. The inclusion of basements in Boise homes is extremely rare. In areas where basements are prevalent (such as in Kootenai County, Idaho), the homes are comparable in size to Montana homes, but the level of building activity is very low. The lack of conditioned basements contributes to the observation that Idaho has the smallest average homes (by heated floor area) of the four states.

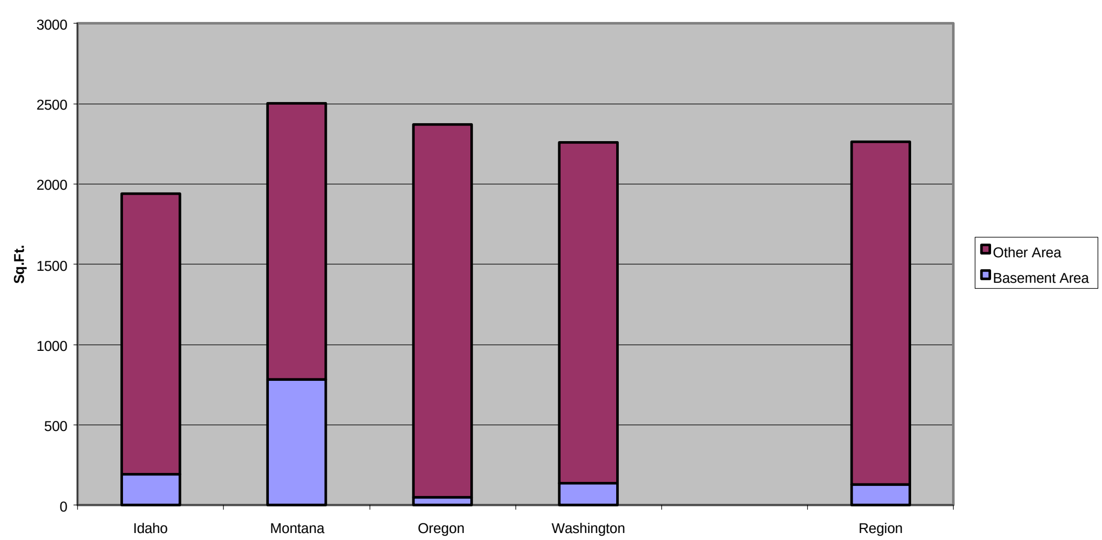
Homes in the Washington and Oregon samples were similar in size. In both these states, homes are much larger in select suburbs surrounding Portland and Seattle (50% and 25% larger than the state average, respectively). These are balanced by smaller homes located in outlying areas with lower property values. However, the metropolitan areas are also experiencing the most new residential construction activity, increasing the overall state average.

The greatest differences in both Oregon and Washington occurred in homes built in the Eastern halves of the states, where basements are more common. The characteristics of home design between western and eastern Washington differ only on one significant dimension: homes in eastern Washington are about four times more likely to include basements than homes in western Washington. While fewer homes in eastern Oregon have basements than in eastern Washington, the same trend holds for that state.

There is, however, an important caution to these data: the Oregon sample is not strictly comparable to the other three samples, since the sample drawn is much smaller and is dominated by several large population concentrations (as discussed in Chapter 2). The 1994 Oregon sample is not subject to this caveat and, in that study, the distribution and saturation of basements was comparable.

Figure 2 shows the distribution of floor area between the basement and the remainder of the home. The sum of the two bars adds to the average house size in each state. The basement area is averaged across all homes and only includes basements that are part of the heated space. In the case of Montana, basements represent about a third of the total floor area. No other population in any state compares with this value. In eastern Washington and Idaho outside of the Boise area, the ratio of basement area to total floor area approaches 20%, but when the more urbanized areas are taken into account the regional basement is less than 6% of the total residential floor area.

Figure 2: Floor Area and Basement Area by State



Trends in house size have not been examined in detail. However, comparing the data to the Oregon 1994 sample (Frankel & Baylon, 1994), a roughly 15% increase in house size seems to have occurred in the five-year period between 1994 and 1999. While the 1999 sample is only about 20% as large as the 1994 sample, this shift is enough to be statistically significant. Both Oregon samples have been summarized in Table 3.1 to allow comparisons.

No sample for the region as a whole exists comparable to the Oregon sample of 1994. However, the NORIS survey of 134 randomly selected homes built between 1980 and 1986 was conducted in 1987. This sample was designed to be regionally representative and so was not analyzed by state. In this sample, the average regional house size was 1,844 ft^2, suggesting that a 22% increase in house size between 1986 and 1999 has been experienced (Palmiter, et al. 1988).

Another dataset was constructed in the late 1980s from areas where utility programs were conducted. These were programs aimed at the electrically heated homes which dominated those markets at the time (Brown, et al, 1991). The sample was drawn from areas throughout the region. Although some of the areas were sampled, there was no effort to represent the whole sector in this study. The average size home in this study was 1840 ft^2.

3.2. Building Characteristics

This study gathered data on the insulation levels and heat loss performance of the individual building components observed in the four states. These components have been examined independently. Because of the variations in code, code enforcement, building standards, and market conditions, the states look extremely different on most important dimensions associated with energy conservation and energy efficiency.

The use of enforced standards is common in Washington and Oregon, and less common in Idaho and Montana. This gradient of standards is opposite from the climate severity in these states, with Montana having the most severe climate by a very substantial margin. Table 3.2 summarizes the U-values associated with the opaque components of the residential buildings in the sample.

Table 3.2: U-Value Comparison of Components (Btu/hr-F-ft^2)

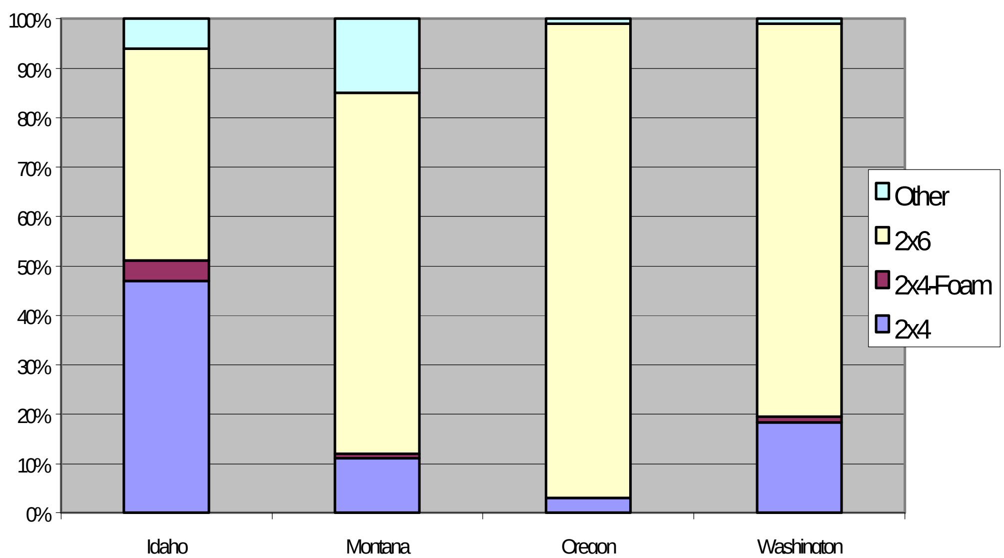
State	Wall		Window		Floor		Ceiling	
	Sample	Code	Sample	Code	Sample	Code	Sample	Code
Idaho	0.071	0.062	0.474	0.495	0.054	0.038	0.026	0.026
Montana	0.063	0.062	0.402	0.400	0.065	0.038	0.026	0.026
Oregon	0.059	0.061	0.371	0.433	0.033	0.032	0.026	0.026
Washington	0.065	0.062	0.460	0.640	0.039	0.041	0.030	0.026

The average U-values seen in the sample are generally consistent with the standards set by the relevant energy code. Only in the Washington code are there appreciable differences. These are the result of code-compliance methodologies which allow trade-offs between components. Window U-values are derived from the average window heat loss including all glazed areas and skylights. The code U-values are based on the average required window U-value for the particular window area in the proposed building. This is usually different from the nominal value in the codes, since the particular value is based on a particular area.

3.2.1. Walls

Figure 3 summarizes the distribution of wall framing types in the region. As can be seen, 2x6 wall framing is dominant throughout the region, usually with R-19 or R-21 fiberglass insulation (R-21 is required by the Oregon code and thus is used almost exclusively in that state). There is a substantial amount of 2x4 framing in Washington and Idaho , usually with insulation of R-11 or R-13 fiberglass. In Idaho there is a fraction of the walls with some foam sheathing (usually about R-3.6).

Figure 3: Wall Framing Types by State (% of wall area)



The use of 2x4 wall construction is rare in Oregon and Montana, and in most of Idaho and Washington. However, this construction technique was dominant in both the Seattle and Boise areas. Table 3.3 summarizes the wall component values for Idaho.

Table 3.3: Wall Framing (Idaho – Fraction of Total Wall)

Type	Boise area	Other areas	Entire State
2x4	0.67	0.11	0.45
2x4 w/ foam	0.06	0.01	0.04
2x6	0.21	0.69	0.40
Below grade	0.03	0.16	0.08
Unknown/other	0.03	0.03	0.03

Under the Idaho Residential Energy Standard (IRES), 2x4 construction is deemed to comply with the prescriptive path if it has R-13 insulation plus 85% of the total wall area sheathed in rigid R-3.6 insulation. This provision is not widely used in most of the state. However, most of the residential construction in Boise utilized 2x4 framing with R-13 batt insulation under this standard (even though 88% of the homes sampled had no insulated sheathing). This is shown separately in Table 3.3, since the results in Boise vary so significantly from those in the remainder of the state.

In Montana, well-built walls appear to be a market requirement. Only 13% of the homes in Montana employ 2x4 construction of any sort and about 20% of these utilize rigid foam insulated sheathing in addition to batt insulation. Interestingly, Montana is the only state with a significant fraction of wall area using various alternative energy-efficient construction techniques. The use of insulated concrete forms (ICF) and Structural Insulated Panels (SIPS) or foam panels represents about 7% of the total wall area in Montana and only about 1% of the wall construction in any of the other states.

In Oregon, the trade-offs allowed under the prescriptive path are not very favorable, and builders throughout the state appear to have standardized around the prescriptive path requirements of the Oregon Residential Energy Code. The majority of total wall area (93%) is made of 2x6 construction with R-21 fiberglass insulation; another 2% utilizes 2x6 with R-19. Only 4% of the Oregon homes use 2x4 framing or other wall framing types.

The Washington energy code allows trade-offs which increase wall construction U-values. Localized market forces and favorable wall/window trade-offs under the energy code for gas-heated homes appear to encourage the use of 2x4 framing techniques. The Washington State Energy Code requires only Class 65 windows, while the window market standard is Class 50. This trade-off between wall and window components is likely responsible for the fact that about one-third of the gas-heated homes in the Seattle area use 2x4 framing. This trade-off methodology also contributes to a 6% increase in window area in the Seattle markets. The Washington wall framing results are shown in Table 3.4.

Table 3.4: Wall Framing Washington (Fraction of Total Wall)

Wall Type	Seattle area	Rest of state	State total
2x4	0.33	0.02	0.18
2x4 w/ foam	0.00	0.01	0.01
2 x 6	0.63	0.85	0.75
Below grade	0.01	0.04	0.02
Unknown/other	0.02	0.08	0.05
N	69	88	157

Interestingly, this pattern does not recur in other parts of the state. About 60% of homes in the remainder of the state are heated with gas and another 25% with heat pumps, which would also be eligible for these trade-offs. Even so, only 2% of the wall area in the remainder of Washington is 2x4 construction.

Alternative wall construction

As mentioned above, alternative wall constructions occur in relatively small fractions throughout the region. As shown in Table 3.5, these alternative wall constructions represent a bit over 1% of the wall area in Washington and Oregon and slightly higher amounts in Idaho and Montana. Primary alternatives are SIPS panels and ICF. The uninsulated walls are primarily associated with basements. Montana allows uninsulated basement walls in unfinished spaces that will ultimately be finished.

Table 3.5: Alternative Wall Construction (Percent of Wall Area)

State	Idaho	Montana	Oregon	Washington
SIPS panel	0.8	2.4	0.0	0.0
ICF walls	0.1	4.2	0.0	0.3
Log walls	0.0	1.6	0.0	0.7
Uninsulated	0.8	4.8	0.0	0.1
Rigid foam	4.3	1.2	1.3	0.3
Total	6.0	14.2	1.3	1.4

It should be noted that walls described as “rigid foam” could utilize either sheathing or in-cavity urethane insulation. In Idaho, an explicit code for insulated sheathing exists, which likely explains why it is the only state where use of that insulation type is somewhat common. Washington homes built in climate Zone II with electric heat are required to have foam sheathing or trade off that component with window performance or window area. Apparently, this trade-off is considered desirable by virtually all builders in the eastern part of the state, since none of the six electrically heated Zone II homes had insulated foam sheathing.

3.2.2. Window and Door Performance

Window performance in most energy codes is characterized by a total window U-value and a total window area (expressed as a percent of total floor area). The Oregon and Montana codes each have a single explicit window U-value requirement and no window area restrictions. This simplifies the compliance path considerably and provides a large incentive on the part of builders to use a single standardized window. Table 3.6 summarizes window performance as observed in the four states.

Table 3.6: Window Performance

State	Reviewed		Code	
	U-Value	% of Floor Area	U-Value	% of Floor Area
Idaho	0.474	12.7	0.50	17
Montana	0.402	13.1	0.50	NA
Oregon	0.371	15.2	0.40	NA
Washington	0.460	14.8	0.65	15

Window U-values

Depending on the components of the window itself, the entire residential window market is based on double glazed vinyl windows. In virtually all Northwest markets this represents the minimum window performance available. Thus the selection of a Class 50 window in any state would be considered the default baseline. In some markets the codes intervene and result in higher performing windows. In some markets the perceived quality of the higher window performance results in better window specifications. The window distribution of the sample in each state is as informative as the average U-value. Table 3.7 illustrates the distribution of window U-values in all four states.

Table 3.7: Window U-value Distribution by State

Window class	Idaho	Montana	Oregon	Washington
< Class 38	21.0	54.2	43.3	25.3
Class 38-40	2.2	25.4	50.7	6.6
Class 41-46	4.9	5.6	3.8	4.8
Class 47-50	47.8	13.5	1.4	47.1
Class 51-60	24.2	0.0	.8	16.1
>Class 60	0.0	1.3	0.0	0.1
Total	100.0	100.0	100.0	100.0

In Washington, the residential energy code for window performance mandates a U-value requirement of 0.65 with a glazing area standard of 15% of the heated floor area for homes not heated with electric resistance. This

code was written in 1986 and envisioned the use of thermally-broken aluminum framed windows. In the intervening years, these windows have been completely replaced in the market by vinyl-framed windows with U-values of 0.50 or better. As a result, virtually all homes in Washington are built with windows that are 20-30% better than the code requires. Since the energy code allows over-performing components to be traded off with otherwise non-compliant components, this can negatively impact other aspects of the building (as noted in the discussion on walls, above).
The lowest window U-values and the highest glazing percentages are in Oregon, although the Oregon glazing area is only slightly higher than that found in Washington. In Oregon, this is caused by the state enforcement of a single standard with few trade-offs allowed against other components, which limits the incentive to use windows that differ from the code standard.

In Montana, the MEC is used as the nominal standard, but the state introduced specific state-level modifications which both reduced the stringency of the window requirements and eliminated the window area restrictions; consequently the Montana energy standards, like Oregon's, assume a Class 40 window with no glass area limit. Interestingly, Montana window performance approaches Oregon in most respects.

The most striking state-wide distribution is seen in Montana, where large and nearly equal fractions of the sample utilized windows that were either below Class 35 or above Class 50. Washington showed the largest distribution. This is partly due to the relationship between overall window area and U-value; i.e., the energy code requirement for larger percentages of glazing area necessitate the installation of higher quality windows. The remaining distinctions are linked to trade-offs with other building components.

In Idaho builders have standardized on Class 50 windows. This seems to be independent of code enforcement, as wall standards on the same homes fall short of the IRES requirements. The IRES mandates a 17% glass-to-floor ratio as a base and allows trade-offs against improved window heat loss rates but not against window area reduction. The best explanation for Idaho window selection would be that these windows represent the most cost effective response to the Idaho market.

Window construction characteristics

Tables 3.8 and 3.9 summarize window frame and glazing selection by state. Window construction characteristics are reasonably homogeneous throughout the region. Over 85% of all windows reviewed use vinyl frames. Only Montana uses substantial amounts of wood and clad wood frames. It is important to note that the glazed doors of any sort are included in these summaries. This causes the percentage of “wood” frames to increase in all states.

Table 3.8: Window Frame Specifications by State

Frame type	Idaho	Montana	Oregon	Washington
Vinyl	89.2	51.2	86.0	87.1
Wood	5.0	41.8	13.9	8.8
Aluminum	0.7	5.7	0.0	2.5
Other	5.1	1.3	0.1	1.6

The use of low-e coatings in this region has become standard in Oregon and Montana. More than 80 percent of the window glazing is treated with low-e coatings. In Oregon this can be traced directly to the energy code which mandates a Class 40 window for all residential buildings. The Montana window requirements in the energy code are very similar to those of Oregon. However, the code is not enforced in about two-thirds of the residences reviewed. Nevertheless, Montana builders employ high performance windows as often as Oregon builders. Idaho and Washington differ significantly: only about a third of the window glazing in these two states uses low-e coatings. In both these cases, the energy code uses a performance standard which is easily met without the use of low-e coatings.

In addition to the use of low-e coatings, auditors checked for the presence of other components that would improve glazing performance. The use of argon gas fill typically improves the window U-value by a small amount. Since this is a colorless gas, the auditor looked for the rivets used to plug injection holes (other means for injecting argon could not be reviewed in the field). In some cases, the window label identified the use of argon gas fill, but Table 3.9 should be taken as a conservative estimate of the use of this technology in the region.

“Warmedge” technology improves the overall glazing performance, but it is also a manufacturing technique that allows a higher level of manufacturing automation. In effect, this characteristic is not readily available to smaller factories, especially custom wood manufacturers. This is the most likely explanation for the small saturation of “warmedge” in the Montana market. In the remaining states, about half of the glazing area uses this technology.

Table 3.9: Glazing Characteristics (Percent of glass area)

State	Low-e Coating	Argon Fill	Warmedge
Idaho	30.4	6.9	47.7
Montana	83.5	27.5	11.2
Oregon	96.0	53.5	50.3
Washington	38.8	24.8	53.2
Region	73.0	38.6	47.2

3.2.3. Floors

A wide variety of floor constructions were found in the region. The most significant difference in floor construction techniques was the use of crawlspaces versa basements in various markets throughout the region. While basements dominated the sample in the coldest areas, crawlspaces were the typical practice is western Washington, western Oregon, and the Boise region.

Table 3.10 presents the distribution of floor area by type and state. Generally, the dominant construction types are vented crawlspaces with perimeter insulation in Idaho, heated basements in Montana, and vented crawl spaces with floor insulation in Washington and Oregon.

Table 3.10: Floor Construction (Percent of Floor Area)

Floor Type	ID	MT	OR	WA
Frame Over Crawl:	75.1	37.0	83.4	71.0
Floor Insulation	23.6	9.1	79.3	62.0
Perimeter Insulation	51.3	25.6	4.1	0.0
Unknown Insulation	0.2	2.3	0.0	9.0
Frame over Basement	0.0	3.2	1.6	0.5
Frame over Garage/Air	4.8	4.7	10.4	12.0
Slab On Grade	2.1	8.2	1.2	10.5
Basement Slab	17.3	46.9	3.5	6.0
Total	100.0	100.0	100.0	100.0

Many homes have multiple floor conditions such as partial basements with crawlspaces under portions of the homes. Summaries of floor characteristics are based upon the areas of particular floor construction.

The housing characteristics of western and eastern Washington differ only on one significant dimension: homes in eastern Washington are about four times more likely to include basements than homes in western Washington. While fewer homes in eastern Oregon have basements than in eastern Washington, the same trend holds true for this state.

3.2.4. Crawlspaces

This study examined the use of perimeter insulation (where the perimeter walls of the crawlspace are insulated but not the floor structure itself), crawlspace venting techniques (either operable vents, open vents or no venting), and under-floor insulation strategies (where the structural cavity is insulated).

Perimeter insulation

The use of perimeter insulation is allowed in Idaho under the IRES, and essentially sanctioned under Montana code. Its use in Washington and Oregon is restricted by the need to demonstrate radon mitigation in addition to energy efficiency. These requirements are apparently seen as burdensome to the builder community (often cited in builder interviews as an aspect of the energy code that is "poorly thought out" – see Section 5). Thus, the use of perimeter crawlspace insulation is nearly non-existent outside of Idaho and Montana. Table 3.11 describes the use and characterization of perimeter installation.

Table 3.11: Crawlspace (Percent of Perimeter Insulation)

Perimeter Insulation	Idaho	Montana
R-19	98.3	21.7
R-13, R-15	1.7	4.3
R-11	0.0	69.6

About two-thirds of the crawlspaces in Idaho and Montana use perimeter insulation strategies. In Idaho, this combines operable vents and R-19 crawlspace wall insulation in more than 90% of the sampled homes. For the most part, this strategy is allowed under the IRES standard, and seems to be adhered to wherever crawlspace perimeter insulation is used.

While perimeter insulation in Montana is used in about two-thirds of homes with crawlspaces, levels are generally lower than in Idaho. More than 70% of the homes with perimeter insulation have ratings below R-19, primarily consisting of R-11 fiberglass. This practice results in reduced floor (over crawlspace) performance in Montana compared to the other three states. It must be noted that only about a third of the homes in the Montana sample had crawlspaces (the remainder had basements).

Crawlspace venting

Operable crawlspace vents are virtually unknown in Washington, whereas they dominate in Idaho and Montana. In Oregon, operable vents are used in about half the crawlspaces in the state and are distributed throughout the jurisdictions reviewed.

Sixty-nine percent of the Montana homes had operable vents in the crawlspace; a much smaller percent had un-vented crawlspaces. Nevertheless, 21% of all Montana crawlspaces with perimeter insulation also had fixed opened crawlspace ventilation, essentially by-passing the crawlspace perimeter wall insulation. This practice, though essentially unheard of in the other three states, seems to be fairly common in Montana and further degrades the energy efficiency of the floor system. Table 3.12 summarizes the installation of vents in the four states.

Table 3.12: Venting by State (Percent of Crawlspaces)

Condition	Idaho	Montana	Oregon	Washington
Operable	92.5	71.9	53.1	3.3
Fixed	1.1	15.6	43.7	86.8
Unvented	4.3	12.5	3.2	1.9

Below-floor insulation

Below-floor insulation is the norm in Washington and Oregon, but represents only about a third of the crawlspaces in Idaho and Montana. Generally, the floor is left uninsulated when crawl space perimeter insulation is installed. The levels of insulation used over crawlspaces are summarized in Table 3.13.

Table 3.13: Crawlspaces-Below Floor Insulation (% of Crawlspaces)

State	Insulation (R-Value)						
	0	19	20-24	25	30	38	% of crawls.
Idaho	6.8	58.7	0.0	4.5	30.0	0.0	37.2
Montana	55.0	21.3	0.0	0.0	23.8	0.0	34.8
Oregon	0.0	3.5	4.0	90.2	0.0	2.3	97.4
Washington	0.8	70.8	4.3	0.2	22.7	1.0	100.00

The importance of building standards is illustrated by the analysis of under-floor insulation in homes with crawlspaces. In Montana, the use of full under-floor insulation is rare, which partly reflects an attitude that the crawlspace treatment is not significant in the overall performance of the house and partly reflects the fact that there is no enforcement of these code provisions. Half of the crawlspace floor area has no insulation at all (perimeter or floor). In Idaho, 90% of homes have under-floor insulation that meets or exceeds the IRES requirement of R-19, but this is only 37% of the crawlspaces reviewed. The Oregon prescriptive code requires R-25 below-floor insulation and, not surprisingly, 87% of Oregon floors meet this standard.

In Washington, under-floor insulation standards are determined by climate zone and fuel type. All homes in Zone II (eastern Washington) and all electrically-heated homes in Zone I must insulate to at least R-30. Gas-heated homes in Zone I may use R-19. Of the Washington homes, 99% meet or exceed R-19 insulation; about 24% exceed R-30 insulation.

This component illustrates the impact of enforced energy standards on building practices. In Washington and Oregon, less than 10% of the crawlspace floors fail to meet the exact code specifications. While only about 5% of homes with crawlspaces have under-floor insulation in Idaho, 85% of these meet the IRES. A few Idaho jurisdictions use standards that exceed the IRES and result in somewhat higher levels of floor insulation. In Montana, 62% of the homes have basements, and two-thirds of homes with crawlspaces use perimeter insulation. Of the remaining homes, half use neither perimeter nor under-floor insulation—a clear violation of the Montana energy standards.

Basements

Basements are popular in the colder climates where deep frost lines require deep foundations. In Montana, half of exposed floor area consisted of basement floor slab. Western Washington and Oregon had some below grade walls and partial basement situations in hilly areas. Situations where only a part of one or two walls was below grade were not considered basements for this summary. Two homes had unfinished above grade concrete first floors (essentially above ground basements designed to lift the house above the flood plane). These were not considered to be basements.

Auditors collected data on several factors to determine whether basements were to be considered inside the conditioned envelope or unheated spaces. If the primary heating system had the ability to supply heat to the basement, it was considered heated space, whether it was finished or not. Table 3.14 summarizes heated vs. unheated basement factors. This table also summarizes the relative importance of the basement floor in the overall floor heat loss calculation. The "% Area" refers to the fraction of all floor areas used in the building heat loss calculation that is located in the basement.

Note that there are few unheated basements and that most will probably be finished in the future. There are three Montana buildings with basements lacking heating systems. All three have a furnace located in the basement with an insulated floor above. A single Oregon basement is unheated. Most basements are either finished or prepared-to-be-finished spaces. Since basement finish is often an owner option, the ultimate degree of finish was often hard to determine during the audit process. This is the minimum amount of basement floor area finished.

Montana has special provisions allowing unfinished basements to be uninsulated as long as they are intended to be insulated, finished, and heated in the future. Many of the Montana basements were unfinished, with no insulation in the floor above and no insulation on the walls.

Table 3.14: Basement Area and Conditioning by State

State	% Area	% Unheated	% Heated	% Finished
Idaho	14.4	0.0	100.0	50.9
Montana	51.7	7.0	93.0	46.3
Oregon	3.0	49.8	50.2	49.8
Washington	9.4	0.0	100.0	52.0

Slab-on-grade

The use of slab on grade floors in homes without basements is rare in all states, although it is more frequent in the Washington sample than elsewhere. Typically, this is an exposed edge of a daylight basement. Slab perimeter insulation is more uniform across states than the other components, at least at the plan level review. The vast majority of cases in the sample use R-10 insulation (although a few cases with higher insulation levels were seen in Montana and the colder regions of Oregon).

Table 3.15: Slab-on-Grade by State

State	Percent of Homes	Insulation (R-Value)
Idaho	4.6	8.3
Montana	8.7	14.5
Oregon	4.8	15.0
Washington	10.4	10.5

The collection of data on slab edge construction is inherently difficult, since field auditors can rarely see it directly. This was more problematic in Washington, where only about half of the houses with slab edge construction had conclusive insulation data on the plans or submittal forms. In cases where the insulation value could not be verified, we assigned an R-value roughly equivalent to a non-thermally broken slab insulated to code values. Table 3.15 summarizes the R-values of the perimeter insulation in the samples. These values are based on only a few homes in each state. Therefore, the reliability of these summaries is open to question.

3.2.5. Ceilings

By and large, ceiling types are dominated by attics formed with manufactured trusses. These take the form of both flat-ceiling and scissor-trusses with sloped ceilings and small attic spaces between roof and ceiling. The ceiling values are detailed in Table 3.16.

Table 3.16: Ceiling Values by State

State	Ceiling type					
	Attic		Scissors		Vault	
	%	R	%	R	%	R
Idaho	52.6	38.0	40.8	37.5	6.6	28.9
Montana	57.1	39.3	29.5	39.3	13.3	35.3
Oregon	61.3	40.6	27.0	38.0	11.7	33.2
Washington	59.7	33.2	22.7	32.2	17.6	30.2

For the most part, the ceiling insulation values are consistent with the code requirements in all states. Even in Idaho, where compliance with other components of the IRES code is problematic, the ceiling insulation seems to be consistent with the requirements.

3.2.6. Heating and Cooling Systems

While heating and cooling system selection varied widely (by climate as much as by state), the types and ratings of similar equipment was uniform throughout the region. Table 3.17 describes the distribution of heating systems and cooling within the four states.

Table 3.17: Heating System Types (Percent)

State	System Type					
	Forced-Air Furnace	Heat Pump	Zone Heat	Boiler	Wood/ Other	% A.C.
Idaho	94.2	1.0	3.8	1.0	0.0	72.1
Boise	97.1	1.5	0.0	0.0	1.5	95.6
Montana	65.0	1.7	11.7	20.0	1.7	18.0
Oregon (1999)	91.1	8.9	0.0	0.0	0.0	18.2
Oregon (1994)	86.1	3.0	8.5	1.8	0.7	23.7
Washington	77.1	14.0	6.4	1.9	0.6	21.0

By and large, gas-fired forced air heating is the dominant system type in the Northwest. The only limitation on the general application of this system is the fact that natural gas service is not available in all the areas where residential developments occur. This is especially true in Montana, but is also problematic in the outlying suburbs of Seattle and Portland. Over 98% of the forced air furnace systems in Table 3.17 were fired by either natural gas or propane.

The use of heat pump systems (which are also ducted forced air systems) is partly explained by the lack of gas availability. This trend does not apply in Idaho and Montana, where heat pumps are thought to be ineffective and expensive. Even in western Oregon, the market seems to avoid heat pumps. In Washington, on the other hand, heat pumps are often used as a substitute for gas heating in areas where gas is unavailable, particularly when cooling is desired.

Electric resistance zone heating has been very common in the region throughout the last two decades. In the NORIS study (Palmiter and Brown, 1989) of homes constructed between 1980 and 1986, 60% of homes were electrically heated, about equally divided between forced air and electric resistance heating. In this review, the total electrical resistance heating is less than 5%, and almost all of these homes have the ability to be wood heated (especially in Montana). Even a comparison with the 1994 Oregon sample shows that electric resistance heat has ceased to be a realistic option in the Oregon market.

The protocol used for this study probably underestimates the level of cooling equipment actually installed. Cooling equipment is often installed at the owner's option after the home's completion. Because field reviews were conducted during the construction process, there was ample opportunity for cooling equipment to be installed afterward.   Cooling equipment is far more prevalent in Idaho than in the other states, with systems evident in more than 70% of new homes. Especially in the Boise market, cooling is apparently considered essential in all new homes and included in permit documentation. In southeast Washington a similar pattern was apparent with cooling included in about 80% of the homes.

Table 3.18 summarizes the characteristics of gas heating systems. Because of the dominance of these systems, the other systems types cannot be summarized—sample size and data collection errors would make such a summary misleading. Included in this table is a summary of the heating system capacity sizing criteria practiced in each state. This ratio is calculated by dividing the observed furnace output capacity by the heat loss rate calculated from the UA analysis done on the building envelope.

Table 3.18: Gas Furnace Efficiency and Capacity

State	Efficiency			Capacity			
	N	AFUE (%)	High Efficiency (%)[1]	N	Load (KBTUH)	System (KBTUH)	Ratio
Idaho	73	82.0	16.4	71	33.3	62.9	1.92
Montana	36	83.3	25.0	34	50.0	75.7	1.60
Oregon	31	81.8	12.9	21	25.6	62.0	2.78
Washington	109	80.50	6.2	114	29.2	61.4	2.16

1 Percent of units with AFUE>90

Heating efficiency for gas forced-air furnaces varies due to the mix of standard efficiency and high efficiency units in a given market. In the Idaho market, the average AFUE is 82.0 percent. This is largely due to a combination of 80% efficient AFUE furnaces in approximately 84% of the homes. About 16% of the homes in the Idaho market have high efficiency (90+) gas furnaces.

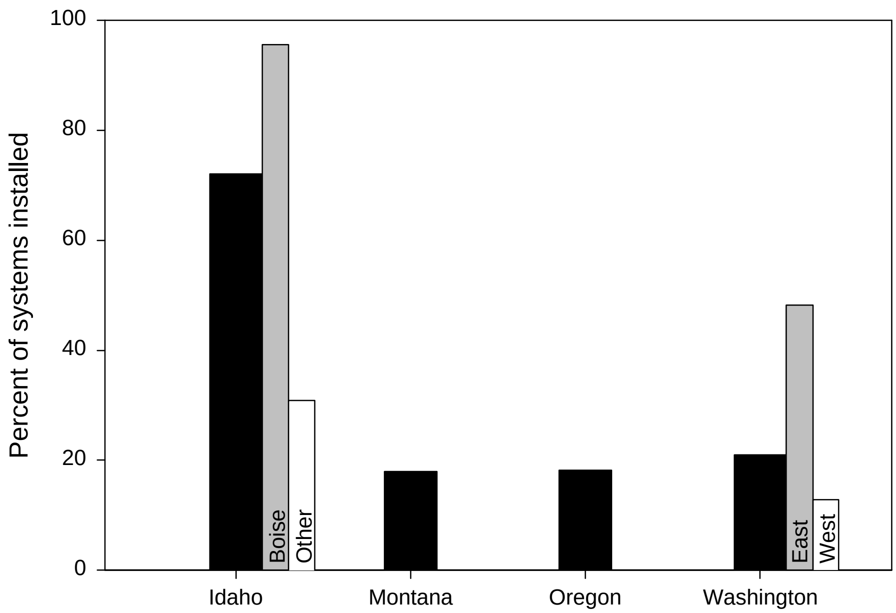
The most wide-spread use of high efficiency (90+) gas furnaces was seen in Montana, where 25% of the sample used these systems. The remainder of the heating and cooling system selections are similar to those of Oregon and Washington.

In the Oregon market, there does not seem to be any significant advantage attributed to high-efficiency gas furnaces, as only roughly 13% of homes are built with such equipment. Even less attention seems to be paid to high efficiency furnaces in the Washington market. Presumably, Washington builders see no advantage in code compliance or marketing for this technology. For the most part, the furnaces observed in Washington met (but did not exceed) the minimum requirements of the energy code.

In Washington and Idaho, the industry seems to have standardized on furnace sizes that are about twice as large as the calculated heat load. In Montana, the overall sizing is influenced by a few homes that are probably designed to use wood as a supplemental fuel. In Oregon, the residential code does not regulate furnace size. The overall load is the lowest of any state in the region, largely the result of the low design temperature difference of the Oregon climate and reduced heat loss rates associated with the Oregon building practices. This seems to result in large furnaces relative to design heating load.

Cooling equipment has become important in the region over the last ten years. Figure 4 summarizes the saturation of cooling equipment observed in homes or planned as part of the HVAC systems. In only a few cases were the auditors able to directly observe the units installed, rendering the specific information on cooling system efficiency unreliable. The information indicates that none of the cooling units observed represent a substantial improvement over minimum code requirements.

Figure 4: Cooling Equipment by State



Aside from Idaho, the region seems to average a cooling equipment saturation of about 20 percent. Based on surveys of other new construction (Baylon, et al, 1995), this estimate is probably biased low for Washington and Oregon. In Montana, Oregon, and Washington, the average size of homes with cooling exceeds the size of other homes by more than 25 percent. This suggests a trend toward upper income homes with installed cooling equipment.

In Idaho, on the other hand, there is no appreciable difference in size between homes with cooling equipment and homes without such equipment. When the Boise area is separated from the rest of the state, the saturation of central cooling falls to about 30 percent. This is higher but comparable to other states in the region.

The largest percentage of homes with heat pumps is in Washington, where they comprise about 13% of the sample. This accounts for about half of the installed cooling equipment. The cooling in the Washington market is dominated by climates in eastern Washington, where saturation of cooling exceeds 50 percent. The Tri-Cities and the Spokane area both have cooling loads and cooling equipment saturation comparable to those of Boise.

3.2.7. Fuel Selection

Natural gas is the dominant heating fuel in all states. Propane, zonal electric systems, and heat pumps have relatively small saturations, and these vary from state to state.

The Washington market has by far the lowest saturation of natural gas in new construction in the region. This seems to be most easily explained by the fact that a great deal of development in the Washington market is occurring outside of the main developed areas where gas is available. Homes in areas like the outlying suburbs of Seattle (where gas is not available) are installed with propane or heat pumps. In the Washington market, the saturation of heat pumps is also the highest of the regional samples, although the saturation of electric-resistance heat is comparable with the markets of the other three states. Table 3.19 summarizes the fuel selection by state.

Table 3.19: Heating Fuel Selection (Percent by State)

State	Fuel Type (Percent of Floor area)				
	Gas	Electric		Propane	Other
		Resistance	H.P.		
Idaho	87.8	5.7	0.9	5.7	0.0
Montana	82.0	6.5	1.8	9.3	0.4
Oregon (1999)	90.3	0.8	4.7	0.0	4.2
Oregon (1994)	72.0	23.6	3.0	0.0	1.4
Washington	67.6	6.5	14.6	10.1	1.3

Montana has one of the larger saturations of electric heat in the region. We suspect that this is primarily used as a back-up to wood heat (although, at the stage of the audit, the presence of wood heat often could not be discerned). The availability of natural gas service seems to determine this decision. In Montana, about an equal number of homes are installed with electrical-resistance heat as are installed with on-site propane.

The Oregon sample is dominated by natural gas heating to a much greater extent than in Washington or Montana, and is fairly comparable to Idaho. This is striking when compared with the 1994 Oregon sample. The saturation of gas heat seems to have increased by a substantial fraction, from 72 to 88 percent. Part of this effect is explained because the relatively small current sample is dominated by Portland area homes, where gas is readily available. Even so, the overall saturation of gas heat seems to have increased by 10% to 15% since 1994.

A more striking comparison can be made by looking at electric heat. In 1994, 24% of the homes used electric-resistance heat (usually with electric-resistance furnaces). This category almost completely disappeared from the current sample and, apparently, from the Oregon market. Where gas is not available, heat pumps have been used, with almost three times as many heat pumps (by percentage) in the 1999 sample as in the 1994 sample.

3.2.8. Duct systems

The data indicates a strong trend towards ducted forced air heating systems. Table 3.20 summarizes the percentage of floor area served by each delivery system for each state. Significantly, baseboard and wall heaters serve a very small portion of the overall floor area. This is a result of the trend toward gas forced air systems throughout the market.

Table 3.20: Delivery Systems Types

State	Heat Delivery System (Percent of floor area)		
	Forced Air	**Hydronic**	**In Space***
Idaho	93.2	1.1	5.7
Montana	69.0	24.0	7.0
Oregon (1999)	100.0	0.0	0.0
Oregon (1994)			
Washington	92.8	2.9	4.3

***Baseboards, wall heaters, and wood stoves**

Field review included a review of the duct system. Inspectors were asked to review the ducts and classify duct location, duct type, and duct sealing technique. Duct leakage measurements were not taken.

Tables 3.21 and 3.22 summarize the findings in the review of duct systems in the four states. The results of this review are as expected, despite the surprising extent to which flex duct (usually in combination with sheet metal) dominates Washington, Oregon, and Idaho—almost to the exclusion of other systems. Only in cases where ducts are in heated spaces (especially basements) do sheet metal ducts dominate in these states.

In contrast, the Montana ducts are almost entirely sheet metal. This is partly due to the preponderance of heated basements in the Montana sample (causing more ducts to be classified as being in conditioned spaces). Yet even when this is not the case (e.g., in attics, crawlspaces, and other unheated buffer spaces), sheet metal ducts seem to be the norm in Montana. Moreover, the percent of homes with ducts in Montana is much smaller than in the other states. About 35% percent of homes in Montana do not have ducts. This is largely due to the large number of hydronic hot water heating systems seen in Montana (almost 20% of the sample). In addition, electric zone heating and gas space heaters are common in Montana, although we suspect these systems are used as back up heat in primarily wood-heated homes. In any case, duct efficiency is not a factor in this subset of homes. Even in homes with ducts, the common practice of locating the ducts in heated spaces negates the effects of heat loss through duct leakage.

Table 3.21: Duct Material (All States) by Location

Duct Location	Duct Type (percent by location)		
	Flex Duct	Sheet Metal	Mixed
Crawlspace	82.2	12.6	5.2
Attic	100.00	0.0	0.0
Garage	68.6	25.7	5.7
Heated Space	19.4	77.4	3.2

Table 3.22: Duct Construction by State

State	Percent Homes	Duct Type (in percent)			Percent Duct Efficiency*
		Flex	Sheet Metal	Mixed	
Idaho	95.2	84.4	10.1	5.5	80.7
Montana	65.6	9.1	90.9	0.0	86.2
Oregon	100.0	78.1	8.8	13.1	80.2
Washington	91.1	69.1	24.0	6.9	82.7

***Duct efficiency is calculated based on reported characteristics**

The mix of hard ducted sheet metal and flex is fairly arbitrary. Generally, even all flex-duct systems have some sheet metal in plenums and fittings. The “Mixed” heading (Table 3.22) applies to systems in which some of the duct runs that could be flex are actually sheet metal.

Duct efficiency in Table 3.22 is based on the duct location, return location, and furnace location. These efficiencies are assigned based on duct research conducted on heating systems throughout the region (see, for example, Davis et al, 1998). While these assumptions do not take into account poor workmanship or other defects, they do account for the expected impact of moderately well-sealed ducts in unheated buffer spaces.

Table 3.23 summarizes duct-sealing and fastening techniques.

Table 3.23: Duct Sealing Type (Percent of Ducts)

State	Duct Tape	Butyl Tape	Mastic	Panduit	Screws	Mechanical Seals Only
Idaho	53.9	3.1	1.8	66.4	33.4	6.1
Montana	9.8	14.0	0.0	9.5	82.0	50.0
Oregon	42.0	15.7	0.0	39.4	61.1	9.1
Washington	55.4	3.4	0.0	38.6	61.7	15.4

Duct tape, butyl tape, and mastic are all sealants. Panduit straps and screws are used in flex duct systems, and screws are used in sheet metal systems. The last column in Table 3.23 summarizes the number of ducts that have no sealant (duct tape or mastic sealant). This is a small percentage in Oregon and Idaho. In Montana, half the ducts have no duct tape or mastic sealant. The vast majority of these ducts are located in heated spaces. The primary sealant in almost all cases is conventional duct tape, supplemented with some higher-quality butyl duct tape; virtually no mastic was observed.

This sample was conducted in homes permitted and built in the first half of 1999, prior to the impact of Oregon's tax credit aimed at higher-efficiency duct systems. For the most part, this picture seems consistent throughout Oregon, Idaho, and Washington: flex ducts are attached with screws and panduit straps, and sealed with duct tapes.

3.2.9. Domestic Hot Water Systems

The type of domestic hot water (DHW) systems observed in this sample were largely determined by the type of fuel selected for the space heating system. About 95% of the domestic hot water systems were fueled by the same fuel that fired the space heating system. In cases where the DHW fuel choice differed from the space heat fuel, the fuel selected was equally divided between electricity and propane. In general, it appears that the DHW system used natural gas if it was available. The variation between states is largely an artifact of the gas availability in the particular sample. Table 3.24 summarizes DHW fuel by state.

Table 3.24: DHW Fuel Selection by State

State	**Fuel Choice (%)**		
	Electric	**Gas**	**Propane**
Idaho	2.6	92.1	5.2
Montana	13.2	77.4	9.4
Oregon	9.1	90.9	0.0
Washington	14.0	75.7	10.3

There was very little variation in tank size of heating capacity provided in the tank. The typical tank size is between 40 and 50 gallons with a 30,000 to 40,000 BTU for DHW systems heated by natural gas or propane and 4.5 kW for systems heated by electricity. These sizes were consistent across states and across other variations in house size and construction.

4. Performance and Energy Efficiency Standards

The characteristics described in Chapter 3 were used to create overall building heat loss rates for each building. In this section, the characteristics information will be combined with climate and heating system characteristics to produce an estimate of the overall energy impacts and performance consequence of the building characteristics observed.

These have been compared in a variety of ways:

- A direct comparison of overall heat loss rates between states.
- A comparison to heat loss rates that would be expected if the building had been built to local standards or energy codes.
- Building energy simulations were completed for each building to create an overall performance measure on space heating; the resulting energy use is compared by state, and compared to energy use simulations resulting from code runs.
- The impact on heating fuel requirements was calculated using the characteristics of the heating system; cooling system impacts were not evaluated.

4.1. Overall Heat Loss Rates (UA)

Overall building heat loss rates were developed from the characteristics data. Infiltration levels were assumed to be the same for all homes (0.35 ACH) and were included in overall heat loss and performance comparisons.

Code heat loss rates were developed by applying the residential codes discussed in the previous section. In Oregon and Montana, the standards are essentially prescriptive, and trade-offs are (theoretically) not allowed. For this analysis, however, we established a performance level using the prescriptive standard applied to these homes and compared them to the heat loss rates of the same homes as observed in the field. In Idaho and Washington, the standards are based on component trade-offs: builders are allowed to reduce the performance of one component of the building if the performance of another standard is correspondingly increased.

The standards by state are fairly similar: Montana, Idaho, and Washington have nominal insulation standards that are quite comparable. This is particularly true in the Washington code regulating natural gas and heat pump homes, which dominate the Washington market. Only Oregon has appreciably higher insulation and thermal performance standards, though Oregon as an aggregate has the warmest climate in the region. Table 4.1 summarizes the results of the standards comparison across the four states. For Idaho and Washington sub-regions are shown separately.

Table 4.1: Overall Heat Loss Rates (by State)

State	UA/FT²		% Pass	N
	Buildings	Code		
Idaho	0.267	0.261	51.9	104
Boise	0.285	0.270	31.7	63
Other	0.240	0.247	82.9	41
Montana	0.245	0.251	86.8	61
Oregon (1999)	0.220	0.230	100.0	44
Oregon (1994)	0.232	0.236	98.5	283
Washington	0.242	0.264	93.6	157
Zone I	0.245	0.265	92.9	142
Zone II	0.217	0.248	100.0	15

4.1.1. Idaho

When compared on a whole-house UA basis, only Idaho has homes considerably below standards. This appears to be the result of spotty enforcement, since almost all of the homes in our sample were theoretically regulated by the IRES in the Boise market. While the overall compliance rate for all homes in Idaho is only 50%, excluding the Boise area increases compliance levels to approximately 80% (in keeping with levels seen in the rest of the region).

The actual heat loss rates for Idaho also improve when one exempts Boise. This is largely due to the use of insulated crawlspace walls as a deemed-to-comply IRES path in the Boise market (almost to the exclusion of other floor insulation or floor construction strategies). This results in a dramatic increase in heat loss rate: almost 20% higher in the Boise area than in the rest of the state. The remainder of Idaho construction, both in overall heat loss rate and standards, is similar to that of the other three states.

4.1.2. Montana

The Montana homes are generally built in areas where residential codes are not enforced. Nevertheless, homes are typically built to comply with a nominal standard (with a compliance rate of about 86%). Furthermore, despite the differences in component requirements in Montana, the use of high-quality glazing often offsets short-falls in opaque components, so that the overall heat loss rates are consistent with the standards set in the Montana code and are comparable with Washington and Idaho (Boise excepted).

4.1.3. Oregon

The Oregon sample was abbreviated in this review. However, the Oregon results presented include both with the current review (which represents a fairly small sample dominated by the urban areas of Oregon) and a much larger survey conducted in 1994 (which represents a broad cross-section of the state). Homes in Oregon seem to have improved, and compliance with the Oregon prescriptive standards is essentially 100 percent.

The performance increase in the homes in the Oregon sample is due almost exclusively to improvements in window specifications between the 1994 and 1999 samples. In 1994, windows were allowed that were not labeled under the NFRC protocol. To make a transition from previous window manufacture testing practice to the NFRC, Oregon allowed a relaxed window standard. This transition period ended at the beginning of 1994; however, most homes surveyed in 1994 were permitted prior to this time. Thus, window performance in Oregon between 1994 and 1999 improved by about 10%; overall heat loss rates improved by roughly 5 percent. Windows aside, Oregon building practices have changed very little over this period.

4.1.4. Washington

The Washington situation suggests high levels of compliance and enforcement in the Washington energy code; this code is less stringent than any other code in the region, aside from that of Idaho. This statement does not apply to electrically-heated homes, but since natural gas and heat pumps dominate the Washington market, the code which must usually be met is less than or equal to that of Idaho. That said, the level of compliance in Washington is well over 90% and the level of performance is 10% better than the standards mandate.

Standards and enforcement for crawlspace insulation have a large impact on overall code compliance, especially in Idaho and Montana. In Idaho, particularly, insulation for crawlspace walls is deemed to satisfy an R-19 floor-insulation strategy. This is reflected in reduced crawlspace performance, so that even though the standard for Washington and Idaho is similar, the enforcement of crawlspace insulation standards in Washington severely restricts the use of crawlspace plenums, while in Idaho it is the building standard.

The Washington non-electric code uses a window standard of U = 0.65 as the basis for trade-off. This level was established in 1986, prior to the advent of mass-produced and inexpensive vinyl windows. In almost all homes in Washington, window performance exceeds standards by 30 – 40 percent. In some cases, builders take advantage of this improved performance by trading-off glazing in favor of 2x4 walls. This reduces the overall performance of the homes, but allows the home to remain in compliance with the standard.

In Zone II, which includes the colder areas of Eastern Washington, standards are somewhat more stringent, though even here the window requirements are U=0.60 or less. Installed windows exceed this standard by 20 – 30 percent. The higher code window standards make a trade-off between 2x4 walls and improved windows impractical in this climate zone.

4.2. Heating Energy Performance

4.2.1. Heating Climates

The above summary of characteristics and heat loss rates is independent of the severity of the climate. Generally, the Montana and Idaho climates are considerably more severe than the Washington and Oregon climates. The number of heating degree days reflects these climatic differences. Montana has a substantially colder climate than any of the other states; Oregon has the mildest climate. Figure 5 summarizes the degree days in the climates reviewed in this study by state and study area.

Each home was assigned to a weather site with an available summary. In some case, these files were derived for regional assessments using weather data adapted from various local sources, and in some cases the files were directly adapted from TMY2 (Typical Meteorological Year) weather summaries developed as part of a national effort. For the most part, these weather assumptions were consistent with previous studies and study results throughout the region, with one notable exception: the Seattle weather site was considerably altered by the use of the TMY2 summary. When compared to the TMY1, TMY2 files for Seattle are almost 10% warmer. Minor changes are observed in all the other sites; but this shift is substantial and reflects difficulties and inconsistencies in the long-term weather record during the TMY1 period which were corrected when TMY2 was assembled.

Figure 5: Annual Heating Degree Days by State

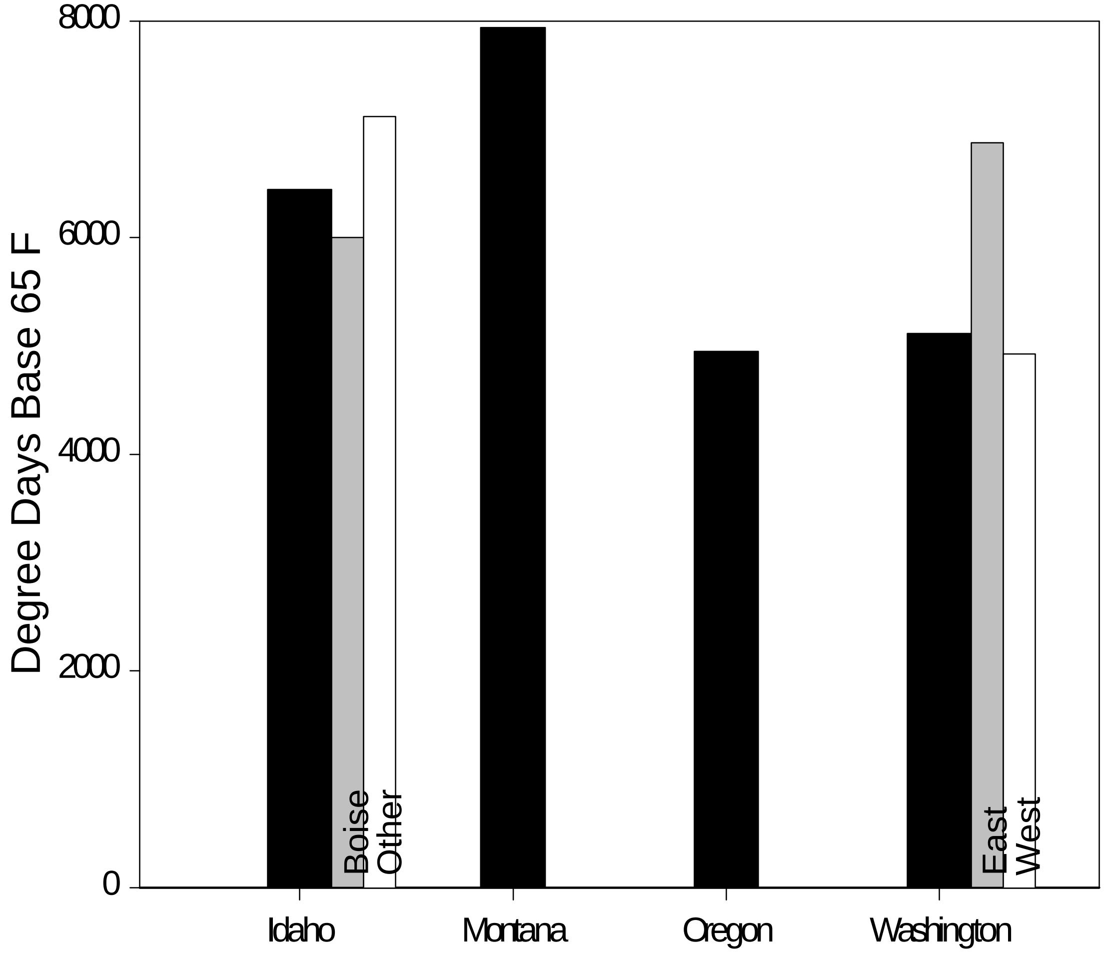


Table 4.2 shows the weather site assignments in each of the states and summarizes the heating degree days associated with those sites. Each home reviewed was assigned an appropriate weather site. The heating degree days (base 65°) shown in Table 4.2 are taken from the TMY files or derived from *Sunday*® files. The number of sites assigned to each weather location is also summarized in Table 4.2.

Table 4.2: Weather Sites

State / Region	N	Degree Days
Idaho		
Boise	73	6,001
Idaho Falls	1	8,171
Pocatello	3	7,292
Soda Springs	10	8,502
Spokane (WA)	17	6,888
Total	**104**	**6,444**
Montana		
Billings	9	7,092
Bozeman	16	8,069
Dillon	2	8,463
Great Falls	1	7,754
Helena	5	7,815
Kalispell	15	8,319
Total	**61**	**7,935**
Oregon		
Eugene	3	4,628
Medford	5	4,830
Portland	21	4,461
Redmond	7	6,735
Salem	8	4,868
Total	**44**	**4,950**
Washington		
Bellingham	5	5,769
Olympia	10	5,491
Portland (OR)	22	4,461
Republic	1	8,341
Richland	5	4,824
Seattle	89	4,867
Spokane	12	6,888
Whidbey	9	5,396
Yakima	4	6,059
Total	**157**	**5,114**

4.2.2. Building Simulations

To evaluate overall performance, a *Sunday*® building simulation tool was employed using heat loss rates derived from the building review. (*Sunday*® is a building load simulation program which predicts heating load based on the building shell characteristics.) This is in keeping with engineering performance predictions used in regional residential conservation supply curves and regional performance evaluation techniques. This simulation used values for a thermostat set point of 65° and building infiltration of 0.35 ACH. This is consistent with the ASHRAE standards and reasonably similar to blower door results from other regional studies (Palmiter, et al. 1989; Frankel et al. 1994).

The *Sunday*® runs were made on buildings as observed in field evaluations. Heat loss rates, window characteristics, orientation, and building mass were all derived from these records. For purposes of this analysis, heating system efficiency and duct system efficiency were analyzed separately from the characteristics review and assigned duct value efficiency discussed in Section 3.

To compare performance standards, some accommodation was made for heating system efficiency. While this modestly changes the overall compliance rates, the nature of these changes depends largely on assumed values for duct and furnace efficiencies in more than half of the cases. Thus, comparison on a performance standard as a compliance evaluation is not appropriate. Nevertheless, Table 4.3 compares the building load using *only* the shell characteristics and climate zone derived directly from the *Sunday*® runs. These results have been normalized to thousands of BTUs per square foot of building area.

Table 4.3: Heating Performance—Building Only (KBTU/ft^2)

State	Proposed			Code		
	Gas	Electric	Heat Pump	Gas	Electric	Heat Pump
Idaho	23.9	23.4	27.0	23.0	26.5	26.1
Montana	27.5	38.3	24.4	29.0	38.8	27.2
Oregon	12.2	14.5	12.3	13.4	16.3	13.7
Washington	15.5	10.7	14.6	17.9	11.7	17.7

Clearly, there are significant climatic differences within the region, although the differences between Idaho and Montana are considerably reduced as the higher heat loss rates in the Idaho sample are taken into account.

In Oregon, the overall impact of both the code and the actual practice result in an aggregate performance superior to that of any other state, although when compared to the Washington electric code and the actual practice in electric-resistance heated buildings, the overall Oregon performance suggests a less effective standard. In fact, the electric resistance code in Washington is somewhat more stringent than Oregon.

In Washington, the most striking feature of the overall load is the difference between the electric and non-electric codes. The non-electric code applies to homes that use heat pumps or gas heating systems. The difference between overall building load for “non-electric” homes versus electric homes results in a 40% increase in normalized heating requirements. This more relaxed standard results in buildings that are less efficient than those of Oregon and comparable to Idaho and Montana. The milder climates of Washington result in a substantial reduction of building load over those observed in Idaho and Montana.

Table 4.4 collapses the building performance described in Table 4.3 and shows the results of the equipment efficiency and duct efficiency on these homes. The information has been normalized to thousands of BTUs per square foot.

Table 4.4: Performance with Heating System (KBTU/ft^2)

State	Building Only	Building with Heat Sys	Building with Heat Sys and Ducts
Idaho	23.9	28.9	35.9
Montana	28.9	33.4	37.2
Oregon	12.4	14.5	18.1
Washington	15.0	16.8	20.1

For the most part, this aggregate reflects the use of ducted heating and heating equipment efficiency systems. In this calculation, the difference between Idaho and Montana almost completely disappears. This is mostly the result of duct locations in the heated envelope (basements), which are common in Montana and much less common in the other states.

Duct efficiencies were derived from the field description assuming reasonably well-sealed supply duct in unheated buffer spaces and moderate leakage from return ducts and furnace cabinets when installed in unheated or buffer spaces (e.g., garages and attics). These efficiencies were multiplied together to get an overall efficiency estimate summarized in Table 3.18. Ducts located in heated spaces were assumed to have delivery efficiencies of 1.0. The duct efficiencies reflect this assumption and likely indicate an optimistic assessment of the long-term performance of ducts, especially in the unheated buffer spaces of Idaho, Oregon, and Washington.

Even though the Montana climate is almost 25% colder than that of Idaho, the overall heating requirement increased by only 3 percent. This is due partly to the improved building shell in the Montana and partly to the fact that more than a third of homes do not use ducted heating systems.

Figure 6 shows the contrast in energy performance within each state. The “Building Only” bars show the comparison between the heating energy demand from the building envelope and infiltration only. The “Heating System” bars reflect the overall energy use when taking the duct and furnace into account.

Figure 6: Heating Performance by State

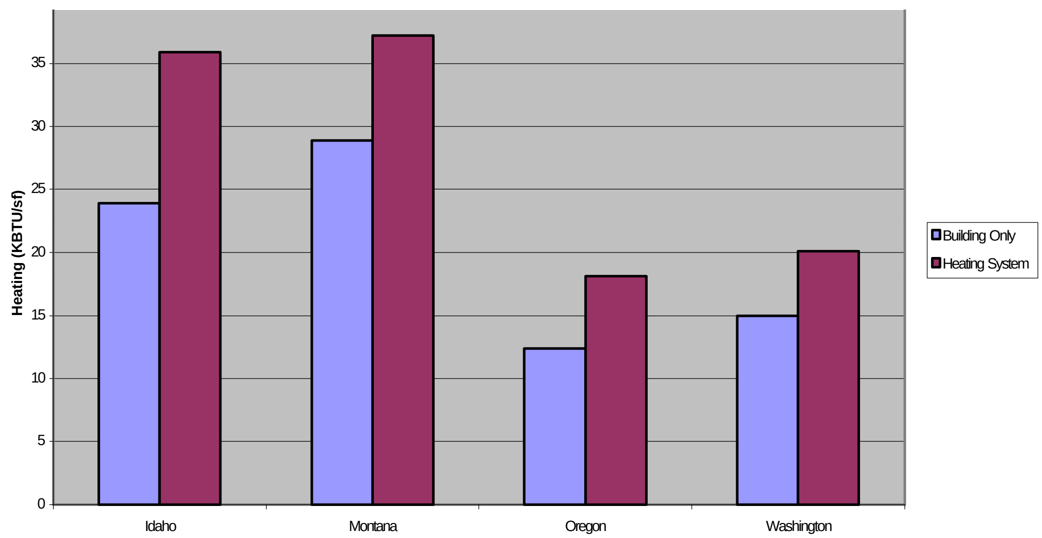


Table 4.5 reassesses the overall heating energy usage in each state, taking into account heating system and duct efficiency. The table expresses total fuel use in therms and kilowatt hours as applicable to the particular heating systems and assumes the entire house is heated to a uniform temperature. The impact of cooling in any of these houses is ignored for this summary. Consumption has been normalized by square feet.

Table 4.5: Overall Fuel Use

State	Gas			Electric			Heat Pump		
	N	Th	Th/ft^2	N	KWH	KWH/ft^2	N	KWH	KWH/ft^2
Idaho	99	683	0.37	4	15,675	6.9	1	9271	5.1
Montana	52	931	0.38	6	17,005	11.7	1	6337	2.3
Oregon	39	462	0.19	1	8,436	5.5	3	4670	2.2
Washington	119	524	0.23	12	6,006	3.5	22	6446	2.6

Wood heating is not accounted for in these homes, although the home in Montana with an explicit wood heat system has been eliminated from the summary.

For convenience, Table 4.6 reiterates overall house size for each fuel category used to normalize performance estimates.

Table 4.6: Sample Characteristics (by Fuel Use)

State	Gas		Electric		Heat Pump	
	N	Ft^2/ Home	N	Ft^2/ Home	N	Ft^2/ Home
Idaho	99	1,925	4	2,399	1	1,818
Montana	52	2,636	6	1,668	1	2,694
Oregon	39	2,394	1	1,520	3	2,224
Washington	119	2,281	12	1,651	22	2,421

These overall performance numbers reflect the results of the performance simulation, particularly in the homes with gas heating. Since gas predominates in all states, the comparison of gas-heated homes is by far the most statistically valid and most easily generalized. With relatively small samples of electric and heat pump homes in all states other than Washington, it would be extremely difficult to generalize results for these fuel types and heating systems, though some interesting observations could be made.

The most dramatic feature of the electric tables is the single Montana heat pump case. This home is built consistent to Montana construction standards, except that it uses a ground-source heat pump. This is the only heat pump in the Montana sample, and we believe that this reflects the market conditions in the state: for better or for worse, air source heat pumps are not considered effective in the severe climates of Montana, but ground source heat pumps have a small market share.

In Idaho, similarly, only one heat pump was recorded, though this was a more conventional air-source heat pump. The impacts of the lower efficiency air source heat pump, coupled with the lower efficiency building shell, result in a striking contrast with the Montana case. The Idaho home shows an energy use about 50% higher than the Montana home in a much colder climate.

The buildings using electric-resistance heating in Idaho, Montana, and Oregon are fairly different from the population at large. They tend to be smaller and are usually characterized with a secondary heating system such as a wood stove. Whether this reflects the nature of electrical heat use in these markets is difficult to say, since the sample size for electric heat is usually too small to generalize to any population. In Washington, it appears that the electric heat sample is sufficient to assert that these homes are representative. When compared to the heating load in other Washington homes, they are considerably more efficient, both in terms of building shell and heating systems. This reflects not only the impact of the improved shell, but also the effect of the un-ducted zonal electric systems typical of this population.

Given these two effects, when cost of heating is compared between the gas and electric homes in the Washington sample, the difference in heating costs is much lower than the difference in fuel costs. In the Washington markets, cost of electricity (per BTU of space heating) is roughly three times the average cost of gas for space heating (1999 prices). Even with this difference in fuel costs, there is only about a 25% difference in the expected heating costs of the electric homes. Furthermore, since the electric systems are generally zonal, the cost difference between the fuel types is further reduced. The difference between consumer heating costs for the two fuels is almost completely erased by the more efficient electric zone heating system and the more efficient building shell mandated by the Washington residential energy code.

5. Residential Builder Interviews

Interviews were conducted with residential builders and other design professionals in all four states. In some cases, the interviews were conducted as part of the field review. When this was not possible, one to three follow-up telephone attempts were made to recruit each builder of homes that had at least received a cover review. This resulted in an interview pool about ten times larger than that of the field reviews. Consequently, interviews did not necessarily correspond to builders who built the homes where field reviews were conducted. The interview protocol and complete results are presented in Appendix B. Response rates varied widely by state, which introduces weighting difficulties when cross-state comparisons are attempted. In general, the level of cooperation was very poor in Idaho and Montana. Table 5.1 summarizes the responding population for each state.

Table 5.1: Residential Professional Interview Sample

Profession	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Builder/Gen. Contractor	5	100	21	100	96	89	80	83	202	88
Developer/ Builder	0	0	0	0	10	9	10	10	20	9
Developer	0	0	0	0	1	1	3	3	4	1
Architect	0	0	0	0	1	1	0	0	1	1
Owner	0	0	0	0	0	0	4	4	4	1
Total	5	100	21	100	108	100	97	100	231	100

In Idaho, each builder was contacted at least twice, and most were contacted three times. Even with this level of effort, only 5 responses were received for the entire state. This sample was much too small to allow any meaningful extrapolation of the results. Therefore, separate results for Idaho have not been presented.

About 60% the builders interviewed build 10 or fewer houses per year, representing less than 25,000 ft^2 of total home construction. Only 2% of those interviewed built more than 500,000 residential ft^2 per year. As expected, the fraction of small builders in Montana was higher than in Washington and Oregon.

When asked about the price ranges of the homes constructed, somewhere over half of the builders in each state claimed to be building “Medium Priced” housing. The distribution of home built for the low end did differ between states, with Montana builders claiming to build for that market less than half as often as Oregon and Washington. It should be pointed out, however, that housing prices in Montana are much lower than in the urbanized areas of Seattle and Portland, so most of the Montana housing would actually classify as “Affordable” if it were built in Washington or Oregon. Table 5.2 summarizes these responses.

Table 5.2: Distribution by House Price

State	Low End		Medium		High End		Total
	N	%	N	%	N	%	N
Montana	3	13	14	58	7	29	24
Oregon	35	30	60	52	20	17	115
Washington	27	26	137	56	19	18	183

In Washington and Oregon the "High End" houses were generally designed by architects as custom homes. In Montana, the category "Custom Home" usually does not imply an architect-designed home but rather a builder-adapted design. This category encompasses both high end and medium priced homes. In all states the combination of custom-designed homes and architect-designed homes represents 60 to 70% of the construction of this group of builders.

5.1. Construction Techniques and Practices

Builders were asked about their current practices regarding some of the same building components focused on in the field reviews. Builders were also asked about their perceptions of the general practices within their respective fields, and about the importance of energy efficiency to them and to their customers.

5.1.1. Insulation

Builders in Oregon consistently reported installing the highest levels of virtually every type of insulation. Compared to Oregon, Montana, and Washington, builders reported using reduced insulation strategies in most categories.

Walls: Oregon respondents indicated that they typically install the highest insulation levels, where 86% of the builders said they typically insulate walls to R-21 or R-22, and an additional 5% indicate even larger R-values. This is presumably driven by the energy code, which mandates R-21. Interestingly, one of the most common remarks about code improvements heard from Oregon contractors was that the non-market standard insulation values required by the code artificially inflate insulation prices.

In Montana, 86% of builders indicated that they typically insulate walls in new homes to R-19, with the remaining 14% indicating they insulate to R-21 or R-22. In Washington, the insulation values were much lower and far more scattered. About 77% of the builders said they typically insulate walls to R-19, with fully 16% indicating their typical wall insulation levels are R-11 or R-13 (consistent with the values seen in the characteristics survey, see section 3.2.1). Only 6% typically use R-21, and only 1% use higher levels in their standard construction. Washington is the only one of the three states in which insulation trade-offs are common paths to energy code compliance. Table 5.3 summarizes the typical wall insulation levels installed by builders.

Table 5.3: Typical Wall Insulation Levels (Percent)

R-Value	Montana	Oregon	Washington
<R-19	0	2	16
R-19	86	7	77
R-21/R-22	14	86	6
>R-22	0	5	1
Total	100	100	100

When asked what other builders typically install, 100% of the builders in Oregon and Montana believed the norm to be R-19. In Washington, 83% said R-19, while 17% thought most builders used R-13 wall insulation.

Floors: Perhaps due to the relative prevalence of basements by state, the levels of floor insulation that builders say they typically install varies widely across the states. Table 5.4 shows the typical floor insulation values cited by builders.

Table 5.4: Typical Floor Insulation Levels (Percent)

R-Value	Montana	Oregon	Washington
None	56	0	3
R-10/R-11	6	0	3
R-19	22	2	58
R-21	0	5	2
R-24/R-25	0	77	2
R-28/R-30	11	11	31
>R-30	5	5	1
Total:	100	100	100

In Montana, more than half of the builders do not install any floor insulation. Perhaps more surprisingly, 22% said they insulate floors to R-19 and 11% to R-30, even though typical new homes in Montana have partially- or fully-finished basements. In Oregon, all builders said they use some floor insulation; 76% indicated they typically install R-25 (Oregon code prescriptive requirement) to crawlspaces, and 10% said they install R-30. (One Oregon builder even indicated that he consistently uses R-54.) In Washington, most builders (57%) typically insulate floors to R-19 and 30% install R-30, consistent with prescriptive code values for Washington homes. These results are consistent with the results of the field survey.

Ceilings: Washington ceiling insulation levels lagged behind the other states when compared to claims of builders in Oregon and Montana. This largely reflects the various energy codes in each state and is quite consistent with the results of the field survey. Table 5.5 summarizes these results.

Table 5.5: Typical Ceiling Insulation Levels (Percent)

R-Value	Montana	Oregon	Washington
R-30	0	12	53
R-31 to R-38	76	80	45
R-40 to R-50	24	7	1
>R-50	0	1	1
Total	100	100	100

5.1.2. Windows

The interview results regarding typical window installations did not vary much from the field review results. In Montana, the most commonly used window is a double-glazed unit with vinyl or wood frames, cited by about 81% of the builders interviewed. In Oregon, coatings and gas fills were mentioned more often as the typical installation. Interestingly, 42% of Washington builders claim to build to the Montana level, while another 42% use windows typical of those cited by the Oregon builders. The characteristics review (Section 3.2.2) suggests that this is an overstatement. The responses of the Washington builders indicated that they typically use Class 40 windows. The Washington homes in the field study, on the other hand, were dominated by Class 50 windows, with almost two-thirds of the windows being in this category. The vast majority of the builders of these homes claim that they use the higher performing windows. For Oregon and Montana, the results of the interviews were consistent with the field observations.

Table 5.6: Typical Window U-Values (Percent)

U-Value	Montana	Oregon	Washington
<Class 40	10	78	42
Class 40	81	22	42
Class 45	0	0	2
Class 50	10	0	14
Total	100	100	100

5.1.3. Energy Code

While this study was not specifically an examination of energy code compliance, attitudinal information about local standards was collected. All of the builders outside Idaho indicated that they were subject to some standard (even in Montana). While the overall tone was that of satisfaction with standard requirements, ventilation and related moisture concerns and insulation requirements were the top two issues mentioned by builders in all of the states. Comments regarding insulation were generally related to perimeter insulation requirements in crawlspaces and to the expense of requiring batt values not commonly produced by manufacturers. No other issues were mentioned by more than 5% of the total respondents to this question (see Table 5.7).

Table 5.7: Builder Attitudes: Negative Elements of Energy Code (%)

Description	Montana	Oregon	Washington	Total
Ventilation/Moisture Problems	67	32	58	46
Insulation Requirements	33	37	23	30
Windows	0	5	5	5
Code should be more flexible	0	5	0	2
Other	0	21	14	17
Total	100	100	100	100

Builder Self-Evaluations: Builders were asked to evaluate how the typical values they listed compared to the energy code, and to the typical practice of their competitors. The Montana builders all said that they just met code – even though many of them build exclusively in non-enforcing jurisdictions. Of these, only 15% thought they followed more energy efficient practices than their competitors.

In both Oregon and Washington, about a quarter of the respondents thought they built more efficient buildings than the competition. However, only 31% of Oregon builders thought that their typical installation exceeded code requirements, while 44% of the Washington builders held this opinion. Table 5.8 provides the complete responses.

Table 5.8: Builder Compliance Self-Evaluation Results (Percent)

	Montana	Oregon	Washington
Exceed Code	0	31	44
Meet Code	100	69	55
Do Not Meet Code	0	0	1
Exceed Standard Practice	15	76	71
Meet Standard Practice	85	24	29

Builders indicating they believed their typical practices exceeded those of their competitors were questioned further. When a detailed response was provided, the components most frequently cited as exceeding competitors' standard practices were insulation levels, heating systems, and windows (see Table 5.9).

The field review showed a surprising consistency in the building standards employed within each state. There was very little evidence that any builder built to standards appreciably different (let alone more efficient) than other builders in the same state or market.

Table 5.9: Components Exceeding Standard Practice (Percent)

Component	Montana	Oregon	Washington	Total
Insulation	56	38	41	41
Heat System	19	30	27	28
Windows	12	14	22	18
Ventilation	6	8	4	6
Framing	6	3	2	3
Other	0	7	5	5
Total	100	100	100	100

The builders were also asked whether they *ever* exceeded energy code requirements and their reasons for doing so. Between 70-80% of the builders did sometimes exceed the energy code; customer request was cited as the reason about 40% of the time. Marketing reasons and personal pride were each cited in about 15% of the cases, and 30% of the total respondents indicated that they use energy efficient construction as a marketing tool. Tables 5.10 and 5.11 summarize these results, while Table 5.12 describes the use of energy efficiency as a marketing tool for builders.

Table 5.10: Builder Ever Exceeds Code (Percent)

	Montana	Oregon	Washington
Yes	77	68	79
No	23	32	21

Table 5.11: Reasons for Exceeding Code

	Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%
Customer Request	8	80	17	36	19	37	44	41
Marketing	0	0	7	15	8	16	15	14
Energy Efficiency	1	10	4	9	3	6	8	7
Moral/Political/ Personal Pride	1	10	7	14	8	16	16	15
Cost-effectiveness	0	0	4	9	7	14	11	10
SGC/EarthSmart	0	0	3	6	2	4	5	5
Sound Barrier	0	0	1	2	1	2	2	2
Construction Ease	0	0	4	89	3	6	7	6
Total	10	100	47	100	51	100	108	100

Table 5.12: Builders: Do You Market Energy Efficiency? (Percent)

	Montana	Oregon	Washington
Yes	61	27	31
No	39	73	69

The findings here are also not reflected in the homes observed in the field. Presumably, if builders were in fact confronted with an informed demand for more energy efficient housing, the responses to these questions could be taken as an indication that they would try to meet it.

When asked whether their customers showed any interest in energy efficiency, almost 45% indicated that they do care at least somewhat. Of these, most noted a general, non-specific interest. The concerns most mentioned by customers are insulation, heating system efficiency, and the installation of the heat pumps. Table 5.13 provides more detailed summaries for each state.

Table 5.13: Customer Interest In Energy Efficiency? (Percent)

	Montana	Oregon	Washington	Total
Yes	31	48	43	44
No	69	52	57	56
Total	100	100	100	100
General Interest	38	40	41	40
Heat Pump/Alternative	0	11	14	12
Heat/Cool Cost	50	8	14	14
Insulation/Framing	13	34	25	28
Occupant Comfort	0	2	0	1
Windows	0	6	5	5
Total	100	100	100	100

When builders were asked to rate the relative importance of various measures on overall energy efficiency, insulation was rated far more important than any other measure, followed by windows. Only two thirds of the builders in Washington and Montana recognized or mentioned the importance of insulation levels in the efficiency of the home. This contrasts with the Oregon builders and suggests an explanation for the higher heat loss rates found in Washington and Montana (in spite of the more severe climates). Table 5.14 details the components receiving the highest rating in each state. (The percentages noted in the table do not add up to 100% because each builder was asked to rate the importance of each component on a scale of 1 to 5 [5 being most important]. The table indicates the percentage of "5" ratings for each component.)

Table 5.14: Most Important Energy Impacts (Percent)

Component	Montana	Oregon	Washington
Insulation levels	67	80	66
Windows	25	42	40
Home design	12	15	18
Home size	14	20	31
Framing	13	14	15
Fuel	57	26	42
Appliances	8	8	9

Some of the more interesting results were obtained when builders were asked what they thought would make consumers more interested in buying energy efficient homes. While almost 45% said that nothing short of dramatically higher fuel costs would work, about a third thought that consumer education (and consumer marketing) was the most important factor. This was substantially higher than the number of builders citing first costs as the primary inhibiting issue (11%). These results are included in Table 5.15.

Table 5.15: What Would Increase Importance of Efficiency? (Percent)

Component	Montana	Oregon	Washington	Total
Higher fuel cost	44	44	45	44
Buyer Education	56	32	21	32
Lower First Costs	0	13	12	12
Mortgage/Tax Credits	0	8	12	9
Better Products	0	3	0	2
Builder Marketing	0	0	3	1
Component Labels	0	0	1	1
Total	100	100	100	100

5.2. Training and Builder Outreach

In an attempt to assess the resources utilized by contractors, builders were asked about their sources for training and information. Only 93 interviewees responded to this question. As shown in Table 5.16, about a third of Oregon and Washington builders indicated that they had participated in some sort of training; more than two-thirds of the Montana builders said they had done so. Super Good Cents programs and state training efforts were the most often cited sources of training and information. It should be noted that the training programs associated with these utility efforts have not been offered in most localities since the early 1990s. Apparently, a large number of builders still point to these as significant training programs.

Table 5.16: Builder Training Participation (Percent)

Training	Montana	Oregon	Washington	Total
Yes	65	33	32	35
No	35	67	68	65
Total	100	100	100	100
Seminars	13	56	22	32
Super Good Cents	38	18	30	28
State Training	25	6	30	21
Self Taught	25	19	4	13
College Training	0	0	13	6
Total	100	100	100	100

Builders were specifically asked whether they were familiar with Energy Star® homes and Energy Star® appliance programs (Table 5.17). Montana builders were most familiar with these programs: 35% had heard of one or both. Washington builders indicated the least familiarity, with only about 10% saying that they had heard of Energy Star® programs.

Table 5.17: Builders Familiar With Energy Star® (Percent)

Program	Montana	Oregon	Washington	Total
Energy Star® Appliances				
Yes	63	24	19	23
No	37	76	81	77
Total	100	100	100	100
Energy Star® Homes				
Yes	35	19	11	17
No	65	81	89	83
Total	100	100	100	100

The overall impression given by builders in these interviews was that the energy efficiency of their homes was determined by the codes and standards of their market. Most builders argued that the market does not insist on energy efficiency and so they provide the minimum. Only in Montana is there some evidence that the market insists on certain levels of insulation and window performance. This is particularly fortunate, since only about a third of the homes are built in jurisdictions that enforce energy codes. It is clear that for these builders a change in the market demand for energy efficiency is a precondition to any change in the energy efficiency of the homes built.

6. Conclusions

6.1. Building Market Conditions

A striking and consistent pattern throughout the region in single-family buildings is the strong adherence to building standards and prescriptive code requirements. With the exception of the Boise area, virtually the entire region delivers homes largely consistent with residential construction standards. This is true independent of enforcement, the particulars of the standards, and/or the opinions and predilections of the building industry.

The codes in Oregon appear most successful, both in terms of delivering very efficient homes and in terms of acceptance by builders. In almost no case did we observe significant differences in code compliance in this state; furthermore, this finding is consistent with previous research. This suggests that the code mandated in Oregon has almost completely pervaded the Oregon market.

By contrast, the Montana code is neither stringent nor strictly enforced. The great bulk of homes in Montana are not required to file building permits and do not receive any inspection except for electrical hook-ups. Although often only advisory, the fairly modest Montana code seems to represent most building practices throughout the state.

This did not hold true in Montana for two specific components: window requirements under the code are less stringent than typical window installations in the state, while floor and basement insulation falls noticeably short of the code standards. In most cases, these two effects cancel each other out. This would be a much more auspicious sign if it weren't for the fact that buildings in Montana have 10-15% more heat loss than the buildings of Oregon, while being constructed in a climate with 70% more heating degree-days and roughly double the design heating temperature difference.

Builders in the Montana and Idaho markets commonly argue that no additional cost-effective measures are available in their state. However, builders in Oregon make the same argument while clearly using added insulation and window performance beyond current practice in those colder states. Indeed, with the severity of the Montana climate, considerably higher standards than in any other area of the region might reasonably be expected and would certainly be cost-effective.

An additional problem (and one occurring in both Idaho and Montana) is the insulation strategy implemented for crawlspaces. There are a substantial number of misunderstandings associated with the problem of crawlspace insulation in these severe climate areas. A great deal of the building community's concern relates to freezing pipes and ground buffering. This suggests that insulation is avoided in order to ensure that plumbing and other services are protected by heat loss through house floors. A second common argument is that heat loss through the floor is not important since the direction of heat flow is up, so that little or no insulation should be required in crawlspace and below-grade applications. We believe this illustrates a lack of understanding of the thermal performance of buildings and, more importantly, a lack of design guidelines, insulation guidelines, and consistent thermal information with which to address the builders' legitimate freeze protection (and building science) concerns.

The survey of Idaho homes suggests an effort on the part of the building community to minimize the code and the expenses of meeting it. This is probably the result of competitive pressures, coupled with a lack of perceived enforcement in the majority of jurisdictions in the Boise area. On the other hand, for years, several Idaho building jurisdictions (outside of Boise) have had a reputation for enforcing relatively stringent standards. Idaho Falls, in southeastern Idaho, and the Kootenai County area of northern Idaho have had consistent code programs that have been supported by local utilities and building officials. This fact is reflected both in the overall heat loss rates and in the levels of compliance observed in these areas.

The Washington situation is also illustrative of the impact of energy standards and codes. While many jurisdictions have modest or no energy code enforcement, the level of compliance is more than 90 percent. This is true even for the rather complex trade-off methodologies required to allow 2x4 construction. Given the complex nature of the Washington code, this suggests that builders have not only absorbed the necessary information to conduct these trade-offs and still meet code requirements, but have accepted the compliance with the energy code as part of their business.

Of course, there are market conditions in certain localized areas that allow or require builders to make different accommodations to the code. In some areas, especially those outside the Seattle area, customers demand 2x6 walls even if the overall performance level would allow 2x4 construction under the code. This is especially true of Clark County area, near Portland. This market is, presumably, more like the Oregon market, with homebuyers using the Washington side of the Columbia as suburbs to the Portland employment markets. Even though the rest of the building components are comparable to all other western Washington jurisdictions, 2x6 walls are almost exclusively used in Clark County.

6.2. Builder Attitudinal Survey

The dominant impression given by the builder interviews is that builders believe (or at least assert) that they meet codes and standards, and that they do so without much complaint over enforcement standards or even code confusion. (The exception to this is Boise, although builders from Boise did assert that they met current standards). This is fairly consistent with field observations.

Montana builders, taken as a whole, argue that they build far in excess of standards as a result of the severe climate and the demands of the Montana market. This is not consistent with field observations. While it is true that builders in Montana meet the current Montana energy code standards (in spite of the lack of enforcement) they are certainly no better than anywhere else in the region. The assertion that the market demands high efficiency is probably correct, but it is also true that these demands and builders' response to these demands is limited by the information, knowledge, and competence of the home-building industry.

The Idaho builders, on the other hand, make no pretense of meeting an energy standard. Their goal seems to be to minimize the expenses associated with building shell construction; consequently, they build only to the minimum levels of efficiency that can be tolerated by the enforcement environment of the Boise area.

In both Montana and Idaho, there seems to be a perception in the market that the homes built meet a high standard for energy efficiency. For these two states the observations in the field suggest a market failure in this regard. The solution can only be partly ascribed to improved codes and standards. In both states the lack of code enforcement might restrict the effectiveness of a more stringent residential energy code. A market approach that informs the home buyers of the advantages and indicators of energy efficiency coupled with more directed information that removes the barriers that builders perceive for construction in these cold climates would address the market failures in these areas. In Idaho, an improved residential energy code is also warranted so that builders have a better guideline for energy efficient construction.

Taken as a whole, the Oregon and Washington building industries reflect the character of their codes. The performance of homes in these states can largely be predicted by the nature of the energy code enforced in each state. Builders in both states seem to indicate that the energy code is met and, even when interviewers gave them the opportunity, the only complaint consistently voiced related to ventilation requirements (which are not part of the energy codes). As for the use of efficient building components, it is quite apparent that the market is largely created and supported by building codes in almost every case.

The major exception to this is the use of high-performance glazing in the Montana and Washington markets. In Montana, even though some builders barely meet other energy code standards, they generally exceed the window standards. In Washington, similarly, builders report exceeding the window standards by about 30% on average, and sometimes by much more. Though this is sometimes used as a trade-off for other components, the window market has transcended the limits of the Washington code to a great extent. Whether this can be traced to a market transformation is uncertain, but it is undeniable that builders' selection of window performance in these states, at least, reflects the market rather than the standards of the code. In most other components of the building, the energy code sets the standards or the energy code was written to reflect the standards in the state at the time the code was promulgated.

In all three states, the impression given by builders is that their practice is not only well beyond the code requirements but also better than other builders in the market. There is no obvious trend like this when the buildings themselves are reviewed. For the most part, builders all build to similar standards; the levels of insulation and window performance are very similar from one builder to the next. It is hard to tell if the builders really believe that their homes are all “above average” or if they have developed a marketing stance for energy efficiency that is reasonably independent of the actual efficiency of their homes. In either case, there is a very strong indication that the market and/or the builders are misinformed on the nature and techniques that would deliver efficient homes. While the effect of this attitude has the largest impact on Montana homes (because of the cold climate), the attitude seems to pervade the other states and interviews. A solution would be to provide more information to the market for new residences so that at least the customers might be able to distinguish between builder claims and true energy efficiency.

6.3. Trends

This study represents the first regional sample of new construction since the NORIS study conducted in 1987. That study had more limited goals, seeking to characterize the infiltration and shell leakage of homes built between 1980 and 1986. In that sense the samples and data sets are not completely comparable. Other studies have characterized various sub-populations but usually they were designed to evaluate particular utility programs (e.g. Super Good Cents). Those studies did not generally try to characterize regional construction. In 1994, the new construction practice in the State of Oregon was reviewed with a very large random sample. This sample was used to supplement the Oregon baseline collected for this study, but it can also be used to track construction practices over the intervening five years.

6.3.1. Floor area

The most striking and significant result of the comparisons is the considerable increase in floor area in the current sample as compared to earlier surveys. In the 1980 to 1986 period the average house size derived from the regional sample was about 1,850 square feet. This sample was only for electrically heated homes but in this period such homes represented about 60% of the single family new construction.

In 1990, a review was conducted of electrically heated homes in several jurisdictions across the region as part of the evaluation of several single family conservation programs (Brown, et al, 1991). This study was referred to as the “Meta-Evaluation”. The survey was not a true regional sample, although it did include a field survey of about 560 homes constructed between 1987 and 1989 used to characterize the building practice in areas with utility conservation programs. In this group the average house size was 1,840 square feet.

In the Oregon code compliance study, a random sample of 283 homes constructed in 1993 and 1994 was conducted. The average house size in this group was 2,056 square feet. Finally, in this sample of 366 homes constructed in 1999, the overall regional average was 2,260 square feet. The overall trend here is an increase of about 22% in house size over the period of 1989 to 1999.

The real effect of the trend towards larger houses is to somewhat offset the trend towards more insulation and better windows. The impact of the Oregon code, for example, was to reduce heat loss rates by 25 to 30 percent. This change has been offset by an increase in house size. In the other states, where the improved thermal standards are less dramatic, the improved thermal standards have barely kept pace with expanding house size.

6.3.2. Windows

Window glazing technology has undergone substantial changes over the last two decades. The performance of window systems was not collected as part of the NORIS study, so comparison with early 1980s homes is difficult. It was assumed that windows installed in this region during this time frame were dominated by non-thermally broken aluminum frames (Palmiter,1982). The Meta-evaluation of homes built in the 1988-89 timeframe, however, did collect this information. This sample was dominated by aluminum double glazed windows. Two-thirds of the windows in this survey had aluminum frames and double glazing. About 3% of the windows in this survey had low-e coatings. About 29% of the windows were wood or vinyl framed.

The contrast between this sample and the Oregon survey four years later is striking. With the advent of the new Oregon energy code, the use of aluminum windows disappeared. In this sample, 99% of the windows used vinyl or wood frame windows and 56% of the glazing used low-e coatings on the windows.

In this survey, the intervening five years have increased the use of coatings in residential windows in some markets. Low-e coatings have captured about 90% of the glazing market in Montana and Oregon, where the code and the market demands more efficient windows. In Washington and Idaho, the saturation of these coatings is less than 35 percent. Vinyl and wood framed windows have almost completely displaced aluminum frames in all states.

The development of the vinyl window business was mostly accomplished in the early 1990s in the Oregon and Washington markets. This trend was supported by the code changes which demanded windows with Class 40 performance values in these states.

The manufacturing of the vinyl window has offered a considerable saving in window costs. As the factory capacity became available in the region, these windows quickly displaced residential aluminum windows.

In Washington, Oregon, and Idaho, vinyl windows represent about 85% of all windows. Wood frames make up about two-thirds of the remaining windows. Only in the Montana market are window frames evenly divided between wood and vinyl windows. The only available survey of this issue from the 1980s is the Meta-evaluation, in which about 6% of window frames were vinyl. It should be noted that the major regional window manufacturers did not introduce a vinyl window line until 1989 or 1990. Previous to that time, vinyl windows were only available from specialty window manufactures.

6.3.3. Heating and Cooling Systems

The other characteristic that can be compared across several of these samples is heating fuel selection. In the NORIS study, 60% of the sample used electric heating. This included homes with electric heat pumps. In the Oregon sample from 1994, this percentage had dropped to 25% of all the homes surveyed. In this 1999 sample, the region-wide share of electric heat (including heat pumps) has fallen to 13 percent. Except for Washington State, where heat pumps are common in certain markets, the level of electric heat has fallen to about 7% in the rest of the region.

Unfortunately, the saturation of cooling equipment was usually not collected in studies conducted on the homes built in the 1980s. It is our impression, however, that the only centralized cooling in these samples was the fraction of homes that had installed heat pumps. In the Meta-evaluation, 20% of the electric heated homes had heat pumps or central air conditioning. If this were projected to the entire population, the result would be a regional estimate of about 12 percent. Since there was no true regional sample frame, this estimate has substantial uncertainty. Nevertheless, the incidence of cooling equipment in this sample and in the 1994 Oregon sample is about 20 percent. In the Boise market and in several of the smaller markets in eastern Washington and southern Oregon, the saturation of air conditioning equipment exceeds 60 percent.

Given the incidental evidence, it appears that the saturation of cooling equipment has about doubled since the 1980s. This trend has resulted in much more central air conditioning in the cooling climates of the region and an increasing saturation of central cooling systems in areas (Seattle and Portland) that have not traditionally used central air conditioning and have no discernable cooling load.

6.4. Other Observations

Across the region, energy codes and standards have been broadly accepted. If the standards were altered, building practices would very likely change accordingly in a relatively short period of time. This, of course, assumes that there would be sufficient enforcement to both inform the builders of the standards and to convince them that such a revised code must be observed. The overall characteristics of the region in terms of building heat loss rates and individual components are fairly similar. The result is that in the more severe climates of Idaho and Montana, these practices fall considerably short of consumer cost-effectiveness and desirable thermal practice.

The overall impression from this review is that reasonably common standards throughout the region are being met, excepting noticeably lower performance in severe climates. This is primarily due to the fact that the home building industry in Idaho and Montana has not become as responsive to climate as the industry in the rest of the region. This can be explained almost exclusively by the variance in the development of codes and standards between the eastern and western portions of the region. It is difficult to imagine that any more likely explanation can be found.

At this point, however, the residential builders of the region realize the importance of energy efficiency in their buildings. The effect of the codes in Washington and Oregon is to give credible guidance. This role has not been developed in Montana and Idaho. Given the climate in these states, it is likely that a combination of public awareness and builder training would be necessary to inform these markets. Builders could then respond to consumer demand and begin to support improved standards through improved building practice. The history of residential building practice in this region suggests that the barriers erected by local building practice can be overcome by a combination of market forces and building standards. Throughout the region, this combination can be expected to continue altering the building practices of the residential sector.

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8. Acknowledgements

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We would also like to especially thank Michael O’Brien of the Northwest Energy Efficiency Alliance for his constant support and consistent efforts to make this extensive review possible. Mike provided us with valuable comments on early drafts and study design, and assisted in ensuring that the baseline survey itself could be made useful to the region’s market transformation efforts. Without his efforts, the work could not have proceeded.

Finally, Jennifer Williamson of the Northwest Energy Efficiency Alliance, who replaced Michael O’Brien near the end of the project, provided the last round of edits, reviews, and questions which made the development of the final report possible.

APPENDIX A

Residential File/Field Review Protocol
Cover Review Protocol

Residential Protocol Instructions

House Number Coding

Each house will be coded with an eight-digit identification number. This number should be indicated on each page of the protocol so that if the pages are separated the house can be identified.

The house coding number is generated as follows:

The first digit (actually a letter) indicates the state in which the house is located. Use the first letter of the state name.

The second part of the ID number will be a 3-digit number representing the jurisdiction within the state. This number will be pre-assigned for each jurisdiction, and will be indicated on the jurisdiction information sheet.

Next will come a single letter representing the plan reviewer. Each plan reviewer will be assigned a single letter so we can follow up with any subsequent questions we have on the file.

The last three digits of the house ID number will be the house number within each jurisdiction. These numbers will be assigned to houses as the files are reviewed at the building department. If there are multiple reviewers working in the same jurisdiction, it is important that these reviewers coordinate among themselves so that the same house number is not assigned twice. For example, two reviewers might each assign only even or odd numbers to the houses they review.
The numbers are to be assigned at the time of cover sheet review.

An example ID number would look like this: **W014-K047**

This would indicate that this house is in Washington jurisdiction #14, the review was conducted by ‘K’, and this was the 47th house in this jurisdiction.

Be sure to include zeros where appropriate.

Plans vs. Field

All questions should be responded to from the plan set. Only the following types of questions can be left blank: those questions which hinge on a previous ‘yes’ answer, and those questions with an asterisk, if they cannot be answered. If no answer can be identified, write in “N/I” for not indicated, or “N/A” for not applicable. Add whatever additional explanations might help the reader to better understand the project.

(State-Jurisdiction-Inspector-House #) (X ### - X ###)

File Components (check boxes to indicate information included in this file):

[ ] Plan Review
[ ] Field Review
[ ] Blower Door Test
[ ] Duct Blaster
[ ] Photos
[ ] Other: ______________________________________

PLAN (FILE) REVIEW

_____________ Date _________________ Plan Reviewer _____________ Permit Number

List House address, city: __________________________________,____________________

[ ] Sketch

Complete a line drawing sketch of the floor plan on graph paper, approximately to scale. Indicate the following: north arrow, room names, rough outside dimensions of footprint, heating system location. Indicate the house ID number on the sketch.

General

The following questions should be answered from the plan set. For projects with a field review, these questions should be verified with field conditions.

_____________ ft^2 Heated Floor Area (HFA) Main: __________
Upper: __________

Do not use area listed on plans; calculate for each house. If there is a basement, keep basement floor area separate.

_____________ ft^3 House Volume (not including basement)

Describe design type: [ ] spec. home [ ] custom home

_______ Number of stories (include basement)
_______ Number of bedrooms _______ Number of bathrooms (1/2, full)

Garage **Field verified:[ ]**

[y] [n] Does the house have a garage? (if yes, check characteristics below)

[ ] list garage size (footprint): _______________
[ ] garage is attached to house
[ ] wall between house and garage is insulated: R-_____
(characterize this wall in WALL TYPES take-offs below)
[ ] living space over garage
(characterize the garage ceiling in FLOOR TYPES take-offs below)
[y] [n] [unk] garage is insulated to outside
[y] [n] [unk] garage is heated by primary house system
[y] [n] [unk] primary house heating system is located in garage
[y] [n] [unk] garage heated by secondary heating system
describe: __________________________________
[y] [n] [unk] garage doors are insulated

Basement **Field verified: [ ]**

[y] [n] Does the house have a basement? If yes, answer the following questions:

The following questions are used to characterize the basement with respect to heating. If there is any chance that the basement is directly or indirectly heated, all basement components should be characterized in the respective take-off sections. If the basement is split into heated and unheated sections, characterize these sections separately in the take-offs, and add a line below to indicate the relative floor areas of *each* section.

__________ ft^2 Basement floor area

__________ ft^3 Basement volume

The primary heating system supplies the basement	[y]	[n]	[unknown]
The heating system is located in the basement	[y]	[n]	[unknown]
A secondary heating system supplies the basement	[y]	[n]	[unknown]
The floor between the basement and the upstairs living space is insulated	[y]	[n]	[unknown]
The basement stair is open to the floor above, (uninsulated door, uninsulated stair walls, etc.)	[y]	[n]	[unknown]

Indicate basement type: [full depth] [partially above grade]

Describe the configuration of the basement in general terms: (i.e. fully finished living space, unfinished concrete, uninsulated, future finish likely, etc.):
____

Crawlspace **Field verified:[ ]**

[y] [n] Does the house have a crawlspace? If yes, check identifiable characteristics:

- [ ] Crawlspace is unventilated
- [ ] Crawlspace is ventilated
  - [ ] vents are fixed open
  - [ ] vents are operable

[y] [n] [unk] Crawlspace wall is insulated

- [ ] insulation: R-_______
- [ ] perimeter: ft: _______
- [ ] avg. wall ht.: ft: _______
- [ ] For perimeter insulated crawlspace, is rim joist insulated?
  - [ ] describe: ______________________________

[y] [n] [unk] Ground cover is specified

[y] [n] [unk] Ground cover is installed

Energy Code

Review the energy code compliance information presented on the plans and check all the boxes below that apply. (There may be some overlap.) This question refers to the plans as submitted; notes and comments made by the building department should be described elsewhere.

- [ ] A compliance path is indicated:
  - Washington
    - [ ] Prescriptive Path (chapter 6) Path #: _________
    - [ ] Component Performance Path (chapter 5)
    - [ ] Systems Analysis (chapter 4)
  - Idaho
    - [ ] Prescriptive Path (IRES)
    - [ ] Trade-offs
    - [ ] WATTSUN® Documentation
    - [ ] MEC-Check Documentation
- [ ] Plans contain no reference to energy code compliance
- [ ] Generic energy code tables or notes which are not project specific are included in the file.
- [ ] Project-specific notes or tables are included in the file.
- [ ] Energy code compliance information is provided on an 'official' compliance form.
- [ ] WATTSUN® Documentation submitted
- [ ] Information about project insulation levels is provided in details/sections/plan notes within the plan set.
- [ ] All insulation information is in attached forms, little or none on plans.
- [ ] Other: ____

[ ] *Describe any energy code enforcement or corrections made by the building department in the project file:

____

TAKE OFFS

In this section, the component area take-offs and descriptions should be completed. Fill out the tables below for each component type. Each component area should be indicated, and a component description form (color coded) should be filled out for each. Double check that all component types are accounted for before moving on to the next section. In the first blank, list the number of components of each type which are indicated on the plan set.

For opaque components (walls, floors, ceilings) the areas indicated should be gross areas; the areas of any windows, doors, or skylights occurring in that component should be **included** in the gross area.

Windows and skylights should be thoroughly described in the appropriate section, including the wall or ceiling type in which they are found.

For projects where a field visit is conducted, the component areas should be reviewed, and the information on the component information sheets should be checked. All field information should be indicated in a different color of pencil or ink. *Make any changes necessary, and* ***circle any field values****.* Describe the revision in the margin.

Floors

__________ Number of Floor Types

Frame floors should be counted separately from slab floors. Slab on grade and below grade slabs should be separated (split slabs which are both). For all slabs, indicate slab **perimeter** instead of slab area. If there is a basement, fill out a floor type for the main floor over the basement, as well as for the basement floor itself.

Fill out a floor component form (green) for each floor type.

Floor Type #	Description/location (ie: main floor over crawl, basement slab, etc.)	Floor Area (or slab perimeter)

Walls

__________ Number of Wall Types

Include separately walls with different insulation types, basement walls, attic sidewalls at vaults, walls between house and garage, etc. as distinct types. Calculate gross wall areas, then account for windows in the window section. Fill out a wall component form (tan) for each wall type.

Wall Type #	Description/location (i.e. typical exterior wall, attic sidewall, house/garage wall, etc.)	Wall Area

Ceilings

__________ Number of Ceiling Types

Separate vaulted ceiling from attic areas. For vaults, calculate area of the vault, not the area of floor it covers. Be sure to calculate vaulted ceilings at dormers, bay windows, etc. Separate areas with different insulation strategies. Calculate gross areas, then indicate skylights in the appropriate section. Fill out a ceiling component form (yellow) for each ceiling type.

Ceiling Type #	Description/location (ie: main attic, vaulted ceiling at living room, dormer, etc.)	Ceiling Area
__________	____	____________
__________	____	____________
__________	____	____________
__________	____	____________

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. 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

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: [ ] (revise 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) **North**	**South**	**East**	**West**	**Total Area**
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______
______	______	____________________	_____	_____	_____	_____	______

HVAC **Field verified: [ ]**

Primary Fuel Type

plans field

[ ] [ ] Electric
[ ] [ ] Natural gas
[ ] [ ] Heat Pump
[ ] [ ] Fuel oil
[ ] [ ] Propane
[ ] [ ] Wood
[ ] [ ] Other: ___________________

Primary Heating System Type

plans field

[ ] [ ] Forced Air Central Furnace
[ ] [ ] Electric Zone Heaters (characterize below)
[ ] baseboard [ ] wall heaters [ ] radiant panels [ ] radiant floor
[ ] [ ] Hydronic Boiler, or [ ] Domestic hot water tank serves as heat+water (characterize distribution below)
[ ] radiators [ ] radiant floor [ ] zone fan coils [ ] coil in furnace
[ ] [ ] Air Source Heat Pump
[ ] [ ] Ground Source Heat Pump
[ ] [ ] Gas Stove (freestanding)
[ ] [ ] Wood Stove
[ ] [ ] Other: ____

Primary Heating Appliance Information:

[y] [n] Information about system indicated on plans

plans		field
________________	Input Capacity	______________
________________	Output Capacity	______________
________________	Efficiency	______________
	[ ] AFUE [ ] SEER [ ] COP [ ] HSPF	

plans		field
____________________________	Manufacturer	____________________________
____________________________	Model	____________________________

List system capacity allowed in energy code forms* (if indicated): ____________________

Thermostat: [ ] single setpoint [ ] programmable [ ] unknown

For combustion heating appliances, exhaust is: [ ] direct vent [ ] flue [ ] unknown

If flue-vented, how is combustion air introduced to room? (high/low vent, single vent, outside in garage, none, etc.)*:____________________________________

For central heating systems, identify system location

- [ ] In heated space (closet, insulated mechanical room, etc.)
- [ ] Insulated basement
- [ ] Uninsulated basement
- [ ] Crawlspace
- [ ] Garage
- [ ] Not indicated on plans
- [ ] Other: __________________

Fireplaces

[y] [n] Fireplaces on plans

[ ] Wood Stove; Quantity: _______ Outside air source? [y] [n] [n/i]

[ ] Wood Fireplace; Quantity: ______ Outside air source? [y] [n] [n/i]

[ ] Gas Fireplace; Quantity: _______ Outside air source? [y] [n] [n/i]

- [ ] vents directly to outside
- [ ] vents directly to living space

In the field, if a gas fireplace has a capacity rating, consider it a secondary heating system, and describe below:

Secondary Heating Systems **Field verified:** **[ ]**

[y] [n] Are there other secondary heating systems?

Describe area served by secondary system:

____

Describe secondary heating system type:

____

Secondary heating system fuel: ________________________________

Describe any differences between field and plans:

____

Secondary Heating Appliance Information:

______________ Input Capacity
______________ Output Capacity
______________ Efficiency
______________________________ Manufacturer
______________________________ Model

Cooling

[y] [n] Cooling is indicated on plans
[y] [n] Cooling is installed in field;
If either answer is yes, characterize below and describe equipment:

[ ] Heat Pump
[ ] Central Air Conditioning
[ ] Packaged Terminal Air Conditioners (PTAC, through-wall)
[ ] Evaporative (swamp cooler)
[ ] Other: ________________________

Cooling Equipment Information:

______________ Output Capacity
______________ Efficiency Rating (& rating type)
______________________________ Manufacturer
______________________________ Model

VENTILATION

Characterize the ventilation system as indicated below. Check boxes for both plan information and field information:

[ ]   Is there ventilation system information on the plans?

Exhaust Side

For the exhaust ventilation, check all boxes below which apply:

[ ]   Spot ventilation fans

plans	field	
[ ]	[ ]	bathrooms
[ ]	[ ]	laundry room
[ ]	[ ]	kitchen
[ ]	[ ]	other: ___________

plans	field	
[ ]	[ ]	“Oversized” exhaust fan serves house from central location; list location: ___________
[ ]	[ ]	Multiple exhaust locations ducted to central exhaust fan
[ ]	[ ]	Fully ducted heat recovery ventilation
[ ]	[ ]	None
[ ]	[ ]	Other: ____

[y] [n] [unk]   At least one fan is controlled by a 24 hour timer

Supply Side

For the supply ventilation, check all boxes below which apply:

plans	field	
[ ]	[ ]	window slot vents
[ ]	[ ]	through-wall ports
[ ]	[ ]	outside air duct integrated into forced air return plenum ([ ] verified in field)
	[ ]	furnace/fan forced
	[ ]	passive duct
[ ]	[ ]	Fully ducted heat recovery ventilation
[ ]	[ ]	None
[ ]	[ ]	Other: ____

Kitchen

[y] [n] [unk] Is there a range hood?

- [ ]   vents to outside
- [ ]   forehead greaser
- [ ]   list cfm if available: _________

[y] [n] [unk] An alternate exhaust fan is indicated/installed in the kitchen area

FIELD REVIEW **_________________Field Reviewer Name**
____________ Field Reviewer Code

Describe construction status at time of field visit:
____

How much of the following is installed at the time of field visit?

[ ] HVAC system
[ ] Finishes
[ ] Insulation
[ ] Windows

Photos

Verify that the camera will date and time stamp photos of this house. Take several pictures of each house visited. Include a photo of the exterior of the home and its surroundings, as well as photos of interesting or unusual features, particularly with regard to construction (i.e. excellent or shoddy construction or detailing, ductwork, insulation, etc.)

Approximate time and date indicated on stamp (show exact format): ______________________

Photo #	Description
________	____
________	____
________	____
________	____
________	____

Go back through the plan review information and verify it's accuracy. Revise any sections that are modified, and add missing information. Use a different color of pen so modifications can be identified. Review each component form to see if changes have been made in the field. Revise the component descriptions and areas as necessary. Check the appropriate field review box on each form as you review field conditions.

[y] [n] Is gas available in this neighborhood? (look for nearby meters if necessary)

Name of Electric utility: _______________________________________
Name of Natural Gas utility: _______________________________________

[y] [n] Is there any indication that the house participated in a conservation program? (Super Good Cents, Natural Choice, Gemstar, etc.) If so, describe: [ ]
____

THE FOLLOWING SECTIONS ARE FOR FIELD REVIEW ONLY

Materials

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

Exterior Walls

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

Roof

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

Miscellaneous Materials

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

Lighting

[y] [n] [unk] Are there any compact fluorescent lamps installed in the house?
If so, how many: [_________]

[y] [n] [unk] Are there recessed can lights installed through the building envelope?
If so, how many: ____________

Ductwork

[ ] Heating system centrally ducted or to be ducted. Characterize the ductwork below. Do not include ductwork that serves for a ventilation-only system. Check all boxes that apply for duct locations:

[ ] ductwork present during field review
[ ] ductwork generally insulated

All	most	some	none	Duct location	insulated?
[s] [r]	[s] [r]	[s] [r]	[s] [r]	inside heated envelope	[y] [n]
[s] [r]	[s] [r]	[s] [r]	[s] [r]	in attic	[y] [n]
[s] [r]	[s] [r]	[s] [r]	[s] [r]	in crawlspace	[y] [n]
[s] [r]	[s] [r]	[s] [r]	[s] [r]	in uninsulated basement	[y] [n]
[s] [r]	[s] [r]	[s] [r]	[s] [r]	in garage	[y] [n]

Check all boxes that apply for duct characteristics:

All	most	some	none	Duct Types
[ ]	[ ]	[ ]	[ ]	sheet metal duct construction
[ ]	[ ]	[ ]	[ ]	flex duct
[ ]	[ ]	[ ]	[ ]	framing cavities act as duct runs
[ ]	[ ]	[ ]	[ ]	ducts are sealed with standard duct tape (grey)
[ ]	[ ]	[ ]	[ ]	ducts are sealed with poly-butyl tape (silver)
[ ]	[ ]	[ ]	[ ]	ducts are sealed with mastic
[ ]	[ ]	[ ]	[ ]	duct connections are screwed
[ ]	[ ]	[ ]	[ ]	duct connections use Panduit straps
[ ]	[ ]	[ ]	[ ]	duct board

Describe mechanical connections to register boots and terminal boxes:

____

Domestic Hot Water

__________________ Fuel
__________________ Capacity (Btu/kW)
__________________ Efficiency Rating
__________________ Tank Capacity (gallons)
__________________ Manufacturer
__________________ Model
__________________ Location
[y] [n] [unk] Insulation pad underneath?

WALLS

Component Description Form (TAN FORM)

______________ Wall Type

Location (i.e. main exterior wall, attic sidewall, etc): ______________________

[ ] Above Grade

[ ] Buffer (to semi-protected space)
    [ ] to attic
    [ ] to crawlspace
    [ ] to garage
    [ ] to other space; describe: ______________________________________

[ ] Below Grade; average depth at base (ft.): _____________

Insulation
Overall installed R-_________(plans) _________(field)
    [ ] indicated as this or better on plans
[ ] fiberglass R- _____
[ ] rigid R- _____ thickness (in.) ______ location: ____________
[ ] loose fill
[ ] other: ____
[ ] rigid insulation/OSB sheathing alternating (Idaho)
    estimate insulation coverage (%): [25 50 75]
[ ] unknown

Structure
[ ] studs [wood] [metal] [unknown] [other]: ______________________
    [ ] depth [4”] [6”] [other]: ______________________
[ ] concrete [6”] [8”] [other]: ______________________
[ ] other (panels, foam forms, etc.) describe: _____________________

[ ] stud spacing [16”] [24”] [n/a] [unknown]
[ ] headers insulated [y] [n] [n/a] [unknown]
[ ] insulated corners [y] [n] [n/a] [unknown]

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

Please describe all changes:

FLOORS

Component Description Form (GREEN 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
[ ] 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

Component Description Form (YELLOW FORM)

______________ Ceiling Type Location: _____________________

[ ] Attic
[ ] Vault-Scissor
[ ] Vault-Rafter

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
[ ] 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-e 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:

Cover Sheet Review

______________ Date
______________ Field reviewer name
______________ Jurisdiction
______________ House # in jurisdiction
Address: ____

______________ State
______________ County
______________ City

______________ Permit date
______________ Permit number
______________ ft^2 Floor Area
_____________% Glazing Percentage*
______________ Valuation ($)

Primary Heating Fuel Type (check one)

- [ ] Unknown
- [ ] Electric
- [ ] Non-Electric (check one if indicated)
  - [ ] Natural gas
  - [ ] Heat Pump
  - [ ] Fuel oil
  - [ ] Propane
  - [ ] Wood
  - [ ] Other: ___________________

[y] [n] Is this project designed by an architect (stamped)?*
[y] [n] Are these stock plans?*

List house designer info:
Company: ____
Contact ____
Phone: __________________________

List builder info:
Company: ____
Contact ____
Phone: __________________________

Construction stage*: [ ] foundation [ ] framing [ ] pre-final [ ] final

APPENDIX B

Builder Interviews - Annotated Protocol

Residential Buildings Energy Efficiency Survey

Building Professional Questionnaire

Interviewer Name ______________________________________ Date __________________

House ID ___________

Comments:

(Arrange contact with a project manager)

Hello, My name is ___________ from ____________, an energy research firm. We are conducting a survey about the energy efficiency in new residential construction. This study is being conducted for NEEA, the Northwest Energy Efficiency Alliance. NEEA is a consortium of Northwest utilities and state governments. Part of this study involves plan reviews, site visits and interviewing builders around the state. Information collected in these interviews will remain confidential; specific builders and projects will not be identified. Your input into this study is very critical. We visited a home that you built in ______(location)____; would it be possible for me to talk to you for about 10 minutes about energy efficiency and construction practices you use? (If not a convenient time, try to arrange another)

General Information

Name of Interviewee: ______________________________

Title: ______________________________

Profession: ______________________________

Firm Name: ______________________________

Type of Firm: ______________________________

Phone Number: ______________________________

Interviewees, by Firm Type and State

Composite Results:

	N	%
Builder/General Contractor	202	87.45
Developer/Builder	20	8.66
Developer	4	1.73
Owner	4	1.73
Architect	1	0.43
Total:	231	100%

Idaho Results:

	N	%
Builder/General Contractor	5	100
Total:	5	100%

Montana Results:

	N	%
Builder/General Contractor	28	96.55
Architect	1	3.45
Total:	29	100%

Oregon Results:

	N	%
Builder/General Contractor	82	90.11
Developer/Builder	8	8.79
Developer	1	1.10
Total:	91	100%

Washington Results:

	N	%
Builder/General Contractor	87	82.08
Developer/Builder	12	11.32
Developer	3	2.83
Owner	4	3.77
Total:	106	100%

How many residential projects do you complete annually? __________

Composite Results:

	N	%
Bin 1: (1-10)	122	53.04
Bin 2: (11-25)	52	22.61
Bin 3: (26-100)	40	17.39
Bin 4: (101-250)	13	5.65
Bin 5: (> 250)	3	1.30
Total:	230	100.00

Idaho Results:

	N	%
Bin 1: (1-10)	2	66.67
Bin 2: (11-25)	1	33.33
Total:	3	100.00

Montana Results:

	N	%
Bin 1: (1-10)	20	66.67
Bin 2: (11-25)	7	23.33
Bin 3: (26-100)	1	3.33
Bin 4: (101-250)	1	3.33
Bin 5: (> 250)	1	3.33
Total:	30	100.00

Oregon Results:

	N	%
Bin 1: (1-10)	37	52.11
Bin 2: (11-25)	20	28.17
Bin 3: (26-100)	8	11.27
Bin 4: (101-250)	5	7.04
Bin 5: (> 250)	1	1.41
Total:	71	100.00

Washington Results:

	N	%
Bin 1: (1-10)	26	41.27
Bin 2: (11-25)	13	20.63
Bin 3: (26-100)	16	25.40
Bin 4: (101-250)	6	9.52
Bin 5: (> 250)	2	3.17
Total:	63	100.00

How long have you been building in (state)? ____________

Composite Results:

	N	%
Bin 1: (11 - 25)	58	25.11
Bin 2: (3 – 5)	34	39.83
Bin 3: (6 – 10)	62	66.67
Bin 4: (< = 2)	18	74.46
Bin 5: (> 25)	59	98.96
Total:	231	100.00

Idaho Results:

	N	%
Bin 1: (3-5)	4	80.00
Bin 2: (6 – 10)	1	20.00
Total:	5	100.00

Montana Results:

	N	%
Bin 1: (11 –25)	4	19.05
Bin 2: (3 –5)	2	9.52
Bin 3: (6 – 10)	5	23.81
Bin 4: (> 25)	10	47.62
Total:	21	100.00

Oregon Results:

	N	%
Bin 1: (11 – 25)	23	21.30
Bin 2: (3 –5)	16	14.81
Bin 3: (6 – 10)	36	33.33
Bin 4: (< = 2)	8	7.41
Bin 5: (> 25)	25	23.15
Total:	108	100.00

Washington Results:

	N	%
Bin 1: (11 – 25)	31	31.96
Bin 2: (3 –5)	12	12.37
Bin 3: (6 – 10)	20	20.62
Bin 4: (< = 2)	10	10.31
Bin 5: (> 25)	24	24.74
Total:	97	100.00

What is the (estimated) total square footage designed/built annually? __________

Composite Results:

	N	%
Bin 1: (< 10,000 ft^2)	77	33.33
Bin 2: (10,000-24,999 ft^2)	61	26.41
Bin 3: (25,000-99,999 ft^2)	59	25.54
Bin 4: (100,000-499,999 ft^2)	29	12.55
Bin 5: (>- 500,000 ft^2)	5	2.16
Total:	231	100.00

Idaho Results:

	N	%
Bin 1: (10,000-24,999 ft^2)	2	40.00
Bin 2: (100,001-500,000 ft^2)	1	20.00
Bin 3: (25,000-99,999 ft^2)	2	40.00
Total:	5	100.00

Montana Results:

	N	%
Bin 1: (10,000-24,999 ft^2)	6	28.57
Bin 2: (25,000-99,999 ft^2)	3	14.29
Bin 3: (100,000-499,999 ft^2)	1	4.76
Bin 4: (<=10,000 ft^2)	11	52.38
Total:	21	100.00

Oregon Results:

	N	%
Bin 1: (< 10,000 ft^2)	35	32.41
Bin 2: (10,000-24,999 ft^2)	31	28.70
Bin 3: (25,000-99,999 ft^2)	29	26.85
Bin 4: (100,000-499,999 ft^2)	11	10.19
Bin 5: (>- 500,000 ft^2)	2	1.85
Total:	108	100.00

Washington Results:

	N	%
Bin 1: (< 10,000 ft^2)	31	31.96
Bin 2: (10,000-24,999 ft^2)	22	22.68
Bin 3: (25,000-99,999 ft^2)	25	25.77
Bin 4: (100,000-499,999 ft^2)	16	16.49
Bin 5: (>- 500,000 ft^2)	3	3.09
Total:	97	100.00

What is the approximate price range of your residential construction projects?

Composite Results:

	N	%
Low Income/Affordable	68	26.98
Medium Priced	137	54.37
High End	47	18.65
Total:	252	100

Idaho Results:

	N	%
Low Income/Affordable	3	33.33
Medium Priced	5	55.56
High End	1	11.11
Total:	9	100

Montana Results:

	N	%
Low Income/Affordable	3	12.50
Medium Priced	14	58.33
High End	7	29.17
Total:	24	100

Oregon Results:

	N	%
Low Income/Affordable	35	30.43
Medium Priced	60	52.17
High End	20	17.39
Total:	115	100

Washington Results:

	N	%
Low Income/Affordable	27	25.96
Medium Priced	58	55.77
High End	19	18.26
Total:	104	100

Do you build mostly:

- **[ ] Stock designs**
- **[ ] Custom houses you design or modify**
- **[ ] Homes designed by architects**

Composite Results:

	N	%
Stock Designs	84	36.52
Architect-Designed	34	14.78
Custom	112	48.70
Total:	230	100

Idaho Results:

	N	%
Stock Designs	1	25
Architect-Designed	1	25
Custom	2	50
Total:	4	100

Montana Results:

	N	%
Stock Designs	8	38.10
Architect-Designed	1	4.76
Custom	12	57.14
Total:	21	100

Oregon Results:

	N	%
Stock Designs	33	30.56
Architect-Designed	14	12.96
Custom	61	56.48
Total:	108	100

Washington Results:

	N	%
Stock Designs	42	43.30
Architect-Designed	18	18.56
Custom	37	38.14
Total:	97	100

In which (WA, OR: jurisdictions/ ID, MT: towns or areas) are you most active?

Note: This variable was tabulated only for Montana.

Montana Results:

	N	%
Not Enforcing Jurisdiction	8	44.44
Enforcing Jurisdiction	10	55.56
Total:	18	100

Are you aware of or have you participated in any utility sponsored energy conservation incentive programs?

Composite Results:

	N	%
No	117	52.47
Super Good Cents	44	19.73
Other utility program	27	12.11
Aware of, did not participate	25	11.21
Unnamed rebate program	10	4.48
Total:	223	100

Idaho Results:

	N	%
No	2	50
Other utility program	2	50
Total:	4	100

Montana Results:

	N	%
No	12	70.59
Super Good Cents	2	11.76
Aware of, did not participate	1	5.88
Unnamed rebate program	2	11.76
Total:	17	100

Oregon Results:

	N	%
No	53	50.00
Super Good Cents	25	23.58
Other utility program	7	6.60
Aware of, did not participate	15	14.15
Unnamed rebate program	6	5.66
Total:	106	100

Washington Results:

	N	%
No	50	52.08
Super Good Cents	17	17.71
Other utility program	18	18.75
Aware of, did not participate	9	9.38
Unnamed rebate program	2	2.08
Total:	96	100

Impacts

For a typical house you build, describe the insulation level or performance in the following categories?

	Typical house you build	Standard Practice Differences
Wall Insulation:		
Floor Insulation:		
Ceiling Insulation:		
Window Frame Type: (Vinyl, wood etc.)		
Glazing Type: (single, dble, low-e, tinted)		
Basement/Perimeter Insulation:		
Heating Equipment Efficiency: Gas and/or Electric		

Typical Wall

Composite Results:

	N	%
R-10/R-11	2	0.88
R-13/R-15	16	7.05
R-19	103	45.37
R-21/R-22/R-23	100	44.05
R-25	5	2.20
R-38	1	0.44
Total:	227	100

Idaho Results:

	N	%
R-13	1	25
R-19	3	75
Total:	4	100

Montana Results:

	N	%
R-19	18	85.71
R-21/R-22	3	14.28
Total:	21	100

Oregon Results:

	N	%
R-13/R-15	2	1.90
R-19	7	6.67
R-21/R-22/R-23	91	86.66
25	4	3.81
38	1	0.95
Total:	105	100

Washington Results:

	N	%
R-10/R-11	2	2.06
R-13/R-15	13	13.40
R-19	75	77.32
R-21/R-22	6	6.18
R-25	1	1.03
Total:	97	100

Standard Wall

Composite Results:

	N	%
R-11	1	4.00
R-13	1	4.00
R-19	23	92.00
Total:	25	100

Idaho Results:

	N	%
R-11	1	100
Total:	1	100

Montana Results:

	N	%
R-19	17	100
Total:	17	100

Oregon Results:

	N	%
R-19	1	100
Total:	1	100

Washington Results:

	N	%
13	1	16.67
19	5	83.33
Total:	6	100

Typical Floor

Composite Results:

	N	%
R-0	13	6.13
R-10/R-11	4	1.89
R-19	60	28.30
R-21	7	3.30
R-24/R-25	78	36.79
R-28/R-30	43	20.28
R-38	5	2.36
R-49	1	0.47
R-54	1	0.47
Total:	212	100

Idaho Results:

	N	%
R-19	1	33.33
R-30	2	66.67
Total:	3	100

Montana Results:

	N	%
R-0	10	55.56
R-11	1	5.56
R-19	4	22.22
R-30	2	11.11
R-38	1	5.56
Total:	18	100

Oregon Results:

	N	%
R-19	2	2.02
R-21	5	5.05
R-25	76	76.77
R-28	1	1.01
R-30	10	10.10
R-38	3	3.03
R-49	1	1.01
R-54	1	1.01
Total:	99	100

Washington Results:

	N	%
R-0	3	3.26
R-10	3	3.26
R-19	53	57.61
R-21	2	2.17
R-24/R-25	2	2.18
R-30	28	30.43
R-38	1	1.09
Total:	92	100

Standard Floor

Composite Results:

	N	%
R-0	3	18.75
R-11	1	6.25
R-19	10	62.50
R-25	1	6.25
R-30	1	6.25
Total:	16	100

Idaho Results:

	N	%
No observations	0	0
Total:	0	0

Montana Results:

	N	%
R-0	3	42.86
R-19	3	42.86
R-30	1	14.29
Total:	7	100

Oregon Results:

	N	%
R-25	1	100
Total:	1	100

Washington Results:

	N	%
R-11	1	12.50
R-19	7	87.50
Total:	8	100

Typical Ceiling

Composite Results:

	N	%
R-21	1	0.45
R-30/R-31/R-32	65	29.28
R-34/R-35	3	1.35
R-38/R-40	140	63.06
R-42/R-44	5	2.25
R-48/R-49/R-50	6	2.65
R-54	1	0.45
R-60	1	0.45
Total:	222	100

Idaho Results:

	N	%
R-38	4	100
Total:	4	100

Montana Results:

	N	%
R-38/R-40	17	80.95
R-42/R-44	3	14.28
R-50	1	4.76
Total:	21	100

Oregon Results:

	N	%
R-21	1	0.97
R-30/R-32	13	12.62
R-35	1	0.97
R-38	81	78.64
R-42/R-44	2	1.94
R-49	4	3.88
R-54	1	0.97
Total:	103	100

Washington Results:

	N	%
R-30/R-31/R-32	52	55.31
R-34/R-35	2	2.12
R-38	38	40.43
R-48	1	1.06
R-60	1	1.06

Total:	94	100

Standard Ceiling

Composite Results:

	N	%
R-30	5	19.23
R-38	20	76.92
R-42	1	3.85
Total:	26	100

Idaho Results:

	N	%
R-38	1	100
Total:	1	100

Montana Results:

	N	%
R-38	17	94.44
R-42	1	5.56
Total:	18	100

Oregon Results:

	N	%
R-38	1	100
Total:	1	100

Washington Results:

	N	%
R-30	5	83.33
R-38	1	16.67
Total:	6	100

Typical Windows

Composite Results:

U-Value	N	%
.37	2	0.88
.40	128	56.14
.44	77	33.77
.49	2	0.88
.50	19	8.33

Total:	228	100

Idaho Results:

U-Value	N	%
.44	1	25
.50	3	75
Total:	4	100

Montana Results:

U-Value	N	%
.40	2	9.52
.44	17	80.95
.50	2	9.52
Total:	21	100

Oregon Results:

U-Value	N	%
.37	2	1.85
.40	86	79.63
.44	20	18.52
Total:	108	100

Washington Results:

U-Value	N	%
.40	40	42.11
.44	39	41.05
.49	2	2.11
.50	14	14.74
Total:	95	100

Standard Windows

Composite Results:

U-Value	N	%
.44	12	46.15
.50	13	50.00
.65	1	3.85
Total:	26	100

Idaho Results:

U-Value	N	%
.50	1	100
Total:	1	100

Montana Results:

U-Value	N	%
.44	9	47.37
.50	10	52.63
Total:	19	100

Oregon Results:

U-Value	N	%
.44	2	100
Total:	2	100

Washington Results:

	N	%
.44	1	25.00
.50	2	50.00
.65	1	25.00
Total:	4	100.00

Typical Perimeter Insulation

Composite Results:

	N	%
R-0	132	60.83
R-4/R-5	2	0.92
R-9/R-10	23	10.60
R-11	21	9.68
R-12/R-13	7	3.22
R-15	6	2.76
R-19	15	6.91
R-21	9	4.15
R-25	2	0.92
Total:	217	100

Idaho Results:

	N	%
R-10	1	25.00
R-11	1	25.00
R-13	1	25.00
R-19	1	25.00
Total:	4	100

Montana Results:

	N	%
R-0	1	5.00
R-11	14	70.00
R-19	5	25.00
Total:	20	100.00

Oregon Results:

	N	%
R-0	81	77.88
R-4	1	0.96
R-10	3	2.88
R-11	1	0.96
R-13	1	0.96
R-15	5	4.81
R-19	1	0.96
R-21	9	8.65
R-25	2	1.92
Total:	104	100

Washington Results:

	N	%
R-0	50	56.18
R-5	1	1.12
R-9/R-10	19	21.34
R-11	5	5.62
R-12/R-13	5	5.62
R-15	1	1.12
R-19	8	8.98
Total:	89	100

Standard Perimeter Insulation

No results.

Typical Heating/Cooling

Composite Results:

	N	%
Low Efficiency Gas	6	2.39
High Efficiency Gas	13	5.18
Electric Resistance	192	76.49
Heat Pump	40	15.93
Total:	251	100

Idaho:

	N	%
Electric Resistance	4	100.00
Total:	4	100

Montana:

	N	%
Electric Resistance	21	100.00
Total:	21	100

Oregon:

	N	%
Low Efficiency Gas	3	2.54
High Efficiency Gas	4	3.39
Electric Resistance	92	77.97
Heat Pump	19	16.10
Total:	118	100

Washington:

	N	%
Low Efficiency Gas	3	2.78
High Efficiency Gas	9	8.33
Electric Resistance	75	69.45
Heat Pump	21	19.44
Total:	108	100

Standard Heating/Cooling

No results.

Do the values you just listed…...
( ) Meet Code ( ) Not Meet Code OR ( ) Exceed Code?

Composite Results:

	N	%
Meet Code	150	66.08
Not Meet Code	1	0.44
Exceed Code	76	33.48
Total:	227	100

Idaho Results:

	N	%
Meet Code	3	75.00
Exceed Code	1	25.00
Total:	4	100

Montana Results:

	N	%
Meet Code	20	100
Total:	20	100

Oregon Results:

	N	%
Meet Code	74	69.16
Exceed Code	33	30.84
Total:	107	100

Washington Results:

	N	%
Meet Code	53	55.21
Not Meet Code	1	1.04
Exceed Code	42	43.75
Total:	96	100

Do any of the values you just listed for insulation and performance differ from the standard practices in your area? Which ones?

Composite Results:

	N	%
No	161	74.88
Yes	54	25.12
Total:	215	100
Better Insulation	37	51.39
Better Heating System	15	20.83
Better Windows	13	18.06
Better Framing	4	5.56
Other	3	4.17
Total:	72	100

Idaho Results:

	N	%
No	3	75.00
Yes	1	25.00
Total:	4	100
Better Insulation	1	33.33
Better Windows	1	33.33
Better Framing	1	33.33
Total:	3	100

Montana Results:

	N	%
No	17	85.00
Yes	3	15.00
Total:	20	100
Better Insulation	1	50.00
Better Heating System	1	50.00
Total:	2	100

Oregon Results:

	N	%
No	78	76.47
Yes	24	23.53
Total:	102	100
Better Insulation	17	51.52
Better Heating System	9	27.27
Better Windows	5	15.15
Better Framing	1	3.03
Other	1	3.03
Total:	33	100

Washington Results:

	N	%
No	63	70.79
Yes	26	29.21
Total:	89	100
Better Insulation	18	64.29
Better Heating System	6	21.43
Better Windows	2	7.14
Better Framing	2	7.14
Total:		100

Do you modify insulation levels based on heating fuel type?
[y]   [n]

Composite Results:

	N	%
Yes	47	21.36
No	173	78.64
Total:	220	100

Idaho Results:

	N	%
No	4	100
Total:	4	100

Montana Results:

	N	%
Yes	2	9.52
No	19	90.48
Total:	21	100

Oregon Results:

	N	%
Yes	3	2.86
No	102	97.14
Total:	105	100

Washington Results:

	N	%
Yes	42	46.67
No	48	53.33
Total:	90	100

Do you install heat pumps in your homes?
[y]   [n]

Composite Results:

	N	%
Yes	89	38.53
No	142	61.47
Total:	231	100

Idaho Results:

	N	%
Yes	0	0
No	5	100
Total:		100

Montana Results:

	N	%
Yes	3	14.29
No	18	85.71
Total:	21	100

Oregon Results:

	N	%
Yes	45	41.67
No	63	58.33
Total:	108	100

Washington Results:

	N	%
Yes	41	42.27
No	56	57.73
Total:	97	100

Why/why not?

Composite Results

Do Install Heat Pumps	N	%
Gas not available	41	34.75
Customer/Architect request	32	27.12
Cooling	18	15.25
Utility rebate program	5	4.24
Increased glazing allowance	22	18.64
Total:	118	100
Do Not Install Heat Pumps	N	%
Too expensive	52	36.36
Prefer gas	58	40.56
Not efficient / Not dependable	26	18.18
Not suitable for climate	7	4.90
Total:	143	100

Idaho Results:

Do Install Heat Pumps	N	%
No results		
Do Not Install Heat Pumps	N	%
Too expensive	1	25.00
Prefer gas	2	50.00
Not efficient / Not dependable	1	25.00
Total:	4	100

Montana Results

Do Install Heat Pumps	N	%
Customer/Architect request	3	100
Total:	3	100
Do Not Install Heat Pumps	N	%
Too expensive	13	61.90
Prefer gas	6	28.57
Not suitable for climate	2	9.53
Total:	21	100

Oregon Results:

Do Install Heat Pumps	N	%
Gas not available	27	45.76
Customer/Architect request	11	18.64
Cooling	11	18.64
Utility rebate program	3	5.08
Increased glazing allowance	7	11.86
Total:	59	100
Do Not Install Heat Pumps	N	%
Too expensive	16	26.98
Prefer gas	28	3.17
Not efficient / Not dependable	17	44.44
Not suitable for climate	2	25.40
Total:	63	100

Washington Results

Do Install Heat Pumps	N	%
Gas not available	14	25.00
Customer/Architect request	18	32.14
Cooling	7	12.50
Utility rebate program	2	3.57
Increased glazing allowance	15	26.79
Total:	56	100
Do Not Install Heat Pumps	N	%
Too expensive	22	40.00
Prefer gas	22	40.00
Not efficient / Not dependable	8	14.55
Not suitable for climate	3	5.45
Total:	55	100

Do you ever include energy efficiency features beyond what is required in the code in your residential design and construction practices?

Composite Results:

	N	%
Yes	137	73.66
No	49	26.34
Total:	186	100

Idaho Results:

	N	%
Yes	4	80.00
No	1	20.00
Total:	5	100

Montana Results:

	N	%
Yes	10	76.92
No	3	23.08
Total:	13	100

Oregon Results:

	N	%
Yes	65	68.42
No	30	31.58
Total:	95	100

Washington Results:

	N	%
Yes	58	79.45
No	15	20.55
Total:	73	100

[ ] If Yes, Why [install energy efficient features]?

Composite Results:

	N	%
Customer request	45	40.54
Marketing	16	14.41
Energy efficiency	8	7.21
Moral/Political/Personal pride	17	15.32
Cost-effectiveness	11	9.91
SGC/Earthsmart	5	4.50
Sound barrier	2	1.80
Construction ease	7	6.31
Total:	111	100

Idaho Results:

	N	%
Customer request	1	33.33
Marketing	1	33.33
Moral/Political/Personal pride	1	33.33
Total:	3	100

Montana Results:

	N	%
Customer request	8	80.00
Energy efficiency	1	10.00
Moral/Political/Personal pride	1	10.00
Total:	10	100

Oregon Results:

	N	%
Customer request	17	36.17
Marketing	7	14.89
Energy efficiency	4	8.51
Moral/Political/Personal pride	7	14.89
Cost-effectiveness	4	8.51
SGC/Earthsmart	3	6.38
Sound barrier	1	2.13
Construction ease	4	8.51
Total:	47	100

Washington Results:

	N	%
Customer request	19	37.25
Marketing	8	15.69
Energy efficiency	3	5.88
Moral/Political/Personal pride	8	15.69
Cost-effectiveness	7	13.73
SGC/Earthsmart	2	3.92
Sound barrier	1	1.96
Construction ease	3	5.88
Total:	51	100

What are these [energy efficient] features?

Composite Results:

	N	%
Framing	6	2.67
Heating Systems/Ducts	63	28.00
Insulation	91	40.44
Ventilation	14	6.22
Windows	39	17.33
Other	12	5.33
Total:	225	100

Idaho Results:

	N	%
Heating Systems/Ducts	1	33.33
Insulation	1	33.33
Ventilation	1	33.33
Total:	3	100

Montana Results:

	N	%
Framing	1	6.25
Heating Systems/Ducts	3	18.75
Insulation	9	56.25
Ventilation	1	6.25
Windows	2	12.50
Total:	16	100

Oregon Results:

	N	%
Framing	3	2.86
Heating Systems/Ducts	32	30.48
Insulation	40	38.10
Ventilation	8	7.62
Windows	15	14.29
Other	7	6.67
Total:	105	100

Washington Results:

	N	%
Framing	2	1.98
Heating Systems/Ducts	27	26.73
Insulation	41	40.59
Ventilation	4	3.96
Windows	22	21.78
Other	5	4.95
Total:	101	100

Do you use energy efficiency to market your homes? Why or Why Not?

Composite Results:

	N	%
No	130	68.06%
Yes	61	31.94%
Total:	191	100.00%

Idaho Results:

	N	%
No	1	50.00%
Yes	1	50.00%
Total:	2	100.00%

Montana Results:

	N	%
No	7	38.89%
Yes	11	61.11%
Total:	18	100.00%

Oregon results:

	N	%
No	66	73.33%
Yes	24	26.67%
Total:	90	100.00%

Washington results:

	N	%
No	56	69.14%
Yes	25	30.86%
Total:	81	100.00%

Why do you market Energy Efficiency?

Composite Results:

	N	%
Selling Point	10	90.91
Super Good Cents	1	9.09
Total:	11	100.00

No results in Idaho or Montana.

Oregon Results:

	N	%
Selling Point	4	80.00%
Super Good Cents	1	20.00%
Total:	5	100.00%

Washington Results:

	N	%
Selling Point	6	100.00%
Total:	6	100.00%

Why not market Energy Efficiency?

Composite Results:

	N	%
No Demand/Not Competitive	29	35.80%
Consumers Won't Pay For	21	25.93%
Too Expensive	14	17.28%
Code is Adequate	16	19.75%
Code is Extreme	1	1.23%
Total:	81	100.00%

Idaho Results:

	N	%
No Demand/Not Competitive	1	100.00%
Total:	1	100.00%

Montana Results:

	N	%
No Demand/Not Competitive	1	20.00%
Consumers Won't Pay For	1	20.00%
Too Expensive	3	60.00%
Total:	5	100.00%

Oregon Results:

	N	%
No Demand/Not Competitive	14	35.00%
Consumers Won't Pay For	11	27.50%
Too Expensive	4	10.00%
Code is Adequate	10	25.00%
Code is Extreme	1	2.50%
Total:	40	100.00%

Washington Results:

	N	%
No Demand/Not Competitive	13	37.14%
Consumers Won't Pay For	9	25.71%
Too Expensive	7	20.00%
Code is Adequate	6	17.14%
Total:	35	100.00 %

Are there specific aspects of energy efficient construction that you can think of which have significant impacts to project cost? Describe.

Composite Results:

	N	%
No	120	56.87%
Yes	91	43.13%
Total:	211	100.00%
Framing Requirements	18	14.75
Heating Systems	22	18.03
Insulation	39	31.97
Windows	23	18.85
Other	20	16.39
Total	122	100.00%

Idaho Results:

	N	%
No	0	0.00%
Yes	5	100.00%
Total:	5	100.00%
Framing Requirements	3	50.00%
Insulation	3	50.00%
Total	6	100.00%

Montana Results:

	N	%
No	5	29.41%
Yes	12	70.59%
Total:	17	100.00%
Framing Requirements	1	5.56%
Heating Systems	3	16.67%
Insulation	5	27.78%
Windows	5	27.78%
Other	4	22.22%
Total	18	100.00%

Oregon Results:

	N	%
No	58	58.59%
Yes	41	41.41%
Total:	99	100.00%
Framing Requirements	8	14.55%
Heating Systems	10	18.18%
Insulation	20	36.36%
Windows	10	18.18%
Other	7	12.73%
Total	55	100.00%

Washington Results:

	N	%
No	57	63.33%
Yes	33	36.67%
Total:	90	100.00%
Framing Requirements	6	13.95%
Heating Systems	9	20.93%
Insulation	11	25.58%
Windows	8	18.60%
Other	9	20.93%
Total	43	100.00%

Do home buyers or real estate agents show any concern for energy efficiency?

Composite Results:

	N	%
Yes	93	44.08%
No	118	55.92%
Total:	211	100.00%

Idaho Results:

	N	%
Yes	2	40.00%
No	3	60.00%
Total:	5	100.00%

Montana Results:

	N	%
Yes	5	31.25%
No	11	68.75%
Total:	16	100.00%

Oregon Results:

	N	%
Yes	49	47.57%
No	54	52.43%
Total:	103	100.00%

Washington Results:

	N	%
Yes	37	42.53%
No	50	57.47%
Total:	87	100.00%

If so [customers ask about energy efficiency], how?

Composite Results:

	N	%
General Interest	47	38.84%
Insulation/Framing	33	27.27%
Heating/Cooling Cost	17	14.05%
Heat Pumps	14	11.57%
Windows	8	6.61%
Occupant Comfort	2	1.65%
Total:	121	100.00%

Idaho Results

	N	%
Heating/Cooling Cost	1	50.00%
Occupant Comfort	1	50.00%
Total:	1	100.00%

Montana Results:

	N	%
General Interest	3	37.50%
Insulation/Framing	1	12.50%
Heating/Cooling Cost	4	50.00%
Total:	8	100.00%

Oregon Results:

	N	%
General Interest	21	38.18%
Insulation/Framing	18	32.73%
Heating/Cooling Cost	4	7.27%
Heat Pumps	6	10.91%
Windows	5	9.09%
Occupant Comfort	1	1.82%
Total:	55	100.00%

Washington Results:

	N	%
General Interest	23	41.07%
Insulation/Framing	14	25.00%
Heating/Cooling Cost	8	14.29%
Heat Pumps	8	14.29%
Windows	3	5.36%
Total:	56	100.00%

Which of the following most effects energy performance in homes?
Rate on a scale of 1 to 5.
(1: no effect on energy performance; 5: large effect on energy performance.)

- **[ ] insulation levels**
- **[ ] window performance**
- **[ ] home design**
- **[ ] house size**
- **[ ] framing methods and construction techniques**
- **[ ] fuel type**
- **[ ] appliances installed**

Composite Results:

	5		4		3		2		1		Tot N
	N	%	N	%	N	%	N	%	N	%	
Insulation levels	167	73.57	50	22.03	7	3.08	3	1.32	0	0.00	227
Window performance	87	38.50	78	34.51	52	23.01	7	3.10	2	0.88	226
Home design	36	16.14	57	25.56	85	38.12	38	17.04	7	3.14	223
House size	55	24.23	47	20.70	81	35.68	38	16.74	6	2.64	227
Framing methods	32	14.48	73	33.03	56	25.34	48	21.72	12	5.43	221
Fuel type	79	35.91	74	33.64	38	17.27	19	8.64	10	4.55	220
Appliance installed	19	8.72	42	19.27	65	29.82	65	29.82	27	12.39	218

Idaho Results:

	5		4		3		2		1		Tot N
	N	%	N	%	N	%	N	%	N	%	
Insulation levels	5	100	0	0.00	0	0.00	0	0.00	0	0.00	5
Window performance	0	0.00	3	60.00	2	40.00	0	0.00	0	0.00	5
Home design	1	20.00	0	0.00	2	40.00	2	40.00	0	0.00	5
House size	2	40.00	0	0.00	1	20.00	2	40.00	0	0.00	5
Framing methods	1	20.00	1	20.00	3	60.00	0	0.00	0	0.00	5
Fuel type	2	40.00	0	0.00	3	60.00	0	0.00	0	0.00	5
Appliance installed	1	20.00	0	0.00	1	20.00	2	40.00	1	20.00	5

Montana Results:

	5		4		3		2		1		Tot N
	N	%	N	%	N	%	N	%	N	%	
Insulation levels	14	66.67	6	28.57	0	0.00	1	4.76	0	0.00	21
Window performance	5	25.00	7	35.00	6	30.00	0	0.00	0	0.00	20
Home design	2	11.76	4	23.53	7	41.18	1	5.88	3	17.65	17
House size	3	14.29	4	19.05	9	42.86	4	19.05	1	4.76	21
Framing methods	2	13.33	6	40.00	1	6.67	4	26.67	2	13.33	15
Fuel type	12	57.14	1	4.76	3	14.29	3	14.29	2	9.52	21
Appliance installed	1	8.33	0	0.00	2	16.67	7	58.33	2	16.67	12

Oregon Results:

	5		4		3		2		1		Tot N
	N	%	N	%	N	%	N	%	N	%	
Insulation levels	85	80.19	17	16.04	3	2.83	1	0.94	0	0.00	106
Window performance	44	41.51	35	33.02	24	22.64	3	2.83	0	0.00	106
Home design	16	15.09	25	23.58	45	42.45	18	16.98	2	1.89	106
House size	21	19.81	22	20.75	40	37.74	19	17.92	4	3.77	106
Framing methods	15	14.15	33	31.13	28	26.42	24	22.64	6	5.66	106
Fuel type	27	26.21	43	41.75	20	19.42	7	6.80	6	5.83	103
Appliance installed	8	7.55	22	20.75	36	33.96	30	28.30	10	9.43	106

Washington Results:

	5		4		3		2		1		Tot N
	N	%	N	%	N	%	N	%	N	%	
Insulation levels	63	66.32	27	28.42	4	4.21	1	1.05	0	0.00	95
Window performance	38	40.00	33	34.74	20	21.05	4	4.21	0	0.00	95
Home design	17	17.89	28	29.47	31	32.63	17	17.89	2	2.11	95
House size	29	30.53	21	22.11	31	32.63	13	13.68	1	1.05	95
Framing methods	14	14.74	33	34.74	24	25.26	20	21.05	4	4.21	95
Fuel type	38	41.76	27	29.67	15	16.48	9	9.89	2	2.20	91
Appliance installed	9	9.47	20	21.05	26	27.37	26	27.37	14	14.74	95

What aspects of residential construction do you think are most in need of improvement with respect to energy efficiency?

Composite Results:

	N	%
Insulation	49	20.33
Ventilation/Infiltration	31	12.86
Heating Systems	31	12.86
Already Adequate or Excessive	30	12.45
Windows/Doors	21	8.71
Moisture (Vapor Barrier/House Wrap)	19	7.88
Framing	13	5.39
Duct Siting/Sealing	7	2.90
Improved Enforcement	6	2.49
Alternative Heat (Solar)	3	1.24
Contractor Education	3	1.24
Walls	3	1.24
Other	25	10.36
Total:	241	100.00%

Idaho Results:

	N	%
Windows/Doors	1	16.67
Framing	1	16.67
Improved Enforcement	1	16.67
Contractor Education	1	16.67
Walls	1	16.67
Other	1	16.67
Total:	6	100.00%

Montana Results:

	N	%
Ventilation/Infiltration	1	12.50
Heating Systems	1	12.50
Already Adequate or Excessive	1	12.50
Windows/Doors	3	37.50
Alternative Heat (Solar)	1	12.50
Other	1	12.50
Total:	8	100.00%

Oregon Results:

	N	%
Insulation	24	21.05
Ventilation/Infiltration	16	14.04
Heating Systems	15	13.16
Already Adequate or Excessive	14	12.28
Windows/Doors	8	7.02
Moisture (Vapor Barrier/House Wrap)	11	9.65
Framing	8	7.02
Duct Siting/Sealing	2	1.75
Improved Enforcement	3	2.63
Alternative Heat (Solar)	2	1.75
Contractor Education	2	1.75
Other	9	7.90
Total:	114	100.00%

Washington Results:

	N	%
Insulation	25	22.12
Ventilation/Infiltration	14	12.39
Heating Systems	15	13.27
Already Adequate or Excessive	15	13.27
Windows/Doors	9	7.96
Moisture (Vapor Barrier/House Wrap)	8	7.08
Framing	4	3.54
Duct Siting/Sealing	5	4.42
Improved Enforcement	2	1.77
Walls	2	1.77
Other	14	12.39
Total:	113	100.00%

What would make energy efficiency more important in the new home market?

Composite Results:

	N	%
Higher Heating Costs	82	44.57%
Consumer Education	58	31.52%
Lower First Costs/Requirement	22	11.96%
Mortgage/Tax Credits	16	8.70%
Better Products	3	1.63%
Builder Marketing	2	1.09%
Labeling for More Components	1	0.54%
Total:	184	100.00%

Idaho Results:

	N	%
Higher Heating Costs	2	50.00%
Consumer Education	1	25.00%
Lower First Costs/Requirement	1	25.00%
Total:	4	100.00%

Montana Results:

	N	%
Higher Heating Costs	4	44.44%
Consumer Education	5	55.56%
Total:	9	100.00%

Oregon Results:

	N	%
Higher Heating Costs	41	44.09%
Consumer Education	30	32.25%
Lower First Costs/Requirement	12	12.90%
Mortgage/Tax Credits	7	7.53%
Better Products	3	3.23%
Total:	93	100.00%

Washington Results:

	N	%
Higher Heating Costs	35	44.87%
Consumer Education	22	28.21%
Lower First Costs/Requirement	9	11.54%
Mortgage/Tax Credits	9	11.54%
Builder Marketing	2	2.56%
Labeling for More Components	1	1.28%
Total:	78	100.00%

Energy Codes

Is there an energy code for residential building enforced in your area?

[ ] Yes
[ ] No

Composite Results:

	N	%
Yes	225	98.25%
No	4	1.75%

Total:	229	100.00%

Idaho Results:

	N	%
Yes	4	80.00%
No	1	20.00%
Total:	5	100.00%

Montana Results:

	N	%
Yes	19	90.48%
No	2	9.52%
Total:	21	100.00%

Oregon Results:

	N	%
Yes	106	99.07%
No	1	0.93%
Total:	107	100.00%

Washington Results:

	N	%
Yes	96	100.00%
Total:	96	100.00%

If no skip to NO ENERGY CODE section

Are the energy code requirements interpreted inconsistently by jurisdictions or within a single jurisdiction?
( ) Yes ( ) No

Composite Results:

	N	%
Yes	50	22.94%
No	168	77.06%
Total:	218	100.00%

Idaho Results:

	N	%
Yes	3	75.00%
No	1	25.00%
Total:	4	100.00%

Montana Results:

	N	%
Yes	50	38.89%
No	168	61.11%
Total:	218	100.00%

Oregon Results:

	N	%
Yes	13	12.38%
No	92	87.62%
Total:	105	100.00%

Washington Results:

	N	%
Yes	27	29.67%
No	64	70.33%
Total:	91	100.00%

Enforced Differently?

Composite Results:

	N	%
Individual Inspectors Differ	4	80.00%
Differences Between Jurisdiction	1	20.00%
Total:	5	100.00%

Oregon Results:

	N	%
Individual Inspectors Differ	2	66.67%
Differences Between Jurisdiction	1	33.33%
Total:	3	100.00%

Washington Results:

	N	%
Individual Inspectors Differ	2	100.00%
Total:	2	100.00%

Are there elements of the energy code that you feel are not cost-effective or poorly thought out? Which ones?

Composite Results:

	N	%
Yes	83	39.34%
No	128	60.66%
Total:	211	100.00%
Ventilation/Moisture Problems	40	46.51%
Insulation	26	30.23%
Windows	4	4.65%
Thermal Mass	3	3.49%
Climate Not Adequately Considered	2	2.33%
More Flexible	2	2.33%
ManuHome Code Too Lenient	2	2.33%
Residential Steel Framing	2	2.33%
Compliance Cost is Excessive	1	1.16%
Ducts/Heating Systems	1	1.16%
Ensure Changes Are Cost Effective	1	1.16%
SGC Should Be Code	1	1.16%
Very Happy With Code	1	1.16%
Total:	86	100.00%

Idaho Results:

	N	%
Yes	2	50.00%
No	2	50.00%
Total:	4	100.00%
Ventilation/Moisture Problems	1	50.00%
Insulation	1	50.00%
Total:	2	100.00%

Montana Results:

	N	%
Yes	4	22.22%
No	14	77.78%
Total:	18	100.00%
Ventilation/Moisture Problems	2	66.67%
Insulation	1	33.33%
Total:	3	100.00%

Oregon Results:

	N	%
Yes	34	33.66%
No	67	66.34%
Total:	101	100.00%
Ventilation/Moisture Problems	12	31.58%
Insulation	14	36.84%
Windows	2	5.26%
Thermal Mass	1	2.63%
Climate Not Adequately Considered	1	2.63%
More Flexible	2	5.26%
Residential Steel Framing	1	2.63%
Compliance Cost is Excessive	1	2.63%
Ducts/Heating Systems	1	2.63%
Ensure Changes Are Cost Effective	1	2.63%
SGC Should Be Code	1	2.63%
Very Happy With Code	1	2.63%
Total:	38	100.00%

Washington Results:

	N	%
Yes	43	48.86%
No	45	51.14%
Total:	88	100.00%
Ventilation/Moisture Problems	25	58.14%
Insulation	10	23.26%
Windows	2	4.65%
Thermal Mass	2	4.65%
Climate Not Adequately Considered	1	4.65%
ManuHome Code Too Lenient	2	2.33%
Residential Steel Framing	1	2.33%
Total:	43	100.00%

Does the general contractor or the individual subcontractor take responsibility for energy code compliance?

Composite Results:

	N	%
General Contractor	172	86.00
Sub-Contractor	28	14.00
Total:	200	100.00

Idaho Results:

	N	%
General Contractor	2	100.00
Total:	2	100.00

Montana Results:

	N	%
General Contractor	16	100.00
Total:	16	100.00

Oregon Results:

	N	%
General Contractor	83	87.37
Sub-Contractor	12	12.63
Total:	95	100.00

Washington Results:

	N	%
General Contractor	71	81.61
Sub-Contractor	16	18.39
Total:	87	100.00

Where do you document energy related issues such as insulation levels, window types, mechanical spec etc.?

( ) Plan Set **( ) Permit Submittal Forms**
( ) Neither **( ) Both**

Composite Results:

	N	%
Plan Set	92	41.63
Permit Submittal Forms	49	22.17
Both	74	33.48
Neither	6	2.71
Total:	221	100.00

Idaho Results:

	N	%
Plan Set	0	0.00
Permit Submittal Forms	1	33.33
Both	2	66.67
Neither	0	0.00
Total:	3	100.00

Montana Results:

	N	%
Plan Set	11	64.71
Permit Submittal Forms	0	0.00
Both	2	11.76
Neither	4	23.53
Total:	17	100.00

Oregon Results:

	N	%
Plan Set	59	56.73
Permit Submittal Forms	17	16.35
Both	28	26.92
Neither	0	0.00
Total:	104	100.00

Washington Results:

	N	%
Plan Set	22	22.68
Permit Submittal Forms	31	31.96
Both	42	43.30
Neither	2	2.06
Total:	97	100.00

If you use energy code compliance forms, how long does it take to complete them?

Composite Results:

	N	%
0 – 15 minutes	39	59.09
15 – 30 minutes	18	27.27
1 hour	4	6.06
2 – 5 hours	4	6.06
6 – 10 hours	1	1.52
Total:	66	100.00

Idaho Results:

	N	%
0 – 15 minutes	3	100.00
Total:	3	100.00

Montana Results:

	N	%
15 – 30 minutes	1	100.00
Total:	1	100.00

Oregon Results:

	N	%
0 – 15 minutes	16	88.89
15 – 30 minutes	1	5.56
1 hour	1	5.56
Total:	18	100.00

Washington Results:

	N	%
0 – 15 minutes	20	45.45
15 – 30 minutes	16	36.36
1 hour	3	6.82
2 – 5 hours	4	9.09
6 – 10 hours	1	2.27
Total:	44	100.00

Is that too much time? How can the code forms be improved?

Composite Results:

	N	%
No	48	78.69%
Yes	13	21.31
Total:	61	100%
Don't Use/Others Complete	122	67.40%
Like Forms	45	24.86%
Should Be Eliminated	9	4.97%
Need to Simplify	2	1.10%
Provide/Accept Software	2	1.10%
More Builder Input	1	0.55%
Total:	181	100%

Idaho Results:

	N	%
No	4	80.00%
Yes	1	20.00%
Total:	5	100.00%
Like Forms	4	100.00%

Total:	4	100.00%

Montana Results:

	N	%
No	3	60.00%
Yes	2	40.00%
Total:	5	100.00%
Don’t Use/Others Complete	8	100.00%
Total:	8	100.00%

Oregon Results:

	N	%
No	7	77.78%
Yes	2	22.22%
Total:	9	100.00%
Don’t Use/Others Complete	77	81.91%
Like Forms	15	15.96%
Should Be Eliminated	2	2.13%
Total:	94	100%

Washington Results:

	N	%
No	34	77.27%
Yes	10	22.73%
Total:	44	100.00%
Don’t Use/Others Complete	37	49.33%
Like Forms	26	34.67%
Should Be Eliminated	7	9.33%
Need to Simplify	2	2.67%
Provide/Accept Software	2	2.67%
More Builder Input	1	1.33%
Total:	75	100%

Please say YES or NO whether the following issues accurately describe the energy codes in your area:

General

[y] [n] Code language is obscure or unenforceable
[y] [n] Jurisdictions lack enforcement resources
[y] [n] There is resistance to code requirements in the building community
[y] [n] The energy code requirements change frequently

The energy code is too complex and needs to be simplified.

[y] **[n]**

Composite Results:

	Yes		No		Tot N
	N	%	N	%	
Code language is obscure or unenforceable	23	10.60	194	89.40	217
Jurisdictions lack enforcement resources	26	11.76	195	88.24	221
There is resistance in the building community	40	17.78	185	82.22	225
Code requirements change frequently	140	61.67	87	38.33	227
The energy code needs to be simplified	50	22.73	170	77.27	220

Idaho Results:

	Yes		No		Tot N
	N	%	N	%	
Code language is obscure or unenforceable	0	0.00	4	100.00	4
Jurisdictions lack enforcement resources	2	50.00	2	50.00	4
There is resistance in the building community	1	25.00	3	75.00	4
Code requirements change frequently	3	60.00	2	40.00	5
The energy code needs to be simplified	1	25.00	3	75.00	4

Montana Results:

	Yes		No		Tot N
	N	%	N	%	
Code language is obscure or unenforceable	2	10.00	18	90.00	20
Jurisdictions lack enforcement resources	3	15.00	17	85.00	20
There is resistance in the building community	4	20.00	16	80.00	20
Code requirements change frequently	11	52.38	10	47.62	21
The energy code needs to be simplified	0	0.00	20	100.00	20

Oregon Results:

	Yes		No		Tot N
	N	%	N	%	
Code language is obscure or unenforceable	8	7.84	94	92.16	102
Jurisdictions lack enforcement resources	8	7.69	96	92.31	104
There is resistance in the building community	10	9.43	96	90.57	106
Code requirements change frequently	66	61.68	41	38.32	107
The energy code needs to be simplified	14	13.33	91	86.67	105

Washington Results:

	Yes		No		Tot N
	N	%	N	%	

Code language is obscure or unenforceable	13	14.29	78	85.71	91
Jurisdictions lack enforcement resources	13	13.98	80	86.02	93
There is resistance in the building community	25	26.32	70	73.68	95
Code requirements change frequently	60	63.83	34	36.17	94
The energy code needs to be simplified	35	38.46	56	61.54	91

No Energy Code

Are you aware of any codes or guidelines for energy efficient construction in your region?

[n]
[y]

Describe: ____

Composite Results:

	N	%
Yes	2	66.67%
No	1	33.33%
Total:	3	100.00%

Idaho Results:

	N	%
Yes	1	50.00%
No	1	50.00%
Total:	2	100.00%
For City	1	50.00%
IRES	1	50.00%
Total:	2	100.00%

Montana Results:

	N	%
Yes	1	100.00%
No	0	0.00%
Total:	1	100.00%
For City	1	100.00%
Total:	1	100.00%

If yes, do you follow these guidelines?

[y] **[n]**

Composite Results:

	N	%
Yes	2	100.00%
No	0	0.00%
Total:	2	100.00%

Idaho Results:

	N	%
Yes	1	100.00%
No	0	0.00%
Total:	1	100.00%

Montana Results:

	N	%
Yes	1	100.00%
No	0	0.00%
Total:	1	100.00%

Why or Why not?

No Results.

Are you aware of any organizations promoting energy efficient construction in the region, with information or incentives?

[y] [n]

Composite Results:

	N	%
Yes	0	0.00%
No	2	100.00%
Total:	2	100.00%

Idaho Results:

	N	%
Yes	0	0
No	2	100.00%
Total:	2	100.00%

Describe organization: ____

Describe type of information or incentives: ____

No Results

Training and Information

Have you participated in any training on energy efficient building practices?

Composite Results:

	N	%
Yes	81	36.49
No	141	63.51
Total:	222	100.00

Idaho Results:

	N	%
Yes	5	100.00
Total:	5	100.00

Montana Results:

	N	%
Yes	11	64.71
No	6	35.29
Total:	17	100.00

Oregon Results:

	N	%
Yes	35	32.71
No	72	67.29
Total:	107	100.00

Washington Results:

	N	%
Yes	30	32.26
No	63	67.74
Total:	93	100.00

What sort of training?

Composite Results:

	N	%
Seminars	16	33.33%
Super Good Cents	13	27.08%
State Training	10	20.83%
Self-Taught	6	12.50%
College Training	3	6.25%
Total:	48	100.00%

Idaho Results:

	N	%
Seminars	1	100.00%
Total:	1	100.00%

Montana Results:

	N	%
Seminars	1	12.50%
Super Good Cents	3	37.50%
State Training	2	25.00%
Self-Taught	2	25.00%
Total:	8	100.00%

Oregon Results:

	N	%
Seminars	9	56.25%
Super Good Cents	3	18.75%
State Training	1	6.25%
Self-Taught	3	18.75%
Total:	16	100.00%

Washington Results:

	N	%
Seminars	5	21.74%
Super Good Cents	7	30.43%
State Training	7	30.43%
Self-Taught	1	4.35%
College Training	3	13.04%
Total:	23	100.00%

Have you ever heard of the "Energy Star" Program for New Homes? [y] [n]
Appliances? [y] [n]

Composite Results:

	Yes		No		Tot N
	N	%	N	%	
Energy Star - New Homes	38	16.89	187	83.11	225
Energy Star - Appliances	51	22.97	171	77.03	222

Idaho Results:

	Yes		No		Tot N
	N	%	N	%	
Energy Star - New Homes	1	20.00	4	80.00	5
Energy Star - Appliances	1	20.00	4	80.00	5

Montana Results:

	Yes		No		Tot N
	N	%	N	%	
Energy Star - New Homes	7	35.00	13	65.00	20
Energy Star - Appliances	7	36.84	12	63.16	19

Oregon Results:

	Yes		No		Tot N
	N	%	N	%	
Energy Star - New Homes	20	18.87	86	81.13	106
Energy Star - Appliances	26	24.30	81	75.70	107

Washington Results:

	Yes		No		Tot N
	N	%	N	%	
Energy Star - New Homes	10	10.64	84	89.36	94
Energy Star - Appliances	17	18.68	74	81.32	91

Would you use advisory services provided by any of the following organizations or individuals to decide on energy efficient measures?

[ ] Utility
[ ] State government
[ ] HVAC subcontractor
[ ] Consultant

Note: This was a "checkmark" field. The table below summarizes the number of "yes" answers. Percentages would not be meaningful in this context.

	Idaho	Montana	Oregon	Washington
Utility	5	10	62	47
State government	4	3	43	22
HVAC subcontractor	3	7	66	53
Consultant	3	8	38	29
Total	15	28	209	151

Do you ever make changes to your building practices as a result of energy efficiency information you have received? Describe.

Composite Results:

	N	%
No	17	9.04
Insulation Strategies	33	17.55
Vapor Barrier	17	9.04
Better Doors/Windows	31	16.49
Sealing Techniques	26	13.83
Framing Techniques	19	10.11
Heating System/Fuel Choice	25	13.30
Other	4	2.13
Super Good Cents	5	2.66
Will Consider	10	5.32
Use of Recycled Materials	1	0.53
Total:	188	100.00

Idaho Results:

	N	%
No	1	50.00
Insulation Strategies	1	50.00
Total:	2	100.00

Montana Results:

	N	%
No	2	10.53
Insulation Strategies	4	21.05
Vapor Barrier	2	10.53
Better Doors/Windows	4	21.05
Sealing Techniques	4	21.05
Framing Techniques	1	5.26
Heating System/Fuel Choice	1	5.26
Use of Recycled Materials	1	5.26
Total:	19	100.00

Oregon Results:

	N	%
No	7	8.64
Insulation Strategies	16	19.75
Vapor Barrier	6	7.41
Better Doors/Windows	6	7.41
Sealing Techniques	11	13.58
Framing Techniques	9	11.11
Heating System/Fuel Choice	10	12.35
Other	2	2.47
Super Good Cents	4	4.94
Will Consider	10	12.35
Total:	81	100.00

Washington Results:

	N	%
No	7	8.14
Insulation Strategies	12	13.95
Vapor Barrier	9	10.47
Better Doors/Windows	21	24.42
Sealing Techniques	11	12.79
Framing Techniques	9	10.47
Heating System/Fuel Choice	14	16.28
Other	2	2.33
Super Good Cents	1	1.16
Total:	86	100.00

I will read three barriers to applying energy efficient designs and technologies and I would like you to choose which one of the three represents the largest barrier for you.

Note: Builders did not appear to like this set of questions. Almost all interviews returned missing values for these fields and eventually the interviewers began skipping this section.

[ ] Initial cost is too high
[ ] Payback is too low
[ ] Clients won't pay for energy efficient features
[ ] Certain energy eff. features are difficult to install with the subcontractors and labor available
[ ] Time, effort and resources required to learn new technologies is too great
[ ] Existing products or designs are unreliable or poorly thought out

[ ] The effect of insulation & window specifications are not understood by the homeowner.
[ ] The home buyer does not consider future energy savings
[ ] Home buyers are not aware of the initial cost and the future savings of energy efficient features.

Are there any other barriers that you have found?

Composite Results:

	N	%
Inspectors	1	0.54%
Vapor Barrier/House Wrap	1	0.54%
Cost of Efficiency	16	8.70%
No	150	81.52%
Lack of Consumer Education	13	7.07%
Excessive Paperwork	3	1.63%
Total:	184	100.00%

Idaho Results:

	N	%
Inspectors	1	50.00%
No	1	50.00%
Total:	2	100.00%

Montana Results:

	N	%
Vapor Barrier/House Wrap	1	16.67%
Cost of Efficiency	1	16.67%
No	4	66.67%
Total:	6	100.00%

Oregon Results:

	N	%
Cost of Efficiency	10	10.31%
No	76	78.35%
Lack of Consumer Education	10	10.31%
Excessive Paperwork	1	1.03%
Total:	97	100.00%

Washington Results:

	N	%
Cost of Efficiency	5	6.33%
No	69	87.34%
Lack of Consumer Education	3	3.80%
Excessive Paperwork	2	2.53%
Total:	79	100.00%

Are there any other issues affecting energy efficient construction which I have not covered?

Composite Results:

	N	%
No	127	72.16
Too Tight/Moisture Problems	14	7.95%
Exempt Remodels	1	0.57%
Offer Rebate Programs/Tax Credits	5	2.84%
Code/Enforcement Should Be Stricter	5	2.84%
Address Alternative Heating Systems	5	2.84%
Consider First Costs More	6	3.41%
Consider Enforcement	1	0.57%
Scale Back Code	2	1.14%
Provide Handbook/Website/Software	2	1.14%
Eliminate Dual Fuel	1	0.57%
Lighting Too Strict	2	1.14%
Paperwork Requirements Excessive	2	1.14%
Educate Consumers	1	0.57%
Glazing Restrictions Excessive	2	1.14%
Total:	176	100.00%

Idaho Results:

	N	%
No	2	100.00%
Total:	2	100.00%

Montana Results:

	N	%
No	4	100.00%
Total:	4	100.00%

Oregon Results:

	N	%
No	62	68.89%
Too Tight/Moisture Problems	10	11.11%
Exempt Remodels	1	1.11%
Offer Rebate Programs/Tax Credits	2	2.22%
Code/Enforcement Should Be Stricter	2	2.22%
Address Alternative Heating Systems	3	3.33%
Consider First Costs More	5	5.56%
Consider Enforcement	1	1.11%
Scale Back Code	1	1.11%
Provide Handbook/Website/Software	1	1.11%
Educate Consumers	1	1.11%
Glazing Restrictions Excessive	1	1.11%
Total:	90	100.00%

Washington Results:

	N	%
No	59	73.75%
Too Tight/Moisture Problems	4	5.00%
Offer Rebate Programs/Tax Credits	3	3.75%
Code/Enforcement Should Be Stricter	3	3.75%
Address Alternative Heating Systems	2	2.50%
Consider First Costs More	1	1.25%
Scale Back Code	1	1.25%
Provide Handbook/Website/Software	1	1.25%
Eliminate Dual Fuel	1	1.25%
Lighting Too Strict	2	2.50%
Paperwork Requirements Excessive	2	2.50%
Glazing Restrictions Excessive	1	1.25%
Total:	80	100.00%

(Thanks for your time)