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

For the

Northwest Energy Efficiency Alliance

ECOTOPE
CONSULTING
RESEARCH
DESIGN

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October, 2001

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Executive Summary to Non-Residential Baseline Study

The purpose of this study is to compile a baseline set of characteristics on non-residential building practices in the Pacific Northwest region. For this purpose, the baseline has four important components:

1. The description of the size and type of buildings constructed in each of the four states.
2. The identification of characteristics associated with energy use in these buildings (components regulated in local, national, and other energy codes).
3. Observations of markets for particular building components and products.
4. The description of the attitudes towards energy-efficiency among design professions.

Sampling

The general methodology for this study was to select a stratified random sample of buildings that began construction during the interval between June 1997 and June 1998. Buildings selected were 'recruited' through their owners and architects and visited to establish their characteristics.

A sample frame was developed from the FW Dodge Dataline®, a private sector database. The sample was drawn within each state so that the data collected would be representative of the building characteristics of that state. Table 1 summarizes the number of buildings (sample frame) and sample size for each state for this study, as well as data from earlier baseline studies done in the region.

Table 1: Non-residential Baseline Samples by State

State	Year	Sample Frame		Sample		Percent Sampled
		N	Ft^2 (000)	N	Ft^2 (000)	
Idaho	98	356	5,568	48	2,037	36.6
Montana	98	168	2,581	32	1,160	44.9
Oregon	98	655	18,814	64	5,021	26.7
Washington	98	1,020	25,804	88	9,771	37.9
Region*	98	2,199	52,767	144	8,218	30.5
Washington	96	792	25,128	88	6,092	24.2
Oregon	90	213	8,290	71	3,817	46.0
Washington	90	468	17,360	70	4,296	24.7

*Regional sample did not include Washington in this year

Because a baseline study was conducted in Washington just 2 years prior to this study, another review of characteristics was not done at this time. Table 1 represents actual

1998 activity for Washington (the sample frame). A sample was designed for Washington so that the size and type of buildings could be compared to the remainder of the region. The sample from the 1995 – 1996 building year was roughly equivalent, and is quoted throughout this report to describe building characteristics in Washington. Two additional samples are also noted from the 1990 building year. These samples were drawn in Oregon and Washington using a similar methodology and protocol. The protocols are not completely comparable, but at several points comparisons and trends can be drawn using these baselines.

In summary, approximately 2,200 new commercial buildings were built in the region in 1998. Of the 1,179 in Idaho, Montana, and Oregon, 144 were analyzed in depth for this study. The analysis is done in such a way that the results presented for 1998 represent characteristics we would expect to see across the full set of 1,179 buildings in Idaho, Montana and Oregon.

The counties surrounding Seattle and Portland accounted for 64% of the new construction that took place. Another 10% was centered around Spokane and Boise. In 1998, 19% of the square footage was in office buildings, 17% warehouse, 13% retail, and 10% education. About 95% of the buildings were small to medium sized (less than 80,000 square feet), but only about 60% of the region's new building area is in these buildings.

Building Characteristics

Building characteristics for this survey were divided into three general categories: building envelope, building heating, ventilating and air conditioning (HVAC) systems, and building lighting. The field protocol required auditors to record detailed information on construction type, insulation levels, glazing specifications, as well as HVAC system characteristics and lighting system type and efficiency. Numerous components were summarized and compared across the individual states. In this summary, only a few key characteristics are represented (additional ones can be found in the full report).

Codes and Standards

Energy codes that regulate the components of the non-residential buildings are used in all states of the region. There are, however, great differences between the provisions and the institutional support for these codes. The federal Model Energy Code (MEC) is actually the ASHRAE Standard 90.1-89, and has been adopted by reference in both Idaho and Montana. In Idaho this code is enforced at the option of the jurisdiction, but is generally ignored by most local building departments. In Montana the code is enforced by the local jurisdictions, but since their authority does not cover most of the state, the Montana State Department of Commerce handles enforcement in most of the state. However, this is done with minimal enforcement resources. In Oregon, a state energy code is mandated for all jurisdictions, although the code differs somewhat from the MEC. The Washington non-residential energy code is similar to Oregon's and is mandated for all jurisdictions in the state. Each Washington jurisdiction must implement a code that is no less stringent than the state code and, in a few cases, may be more stringent.

Building Envelope

Building envelope characteristics are somewhat complex, and codes use a combination of insulation regulations on the opaque surfaces, and glazing performance regulations for the glass. The field survey reviewed all aspects of the energy code. Table 2 summarizes overall building heat loss rate, and the heat loss rate resulting from applying code to each of the buildings in the sample.

Table 2: Heat Loss Rates

Sample	**Code**	**Sample Heat Loss Rate (UA/ft^2)**		**Code Heat Loss Rate (UA/ft^2)**	
		Mean	**Std Dev**	**Mean**	**Std Dev**
1998 Oregon	OR '96	0.20	0.085	0.19	0.083
1998 Idaho	ASHRAE 90.1-89	0.17	0.119	0.13	0.096
1998 Montana	ASHRAE 90.1-89	0.12	0.050	0.13	0.064
1996 Washington	WA '94	0.17	0.111	0.19	0.115
1990 Washington	WA '86	0.13	0.076	0.15	0.045
1990 Oregon	OR '89	0.18	0.070	0.21	0.071

The overall impression is that building shell heat loss rates have largely centered on values between .17 and .20 UA per square foot of heated area (Note: a higher heat loss rate equates to higher heating energy use). In the six samples summarized in Table 2, there are five separate envelope codes represented. The current Oregon and Washington codes are the least stringent, and the ASHRAE Standard the most.

In the Oregon and Washington code, there are trade-offs allowed between envelope performance (more glazing) and improved lighting and HVAC systems. Table 2 shows that overall the sample buildings have a heat loss rate very close to code. Only in Idaho, where no particular code is enforced, are building practices dramatically different from the ASHRAE standard. This is due to the substantially lower levels of insulation and the lower qualities of glazing typical in Idaho buildings. Table 3 describes the type of windows installed in each state.

Table 3: Window Characteristics by State (percent of glazing area)

State	Low-ε	Tint	Reflective	Argon
Idaho	38.9	48.9	6.7	7.0
Montana	93.2	46.8	2.2	7.3
Oregon	63.7	83.7	6.4	9.6
Region	64.7	73.8	5.9	8.6
Washington 1996	27.0	22.4	-	0.3

All codes attempt to regulate both the heat gain and heat loss through windows. As can be seen in Table 3, Oregon and Montana use low-ε coatings extensively, in addition to large amounts of sun control tints. In the case of the Oregon building stock, this is required under the state energy code. In the case of Montana, there appears to be considerably more low-ε coating and tint than would otherwise be required. This is part of the larger trend in the Montana sample towards better envelopes.

In Idaho, a noticeably smaller number of the windows use low-ε or tints for sun control. In the older Washington sample, there are even fewer. Other work done in Washington since 1998 indicates that the fraction of low-ε coatings exceeds 75% of the glazing area and would have been comparable to Oregon and Montana had a contemporary sample been drawn.

HVAC Systems

HVAC systems cover a wide variety of system types and efficiencies. However, in the last decade, the ASHRAE Standard 90.1 mandates a table of minimum efficiencies for building equipment. This standard is the basis for energy codes in the region. The other principal regulation for cooling loads for HVAC systems are economizer requirements that mandate HVAC equipment (above a certain size) be designed to use outside air (when at appropriate temperatures and conditions) instead of mechanically cooling returned indoor air. About a third of the Montana buildings with cooling use only the economizer cooling load system. This approach is almost non-existent in the other states.

The level of compliance with efficiency and economizer requirements for cooling equipment exceeds 95%. This largely results from the fact that the ASHRAE equipment efficiency requirements have become a manufacturing standard as a result of federal regulations. In effect, there is little or no opportunity to purchase equipment that would not comply with current energy codes. Only about 20% of the new construction uses electricity as the primary heating fuel; however, all HVAC systems typically use a significant amount of electricity for fans and cooling.

A more interesting issue is the trend towards package equipment and more particularly constant-volume, single-zone package equipment. This equipment typically includes a fan, a gas furnace or heating element, a compressor, and a series of dampers that allow for the operation of returned air, ventilation air, and economizer. The units are designed to sit on the rooftop and supply the space below with minimal ducting. Such systems represent about 70% of the region's HVAC capacity. Only in Montana are the majority of HVAC systems not package systems (54% of the systems are built-up) mostly as a result of smaller scale split heat pump and cooling systems associated with much smaller buildings.

For most small, simpler buildings, these packaged rooftop technologies have always been the main commercial equipment. In more recent years, two new sectors have begun including package rooftop units. The first is single-story suburban retail warehouse-type facilities and the second is office. In the case of offices, the package units are large and sophisticated but remain true packages, being designed and engineered at the factory. The systems include variable flow fans and sophisticated control modulation for operating large and complex buildings.

Variable air volume (VAV) systems either packaged or built-up account for about 14% of the regional floor area, mostly as a result of larger office buildings in Washington and Oregon. Outside of the large urban areas the VAV systems are relatively uncommon.

One other important trend identified in this review is the advent of adjustable speed drives (ASDs) as the primary motor control for variable flow air systems in large buildings. In this sample, when motors that control variable airflow were reviewed, about 90% of the motors included ASD controls.

Lighting

The lighting review revealed a reasonably uniform approach to lighting design and fixture selection throughout the region. Energy codes regulate watts of installed lighting per square foot. Designers have largely standardized their designs on efficient fixtures, and for the most part they specify the appropriate layout of fixtures to meet the lighting power densities required by code (watts per square foot). Table 5 summarizes lighting power densities (LPD) in the sample reviewed in this study and compares them to the code LPD required for this sample.

Table 5: Lighting Power Density (Watts per ft^2)

State	LPD	Std. Dev.	Code		
			OR	WA	ASHRAE 90.1
			LPD	LPD	LPD
Idaho '98	1.24	0.33	1.38	-	1.58
Montana '98	1.25	0.32	1.25	-	1.42
Oregon '98	1.11	0.43	1.30	-	1.66
Region '98	1.16	0.39	1.30	-	1.60
Washington 1996*	1.15	0.59	-	1.28	-
Washington 1990*	1.58	0.53	-	1.74	-

*1994 Washington code used in 1996; 1986 Washington code used in 1990

Table 6 shows that there has been a consistent downward trend in lighting power. In all cases noted above, the sample LPD beat code on average. However, it is instructive to note that a standard deviation indicates that a significant number of buildings exceeded code, and a significant number installed more lighting than code allows.

For the most part, the lighting systems in the non-residential sector were based on either T-8s with electronic ballasts, or High Intensity Discharge (HID) lights, such as metal halide (for large area lighting). On the whole, T-8s with electronic ballasts have not only pervaded the Washington and Oregon markets in response to the stringent lighting codes, but all markets as a result of the declining prices of these fixtures and the continuing standardization of office design and retail design around these fixtures.

The level of lighting control equipment (e.g. automatic on-off control, daylighting control, etc.) in Oregon is more than twice that of Montana, and about five times that observed in Idaho. Most of the additional control and design in Oregon is the direct result of lighting control requirements in the Oregon Energy Code.

Designer Interviews

A total of 220 interviews of building professionals were conducted. Approximately 60% of the interviews were with architects, about 20% were with design engineers, 10% with building owners or clients, and 10% with contractors and installers. The questions focused on the energy code as a surrogate for energy-efficient specifications and standards, and on the attitudes and various opportunities associated with energy-efficiency in non-residential buildings.

As might be expected, the results of the survey associated with energy codes and standards differed markedly between the Washington and Oregon responses and those of Idaho and Montana. On the whole, less than 10% of Idaho/Montana architects and engineers interviewed had any contact with the energy code or energy code officials, either in terms of enforcement or modifying building design requirements. This contrasts with Oregon and Washington, where almost 50% had direct feedback from code officials and/or had modified designs to accommodate energy code requirements.

In describing energy-efficient design techniques, most of the Idaho and Montana respondents cited the high cost of energy-efficiency as a serious barrier. In most cases, it was also noted that the majority of owners and clients had included energy-efficiency as part of their design criteria, even though their buildings seldom met the same levels of efficiency as those in Oregon. When discussing the opportunities for developing energy-efficiency in building projects, almost 80% of the respondents from Oregon and Washington suggested that this should be done early in the design process with some mechanism for integrating various disciplines. In Idaho and Montana, by contrast, only about half of the architects mentioned the possibility of integrated design in establishing energy-efficiency.

Conclusions

The pattern that emerges from this review is that the market transformation efforts over the last decade have been successful. Once these technologies are proven and become part of the marketplace, they are accepted by design professionals and integrated into building design. This transformation may be due to a variety of factors. Among them are 1) conservation programs which impact price and availability, and 2) the products providing value beyond energy savings (e.g., improved reliability, comfort, etc.). Over the decade in which baseline studies have been conducted, a considerable technology shift has been observed:

- Low-ε window treatments and tints now dominate the glazing market;

- T-8s with electronic ballasts and compact fluorescent or HID downlights are prevalent;

- Adjustable speed drives control most of the fan motors associated with variable air flow; and packaged rooftop heating and cooling equipment is used in approximately 70% of the HVAC system capacity.

The study results suggest that energy codes have effectively encouraged progressive improvements to energy-efficiency in the non-residential sector, especially in Oregon and Washington. In Idaho and Montana, although certain components are very efficient, there are areas and technologies that have not been adopted or integrated into building practice. It is apparent that because codes exist in Washington and Oregon, they are routinely factored into the design of almost every building. In Idaho and Montana, this is left up to the discretion of the owner and design team, with varying results.

Codes in every state in the region have room for improvement. It is important to realize that building efficiency is not only a function of the energy code and the efficiency of the individual components, but of the design of how these components are sized, controlled, and integrated. One example of this is with the prevalence of packaged HVAC systems. Since these are packaged units, the efficiency is set for the equipment as a whole. The efficiency of the air handler motor or the compressor motor is not rated separately. As a result, the rating of the equipment across the range of operating conditions and part loads is more crucial. The energy-efficiency rating (EER) typically used to designate efficiency level is not particularly indicative of the actual operating efficiency.

Though relatively little of this type of design criteria can be regulated within the energy code, there is evidence that, at least on some dimensions, building practices are moving towards a more integrated approach. In addition, many designers subscribe to the effectiveness of such an approach, even though they have not actually taken the necessary steps in their current practice.

The conclusion of this review is that the underlying impact of an energy code is to serve as a minimum standard for building components. Designers actually deliver these components when mandated by the code to do so. The efficient operation of these buildings, however, is not necessarily assured. There is surprising agreement that the steps necessary to deliver energy-efficient *buildings* involve the use of design practices that can transform the design approach and the market toward increased energy-efficiency.

1. Introduction

The Northwest Energy Efficiency Alliance (the Alliance) funded a 16-month study to collect detailed information about the standard practices and attitudes of the building and design community in each of its member states (Idaho, Montana, Oregon and Washington). The Alliance and its member utilities have embarked on an effort to identify markets and measures that can improve the energy efficiency of non-residential buildings throughout the Northwest and fund programs to support a market for these buildings and building practices. This study is intended to provide baseline information about current building practices and attitudes in the Pacific Northwest region, and to provide the market information necessary to target programs. This data could also be used as a benchmark to evaluate the impact of Alliance initiatives on the future building stock.

For most of the past five years, the utility community as a whole has been moving away from the package of enforced energy efficiency standards and utility incentive payments that had characterized regional efforts to increase the energy efficiency of non-residential buildings. Beyond doubt, the advent of these standards and incentive programs acted as a catalyst for significant improvement in building and design practice in the region. However, the adoption, enforcement and support of energy codes and standards has not been uniform throughout the region, and a characterization of non-residential building stock in unregulated locations has never been systematically undertaken. While the importance of energy efficiency in buildings remains a high priority throughout the region, the Alliance has focused on the need for market-based programs as the next step in delivering improved building performance. The role of the Alliance is to develop a market-based approach that supports and enhances the demand for cost-effective energy efficiency in new buildings throughout the region.

Beginning in the late 1980s, an effort at tracking building practice in the non-residential sector was made in various Pacific Northwest markets. A sample of new Oregon and Washington buildings was drawn from the 1990 building year to provide a picture of construction practices in the non-residential sector of these two states. Various supplemental reviews were conducted in particular jurisdictions (e.g., Portland and Tacoma) over the next five years. A larger study of the state of Washington was conducted in 1996 using a sample drawn from the 1996 building year. These studies were all characterized by an effort to use a stratified random sample to arrive at a representative population of commercial buildings for new construction during the relevant time period. These samples are, by definition, snapshots. However, as these studies are repeated, a set of records is created documenting the transition to energy efficient building construction and design practice in these individual states and in particular building sectors. In all cases, the primary goal of these reviews was to assess the level of compliance with energy codes applied to the non-residential building sector. Establishing baseline characteristics was, at best, a secondary goal.

Over the period of 1986 to 1996, both Washington and Oregon introduced extensive modifications to both the language and enforcement of energy codes, and the studies were designed to track the transitions that resulted from these code changes. In Idaho and Montana statewide energy codes aimed at the non-residential sector were not instituted (although some advisory standards were published). No similar studies have ever been conducted in Idaho and Montana. However, as the region moves toward market-based energy efficiency programs and direct intervention in the design process, it becomes relevant to understand both the current baseline conditions across the entire region and the factors that can impact these conditions.

This study was a response to the need to assess the current characteristics of the non-residential building industry and provide the initial information with which to evaluate future market based programs. The approach selected for this regional baseline review centered on a detailed review of building characteristics and a direct assessment of the current design approaches used by architects and engineers in the energy using features of new non-residential buildings. A particular emphasis is on building components which are regulated by the energy codes. This building review was supplemented, insofar as possible, by brief interviews with design professionals to determine attitudes and conditions that lead to the design decisions on energy efficiency and energy code compliance.

A regional review of this sort affords the opportunity to compare building practices over time between states with limited or non-existent energy codes or enforcement and states with substantial commitments to energy codes and standards as the basis for establishing building design practice.

1.1. Goals

The purpose of this study is to compile a baseline set of characteristics information on non-residential building practices in the Pacific Northwest region. This baseline study involved a review of all four states using a sampling methodology designed to be representative of the individual states.

The goals of the study were to:

- Provide a detailed picture of the distribution of non-residential buildings in the region. This would include the size and building types that make up new non-residential construction in each state.

- Establish some of the detailed characteristics of the energy using components of the buildings (i.e., building shell, HVAC systems, lighting systems, etc). These characteristics are defined by the components regulated in local and national energy codes, which collectively serve as indicators for the efficiency of the building stock.

- Develop comparisons to energy codes and standards in each state and document the response to these standards both between and within the states.

- Describe the characteristics of markets for particular building components and products that enhance the energy efficiency of non-residential buildings.

- Provide a picture of attitudes towards energy efficient design and product selection in the building professions.

1.2. Objectives and Methodologies

The general approach to this project was to define a representative sampling of non-residential buildings in each of the four states. This sample was designed to be both efficient and representative of the particular construction patterns in each state. The sample frame was developed using a using a private database, F.W. Dodge, Dataline®, which is an unbiased and reasonably complete compilation of the new non-residential construction activity in the region. This database allowed sampling to proceed in all states on the same basis.

The next step was to develop a characteristics survey of buildings. This protocol is based on previous characteristics surveys conducted by Ecotope in Oregon and Washington (Baylon, et al., 1992; Baylon, et al., 1997). In these studies, characterizing code compliance and energy code response were primary objectives. All three studies collected data on the construction characteristics primarily responsible for energy consumption in most commercial buildings.

Appendix A contains the field protocols used in this study. These protocols were designed to be used in a two-step review process. The first review involved collecting detailed plan information using as-built drawings provided by the project architect or owner. This was followed by a field review to verify the plan data and collect additional details not available on the plan sets.

Interviews were conducted with designers and architects associated with individual buildings in each sample. The general objective was to secure one to two interviews for each building, either with the architect or one of the consulting engineers involved in energy code compliance and energy decisions. The interviews were designed to be very brief and address general attitudes towards energy conservation and energy efficient design.

Characteristics data collected during field reviews was compiled for each state. Because of the differences in building types between states, comparisons were somewhat restricted. For some characteristics, the building type characterized the region as a whole, transcending individual states. The goal of all comparisons was to highlight differences and similarities among building construction decisions associated with energy use and state energy code standards as published or enforced by the relevant state agencies.

The Washington state sample, while drawn and reviewed in accordance with this project, was actually developed in 1996 from the buildings permitted between July 1995 and June 1996. This was thought to be recent enough to obviate the time and expense inherent in reconstructing a similarly sized sample for this state. The sample of buildings for the remaining states was drawn from the same construction period (buildings permitted and started between July 1997 to June 1998) for all the remaining states. Interviews were conducted with the relevant architects and engineers associated with those buildings.

The results of the Washington sample are thoroughly explained in the 1997 report for the Utility Code Group (Baylon, et al, 1997). Relevant tables and results have been abstracted here to allow comparisons between states and across regional construction strategies. Some additional summaries were developed for this report that would facilitate comparison among the states. New interviews were also conducted with a sample of architects derived from a new sample of Washington buildings.

1.3. Energy Codes

While this study was not designed to address compliance with local energy codes and standards, the impact of these requirements clearly dominates the decision-making of building designers throughout the region. Compliance with the special components of local energy codes is relevant to characterizing the individual construction techniques noted in the states. A review of the similarities and differences of buildings in various jurisdictions can go a long way towards informing the understanding of building characteristics in the non-residential sector. Each state has different provisions and methodologies for applying energy codes and standards to non-residential buildings.

1.3.1. Idaho

The state of Idaho does not have a state building code of any sort. 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. The Idaho legislature has adopted the Model Energy Code (MEC), by reference, as its non-residential energy code. Our observations in Idaho suggest that only limited portions of the MEC (or any other energy code) are actually enforced. However, the MEC represents a design standard promulgated by ASHRAE Standard 90.1 that architects and engineers expect to follow for non-residential buildings.

1.3.2. Montana

The Montana situation is less easily articulated. As in Idaho, the MEC and ASHRAE 90.1 form the state-recommended standards, 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 non-residential construction only within a three mile radius of city limits. The remainder of the state (about 60%) is divided into six jurisdictions, which are regulated by the State Department of Commerce, Building Codes Division. Given the large size and widely dispersed population within each of these jurisdictions, enforcement of energy codes or any other building code in the private non-residential sector is problematic. However, public buildings are also regulated by the State Architect's Office and considerable effort is expended to enforce the Uniform Building Code and other state-adopted codes (including the energy code) in this sector.

1.3.3. 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 the building departments throughout the state. The state also qualifies building inspectors and prescribes the limits of their inspections and authority.

The individual jurisdictions are charged with enforcing and interpreting this code. The current Oregon Non-Residential Energy Code (ONEC) was adopted in 1996. While many provisions of it are based on the ASHRAE 90.1 Standard, many other provisions represent improvements, simplifications or edits of this standard. The ONEC is nominally enforced in all jurisdictions with additional support from the state in jurisdictions with larger buildings and more complex code enforcement problems.

1.3.4. Washington

The state of Washington is similar to the state of Oregon in that the non-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 have not traditionally had any flexibility in the nature of the codes adopted. Recently, increased flexibility has allowed some jurisdictions to evolve more stringent standards. State Building Code Council has control over the revisions to the energy code, which it can revise or extend on a three-year cycle. As in Oregon, the non-residential energy code in Washington is noticeably different than the MEC used in Idaho and Montana. Though the ASHRAE Standard 90.1 was referenced in the development of the Washington code, many decisions were made that simplified and extended this standard.

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, if for no other reason than to access the revenue flow associated with building permits and building inspections.

Individual jurisdictions have greater flexibility in devoting enforcement resources to particular aspects of the code, since they can establish fees that pay for these priorities. The Washington State Non-Residential Energy Code (NREC) was passed in 1994 and has been enforced throughout the state since the beginning of 1996.

1.4. Report Organization

The sampling protocol used for this study was designed to allow non-residential construction in each state to be individually characterized, and to allow for cross-state comparisons. Section Two describes the sampling methodology for each state and sample frame characteristics for each non-residential sector in these states. The next three sections are devoted to by-state descriptions of each major energy component: building envelope, mechanical systems, and lighting. An effort is made to compare these characteristics with the respective local energy efficiency standards. This section includes the 1995 and 1996 sample for Washington, as well as the 1998 samples for Idaho, Montana and Oregon. A summary is provided of the market positions for the major design and equipment options for each state. The sixth section summarizes the results of the interviews with building designers and other building professionals involved in the non-residential surveys. The seventh section summarizes the conclusions and observations developed from this evaluation.

2. Sample Frame & Sampling

The general strategy of the baseline was to draw a representative random sample of new construction activity in each state. To do this, a sample frame was developed which represented the total number of new buildings constructed in each state in a particular building area. This problem has been addressed on several previous projects (see Baylon et al. 1992; Baylon et al, 1997; RLW, 1999). In all of these studies, a private sector database developed by the F.W. Dodge® Corporation, Dodge Dataline®, was used. This database is designed to provide contractors, subcontractors and other building professionals information on building activity needed to identify marketing and bidding opportunities across a broad range of construction markets. The database includes all types of construction, from highways and paving projects to small-scale multi-family buildings. The database also includes various modifications to existing buildings, ranging from fairly minor tenant improvements (TIs) to major additions such as new hospital wings and campus expansions. The data is collected from public documents, contacts with architect and engineering professionals, building permit records and related sources. We believe this database captures most of the non-residential building activity in the nation and is certainly the most representative sample frame across the Pacific Northwest.

To use the Dodge® database, substantial data cleaning and handling was conducted. Projects were screened for actual building activity (since more than half of the projects noted in the database are non-building construction projects such as water, sewer and highway projects). In addition to these non-building projects, the Dodge® database tracks tenant improvements, remodels, renovations and additions. Many of these are relatively minor, neither affecting the energy use of the buildings nor representing new construction. While the database does characterize the type of work that is being conducted, this characterization is somewhat inaccurate, and requires considerable cleaning in order to ensure that only new buildings are reviewed. Even with this level of cleaning, some inaccuracies and misclassifications were included in the sample frame. These were corrected where possible, using information gathered from the final sample.

The database also documents the total value of the work. However, this value can come from many sources and is not necessarily accurate. The primary data source is the permit valuation defined by individual building jurisdictions, which is inconsistent from one project to another. Other sources include estimated preliminary evaluations from developers, architects and engineers, which are usually realistic. Some of the valuations come from public bid documents reflecting the total contract for the actual building construction. However, it is impossible to distinguish the sources for the individual building reports, since Dodge® does not distinguish between the sources of the project valuations in their database.

Estimating floor area was crucial to the sample design; however, project area is only reported in a fraction of the buildings included in the database and has the same limitations as the reported valuation. Since area is taken to be a primary variable impacting energy use across the non-residential sector, an estimate of the floor area of individual buildings had to be made. For this purpose, the relationship between reported floor area and reported valuation was established for buildings that reported both and then extended to those buildings where no floor area data was available by using a regression fit. In order to reduce variance and some of the problematic nature of the reporting, building projects with less than a $200,000 valuation were screened out.

Restricting the buildings to be reviewed to a single building year further refined the sample frame. The building year of June, 1997 through June, 1998 was used as the basis for the sample frame. This year was selected so that when fieldwork began in the summer of 1999, most or all of the buildings would have neared completion. This would allow lighting and finished details to be field-reviewed. In smaller buildings, this was almost always the case. In larger buildings, auditors often had to review buildings that were not substantially completed at the time of the survey.

The result of these screenings was that two-thirds of the construction projects listed in the original database were removed from the sample frame. The buildings removed included those that were reported but had not yet begun construction by the first of July 1998, as well as highway construction projects, water projects and various types of manufacturing plant processes. The remaining buildings were a mix of renovations, additions and new construction that were carefully screened to remove the renovations that did not increase the area of the building or affect a full range of building systems comparable to a new building project. Table 2.1 presents the sample frame and sample for the four states from which new samples were drawn for each state. This table represents the best estimate from the Dodge® database of the new construction square footage in the region in the 1997 to 1998 period.

Table 2.1: Four State Population / Sample Summary

	1998 Population			**1998 Sample Design**			**1998 Actual Sample**			
Building Type	**#**	**ft^2 (000)**	**%**	**#**	**ft^2 (000)**	**%**	**#**	**ft^2 (000)**	**%**	**% Pop.**
Assembly	197	4081.6	7.7	18	1,440.8	7.5	10	444.7	5.4	10.9
Education	188	5,323.0	10.1	20	1,481.7	7.8	21	1,065.4	13.0	20.0
Grocery	66	1,424.7	2.7	7	239.1	1.3	6	291.7	3.5	20.5
Health	142	2,678.4	5.1	19	977.9	5.1	11	297.9	3.6	11.1
Institution	61	831.4	1.6	4	180.6	0.9	3	157.2	1.9	18.9
Lodging	84	4,276.5	8.1	20	1,641.6	8.6	10	427.3	5.2	5.5
Manufacturing	0	0	0.0	0	0	0.0	12	1,033.9	12.6	24.2
Office	447	9,940.4	18.8	31	2,906.0	15.2	26	1,798.7	21.9	0.0
Other	289	7,791.7	14.8	38	3,634.1	19.0	15	503.7	6.1	5.1
Restaurant	121	580.0	1.1	3	6.9	0.0	1	2.7	0.0	0.5
Retail	294	7,090.4	13.4	36	3,363.8	17.6	15	963.3	11.7	13.6
Warehouse	310	8,749.8	16.6	44	3,218.4	16.9	14	1,232.6	15.0	14.1
Total	2,199	52,767.9	100.0	240	19,090.9	100.0	144	8,219.1	100.0	15.6

The overall new construction in the region in this year was (by this accounting) almost 53 million square feet. This total is derived from the records, with a substantial number of entries removed. Judging from the full Dodge® record, the overall square footage of all the renovations and remodels (including misclassified new construction) not included in this set represents about a 15% increase in the total value of construction. Some of this actually consists of tenant improvements and various renovation projects not impacting the entire building or major energy-using systems. This resulted in a 50% reduction in the total number of projects in the sample frame and a 15% reduction in the total construction value in the sample frame. Overall, the data screening employed to review the Dodge® database resulted in a sample frame that improved the quality of the new construction sample by focusing sampling and recruiting efforts on building projects which would represent the non-residential new construction in each states.

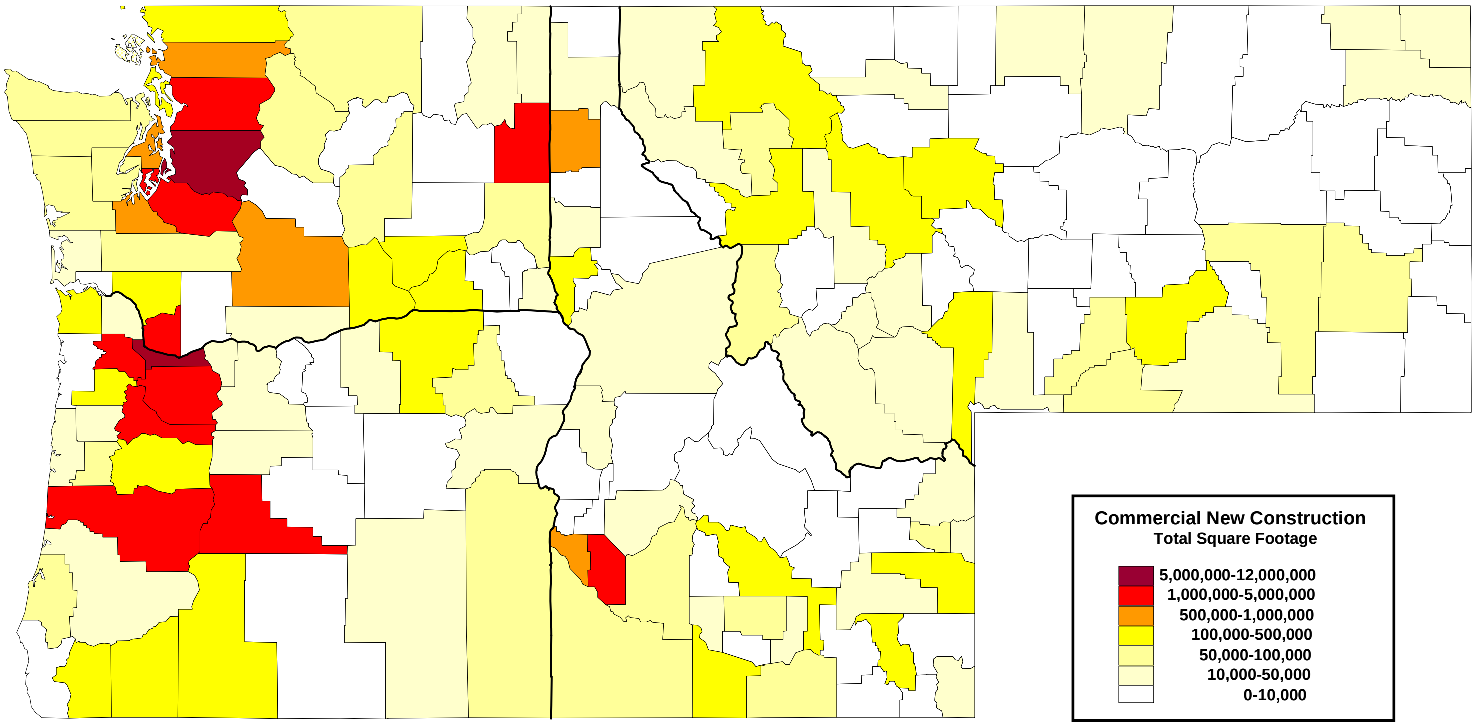
2.1. Regional Distribution

The distribution of construction across states is as highly skewed as the distribution of buildings themselves. The great bulk of commercial construction occurs in the two main urban centers, Seattle and Portland. A total of 64% of the construction activity in the region occurs in the counties which contain these cities and the adjacent suburban counties. Another 10% of the new construction is concentrated in the other major urban areas of the region, Spokane and Boise. These two urban areas dominate Idaho and eastern Washington construction activity.

During the recruitment process, buildings were identified using the Dodge® information on architects and owners and the telephone contact that was part of the record. This process resulted in corrections in building size and type when individual records were reviewed. In summarizing the results of the overall construction activity, these corrections were used in the description of the sample but not in the description of the sample frame. In a few cases this resulted in some anomalous sample characteristics. The Idaho “Grocery” building type is the most obvious correction, but similar less apparent corrections were part of all three states where field samples were recruited. In this context, it should be noted that these samples are drawn to be representative of the overall state building populations. Subsets of this sample can be compared only with substantial reservations.

Figure 1.0 shows the distribution of non-residential construction across the region. The western slopes of the Cascades represent the great bulk of all new non-residential construction. Similar sampling techniques were used for each state, although the size and impact varied with both the distribution of buildings within the state and the overall rate of activity.

Figure 1: 1998 Commercial New Construction for the Pacific Northwest



2.1.1. Idaho

The Idaho sample design called for a stratified sample of 50 buildings. The initial sample was drawn from the cleaned database (as summarized in Table 2.1). Table 2.2 compares the Idaho sample to the initial sample frame.

Table 2.2: Idaho Population and Sample

Building Type	1998 Population			1998 Sample			
	#	ft^2 (000)	%	#	ft^2 (000)	%	% of Pop.
Assembly	37	350.5	6.3	4	43.6	2.1	12.5
Education	27	694.1	12.5	7	306.7	15.1	44.2
Grocery	8	101.0	1.8	2	133.7	6.6	132.4
Health	24	225.5	4.0	5	122.4	6.0	54.3
Institution	8	126.2	2.3	2	35.9	1.8	28.4
Lodging	7	322.3	5.8	2	129.7	6.4	15.4
Manufacturing	0	0.0	0.0	5	294.1	14.4	91.3
Office	89	872.1	15.7	6	304.6	14.9	0.0
Other	48	843.3	15.1	7	154.0	7.6	17.7
Restaurant	27	117.1	2.1	0	0	0.0	0.0
Retail	42	1,276.0	22.9	6	410.1	20.1	32.1
Warehouse	39	640.5	11.5	2	103.1	5.1	16.1
Total	356	5,568.7	100.0	48	2,037.9	100.0	36.6

The primary contact used to recruit the buildings into the study was the architect listed in the Dodge® database. Secondary contacts were the owners and engineers. These contacts were called and asked to participate in the study. A large percentage of these recruitment calls failed. The field staff was given a list of primary contacts drawn from the initial sample as well as contacts representing a random sample of the remaining buildings stratified by size. Individual buildings that refused to participate were replaced at random with other buildings from the sample frame.

In the Idaho sample, however, no additional Stratum 3 buildings (the largest buildings) beyond the sample size itself appeared in the Dodge® database. This meant that any buildings that could not be recruited could not easily be replaced. Field personnel were instructed to draw additional Stratum 3 buildings meeting the criteria from local sources if necessary. In some cases, the database screening criteria failed to identify large projects because the start of the construction permitting and subcontracting artificially extended the construction period outside of the window. If buildings were identified that met this criteria, they were added to the population and appear as part of the sample frame summarized in Table 2.2 (this was true of all three states).

Unfortunately, some buildings were recruited that could not be used for this sample because of factors identified upon site inspection. Despite the thorough data screening process, two Idaho projects had to be dropped. Finally, no additional buildings could be identified to replace the failed recruiting efforts; as a result, summaries for Idaho were made on 48 buildings and sample characteristics were extended from this population.

As can be seen from Table 2.2, more than 35% of all square footage built in Idaho was represented in the stratified random sample. Of this amount, about half is located in the Boise area. When the sample is used to characterize the non-residential buildings in Idaho, sampling weights appropriate to each stratum have been used to extend the results from individual buildings. It should be pointed out that this sample design does not accommodate generalizations to renovations or to very small new construction projects under $100,000 in value, since these sectors were not included in the sample design.

2.1.2. Montana

The Montana sample was developed using a similar methodology. The database was collected and screened in the same process in the hopes of eliminating disqualifying renovations and relatively small construction projects. For Montana, this meant that 15% of the construction value was eliminated from the original database. Only about 1% of those screened were new construction, and the remainder was small additions and renovations. The number of projects eliminated by this screening totaled about 40% of the Montana entries in the Dodge® database (similar to the other three states).

The principal difference between the Montana sample and remaining states is the relatively small amount of non-residential construction in Montana and the noticeably smaller buildings. As with Idaho, the Montana sample used a three-level stratification design wherein the largest buildings were sampled as a census. This amounted to a total of 11 buildings from the Dodge® records. During recruitment and review, the largest Montana building in the database had been listed in error as a 400,000 square foot building when in reality it was a 4,000 square foot building. This project was returned to the smaller stratum, but the result was a reduction in the apparent size of the entire Montana non-residential population by 10%.

Table 2.3 shows the nature of the Montana sample as it was originally designed and developed in the recruitment process.

Table 2.3: Montana Population and Sample

Building Type	1998 Population			1998 Actual Sample			
	#	ft^2 (000)	%	#	ft^2 (000)	%	% of Pop.
Assembly	20	307.4	11.9	1	5.6	0.5	1.8
Education	21	463.8	18.0	8	283.8	24.5	61.2
Grocery	8	150.0	5.8	0	0	0.0	0.0
Health	16	215.7	8.4	3	88.4	7.6	41.0
Institution	8	271.3	10.5	1	121.3	10.5	44.7
Lodging	6	152.6	5.9	4	131.3	11.3	83.1
Manufacturing	0	0	0.0	0	0	0.0	0.0
Office	26	186.9	7.2	6	96.8	8.3	0.0
Other	13	157.9	6.1	2	114.8	9.9	61.5
Restaurant	3	18.1	0.7	0	0	0.0	0.0
Retail	29	507.2	19.7	5	305.0	26.3	60.1
Warehouse	18	150.0	5.8	2	12.8	1.1	8.5
Total	168	2,581.0	100.0	32	1,159.9	100.0	44.9

Although the Montana sample is by far the smallest, it represents about 45% of the new building area in Montana owing to the nature of the stratification design. During the recruitment process, it became apparent that even these projects were dominated by additions to existing facilities, especially schools and retail spaces.

The recruitment process in Montana was somewhat more successful than in other states; 60% of the initial sample was successfully recruited into the population. Problems of recruitment in Montana stemmed primarily from the lack of large buildings that could replace a failed recruitment. Field crews were instructed to focus on recruitment for this group. As with Idaho, the characteristics associated with this population (weighted by the stratified sample design) reflected the sampling probabilities in each building strata.

2.1.3. Oregon

The new construction sector in Oregon includes one of the two major commercial centers in the Pacific Northwest region (Portland/Multnomah County). The Oregon new building stock represents slightly more than 35% of all the new construction in the Pacific Northwest region. As with Idaho and Montana, the database was carefully screened to eliminate new construction projects and small additions that involved relatively little square footage or value. This process eliminated about 15% of the valuation listed in the Dodge® database for the state of Oregon. The screening process in Oregon eliminated approximately 40% of the entries in the cleaned database for the construction year, June, 1997 through June, 1998. Table 2.4 summarizes the population and sample for Oregon.

Table 2.4: Oregon Sample and Population

Building Type	1998 Population			1998 Sample			
	#	ft^2 (000)	%	#	ft^2	%	% of Pop
Assembly	53	973.5	5.2	5	395.4	7.9	40.6
Education	51	1,631.1	8.7	6	474.9	9.5	29.1
Grocery	18	528.5	2.8	4	158.0	3.1	29.9
Health	48	721.4	3.8	3	87.1	1.7	12.1
Institution	17	170.0	0.9	0	0	0.0	0.0
Lodging	35	1,621.8	8.6	4	166.3	3.3	5.1
Manufacturing	-	-	-	7	739.7	14.7	-
Office	125	3,856.1	20.5	14	1,397.3	27.8	36.2
Other	99	3,261.9	17.3	6	234.9	4.7	29.9*
Restaurant	34	172.7	0.9	1	2.7	0.1	1.5
Retail	67	1,593.3	8.5	4	248.2	4.9	15.6
Warehouse	108	4,283.8	22.8	10	1,116.7	22.2	26.1
Total	655	18,814.2	100.0	64	5,021.3	100.0	26.7

*Manufacturing end use was combined in the population with Other this percentage represents the combination of both groups.

The methodology resulted in slightly more than 25% of the square footage in Oregon being sampled under this study. The principal difficulty was the large building sector. As with Idaho, the large building sample was extended to buildings that were constructed in the appropriate interval but not included in the Dodge® database within the target year. These buildings included two large high schools which were permitted and began construction during the target year but which had additional bidding and construction activity after June of 1998 that caused them to be screened out during the data cleaning process. When it became apparent that some large projects had been eliminated, these projects were returned to the recruiting database and the field staff made recruitment attempts.

In Oregon, a new energy code was put in place beginning in April of 1996. Many buildings were “grandfathered in” under the old code. Even though this code was promulgated a year before the construction window, some buildings were not included in the sample as a result of permitting under the old code.

Commercial construction was dominated by the Portland metropolitan area; 68% of the construction in Oregon occurred in the three Oregon counties around the city. An additional 20% of the commercial construction in the

Portland metropolitan area is in Clark County, Washington (just across the Columbia River). This is not included in the Oregon sample.

Recruitment in Oregon was more difficult than in Idaho or Montana. Only about 40% of the buildings contacted consented to participate in the project. The overall result is that the sample includes 27% of the floor area of non-residential construction in Oregon. As with the other states, the stratification design reflects a weighting scheme for extending the results of the survey to the overall new construction sector in Oregon. Because this stratification design cuts across building types, indexes of comparison are based on the code standards for Oregon, not on individual building performance. This allows lighting measures and HVAC measures to be compared between similar building types and code standards.

2.1.4. Washington

The Washington sample and regional characterization has been handled considerably differently from that of the other three states. This is because a full baseline study of Washington designed in a similar fashion using F.W. Dodge® data was conducted using the 1995 – 1996 building year. Reassessing the nature of building practices was thought to be premature, given this recent study. Thus, field evaluations conducted on buildings constructed in 1995 and 1996 have been used to characterize the Washington sample. To facilitate this comparison, the database was screened and edited in the same way for Washington as for the other states using the 1997 – 1998 building year. This allowed a cursory comparison between the sample as drawn in 1996 and the sample that would have been drawn for this study. Table 2.5 compares these two samples.

As can be seen in Table 2.5, the samples drawn from 1996 and 1998 were comparable. The overall size of the sample frame was also comparable. However, we did not include the Washington sample in the regional summaries, electing instead to present the Washington results in parallel with the other states. This decision was based on the perception that the construction practice changed in some ways between 1996 and 1998 and because there were several improvements made in the field protocol designed to get more specific technology information that did not correspond to the earlier Washington review. Moreover, the particular mix of building types between the two years changed significantly with large decreases in retail construction and large increases in school construction. How this would have been reflected in the 1998 sample would have been impossible to determine without a field sample.

Table 2.5: Washington Sample Design

Building Type	1998 Population			1998 Sample design			
	#	ft^2 (000)	%	#	ft^2 (000)	%	% of Pop
Assembly	86	2,434.6	9.4	5	1,205.9	12.3	49.5
Grocery	32	645.2	2.5	0	0	0.0	0.0
Health	53	1,365.7	5.3	7	527.6	5.4	38.6
Institution	25	212.3	0.8	1	13.8	0.1	6.5
Lodging	39	2,231.3	8.6	9	916.4	9.4	41.1
Office	208	5,093.8	19.7	13	2,144.7	21.9	42.1
Other	132	3,706.1	14.4	14	1,776.4	18.2	47.9
Restaurant	57	272.0	1.1	1	1.3	0.0	0.5
Retail	156	3,713.7	14.4	15	1,674.1	17.1	45.1
School	89	2,533.9	9.8	7	598.2	6.1	23.6
Warehouse	143	3,595.5	13.9	16	912.9	9.3	25.4
Total	1020	25,804.1	100.0	88	9,771.4	100.0	37.9
Building Type	**1996 Population**			**1996 Sample**			
	#	**ft^2 (000)**	**%**	**#**	**ft^2 (000)**	**%**	**% of Pop.**
Assembly	54	1,218.2	4.8	6	257.0	4.2	21.1
Grocery	39	1,250.3	5.0	6	348.8	5.7	27.9
Health	36	921.4	3.7	2	68.2	1.1	7.4
Institution	46	1,587.2	6.3	4	39.7	0.7	2.5
Lodging	5	166.0	0.7	2	81.0	1.3	48.8
Office	197	4,936.4	19.6	10	582.5	9.6	11.8
Other	50	1,550.0	6.2	17	1,091.2	17.9	70.4
Restaurant	52	219.8	0.9	6	24.2	0.4	11.0
Retail	141	6,547.2	26.1	13	1,329.1	21.8	20.3
School	51	1,589.1	6.3	7	665.8	10.9	41.9
Warehouse	121	5,142.8	20.5	15	1,604.5	26.3	31.2
Total	792	25,128.5	100.0	88	6,092.1	100.0	24.2

As with the baselines in the other three states, the 1996 sample was substantially influenced by the success of recruitment. While the recruitment results approximate the recruitment experience in the Oregon sample, there were substantial difficulties in recruiting large retail buildings into the sample. As a result, there is a considerable reduction in overall square footage in the sample. The actual sample size and characteristics resulting from this shortfall caused the 1996 sample to appear more characteristic of the buildings observed in the 1998 sample (because the amount of retail construction had declined by 50% in that year).

In order to accommodate some of the difficulties with interpreting the previous sample into this baseline, interviews were conducted with at least one architect or engineer for every building that was included in the 1998 sample. An effort was made to ask questions similar to those asked of building professionals in other states, although in Washington there was relatively little chance of linking the answers to these questions to their actual building practices.

The full development of this sample is summarized in Baylon, et al, 1997, but we have used tables or summaries from that database to compare the Washington results to the other states in the region. It should be noted that Washington represents 50% of the new commercial construction in the region.

As with Oregon, the three counties surrounding Seattle represent two-thirds of the state's new commercial construction. These buildings dominate both the 1998 and the 1996 sample. The remaining commercial buildings in this state are widely scattered, with significant concentrations in Clark County (adjacent to Portland), Spokane County and Yakima County in eastern Washington. For this summary, we have not re-weighted the 1996 sample to characterize Washington. For the most part, the Washington sample have not been included in the regional summaries. However, where data is available, the results of the 1996 sample are included for comparison.

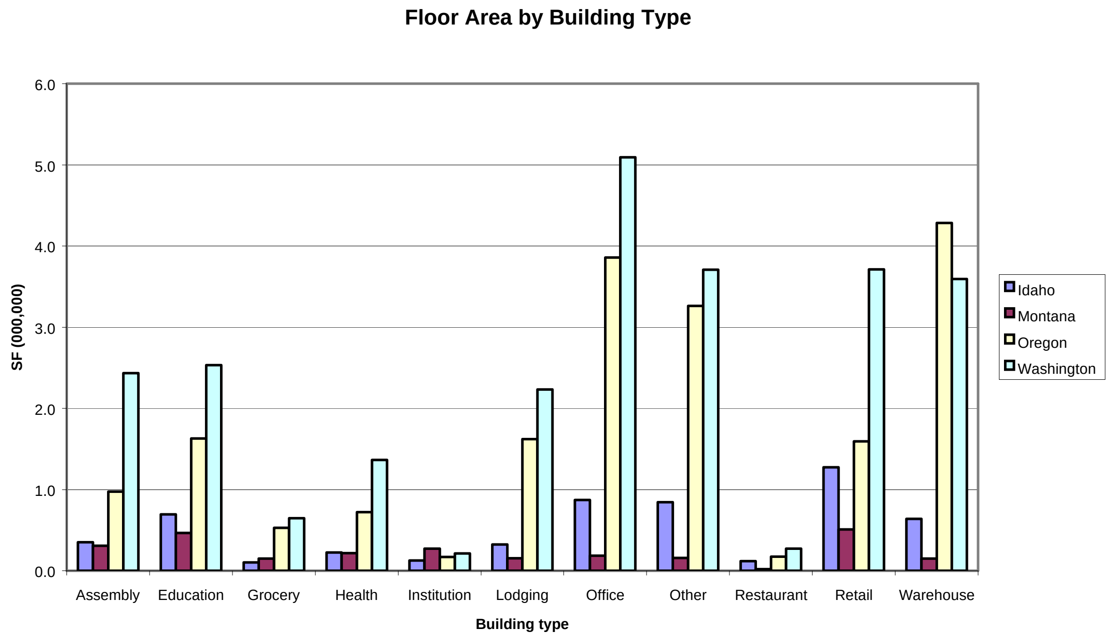
2.2. Building Type Distribution

Figure 2 shows the distribution of building types in the Dodge® database for the 1998 building year. The overall picture here is that in local areas various building types dominate at any one time. The relationship between the states is consistent in some building types but not others.

Furthermore, when this distribution is compared to other sample frames from previous years, it is apparent that the distribution changes between building years. In Washington state, for example, the fraction of the building stock in 1996 that was retail space was over 26% but by 1998 it had fallen to less than 15% of the total floor area constructed. Similarly, in 1990 schools represented 13% of all new construction in the state; by 1996 this had fallen to 6% and in 1998 it had increased to about 10%.

Because of these shifts in construction patterns, the distribution of construction practices in any one year should be viewed with some caution. While in any particular building type comparisons across years are probably representative, when these building types are combined into a single weighted average the mix of buildings may not be comparable. Fortunately, the energy code does provide a consistent standard across all building types, so summaries associated with code response can be compared across all building types and from one state to the next.

Figure 2



2.3. Recruitment

Recruitment in Idaho, Montana, and Oregon was performed in a similar way. Non-response and non-cooperation by building professionals had significant influence on the overall sample. There was some effort to assess the biases introduced by non-response in these samples, though these are minor and the degree to which buildings were restricted from the sample is similar across all strata within any particular state. There are large differences in recruiting percentages between states. In Montana, approximately 60% of the buildings contacted were recruited, while less than 40% were recruited in Oregon. The experience in Oregon was similar to the recruitment rate in Washington for the 1996 sample. Both these samples were complicated by the fact that a new energy code had been recently adopted and there is a tendency among building professionals to avoid discussions that may turn into code compliance judgments. Even though the recruitment in the Oregon sample emphasized that this judgment was not a primary goal of the study and would be held confidential, a high fraction of buildings could not be recruited.

One additional problem common to all four states was the misclassification of renovation and tenant improvements by F.W. Dodge®. This was a large problem in Washington and Montana, where approximately 20% of buildings that did not participate were restricted as a result of details identified during the recruitment process.

2.4. Sample Weights and Data Summaries

Table 2.6 summarizes the sampling done in each state as well as the populations and samples used in previous baseline studies in the region. In all these cases the sample design involved a stratified random sample of a cleaned F.W. Dodge® database. Summaries of each state used the case weights relevant to the sample design for each study. The "regional" summaries presented in this report use only data from the Idaho, Montana, and Oregon samples developed for this work. Given the differences in construction year and sampling methodology , the Washington summaries from 1996 were not used in the regional summaries. In the 1998 building year, non-residential construction in Washington accounted for about half of all commercial construction. In every case where data is available, the summaries of the 1996 buildings were included.

Table 2.6: Sample Non-residential Baseline Samples by State

State	Year	Sample Frame		Sample		Percent Sampled
		N	Ft^2 (000)	N	Ft^2 (000)	
Idaho	98	356	5,568	48	2,037	36.6
Montana	98	168	2,581	32	1,160	44.9
Oregon	98	655	18,814	64	5,021	26.7
Washington	98	1,020	25,804	88	9,771	37.9
Washington	96	792	25,128	88	6,092	24.2
Oregon	90	213	8,290	71	3,817	46.0
Washington	90	468	17,360	70	4,296	24.7

Table 2.7 summarizes the stratification design and weights associated with the sample as completed. The sample includes the actual observed square footage (which differs from the initial database estimates, particularly in buildings with parking areas, outdoor display areas etc. outside of the heated shell). These corrections have been made in the final summaries of building characteristics and sample stratification characteristics.

These weights are the inverse of the sampling probability for each state. The stratification design is also illustrated in Table 2.7. As can be seen, the stratification design is fairly similar between Idaho and Montana. The Oregon sample resulted from not only many more buildings in the population but, on average, 73% larger area in each building when compared to the other two states.

Regional summary values throughout this report also use these case weights. They are normalized against the entire building population in Idaho, Montana and Oregon. When used with building area, they give a weighted estimate applicable to the whole region.

The 1998 Washington sample has been partially summarized in Table 2.7, although the weights were not calculated for the sample, since the recruitment steps and the field review were not conducted.

Table 2.7: Stratification Design

State / Stratum	Population	Sample	Size Range (ft^2)	Case Weight
Idaho				
1	261	19	0-13,800	13.74
2	73	15	13,800-62,000	4.87
3	19	14	62,000-249,010	1.36
Montana				
1	114	10	0-13,000	11.40
2	45	14	13,000-49,000	3.21
3	9	8	49,000-135,000	1.13
Oregon				
1	464	21	0-25,500	22.10
2	45	20	25,500-102,000	7.60
3	9	23	102,000-450,000	1.52

For the Washington sample, the weights are based on the sample frame and sample developed for the 1996 review (Baylon et al, 1997). The weighting scheme used was derived from this sample. The Washington sample was not designed with any reference to the rest of the region but, since it was not included in the “regional” summaries in this report, the sample was not re-weighted. Table 2.8 summarizes the weights used for the Washington summaries.

Table 2.8: Case Weights and Adjustments, 1996 Washington Sample

Stratum	Case Weight	Sample	Population	Size Range (ft^2)
1	15.46	30	462	0-30,000
2	4.14	37	153	30,000-122,000
3	2.38	21	50	>122,000

3. Building Envelope Characteristics

In the non-residential sector, the building envelope is determined as much by the nature of the building and its end use as it is by code, standards and all other factors. Clearly, a building designed as an office space will have much more glass and carefully detailed exteriors than a building designed to be a warehouse or a manufacturing facility.

Nevertheless, the codes in Oregon and Washington do not distinguish between non-residential buildings in any particular way. In principle, the same standards are required for wall insulation, window performance, etc., regardless of a building's end use. The one exception in both the Oregon and Washington codes is the provision for "semi-heated" spaces. This means that buildings designed to be maintained at temperatures below 50^{o} are not expected to be insulated to the same standards as other non-residential buildings. Particularly in warehouse and manufacturing end uses, the mix of semi-heated and unheated spaces with other, more conditioned, spaces is crucial to the overall observed heat loss rate in any particular building.

Tables 3.1 and 3.2 compare building heat loss rates between the four states. These values have been normalized by overall conditioned area and case weighted. Regional average values are computed for the 1998 year in the three states using the case weights and the area weights in Table 2.7. The differences in building type stem from three causes: some building types (e.g., Warehouse, Manufacturing) have a high fraction of their floor area in semi-heated space which has a much higher heat loss allowance; some building types (Office) use more energy budget trade-offs to increase the code allowed envelope heat loss rates; some building types (Office) tend to maximize glazing allowance, thus increasing the apparent heat loss rate when compared to building types (Grocery) with low glazing levels (see Table 3.5).

In general, Montana buildings tend to be better insulated than those of either Idaho or Oregon. Though this is not as consistent among building types that would be well-insulated under any code (e.g., lodgings and health services), there remains a clear trend toward better insulation and thermal performance in the Montana buildings. However, the Montana buildings are smaller and presumably more envelope-dominated than buildings in Oregon, where average building size is twice that of Montana.

Idaho, on the other hand, has building standards comparable with Montana (though such standards are voluntary), but Montana still delivers a notably lower UA per square foot of building than the Idaho sample. Clearly, standard practice in these states determines these decisions far more than does enforced building code, and the contrast between Idaho and Montana is striking. Table 3.3 shows the comparison in overall heat loss rate between various audited samples over the past ten years. The code heat loss is shown as the current "enforced" codes for the samples drawn previously.

Table 3.1: Building Heat Loss Rate by State and Building Type

Building type	Average Heat Loss Rate (UA/ft^2)				ASHRAE 90.1 (UA/ft^2)				Oregon Code (UA/ft^2)
	ID	MT	OR	Region	ID	MT	OR	Region	OR
Assembly	0.12	0.22	0.19	0.18	0.13	0.24	0.17	0.16	0.20
Education	0.13	0.12	0.15	0.13	0.12	0.12	0.16	0.13	0.17
Grocery	0.24	-	0.24	0.24	0.10	-	0.17	0.16	0.23
Health Services	0.13	0.17	0.15	0.14	0.12	0.16	0.15	0.14	0.16
Institution	0.14	0.07	-	0.11	0.16	0.09	-	0.12	-
Manufacturing	0.19	-	0.22	0.22	0.15	-	0.19	0.18	0.17
Office	0.15	0.14	0.17	0.16	0.14	0.15	0.16	0.16	0.17
Other	0.16	0.15	0.23	0.18	0.12	0.15	0.21	0.15	0.25
Residential/Lodging	0.08	0.09	0.11	0.10	0.10	0.10	0.12	0.11	0.09
Restaurant / Bar	-	-	0.28	0.28	-	-	0.34	0.34	0.34
Retail	0.26	0.10	0.22	0.20	0.13	0.11	0.19	0.14	0.20
Warehouse	0.37	0.21	0.24	0.25	0.17	0.16	0.16	0.17	0.23
Total	0.17	0.12	0.20	0.18	0.13	0.13	0.17	0.15	0.19

Table 3.2: Building Heat Loss Rate (Washington) by Building Type (1996)

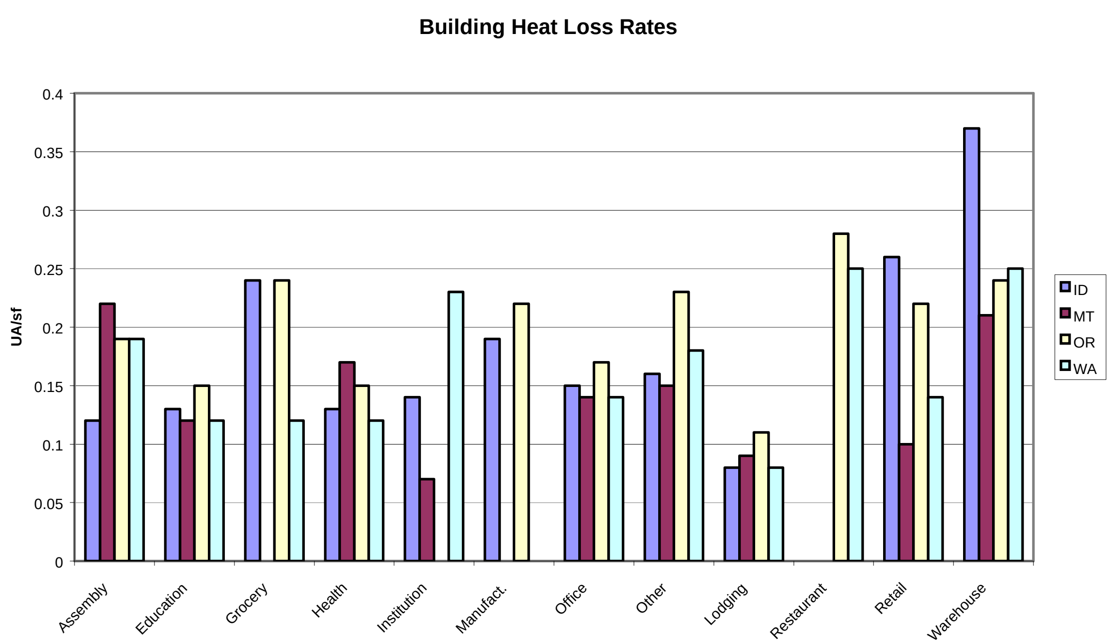
Category	Building (UA/ft^2)	WA. Code (UA/ft^2)
Assembly	0.19	0.20
Education	0.12	0.15
Grocery	0.12	0.13
Health Services	0.12	0.09
Institution	0.23	0.22
Manufacturing	-	-
Office	0.14	0.14
Other	0.18	0.18
Residential/Lodging	0.08	0.13
Restaurant / Bar	0.25	0.32
Retail	0.14	0.14
Warehouse	0.25	0.27
Total	0.17	0.19

Table 3.3: Compared Heat Loss Rates

Sample	Code	#	Sample Heat Loss Rate (UA/ft²)		Code Heat Loss Rate (UA/ft²)	
			Mean	Std Dev	Mean	Std Dev
1996 Washington	WA '94	84	0.17	0.111	0.19	0.115
1990 Washington	WA '86	70	0.13	0.076	0.15	0.045
1990 Oregon	OR '89	71	0.18	0.070	0.21	0.071
1998 Oregon	OR '96	64	0.20	0.085	0.19	0.083
1998 Idaho	ASHRAE 90.1-89	48	0.17	0.119	0.13	0.096
1998 Montana	ASHRAE 90.1-89	32	0.12	0.050	0.13	0.064

Figure 3 compares the heat loss rate by building type across all states using the current samples (1998 and 1996). As can be seen, the impact of building type is at least as great as the particular practice in each state. A more careful review, however, shows much more consistency across building types in Washington and Oregon than in Idaho and Montana. This is the impact of an enforced code, in that it reduces the variation as designers strive to meet the same standards in all building types.

Figure 3



The 1990 Washington sample has a heat loss rate lower than the current or previous practices of all states excepting Montana. The Washington code regarding non-residential building envelopes changed significantly in 1994, relaxing considerably the applicable standards. The result was a corresponding drop in envelope standards in Washington between the 1990 and 1996 samples. Only in Idaho are the code values largely unrelated to the characteristics observed in the survey. Presumably, this is explained by the fact that the non-residential code is not enforced in most jurisdictions.

This summary suggests that Montana designers use a better thermal standard than the energy code designates. When these matters were discussed with architects and building officials in Montana, there seemed to be considerable confusion over what envelope standards ought to be applied. Quite frequently, the residential energy standard is viewed as the non-residential envelope standard. This is an appreciably higher standard than either Oregon or Washington's non-residential energy code or, for that matter, the ASHRAE Standard 90.1.

3.1. Envelope Code Compliance

In most of these energy standards, compliance can be achieved without directly meeting the heat loss standards. This is particularly true of the Oregon 1998 and the Washington 1990 samples, where compliance was demonstrated using whole building simulations. Consequently, non-compliance with envelope requirements is offset by other efficiency features.

In Oregon, most of the larger buildings employ these trade-offs in order to expand the window area allowance. This results in a considerable reduction in the compliance rates once area weights are applied to the sample. Table 3.4 shows the envelope compliance rates in each state and in the two previous Washington samples. For the current sample, the compliance rate was calculated for both the Oregon code and the ASHRAE code. As can be seen, compliance with the current Oregon standards is somewhat easier in all cases. The data necessary to compare the Washington sample was not collected in that older sample, although the Oregon and Washington codes are very similar for purposes of this compliance summary. These rates do not include the compliance with window shade coefficient (SC), since auditors were not able to verify these values in the field. Estimates of the SC were made and reported separately (Section 3.2.3).

Table 3.4: Percent Envelope Compliance by State

Sample	Weighting	Code		
		ASHRAE 90.1	Oregon	Washington
Idaho	Area/case	42.1	60.4	-
	Case	55.0	72.7	-
Montana	Area/Case	76.3	79.1	-
	Case	70.0	81.0	-
Oregon	Area/case	45.7	55.7	-
	Case	63.4	73.3	-
Washington, 1996	Area/Case	-	-	86
	Case	-	-	84
Washington, 1990	Area/case	-	-	60
	Case	-	-	78

The impact of energy budget trade-offs is clear in both the Oregon sample and in the 1990 Washington results. Both of these groups relied heavily on simulation to increase window glazing area beyond the code restrictions. This trend is not very apparent in Montana or Idaho, although there is no reason to believe that any particular effort was made to demonstrate code compliance in these states. The most interesting result is the 1996 Washington sample, since the 1994 Washington code reduced the stringency of the energy code as applied to the building envelope and discouraged energy budget trade-offs. This resulted in practically no submittals under the energy budget paths.

The nature of this review suggests that architects have the most difficulty with developing compliance for building envelopes in Oregon, where they frequently resorted to energy budget trade-offs to demonstrate compliance. This code is actually less restrictive than the ASHRAE Standard 90.1 and roughly the same as the current Washington code. It is much less restrictive than the Washington code of 1990.

3.2. Window Performance

Window performance under most codes and standards—residential and non-residential—revolves around both normalized window area (in non-residential codes, usually window area as a percent of wall area) and actual window U-value performance. In non-residential construction, particularly buildings in which cooling is installed, this also includes the shade coefficient (SC) or tint of the windows (the percentage of solar heat transmitted into the space by the glazing system). Both the Oregon code and the Washington code address the SC.

3.2.1. Window Area

Table 3.5 summarizes window percentages by state**.** These percentages are calculated as a ratio between total wall area and total window area. The ratio is summarized using case weights and building area. The Washington area summary is based on the summaries done for that sample. Though these summaries are comparable, some of the definitions of building type differ. Specifically, the "Manufacturing" category was included with the "Other" category in the 1996 sample; some of the "Health Services" included in the 1998 survey for the other states were not included in the 1996 Washington sample because of the definition of non-residential uses in the Washington code.

Table 3.5: Percent Window by State and Building Type (% Gross Wall)

Building Type	Idaho	Montana	Oregon	Region	Washington 1996
Assembly	6.9	10.4	10.2	9.4	8.8
Education	8.1	6.8	16.1	10.7	17.0
Grocery	1.5	-	3.7	3.4	6.2
Health Services	9.8	15.8	31.5	19.8	13.5
Institution	9.9	5.8	-	7.9	11.3
Manufacturing	2.3	-	9.1	7.8	-
Office	22.8	18.9	30.5	27.0	25.6
Other	6.8	29.0	21.7	14.4	6.9
Residential/Lodging	17.5	17.0	21.4	20.0	11.0
Restaurant / Bar	-	-	14.3	14.3	16.2
Retail	9.0	5.3	16.9	11.2	11.5
Warehouse	1.4	10.4	5.3	5.3	9.1
Total	9.6	12.6	15.3	13.5	12.0

For the most part, these glazing percentages are determined as much by building type and building scale as by any feature of the individual state. The retail sector offers an interesting contrast among the states. Large "big box" retail is dominant in most markets of the region (outside of major urban areas), and these buildings have a very small amount of glazing; in contrast, multi-story and street-level urban retail malls are heavily glazed, and these dominated the Oregon sample for this building type in 1998. At the same time, the Idaho and Montana retail sector is almost exclusively single story structures with very limited glazing area. In the 1996 Washington sample, the retail sector was equally divided between urban retail developments and suburban/rural big box developments. The result is that percent glazing in "Retail" are about half of the Oregon sample in these two states; Washington is between Oregon and the other two states.

When the results of the 1996 Washington sample are compared to the other state samples, most of the patterns disappear. Except for "Office" and "Warehouse" uses, none of these trends seem more than an artifact of the particular sample. It is important to note that when Idaho is compared to the other states, a pattern of lower glazing areas across almost all building types is apparent. This results in about a third less glazing in the Idaho sample. Without this reduced glazing area, the increased heat loss in the Idaho building stock shown in Table 3.3 would be even more striking.

3.2.2. Thermal Performance

Table 3.6 describes the actual window performance by window class. In this case, “class” refers to the two-digit whole number that represents the actual U-value of the window multiplied by 100describing the thermal performance/heat conductivity of the window.

Table 3.6: Window Thermal Performance by State

State	Average U-value	% Area in Window Class				
		30-40	41-50	51-60	>60	Total
Idaho	0.557	3.9	42.4	13.0	40.7	100.0
Montana	0.453	21.2	70.7	5.7	2.4	100.0
Oregon	0.583	5.9	20.6	41.2	32.3	100.0
Region	0.557	8.1	32.5	30.6	28.7	100.0
Washington 1996	0.673	-	-	-	-	-

The Montana windows have noticeably lower U-values than those of Idaho or Oregon. This pattern is somewhat similar to patterns in the residential sector, where Montana builders tend to treat window performance as a major response to their relatively cold climate. The window area of the Idaho sample largely cancels out the difference between the Idaho and Montana samples making the window heat loss between the two states comparable. The Oregon sample, on the other hand, has much higher overall heat loss. This is largely an artifact of a few large urban developments (especially “Office” and “Retail”) that use trade-offs to allow more glass in exchange for improvements in other building systems.

Most of the differences in performance shown here can be explained by the use of low-ε coatings on the glazing systems. Table 3.7 shows the distribution of various higher-performance window components.

Table 3.7: Window Characteristics by State (Percent of Area)

State	Low-ε	Tint	Reflective	Argon
Idaho	38.9	48.9	6.7	7.0
Montana	93.2	46.8	2.2	7.3
Oregon	63.7	83.7	6.4	9.6
Region	64.7	73.8	5.9	8.6
Washington 1996	27.0	22.4	-	0.3

As with all other window summaries, the overall results are determined in some measure by the particular buildings in the sample. Nevertheless, a review of this summary shows a striking pattern.

First, low-ε coatings have become dominant in non-residential windows in both the Montana and Oregon markets. In fact, in Montana they have overcome virtually all other non-residential window glazing types. Similarly, the use of shading tints has become dominant in Oregon. This can be attributed to the code requirements in Oregon for shade coefficient as a major trade-off component in building envelope design. Low-ε coatings and tints are used in combination in the Oregon market to decrease SC and thus reduce cooling loads. In both Montana and Oregon, there seems to have been a considerable effort in the market to upgrade glazing performance. In Oregon this can be attributed to code requirements, while in Montana no code requires this level of window performance, though it seems to be well-established in the Montana market.

By contrast, Idaho does not use low-ε coatings to any major degree, nor does it employ tints for sun control or cooling. Idaho, in fact, does not use window shadings and tints as much as Montana, though the Idaho buildings are generally in a climate with a much greater cooling load and, more particularly, much greater cooling load derived from solar gains on windows. Reflective coatings and argon fill remain fairly minor throughout the region, presumably being used only in special cases.

The Washington sample was drawn in 1996 and involved window specifications done somewhat prior to this date. The Washington code requires shade coefficient and window performance similar to Oregon code. The availability of low-ε coatings has improved since 1996. Clearly, this market change has (at least in Oregon and Montana) been reflected in a major increase in the non-residential use of low-ε coatings. Furthermore, the use of tints and other coatings was far less present in the Washington sample. It is reasonable to speculate that a contemporary Washington sample would look similar to the Oregon results, at least for the use of low-ε as a result of market shifts in the glazing market.

In 2000 a sample of large buildings in the city of Seattle was conducted. This sample was dominated by large office buildings that were built between 1997 and 1999 and are contemporary with the buildings sampled for this survey. In this Seattle sample, approximately 80 percent of the window area was treated with low-ε coatings (Kennedy & Baylon, 2001). This lends weight to the thesis that the differences between window treatments in the 1996 Washington sample and the 1998 Oregon sample is the result of a change in practice in both states during this two-year window.

3.2.3. Shade Coefficient

The Oregon and ASHRAE Standard 90.1 regulate the Solar Heat Gain Coefficient (SHGC) and/or the Shade Coefficient (SC). These two index values are related, both describe the amount of solar energy that is transmitted through the window. Low-ε coatings and various tints are used to provide for sun control and other architectural considerations. Table 3.8 summarizes the SC observed in the samples. Most of these values were not available from either the window specification or the window labels; the values were derived from the coatings and tints observed and the assigned shading values for these features.

Table 3.8: Shading Coefficient (Percent of Window Area)

SC	ID	MT	OR	Total	WA 1996
Clear	56.6	7.2	14.2	20.1	50.9
SC=55-86	8.3	0.0	4.0	4.2	27.6
SC=35-50	34.8	90.1	64.2	62.8	19.5
SC=17-35	0.4	2.7	17.7	12.9	2.0
Total	100.0	100.0	100.0	100.0	100.0

The contrast between the window SC reflects a pattern similar to that of thermal performance (partly explained by the extensive use of low-ε coatings in Oregon and Montana). In Idaho and Washington, clear glass dominates the buildings in this sample.

The Idaho climate has substantial cooling loads, and even in smaller buildings the use of sun control could substantially reduce the cost of cooling equipment. Even without a code, this seems to have entered into the window specifications in Montana. In Idaho, where the cooling loads are higher, it has not become accepted practice.

Washington's case largely results from the age of the sample, but it should be noted that the Washington code does not require shading on most buildings as long as glazing areas do not exceed 20%. The more current Seattle sample shows a pattern similar to the 1998 Oregon sample. It is reasonable to assume that the Oregon code has had an impact on the SC, though the size of this impact is difficult to infer from this data.

Overall, when comparing practices across the four states—even when window performance is taken into account—the patterns of building insulation and glazing selection are reasonably similar. Only in Idaho are window components appreciably different from those of other states, and even there the use of lower glazing areas partly cancels out most of the differences between Idaho, Washington and Oregon. In Montana, the attention to building shell seems to dominate the market, and is clearly a major concern of designers and builders in the non-residential sector. This concern transcends the nominal standard in the MEC and ASHRAE 90.1, and probably represents a true response to the local market conditions.

4. Heating, Ventilating and Air Conditioning Systems

A complete review of the HVAC equipment of each building was made. System and equipment types, ratings, and size information were collected. Where possible, name plate information was gathered in order that capacity and efficiency data could be determined. In general, the collected system information was aimed at establishing the efficiency of the HVAC system *components*, not the overall efficiency of the system. The nature and details of the system controls, the installation and the commissioning, all contribute to the overall system efficiency, and these operational issues were not addressed in the audits.

4.1. System Description

Commercial HVAC systems are designed to meet heating, ventilation, and cooling needs. A vast majority of installed HVAC systems meet these needs. Constant or variable volume air handlers with heating, cooling, and outside air (ventilation) intake are all part of a package unit which provides conditioned air to the zones of buildings. Systems may consist of either unitary package equipment that comes factory-equipped with all elements or site assembled built-up systems, in which heating and/or cooling coils, economizer dampers, etc. are installed on site with an air handling unit, with overall heating and cooling provided by separate pieces of equipment (e.g. chiller, boiler, etc).

Unitary package equipment comes as an integrated air handling and conditioning package. Heating is generally provided with natural gas or electric resistance coils; cooling through compression-driven direct expansion. Unitary package equipment comes with integrated controls and is regulated based upon heating and cooling efficiency. Fan motor energy is included in efficiency calculations.

Built-up systems generally revolve around the air handler to which heating and cooling are added. Heating is often provided with hot water coils supplied from a boiler or central steam plant. Cooling is divided between add-in condensing coils and chilled water coils from a chiller. Built-up systems require controls to integrate the various pieces of equipment.

In smaller buildings, various single zone systems are used. These range from residential-scale furnaces to small package terminal heat pumps and air conditioners (PTHP,PTAC). These systems are typically not integrated, being controlled by single-zone, single-stage thermostats.

In modern manufacturing and equipment design, the difference between unitary package equipment and site built systems is diminishing. Large unitary package equipment can be ordered from factories based upon specific heating and cooling capacity, efficiency, and ventilation needs. The equipment comes as a factory-assembled package that is unique to customer specifications. The second-largest building in the sample, a 24-floor office tower, utilizes a 290,000 CFM rooftop package VAV with integrated chiller: essentially a large package unit.

An additional distinction between HVAC systems lies in capability to serve zones with different condition requirements or loads. Single zone equipment is designed to meet the needs of a single thermal zone. The equipment is either in heating mode or cooling mode and generally has a constant volume air supply regardless of the thermostat status. A building may have several different pieces of single zone equipment to meet the requirements of various zones. These can generally be controlled separately, and each zone can operate with separate temperature setpoints and separate operating schedules.

Multi-zone systems are designed to be able to heat one zone while cooling another using a central system. The most common multi-zone systems found were VAV, including one TRAV (terminal regulated air volume system controls). A much smaller number of heat pump loop systems, and a small number of constant volume multi-zone and unit ventilator systems, were also found.

A small number of buildings have separate systems serving the same space in order to provide heating, venting and cooling loads. Heating is supplied by one system, such as a radiant floor or perimeter fin-tube radiators. Ventilation and cooling are supplied with a central air system. Control interactions are always a concern in these systems.

Warehouse, shop and industrial spaces differ in that ventilation often is assumed to be adequate by nature of the space activity (goods transfer through open doors). HVAC systems are often limited to package unit heaters with no cooling or outside air. In addition, these heating-only systems are often designed to provide freeze protection, not fully heat the space. The Oregon code has a separate "semi-heated" path that includes a capacity requirement. This definition has been used throughout the region to determine the status of semi-heated spaces. Table 4.1 summarizes the level of heating by state.

Table 4.1: Degree of Heating (Percent of floor area)

State code	Heated	Semi-heat	Unheated	Unknown	Total
ID	98.30	1.70	0.00	0.00	100.00
MT	98.76	1.24	0.00	0.00	100.00
OR	83.63	6.80	1.56	8.01	100.00
Region	89.47	4.73	0.95	4.85	100.00

The greater degree of semi- and un-heated spaces in Oregon is attributable to the much higher number of warehouse and manufacturing spaces in the sample. Of warehouse spaces in the region, 31% were heated (mostly in combination with office areas), 34% were semi-heated, 8% unheated, and 27% are unknown but probably would qualify as semi-heated spaces.

4.2. HVAC Systems

Commercial HVAC systems come in a wide variety of combinations of the above traits, and many of the audited facilities have a mixture of equipment and system types. Systems with reheat coils (coils or elements that add heat to cooled air or outside air that is not warm enough to meet interior space conditioning needs) were classified by the reheat fuel rather than the fuel source for the primary heating coil. Consequently, the electric fuel type is somewhat overstated. Forty-eight percent of the floor area with electric heat has a non-electric primary coil or secondary heat. Typically, the primary coil is used in limited situations to boost the temperature of the make-up air or in warm-up cycles. Normal heating operation in perimeter zones usually relies on the reheat coils alone. Table 4.2 summarizes system configurations by state.

Table 4.3 summarizes system configuration by fuel type. Package equipment, both single zone and VAV, serve 80% of the floor area in the region. Sixty percent of the floor area served by VAV systems is served with package rooftop VAV units. Montana has a much higher percentage of floor area served by built-up systems than either Idaho or Oregon. This is due to the unusually high number of built-up single zone systems which are, for the most part, small furnace units with split compressors for cooling.

Table 4.2: System Configuration by State (Percent of floor area)

System Type	Idaho	Montana	Oregon	Region
Single-Zone				
Package Single Zone	77.0	43.4	71.5	68.8
Built-up Single Zone	7.4	24.2	2.1	6.8
Multizone/Complex				
Package VAV	0.8	2.6	16.1	10.0
Built-up VAV	4.9	12.9	5.8	6.6
Package Other	0.0	0.0	1.4	0.8
Built-up Other	10.0	17.0	3.1	7.0
Total	100.0	100.0	100.0	100.0

Table 4.3: System Configuration and Primary Heating Fuel

System Type	Electric	Heat Pump	Natural Gas	Other	Total
Single-Zone					
Package Single Zone	4.9	3.9	59.0	1.0	68.9
Built-up Single Zone	0.0	0.0	6.6	0.0	6.6
Multizone/Complex					
Package VAV	8.8	0.0	1.3	0.0	10.0
Built-up VAV	2.8	0.0	3.2	0.7	6.6
Package Other	0.1	0.0	0.7	0.0	0.8
Built-up Other	0.1	0.0	6.5	0.5	7.0
Total	16.6	3.9	77.3	2.2	100.0

Table 4.4 presents the primary heating fuel by state. Other fuels include central steam plants and geothermal.

Table 4.4: Primary Heating Fuel by State (Percent of floor area)

Primary Heating Fuel	Idaho	Montana	Oregon	Region
Natural Gas	78.4	85.6	69.3	74.1
Electric	7.5	0.7	23.9	16.1
Heat Pump	3.8	6.9	3.0	3.8
Propane	8.8	4.9	1.3	3.8
Other	1.5	1.9	2.5	2.1
Total	100.0	100.0	100.0	100.0

Table 4.5 summarizes the system and fuel types found. Forced air furnaces with AC (indoor and rooftop) dominate the package single-zone equipment. VAV systems dominate the complex systems. The saturation of electric heat is somewhat overstated. For VAV systems with primary coils, the sub-zone reheat coils were chosen as the fuel type. In many cases, the primary coils are gas-fired with electric reheat coils. These systems have been categorized as electric, though a substantial portion of their heat may be provided by gas-fired primary coils. The saturation of gas heat (via boilers and hot-water coils) in VAV sub-zone reheat is a marked departure from previous regional work. In these studies, reheat fuel was almost universally electric.

Table 4.5: Equipment Type by Fuel (Percent of floor area)

Equipment Type	Primary Heating Fuel				
	Electric	Heat Pump	Natural Gas	Other	Total
Package Single Zone					
FRN-Furnace/AC	2.4	0.8	38.7	0.0	41.9
Other Furnace	0.0	0.0	7.6	1.0	8.6
PTAC/HP	2.0	3.0	0.0	0.0	5.0
Radiant Heaters	0.0	0.0	4.8	0.0	4.8
Zone/Unit Heater	0.3	0.0	9.2	0.0	9.4
Sub-total – PSZ	4.8	3.8	58.2	3.1	69.8
Complex Systems – Built-up and/or Multi-zone					
Const.Vol.	0.0	0.0	6.0	0.0	6.0
HP Loop	0.2	0.0	2.5	0.0	2.6
Misc. Complex	0.0	0.0	1.4	0.5	1.8
Unit Ventilator	0.0	0.0	3.0	0.0	3.0
VAV	11.2	0.0	4.8	0.7	16.7
Sub-Total – Multi-zone	11.4	0.0	17.1	0.8	30.2
Total	16.1	3.8	76.3	3.8	100.0

Table 4.6: Equipment Type by State (Percent of floor area)

Equipment Type	ID	MT	OR	Total	% Electric
Package Single Zone (PSZ)					
Furnace/AC	56.3	27.2	38.8	41.8	7.7
Other Furnace	5.9	0.6	11.9	8.6	0.0
PTAC/HP	1.9	6.9	6.0	5.0	100.0
Radiant Heaters	3.0	4.5	5.7	4.8	0.1
Zone/Unit Heater	8.4	4.2	11.2	9.4	3.1
Sub-total – PSZ	75.5	43.4	73.5	69.7	12.3
Complex Systems – Built-up and/or Multi-zone					
CV	6.0	23.1	2.0	6.1	0.0
HP Loop	4.0	9.6	0.3	2.6	6.8
Misc. Complex	1.7	4.6	1.2	1.8	0.0
Unit Ventilator	5.5	4.0	1.7	3.0	0.0
VAV	7.3	15.5	21.3	16.7	67.0
Sub-Total – Multi-zone	24.4	56.6	26.5	30.3	37.4
Total	100.0	100.0	100.0	100.0	19.9

Systems have also been summarized by building in order to facilitate comparisons with the 1996 Washington sample. The protocol for reviewing the systems in the Washington survey focused on the distinction between “simple” and “complex” systems in the Washington energy code. Because of this distinction, the results of the 1996 survey are not directly comparable. Simple systems in the code are single-zone package systems with constant volume air handlers. Small split systems and heating-only systems are also included in this definition.

In the 1996 Washington sample, 72% of the buildings used simple systems. In the 1998 sample for the other three states, 75% of buildings used simple systems. These simple systems are mostly single-zone package units in all states. Package systems that were more complex were not tracked separately in the 1996 Washington sample, so the comparison between this sample and the previous Washington sample was simplified. The distribution of system types in the 1990, 1996, and 1998 samples is shown in Table 4.7. Grocery systems are in the "Single Zone" category.

These systems would not generally qualify as simple systems under the Washington State code definition. Even in large buildings, simple systems were used where single-zone packaged rooftop units were employed (especially "big-box" retail). At least in this summary, there seems to be a trend toward simple single-zone systems. While the trend toward package systems is pronounced, the trend toward single-zone systems may be an artifact of these particular samples and the auditing procedures used in each sample.

Table 4.7: Washington 1996 System Comparison

System Type	Path	Sample		
		Region 1998	WA 1996	WA 1990
Single-zone	Simple	75.8	72	66
VAV	Complex	16.7	11	15
Groceries	Complex	-	7	6
Complex-Other	Complex	7.5	10	12
Total		100	100	100

4.3. Equipment and Efficiency

4.3.1. Heating

Table 4.8 presents the efficiency data (where available) for unitary package heating equipment. Electric resistance units have not been included. The percent column roughly indicates the percentage of floor area served by the equipment and provides a basis for determining the relative importance of the equipment classes. The code requirement is the ASHRAE 90.1. This requirement is used in both the Oregon and Washington codes with some modification. The "Percent Fail" column indicates the percent of floor area served by the given type of equipment that fails the code efficiency requirements. Duct furnaces and unit heaters are the only equipment category with significant numbers of below-code units. It is very difficult to get reliable information on duct heaters; auditors were obliged to rely almost entirely upon drawings.

Table 4.8 presents the equipment efficiency and percentage passing code by state. On average, Montana has significantly better equipment than Idaho or Oregon. This is mainly due to a much higher saturation of condensing furnaces in Montana.

Table 4.8: Heating Equipment Efficiency and Code Compliance

Heating Equipment (Eff. Units)	**Region**				**Idaho**		**Montana**		**Oregon**	
	% of Equip	**Avg. Eff.**	**Code Eff.**	**% Fail**	**Avg. Eff.**	**% Fail**	**Avg. Eff.**	**% Fail**	**Avg. Eff.**	**% Fail**
Furnaces/<225K (AFUE)	59.9	82.5	78.0	1.2	82.5	4.0	84.3	0.0	82.2	0.4
Furnaces/>225K (AFUE)	16.2	80.1	80.0	12.0	80.1	0.0	79.4	32.8	80.0	15.2
Duct Heaters (AFUE)	8.2	79.5	78.0	67.5	77.0	100	80.0	0.0	80.3	58.0
Unit Heaters (AFUE)	13.9	80.0	78.0	5.4	79.1	28.3	80.0	0.0	80.4	0.0
Heat Pump (HSPF)	0.2	6.8	6.6	0.0	-	-	-	-	6.8	0.0
PTHP (COP)	1.6	3.2	2.7	0.0	-	-	3.2	0.0	3.1	0.0
Total[1]	-	-	-	9.0	81.1	14.1	83.2	3.8	81.4	8.0

1 Total Efficiencies are for combustion equipment only

Equipment efficiency is regulated by the Oregon code and by ASHRAE 90.1 and federal standards. Oregon code efficiency requirements, like those of most state codes, are in turn based on ASHRAE 90.1 and federal standards. Since equipment is distributed nationally, equipment efficiency has generally tracked these standards. It has become difficult to purchase new equipment that does not meet code efficiency levels, even in areas without code. Very few buildings in this sample used equipment not meeting ASHRAE 90.1 efficiency standards and, even in these cases, the required code efficiency was missed by only a small amount.

4.3.2. Boilers

Boilers provide heated water or steam to built-up HVAC equipment. They can also provide service hot water and process loads. Tables 4.9 and 4.10 summarize boiler size, type and efficiency. All boilers had better efficiency than ASHRAE 90.1 standards, generally by a substantial margin.

Table 4.9: Boiler Sizes (kBtu)

Size Range (kBtu)	% of Boilers	% of Capacity
70-600	24.5	2.0
600-1000	22.7	6.3
1000-1250	21.1	7.8
2500-4000	18.9	19.7
4000-10000	0.9	2.0
10000-30000	11.9	62.1
Total	100.0	100.0

Table 4.10: Boiler Efficiency

Boiler Category	Idaho		Montana		Oregon		Region	
	N	Eff	N	Eff	N	Eff	N	Eff
Gas Fired <300kBtu	0	-	6	85.7	0	-	6	85.7
Gas Fired >300kBtu	8	83.5	14	82.4	5	80.9	27	82.3
Total	8	83.5	20	83.1	5	80.9	33	82.8

4.3.3. Cooling

Cooling strategies in the region vary widely:

- A majority of commercial floor area in the region is cooled, with the exception of warehouses and manufacturing areas.
- Forty percent of school floor area is not cooled.
- Traditional compressor driven cooling dominates the Oregon sample.
- Because of the colder climate, Montana has significantly less cooling than the other states, even though the proportion of warehouse spaces in that sample is less than the other states. Less that 50% of the Montana floor area is mechanically cooled, compared with 80% in Idaho and Oregon. There are also many building types in Montana with free economizer cooling but no compressor driven or evaporative cooling. The relatively high quality building envelope and glazing systems in the Montana buildings probably facilitate the success of this approach.

Table 4.11 summarizes types of cooling by state.

Table 4.11: Cooling Type by State (Percent of floor area)

Type of Cooling	Idaho	Montana	Oregon	Total
DX	15.7	7.3	17.8	15.7
DX, Economizer	36.0	16.3	35.3	32.6
DX, Econ. Unknown	13.7	10.8	11.6	12.1
Chiller[2]	10.1	11.9	11.4	11.1
Evaporative	0.6	3.4	1.2	1.4
Cooling Tower Only[1, 2]	4.2	9.4	0.0	2.5
Economizer Only	0.5	28.9	0.3	4.7
No Cooling	19.3	11.9	22.3	19.9
Total	100.0	100.0	100.0	100.0

1 Includes one facility with a pump and dump well
2 These systems also have economizers

Regulated cooling equipment efficiencies were very near or better than code in all cases. Table 4.12 presents average efficiency and average code values for regulated cooling packages. Package terminal AC and heat pumps, together with large unitary equipment, were often significantly better than code. Efficiency data was not available for water source heat pumps. Table 4.13 presents chiller efficiency by equipment type. Again, all equipment exceeded code.

Table 4.12: Cooling Equipment Efficiency (Percent of floor area)

Equipment Category	Freq.	Percent	EER	Code	Fails
AC/Air/<65K (less than 5 Tons)	137	40.8	10.5	9.8	2.8
AC/Air/65K -135K (5-11 Tons)	68	24.7	9.3	8.9	0.0
AC/Air/>135K (greater than 11 tons)	49	19.1	9.3	8.5	9.2
PTAC/PTHP	15	15.4	11.1	8.4	0.0
Total	269	100.0	10.1	9.1	3.0

Table 4.13: Chiller Efficiency

Chiller Category		Chiller Efficiency				
	Total	N	COP	S. dev	Code	% fail
Water Cooled – 150-300 Tons	3	2	5.4	0.8	4.2	0.0
Water Cooled – 300-900 Tons	3	2	6.4	0.7	5.2	0.0
Air Cooled - 150-300 Tons	7	6	3.3	0.5	2.7	0.0
Air Cooled - 300-900 Tons	4	2	2.7	0.1	2.5	0.0
Total	18	12	4.2	1.6	3.4	0.0

While these efficiencies exceed the relevant codes, there is a new standard, ASHRAE 90.1-99, which would increase standards nationally effective 2001. When the equipment observed in this survey is compared to that standard, about a third of the equipment fails to meet the new code. This is largely due to certain classes of equipment where existing manufacturing standards do not meet the new ASHRAE standards. Presumably, in states that enforce the efficiency standards, the equipment specified and installed would continue to comply; this is largely because manufacturers are compelled to produce equipment in compliance with these standards. Over time the enforcement becomes irrelevant, since ASHRAE Standard equipment becomes the only type available. In the near term, states without enforced equipment standards would become a tempting market to supply from areas where the new standards are enforced, rendering the inventory obsolete. Both Montana and Idaho could be affected by the lack of enforced standards in their jurisdictions.

4.3.4. Motors

With the predominance of package equipment, a vast majority of motor horsepower is installed by equipment manufacturers and is regulated as part of system efficiency. Motor size, drive and control information were gathered for site-installed fan and pump motors. Motor efficiency was often so difficult to acquire that it could not be summarized.

On the other hand, motor control strategies could be identified from field review. Table 4.14 presents a summary of fan motor control strategies as a percentage of motors and of horsepower. The “HVAC” column denotes fans directly involved with HVAC equipment. The “Other” column denotes fans uninvolved or indirectly involved with the HVAC equipment (e.g., exhaust fans). Unfortunately, motor control strategies were not collected from the 1996 Washington sample, so no direct comparison is available.

Forty-six percent of site-installed HVAC fan motors are controlled with adjustable speed drives. Significantly, no other variable flow control device was identified in site-installed fans. To further explore this point, control devices in package VAV were examined. In units where all model number digits were available or site inspection verified motor control (about 50% of the cases), fans were universally controlled with ASDs.

The near-complete adoption of adjustable speed drives is a major change from previous surveys of Northwest buildings. ASD control is seen as the more reliable choice, and designers favor its soft-start ability. In addition, the cost differential between ASDs and inlet vanes has become minimal in most equipment.

Table 4.14: Fan Motors – Controls Summary

	Percent of motors			Percent of horsepower		
Controller type	HVAC	Other	All	HVAC	Other	All
ASD	46.0	4.2	28.6	76.7	11.6	54.1
Multi-speed	5.1	5.3	5.2	6.3	0.7	4.3
Constant	49.0	90.5	66.2	17.1	87.7	41.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

1 fan motors >1hp not part of package equipment

Pump motors are characterized in Table 4.15. Modulation was typically accomplished with staging or adjustable speed drives. Motor staging was the primary modulation technique in large applications. The saturation of ASD in this application is much lower. Though this is partly due to the perception that the pumps generally are running at high load factors, it mostly reflects the practice of the engineers that design these systems: there is a wide-spread perception that the use of variable flow systems result in increased costs for the heat pumps and fan coils that comprise of these systems.

Table 4.15: Site Built Pump Motors – Size

Control Type	Percent of Motors	Percent of Horsepower
ASD	10.7	4.8
Constant	44.2	20.8
Cycling	21.9	5.0
Staged	23.1	69.4
Total	100.00	100.00

4.3.5. Controls

The large number of package systems greatly reduced the control complexity. Central energy management system (EMS) controls were present in larger projects of most building types. In all, 51 out of 144 projects had central EMS systems. “Manufacturing,” “Warehouse,” and “Lodging” were the exceptions, with almost all control being done through individual thermostats. Interestingly, Montana had twice the rate of EMS control of Idaho or Oregon. Table 4.16 summarizes the control systems observed throughout the regional sample and also includes the saturation of EMS control systems observed in the 1996 Washington sample. As can be seen, the results of the 1996 Washington survey were nearly identical to observations in the rest of the region. Furthermore, while only about a third of the buildings reviewed included EMS systems, virtually all the larger buildings in all states used this technology. This observation applies equally to both the 1998 and the 1996 samples.

Table 4.16: HVAC Controls Summary

Control Type	All Projects			Most Projects[1]		
	Obs	% of projects	% of Area	Obs	% of projects	% of Area
Thermostat	93	81.1	58.3	60	76.4	44.5
EMS	51	18.9	41.6	48	23.6	55.5
EMS WA 1996	24	19.5	39.5	24	24.1	56.4

1 Excluding manufacturing, warehouse, and lodging.

EMS systems were almost completely direct digital control (DDC), with only 12% utilizing pneumatics. In the Washington sample, no pneumatic controls were observed in the EMS systems. Typical control strategies included night setback, optimum start, and occupancy-controlled ventilation.

4.3.6. Domestic Hot Water

Table 4.17 presents the domestic hot water fuel by state. In general, electricity was the fuel of choice in buildings with low hot water demands, such as warehouses and offices. Building types with significant water use had gas-fired water heating if it was available.

Table 4.17: Domestic Hot Water Fuel by State (% of area)

Primary Fuel Type	ID	MT	OR	Total
Electric	26.5	24.7	45.6	38.1
Natural Gas	50.0	70.5	38.5	45.7
Natural Gas/Electric	20.3	2.7	10.6	11.8
Other	1.7	2.0	3.5	2.9
None	1.6	0.0	1.8	1.5
Total	100.0	100.0	100.0	100.0

4.4. Code Compliance

Overall, the HVAC systems comply with code efficiency. This is partly because the codes are all based on the ASHRAE Standard 90.1-89 and the equipments efficiency standards enforced by the Federal government are based on the same standards. Furthermore, for equipment not regulated in this way (such as economizers), the level of compliance is usually well above 90 percent. This pattern is consistent with findings of previous characterizations of Washington (1996 and 1990) and Oregon (1990).

The code does not regulate commissioning or system design, let alone the integration of the HVAC system with the building envelope and lighting systems. This means that the design of the HVAC system (which has the greatest effect on overall efficiency) is not specified by any code requirement. Moreover, the nature of the building permit and inspection process probably precludes the energy codes from effectively regulating the quality of the design, controls, and installation. In this sense, what is regulated (or identified in these audits) reflects the quality of the equipment; not, necessarily, the efficiency of the systems.

5. Lighting

Lighting systems were evaluated in each building. In general, the efficiency of a lighting system is determined by the installed lighting wattage. When normalized to building floor area, this is referred to as Lighting Power Density (LPD). While the efficiency of each individual fixture is important in determining overall efficiency, design and controls are also important. Typically, lighting standards are set in the code based on the use of efficient fixtures. This has come to mean fluorescent lamps (T8) with electronic ballast combinations. In these samples, this also includes the use of high intensity discharge (HID) lighting in warehouses and other applications as well as such compact fluorescent lamps (CFLs) as downlights, sconces, and other small area or emphasis lighting.

Lighting systems were characterized based on fixture, lamp and ballast type information derived from plans and field reviews. Fixture energy use and/or make and model were often available from the plan sets. However, this information was determined to be, more often than not, guidelines for wiring.   Actual installed fixtures were based on what was available through contractors and local suppliers. In addition, many of the fixture model numbers did not conform to the manufacturers' numbering systems for all the various options, indicating that designers were often slipshod in specifying fixtures.

For this reason, fixture energy use was developed from standard tables based upon fixture characteristics collected by auditors in the field. Lighting power includes the lamp, ballast and transformer energy for each fixture. Lighting power densities were calculated from the resulting fixture energy use. Ballast type was sometimes difficult to determine from the plans. The main fixtures in most buildings were checked with a "flicker checker" to determine ballast type.

5.1. Lighting Power Density

Table 5.1 presents the average lighting power density (watts per square foot of building area) for each state and for the sample as a whole. Comparisons between states, or between different samples, are complicated by the distribution of building types within the various samples. Since lighting power density varies significantly between building types, differences in building type composition changes the average LPD.

Table 5.1: Lighting Power Density by State (Watts per ft^2)

State	N	LPD	Std. Dev.	Code		
				OR LPD	WA* LPD	ASHRAE 90.1 LPD
Idaho	48	1.24	0.33	1.38	-	1.58
Montana	32	1.25	0.32	1.25	-	1.42
Oregon	63	1.11	0.43	1.30	-	1.66
Region	143	1.16	0.39	1.30	-	1.60
Washington 1996	88	1.15	0.59	-	1.28	-
Washington 1990	70	1.58	0.53	-	1.74	-

*1994 Washington code used in 1996; 1986 Washington code used in 1990

This essentially similar lighting power density between the states is significant in that Idaho and Montana generally do not regulate lighting power. In the Montana public sector, the state architect enforces the MEC and ASHRAE 90.1 energy codes. This accounts for almost half of the Montana sample. In this sense, a large part of the non-residential sector is actually built under an enforced energy code (at least at the permit level). In Idaho there is very little enforcement of any lighting code in most jurisdictions. Some areas outside the Boise area do enforce the MEC, but this is a small fraction of the total non-residential construction in Idaho. Even so, efficient lighting systems dominate the public and private sectors in all three states. Lighting distributors report that engineered projects are generally using efficient lighting such as T8 lamps, while small design build projects are using older technologies such as T12 fluorescents.

The lighting code requirements from both the Oregon and ASHRAE 90.1 are shown. These values are computed from the end uses and building areas in each particular sample. While these values suggest a substantial reduction of current practice below the relevant code, there still would be a substantial improvement if the Oregon code LPD allowance had been followed by all buildings. In that event, buildings whose lighting power exceeded the Oregon code allowance would reduce their LPD to meet the Oregon code and the remaining buildings (which already comply) would remain as found by the auditors. In the case of Idaho, this would have resulted in a roughly 10 percent reduction in the overall *statewide* lighting power. In the case of Montana and Oregon, the reduction would have been about 5 percent. These reductions would have been the result of bringing the non-complying lighting systems in these states up to the standards mandated by code.

Despite sample composition differences, comparison with the previous Washington samples is instructive. The 1990 sample has a significantly higher LPD than the 1996 Washington sample or the 1998 regional sample. It is apparent that a persistent, dramatic shift in LPD has occurred over the past 8 years. The 1994 Washington code is very similar to the 1996 Oregon code. The latter mandates slightly lower LPD. In comparing the two states, however, the lighting practice is virtually identical between the 1996 and the 1998 samples. LPDs in both states are about 10% lower than the Idaho and Montana samples.

Table 5.2 presents the lighting power density by building type. Differences between the building types were generally not found to be statistically significant. Except in the retail sector, where there has been a 25% reduction in LPD, there is a great deal of similarity between this and the 1996 Washington sample. Retail is a diverse sector with many building styles. Building mix likely explains these reductions.

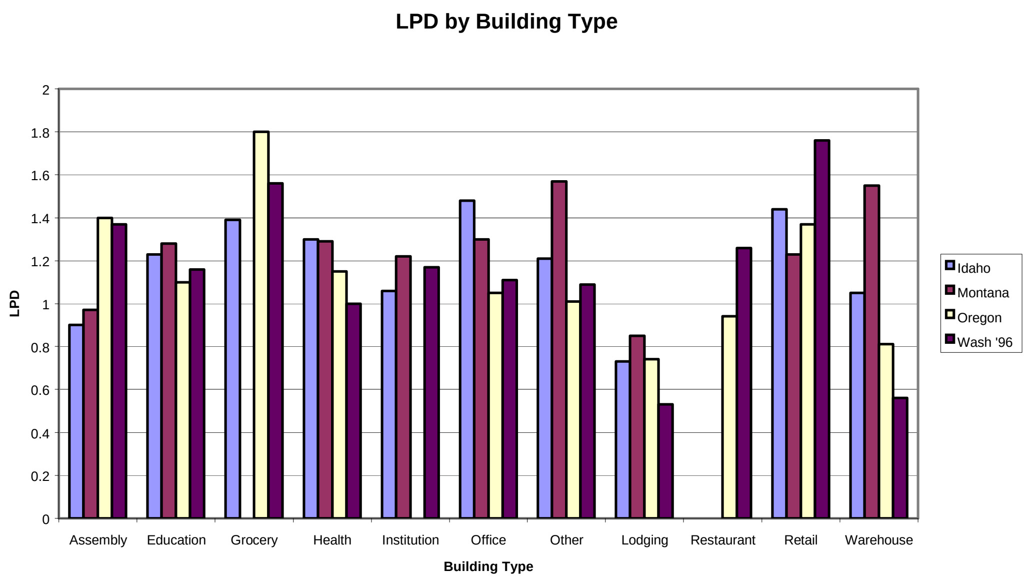
Table 5.2: Lighting Power Density by Building Type

Building type	Obs	LPD	Oregon LPD	ASHRAE 90.1 LPD
Assembly	10	1.25	1.30	1.82
Education	21	1.20	1.25	1.59
Grocery	6	1.70	1.83	2.58
Health Services	11	1.25	1.50	1.34
Institution	3	1.13	1.13	1.13
Manu	12	1.03	1.04	1.28
Office	25	1.18	1.23	1.81
Other	15	1.18	1.36	1.34
Residential/Lodging	10	0.76	1.22	1.29
Restaurant / Bar	1	0.94	1.50	1.43
Retail	15	1.30	1.56	1.89
Warehouse	14	0.92	1.07	1.18
Total	143	1.17	1.31	1.60

The Oregon and ASHRAE 90.1 lighting codes have been applied to the buildings and a code LPD has been developed. Oregon code lighting power density was established using Table 5a. Lighting control adjustments were applied to the lighting budgets. ASHRAE 90.1 interior lighting levels were established using the prescriptive Unit Lighting Power Allowance (ULPA) Table 6-6. Adjustments were made to the UPLA to reflect the allowed control credits so that an effective LPD allowance could be calculated. This value was then comparable to the Oregon code.

Figure 4 compares the LPD by building type in each state. As expected, there is a consistent pattern in most building types with lower LPDs in Oregon and Washington. There are some notable exceptions. The most important is the retail sector. The difference between the types of retail in the four states explains some of the difference. The Oregon and Washington sample have more specialty retail stores with more display lighting. In Washington, however, there is an added factor: the code for retail and grocery occupancy is confusing and most jurisdictions had trouble interpreting the requirements. As a result there was substantial non-compliance in these buildings. Overall, about half the non-compliance in the overall Washington sample appeared in these building types.

Figure 4



5.2. Lighting Technologies

A wide range of lighting technologies was found. Area lighting is generally provided with 4-foot fluorescent or metal halide HID lighting, while accent and decorative fixtures are incandescent and compact fluorescent lamps. A substantial majority of the lighting power is consumed by high efficacy fixture types. The two main area lighting technologies accounted for over 70% of the connected watts. Electronically ballasted, 4-foot T8 fluorescents accounted for 44% of the installed watts. Metal halide fixtures accounted for 25%. In all, the top six-lamp/ballast combinations account for 87 % of the installed watts.

The “Other Fluorescent” category includes odd length, circuline, and the new T5 fixtures. Only one building had T5 fluorescent strip fixtures. This is said to be popular among designers, but was not found to be significant in this sample.

While LPD does not provide a statistically significant comparison between states, lighting technology does provide some clues. Lamp information is summarized in Tables 5.3 and 5.4. Table 5.3 presents lamp type by ballast. This includes ballasts on compact and standard fluorescent fixtures. Oregon had half as many magnetic-type ballasts as Idaho or Montana. Table 5.4 presents lamp type by state. Lamp technology varied somewhat between states. Oregon had fewer T12 fixtures (6% of total T8 and T12 watts), while Idaho had 16%. The increased use of HID lighting in Oregon results from the greater number of warehouses in the Oregon sample.

Table 5.3: Lamp Type by Ballast (Percent of Watts)

Lamp Type	Ballast Type			
	Unknown/ NA	Efficiency	Electronic	Total
Fluorescent				
F32T8	3.0	3.4	44.4	50.8
F40/96T12	1.4	3.8	0.7	5.9
Compact	1.6	0.7	2.2	4.5
Other Fluorescent	0.2	0.3	0.8	1.3
HID				
Metal Halide	25.1	-	-	25.1
H.P. Sodium	2.1	-	-	2.1
Mercury Vapor	0.3	-	-	0.3
Incandescent/Unknown				
Incandescent	8.6	-	-	8.6
Low Voltage Incandescent	0.9	-	-	0.9
Unknown Lamp	0.5	-	-	0.6

Table 5.4: Lamp Type by State

Lamp Type	Percent of Watts				
	Idaho	Montana	Oregon	Region	1996 Washington
Fluorescent	66.5	71.1	50.1	57.9	44.7
T8	55.8	61.8	46.6	51.5	34.5
T12	10.6	8.7	3.2	6.0	10.2
Other	0.1	0.7	0.3	0.3	0.0
CFL	3.3	4.5	5.1	4.5	4.3
HID	21.8	16.7	34.0	27.9	44.2
Incandescent	8.1	7.5	9.1	8.6	6.9
Inc. (24V)	0.2	0.1	1.5	0.9	-
Exit	0.2	0.2	0.1	0.1	-
Total	100.0	100.0	100.0	100.0	100.0

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

The development of the market for T8 lamps in the application of general commercial lighting has advanced steadily over the past decade. The 1990 sample included about 8% T8 technology fixtures in such applications. As can be seen in Table 5.4, the process has continued, with about 94% of Oregon's fluorescent area lighting served by T8 lamps. The Idaho-Montana market lags somewhat behind Oregon, though T8 lamps exceed 85% of the market in these states. This should be attributed to the impact of the Oregon code. The code seems to have decreased the LPDs across the board in Oregon, but this decrease is not especially striking since the use of efficient fluorescent and H.I.D. technology seems to pervade all regional lighting markets.

An interesting comparison can be made with the older Washington sample. More than 20% of the fluorescent area lighting in this sample uses T12. Given the trend observed from the 1990 sample, this is probably best explained by the maturation of the T8 lamp over the last 10 years. We suspect that this process has probably resulted in similar saturations in Washington; consequently, a contemporary sample would show a pattern similar to that of the Oregon sample.

Compact fluorescent fixtures were present in a majority of buildings. In aggregate, they formed a diverse group of fixture and lamp types being used as accent or can lighting. Their attraction to designers is better color rendition, and, in the case of biax fixtures, higher light output. Thirteen and twenty-six watt lamps were the most common, in twin and quad form. A significant number of the long tube biax fixtures were also found, including two Idaho buildings in which this was the dominant lamp type.

A surprising number of compact fluorescents were electronically ballasted. Ballast type showed a strong correlation with state. Montana in particular had significantly fewer electronic ballasts.

Table 5.5 summarizes the ballasts observed by state. This table is separated into conventional and dimmable electronic ballasts and magnetic ballasts.

Table 5.5: Fluorescent Ballast Type by State (Percent of fixtures)

Ballast Type	Idaho	Montana	Oregon	Region	1996 Washington
DIM ELECT	0.0	0.5	3.3	1.8	-
EFF	20.0	18.4	10.0	14.4	22.4
ELECT	80.0	81.1	86.7	83.8	77.6
Total	100.0	100.0	100.0	100.0	100.0

Standard 4-foot fluorescent fixtures light the vast majority of the region's floor area. T8 lamps and electronic ballasts are the dominant combination in all states, though magnetic ballasts are found in a few cases. This latter group seemed to contradict the prevailing assumption that T8 lamps are always electronically ballasted. Seven buildings were reported to have magnetic ballasts with T8 lamps. These fixtures were reviewed and in several cases found not to have been field verified. Either the fixtures had not been installed or the auditor had not been equipped with a flicker checker. Lighting distributors report small sale numbers of electronic ballasted T8s in Idaho and Montana. Table 5.5 summarizes the ballast findings in the field review.

T12 lamps typically were installed with magnetic ballasts. Seventeen buildings used T12 lamps; these were the main light source in eight buildings. An estimated one-third of magnetically ballasted T12 lamps were used in situations where electronic ballasts and T8 lamps are not commonly employed. These include cold start and high output fixtures in loading docks, warehouses and manufacturing. As with the T8 lamps the 1996 Washington sample suggests that some increased saturation of electronic ballasts has occurred over the last five years, largely in CFLs. Given the trends in the other states, it would be reasonable to suppose that the use of these ballasts has also become more common in Washington.

5.3. Lighting Controls

The presence of advanced lighting controls is summarized in Table 5.6 and Table 5.7. Advanced controls were concentrated in the larger projects, and multiple strategies were often employed in the same project. The two largest buildings in the sample, Oregon offices, accounted for one-third of Oregon's advanced controls and 25% of the region's. Oregon had significantly better lighting controls than the other states. This is perhaps reflective of the larger buildings in the Oregon sample.

Office, assembly, education, and retail were the main sectors with advanced controls. Spaces in assembly and retail that employed advanced controls were generally large open spaces such as exhibition halls and "big box" retail spaces. Daylighting controls were installed in six buildings and were generally associated with very large amounts of glass. Two of the six buildings were offices utilizing perimeter lighting control. These projects were the two largest buildings in the sample.

For the most part, advanced lighting controls are not any part of lighting design in non-residential buildings. Furthermore, most lighting controls are sweep-type controls integrated into building E.M.S. controllers. These controls require little or no lighting design. The use of daylight controls remains insignificant, as noted in previous studies. Generally, the lighting codes do not regulate controls to any large degree. The use of sweep controls in Oregon, however, is mandated in office lighting systems above 2000 ft^2 in size, which results in most of the observed automatic controls.

Table 5.6: Lighting Controls by State (Percent of Watts)

State	Lighting controls			
	Daylight	Occupant	Sweep	Total
Idaho	3.4	0.1	0.0	3.5
Montana	1.5	0.4	6.3	8.2
Oregon	5.0	8.6	13.2	17.9
Region	4.1	5.3	8.9	12.9

Table 5.7: Lighting Controls by Building Type (Percent of Watts)

Building Type	Lighting controls			
	Daylight	Occupant	Sweep	Total
Assembly	10.1	0.0	31.9	31.9
Education	0.0	1.3	16.4	17.6
Grocery	0.0	0.0	0.0	0.0
Health Services	0.0	10.2	0.0	10.2
Institution	0.0	0.0	0.0	0.0
Manufacturing	0.0	1.7	3.2	4.9
Office	6.5	15.9	20.6	23.4
Other	15.7	13.9	0.0	16.0
Residential/Lodging	0.0	0.0	0.0	0.0
Restaurant / Bar	0.0	0.0	0.0	0.0
Retail	12.4	0.0	14.1	26.5
Warehouse	0.0	1.0	0.0	1.0
Total	4.1	5.3	8.9	12.9

5.4. Exit Lighting

Table 5.8 shows exit light technology by state. Since exit lights are installed to mark exit locations, the data have been summarized on a fixtures rather than buildings. The incandescent exits were located in aircraft hangars and manufacturing spaces. It is not clear why this choice was made. Tritium exit lights were used in four buildings in Idaho.

Table 5.8: Exit Light Type (Percent of Fixtures)

Lamp Type	Idaho	Montana	Oregon	Region
CFL	5.9	5.3	0.9	3.8
CFL-Twin	0.0	0.0	6.6	2.5
Incandescent	7.5	0.0	17.9	9.4
LED	73.0	94.7	74.5	79.7
Tritium	13.6	0.0	0.0	4.5
Total	100.0	100.0	100.0	100.0

5.5. Lighting Code Compliance

Compliance was tested against two different code standards: the Oregon code and the ASHRAE Standard 90.1. Overall, the Oregon code is about 25% more stringent than the ASHRAE code. This is largely the result of the treatment of various Class A and B occupancies, and the generous ASHRAE control credits. Table 5.9 summarizes compliance levels with these two codes in the three states. A 5% margin of error was factored into the comparison, allowing buildings that just miss code to be counted as passing.

Table 5.9: Lighting Power Compliance by State

State/Weightings	Code		
	Oregon	ASHRAE 90.1	Washington
Idaho			
Case	71.0	77.4	-
Area	69.5	82.2	-
Montana			
Case	57.5	59.4	-
Area	65.3	66.8	-
Oregon			
Case	71.7	87.9	-
Area	73.5	92.6	-
Region			
Case	69.5	80.7	-
Area	71.1	85.9	-
Washington 1996			
Case	-	-	67
Area	-	-	83

The compliance level with the Oregon code is about 70% in Oregon and Idaho and 60% in Montana. Full compliance with the Oregon code would result in a 5% reduction in lighting power in Oregon and Idaho, and a 10% reduction in Montana.

The overall impression from these compliance numbers suggests that the differences between the three states are not very large. In Oregon this could be attributed to the energy code and to a 70% compliance rate. But the results from Idaho and Montana suggest that similar design standards are being used and accepted in these states. Apparently, current lighting practices transcend the presence of codes, at least in much of the building industry in Montana and Idaho.

Comparing these three states with Washington code performance in the 1996 sample suggests that, at a minimum, the acceptance of these standards in the Washington sample was better than the acceptance of the Oregon code in the Oregon buildings. This suggests more extensive enforcement and/or more general acceptance of the 1994 Washington energy code than the 1996 Oregon code. This may be partly due to the extensive enforcement support during this period throughout Washington. In more recent compliance reviews in the City of Seattle, lighting code compliance was comparable to the Oregon sample and considerably below the 1996 Washington sample (Kennedy & Baylon, 2001).

With the exception of the 1996 Washington sample, compliance with the lighting code has been consistently around 70 percent. This was true in the 1990 reviews of Washington and Oregon, where the LPD requirements were 30 to 40 percent higher. This suggests that the lighting technologies and lighting practice have kept pace with the code. Only in the case where there was significant enforcement support was there an appreciable improvement in compliance.

Furthermore, in all the samples reviewed here, non-compliance is concentrated in a few building types, notably retail and grocery, where the perceived need for display lighting seems to transcend both the code and the available efficient lighting technologies. It should be pointed out that the overall impact of this non-compliance is less than 10% of the LPD. Overall, this pattern seems consistent with minimal enforcement of the lighting code throughout the region.

6. Interviews

Interviews were conducted with design professionals in all states, including Washington. The Washington interview sample was drawn from the buildings selected from 1998 Dodge® database. Thus this group is comparable to the other states in that they were involved in current (1997-1998) building projects, even though the buildings themselves were not surveyed.

A total of 220 interviews were conducted. The majority of respondents were architects (64%) followed by mechanical engineers (16%). The remainder of the sample included owners, owners' representatives, developers, contractors, and other design professionals. No other group comprised more than 5% of the sample. Table 6.1 shows the sample distribution by design role. A complete copy of the interview protocol, including responses to each interview question, is contained in Appendix A.

Table 6.1: Sample Distribution by Design Role (Percent)

Design Role	Idaho	Montana	Oregon	Washington	Total
Architect/Envelope Designer	61	100	60	56	61
Building Owner	20	0	3	1	5
Corporate HQ	0	0	5	1	1
General Contractor	7	0	0	1	2
Lighting Designer	2	0	2	2	2
Mech. Contractor	5	0	3	5	4
Mech. Engineer	5	0	19	26	18
Owner's Rep / Other	0	0	8	9	6
Total	100	100	100	100	100

Smaller firms (5 or fewer employees) dominated the sample in Idaho (30%) and Montana (50%), while medium sized firms (26 to 100 employees) made up the largest group in both Oregon (45%) and Washington (35%). In the majority of cases, the architects and engineers identified and interviewed in this process were located in the state where the sampled building project was located (83%).

6.1. Energy Codes

The interview responses suggest that decisions affecting energy efficiency are made by the individual design professional for each major building component, with the architect and/or owner communicating general goals and retaining final authority. However, the impact of the owners and architects varies widely by state and individual engineers have substantial discretion in the design decisions in their specialty. Mechanical engineers select equipment and designs in 87% of the Montana sample, while energy efficiency decisions are made by these professionals in only 27% of the Idaho sample. Table 6.2 describes the decision-making chain for the three major components examined in this study.

This result is most striking when Idaho is compared with the other states. The fact that fully half of the decisions on energy efficiency are not made by design professionals suggests that these decisions are not even addressed in the design process, let alone in the building permit process. Given this finding, it is apparent that the design professionals view energy efficiency decisions as outside their concern. This could be the result of a lack of an enforced energy code, which may cause all these decisions to be viewed as optional.

An additional feature of these responses is the almost total lack of involvement from contractors or subcontractors in Idaho and Montana. Presumably, this is the result of fewer designer/builder contracts in HVAC equipment and lighting than is typical in Washington and Oregon. This may have little impact on overall efficiency, but it does suggest that the decision making in these markets is dominated by design professionals and/or building owners. In the larger markets, a significant amount of these decisions have been transferred to design/build subcontractors and contractors.

Table 6.2: Energy Efficiency Decision Makers (Percent)

Decision maker	Envelope				Mechanical				Lighting			
	ID	MT	OR	WA	ID	MT	OR	WA	ID	MT	OR	WA
Architect	25	88	61	59	23	13	4	2	23	31	13	8
Structural	20	6	6	8	0	0	0	0	0	0	0	0
Mechanical	0	0	0	0	27	87	63	60	0	0	0	0
Electrical	0	0	0	0	0	0	0	0	25	56	52	47
Contractor	2	0	2	6	5	0	16	17	2	0	15	12
Owner	36	6	8	10	34	0	11	12	34	0	10	17
Other	17	0	23	17	11	0	6	9	16	13	10	16
Total	100	100	100	100	100	100	100	100	100	100	100	100

Washington and Oregon professionals typically said they were governed by their state's non-residential energy code. In Montana, 93% of the respondents said they designed to MEC standards, with the remainder citing ASHRAE Standard 90.1. Responses from Idaho, on the other hand, were much more equivocal. Fully 38% of the Idaho sample said they did not design to any of these standards, while 27% said they were governed by ASHRAE Standard 90.1. About 18% said they designed to Oregon or Washington Energy Code standards, 7% said they use the MEC as a guideline, and almost 5% said they use the Idaho *Residential* standard.

Interviewees were asked if they had received any feedback from code officials during the permitting process. Table 6.3 summarizes the results in each state. The amount of feedback from code officials can be viewed as a surrogate for enforcement. With only about 11% of Montana and 3% of Idaho acknowledging *any* feedback from code officials, the inescapable conclusion is that the MEC codes in these states are viewed as advisory. Designers in Montana often use the code as a realistic guideline; in Idaho almost no effort at compliance was observed in the major commercial market, Boise. What little enforcement was mentioned was located in Kootenai County in the far north of the state.

In contrast, the results of Washington and Oregon suggest fairly pervasive code enforcement activity. Here, a substantial fraction of interviewees (almost half) noted some feedback from local officials. This is a significant contrast with interviews conducted as part of the 1990 sample, where less than 7% noted any feedback from code officials. In the 1996 sample, the same question was asked of Washington designers. About 21% of the respondents noted some feedback during the permit process. By this standard, both the Oregon and Washington interviews suggest a considerable increase in attention to the energy code by the jurisdictions in these states. More importantly, the jurisdictions in the Seattle and Portland areas were the ones where designers mentioned direct feedback on the energy code most frequently.

Table 6.3: Code Official Feedback and Response

Received Feedback at Plan Review	**Idaho**		**Montana**		**Oregon**		**Washington**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
No	29	97	8	89	25	46	58	64	120	66
Yes	1	3	1	11	29	54	32	36	63	34
Total	30	100	9	100	54	100	90	100	183	100
Received Feedback at Inspection	**Idaho**		**Montana**		**Oregon**		**Washington**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
No	29	100	8	89	44	88	65	80	146	86
Yes	0	0	1	11	6	12	16	20	23	14
Total	29	100	9	100	60	100	81	100	169	100

Dissatisfaction with the energy code varied by enforcement. In Washington and Oregon, more than 50% of the respondents felt that at least one aspect of the energy code was "poorly thought out or not cost effective". The respondents in Idaho and Montana frequently did not even answer this question; only one Montanan and six of the Idaho respondents expressed dissatisfaction. (The Montana architect felt lighting levels were too restrictive; the Idaho respondents expressed frustration with a variety of parameters). While areas of dissatisfaction and suggested improvements covered many topics, four items were frequently mentioned: restrictive lighting levels, ventilation requirements and associated moisture concerns, perimeter and slab edge insulation, and economizer requirements. Table 6.4 summarizes these responses.

Table 6.4: Reaction to Energy Code Provisions

Aspects of Energy Code poorly thought out?	**Idaho**		**Montana**		**Oregon**		**Washington**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
No	19	76	12	92	24	41	37	43	92	51
Yes	6	24	1	8	34	59	49	57	90	49
Total	25	100	13	100	58	100	86	100	182	100
Lighting levels too restrictive	1	20	1	100	10	26	7	13	19	19
Slab insulation	1	20	0	0	4	10	9	17	14	14
Ventilation requirements	1	20	0	0	0	0	10	19	11	11
Insulation/Framing/Envelope	0	0	0	0	4	10	5	9	9	9
Economizer/VAV requirements	0	0	0	0	2	5	7	13	9	9
Glazing levels too restrictive	0	0	0	0	3	8	3	6	6	6
Too confusing	0	0	0	0	2	5	3	6	5	5
Trade-offs are not reasonable	0	0	0	0	5	13	0	0	5	5
More consistent enforcement	1	20	0	0	0	0	2	4	3	3
Need more flexibility	0	0	0	0	2	5	0	0	2	2
Conflicts between UBC and Energy Code	0	0	0	0	0	0	2	4	2	2
Switching/Controls	0	0	0	0	2	5	0	0	2	2
Orientation	0	0	0	0	1	3	1	2	2	2
Remodel/TI restrictions	0	0	0	0	1	3	0	0	1	1
Other	1	20	0	0	3	8	4	8	8	8
Total	5	100	1	100	39	100	53	100	98	100

Those interviewed were also asked whether additional requirements or procedures had been imposed as a result of the most recent energy code revision. Based on the responses (summarized in Table 6.5), it seems that this question was frequently interpreted as "What changes have you noted since the last energy code was implemented". In Idaho and Montana there was almost no response to this question. Presumably, the code has to be a significant factor before it causes a designer to be concerned about its evolution. In Oregon and Washington, about a quarter of the interviewees mentioned some area where the code changed their design practice.

Table 6.5: Changes Since Most Recent Energy Code Adopted

Change	Oregon		Washington		Total	
	N	%	N	%	N	%
No change	43	73	55	78	112	78
Overall approach changed	7	12	5	7	12	8
Ventilation changed	2	3	3	4	5	3
Enforcement is increasing	0	0	4	6	4	3
Glazing practices changed	2	3	1	1	3	2
Insulation changed	2	3	0	0	2	1
Lighting approach changed	2	3	0	0	2	1
Other	1	2	2	3	4	3
Total	59	100	70	100	144	100

The majority of respondents said they design their buildings in accordance with applicable energy codes; however, the number claiming to exceed energy code requirements varied substantially by component. Table 6.6 shows only the positive responses; therefore, the total does equal 100 percent. The reasons most commonly cited for installing more efficient components than mandated were to reduce operating expenses, decrease the size of the HVAC equipment required, and allow heat recovery.

Table 6.6: Components Exceeding Energy Code Efficiency Mandates

Component	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Lighting	6	14	0	0	27	44	19	21	52	25
HVAC	4	9	1	6	25	40	30	34	60	28
Envelope	4	9	0	0	21	34	22	25	47	22

The main effect of the energy codes in Washington and Oregon is to bring energy efficiency into the design process. The results shown in Table 6.6 are a good illustration of this point: about a third of the designers in Washington and Oregon consider energy efficiency measures beyond the code requirements. In Idaho and Montana, with a code that is not enforced, only for about 10% of the designers did concern over energy efficiency advance to the point where it became a part of the design decision. While the energy code requirements are not necessarily followed in Washington and Oregon, designers there are much more acutely aware of energy efficiency in their buildings.

6.2. Attitudes Toward Energy Efficiency

When questioned about the overall attitudes of their peers and clients toward energy efficiency, the results were somewhat contradictory. About 45% of respondents from Oregon and 35% from Washington said the design team (including the owner) would rate energy efficiency “important” or “very important". No one interviewed in Idaho or Montana indicated this. Two-thirds of the Montana respondents and half of Idaho respondents rated the overall design team interest at "moderate," with the remainder saying it was of little or no importance (see Table 6.7).

Table 6.7: Importance of Energy Efficiency to Design Team (Percent)

Efficiency Importance	Idaho	Montana	Oregon	Washington	Total
Very Important	0	0.00	28	24	24
Important	0	0.00	17	6	9
Moderately Important	50	67	6	15	15
Limited Importance	0	33	3	8	7
Not Important	50	0	47	47	46
Total	100	100	100	100	100

Interestingly, when asked whether the owner had ever mentioned energy efficiency as an important design element, far more Idaho and Montana respondents answered "yes" (65% and 44%, respectively) than in either Oregon (37%) or Washington (36%). In a separate part of the questionnaire, the question was slightly rephrased to "What percentage of your clients consider energy efficiency important?" and this elicited a different set of responses. These responses are detailed in Tables 6.8 and 6.9 for comparison. Additional comments recorded during the interviews indicate that most owners are interested in energy efficiency during the initial design phase.

Table 6.8: Initial Owner Interest in Energy Efficiency

Owner Mentioned Efficiency	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	12	35	9	56	39	63	59	64	119	58
Yes	22	65	7	44	23	37	33	36	85	42
Total	34	100	16	100	62	100	92	100	204	100

Table 6.9: Percentage of Clients Valuing Efficiency

Percentage of Clients	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
0 – 10	7	18	0	0	9	16	33	38	49	25
11 – 25	4	10	1	7	10	18	5	6	20	10
26 – 50	6	15	7	47	15	27	17	19	45	23
51 – 75	1	3	1	7	4	7	5	6	11	6
76 – 100	21	54	6	40	18	32	28	32	73	37

Given the results of the characteristics survey, owner interest in efficiency seems to be high where the delivery of energy efficiency is low, rendering an unmet consumer demand. Idaho buildings, especially, seem to lag behind the rest of the region: although nearly two-thirds of the owners expressed interest, most buildings did not meet the MEC building standards. When the question is rephrased as "valuing energy efficiency," twice as much interest among clients is noted by the designers. This appears to be true in all states, although the concern in Montana and Idaho seems to exceed the Oregon and Washington responses by a factor of two.

The implication of these results is especially revealing in the Montana and Idaho markets. Clients and owners are even more concerned about energy efficiency in those states than in the states where energy codes are enforced. In spite of this concern, there is a consistent pattern throughout the building characteristics summaries.

Despite the wishes of the clients in Idaho, most designers argued that energy efficiency was not cost effective beyond the level they provided in their designs. It is difficult to imagine that this is true, given that the characteristics of the buildings lag design practice in every other state.

Montana designers are much more careful with the building envelope and glazing systems. In lighting and HVAC, however, energy efficiency concerns do not appear as a significant factor in the design. Among Montana respondents, there is an underlying assumption that the code and energy efficiency are an important part of the design process; overall this suggests a gap between the intentions and the implementation in this state.

Oregon and Washington are much more consistent. Clients ask for energy efficiency less than in Idaho and Montana, but they get buildings that comply with an energy code. Presumably, the clients believe that the code will be followed and that they will get an efficient building constructed to current design standards.

6.3. Energy Efficiency in the Design Process

In the interviews, an effort was made to track the decision-making process related to energy efficiency. It should be noted that the meaning of "cost effective" is very different in an environment where the measures are mandated by an enforced energy code. Only measures beyond that code are subject to a cost-benefit analysis. "First cost" considerations dominate, and the importance of efficiency decreases as the component selection process proceeds. Cost was seen as the major barrier to increased energy efficiency in all four states, cited by 75% of the overall sample and more than 90% of the Idaho respondents. No other barrier was mentioned by more than 5% of the sample. These results are presented in Table 6.10.

Table 6.10: "Biggest" Barriers to Increased Energy Efficiency

Efficiency Barriers	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Cost	37	90	8	73	21	62	52	76	118	77
Design criteria	1	2	0	0	2	6	4	6	7	5
System complexity	1	2	0	0	2	6	1	1	4	3
Owner disinterest	1	2	2	18	2	6	2	3	7	5
Other	1	2	1	9	7	21	9	13	18	12

Interviewers also asked about the best opportunities for increasing energy efficiency. This set of responses is shown in Table 6.11. More than 70% of the respondents said considering energy efficiency earlier in the design phase would be the single biggest opportunity available. This result is more pronounced in Oregon and Washington, probably because there is more experience with energy efficiency in the non-residential sector. In all states there seems to be an acknowledgment of the importance of integrating energy efficiency into the design process. As with the "barriers," the "opportunities" are strongly influenced by the enforcement of a minimum energy code. The respondents in Idaho and Montana were more interested in specific measures that might be added to their designs. In Washington and Oregon, such measures are largely mandated by the code, so that obvious improvements could only be made with more design consideration.

Table 6.11: "Best" Opportunities to Increase Efficiency

Opportunities	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Address early in design	24	57	7	44	51	88	54	69	136	70
Improve ventilation/HVAC	7	17	4	25	2	3	8	10	21	11
Education	2	5	3	19	2	3	2	3	9	5
Improve lighting design	2	5	0	0	1	2	5	6	8	4
Improve components	2	5	0	0	0	0	1	1	3	2
Improve controls	3	7	0	0	1	2	5	6	9	5
Other	2	5	2	13	1	2	3	4	8	4
Total	42	100	16	100	58	100	78	100	194	100

7. Conclusions

The primary purpose of this baseline analysis is to describe, in so far as possible, the characteristics of non-residential construction throughout the region. In this case, the description has focused on the energy-using components of the building stock. A second purpose is to glean the attitudes and market conditions in the region by sampling the designers that operate in the non-residential sector. To some extent, this also includes the motivations and market conditions associated with the particular sets of design decisions made in the context of current building practice. It is important to note that the region is not a homogeneous market with similar practices or building standards. Indeed, the diverse nature of non-residential construction is more striking when reviewed over the entire Pacific Northwest area. This diversity is also apparent when reviewing buildings themselves: the size and end use of a building can be as significant as its location. This diversity is apparent in the nature of the energy codes, their enforcement in each state, as well as the market conditions and climates, all of which contribute to the distinctions within the region's non-residential building practice.

7.1. Energy Codes

Energy codes and standards have been part and parcel of non-residential construction in Washington and Oregon for almost two decades. Over this time, they have been virtually unknown—and certainly unenforced—in Idaho and Montana. It is therefore reasonable to expect that, to the extent that energy standards result in evolution of building practices, that some divergence in building practice should be observed when comparing buildings in Idaho and Montana to buildings in Washington and Oregon.

The results of this survey show some differences between these states. Washington and Oregon are very similar in both building type and energy efficiency characteristics. Idaho consistently lags in the acceptance of energy efficiency measures. The Montana building stock is the most efficient building envelope in spite of a poorly enforced code. It is clear that the practice and the relatively sever climate in Montana demands attention to components of the building envelope. Nonetheless, the Montana lighting systems are more similar to Idaho, lagging Oregon and Washington appreciably.

On the other hand, there is some evidence that the national or regional design standards have an effect on Montana and Idaho independent of the enforcement of any code. Mechanical equipment is designed, manufactured and marketed nationally and all designers must use such equipment, rendering local enforcement in this area largely irrelevant. The lighting standards are built on efficient fixtures that have become a design standard throughout the region. While more deviation is possible, dramatically poorer lighting systems are not really practical.

Compliance with the relevant state energy standards is surprisingly consistent between the states. In Montana and Idaho this could as easily be attributed to local market response as to any effort to meet the code. Furthermore, the meaning of compliance to a national energy code in an in areas where the codes are neither promulgated nor enforced is questionable.

Such a comparison is, however, useful to assess the degree to which the standards represented by the Oregon Non-Residential Energy Code or the ASHRAE Standard 90.1 are used as guides to common practice in these other states. From this perspective, the principle impact of codes and standards is on the uniformity of particular building and design practices. While this is far from a uniform effect, there is more variation in window selection, lighting, and equipment selection in the Idaho and Montana markets. In these states, while the energy codes predict how the buildings will be designed on average there is no consequence to reducing the standards for budget or other reasons, so the variation observed is greater even if the level of compliance is comparable.

A second effect of energy codes was also observed. Independent of the actual building characteristics, there was a contrast in the attitude toward energy efficiency when architects and other designers were interviewed. The presence of an enforced energy code has an effect on the entire design process. Architects and engineers are given the responsibility of designing to the codes and the clients are not included in that process. This results in a greater sophistication in the selection of energy efficiency measures and a considerably reduced emphasis on cost effectiveness as a barrier to greater energy efficiency. In Idaho, by contrast, the cost of measures is mentioned almost to the exclusion of any other barrier, even though these measures are standard practice in Oregon and Washington.

7.2. Climate Response

Interestingly, the impact of climate on Montana building design seems to be very important. On the whole, Montana buildings outperform the thermal requirements of both the Washington and Oregon codes by about 25%. Indeed, these design decisions seem to be heavily focused on the use of thermal integrity to maintain comfort and function in these buildings. In the Washington and Oregon cases, the code itself provides a guideline for building shell performance and relatively little variation from this standard is observed in either state.

In the case of the non-residential sector, the importance of the insulation level and envelope tightness in mild climates such as those of western Washington and Oregon is debatable: often, heating is not required in these buildings until outside temperatures fall below 50° F. Thus, in most mild climates, very little space heating is required to compensate for the characteristics of the building shell. Rather, extensive cooling loads could be expected but, once again, these are largely due to internal operations in the building and solar gains through the windows: they are not particularly the result of heat loss or gain through the building shell.

In Montana, this is not so obvious. Climates are much colder, and even relatively low balance points result in significant heating loads. The market in Montana seems to have responded to this condition. In addition, because most of Montana covers localities with very little cooling load, far less of the building population uses any cooling equipment. Whether this is a feature of the market or the result of detailed calculations that trade off efficient building shells against installed heating and cooling capacity is difficult to assess, but some market response seems to be at work in this state. It should be pointed out that there are many areas of Idaho with climates similar to Montana. No similar climate or market response was apparent in these areas.

7.3. Market Transformation

One interesting feature of this baseline can be observed by comparing its results with those of past studies. There are three different regional baseline studies that have been used in this work. The first used a sample of buildings in Washington and Oregon from 1990-1991. The second used a sample of Washington buildings from 1996; the third is this effort, with a sample of Idaho, Montana, and Oregon buildings from 1997-1998. There are numerous caveats throughout this report on the limitations of comparisons among these samples, but it should be noted that there were 369 new buildings surveyed in these studies. Thus a comparison across these samples offers the most complete picture of regional building practice available. In this context, it is possible to track on several dimensions the development of market acceptance of particular energy saving technologies.

7.3.1. Window Treatments

When reviewing the Oregon, Idaho, and Montana survey, the presence of low-ε coatings, particularly in the Oregon and Montana markets, has become dominant: more than 60% of the windows in Oregon and more than 90% of the windows in Montana included low-ε coatings. In addition, a high percentage of these windows include tints and shading for sun control. The Idaho sample looks similar to the Washington sample of 1996, with about a third of windows using low-ε coatings, and about a third using tints or shading. In 1994 and 1996, two large low-ε glass coating plants were opened in the Pacific Northwest; this reduced the price and increased the availability of these coatings throughout the region. In a more recent survey of about 50 buildings in the Seattle market permitted between 1996 and 1998, low-ε coatings were observed on 80% of the window area (Kennedy & Baylon, 2001). Thus the evidence is that low-ε coatings as a sun control and window performance enhancement technology have become accepted in Washington markets at a level similar to Oregon and Montana. Idaho practice seems to lag the rest of the region.

7.3.2. Lighting Technology

A second technology that can be tracked through the data sets is the use of T8 lamps with electronic ballasts in four-foot fluorescent area lighting applications. This is by far the most common lighting fixture type in the non-residential sector, pervading virtually every corner of the market from office to retail to institutions.

In the 1990 studies, T8s with electronic ballasts were a very minor segment of overall lighting systems (roughly 7% of four-foot fluorescent lamps were T8 with electronic ballasts). The number of T8s with electronic ballasts in the Washington market jumped to over 90% in 1996 in response to the changes in the Washington energy code (1994) and other efforts by utility programs to support the adoption of these technologies.

In the current surveys, this trend seems to be continuing, with the Oregon market being virtually 100% T8 with electronic ballasts, and somewhat smaller percentages (85-90%) in the other two states. This suggests that, on the whole, this technology has not only pervaded the Washington and Oregon markets as a result of the codes, but all markets as a result of the declining prices of these fixtures and the continuing standardization of office design and retail design around these fixtures. Even in Idaho, these fixtures have become standard with the result of significantly reduced lighting power density.

7.3.3. Adjustable Speed Drive Motors

The market for adjustable speed drive motors in building HVAC systems has almost completely materialized in the period since 1990. There were no ASD motors associated with any HVAC system in the 1990 sample. By the 1998 sample, virtually all the fan motors associated with variable flow fan systems had ASD drives installed.

The impetus for the transformation is probably not directly related to the code. Both the Oregon and Washington code allow other methods to accomplish variable flow in air handlers. Most utility conservation programs include ASD motors as a conservation measure, but these programs were largely abandoned in the mid 1990s. It appears that the switch to ASD was brought on by cost reductions and improved reliability that made this technology the logical selection to handle the needs of variable air flow in HVAC systems.

It should be noted that the same transition did not occur with variable speed pump motors. This is due in part to the need for flow and pressure reducers by equipment attached to the variable flow device. This adds costs beyond the cost of the drive itself. In air systems, the ASD drive actually allows the engineer to remove the inlet vane or other flow control device, reducing the complexity of the system.

7.3.4. Package HVAC Systems

One significant observation in this sample is the development of package HVAC equipment to serve virtually all buildings regardless of size and type. In the 1990 sample, larger buildings used built-up systems engineered for a particular purpose and a particular building. Package equipment was confined to single zone constant volume systems on smaller or simpler buildings.

Over the last decade, the manufacturers of larger equipment have begun offering pre-engineered systems that can be ordered for a project. The manufacturers provide all the engineering and performance verification, and include options at the behest of the engineering specifications. This change in the market seems to have been brought on by the advantages inherent in a single source of supply and factory level engineering to integrate the components of the system.

Since these are package units, the efficiency is set for the equipment as a whole. The efficiency of the air handler motor or the compressor motor is not rated separately. As a result, the rating of the equipment across the range of operating conditions and part loads is more crucial. The EER rating used by utility programs is not particularly indicative of the operating efficiency.

7.4. Energy Efficiency Market Acceptance

One obvious conclusion from this review is that market acceptance of energy efficiency measures in the non-residential sector can be a strong determinant of building characteristics and design practice. The example of Idaho provides an additional piece of information: even unenforced or haphazardly enforced codes seem to have impacts upon the overall community. The result is quite apparent: building practices are comparable even though they lag the practices in Washington and Oregon. Although some efficiency measures have not completely penetrated the Idaho markets, there is evidence that the standard practice in other states might eventually penetrate the Idaho market. The energy code accelerates this process.

The equipment market is really a national market. The ASHRAE Standard 90.1 is, in effect, a manufacturing standard. Thus it is difficult to install a system that does not meet code efficiency standards. The comparison of Idaho and Oregon shows that there is no real impact from a local HVAC efficiency standard when there is a national manufacturing standard. This would also be true if a jurisdiction tried to improve on the ASHRAE standard and increase equipment standards.

The design of the HVAC control systems is another matter. The use of control strategies should be viewed as a surrogate for a more careful design of the HVAC and lighting systems in non-residential buildings. When architects in Idaho were asked about the use of integrated design for energy efficiency, they largely took refuge in the argument that such practices were not cost effective. In Washington and Oregon, by contrast, control strategies were almost universally mentioned as a basis for potential improvements in the buildings and are widely adopted. The result is that in Idaho integrated control systems are used about a quarter as much use of such strategies as Oregon. The inference is that integrated design of energy efficiency has not been a high priority in the Idaho market. Whether this is unique to Idaho is debatable, but it is apparent that efforts to change or expand either the local vocabulary or the design criteria with respect to energy efficiency have not made as much progress in this state. As a result, the acceptance of modern control strategies (as a surrogate for integrated system design) seems to lag the rest of the region.

No energy code is particularly effective at mandating well designed control systems. The role of the code in this context is to get energy efficiency on the design agenda and keep it there (even if the control system are not directly addressed in the code language). It is unlikely that any combination of owner interest and marketing would be able to sustain a similar result.

Developing any sort of integrated design approach to new building construction would probably transcend the role of energy codes. For that effort, serious attention should be devoted to marketing and to developing the view that efficient buildings are a benefit to both occupants and clients. This may not mean more expensive buildings; there are often substantial trade-offs between efficient practices and size or complexity of building systems, but it certainly means more careful and informed design.

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9. Acknowledgements

This study involved numerous engineers and building auditors to examine commercial buildings stretching from central Montana to the Pacific Ocean. The most challenging feature of this effort was to coordinate the data delivered and to maintain contact with the people delivering this data.

For the most part, this effort involved audit teams in each state. In Idaho, Mike Rohm and John Wennstrom of EnerTech Services managed this process. In Montana, John Krigger, Chris Dorsey, Michael McPherson, and Gary Mazade were responsible for the field audits. In Oregon, Curtis Clark, Dennis Oberto and Alan Seymore of Clark's Energy Services and Carol Gardner recruited and reviewed the buildings sampled and conducted the interviews. In Washington, Kevin Madison and Jack Zieger interviewed architects and engineers, though no audits were conducted in Washington.

In addition to these field contractors, several people were involved in quality control and data entry. These included Mark Frankel and Larry Palmiter of Ecotope, who assisted in the development of the interview and data collection forms. Kiesy Strauchion and James Martinez provided the data entry for the field notes and interviews as they were produced.

We would also like to thank Michael O'Brien of the Northwest Energy Efficiency Alliance, who served as the Alliance's project manager for this study and provided continuous support and comments as the work plan proceeded and as the report was finished. Without his efforts, this work could not have proceeded. Finally, Jennifer Williamson of NEEA, who replaced Michael O'Brien near the end of the project, provided the last round of editing and took on the Herculean task of coordinating comments from numerous sources, which enabled the completion of the final document.

APPENDIX A

PROTOCOLS & INTERVIEW

Project ID:_________

PROJECT INFORMATION

Plans Inspector ____ Date _____________________

Field Inspector ____ Date _____________________

Building Name ____

Contact At Building______________________________ Phone _____________________________

Electric Utility___________________________________Gas Utility _________________________

Permit Date ___________________ Complete Date ________________

% Complete ___________________ % Occupied __________________

Class of Work [New] [Addition] [Other] ____

Total Floor Area _________________ Number of Buildings __________________

Number of Stories ________________

BUILDING/SURVEYED AREA

Surveyed Floor Area _______________ Surveyed Volume(approx)____________

Surveyed Area and Building Description____

STANDARD BUILDING USE CATAGORY (choose one)

☐ Assembly
☐ Education
☐ Grocery
☐ Health Services
☐ Institution
☐ Office
☐ Residential and Lodging
☐ Restaurant/Bar
☐ Retail
☐ Warehouse Storage/Distribution
☐ Other (describe)

STANDARD BUILDING USE TYPES

Space ID[1]	**Use Description**	**Floorspace**		**Heat Level**[2]
		New	**Total**	
SPACE-				
Total:				

[1] See "Standard Building Use Types". Separate unfinished tenant areas into separate spaces.
[2] Heated, Semi-heated, Unheated

CAPACITY (Specify total capacity or occupancy the following categories)

Building Type	**New**	**Total**
Hospital Beds		
Restaurant Seats		
Cafeteria Capacity		
School Capacity		
Hotel/Motel Rooms		
Apartment/Condominium Units		

Project ID:_________

Component Area Take Offs
Gross Areas

WALLS					
Space ID	Wall Type ID	Location	Gross Area	To Space ID[1]	Verified
SPACE-	WALL-				
CEILINGS/ROOFS					
SPACE-	ROOF-				

FLOORS						
Space ID	Type ID	Location	Gross Area	Perimeter	To Space ID[1]	Verified
SPACE-	FLR-					

[1] For wall, roof/ceiling, floor to semi or unheated spaces only.

WINDOWS									
Space ID	In Wall Type ID	Window Type ID	Location	Area	Percent North	Percent East	Percent South	Percent West	Verified
SPACE-	WALL-	WIN-							
SKYLIGHTS									
SPACE-	ROOF-	WIN-							
DOORS									
Space ID	In Wall Type ID	Door Type ID	Location	Area					Verified
SPACE-	WALL-	DOOR-			-----	-----	-----	-----	
					-----	-----	-----	-----	
					-----	-----	-----	-----	
					-----	-----	-----	-----	

Mechanical

Individual Package equipment only	[Yes]	[No]	[Unknown]			
Built up or complex system	[Yes]	[No]	[Unknown]			
Single Zone equipment	[Yes]	[No]	[Unknown]			
Multi Zone equipment	[Yes]	[No]	[Unknown]			
Primary Heating Fuel	[Gas]	[Oil]	[Electric]	[	]	[Unknown]
Secondary Heating Fuel	[Gas]	[Oil]	[Electric]	[	]	[Unknown]

Single zone package equipment instructions: Fill out the rest of this page and the package equipment page.
All other systems: Fill out the rest of this page, and for each system, fill out a multi-zone/built-up system schedule and the appropriate boiler, chiller, cooling tower, fan, pump, and package equipment schedules. Package multi-zone equipment that is or part of a built-up system should be entered on the package equipment page and referenced in the built up system schedule.

All Systems -Quickly describe the HVAC. For multi-zone/build-up systems describe with reference to boiler, chiller, and delivery system numbers and other components.
____

Control System
Space ID Served: SPACE-

[ ] Equipment controlled directly by Thermostat
    [ ] Tstat Type [programmable] [manual] [n/a] [unknown]
[ ] Equipment controlled by centralized Energy Management System (EMS)
    [ ] Linkage Type [pnumatic] [digital] [n/a] [unknown]
    [ ] [Scheduling/setback] [Yes] [No] [Unknown]
    [ ] [ventilation reset on occ] [Yes] [No] [Unknown]
    [ ] [optimum start] [Yes] [No] [Unknown]
    [ ] [coil/equip temp reset] [Yes] [No] [Unknown]

Space ID Served: SPACE-

[ ] Equipment controlled directly by Thermostat
    [ ] Tstat Type [programmable] [manual] [n/a] [unknown]
[ ] Equipment controlled by centralized Energy Management System (EMS)
    [ ] Linkage Type [pnumatic] [digital] [n/a] [unknown]
    [ ] [Scheduling/setback] [Yes] [No] [Unknown]
    [ ] [ventilation reset on occ] [Yes] [No] [Unknown]
    [ ] [optimum start] [Yes] [No] [Unknown]
    [ ] [coil/equip temp reset] [Yes] [No] [Unknown]

Building has a Ducted Heating System [Yes] [No] [Unknown]

Location

[ ] Interior Space	[Some]	[All]	[None]	[NA]	[Unknown]
[ ] Buffer Area	[Some]	[All]	[None]	[NA]	[Unknown]
[ ] Roof	[Some]	[All]	[None]	[NA]	[Unknown]
[ ] Crawlspace	[Some]	[All]	[None]	[NA]	[Unknown]

Insulation [Some] [All] [None] [NA] [unknown]

Pipe Insulation

[ ]	DHW Circ Ins	[Yes]	[No]	[Unknown]
[ ]	Heating Circ Ins	[Yes]	[No]	[Unknown]
[ ]	Cooling Circ Ins	[Yes]	[No]	[Unknown]

Project ID:_________

Package Equipment

Unit Dsg[1]	Space ID[2]	Qty	Equip Type	CFM	Min OA	Econo (y/n)	Cooling Output Cap+Units	Cooling Eff+Units	Heating Burner Type	Heating Fuel	Heating Output Cap+Units	Heating Eff+Units
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______
Brand, Model:												
______	______	______	______	______	______	______	______	______	______	______	______	______

[1] Enter unit designation to be refered to by multizone form if equipment is part of built up or multizone system
[2] Enter SPACE ID if single zone package equipment.

EQUIPMENT TYPE	9.1.1. CAPACITY UNITS	BURNER TYPE
RTCV = ROOFTOP PKG CV RTVAV = ROOFTOP PKG VAV FRN = FURNACE/AC HP = SPLIT HEAT PUMP PTAC = PACKAGE TERMINAL AC PTHP = PACKAGE TERMINAL HEAT PUMP RAD=RADIANT UH = UNIT HEATER WSHP = WATER SOURCE HEAT PUMP OTHER *(SPECIFY)*	KW KBTU MMBTU HP(*horsepower)* TON OTHER *(SPECIFY)*_	NAT = NATURAL DRAFT PWR = POWER DRAFT **HEATING FUELS** E = ELECTRICITY NG = NATURAL GAS OIL = FUEL OIL / DIESEL P = PROPANE / BUTANE OTHER *(SPECIFY)*

MultiUse and Built Up Systems

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

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

Description:

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

Control Strategies *(this system)*
Description:

Specific items:

[ ]	OA control	[economizer]	[CO2]	[n/a]	[unknown]	[Other] ___________
[ ]	Deck Temp. Reset	[Y]	[N]	[n/a]	[unknown]	
[ ]	Deck Pressure Reset	[Y]	[N]	[n/a]	[unknown]	
[ ]	Night Time "setback"	[Y]	[N]	[n/a]	[unknown]	
	Setback Duration_______					

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

Project ID:_________

Boilers

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

Make, Model:

____ ____ _____ _____ _____ ______ ______ _____ _____ _____ ________

Make, Model:

____ ____ _____ _____ _____ ______ ______ _____ _____ _____ ________

Make, Model:

____ ____ _____ _____ _____ ______ ______ _____ _____ _____ ________

[1] include all applicable control strategies

FUEL TYPE CODES
- E ELECTRICITY
- NG NATURAL GAS
- OIL FUEL OIL / DIESEL
- GO GAS/OIL (DUEL FUEL)
- P PROPANE / BUTANE
- WH WASTE
- ST STEAM *(purchased from outside)*
- OTHER *(SPECIFY)*

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

BOILER TYPES
- HW HOT WATER
- S STEAM

BURNER TYPE
- NAT = NATURAL DRAFT
- PWR = POWER DRAFT

CAPACITY UNITS
- KBTU
- MMBTU
- HP(*horsepower)*
- KW
- OTHER *(SPECIFY)*______________________

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

Chillers

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

Make, Model:

____ _____ ________ ______ ___________ ________ ________ _________ _____ __________

Make, Model:

____ _____ ________ ______ ___________ ________ ________ _________ _____ __________

Make, Model:

____ _____ ________ ______ ___________ ________ ________ _________ _____ __________

[1] include all applicable control strategies

COMPRESSOR TYPE	9.1.2. CAPACITY UNIT CODES
CENT CENTRIFIGAL RECIP RECIPROCATING SCRO SCROLL ABO ABSORPTION FROM OIL ABG ABSORPTION FROM GAS ABW ABSORPTION FROM WASTE HEAT ABS ABSORPTION FROM STEAM OTHER *(SPECIFY)*	KBTU MMBTU HP(*horsepower)* TON OTHER *(SPECIFY)*______________________ **CONTROL TYPE CODES** C1 TEMPERATURE RESET C2 MODULATING C3 MODULATING –VFD C4 STAGED

COOLING TOWER

Natural draft: ☐ Yes ☐ No

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

Heat exchanger loop : ☐ Yes ☐ No

Temperature control : ☐ Fixed ☐ Wetbulb reset ☐ Other

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

Project ID:_________

Fans (except fans in package units)

Unit Dsg	Qty	HP	BHP	Work Type	Control[1]	------Motor------ Eff (plans)	Eff (fld)	Dsgn Flow	Dsgn dP	Motor Speed	Open/ Closed

[1] include all applicable control strategies

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

Pumps

Unit Dsg	Qty	HP	BHP	Work Type	Control[1]	Eff (plans)	Eff (fld)	Dsgn Flow	Dsgn dP	Motor Speed	Open/ Closed

[1] include all applicable control strategies

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

Lighting

Fixture Schedule:

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

Project ID:_________

Interior Lighting

Subspace Information				Fixture Takeoff			
SpaceID, Subspace Type[1]	**Area (ft^2)**	**Ceiling Height**	**Control Codes[2]**	**Fixture Type ID**	**Code Exmpt (Y/N)**	**Count**	**Total Count**

[2] See lighting control reference, enter all the apply, do not leave blank

[1] Subspace Type Codes

Acc	Accessory spaces	Exam	Medical exam rooms
Aud	Auditoriums	OffOp	Open office
Class	Classroom	OffCl	Private office
Conf	Conference rooms	Recep	Reception areas
Corr	Corridor	Retail	Retail
Eating	Eating areas	Storage	Storage rooms
Groc	Grocery	Toilet	Toilet rooms
Gym	Gyms	Ware	Warehouses
Kit	Kitchens	Show	Wholesale showrooms
Lobby	Lobbies	Other	Other

Project ID:_________

Exterior Lighting:

Parking Area: ______________________
Outdoor Area: _____________________
Building Facade Area: _______________
Building Perimeter (linear foot):________

Discussion:____

Fixtures:

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

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

Project ID:_________

Domestic Hot Water

General System Type

[ ] None
[ ] Individual water heating tank(s)
[ ] Central Boiler(s) (for water heating only): Indicated Boiler #:_____________
[ ] Central boiler (combined with space heating): Indicated Boiler #:_____________
[ ] Other (Please specify)
[ ] Don't Know

Heat Exchanger to storage tank? [y] [n] [?]
Circulation Loop [y] [n] [?]

Water Uses *(Mark ALL boxes that apply)*

Kitchenette/Lavatory 1
Showers 2
Laundry...3
Commercial Laundry 4
Commercial Kitchen 5
Commercial Dishwasher 6
Sterilization 7
Other (Please Specify).......................8
Don't Know 9

Service Hot Water Heater System Info (DHW tanks and storage tanks)

Qty	Fuel[1]	Storage (gallons)	Cap	Cap Units	Eff.	Eff Units

[1] Enter fuel code or boiler number

FUEL TYPE CODES	CAPACITY UNITS
E ELECTRICITY	KBTU
NG NATURAL GAS	MMBTU
OIL FUEL OIL / DIESEL	HP*(horsepower)*
GO GAS/OIL (DUEL FUEL)	KW
P PROPANE / BUTANE	OTHER *(SPECIFY)*_______________________
WH WASTE	
ST STEAM *(purchased from outside)*	
OTHER *(SPECIFY)*	

Project ID:_________

Miscellaneous

Heat Recovery Equipment [Yes] [No] [NA] [Unknown]

[ ] Building Exhaust Air
[ ] Combustion flue gases
[ ] Laundry Dryer Exhaust
[ ] Waste Water
[ ] Refrigeration Equipment
[ ] Range Hood
[ ] Dishwasher Hood
[ ] Other (specify)

Pools and Spas

Indicate the surface area of pools or spas. Check “do not have” if not present. Leave fuel entries blank for zero.

Equipment	not sure	Not Present	Do not Have	Natural Gas	Electric	Electric Heat pump	Fuel Oil	Propane/ butane	Other
Swimming Pool	☐	☐							
Spa	☐	☐							

Additional Equipment

Indicate type and number of other major equipment. Check “do not have” box if equipment not present. Leave entries blank for zero.

EQUIPMENT	NOT SURE	DO NOT HAVE	NATURAL GAS	ELECTRIC	FUEL OIL	PROPANE/ BUTANE	OTHER
LAUNDRY DRYERS	☐	☐					
OVENS	☐	☐					
RANGE	☐	☐					
OVEN/RANGE COMBO	☐	☐					
GRIDDLES	☐	☐					
FRYERS	☐	☐					
OTHER COOKING	☐	☐					
IN-LINE WATER HEAT BOOSTERS	☐	☐					
KILNS OR INDUSTRIAL FURNACES	☐	☐					
MEDICAL EQUIPMENT	☐	☐					
AIR COMPRESSORS *(Enter hp for each)*	☐	☐					
BACKUP GENERATORS *(Enter MW)*	☐	☐					
COGENERATION FACILITY *(Enter MW)*	☐	☐					
VEHICLE REFUELING (*Enter number of vehicles)*	☐	☐					
SPECIFY TYPE AND FUEL OF OTHER LARGE LOADS NOT COVERED ELSEWHERE							
	☐	☐					
	☐	☐					
	☐	☐					

WALLS

Component Description Form (TAN FORM)

Wall Type ID: WALL- _______
Plans U-Factor: ____________

[ ] Above Grade
[ ] Buffer
[ ] Below Grade; average depth at base (ft.): ____________
[ ] Rim Joist

Description/Notes: ____

Structure

[ ] framed [2x4] [2x6] [other]: ____________________
  [ ] material [wood] [metal] [n/a] [unknown]
  [ ] dimension [2x4] [2x6] [other]: ____________________
  [ ] stud spacing [16”] [24”] [n/a] [unknown]
  [ ] sheet metal siding [y] [n] [n/a] [unknown]
[ ] concrete [6”] [8”] [other]: ____________________
[ ] concrete blocks [4”] [6”] [8”]
[ ] brick [4”] [8”] [12”]
[ ] other (panels, foam forms, etc.) describe: ___________________

Insulation

Overall installed R-_________
[ ] batts R- _____
[ ] rigid R- _____ thickness (in.) ______ [int] [ext]
[ ] Spray On
[ ] loosefill cores
[ ] rigid cores
[ ] other: ______________________________________

Field Review:

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

Project ID:_________

ROOF/CEILINGS

Component Description Form (YELLOW FORM)

Ceiling Type ID: ROOF- _____
Plans U-Factor: ____________

Description/Notes: ____

Structure

[ ] Wood Frame
[ ] I-joists - wood
[ ] Metal Truss
[ ] Metal Purlins
[ ] Concrete
[ ] Unknown
[ ] other, describe: ___________________

Misc

[ ] Roof Pitch ____ in 12
[ ] Attic Space [y] [n] [n/a] [unknown]

Where is Insulation

[ ] Attic
[ ] Built up roof
[ ] Framed Cavity
[ ] Underside of Roof open cavity or other
[ ] On Dropped Ceiling
[ ] Under Purlins
[ ] Over Purlins
[ ] Unknown

Insulation

Total Installed R-____________

[ ] batts R- _____
[ ] blanket R- _____
[ ] loose fill R-_____ or [cellulose] [fiberglass] [unknown] depth:______
[ ] rigid R- _____ or thickness (in.) ______
[ ] Spray On R- _____ or thickness (in.) ______
[ ] other: ______________________________________

Field Review:

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

Project ID:_________

FLOORS

Component Description Form (GREEN FORM)

Floor Type ID: FLR- ________
Plans U-Factor: ____________

Description: ______________________

[ ] Over Crawl or buffer

Structure

[ ] Frame
Material [lumber] [I-joists] [metal]

[ ] Concrete
Type [slab on grade] [below grade] [not in earth contact]
for below grade slabs depth: ____________

[ ] Other (panels, etc.) describe: ___________________

Frame Insulation

[ ] Batts in joists R- _____
[ ] Continuous Rigid R- _____
[ ] Continuous Spray On R- _____
[ ] other: ______________________________________

Slab/Concrete Insulation

[ ] none
[ ] perimeter: R- _____
[ ] center/underfloor: R- _____
[ ] thermal break? [y] [n] [unknown]

Field Review:

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

Project ID:_________

WINDOWS

Component Description Form (BLUE FORM)

Window Type ID: WIN-_______________
Plans U-Factor: ______________________
Plans Shade Coefficient: ______________

[ ] Window
[ ] Skylight
[ ] Other ____________________

Description/Notes: _____________________

Frame Material

[ ] unknown
[ ] vinyl
[ ] wood
[ ] aluminum [thermal break] [no thermal break]
[ ] other: ____

Glazing

Number of glazing layers:	[1]	[2]	[3]	[unknown]
Low-ε coating:	[y]	[n]		[unknown]
Tinted:	[y]	[n]		[unknown]
Reflective	[y]	[n]		[unknown]
Gas filled (rivets visible):	[y]	[n]		[unknown]
Spacing:	[<=3/8"]		[>=1/2"]	[unknown]

Manufacturer: ____

Are labels present on windows? [y] [n] [unknown]

[ ] NFRC
[ ] small manufacturer default
[ ] other: _______________________________________

Window U-value on labels: _____________ SHGC on labels:____________

Field Review:

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

DOORS

Component Description Form

Door Type ID: DOOR-

Plans U-Factor: _______

Description: ______________________

[ ] Wood door
[ ] Insulated steel door
[ ] Standard steel door
[ ] Insulated overhead door
[ ] Standard overhead door
[ ] Coil door
[ ] Other _________________________________

Automatic door controls
[ ] No
[ ] Yes, decribe ____________________________

Field Review:

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

Door Type ID: DOOR-

Plans U-Factor: _______

Description: ______________________

[ ] Wood door
[ ] Insulated steel door
[ ] Standard steel door
[ ] Insulated overhead door
[ ] Standard overhead door
[ ] Coil door
[ ] Other _________________________________

Automatic door controls
[ ] No
[ ] Yes, decribe ____________________________

Field Review:

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

Standard Building Use Types

Assembly
- CHURCH, RELIGIOUS, OR CIVIC ORGIZATION . ☐1
- ENTERTAINMENT FACILITY OR THEATER .... ☐2
- LIBRARY / MUSEUM .... ☐3
- INDOOR RECREATIONAL OR AMUSEMENT FACILITY *(Dance studio, Gymnasium, etc.)* .... ☐4
- OUTDOOR RECREATIONAL FACILITY .... ☐5

Education
- DAYCARE CENTER OR PRESCHOOL .... ☐6
- ELEMENTARY SCHOOL .... ☐7
- JUNIOR OR SENIOR HIGH SCHOOL................... ☐8
- COLLEGE OR UNIVERSITY .... ☐9
- TRADE OR VOCATIONAL SCHOOL .... ☐10

Grocery
- GROCERY OR FOOD RETAIL............................. ☐11
- MINI MARKET/GAS STATION .... ☐12
- WHOLESALE FOOD SALES................................ ☐13

Health Services
- HOSPITAL.. ☐14
- MEDICAL OFFICE *(MD, DDS, Other)*.................... ☐15
- OUTPATIENT CARE SERVICE............................ ☐16
- RETIREMENT CENTER....................................... ☐17
- SKILLED NURSING OR RESIDENTIAL CARE ..... ☐18
- MEDICAL LABORATORIES .... ☐19

Institution
- JAIL FACILITY... ☐20

Office (private sector or governmental)
- GENERAL .... ☐21
- CITY HALL / COURTHOUSE .... ☐22

Residential and Lodging
- MOTEL... ☐23
- HOTEL .... ☐24
- MULTIFAMILY BUILDING*(apt, condo, coop)*......... ☐25
- MASTER METERED RESIDENTIAL *(single family, duplex)* .... ☐26

Restaurant / Bar
- DELICATESSEN.. ☐27
- FAST FOOD OR SELF SERVICE .... ☐28
- TABLE SERVICE .... ☐29
- TAVERN, BAR, NIGHTCLUB, ETC. .... ☐30
- KITCHEN .... ☐31

Retail
- SELF-SERVICE GAS STATION *(Gas Sales Only)* .... ☐32
- AUTO SUPPLIES / PARTS .... ☐33
- OTHER RETAIL SALES....................................... ☐34
- OTHER WHOLESALE SALES .... ☐35
- POST OFFICE .... ☐36

Warehouse Storage / Distribution
- WAREHOUSE.. ☐37
- REFRIGERATED WAREHOUSE .... ☐38
- MINI-STORAGE / SELF-STORAGE...................... ☐39

Other (miscellaneous)
- AUTO REPAIR ONLY .... ☐40
- AUTO BODY REPAIR.. ☐41
- GAS STATION WITH AUTO REPAIR .... ☐42
- TELEVISION OR RADIO BROADCASTING.......... ☐43
- PERSONAL SERVICES *(Beauty Salon, Photo Studio, etc.)*.. ☐44
- COIN-OP LAUNDRY.. ☐45
- COMMERCIAL LAUNDRY .... ☐46
- DRY CLEAN LAUNDRY....................................... ☐47
- LINEN SERVICE*(without laundry)*......................... ☐48
- FUNERAL HOME, CEMETERY, MORTUARY ...... ☐49
- LABORATORY, RESEARCH .... ☐50
- REPAIR SERVICES *(non-auto)*............................ ☐51
- POLICE / FIRE STATION..................................... ☐52
- OTHER ACTIVITIES NOT ELSEWHERE CLASSIFIED. *(Please Specify)* __________________________ ☐53

- DON'T KNOW.. ☐54

Fixture Type	Description
1X4-G15	1x4 Grid Troffer, Cells >= 1.5"
1X4-I	1x4 Industrial
1X4-IU	1x4 Industrial w/uplight
1X4-L	1x4 Prismatic Lensed Troffer
1X4-P16	1x4 Deep Cell Parabolic, 16 cells
1X4-P8	1x4 Deep Cell Parabolic, 8 Cells
1X4-S	1x4 Strip
1X4-W	1x4 Wraparound Lens
1X8-I	1x8 Industrial
1X8-IU	1x8 Industrial w/uplight
1X8-S	1x8 Strip
2X2-L	2x2 Prismatic Lensed Troffer
2X2-P16	2x2 Deep Cell Parabolic, 16 Cells
2X2-P9	2x2 Deep Cell Parabolic, 9 Cells
2X4-G1	2x4 Grid Troffer, Cells <= 1"
2X4-G15	2x4 Grid Troffer, Cells > 1.5"
2X4-L	2x4 Prismatic Lensed Troffer
2X4-P12	2x4 Deep Cell Parabolic, 12 Cells
2X4-P18	2x4 Deep Cell Parabolic, 18 Cells
2X4-P32	2x4 Deep Cell Parabolic, 32 Cells
2X4-W	2x4 Wraparound Lens
CFL EXIT	Compact Fluorescent Exit Sign
CFL EXIT	Exit Sign Ballast
CFL TASK	Ballast For CFL Task Light
CFL TASK	Compact Fluorescent Task Light
EAR	Enclosed Aluminum Reflector (HID)
ELECT EXIT	Electroluminescent Exit Sign
EPR	Enclosed Prismatic Reflector (HID)
INC EXIT	Incandescent Exit Sign
INC TASK	Incandescent Task Light
INCAND	Incandescent Fixture
LED EXIT	LED Exit Sign
OAR	Open Aluminum Reflector (HID)
OPR	Open Prismatic Reflector (HID)
TRIT EXIT	Tritium Exit Sign

Ballast Type	Description
CFL EXIT	Exit Sign Ballast
CFL TASK	Ballast For CFL Task Light
EFFICIENT	Efficient Electromagnetic
ELECT DIM	Electronic Dimmable
ELECT FULL	Electronic Full Output
HID	HPS, MH, or MV Ballast
HPS-RETRO	50 Watt White HPS Screw Base
HYBRID	Hybrid/Cathode Cutout
NONE	No ballast required
SCREW BASE	Retrofit Screw Base
STANDARD	Standard Electromagnetic

Control Type	Description
NONE	No Control Installed, only large area manual switching
LOCAL	Local Switching
OS	Occupancy Sensors
SWEEP	Automatic Sweep Control with Unknown Switching
TIMESWITCH	Automatic Sweep Control with Timed Switching
EMS	Automatic Sweep Controls with EMS System
DS	Daylight Sensing, Details Unknown
SS	Daylight Sensing, Single-Step Dimming
MS	Daylight Sensing, Multiple Stepped Dimming
CD	Daylight Sensing, Continous Dimming

Lamp Type	Lamp Wattage	Description
NONE	0	No ballast required
96T12/62	60	8' T12 Lamp, 62 CRI, Energy Saving
96T12/62	75	8' T12 Lamp, 62 CRI
96T12/62	95	8' T12 Lamp, 62 CRI, High Output, Energy Saving
96T12/62	110	8' T12 Lamp, 62 CRI, High Output
96T12/62	185	8' T12 Lamp, 62 CRI, Very Hight Output, Energy Saving
96T12/62	215	8' T12 Lamp, 62 CRI, Very High Output
96T8/75	59	8' T8 Lamp, 75 CRI
T12U3/62	35	2' T12 3" Base U-Lamp, 62 CRI, Energy Saving
T12U3/62	40	2' T12 3" Base U-Lamp, 62 CRI
T12U6/62	35	2' T12 6" Base U-Lamp, 62 CRI, Energy Saving
T12U6/62	40	2' T12 6" Base U-Lamp, 62 CRI
T12U3/73	40	2' T12 3" Base U-Lamp, 73 CRI
T12U6/73	40	2' T12 6" Base U-Lamp, 73 CRI
T10/80	42	4' T10 Lamp, 80 CRI, Extended Output
T12U3/82	40	2' T12 3" Base U-Lamp, 82 CRI
T12U6/82	40	2' T12 6" Base U-Lamp, 82 CRI
T12/62	34	4' T12 Lamp, 62 CRI, Energy Saving
T12/62	40	4' T12 Lamp, 62 CRI
T12/73	34	4' T12 Lamp, 73 CRI, Energy Saving
T12/73	40	4' T12 Lamp, 73 CRI
T12/82	34	4' T12 Lamp, 82 CRI, Energy Saving
T12/82	40	4' T12 Lamp, 82 CRI
T12HL/82	40	4' T12 High Lumen Lamp, 82 CRI
T12HL/73	40	4' T12 High Lumen Lamp, 73 CRI
T5/82	39	2' T5 Single End Twin, 82 CRI
T8U/75	31	2' T8 U-Lamp, 75 CRI
T8/75	17	2' T8 Lamp, 75 CRI
T8/75	32	4' T8 Lamp, 75 CRI
T8/85	32	4' T8 Lamp, 85 CRI
T8U/85	31	2' T8 U-Lamp, 85 CRI
CFL	XXX	Unidentified Compact Fluorescent
CFL-TWIN	XXX	Twin Tube Compact Fluorescent
CFL-QUAD	XXX	Quad Tube Compact Fluorescent
HPS	XXX	High Pressure Sodium
HPS-RETRO	50	50 Watt White HPS Screw Base
MH	XXX	Metal Halide
MV	XXX	Mercury Vapor
INC	XXX	Unidentified Incandescent
INC-A	XXX	Incandescent A-Lamp
INC-PS	XXX	Incandescent PS-Lamp
INC-R	XXX	Incandescent R-Lamp
INC-PAR	XXX	Incandescent PAR-Lamp
INC-ER	XXX	Incandescent ER-Lamp
INC-T6	XXX	Incandescent T-6 Lamp
INC-IR-PAR	XXX	Incandescent IR PAR-Lamp

Lamp Type	Lamp Wattage	Description
F17T8	17	2' T8
F25T8	25	3' T8
F32T8	32	4' T8
F40T8	40	5' T8
T32T8U	31	2' T8 U-Lamp
F30T12ES	25	3' T12 Energy Saving
F30T12	30	3' T12 Standard
F40T12ES	34	4' T12 Energy Saving
F40T12	40	4' T12 Standard
F40T12UES	34	2' T12 U-Lamp, Energy Saving
F40T12U	40	2' T12 U-Lamp, Standard Lamp
F40T10EO	42	4' T10 Extended Output
F96T8		8' T8 Lamp, Unidentified Type
F96T8ES	60	8' T8 Lamp, Energy Saving
F96T8HO	86	8' T8 Lamp, High Output, Energy Saving
F96T12	75	8' T12 Lamp, Standard or Unidentified Type
F96T12ES	60	8' T12 Lamp, Energy Saving
F96T12HOES	86	8' T12 Lamp, High Output, Energy Saving
F96T12HOES	95	8' T12 Lamp, High Output, Energy Saving
F96T12HO	110	8' T12 Lamp, High Output
F96T12VHOES	195	8' T12 Lamp, Very High Output, Energy Saving
F96T12VHO	215	8' T12 Lamp, Very High Output
T5	39	2' T5 Single End Twin
CFL	XXX	Unidentified Compact Fluorescent
CFL-TWIN	XXX	Twin Tube Compact Fluorescent
CFL-TRI	XXX	Triple Tube Compact Fluorescent
CFL-QUAD	XXX	Quad Tube Compact Fluorescent
CIRC	22,32,40	Circuline Fluorescent
HPS	XXX	High Pressure Sodium
MH	XXX	Metal Halide
MV	XXX	Mercury Vapor
INC	XXX	Unidentified Incandescent
INC-A	XXX	Incandescent A-Lamp
INC-PS	XXX	Incandescent PS-Lamp
INC-R	XXX	Incandescent R-Lamp
INC-PAR	XXX	Incandescent PAR-Lamp
INC-ER	XXX	Incandescent ER-Lamp
INC-T6	XXX	Incandescent T-6 Lamp
INC-IR-PAR	XXX	Incandescent IR PAR-Lamp

Building Designer Introduction

Dodge Number: ____

Ecotope ID Number: ____

Building Name: ____

Square Footage: ____

Address: ____

____

City: ___________________ State: __________________

Firm: ____

Contact First Name __________________ Last Name:_______________

Contact Address:____

____

City: ___________________ State: ______________

Telephone: (___)__________________________________

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

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

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

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

Building Designer/Engineer Interview

(Draft)

Project Name: ___________________________________

Check one:

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

Design Role	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Architect/Envelope Designer	27	61.36	16	100.00	37	59.68	55	56.12	135	61.36
Building Owner	9	20.45	0	0.00	2	3.23	1	1.02	12	5.45
Corporate HQ	0	0.00	0	0.00	3	4.84	0	1.02	3	1.36
General Contractor	3	6.82	0	0.00	0	0.00	1	1.02	4	1.82
Lighting Designer	1	2.27	0	0.00	1	1.61	2	2.04	4	1.82
Mech. Contractor	2	4.55	0	0.00	2	3.23	5	5.10	9	4.09
Mech. Engineer	2	4.55	0	0.00	12	19.35	25	25.51	39	17.73
Owner's Rep / Other	0	0.00	0	0.00	5	8.06	9	9.18	14	6.36
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

General Questions

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

1.1 How many employees are at your company?

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

Number of Employees	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
1-5	13	29.55	8	50.00	10	16.13	18	18.37	49	22.27
11-25	11	25.00	4	25.00	8	12.90	17	17.35	40	18.18
26-100	8	18.18	1	6.25	28	45.16	34	34.69	71	32.27
6-10	6	13.64	3	18.75	8	12.90	8	8.16	25	11.36
Over 100	6	13.64	0	0.00	8	12.90	21	21.43	35	15.91
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

1.2 What is your company's primary business?

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

Primary Business	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Architecture	29	65.91	15	93.75	36	58.06	59	60.20	139	63.18
Design Professional	2	4.55	0	0.00	2	3.23	1	1.02	5	2.27
Developer	4	9.09	1	6.25	4	6.45	0	0.00	9	4.09
General Contractor	3	6.82	0	0.00	0	0.00	6	6.12	9	4.09
Lighting Specialist	1	2.27	0	0.00	0	0.00	0	0.00	1	0.45
Manufacturer	1	2.27	0	0.00	0	0.00	2	2.04	3	1.36
Mechanical Engineer	4	9.09	0	0.00	12	19.35	20	20.41	36	16.36
Specialty Contractor	0	0.00	0	0.00	2	3.23	8	8.16	10	4.55
Structural Engineer	0	0.00	0	0.00	4	6.45	1	1.02	5	2.27
Supplier	0	0.00	0	0.00	2	3.23	1	1.02	3	1.36
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

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

Number of Projects	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
1 to 10	5	13.89	2	14.29	4	7.84	17	19.10	28	14.74
11 to 25	10	27.78	4	28.57	11	21.57	10	11.24	35	18.42
26 to 50	5	13.89	6	42.86	11	21.57	17	19.10	39	20.53
51 to 150	11	30.56	2	14.29	11	21.57	20	22.47	44	23.16
> 150	5	13.89	0	0.00	14	27.45	25	28.09	44	23.16
Total	36	100.00	14	100.00	51	100.00	89	100.00	190	100.00

Square Footage	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
0 to 100,000	8	29.63	3	27.27	3	10.34	4	5.06	18	12.33
100,000 to 250,000	5	18.52	3	27.27	4	13.79	11	13.92	23	15.75
250,002 to 1,000,000	8	29.63	3	27.27	8	27.59	23	29.11	42	28.77
1,000,001 to 25,000,000	6	22.22	2	18.18	12	41.38	36	45.57	56	38.36
> 25,000,000	0	0.00	0	0.00	2	6.90	5	6.33	7	4.79
Total	27	100.00	11	100.00	29	100.00	79	100.00	146	100.00

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

1.4A - Building Shell:

Structural Engineer [ ]
Owner [ ]
Architect [ ]
General Contractor [ ]
Consultant [ ]
Code [ ]
Corporate Manager [ ]
Local Management [ ]
Other [ ]

Decision Maker: Building Shell	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Architect	11	25.00	14	87.50	38	61.29	58	59.18	121	55.00
Code	0	0.00	0	0.00	0	0.00	6	6.12	6	2.73
Consultant	0	0.00	0	0.00	5	8.06	4	4.08	9	4.09
Corporate Manager	1	2.27	0	0.00	2	3.23	1	1.02	4	1.82
General Contractor	1	2.27	0	0.00	1	1.61	6	6.12	8	3.64
Local Management	0	0.00	0	0.00	0	0.00	1	1.02	1	0.45
Other	6	13.64	0	0.00	7	11.29	4	4.08	17	7.73
Owner	16	36.36	1	6.25	5	8.06	10	10.20	32	14.55
Structural Engineer	9	20.45	1	6.25	4	6.45	8	8.16	22	10.00
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

1.4B - Mechanical System

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

Decision Maker: Mechanical Systems	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Architect	10	22.73	2	12.50	3	4.84	2	2.04	17	7.73
Code	0	0.00	0	0.00	0	0.00	1	1.02	1	0.45
Consultant	0	0.00	0	0.00	1	1.61	2	2.04	3	1.36
Corporate Manager	1	2.27	0	0.00	2	3.23	0	0.00	3	1.36
General Contractor	1	2.27	0	0.00	3	4.84	2	2.04	6	2.73
HVAC Contractor	1	2.27	0	0.00	7	11.29	15	15.31	23	10.45
Mechanical Engineer	12	27.27	14	87.50	39	62.90	59	60.20	124	56.36
Other	4	9.09	0	0.00	0	0.00	5	5.10	9	4.09
Owner	15	34.09	0	0.00	7	11.29	12	12.24	34	15.45
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

1.4C - Lighting System

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

Decision Maker:	Idaho		Montana		Oregon		Washington		Total	
Lighting Systems	N	%	N	%	N	%	N	%	N	%
Architect	10	22.73	5	31.25	8	12.90	8	8.16	31	14.09
Consultant	0	0.00	2	12.50	2	3.23	2	2.04	6	2.73
Corporate Manager	1	2.27	0	0.00	1	1.61	0	0.00	2	0.91
Electrical Engineer	11	25.00	9	56.26	32	51.61	51	52.04	103	46.82
General Contractor	1	2.27	0	0.00	2	3.23	3	3.06	6	2.73
Lighting Contractor	0	0.00	0	0.00	7	11.29	13	13.27	20	9.09
Local Management	1	2.27	0	0.00	0	0.00	2	2.04	3	1.36
Other	5	11.36	0	0.00	4	6.45	2	2.04	11	5.00
Owner	15	34.09	0	0.00	6	9.68	17	17.35	38	17.27
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

Practices and Attitudes Related To The Energy Code

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

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

Applicable Code	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
ASHRAE Standard 90.1	12	27.27	1	6.25	3	4.84	3	3.06	19	8.64
Idaho Residential Energy Standard	2	4.55	0	0.00	0	0.00	0	0.00	2	0.91
Model Energy Code	3	6.82	15	93.75	0	0.00	4	4.08	22	10.00
No Energy Codes Apply	11	25.00	0	0.00	0	0.00	0	0.00	11	5.00
Oregon State Energy Code	4	9.09	0	0.00	54	87.10	6	6.12	64	29.09
Washington State Energy Code	4	9.09	0	0.00	3	4.84	79	80.61	86	39.09
None of the Above	8	18.18	0	0.00	2	3.23	6	6.12	16	7.27
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

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

Yes [ ] No [ ]

Codes Mentioned	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	17	50.00	12	75.00	17	27.42	4	4.30	50	24.39
Yes	17	50.00	4	25.00	45	72.58	89	95.70	155	75.61
Total	44	100.00	16	100.00	62	100.00	98	100.00	205	100.00

If yes:

2.2 a Did you receive feedback from building officials on energy code compliance for this project at plan examination?

Yes [ ]   No [ ]

Feedback at Examination	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	29	96.67	8	88.89	25	46.30	58	64.44	120	65.57
Yes	1	3.33	1	11.11	29	53.70	32	35.56	63	34.43
Total	30	100.00	9	100.00	54	100.00	90	100.00	183	100.00

At inspections?

Yes [ ]   No [ ]

Feedback at Inspection	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	29	100.00	8	88.89	44	88.00	65	80.25	146	86.39
Yes	0	0.00	1	11.11	6	12.00	16	19.75	23	13.61
Total	29	100.00	9	100.00	60	100.00	81	100.00	169	100.00

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

Changes	Oregon		Washington		Total	
	N	%	N	%	N	%
No Change	6	60.00	1	3.33	7	17.50
Perimeter Slab Insulation	0	0.00	8	26.67	8	20.00
Semi-Heated Space	0	0.00	1	3.33	1	2.50
Sealing	0	0.00	1	3.33	1	2.50
Glazing	0	0.00	6	20.00	6	15.00
Insulation	2	20.00	6	20.00	8	20.00
Minor (Unspecified)	0	0.00	2	6.67	2	5.00
Documentation	2	20.00	3	10.00	5	12.50
Lighting Controls	0	0.00	2	6.67	2	5.00
Total	10	100.00	30	100.00	40	100.00

[No responses for either Idaho or Montana.]

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

Yes [ ]   No [ ]

Hire Consultant	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	5	20.83	5	31.25	33	53.23	53	58.24	96	49.74
Yes	19	79.17	11	68.75	29	46.77	38	41.76	97	50.26
Total	24	100.00	16	100.00	62	100.00	91	100.00	193	100.00

2.3a Did such a person participate in this project?
Yes [ ] No [ ]

Consultant on this Project	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	16	50.00	13	81.25	45	75.00	74	87.06	148	76.68
Yes	16	50.00	3	18.75	15	25.00	11	12.94	45	23.32
Total	32	100.00	16	100.00	60	100.00	85	100.00	193	100.00

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

Building shell? Yes [ ] No [ ]

Building Shell	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	32	72.73	0	0.00	6	9.68	12	12.24	50	22.73
Yes	12	27.27	16	100.00	56	90.32	86	87.76	170	77.27
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

Mechanical system? Yes [ ] No [ ]

Mechanical System	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	33	75.00	3	18.75	9	14.52	15	15.31	60	27.27
Yes	11	25.00	13	81.25	53	85.48	83	84.69	160	72.73
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

Lighting system? Yes [ ] No [ ]

Lighting System	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	33	75.00	3	18.75	10	16.13	19	19.39	65	29.55
Yes	11	25.00	13	81.25	52	83.87	79	80.61	155	70.45
Total	44	100.00	16	100.00	62	100.00	98	100.00	220	100.00

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

Compliance Path	Oregon		Washington		Total	
	N	%	N	%	N	%
A	3	100.00	3	30.00	6	46.15
B	0	0.00	7	70.00	7	53.85
Total	3	100.00	10	100.00	13	100.00

[No responses for either Idaho or Montana.]

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

If yes: What are they?

Codes Mentioned	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	19	76.00	12	92.31	24	41.38	37	43.02	92	50.55
Yes	6	24.00	1	7.69	34	58.62	49	56.98	90	49.45
Total	25	100.00	13	100.00	58	100.00	86	100.00	182	100.00
Ventilation Requirements	1	20.00	0	0.00	0	0.00	10	18.87	11	11.22
More Flexibility Needed	0	0.00	0	0.00	2	5.13	0	0.00	2	2.04
More Consistent Enforcement	1	20.00	0	0.00	0	0.00	2	3.77	3	3.06
Slab Insulation	1	20.00	0	0.00	4	10.26	9	16.98	14	14.29
Too Confusing	0	0.00	0	0.00	2	5.13	3	5.66	5	5.10
Glazing Levels Too Restrictive	0	0.00	0	0.00	3	7.69	3	5.66	6	6.12
Lighting Too Restrictive	1	20.00	1	100.00	10	25.64	7	13.21	19	19.39
Conflicts Between UBC and Energy Codes	0	0.00	0	0.00	0	0.00	2	3.77	2	2.04
Insulation / Framing / Envelope	0	0.00	0	0.00	4	10.26	5	9.43	9	9.18
Trade-offs are not Reasonable	0	0.00	0	0.00	5	12.82	0	0.00	5	5.10
Economizers / VAVs	0	0.00	0	0.00	2	5.13	7	13.21	9	9.18
Switching / Controls	0	0.00	0	0.00	2	5.13	0	0.00	2	2.04
Orientation	0	0.00	0	0.00	1	2.56	1	1.89	2	2.04
Remodel / TI Restrictions	0	0.00	0	0.00	1	2.56	0	0.00	1	1.02
Other	1	20.00	0	0.00	3	7.69	4	7.55	8	8.16
Total	5	100.00	1	100.00	39	100.00	53	100.00	98	100.00

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

Still Implement	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	1	33.33	1	50.00	1	2.63	12	23.53	15	15.96
Yes	2	66.67	1	50.00	37	97.37	39	76.47	79	84.04
Total	3	100.00	2	100.00	38	100.00	51	100.00	94	100.00

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

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

Use Software	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	4	100.00	14	93.33	27	45.00	43	51.81	88	54.32
Yes	0	0.00	1	6.67	33	55.00	40	48.19	74	48.19
Total	4	100.00	15	100.00	62	100.00	98	100.00	205	100.00
Carrier	NA	-	NA	-	0	0.00	2	6.45	2	4.00
CodeComp	NA	-	NA	-	10	52.63	2	6.45	12	24.00
Custom	NA	-	NA	-	1	5.26	1	3.23	2	4.00
DOE2	NA	-	NA	-	5	26.32	9	29.03	14	28.00
ELITE	NA	-	NA	-	0	0.00	1	3.23	1	2.00
MicroPass	NA	-	NA	-	0	0.00	1	3.23	1	2.00
MicroAccess	NA	-	NA	-	0	0.00	1	3.23	1	2.00
NREC	NA	-	NA	-	0	0.00	10	32.26	10	20.00
NREX	NA	-	NA	-	0	0.00	1	3.23	1	2.00
TRACE	NA	-	NA	-	2	10.53	2	6.45	4	8.00
WATTSUN	NA	-	NA	-	1	5.26	1	3.23	2	4.00
Total	NA	-	NA	-	19	100.00	31	100.00	50	100.00
Opinion on Software	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Favorable	NA	-	NA	-	10	45.45	22	81.48	32	65.31
Unfavorable	NA	-	NA	-	12	54.55	5	18.52	17	34.69
Total	NA	-	NA	-	22	100.00	27	100.00	49	100.00

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

Change	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No change	0	0.0	14	93.33	43	72.88	55	78.57	112	77.78
Overall approach	0	0.0	0	0.0	7	11.86	5	7.14	12	8.33
Ventilation changed	0	0.0	0	0.0	2	3.39	3	4.29	5	3.47
Enforcement increasing	0	0.0	0	0.0	0	0.0	4	5.71	4	2.78
Glazing practices	0	0.0	0	0.0	2	3.39	1	1.43	3	2.08
Insulation changed	0	0.0	0	0.0	2	3.39	0	0.0	2	1.39
Lighting approach	0	0.0	0	0.0	2	3.39	0	0.0	2	1.39
Other	0	0.0	1	6.67	1	1.69	2	2.86	4	2.78
Total	0	0.00	15	100	59	100	70	100	144	100

Energy Efficient Design Criteria

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

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

Energy Efficient Measures	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Lighting	6	42.86	0	0.00	27	36.99	20	25.97	53	32.12
HVAC	4	28.57	1	100.00	25	34.25	33	42.86	63	38.18
Envelope	4	28.57	0	0.00	21	28.77	24	31.17	49	29.70
Total	14	100.00	1	100.00	73	100.00	77	100.00	165	100.00

3.1 a. What were the main reasons?

Main Reasons	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Design flexibility	0	0.00	0	0.00	1	3.33	3	8.57	4	5.48
Decrease equip size	1	20.00	0	0.00	2	6.67	9	25.71	12	26.03
Cost	0	0.00	3	100.00	3	10.00	0	0.00	6	34.25
Meet other stds	0	0.00	0	0.00	5	16.67	0	0.00	5	6.85
Daylight controls	0	0.00	0	0.00	3	10.00	4	11.43	7	9.59
Component trade-offs	0	0.00	0	0.00	2	6.67	0	0.00	2	2.74
Operating costs	0	0.00	0	0.00	10	33.33	16	45.71	26	35.62
Heat recovery	4	80.00	0	0.00	2	6.67	2	5.71	8	10.96
Incentive	0	0.00	0	0.00	2	6.67	1	2.86	3	4.11
Total	5	100.00	3	100.00	30	100.00	35	100.00	73	100.00

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

Efficiency Importance	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Very Important	0	0.00	0	0.00	10	27.78	21	24.42	31	24.03
Important	0	0.00	0	0.00	6	16.67	5	5.81	11	8.53
Moderately Important	2	50.00	2	66.67	2	5.56	13	15.12	19	14.73
Limited Importance	0	0.00	1	33.33	1	2.78	7	8.14	9	6.98
Not Important	2	50.00	0	0.00	17	47.22	40	46.51	59	45.74
Total	4	100.00	3	100.00	36	100.00	86	100.00	129	100.00

3.2 Did the building owner request energy efficiency in the building design?

Yes [ ] No [ ]

If yes: What measures?

Owner Requested Efficiency Measures	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	12	35.29	9	56.25	39	62.90	59	64.13	119	58.33
Yes	22	64.71	7	43.75	23	37.10	33	35.87	85	41.67
Total	34	100.00	16	100.00	62	100.00	92	100.00	204	100.00
Insulation	2	50.00	0	0.00	0	0.00	5	16.67	7	12.07
HVAC	1	25.00	2	40.00	4	21.05	14	46.67	21	36.21
Throughout bldg	0	0.00	0	0.00	6	31.58	3	10.00	9	15.52
Lighting	0	0.00	2	40.00	3	15.79	6	20.00	11	18.97
Glazing	1	25.00	1	20.00	4	21.05	0	0.00	6	10.34
Controls	0	0.00	0	0.00	1	5.26	0	0.00	1	1.72
Other	0	0.00	0	0.00	1	5.26	2	6.67	3	5.17
Total	4	100.00	5	100.00	19	100.00	30	100.00	58	100.00

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

Dominant Lighting Fixture	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Fluorescent	NA	-	11	78.57	43	75.44	47	70.15	101	73.19
HID	NA	-	0	0.00	12	21.05	17	25.37	29	25.37
Incandescent	NA	-	3	21.43	2	3.51	3	4.48	8	4.48
Total	NA	-	14	100.00	57	100.00	67	100.00	138	100.00

3.4 Was a performance analysis of the energy requirements of this building done as part of the design or code compliance process?

Yes [ ] No [ ]

Performance Analysis	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	1	100.00	7	53.85	30	50.00	33	37.50	71	43.83
Yes	0	0.00	6	46.15	30	50.00	55	62.50	91	56.17
Total	1	100.00	13	100.00	60	100.00	88	100.00	162	100.00

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

Yes [ ] No [ ]

"Commission" Completed	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	1	100.00	10	66.67	37	59.68	45	51.72	93	56.36
Yes	0	0.00	5	33.33	25	40.32	42	48.28	72	43.64
Total	1	100.00	15	100.00	62	100.00	87	100.00	165	100.00

If yes:

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

3.4 b. Was training or an operating manual provided for the building operator?

Yes [ ] No [ ]

Note: There were no positive responses to this question. There were 110 "no" answers.

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

Efficiency Barriers	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Cost	37	90.24	8	72.73	21	61.76	52	76.47	118	76.62
Lighting	0	0.00	0	0.00	2	5.88	0	0.00	2	1.30
Design criteria	1	2.44	0	0.00	2	5.88	4	5.88	7	4.55
System complexity	1	2.44	0	0.00	2	5.88	1	1.47	4	2.60
Owner disinterest	1	2.44	2	18.18	2	5.88	2	2.94	7	4.55
Other	1	2.44	1	9.09	5	14.71	9	13.24	16	10.39
Total	41	100.00	11	100.00	34	100.00	68	100.00	154	100.00

Support and Information Requirements

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

Idaho Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Catalogs	3	6.98	0	0.00	0	0.00
Utility/State Training	4	9.30	2	5.41	1	5.26
Suppliers/Mfrs/Subs	7	16.28	11	29.73	5	26.32
Consultants/Architects	9	20.93	5	13.51	2	10.53
Magazines/Journals/Books	6	13.95	8	21.62	6	31.58
Engineers	11	25.58	8	21.62	1	5.26
Code	1	2.33	0	0.00	0	0.00
Seminars/Prof Assoc/Peer	0	0.00	2	5.41	3	15.79
Other	2	4.65	1	2.70	1	5.26
Internet	0	0.00	0	0.00	0	0.00
Total	43	100.00	37	100.00	19	100.00

Montana Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Catalogs	0	0.00	0	0.00	0	0.00
Utility/State Training	1	7.14	0	0.00	0	0.00
Suppliers/Mfrs/Subs	1	7.14	1	10.00	0	0.00
Consultants/Architects	0	0.00	0	0.00	0	0.00
Magazines/Journals/Books	6	42.86	4	40.00	1	50.00
Engineers	1	7.14	1	10.00	0	0.00
Code	3	21.43	0	0.00	1	50.00
Seminars/Prof Assoc/Peer	2	14.29	1	10.00	0	0.00
Other	0	0.00	0	0.00	0	0.00
Internet	0	0.00	3	30.00	0	0.00
Total	14	100.00	10	100.00	2	100.00

Oregon Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Catalogs	3	5.17	0	0.00	0	0.00
Utility/State Training	4	6.90	3	6.82	3	13.64
Suppliers/Mfrs/Subs	12	20.69	8	18.18	5	22.73
Consultants/Architects	6	10.34	2	4.55	3	13.64
Magazines/Journals/Books	19	32.76	13	29.55	3	13.64
Engineers	5	8.62	4	9.09	1	4.55
Code	3	5.17	4	9.09	0	0.00
Seminars/Prof Assoc/Peer	0	0.00	7	15.91	6	27.27
Other	5	8.62	1	2.27	1	4.55
Internet	1	1.72	2	4.55	0	0.00
Total	58	100.00	44	100.00	22	100.00

Washington Results

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Catalogs	4	4.65	0	0.00	0	0.00
Utility/State Training	2	2.33	3	4.62	0	0.00
Suppliers/Mfrs/Subs	14	16.28	18	27.69	9	29.03
Consultants/Architects	13	15.12	6	9.23	5	16.13
Magazines/Journals/Books	30	34.88	16	24.62	6	19.35
Engineers	3	3.49	1	1.54	0	0.00
Code	13	15.12	7	10.77	1	3.23
Seminars/Prof Assoc/Peer	4	4.65	10	15.38	8	25.81
Other	3	3.49	2	3.08	1	3.23
Internet	0	0.00	2	3.08	1	3.23
Total	58	100.00	65	100.00	31	100.00

Total

Information Sources	1st Choice		2nd Choice		3rd Choice	
	N	%	N	%	N	%
Catalogs	10	4.98	0	0.00	0	0.00
Utility/State Training	11	5.47	8	5.13	4	5.41
Suppliers/Mfrs/Subs	34	16.92	38	24.36	19	25.68
Consultants/Architects	28	13.93	13	8.33	10	13.51
Magazines/Journals/Books	61	30.35	41	26.28	16	21.62
Engineers	20	9.95	14	8.97	1	1.35
Code	20	9.95	11	7.05	3	4.05
Seminars/Prof Assoc/Peer	6	2.99	20	12.82	17	22.97
Other	10	4.98	4	2.56	3	4.05
Internet	1	0.50	7	4.49	1	1.35
Total	201	100.00	156	100.00	74	100.00

4.2 Do you believe you had enough information to implement energy efficiency into this project?

Yes [ ]   No [ ]

Sufficient Information on Energy Efficiency	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	5	12.20	0	0.00	4	6.67	6	6.59	15	7.28
Yes	36	87.80	14	100.00	56	93.33	85	93.41	191	92.72
Total	41	100.00	14	100.00	60	100.00	91	100.00	206	100.00

4.3 Do you believe you had enough information on the energy code as it applied to this project?

Yes [ ]   No [ ]

Sufficient Information on Energy Code	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	1	7.14	0	0.00	4	6.67	5	5.62	10	5.65
Yes	13	92.86	14	100.00	56	93.33	84	94.38	167	94.35
Total	14	100.00	14	100.00	60	100.00	89	100.00	177	100.00

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

Information Type	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Technical / Cost Data	1	100.00	NA	-	4	44.44	2	22.22	7	36.84
Code Compliance Info	0	0.00	NA	-	4	44.44	2	22.22	7	36.84
Software	0	0.00	NA	-	1	11.11	2	22.22	3	15.79
Information Clearinghouse	0	0.00	NA	-	1	11.11	0	0.00	1	5.26
Informed Suppliers	0	0.00	NA	-	0	0.00	1	11.11	1	5.26
Marketing Tools	0	0.00	NA	-	0	0.00	1	11.11	1	5.26
Total	1	100.00	NA	-	9	100.00	9	100.00	19	100.00

General Attitudes and Suggestions for Improvement

5.1 In your opinion, has client demand for an energy efficient design changed your design practices in general?

Yes [ ] No [ ]

Client Demand Changed Practice	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
No	21	53.85	7	43.75	41	67.21	60	66.67	129	62.62
Yes	18	46.15	9	56.25	20	32.79	30	33.33	77	37.38
Total	39	100.00	16	100.00	61	100.00	90	100.00	206	100.00

If yes, what design elements?

Design Elements	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Controls	0	0.00	1	20.00	1	6.25	5	22.73	7	15.22
Whole Building	0	0.00	2	40.00	6	37.50	5	22.73	13	28.26
Operable Window	0	0.00	0	0.00	1	6.25	0	0.00	1	2.17
Daylighting	0	0.00	0	0.00	4	25.00	0	0.00	4	8.70
Envelope	1	33.33	1	20.00	0	0.00	3	13.64	5	10.87
Cost v. ROI	1	33.33	0	0.00	3	18.75	2	9.09	6	13.04
Lighting	0	0.00	1	20.00	1	6.25	3	13.64	5	10.87
Mechanical	0	0.00	0	0.00	0	0.00	3	13.64	3	6.52
IAQ	0	0.00	0	0.00	0	0.00	1	4.55	1	2.17
Other	1	33.33	0	0.00	0	0.00	0	0.00	1	2.17
Total	3	100.00	5	100.00	16	100.00	22	100.00	46	100.00

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

Clients Value Energy Efficiency	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
0 – 10	7	17.95	0	0.00	9	16.07	33	37.50	49	24.75
11 – 25	4	10.26	1	6.67	10	17.86	5	5.68	20	10.10
26 – 50	6	15.38	7	46.67	15	26.79	17	19.32	45	22.73
51 – 75	1	2.56	1	6.67	4	7.14	5	5.68	11	5.56
76 – 100	21	53.85	6	40.00	18	32.14	28	31.82	73	36.87
Total	39	100.00	15	100.00	56	100.00	88	100.00	198	100.00

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

Opportunities	Idaho		Montana		Oregon		Washington		Total	
	N	%	N	%	N	%	N	%	N	%
Address early in design	24	57.14	7	43.75	51	87.93	54	69.23	136	70.10
Improve ventilation/HVAC	7	16.67	4	25.00	2	3.45	8	10.26	21	10.82
Education	2	4.76	3	18.75	2	3.45	2	2.56	9	4.64
Improve lighting design	2	4.76	0	0.00	1	1.72	5	6.41	8	4.12
Improve components	2	4.76	0	0.00	0	0.00	1	1.28	3	1.55
Improve controls	3	7.14	0	0.00	1	1.72	5	6.41	9	4.64
Other	2	4.76	2	12.50	1	1.72	3	3.85	8	4.12
Total	42	100.00	16	100.00	58	100.00	78	100.00	194	100.00

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

Opportunities	**Idaho**		**Montana**		**Oregon**		**Washington**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Address early in design	24	57.14	7	43.75	51	87.93	54	69.23	136	70.10
Improve ventilation/HVAC	7	16.67	4	25.00	2	3.45	8	10.26	21	10.82
Education	2	4.76	3	18.75	2	3.45	2	2.56	9	4.64
Improve lighting design	2	4.76	0	0.00	1	1.72	5	6.41	8	4.12
Improve components	2	4.76	0	0.00	0	0.00	1	1.28	3	1.55
Improve controls	3	7.14	0	0.00	1	1.72	5	6.41	9	4.64
Other	2	4.76	2	12.50	1	1.72	3	3.85	8	4.12
Total	42	100.00	16	100.00	58	100.00	78	100.00	194	100.00