Oregon Residential Energy Code Compliance Evaluation
Pilot Study Report

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1 Introduction

The goals of this study are to evaluate residential compliance with the requirements of the Oregon State Energy Code, determine the energy impacts of this compliance level, and characterize current residential construction techniques in the State of Oregon.

The Oregon State Energy Code includes a variety of compliance options, or paths, in order to allow flexibility to home builders in meeting the code requirements. There are also a number of specific requirements which must be met for all projects. The compliance options allowed under the code have been developed based on a cost effective reference path, which uses a set of prescriptive requirements for insulation and thermal performance for various house components. This "path" is modified to accommodate such variations as smaller, low income housing, log homes, solar or sun-tempered homes, etc. Each of these variations describe a set of components which combine to form a compliance "path". Path One is the reference path, and 8 other prescriptive paths are included in the energy code. A performance path option, where component trade-offs are allowed based on the Path One baseline, is also allowed under the code.

The "prescriptive" paths have several features that define compliance with their provisions. First, the provisions are not designed to be altered by trading off a lower-performing component against a better one. This is supposed to be limited to the "performance" path alone. Second, all paths except Path Eight have no limit on the amount of window area, although it has very specific performance requirements. Third, the prescriptive paths allow some flexibility in accommodating "architectural" features which cannot be easily adapted to the individual provisions of the code. These include dormers and other ceiling features, solid wood panel doors for use in entry areas, and small amounts of glazing which do not meet the code requirements.

This variety of compliance paths and options complicates the definition of code compliance somewhat, since any given house must be evaluated in a variety of ways before its energy code compliance can be characterized or ruled out. In particular, the performance path option means that a house may incorporate components which do not meet the prescriptive code requirements for individual components, while still meeting the building performance requirements. This makes the evaluation of energy code impacts on individual building components problematic. Another complicating factor is that a particular building may seem to meet the code from a performance standpoint, but still fail to comply with more specific requirements of the code. Finally, some jurisdictions allow trade-offs within a prescriptive path, even though this is not allowed under the code using the prescriptive paths. It does, however, result in a building with equivalent performance, and thus nominal compliance.

With these issues in mind, we have developed several levels of compliance evaluation for use in characterizing residential energy code compliance in the State of Oregon.

1.1 Prescriptive Compliance

There are nine prescriptive paths in the Oregon State Energy Code. These paths have different combinations of insulation, window area and other related requirements. In principle, to comply with any one of these prescriptive paths, the builder would ensure that each separate component defined in the prescriptive path met the requirement contained in the code. Thus, if the prescriptive path calls for R-21 walls and R-38 ceilings, the builder would be obligated to deliver at least that level of performance for those two components. In effect, the prescriptive compliance would review each of these components *individually* and assess whether they meet the code as written. If they did not, the home would not be in compliance with the letter of the energy code, and neither would the component(s) in question. This result can be summarized as a percentage of non-compliance by home, and as a percentage of non compliance by component.

As part of this evaluation, certain code requirements were not necessarily characterized by a performance evaluation, such as the presence or absence of pipe insulation, low-flow fixtures, etc., which are nevertheless requirements of the code.

1.2 Component Performance for Component Trade-offs

A second level of compliance consists of trade-offs between individual components to achieve the overall level of performance defined by the code. By determining the overall building heat loss rate, and comparing it to the energy code's standards, the whole house can be evaluated vis-à-vis the requirements of the component trade-offs provided for in the Oregon code. Since this path is seldom used, this analysis is a convenient fiction for purposes of evaluating code performance. The analysis will be used to assess the overall effects of code compliance, rather than assessing the impact of minor variations in individual components.

It should be noted that many decisions are made based on trading off particular components, either on an *ad hoc* basis at the building department or on a limited basis. For example, two particular components might be traded off, and the remainder of the building is said to comply with a prescriptive standard. In either case, the definition of compliance under this method is that the building complies *overall* with the energy code, on the basis of total heat loss rate, even though a particular component may not comply with the individual requirements of a prescriptive path. At the outset, our analysis of this process will use a comparison between the overall UA of the building and the overall UA required by the component performance trade-off method.

1.3 Systems Analysis

Another aspect of our evaluation was determining whether a building actually meets the goals of the Oregon State Energy Code, given its overall energy performance. This will allow a less rigorous definition of compliance, since the result of this analysis is a heating energy prediction. This prediction will be based upon a comparison between the code building as defined by the prescriptive path or the component performance path, and on the actual building. The actual building may have a higher heat loss rate than the code requires, but if building orientation or a relaxed standard are employed, there may be sufficient evidence to suggest that a particular building has no impact on the overall compliance of residential buildings in Oregon. The criterion tentatively selected to assess the performance of building systems is as follows: the building will demand no more than 5% extra heating energy than it would if it were built exactly to code.

This criterion was applied without considering building heating systems. Since the Oregon code does not allow trade-offs of furnace or heat pump efficiency, the same overall heating efficiency was applied to the building as built, and to the comparison building evaluated with the code requirements only. This assumption substantially reduced the effect of a relaxed performance criterion, since the only source for improved performance over the heat loss rate is the coincidental placement of windows.

1.4 Characterizing The Sector

The final goal of this study is to characterize the nature of residential construction with regard to implications for energy consumption. This includes the evaluation of home size, construction characteristics, and energy performance. An understanding of these practices can inform Oregon residential construction and future building code formulation, and the impact of the Oregon energy code on these practices can also be assessed. We gathered this information, both from submitted plans and on-site characteristics, to determine the building materials and components used by Oregon builders. We also examined the selected heating system types and their efficiencies and construction practices. In addition, we studied the distribution of new single-family residential construction throughout the state, and the local variations in building practices.

The second aspect of construction practice will be code enforcement and documentation practices. This review will include both detailed interviews with builders and building officials, and will assess the building community's decisions regarding compliance with the Oregon energy code.

Finally, the overall performance of Oregon buildings constructed under this code, permitted and built in 1993 - 1994, will be assessed using the heat loss evaluation developed for the building systems analysis review of code compliance.

2 Study Methodology

The goals of this study will be attained using three main sources of information:

1. *The selection of a representative random sample of new Oregon homes.*
   This sample will be drawn from homes built and inspected during the period when field work is conducted, and will be constructed to represent the distribution of new single-family homes permitted in Oregon in 1993.

2. *A review of each home selected, through the building departments.*
   Code documentation provided by the builders and evaluated by the building departments will be reviewed. This review will include any field notes made by plan reviewers for the permanent application regarding whether the building met the energy code, or what modifications were required.

3. *A field review of buildings as found during the final inspection process.*
   This inspection will verify information gathered during the review of plans and permit documents, and obtain other data about construction types. Quality of installation will be assessed where possible.

4. *Interviews with building officials and builders will be conducted.*
   This will allow us to assess responses and attitudes towards the Oregon energy code's adoption and enforcement, and to clarify enforcement and compliance procedures used by these groups.

In order to accomplish these goals, we must review a sufficient number of Oregon homes to obtain results representative for the entire state. The reviewed buildings will be under construction and no centralized permit records exist in the state of Oregon. Therefore, this sampling methodology must take into account the individual jurisdictions' impact on the entire building stock, and a method must be developed to ensure that homes reviewed in each of these jurisdictions are an unbiased representation of building practices in those areas.

2.1 Sample Development

2.1.1 Designing the Sample Frame

The goal of the review of the sample design is to establish a random sample of about 270 homes representative of single-family residential construction in Oregon State. To achieve a representative sample, the buildings selected must be selected at random, since all buildings in the target population must have an equal chance of being selected. A random sample of single-family residences currently under construction in the State of Oregon is more problematic than it might appear to be.

The project's first challenge is to establish an initial sample frame. This is significant, since the State of Oregon does not maintain a list of buildings currently under construction. Indeed, in the case of many jurisdictions, no list is available even for the jurisdiction itself. In Portland, for example, once a building is under construction it is assigned by geographic area to a particular inspector or inspectors. After this, the building's progress is solely the responsibility of the inspector. The building is listed in City of Portland's records only after completion and final inspection. This process is typical of jurisdictions that do not have a computerized tracking system for buildings proceeding through the inspection process. While the City of Portland is the largest of these jurisdictions with no computerized tracking system of this kind, it is by no means the only one. The City of Salem also does not maintain such a tracking system. Several, (in fact, most) smaller jurisdictions maintain no central tracking systems, either during the permitting or inspection processes. As a result, it is impossible to assemble the number of active permits to sample, even if jurisdictions are individually surveyed.

The second challenge of this project is developing the sample in the field. The field review process will begin in February 1994 and will take approximately four months to complete. It will be conducted by about four field teams working at various locations throughout the State of Oregon. These teams are scheduled to assess two to three houses per day during this period. They will work in particular jurisdictions, selecting homes to be reviewed. Several jurisdictions will receive more than one visit, and other jurisdictions may only be visited once. The homes identified as available during this visit will be sampled; thus the sampling frame will be limited to only those homes available at that time. This is very different from the total number of homes permitted in Oregon in 1993. This will actually be a sample of homes that are available to be surveyed in any one jurisdiction at some time in the first quarter of 1994. The homes will have been permitted in 1993, but probably only in the latter half of that year. Only when the homes near final inspection will they be surveyed for this project. For any particular home, its chances of being drawn into the sample for review are strictly a function of its position in the inspection process at the time of the visit.

The project's third challenge is related to the absence of a computerized building tracking system. Without such a system it is very difficult to discover which homes will be available at the time of field inspection. We may not be able to tell, except in the smaller jurisdictions, how many homes were even ready for inspection. Furthermore, a single inspection at any time during construction would reveal only some of the specifics of energy code requirements. It is highly unlikely that a single inspection would be able to cover *all* of the energy code requirements. Wall insulation, for example, is covered by sheet rock before the cover inspection.

Insulation is blown into attics and placed in floors after "cover" inspection, but before final inspection. Caulking and sealing of various openings in a home might occur during framing and be completely invisible, even prior to any insulation inspections. Slab and foundation insulation would be installed at the very beginning of construction, during concrete work. While at any one point we could review the insulation present, at no time will we be able to review *all* of the insulation in a home to assess its compliance with the energy code.

To schedule our visits and assessments, we will rely on a review of plans and requirements that can be seen during inspection. For this reason we will attempt to inspect the majority of the houses near or on the same day as the final inspection. In larger jurisdictions, such as Portland and Salem, we will use those permits that have assigned an inspection date that coincides with the date of our visit. In other larger jurisdictions, such as Clackamas County, Washington County and the City of Beaverton, where inspection records are kept and are accessible, we would select homes that have undergone the major insulation inspections, but that may not be ready for final inspection. This will allow us to review the buildings at an earlier stage of construction, and we should be able to better assess wall insulation and framing techniques. While this method of sampling is not as thorough as we would like it to be, there is no real alternative, given the requirement that the building be inspected and reviewed during the permitting process rather than after occupancy. Also, once the permit has been granted, recruitment of the occupant would be necessary. This is beyond the scope of this project.

2.1.2 Number of Buildings Per Jurisdiction

The number of buildings to be drawn from each jurisdiction is the second part of sample selection. The project team has reviewed various methods for using this sample, including the use of a random drawing from all available jurisdictions. Each jurisdiction in this random drawing would be represented by the number of permits issued in the first nine months of 1993. The other alternative would be to develop a ratio between the number of homes built in any particular jurisdiction and the number of homes built in the entire state of Oregon in the first nine months of 1993. This might be called an "expected values sample", since the expected value in any one jurisdiction would be the ratio of the total sample frame to the total permits in any jurisdiction. A third approach would be to combine the two, drawing a random number and allowing that number to vary by one case either way.

We have elected to use the second method outlined above for two reasons:

1. For most homes (75% of the homes and 1/3 of the jurisdictions), we want to be certain that the maximum number of buildings are drawn, without compromising the representativeness of the entire sample for these larger jurisdictions. Since the individual houses cannot be randomized, we do not believe that further randomizing the jurisdictions will result in an improvement in representativeness.

2. A true random sample will cause a number of homes to be drawn from jurisdictions that have little or no building activity. We do not believe that this is an effective course of action. It is unlikely that characterizing small jurisdictions (under 40 homes permitted each year, out of approximately 15,000 statewide) will provide any insights into the nature of building activity, code compliance or energy requirements in the State of Oregon or in these jurisdictions themselves. Because of limited resources, jurisdictions with minimum construction will probably strain project budgets without appreciable benefits. It is of greater importance to have an adequate sample of jurisdictions that will characterize the state as a whole. These consist of: the four counties in the Portland-Salem area; and Deschutes, Jackson, Josephine and Lane Counties in western and central Oregon. Therefore, we will draw homes from smaller jurisdictions, but when these jurisdictions are not accessible, we will not include them. To the extent that we do not use houses from outlying jurisdictions with little or no construction, we will re-allocate that part of the sample to the larger jurisdictions, in proportion to their total amount of construction. Such sample subsets may also be re-allocated to a specific aspect of the study, if other issues arise.

Appendix A shows the sample by jurisdictions sorted by sample size with the outlying areas removed, to illustrate the number of homes to be reviewed in each jurisdiction. As can be seen, the top 14 jurisdictions represent approximately 60% of the sample. These jurisdictions are all in one of seven Oregon counties; specifically, Clackamas, Deschutes, Jackson, Lane, Marion, Multnomah and Washington counties. The next ten jurisdictions are also in those counties; thus, in the seven counties represented here, the jurisdictions actually account for over 75% of the total sample. The remaining 25% of the sample is found in smaller jurisdictions, mostly on the Oregon coast. The distribution shown here reflects the distribution of single-family homes built in Oregon. These jurisdictions provide a large number of Oregon building samples, and characterize the Oregon home-building economy, almost to the exclusion of the rest of the state. A total of 260 houses is included in the sample. The 10 remaining projects can be allocated to particular jurisdictions, or to enhance the sample in the larger counties, if need be.

The sample distribution shown in the Appendix A represents targets that the field team will use in approaching each jurisdiction. The number of days spent in each jurisdiction will be a function of the number of homes required to successfully complete this phase of the work.

The pilot study sample was basically a sample of convenience, to reduce the amount of logistical preparation needed to coordinate a variety of field teams and managers. Since we anticipated that there would be a variety of questions about the field protocol during the pilot study, we conducted the pilot study entirely in larger jurisdictions mostly in the Portland and Salem areas. Part of our criteria for selecting jurisdictions was the building officials themselves, some of whom had helped us in developing the sampling methodology.

2.1.3 Sampling

Because of the nature of the sample and the situation in each building department, the actual sample will be drawn by the individual field teams when then they visit the jurisdiction. The schedule for testing each jurisdiction would largely depend upon the schedules of the field contractors. Since the bulk of the jurisdictions and housing are in the Portland-Salem vicinity, this will be fairly random. Currently, we have interviewed a dozen of the larger jurisdictions, and we believe that three strategies will be employed in all cases:

1. *For jurisdictions that have relatively limited tracking systems:*
   These jurisdictions will be asked to provide us with a list of homes scheduled for final inspection during the time the field contractors are there. Two of the larger jurisdictions that fit into this category are the City of Portland and the City of Salem.

2. *For jurisdictions that have tracking systems:*
   Virtually all of the state's other large jurisdictions have tracking systems. In these cases, the field contractor will request a summary of all homes that are under construction and have received a cover inspection but have not yet received a final inspection. The field inspector will select homes from this list at random. The contractors for the selected homes will schedule a visit, and the field inspectors will then review permit records and conduct a field review.

3. *For smaller jurisdictions where four or fewer homes are required:*
   The individual jurisdictions will be asked to provide a list of homes which have received a "cover" inspection but have not yet received a final inspection. This list may or may not come from a tracking system, but would probably involve the cooperation of the primary building inspector. At any one time these jurisdictions might have as many as 20 homes in that category, and as many as two inspectors to review them. We believe that this will be practical and will not require either a burdensome review on the part of either the field inspectors or the building officials. Our field team would then select the homes to be reviewed from this list with the assistance of the inspectors, ensuring that there will be access to the homes for field review and/or blower door testing.

Blower door testing will be conducted on 25% of the homes to be reviewed. In the case of larger jurisdictions, a target number of blower door tests will be identified, and the field contractor will conduct such tests on buildings nearing the final inspection with the consent of the contractor. Once the target for that jurisdiction is achieved, no further blower door tests will be conducted, depending on the state of the home. The field testers will be given wide latitude in deciding when and whether a blower door test will be conducted. The emphasis will be on meeting the target number of door tests for each jurisdiction and for the sample as a whole. Appendix A shows the number of blower door tests targeted for each jurisdiction. As can be seen, we anticipate conducting the blower door tests only in the larger jurisdictions, with a few tests scattered among the mid-sized and smaller jurisdictions. Blower door tests were not conducted as part of the pilot study.

2.2 Field Review/Protocol Development

Ecotope drew on multiple sources in the development of the pilot study field protocol. The goals of the project included the review of several different aspects of energy code compliance, as well as residential construction characterization. Documenting this variety of information required the development of a complex field protocol. The protocol was revised based on the results of the pilot study, as discussed below. A copy of the revised protocol is included in Appendix B.

The primary guide for the development of the field protocol was the Oregon Energy Code itself. The protocol is based on specific requirements of the code. In many instances the code sets forth a list of conditions under which certain construction types or performance levels are acceptable, such as the incorporation of R-21 vault ceilings covering less than 150 sq. ft. of floor area. The field protocol is designed to collect information on these conditions in order to allow compliance levels to be determined.

The energy code also sets up the basis for performance review of the buildings. To develop trade-offs between prescriptive requirements and overall building performance, a full building heat loss calculation was developed in each home. This involved an assessment of component areas as well as the heat loss rate of each component. In addition, efforts were made to assess the heating system type and efficiency.

For each house we must determine a code baseline from which to compare project compliance, both on a component by component basis, and for the project as a whole. The code performance requirements are closely related to project window area in most cases, as well as floor area and construction type. This evaluation necessitated the development of a thorough envelope component takeoff form, and another series of questions about building configuration to guide our baseline modeling.

In addition to specific energy code requirements, the proposal for this project requested additional information in order to evaluate other factors which may affect energy code compliance. Information about product labeling, installation quality, and enforcement procedures were also incorporated into the study goals.

2.3 Field Protocol Organization

A primary goal of the organization of the field protocol was to ensure that the field personnel would be able to quickly recognize the information requirements, and to collect that information expeditiously and consistently. To simplify the organization of the form, a right and left column convention was adopted and adhered to throughout the form. To simplify this information, responses to questions about the plans are always entered on the left side of the form, and field verification questions are always entered on the right side of the form. This also simplifies evaluation of the data, since variations between the plans and the field conditions can be quickly recognized. Presenting the data in columns makes it easy for field personnel to glance quickly through the form and identify unanswered questions. This reduces the need to answer the questions in any particular order, improving field efficiency.

The form is organized in several sections. First the project is characterized as to jurisdiction, project type, and house configuration. This information will allow us to characterize the projects by cost, style, jurisdiction, etc. In this section, the field reviewer is also directed to sketch the floor plan and photograph the house. The next section indicates the compliance path used by the project, and identifies the extent and type of documentation submitted to demonstrate code compliance. Based on information gathered in this section, the field reviewer determines whether energy code compliance can be determined from the information submitted.

The "enforcement" section of the field protocol is geared toward the type of enforcement applied to this project. The questions in this section are necessarily fairly open, since the type of enforcement encountered can vary widely. Enforcement information from field inspections is also characterized here.

The next section of the form consists of project component area takeoffs. These takeoffs are oriented to allow us to develop compliance and performance characterizations of the project. First the field reviewer determines the number and types of various building components present. For each of these components, a one page description form is developed which describes in detail the construction of each component, such as wall, floor, or ceiling. In the pilot study, these characterizations were pulled from a master list of building assemblies. For windows, a more extensive characterization is required. In addition to the performance information about each window type, each individual window is listed by size and orientation, so that changes of area, configuration, or performance can be verified in the field. Doors are also given a more specific treatment with regard to performance and construction.

The field protocol specifically asks for field verification of all of the information generated in the takeoffs section. In many cases, this is impossible, since the field inspection will occur when the building is nearly complete and many components will no longer be visible. In these cases, inspectors will not enter a verification in the protocol, and we will generally assume that the component is installed as documented, unless evidence to the contrary is observed.

For houses which are very near to completion, the protocol includes a blower door test to evaluate air infiltration rates for the project. This information will be used to assess the impact of air infiltration on the overall performance of Oregon homes. Since this evaluation will be conducted on a sub-sample of the reviewed homes, it will not directly impact the performance estimates of individual homes in the sample, but will be evaluated separately. Blower door tests were not conducted in the pilot study.

The final section of the protocol guides the field reviewer through a list of specific characterizations of the project. These questions are based on specific code requirements and construction characteristics we are trying to identify. This section includes questions designed to characterize mechanical and ventilation systems installed in the house. There are also questions about the quality of insulation installation, and other insulation problems. Like other sections of the protocol, many of these questions are set up to compare plan information to field conditions.

2.4 Problems with Protocol, and Revisions

In the course of conducting the pilot study of 21 homes, and reviewing the data obtained in the study, several problems with the field protocol became evident which led us to modify the field protocol. These problems, and the modifications, are summarized below.

2.4.1 Component Characterization

Each field inspector was provided with a list of common construction assemblies for walls, floors, and ceilings. These assemblies were coded, and the inspector was asked to list the code for each type of wall, ceiling or floor found on each project. Although there were few problems with this system, when the data was coded in the database, we found the system somewhat unwieldy. Furthermore, the protocol did not differentiate whether the construction code was obtained from the plans or modified in the field. Although this distinction does not necessarily affect the characterization, it does provide useful information about how closely the plans relate to actual construction.

It was decided that rather than relying on a separate construction code sheet, we would require more descriptive information about each component. By adding a specific section describing field changes to this construction description, construction changes in the field are more easily identified. This system also allows us to be more consistent in determining U-values for various construction types, since a description will more accurately characterize construction than a standard code.

Determining the difference between data obtained on the plans and data modified in the field was also somewhat problematic for window and door characterizations. It was quickly realized in analyzing the pilot study field data that the window and door characterization sheets did not necessarily differentiate these two data sources on a unit by unit basis. This made the extent of field changes somewhat hard to characterize. This led us to add specific field verifications sections to the window and door characterization sheets, and to modify the window list form to allow field modifications.

Another issue we encountered with window and door characterizations was the wide variety of window and door label conditions present in the field. These labels were often missing altogether, yet the form asked the field inspector to list window U-value. Without window label information, this determination is a judgment call on the part of the field inspector, and may not reflect accepted default or code window U-values. This problem was further complicated by the fact that in many cases, window labels indicate "Class 40" compliance, which can represent a wide range of actual performance.

It was decided that the best way to resolve this issue was to have the field inspectors merely characterize the windows as best as possible, and gather as much performance data as was available, but to leave the actual U-value characterization for the data analyst. In this way windows of any specific type could be consistently evaluated. This also allowed the use of the default tables for window U-values developed by the State of Oregon to serve as an interim standard until the new NFRC window testing and labeling became generally available. Unfortunately, the exact requirements for window labeling enforced at the time of the permit can be difficult to determine. We have elected to use the ODOE interim directives for establishing compliance and performance, but this results in an overestimation of window performance in most homes.

In the case of doors, the evaluation issues are similar, but doors are even more difficult to characterize, since their construction type is often less obvious and labeling is less frequent.

2.4.2 Insulation Quality

Although the issue of insulation installation quality was addressed by the pilot field protocol, the responses did not allow us to sufficiently quantify these issues. The plot study was set up to identify cases where insulation quality was an issue, but not to address the impact of substandard insulation performance on building energy use. The protocol has been modified to incorporate a more detailed evaluation of insulation quality issues, and attempts to quantify the extent to which such problems might impact the house. Based on this information, an energy impact can be evaluated during the analysis phase of the project.

We have also required more specific field review of insulation types, depths and densities, including the incorporation of an insulation density testing protocol.

One issue that will need to be addressed is the fact that only a subset of the houses will have insulation visible for this evaluation. We tentatively plan to modify overall project energy performance based on the average installation quality in projects where insulation is visible and can be evaluated.

2.4.3 Data Organization

When we reviewed the data obtained in the pilot study, we began to develop the database format we will use to evaluate the collected data. In developing this format some aspects of the wording and organization of the field protocol were deemed unworkable. This led to a variety of modifications to the protocol. Most notably, the component and window characterization sheets were expanded and reorganized to make the data more accessible to the evaluation spreadsheets. Revisions were also made to the organization of questions about insulation quality.

3 Enforcement Procedure

One aspect of this study is to try to determine the extent of energy code enforcement and at what point in the permitting and construction process residential projects may become non-compliant with energy code requirements. To this end the field protocol contains a series of questions about the type of information submitted on the plans to the building department, and how the building department responds to this information through notation, corrections, and inspections.

There is a wide variation among submitted projects with regard to the completeness of energy code compliance information available on the plans. When information about insulation strategies or door and window performance is not included on the plans, it becomes impossible for the plan reviewer at the building department to verify energy code compliance without relying on field inspections.

The field protocol leads field personnel through a series of questions which attempt to characterize the extent of information provided on the plan sets, and then asks the field inspector whether the plans as submitted contain enough information to determine energy code compliance from the plans. Of the 21 projects reviewed for the pilot study, 10 projects, or nearly 50% did not contain enough information about insulation and performance levels to determine compliance from the plans alone.

Despite the lack of complete compliance information on plans, most projects contain some reference to energy code compliance. A description of the different sorts of plan documentation provided portrays the variation in how the energy code is responded to and what the code officials face in reviewing code compliance: 13 of the projects reviewed included some sort of code compliance table which specifically indicated compliance strategies for the project, though not all were complete; 3 projects were submitted with generic code requirements and references, which did not necessarily correspond to information about insulation or performance provided elsewhere in the drawings; 4 projects included the compliance path number as the sole reference to energy code compliance; 1 project contained no reference whatsoever to energy code requirements. Not surprisingly, this project failed to meet prescriptive, performance, or system code requirements (as discussed above), and also failed to follow other code requirements such as installation of pipe insulation and low-flow water fixtures.

Most projects contain at least some information about insulation and performance levels for various components. Table 3.1 below shows how often the insulation or performance information about the component listed was provided on the plans reviewed for the pilot study. Also indicated is the compliance rate for each component with the requirements of the path each particular project was submitted under. (Basements and slabs are not included in this table due to the infrequency with which they occurred in the pilot study.)

TABLE 3.1: FREQUENCY OF INSULATION/COMPONENT PERFORMANCE LISTING

Component	Performance information on plans (%)	Compliance (all projects) (%)
Walls	95	95
Floors	90	90
Ceilings	100	85
Doors	40	90
Windows	70	76*
Duct insulation	65	100

* 60% of the non-complying projects contain doors which did not meet window performance requirements, according to the Oregon interim window and door rating system. See discussion in Section 4.

Since plan review by the building department is the first (and potentially most important) stage of energy code enforcement, one would anticipate that plan reviewers would require additional performance information in cases where the submitted plans do not contain enough information to determine compliance. The pilot sample was too small to characterize the frequency with which additional information was requested by the plan reviewer. In many cases the plan reviewer simply added notes to the plans requiring specific insulation or performance levels, or the reviewer would attach a generic energy code requirement sheet to the plans. As discussed above, these sheets did not always match the details already provided on the plans.

Beyond this, energy code enforcement tended to rely on field inspectors to enforce the code in the field. This type of enforcement is unfortunately somewhat more difficult to track. When available, the field inspectors (ours) would review the inspection card for any evidence of energy code enforcement in the field. These notes tended to address issues such as missing insulation, weather-stripping, pipe and duct insulation, and vapor barriers.

4 Interviews

To supplement compliance and enforcement information obtained from the review of specific projects, we have developed interview protocols to guide conversations with building officials and contractors in the jurisdictions in which project reviews are conducted. The protocols have undergone review and revision by various interested parties to this study, and a format which attempts to respond to various comments of these groups has been developed.

We have used the building official interview form for a few pilot interviews, and we anticipate that the information from jurisdiction officials will provide important insights into the enforcement issues of the Oregon Residential Energy Code. Unfortunately, in its current form the interview requires approximately 40 minutes to conduct. This may be significantly more time than we can reasonably expect from all of the building officials we would like to contact. We anticipate reducing the length of this interview significantly. The interview form for building code officials is included in Appendix C.

5 Compliance

The field and plan reviews of the code compliance documentation for the Oregon jurisdictions were conducted, and compliance was assessed based on three issues:

1. Compliance with the nominal prescriptive path selected by the builder or building department during the plan review

2. Actual compliance with performance levels, implied by the component performance section of the Oregon code

3. Compliance by systems analysis, determined using SUNDAY™; determining the buildings' overall heating energy demand and comparing this to code requirements.

5.1 Compliance Path

The compliance path selected by Oregon builders throughout the jurisdictions was weighted towards prescriptive Path One. 81% of all buildings reviews used this path. Typically this path was identified on the plans, either as part of the detailing or as part of a code submittal sheet. When the compliance path was not specified on the drawings or any building documents, the building official assigned this path during the plan check.

The only other prescriptive path used was Path Eight, the "affordable home" path. This accounted for 9% of the buildings submitted, and was used only in the City of Portland. 5% of the buildings used the component performance trade-off path, and the remaining 5% claimed "compliance by professional" stamp. Although the Oregon energy code had been revised to exclude this last option, at least one jurisdiction accepted the stamp as evidence of code compliance. In that particular case, we reviewed the house as though it had been submitted as a prescriptive Path One, and it did comply with that path.

5.2 Compliance Review

We conducted a review of the components of the prescriptive path and the requirements of the performance path. Table 5.1 presents the levels of compliance found in plan and field reviews for each compliance method. These evaluations are conducted using the code as written, and are not based on any prescriptive path trade-offs. As can be seen, 23% of the homes reviewed did not comply with the prescriptive path as rigorously defined. The reasons for non-compliance with this path are usually the result of field changes not directly reflected in the plan review. There are several field changes that accounted for the difficulties. In the homes that attempted to comply with the prescriptive path, field changes included: a reduction in the performance levels of the windows (failure to use either low-E or argon as part of the vinyl frame window); an alteration of the door specifications (door installation exceeding the 24 ft^2 limit, with performance levels of approximately .54); the expansion of the area of R-21 vault (greatly exceeding plan specifications); and the reduction in ceiling insulation resulting from poor quality control during installation. Each of these reasons for non-compliance accounted for one quarter of the total non-compliance with prescriptive Path One. All of these field changes were made by the builder.

In the case of component performance, non-compliance was mostly due to the addition of glass block and window area to the building plan after permit issuance. This was exacerbated by lower levels of floor insulation than was required under the component performance path. The insulation levels were usually documented on the original plans, but with the addition of the glass block, the component performance path could not be met.

TABLE 5.1: ENERGY CODE COMPLIANCE

			NON-COMPLIANCE % OF SAMPLE		
PRESCRIPTIVE PATH/OPTION	% OF SAMPLE	% COMPLYING	PRESCRIPTIVE PATH	COMPONENT	SYSTEM
PATH 1	81.0	.77	19.0	14.3	9.5
PATH 8	9.4	100	0	0	0
COMPONENT	4.8	0	4.8	4.8	4.8
PROFESSIONAL STAMP	4.8	100	0	0	0
TOTAL	100	76	23.8	19.0	14.3

5.2.1 Overall Component Performance

To assess the impact of non-compliance in the prescriptive paths, we reviewed the actual heat loss rates of the buildings to assess whether the overall performance of the building was acceptable. We reviewed the components allowed under the prescriptive path and compared this to the actual components in the building. In one case, other component accommodations actually exceeded the requirement, and the overall heat loss trade-off resulted in compliance. Using this method, the percentage of non-complying buildings was reduced to 19%.

5.2.2 System Analysis

We conducted a systems analysis using the SUNDAY™ program to predict heating energy use with standard assumptions. The SUNDAY™ inputs corresponded as closely as possible to the standard assumptions used in regional code compliance tools. The code comparison building assumptions included: a thermostat set-point of 68° F; building orientation as built; 25% of the building's glass in each cardinal direction; 3,000 BTUs per hour of internal gains. Overall thermal mass was delivered from the building components: structures with crawl spaces were considered light mass, and structures with slabs were customized to accurately reflect concrete mass. The proposed building was specified with identical operating assumptions. Only window orientation was changed to use the actual conditions on the site. For both the code building and the proposed building, a shading coefficient of 0.5 was used for all windows with clear glass, and 0.45 for all windows with low-E specified in the glazing. We did not review any buildings which had complied under solar tempering provisions, and so we did not assess solar exposure beyond this conservative shading coefficient assumption.

Given the nature of this analysis, buildings that already complied with the component performance or prescriptive path will also comply at the systems analysis level. Only those buildings that did not comply with the component performance would potentially not comply under the systems analysis option. However, since orientation for that subset of buildings was not crucial, these buildings did not have appreciable amounts of north-facing glass, and could not benefit from the provisions of the SUNDAY™ systems analysis. As requested by ODOE, we made a systems comparison giving a 5% margin to the SUNDAY™ runs, allowing compliance to be defined as a building which used no more than 5% more heating energy than required by the code building. Using this criterion, the level of non-compliance fell from 19% associated with the component performance option and 23% associated with the prescriptive path to 14% associated with the systems analysis.

In all the remaining cases, non-compliance involved major field changes which caused the heat loss rate of the building to increase by 10% to 15% over the heat loss submitted in the permit documentation. Non-compliance occurred at the level of the field review.

5.3 Non-Compliance Distribution

For the pilot study, it is not possible to complete this section. In the final study, this section will consist of compliance methods by jurisdiction and a distribution of actual non-compliance broken down by plan review and field inspection. The findings will also be broken down by jurisdiction size and major geographical area in the state. This will provide a sample sufficient to address the distribution of non-compliance. We will not single out individual jurisdictions, but will combine a number of jurisdictions in order to summarize the general geographical distribution of compliance and non-compliance. We will also divide jurisdictions by size, insofar as the sample will allow this. The ten largest jurisdictions will probably be used for one set of comparisons, and the remaining smaller jurisdictions will be summarized together. Finally, the distribution of compliance requirements by the building officials will be presented. The number of prescriptive paths versus component performance or systems analysis will also be presented, broken down by jurisdiction or county.

5.4 Compliance Methods

During the plan review, individual inspection departments and/or building officials were interviewed regarding energy code review procedures. These procedures are similar in all the jurisdictions that we reviewed, especially in plan intake and initial code review. The jurisdictions and plan checkers seemed to assign prescriptive compliance Path One unless the builder was specific about which path was to be used. In 35% of the cases, the plan review could not identify a code compliance path from the builders' submittals, and we assumed that the markings on the plan resulted from plan review. There was only one case of such a plan turning out to be a non-complying building during field review.

From our conversations with building officials, builders throughout the state expect to build according to the Oregon Energy Code, complying with Path One. Only in the City of Portland did we find an appreciable number of homes built to Path Eight, the "affordable" path. Builders in this area felt that this was an important path for their market. In general, these homes were much smaller and less expensive than the homes in other parts of the state or the Path One homes in Portland.

We expect that the distribution of compliance paths and the nature of the path selection process will become much more clear once we have collected more information. Additional interviews with builders and reviews of homes from jurisdictions throughout Oregon will greatly enhance our understanding of energy code issues.

6 Building Characteristics

The purpose of this section is to summarize the nature of building practices in Oregon, as revealed by the field review. The residential buildings' characteristics can be divided into three parts:

1. Characteristics of components used by the builders
2. Overall building size
3. Performance and other energy use characteristics

In reviewing this information it is important to keep in mind that the characterizations are based on a very small sample which is by no means large enough to characterize Oregon residential construction. The evaluations conducted on this sample were undertaken in order to evaluate the effectiveness of our data-gathering protocol and our analysis methods. We anticipate that the data gathered in the main portion of this study will significantly change the results of the evaluations conducted on this small subset of the overall sample.

6.1 Components

Our review of the general characteristics of the Oregon buildings revealed a remarkable correspondence between the energy code requirements (especially prescriptive Path One) and the actual building practices. We have reviewed these compliance practices for each major component and system of the building.

6.1.1 Wall Construction

With the exception of the 10% of the buildings complying under Path Eight, virtually all of the walls constructed in this sample used R-21 high-density batt insulation. Of these, 21% used 2-foot stud spacing in their construction. Only one of the buildings of this 21% actually indicated the advance framing as part of the plan submittal. However, it should be noted that we were not always able to see the wall insulation during our field reviews, since the homes were already well under construction, with the sheet rock and wall finishes in place. Our assessment of the R-21 batts was made based on the field inspector's or plan checker's notes. We cannot assess whether these notes varied from actual practice at this time. In the larger sample, we should be able to review a fraction of the homes at an earlier stage of construction in order to establish wall insulation levels. The remaining 10% of the buildings used R-15 batts and 2' X 4' walls as part of Path Eight construction. The builders that used this path seemed convinced that this reduced the price of their framing or lumber packages.

6.1.2 Ceiling Construction

We found that the ceiling construction was mostly R-38, with blown insulation in attics, and R-30 was generally applied to vault areas. It is apparent that scissor trusses were defined both by the building department and by the builders as vault ceilings, and were thus eligible for reduced insulation levels. Field practice did vary slightly from submitted information, with batt and loose-fill insulation strategies frequently interchanged. The problems that we encountered with the ceiling insulation were usually related to poor quality control in the blown insulation. In 10% of the cases reviewed, the field evaluation revealed lower levels of insulation than specified on the plans. Although the field protocol identified insulation quality problems in ceilings, the protocol did not adequately quantify these problems. The protocol has been modified to incorporate more specific measurement of loose-fill insulation levels, as discussed above. In most cases we were able to review much of the ceiling insulation and assess whether it had achieved code-specified performance levels. As a whole, ceiling insulation was installed at about the level required by the building code.

One problem area we encountered was the use of R-21 vaulted ceilings. The code allows this for up to 150 ft^2 of ceiling area. In several homes this insulation strategy was adopted, but the 150 ft^2 area limit was exceeded in at least one, and possibly two cases. In one case, the area of vault itself was larger, but the floor area it covered was only 150 ft^2. In the other case, the vault area was much larger, but we could not determine for certain whether the insulation was in fact only R-21, since the vault was fully covered, and inaccessible.

In the case of the buildings complying under Path Eight, one of the buildings achieved the R-49 required for flat ceilings, and the other did not. The building that did not comply did include the R-30 ceiling insulation level.

6.1.3 Floors

The prescriptive path in the Oregon code mandates an R-25 floor insulation level for crawl spaces. 81% of the homes in this sample had full crawl spaces. In three of these homes, a 2' x 8' or 2' x 10' joist system was used for some or all of the floor space. Only one of those three used joisted floors instead of post-and-beam floors and car-decking. The use of R-25 insulation was very prominent, with only one building failing to meet the R-25 requirement because it used an R-22 batt instead. In virtually all cases the floor insulation in crawl spaces was accessible for review, and we are confident of these results. Of the buildings that did not use Path One, the R-21 or R-22 batts were used for Path Eight. In the case of the one building using component performance, an R-22 batt was used as well. In 19% of the buildings, floor slab was the primary floor. Two of these homes had slab-on-grade or slightly below-grade floors; the remaining two used a full basement slab. Insulation in these floors was not accessible and so could not be physically checked during review; but in all cases, R-15 perimeter insulation with a thermal break was specified on the plans. Since these buildings were well past the slab construction stage, we were unable to review this insulation.

6.1.4 Windows

By far the most complex problem in characterizing Oregon buildings is representing the windows accurately. This is due to the ambiguous nature of window testing requirements, and the transition that the window performance rating system is undergoing. In 1993, a federal suit called into question the vast majority of the performance tests associated with windows manufactured and installed in this region. Specifically, this suit claimed that the tests were fraudulent and thus not applicable. A new rating system had been proposed by the National Fenestration Rating Council (NFRC) and adopted by the State of Oregon, effective January 1, 1994. However, in the interim, the State of Oregon issued an emergency rule allowing U-values based on the fraudulent tests to be used until the new system became effective. The buildings reviewed in the pilot study were permitted during this transition period.

The effect of the interim ruling was to allow all windows with vinyl frames, clear glass and argon fill to comply with the Oregon code, even though the NFRC performance ratings for these window types were approximately 20% higher than allowed by the Oregon code. Since the rating system that might substitute for these tests was not yet instituted, as a result of the suit, Oregon builders also used two other classes of windows (vinyl with low-E only, and vinyl with both low-E and argon). In the latter case, these windows comply with Class 40 requirements, and quite often exceed those requirements by 10% to 15%. The type of low-E coating determines whether or not a window will meet the Class 40 requirements. In the interim period, windows with any low-E coating were deemed equivalent to Class 40. As a result, the window performance can be arbitrary, both in terms of compliance and overall heat loss rate. This problem will be solved by the NFRC rating system; however, this system will not be implemented until spring of 1994. In the meantime, the confusion and contradictory labeling requirements will continue to make field evaluations problematic.

Of the houses reviewed in the pilot study, only 52% had window performance labels present. In 67% of the houses, the window area in the field was different than that shown on the plans, almost always larger, and in 38% of the cases the window performance was different in the field than shown on the plans. In cases where skylights were installed, 50% of the houses had performance labels on the skylights.

Table 6.1 presents the distribution of window types within the sample. As can be seen, nearly 60% of the primary windows employ the low-E argon or vinyl with argon fill. This included one window which employed clear glazing in a vinyl frame without any low-E coating or argon fill; this window did not comply with the Oregon code. In every other case, a nominal Class 40 could have been assumed for the windows used. In the 57% of the cases in which clear glass with argon fill was used, these windows would be significantly affected by the NFRC testing, and builders using this type of window would be required to use a low-E soft coat, or a low-E with argon fill to meet the Class 40 requirement. It is quite apparent that in 95% of the cases, builders attempt to meet the Class 40 window directly, because of the code requirements. Because of the unlimited glazing paths associated with the Path One prescriptive code, Class 40 windows dominate the window market, almost to the exclusion of any other window type. 100% of the homes reviewed use vinyl-framed windows, with a few decorative windows as the only exception. Even in homes using compliance Path Eight, the windows were Class 40 windows. This generally improved performance of the homes, and suggests the dominance of the vinyl window with argon fill in the market.

TABLE 6.1 GLAZING CHARACTERISTICS

CHARACTERISTIC	U_A*	U_N**	% HOMES
VINYL FRAME			
CLEAR GLASS	0.5	0.51	4.8
ARGON FILL	0.4	0.48	57.1
LOW-E COATING	0.4	0.37 - 0.42	19.0
LOW-E W/ ARGON	0.4	0.34 - 0.37	19.0

* AAMA TEST/INTERIM RULE
** NFRC DEFAULT RATING

6.1.5 Doors

The performance of doors in this building sample presents a somewhat ambiguous evaluation problem due to the language of the Oregon Energy Code. According to the code, doors must have less than 2.5 ft^2 of glass in order to be considered a door. In the event that they have more than this amount of glass, doors must meet the window requirements (Class 40 or U-value of 0.40). This is not usually a problem for doors if the glazing is a fraction of the total door, and the door is a thermally broken insulated door. However, our review suggests that this is not usually achieved, and quite often the doors do not meet nominal standards for Class 40 windows. This is complicated by the fact that labels and ratings for these doors are not usually available, and the standards even from NFRC or other rating services do not generally apply to French doors or other types of locally-manufactured doors. Even when the doors do incorporate thermal breaks and high performance glazing, it is difficult to determine the actual heat loss rate. The nature of this problem was not fully anticipated by the pilot study field protocol, and as a result we had to rely on a rather general default table in evaluating door performance. We presume that the building inspectors have an equally difficult time evaluating this problem.

This ambiguity regarding whether doors are to be considered doors or windows is actually a loophole in the code and a potential code enforcement problem. As a result of these ambiguities we did not include violations of the window requirement by glazed door in assembling the final compliance review. This would have increased non-compliance to the prescriptive paths to 34%, although it would have had no impact on the component performance or systems assessment of compliance. Since doors represent a relatively small portion of the total heat loss rate, the performance penalty associated with this issue is minimal.

The (opaque) doors that we reviewed generally met the code requirements. 38% of the homes used a solid wood door as an entry door, with only one home using more than the allowed area. This home used three wood doors in various locations, in clear violation of the code allowance of 24 ft^2. Other non-glazed doors were generally thermally broken, insulated-core doors, meeting the requirements for a U-value of 0.20. These doors were used both as entry doors and as back doors and other non-entry doors. In 58% of the cases, thermally broken metal doors constituted all of the doors in the home with the exception of sliding glass doors. In only two cases were door performance labels present, indicating a potential field problem with door classification, especially since this information was also scarce on submitted plans. "Partially glazed" doors, which should have been considered windows, were not encountered in the pilot study.

6.1.6 Other Characteristics

The field protocol also gathered a variety of information about construction characteristics as well as compliance information for other general energy code provisions. As discussed, the size of the pilot sample makes the significance of this information very limited until more data is collected. Once the main study is completed, we will be able to characterize issues such as construction techniques, house size and layout, ventilation systems, and other information.

Information about vapor barriers and house "tightness" will also be characterized, in conjunction with the discussion of blower door test results.

Despite the small size of the sample, some significant data trends are apparent even in the pilot sample. In brief, the following characteristics were found in the pilot study sample:

In cases where recessed incandescent lights were installed through the heated envelope (into attic, etc.), only 30% indicated an IC rating. Although unrated can lights could be positively identified in only one case, the other cases present an enforcement issue, since their rating could not be determined by the building inspector in these cases either.

In 29% of the houses visited, pipes exposed to outside conditions were definitely not insulated. In another 24% of the houses, these pipes were not yet insulated, although installation of insulation may have been pending.

Only 14% of the houses visited had definitely installed low flow water fixtures. Only 10% of the plans reviewed indicated that low flow fixtures were to be installed.

All of the houses visited contained at least one fireplace.

None of the houses visited had installed any ventilation system beyond spot ventilation.

6.1.7 Overall Building Component Characteristics

This sample of homes built under the Oregon code were well predicted by the code. Table 6.2 compares the average U-values observed in these homes with the U-values required for each of these components under the Oregon code. As can be seen, the average U-values of all the Oregon homes are quite close to the code values. Averages exceeded the code requirements only in the case of ceilings. This is due to the fact that ceiling insulation almost always exactly met the code requirement, except in 10% of the houses in which ceiling insulation did not comply. This resulted in a slightly higher overall average than the code allowed.

Window U-values are similarly problematic, since both windows and doors use default U-values which may not accurately reflect actual performance (as discussed above). Even with the loose interpretation of window performance requirements, 10% of the buildings included at least some windows which did not meet the Oregon requirement for their particular compliance path.

TABLE 6.2 AVERAGE COMPONENT PERFORMANCE

COMPONENT	INSTALLED	CODE REQUIREMENT
WINDOW	0.41	0.40
WALL	0.059	0.060
FLOOR	0.032	0.032
CEILING	0.030	0.029

6.1.8 Heating Systems

The heating systems installed in the homes that we reviewed were almost all gas-fired furnaces ducted through crawl spaces, attics and other unheated spaces, into the home. The most common location for these furnaces was in a garage-type area, with a few houses in which full basements were the heating system sites. 90% of all heating systems installed were gas-fired central furnace systems with the remaining systems being an electric heat pump and electric zone heating.

74% of the gas furnaces had sufficient information available to the auditors to assess the efficiency ratings. Only 5% of these had efficiencies that were apparently below those required under the Oregon energy code. In no case was it possible to assess this information without referring to manufacturer or GAMA ratings. Thus, it is impossible to tell how a building inspector might determine the efficiency of a furnace as installed, even though the drawings call for a particular rating. In 26% of the cases, the drawings specified a furnace efficiency rating without identifying a particular product that might meet such a rating. In all other cases, the efficiencies were not noted on the drawing, and in most of the cases the heating system itself was not noted on the drawing.

The Average Fuel Utilization Efficiency (AFUE) for those gas burners where this was available was 79.1%. One of the electric systems consisted of a ducted heat pump using a water source via a thermal system installed in the basement. This is extremely atypical, and actual ratings for this equipment are not available. These systems may have ratings well above the HSPF requirements of the Oregon code for heat pump systems, but we could not verify this with the field information. The other electric system is an electric zone system using wall heaters.

Two homes had air conditioning installed or specified; one of these homes was a heat pump installation at the outset; in the other, the cooling equipment was installed in conjunction with a gas heating system. We are not prepared at this point to estimate the system efficiencies beyond the AFUE. Anomalies in manufacturer's serial and model numbers, as well as difficulties we encountered with furnace accessibility, prevent us from establishing system efficiencies. In two cases, the furnace was being used for sheet rock drying during the inspection, so that the inspector could not directly access the furnace without turning it off. More importantly, it is very difficult to see how the building inspector could, with the documentation available on site, assess the HSPF for the AFUE of the furnace. It appears that enforcement of the heating efficiency standards depends almost exclusively upon the fact that suppliers and installers have understood the requirements of the code. They must also understand the federal appliance efficiency standards and produce furnaces that meet those requirements, regardless of the lack of inspection and enforcement. This appears to be true in the sample of homes that we reviewed.

6.1.9 Ducting Systems

Duct systems were typically constructed using flex duct, but had metal ducting for the supply and return plenums. The plenums were wrapped with R-8 duct insulation material, and the flex duct, where it could be observed, was usually rated at R-8. 90% of the ducted systems used flex ducts for a large portion of the supply distribution system, and in some cases for the actual return plenum. 10% of the ducting systems used building cavities as return plenums or for some parts of the supply system. In 15% of the systems, duct board was used for some or all of the ducting systems. One home used a fiberglass duct board system for the entire ducting system. The duct board in the remaining homes was used as part of the return plenum system and was usually located in the attic. Duct insulation was installed in every ducted home in the pilot study, as required by the Oregon code. The duct board systems, however, were generally insulated to R-5, since that is the insulating value of duct board. In these cases, no additional insulation was installed. In this respect, one home did not meet the requirement for the entire ducting system, and two homes had potential difficulties in their return plenums only.

6.2 Code Impacts

6.2.1 Building Performance

To evaluate the energy impacts of the Oregon code on building practices and the energy requirements of single-family houses in Oregon, a series of simulations were run. We used the values observed in the field as installed by builders. Heat loss was generated as part of the assessment of component performance and system compliance. This heat loss rate, combined with window orientation and Oregon code standard assumptions, was used to estimate space heating load with the SUNDAY™ building energy simulation program. Since the buildings were unoccupied at the time of the inspection, we did not vary the values of lifestyle energy impacts such as thermostat set-point and internal gains from house to house. Building mass was varied depending upon construction and the amount of concrete slab and surfaces specified in the original design. Our assumptions included: thermostat set-point at 68° F, internal gains of 3,000 BTUs per hour per home, and an overall window shading coefficient of 0.5, accounting for shading from local obstructions, curtains, and other factors. The shading coefficient was further reduced if the windows as installed included low-E coatings (which would result in higher shading coefficient than windows with clear glass only). Window orientation was taken directly from the buildings' plans and field inspections. To characterize the code building's windows for the SUNDAY™ run, the figure representing the total window area was divided evenly to face each of the four cardinal directions. All of these aforementioned assumptions were used for the SUNDAY™ run for the code building, and were compared with the exact specifications from the prescriptive path selected by the builder. In this way we estimated the performance if the code had been followed exactly. As pointed out in Section 4, "Compliance", the impact of non-compliance on these overall estimates was minimal.

The estimates of the space heating requirements for the sample buildings were established in two different ways. The first method used a heating load estimate which was meant to assess the load required to maintain the thermostat set-point. This was equivalent to the energy use in a home with zoned electric heat, in which no duct or furnace losses are included. The second run was conducted using an estimate of system effects; when furnace efficiency could be obtained, it was combined with an estimated duct efficiency derived from the duct characteristics observed during the audit. These system effects were approximate, since no specific measurement was made of duct leakage. Duct characterization was based largely on previous work done for the State of Washington and the Bonneville Power Administration (Olson, et al., 1993).

For those homes with ducted heating systems and gas furnaces, these figures were combined with the AFUE for the furnace to estimate the total heating load. For the gas furnaces alone, this adjustment amounted to a 64% efficiency adjustment, or a 1.57 increase in the energy requirement in homes with gas furnaces. Of the 10% of the systems with electric heating, one had a high-efficiency ground source heat pump, and the other had a zone baseboard. In the case of the heat pump, the duct efficiency was multiplied by the system COP to obtain total system efficiency. For the zone baseboard case, the SUNDAY™ output was used as the space heating estimate, including all system adjustments. Table 6.3 summarizes the results of the heating load estimates in BTUs per square foot. The sample size can make comparisons between classifications difficult; however, buildings complying with the code have heat loads that are about 96% of the heat loads that would result from strict code compliance as a result of marginal improvements in some components, beyond code requirements. In the non-complying buildings, the increased energy requirements for this set of buildings is about 8% over what would be expected if they were all brought into compliance.

TABLE 6.3 BUILDING PERFORMANCE, HEATING LOAD REQUIREMENT

	ALL BUILDINGS		COMPLYING BUILDINGS		NON-COMPLYING BUILDINGS	
	N	MBTU/FT^2	N	MBTU/FT^2	N	MBTU/FT^2
HEATING AS BUILT (MBTU)	21	16.1	18	15.4	3	19.8
CODE HEATING (MBTU)	21	16.4	18	16.1	3	18.3
RATIO	21	.980	18	.958	3	1.080

Table 6.4 presents this information and includes the heating system type. Complying and non-complying buildings are combined in this table, since the sample was very small. However, the impact of system effects on the overall estimate of heating requirements can be seen here. In the case of gas heating systems with central ducting, the average system-delivered efficiency for the entire system is 63.8%, resulting in an almost 57% increase in the amount of energy required for the home's envelope load alone. The electric heating systems' case is somewhat different, since one of these homes has a heat pump with a large COP, and the other is a zoned system with no duct losses. Thus, the impact of system efficiency on the electric side is to reduce the overall heating requirements by about 220%. Because of the small sample size, this is not necessarily significant, although as additional homes are added the analysis will become complete.

TABLE 6.4 SYSTEM PERFORMANCE

	GAS		ELECTRICITY	
	THERM/YR	MBTU/FT^2	KWH/YR	KWH/FT^2
HEAT LOAD	31.4	16.2	11846	3.6
CODE HEAT LOAD	31.6	16.3	12380	3.7
SYSTEM LOAD	49.4	25.6	6667	2.0
CODE SYSTEM	49.7	25.7	7319	2.2

We have not constructed a prototypical base case for the code evaluation. At this time, we believe that the code requirements applied to the actual buildings are a better indicator of code performance and are also better for comparing building performance to the code. Overall, in spite of the 15% non-compliance, the energy use of single-family buildings built under the Oregon code is slightly less than the energy use anticipated if all buildings were built exactly to code.

7 Conclusions and Recommendations

The impact of the Oregon state energy code on single-family residential buildings in the state has been very positive. It is apparent that building practices are often corresponding to the letter of the code. Particular patterns of enforcement, at least in jurisdictions selected for the pilot study, have resulted in buildings compatible with the code. Similarly, with heating equipment efficiencies, the requirements for system efficiency seem to correspond to what is provided by furnace suppliers. Thus, builders almost always produce homes with heating systems that comply with the code. Difficulties with code compliance are usually associated with anomalies that are usually beyond the builders' control, or are confusing for the builders and inspectors. The principal problem in this area is quality control for the blown-in attic insulation. In two homes, an inadequate amount of attic insulation was installed. In these homes, a blown-in fiberglass product was used, and the builder was unable to discern that the insulation's depth was not sufficient. In one home's case, one section of ceiling insulation was missing altogether. In all cases, the builder seems to have been unaware of the fact that he had received less insulation than he had purchased. In at least one case in which the builder was present for our inspection, he promised to contact the insulation subcontractor, since he felt he had received less than what he expected to receive under his contract with the insulation installer.

In the main study, we will spend more time assessing insulation depth and density, so that we can assess whether buildings are complying with ceiling insulation provisions. It is apparent that if the pilot study findings hold true for the entire residential single-family sector, additional effort for the inspection of ceiling insulation may be required.

A second area that occasionally presented prescriptive path problems was the use of R-22 batt insulation instead of R-25 batt insulation in the floor. The building practices discovered during the pilot study indicated a post-and-beam floor system over a crawl space with car-decking with particle board or plywood underlayment. The insulation is held up by strings or wires that are strung between the beams, and it is not always easy to discern whether the insulation is R-22 or R-25. When unfaced batts are used, it is important that inspectors establish the insulation's R-values. While it appears that this is almost always the case, it also appears that the insulation contractors do not always ensure the proper amount of insulation in the floor system.

In spite of these difficulties, however, the overall heat loss rates of buildings seem comparable to those required under the code. This is due to a few homes in which windows were noticeably better than the Class 40 required, and to those homes built under Path Eight, in which the window requirements were 0.5 (although the windows installed were usually Class 40). The difficulty with this analysis is that the window rating system often does not correspond to the actual window performance. The default ruling allowing vinyl argon windows to be used as Class 40 solved the immediate problem created by the court decisions on questionable window performance tests, but may result in confusion when the NFRC testing requirements become effective in 1994. The default table may be very useful even after the NFRC requirements are in place, because the window specifications on the plans are usually generic, and plan reviewers often need to evaluate a window U-value with inadequate information from the code submittals.

Doors are another component that present specific concerns in regard to the Oregon energy code. Under the code, doors with more than 2.5 ft^2 of glass are considered "windows". However, the rating system for doors with any amount of windows in them has not been established. The NFRC has not established a rating system, and most door manufacturers do not use AAMA tests on their products. There are many insulated-core metal doors with thermal breaks on the market which are much better than Class 40; however, when they are made into French doors with double-glazed clear glass, their performance decreases. We were not able to observe any consistent rating for the doors, and it seems to us that the inspectors could not either. It is not clear how the inspectors review these products, and we suspect that glazed doors are probably not reviewed. Even if we had ratings for doors, the ratings themselves would be subject to the same uncertainties that the AAMA window tests are subject to.

Opaque doors are only a slight improvement; these doors are not usually rated. For thermally-broken metal doors, a default setting is reasonable, but for wood doors the default may not always be acceptable. In most cases, doors do not represent a substantial fraction of total heat loss; and moderate changes, such as increased ceiling insulation or improved windows can offset poor door U-values. Only one building in our sample had a sufficient number of doors with poor performance to result in non-compliance not only with the prescriptive path but with component performance and systems analysis. In that case, the doors were site-built and represented nearly 100 ft^2 of total building shell area.

8 References

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Appendix A: Sample Distribution

Oregon Residential Sample by Jurisdiction
Based on September 1993 Permit Data

Jurisdiction	Sample	%	Cumulative	BD	County
Washington Co.	29	0.11	29	7	Washington
Clackamas Co	16	0.17	45	4	Clackamas
Portland	16	0.23	61	4	Multnomah
Deschutes Co.	11	0.28	72	3	Deschutes
Marion Co.	11	0.32	83	3	Marion
Salem	11	0.36	94	3	Marion
Tigard	9	0.4	103	2	Washington
Bend	9	0.43	112	2	Deschutes
Medford	9	0.47	121	2	Jackson
Eugene	9	0.5	130	2	Lane
Beaverton	9	0.53	139	2	Washington
Jackson Co.	6	0.56	145	2	Jackson
Gresham	6	0.58	151	2	Multnomah
Hillsboro	5	0.6	156	1	Washington
Redmond	4	0.62	160	1	Deschutes
Springfield	4	0.63	164	1	Lane
Lincoln Co.	4	0.65	168	1	Lincoln
Various County	4	0.66	172	1	Multnomah
Josephine Co.	4	0.68	176	1	Josephine
Lane Co.	4	0.69	180	1	Lane
Lake Oswego	4	0.71	184	1	Clackamas
West Linn	4	0.72	188	1	Clackamas
Tualatin	4	0.74	192	1	Washington
Troutdale	4	0.75	196	1	Multnomah
Sherwood	3	0.77	199	1	Washington
Albany	3	0.78	202	1	Linn
Central Point	3	0.79	205	1	Jackson
Wilsonville	3	0.8	208	1	Clackamas
Mcminnville	3	0.81	211	1	Yamhill
Corvallis	3	0.82	214	1	Benton Co
Columbia Co.	3	0.83	217	1	Columbia
Benton Co	2	0.84	219	1	Benton Co
Oregon City	2	0.85	221	1	Clackamas
Yamhill Co.	2	0.86	223	1	Yamhill
Newberg	2	0.87	225	1	Yamhill
Grants Pass	2	0.87	227	1	Josephine
Curry Co.	2	0.88	229	1	Curry
Canby	2	0.89	231	1	Clackamas
Linn Co.	2	0.9	233	1	Linn
Crook Co.	2	0.9	235	1	Crook
Happy Valley	2	0.91	237	1	Clackamas
Ashland	1	0.92	238	0	Jackson
Dundee	1	0.92	239	0	Yamhill

Jefferson Co.	1	0.92	240	0	Jefferson
Florence	1	0.93	241	0	Lane
Milwaukie	1	0.93	242	0	Clackamas
BCA	1	0.93	243	0	Coos
Cornelius	1	0.94	244	0	Washington
Lincoln City	1	0.94	245	0	Lincoln
Lebanon	1	0.95	246	0	Linn
Douglass Co.	1	0.95	247	0	Douglass
BCA	1	0.95	248	0	Clatsop
Roseburg	1	0.96	249	0	Douglass
Seaside	1	0.96	250	0	Clatsop
Tillamook Co.	1	0.97	251	0	Tillamook
Brookings	1	0.97	252	0	Curry
Dallas	1	0.97	253	0	Polk
King City	1	0.98	254	0	Washington
Warrenton	1	0.98	255	0	Clatsop
Newport	1	0.98	256	0	Lincoln
Forest Grove	1	0.99	257	0	Washington
Manzanita	1	0.99	258	0	Tillamook
Sandy	1	1	259	0	Clackamas
Cannon Beach	1	1	260	0	Clatsop
Total	**260**			66	

Appendix B: Field Protocol

Oregon Residential Energy Code Evaluation

Instructions for Field Protocol Form

General instructions for filling out the inspection protocol form:

Building Identification Number The building identification number should be completed as follows: The building identification number will be a five digit number; the first two digits will be the jurisdiction code number; the third digit will be the field team code number, and the fourth and fifth digits will be the house sequence number within that jurisdiction. For example;

Jurisdiction	02
Field Team number	3
House number within jurisdiction	14

Would have a building identification: 02314
(Be sure to include zeros where appropriate)

All of the blanks on this form should be filled out, checked, circled, or otherwise responded to in some way. If the necessary, fill in additional answers or question marks, etc. All questions with check-boxes in the far left or right margins should be answered. A small number of the questions are dependent on the answers to previous questions, and may not be applicable to all projects. These questions are typically indented from the left or right margin, below the question on which they depend.

The left hand column, and indented columns on the left contain blanks and boxes which should be filled out when the plan review is conducted. On the right are corresponding blanks to be filled out during the field visit. Most questions require a response during the plan review and a verification during the field visit.

The project identification number should be included at the bottom of each page of the protocol form.

The heated floor area calculation should include all floor areas within the heated envelope. Basements which are not heated but are not insulated from the heated space should be counted as heated space, but should be described more specifically in the HVAC section.

When completed, each field protocol should contain the following pieces:

- Inspection Protocol Form
- Sketch of Project Floor Plan
- Photographs of Site
- Window Worksheet
- Window List - blue form
- Door Worksheet
- Component Description Sheets for **each** component type
  - Walls - tan forms
  - Floors - green forms
  - Ceilings - yellow forms
  - Windows - purple forms
  - Doors - orange forms

Depending on project characteristics, the package may also include the following:

- Blower Door Protocol Form
- Performance Path Summary Sheet
- Other forms or information collected

Project Identification

[ ] Jurisdiction Name: ______________________________

______________ Jurisdiction Code

______________ House number in this jurisdiction

[ ] Field Inspector Name: ______________________________

______________ Field Inspector Code

[ ] Project Address:

______________ City/County

____/____/____ Permit Date

[ ] Permit #: ____________________

[ ] Building Valuation (if available): $_____________

____/____/____ Document Review Date Field Review Date ____/____/___

[ ] Contractor Name: ______________________________
Phone Number: ______________________________

[y] [n] Plan set is stamped by a registered architect
If so, Name: ______________________________
Phone Number: ______________________________

Indicate the stage of construction of the house at the time of the field visit, and the status of the building department inspections. [ ]

Insulation not covered [ ]
Insulation covered, but house not yet sealed [ ]
Final Inspection, house fully sealed [ ]

Describe if necessary:
____
____

[ ] Sketch the floor plan of the house, or obtain a copy of the floor plan. Include a plan for each floor and the basement, if any. Be sure that each room is individually labeled for reference with window locations. [ ]

[ ] Number of stories above grade: ________
(For split level, describe below)

In the space below, describe the general configuration of the house (# of stories, style, spec. home or custom, unusual site conditions, etc.) [ ]

____

____

____

[ ] Rooms: # of bathrooms:______ # of bedrooms:______

Describe a notable feature of the house for future reference (Do no use generic descriptions) [ ]

____

Attached Garage; for ______ cars. [ ]

Garage insulated **[y] [n] [?]**
Garage heated **[y] [n] [?]**

Floor plan matches permit drawings **[y] [n]**

Describe any changes to floor plan encountered in field. [ ]

____

____

____

Indicate direction main entry faces (**n, ne, e, se, s, sw, w, nw**): ______ [ ]

Describe neighborhood density (circle) [ ]

urban suburban rural

Field review includes blower door test [y] [n]
If yes, be sure to include blower door protocol form

Describe each photograph taken of the project in the space below Be sure to include a photo of the exterior of the home and its surroundings. Include photos showing insulation or other construction problems, or perfect installations, if you find them. [ ]

Photo #	Description
______	______________________________
______	______________________________
______	______________________________
______	______________________________

[y] [n] [?] Is gas available in this area? (In the field, check for nearby meters, pipeline markers, etc) [y] [n] [?]

[ ] Name of Electric utility ____________________

[ ] Name of Gas utility ____________________

Compliance Information in Documentation

[ ] Check the Compliance Path Indicated on Plans

- [ ] **Prescriptive** Path (circle a path # below)
  1 2 3 4 5 6 7 8 9
- [ ] **Performance** Path
- [ ] **None** indicated

For all **prescriptive paths**, compliance path was indicated on plans by:

- [ ] **Builder**
- [ ] **Plans Examiner**

For **prescriptive path 2, 4, 6**, or **7**; (sun tempered) complete the following:

[y] [n] At least 50% of glazing area faces south [y] [n]

[y] [n] One lot line abuts street within 30° of east/west [y] [n]

Check below the amount of shading from nearby homes, trees, etc. to the south [ ]

completely shaded [ ]

mostly shaded [ ]

partly shaded [ ]

no shading [ ]

For **prescriptive path 8**; (limited floor area/low income) complete the following:

[y] [n] Glazing area less than 12% of Heated Floor Area [y] [n]

[y] [n] Total Heated Floor Area is less than 1500 sq. ft. [y] [n]

[ ] If the project was submitted as **performance path** compliance, or if other **component trade-offs** are used to demonstrate compliance; complete a **performance path summary sheet** and include it with this form. Do not use the performance path summary form for 'window averaging' unless window performance is traded for other house components.

For **all** projects, complete the following:

[y] [n] [?] Did the contractor submit calculations to show that the average U-value of the windows meets code window U-value requirements, rather than each individual window meeting the requirements?

[ ] Review the energy code compliance information presented on the plans and check all boxes below that apply. This question refers to the plans *as submitted*; energy code compliance notes made by the plan reviewer should be described elsewhere.

- [ ] Plans contain **no reference** to energy code compliance path
- [ ] **Compliance path** is indicated on the plans
- [ ] A **generic** energy code table which is not project specific is included on the plans (or **generic** notes or details describing compliance requirements)
- [ ] **Project-specific** notes or tables are included on the plans which specifically describe energy code compliance for this project.
- [ ] Energy code compliance information is provided on an 'official' **compliance form**.
- [ ] Information about project specific insulation levels is provided only in details/sections, not in table form.
- [ ] If the above descriptions do not accurately portray the way energy code compliance info is presented, describe here: ______________________________
____
____

[y] [n] Does the information about insulation levels, etc. listed in compliance forms, tables, or standardized details above match the other details or descriptions in the plans? Describe any inconsistencies below:

____

____

[ ] Compliance information on drawings was apparently developed by:

- [ ] Builder (check here if no other is indicated)
- [ ] Architect
- [ ] Engineer
- [ ] Utility Consultant
- [ ] Plans Examiner
- [ ] Other: ______________________________

For All Projects, answer the following:

Verify that insulation R- or U-values are specifically indicated in the plan set for each of the following components.

If the information is not on the plans; circle NO.
If the information is provided **only** in a **generic** code table; circle **no**.
If the information for the component is provided **only** by the **plan reviewer;** circle no, check the enforcement column, and describe the requirements.

Indicated on plans	Component	Enforcement	Requirements
[y] [n]	Walls	[ ]	______________
[y] [n] [n/a]	Floors	[ ]	______________
[y] [n]	Ceilings	[ ]	______________
[y] [n] [n/a]	Basement Walls	[ ]	______________
[y] [n] [n/a]	Slab Edge	[ ]	______________
[y] [n]	Entry Door	[ ]	______________
[y] [n] [n/a]	Other Doors	[ ]	______________
[y] [n]	Windows	[ ]	______________
[y] [n] [n/a]	Duct Insulation	[ ]	______________

Based on the answers to the questions above, did the plans **as submitted** include enough information to determine whether the project meets energy code requirements? (Not including information provided by plans examiner)

[y] [n]

If **no**, describe:

____

____

Code Enforcement Notes

Review the permit file for any indication of corrections required for energy code compliance, or other notes on energy code enforcement. Describe below any notes or other information in the file regarding energy code enforcement. Specific requirements which are identified as corrections required should be listed.

[ ] General notes on energy code enforcement:

____

____

____

____

____

____

[ ] List specific energy code notes/corrections indicated for this project by the code officials during the **plan review**. Look for these corrections in the field.

____ [ ]

____

____

____

____

____

List specific energy code notes/corrections indicated for this project by the code officials during **field inspections**. (Review the inspection card if available) Look for these corrections in the field. [ ]

____

____

____

____

____

____

Did the corrections specifically require additional inspections? **[y] [n] [?]**

If yes, describe:

____

____

Plan Take-offs
Envelope

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

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

Windows, doors, and skylights should be thoroughly described in the appropriate section.

All information should be verified during the field visit. If variations are discovered in the field, **make a note of new values and any construction changes,** on the component description forms. **Be sure to verify field areas below.**

__________ Floor Area listed on plans (if available)

__________ **Heated Floor Area (HFA) ft^2**
Do not use area listed on plans; calculate for each house. If there is a basement, be sure to determine if it is part of the *heated* space, or just a buffer space. Verify this information in the field.

Verify Heated Floor Area in field: __________

__________ **House Volume ft^3** [ ]

WALLS

________ **Number of Wall Types**
Include walls with different insulation types, basement walls, vault walls, walls between heated space and attics/garages, etc. as distinct types. Calculate gross wall areas, then account for windows in the window section. Fill out a wall component form **(tan)** for each wall type.

Type #	Description	Plan Area (gross)	Field Area (gross)

FLOORS

________ **Number of Floor Types**
Frame floors should be separated from slab floors. Slab floor area should be calculated as a perimeter. Separate slab on grade from below grade slabs. Fill out floor component form **(green)** for each floor type.

For **slabs**, indicate **perimeter** instead of area.

Type #	Description	Plan Area (slab perim.)	Field Area (slab perim.)
______	______________________________	__________	__________
______	______________________________	__________	__________
______	______________________________	__________	__________
______	______________________________	__________	__________

CEILINGS

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

Type #	Description	Plan Area (gross)	Field Area (gross)
______	______________________________	__________	__________
______	______________________________	__________	__________
______	______________________________	__________	__________
______	______________________________	__________	__________

WINDOWS

For each project, fill out the following to characterize the **windows**:

Window Worksheet
Window List (blue)
Window/Skylight/Glazed Door Type Description Form (purple) for each type

DOORS

For each project, fill out the following to characterize the **doors**:

Door Worksheet
Door Type Description Form (orange) for each type

Each of the types of each component listed above must be described on the component forms. These descriptions should be verified in the field. If new component types are encountered in the field, a new component description should be filled out.

After developing envelope takeoffs, answer the questions below:

Ceilings

[y] **[n]** Advanced Framing is indicated/installed in the ceiling (If **yes**, answer the following) [y] [n] [?]

______	Rafter spacing	______
______	Rafter depth at walls	______
[y] **[n]**	Ceiling fully insulated at perimeter (above exterior walls)	[y] **[n]** [?]
	Describe (full depth heels, use of rigid insul, etc.): ______________________	

[y] **[n]** Loose fill insulation is indicated/installed in the ceiling (If **yes**, answer the following) [y] [n] [?]

[y] [n]	Roof slope is 4:12 or steeper	[y] [n] [?]
[y] [n] [?]	Headroom at ridge is at least 44"	[y] [n] [?]
[y] [n] [?]	Baffles are indicated/installed	[y] [n] [?]
______	Depth of insulation specified	

Check all structural systems installed in roof [ ]

dimensional lumber	[ ]
manufactured trusses-dimensional lumber	[ ]
manufactured trusses-manufactured lumber	[ ]
steel members	[ ]
stress-skin panels	[ ]
other ______________________	[ ]

[ ] For vaulted ceilings at dormers, bay windows, or elsewhere, try to determine the structural depth and insulation levels specified for those areas. If there is indication on plans or in field that part of the ceiling will be insulated to only R-21 or less; [ ]

Indicate the area of R-21 vaulted ceiling: __________

Walls

[y] [n] Advanced Framing is indicated in the walls
(For plan takeoffs, answer the following only if advanced framing is indicated; in the field, answer these questions in either case.)

[y]	[n]	Stud spacing 2 ft.	[y] [n] [?]
[y]	[n]	Headers insulated	[y] [n] [?]
[y]	[n]	Corners insulated	[y] [n] [?]
[y]	[n]	Insulation on outside of partition wall intersections	[y] [n] [?]

Check all wall structural systems installed [ ]

dimensional lumber	[ ]
manufactured lumber	[ ]
steel studs	[ ]
stress-skin panels	[ ]
other ______________________________	[ ]

Floors

[y] [n] Concrete Slab indicated/installed [y] [n]

[y]	[n]	For slab on grade, perimeter insulation indicated/installed	[y] [n] [?]
[y]	[n]	For foundation w/ slab, thermal break indicated/installed	[y] [n] [?]

Check all floor structural systems installed [ ]

post & beam w/ 'car decking'	[ ]
dimensional lumber joist system	[ ]
manufactured lumber joist system	[ ]
slab	[ ]
other ______________________________	[ ]

For projects with basements, answer the following

[y] [n] [?] Do submitted plans indicate that the basement is heated?

In the field, basement is part of heated space [y] [n] [?]

(Answer **yes** if any of the following is true:)

The primary heating system supplies the basement.
A secondary heating system supplies the basement.
The floor between the basement and the living space above is uninsulated.
The basement stairway is open to the floor above.

If the answer to above is **yes**, be sure that component descriptions of the basement walls, windows, doors, floor are filled out, and revise component lists to indicate basement component areas. [ ]

[y] [n] [?] Do submitted plans indicate that the basement is insulated?

Describe how the basement is insulated from the house above, and from the outside. [ ]

____

____

Describe how the basement is heated, if at all. [ ]

____

____

Insulation Quality

Insulation installed in the field should be compared with notes on the component worksheets to verify component performance. In addition, the following questions should be answered in the field with regard to the insulation itself.

Attic

Indicate the type of insulation installed in the attic: [ ]
(No attic [ ])

Fiberglass Batt [ ]
BIBS [ ]
Blown Fiberglass; pink or yellow cubes [ ]
Blown Fiberglass; white [ ]
Cellulose [ ]
Mineral Wool [ ]
Other [ ]

____

Is there an insulation certificate? [y] [n] [?]

If so, describe specs:

____

____

—

Describe insulation: [ ]

Brand: ____________________
Color: ____________________
R-value coding, (batt): ____________________

Rafter spacing: __________

For loose fill insulation answer the following: [ ]
(No loose fill [ ])

Insulation Density: __________ [ ]

Are depth indicator strips installed? **[y] [n] [?]**

Circle the consistency of insulation depth [ ]

even somewhat uneven very uneven

Measured insulation depth: __________ [ ]

Weight per sq. ft. of insulation: __________ [ ]

For batt insulation, answer the following: [ ]
(No batts in attic [ ])

Are truss bottom chords covered by insulation? **[y] [n] [?]**

Is attic hatch insulated to same level as attic? **[y] [n] [?]**

Describe any missing insulation or other problems: [ ]

____

____

Walls

Describe how much of the wall insulation you are able to review (i.e., how much is covered vs. accessible) [ ]

____

____

Review each wall component description sheet and verify that the wall insulation is accurately characterized. Then answer the questions below. [ ]

Look for the following insulation problems, and check boxes if found: [ ]

Short batts [ ]
Compressed insulation [ ]
Utility cuts [ ]
Batts inside stapled, not lapped [ ]
Other ______________ [ ]

Describe the extent of these problems: [ ]

____

____

____

For houses with an upper floor, check for insulation at the perimeter (rim joist). Is this area insulated? **[y] [n] [?]**

Based on the above questions, estimate the percent of wall area which is underinsulated: ________

Floors

For floors over unheated space or crawlspace, answer the following: [ ]

(Not applicable [ ])

Depth of floor joists ________

Describe how underfloor insulation is supported: ______________________ [ ]

____

Underfloor insulation installed flush to 'warm side' of floor **[y] [n] [?]**

Is any insulation missing, or hanging down out of floor joists? **[y] [n] [?]**

If the crawlspace access hatch is inside the house, is it insulated to the same level as the rest of the floor? [y] [n] [?]

Based on the answers above, estimate the percent of floor that is underinsulated: __________

Perimeter of crawl space is insulated [y] [n] [?]

If yes, **R-value:** __________

Crawlspace is ventilated (screened vents to outside) [y] [n] [?]

Describe crawlspace access: [ ]

____

Vapor Barriers

[ ] For each of the components below, indicate whether the plans call for vapor barriers. In the field verify vapor barrier installation. Beneath each component, indicate the type of vapor barrier installed. [ ]

Indicated on plans	Component	Installed in field
[y] [n]	**Walls**	[y] [n] [?]
	type: __________	
[y] [n]	**Vaulted Ceiling**	[y] [n] [?]
	type: __________	
[y] [n]	**Floor**	[y] [n] [?]
	type: __________	
[y] [n] [n/a]	Ground cover in crawlspace (continuous)	[y] [n] [n/a]
[y] [n] [n/a]	Vapor barrier under slab on grade	[y] [n] [n/a] [?]

Describe any problems with vapor barrier installation here:

____

____

For each of the locations listed below, indicate whether sealant/weather-stripping was installed. [ ]

Location	Installed
Window edges	[y] [n] [?]
Operable window sash (if custom)	[y] [n] [?]
Door frame edges	[y] [n] [?]
Door weather-stripping	[y] [n] [?]
Wall at sole-plate/sub-floor	[y] [n] [?]
Walls at roof	[y] [n] [?]
Wall seams	[y] [n] [?]
Floor seams	[y] [n] [?]
Utility penetrations	[y] [n] [?]
Shower/Tub	[y] [n] [?]
Attic/crawl space access doors	[y] [n] [?]

[y] [n/a] If sealant type and/or application is described in general terms on the plans, include the description below.

____

____

____

Lighting

[y] [n] [?] Recessed light fixtures are indicated on plans — Installed in field [y] [n] [?]

__________ Number of recessed fixtures (Count only fixtures installed through insulated ceiling, not between floors) __________

[y] [n] IC rating indicated [y] [n] [?]

Are any compact fluorescent lamps installed in the house? [y] [n]
Are any 'conventional' fluorescent fixtures installed in the house? [y] [n]

HVAC

[ ] [?] **Primary Heating system type** [ ]

[ ] Ducted Furnace [ ]
[ ] Hydronic [ ]
[ ] Wall Heaters/Electric Baseboard [ ]
[ ] Heat Pump (ducted) [ ]
[ ] Other ______________________ [ ]

[ ] [?] Fuel [ ]

- [ ] Electric [ ]
- [ ] Gas [ ]
- [ ] Propane [ ]
- [ ] Oil [ ]
- [ ] Other ______________________ [ ]

[ ] [?] Make/Model ____________________________________ [ ]

[ ] [?] Model Number: ____________________________________ [ ]

[ ] [?] Total capacity (fill in all that apply) [ ]

- [ ] Input ________________ [ ]
- [ ] Output ________________ [ ]
- [ ] kW ________________ [ ]
- [ ] Other ________________ [ ]

[ ] [?] Efficiency ___________ [ ]

- [ ] AFUE
- [ ] Steady State
- [ ] HSPF
- [ ] COP
- [ ] Electric (Efficiency=1)
- [ ] Other ______________________

[ ] [?] If there is a secondary system, describe type and size: [ ] [n/a]

____

____

For Heat Pumps, indicate make/model and capacity of outdoor unit [ ] [n/a]

____

List the number fireplaces or other wood burning appliances below [ ]

gas fireplace _____
wood fireplace _____
woodstove _____
pellet stove _____

For combustion furnaces, does the flue include a forced-draft system? [y] [n]

Indicate location of heating system (for example, attic, crawl space, interior closet, garage, basement) [ ]

____

Located within **heated** space [y] [n]

Located within **insulated** space [y] [n]

If the heating equipment is located in a basement, describe the extent to which the basement is finished, and heated. Is this a fully heated space, a buffer space, or an uninsulated area? [ ]

____

____

____

Verify in the field that the basement is finished and insulated to the same degree indicated on the plans. If not, describe changes below. [ ]

____

____

Thermostat Type [ ]

Programmable [ ]
Simple Setback [ ]
Single Temperature [ ]
Zoned/Unit by Unit [ ]
None [ ]
Other [ ]

____

Number of Thermostats __________

Cooling system type [ ] **[none]**
(Obtain this information in the field unless it is readily available on plans.)

Central A/C [ ]
Heat Pump [ ]
Swamp Cooler [ ]
Zoned Thru-wall A/C [ ]
Other [ ]

____

Describe cooling system changeover control: [ ]

Cooling system must be **manually switched** to cooling mode (e.g. switch on thermostat) [ ]
Thermostat provides **automatic switching** to cooling mode based on temperature setting [ ]
Other:____________________ [ ]

____

Capacity [ ]

____

Make/Model [ ]

____

Model Number [ ]

____

Efficiency [ ]

____

EER [ ]
SEER [ ]
Other [ ]

____

Location of cooling system (describe indoor and outdoor components) [ ]

____

Located within insulated space **[y]** **[n]**

Ductwork

Describe the **location** and **construction** of the ductwork: [ ]

____

____

____

____

Describe any obvious leaks or problems with the duct system, and whether any attempt has been made to seal the ductwork for air leakage. [ ]

____

____

Check all types of ductwork present below [ ]

Sheet Metal [ ]
Flex Duct [ ]
Duct board [ ]
Cavity used for ducting; supply [ ]
Cavity used for ducting; return [ ]
Other [ ]

____

Indicate the R-value installed for ductwork insulation _________

Estimate the percentage of the total length of supply ductwork located in **unheated** space. __________

Estimate the percentage of the total length of return ductwork in **unheated** space. __________

Pipes/Hot Water

[y] [n] Is pipe insulation indicated/installed for water system pipes? [y] [n] [?]

Type: ______________________________ [ ]

[y] [n] Insulation under hot water tank indicated/installed? [y] [n] [?]

Use information on the **'Energyguide'** label on the hot water tank : [ ]

Fuel type: ______________

Annual operating cost for this model: ($)______________

National average fuel cost: ($)__________ per (units)__________

[y] [n] Low-flow shower heads indicated/installed? [y] [n] [?]

Verify flow if possible __________ [ ]

Ventilation System

Indicate the type of ventilation system installed. [ ]

None [ ]

Spot ventilation (list locations) [ ]

____

____

____

Whole house fan (without heat recovery) [ ]

Air-to-air heat exchanger [ ]

Other type of heat recovery ventilation [ ]

Other [ ]

____

____

Site Visit Summary [ ]

Describe general observations or issues you noticed during the site visit which might affect longevity or energy performance.

____

____

____

____

Door Worksheet

__________ Total number of exterior door types in this project

Each of the following should be counted as a separate door type:

Main entry doors

Each different type of entry door between heated and unheated space

Doors which have more than 2.5 sq. ft. of glazing area
(sliding glass doors should be counted as windows)

[ ] For each door type fill out a door type description sheet (**orange**).
For glazed 'swing' doors, fill out a window type description (**purple**)

[y] [n] Entry door includes 'ornamental' single glazing on plans

Single glazing present in field [y] [n] [?]

______ Area of single glazing on plans

in field: ______

[y] [n] Double entry door is indicated on plans

Double entry door installed in field [y] [n]

Indicate total door area by type in the table below. Verify this information in the field.

OPAQUE DOORS

Door Description	Wall Type	Plans		Field	
		Type #	Area	Type #	Area

GLAZED 'SWING' DOORS

Door Description	Wall Type	Plans		Field	
		Type #	Area	Type #	Area

__________ **Building Identification Number** (Revised Protocol 01/26/94)

Window List   Building Identification Number__________

Using the window types defined on the window worksheet, list **each** window by size and location, using room names/numbers on sketch. Verify this list in the field and note any modifications. Use additional sheets if necessary. Do not list skylights or glazed 'swing' doors here.

Location Info				**Plan Info**				**Field Info**				
Win # from sketch	**Location**	**Direction**	**Wall Type**	**Window Type (#)**	**Operation***	**Size (width x height)**	**Area**	**(✓) if same in field**	**Window Type (#)**	**Operation***	**Size (width x height)**	**Area**

* **Window operation:** (f):fixed (c):casement (s):slider (sh,dh):single or double hung (a):awning (sd):sliding door (gd):glazed door

WALLS Component Description Form

__________ Wall type

Wall construction different in field (if so, indicate changes below) [y] [n] [?]

Location

____

Stud spacing: [16"] [24"]

Wall thickness: [2x4] [2x6]

__________ **Insulation on plans** **Insulation in field:** __________

If insulation R-value is not apparent, look for coding stripes, and describe brand, color, and thickness: [ ]

____

____

[y] [n] Is there rigid insulation indicated on plans?

Is there rigid insulation installed in field? [y] [n] [?]

If yes, describe:
R-value:________
Thickness, brand, etc: ____________________________

Description of wall construction (materials, finishes)

[ ] plans:

____

____

field: [ ]

____

____

Insulated headers: [y] [n] [?]

FLOORS Component Description Form

__________ Floor type

Floor construction different in field (if so, indicate changes below) **[y] [n] [?]**

[ ] Frame
[ ] Slab

Location

____

For **slabs:**

Slab depth below grade: ______________________________
Describe slab insulation strategy: _________________________
Describe connection between slab and foundation wall, if any:

____

__________ **Insulation on plans** **Insulation in field:** __________

If insulation R-value is not apparent, look for coding stripes, and describe brand, color, and thickness: [ ]

____

____

Description of floor construction (thickness, materials, finishes)

[ ] plans:

____

____

field: [ ]

____

____

Joist spacing: __________

CEILINGS Component Description Form

__________ Ceiling type

Ceiling construction different in field (if so, indicate changes below) **[y] [n] [?]**

[ ] Attic
[ ] Vault

Location

____

For vaults, indicate structural depth: __________

__________ **Insulation on plans** **Insulation in field:** __________

If insulation R-value is not apparent, look for coding stripes, and describe brand, color, and thickness: [ ]

____

____

Description of ceiling construction (materials, finishes)

[ ] plans:

____

____

field: [ ]

____

____

Rafter spacing: __________

WINDOW Type Description

Fill out a description for each window or skylight type.

During plan review, answer as many of the plan side questions as possible. In the field, verify, add, or change information **in the field column only**. If new window types or variations are found in the field, fill out a **new** window description form, and update the window list.

_____________ **Window Type (#)** Window type in field is different from plans **[y] [n] [?]**
(If **yes**, fill in modifications below)

[ ] Window
[ ] Skylight
[ ] Sliding Glass Door
[ ] Glazed 'Swing' Door (% glazing of total door area _______)

Window type description: ____

Plans		Field
[wood] [vinyl] [alum] [clad]	Frame material	**[wood] [vinyl] [alum] [clad]**
[y] [n] [?] [n/a]	Thermal break? (if alum)	[y] [n] [?] [n/a]
	Glazing layers (#)	[1] [2] [3]
	Tint	[y] [n] [?]
__________	Spacing	______________
[y] [n] [?]	Low-ε coating	[y] [n] [?]
[y] [n] [?]	Argon filled	[y] [n] [?]

Manufacturer: [ ]

[y] [n] Window specification on plans

If yes, U-value indicated: ______

Window performance labels present in field [y] [n]

If yes, labeled U-value:_________

Type of rating:
- NFRC [ ]
- AAMA [ ]
- Limited. prod. default [ ]
- Sigma, custom glazing [ ]

_____________ **Building Identification Number** (Revised Protocol 01/25/94)

DOORS Type Description

Fill out a description for each door type. If the information cannot be determined, describe why not.

____________ **Door Type (#)** Door type in field is different from plans (If **yes**, indicate changes in the **field** section below) **[y] [n] [?]**

[ ] Main Entry Door
[ ] Other Opaque Door

[ ] Location:
____

[ ] Description of construction:

plans:____________________________________

field:____________________________________

Manufacturer: [ ]

[y] [n] Door thermal specification on plans
Specified U-value: __________

Door labels present in field **[y] [n]**
U-value on label: __________

________ Building Identification Number

____/____/____ Date

BLOWER DOOR TEST

Describe construction status of house, with particular attention to sealant, weather-stripping, and other issues which might effect the outcome of the blower door test.

____

____

____

____

Set-up: Close all windows and doors to the outside. Open all interior doors, close all dampers and doors on wood stoves and fireplaces. Ensure that furnace and water heater can not come on during test. Make sure all fans are off.

House Volume _________

Reference Pressure ______ Plug fan hole and record pressure difference across the door

Turn blower door on and depressurize house to 25 PA from reference pressure.

Negative house pressure _______Pa
Ring size (O,A,B,C) _______
Flow pressure _______Pa
CFM _______

Turn blower door on and depressurize house to 50 PA from reference pressure.

Negative house pressure ______Pa
Ring size (O,A,B,C) ______
Flow pressure ______Pa
CFM ______

Restore doors, flues, and equipment to condition you found them in.

__________ Building Identification Number

Performance Path Summary

Fill out this form for each project submitted under **performance** compliance path. Include this form with the field forms.

[ ] UA Calculations

______ Indicate the **proposed UA** shown for the project in the calculations

______ Indicate the **target UA** shown for the project.

Using the performance information in the submittal, fill out the components and their areas and U-values in the table below. In the field, verify that these components were constructed as indicated, or note any changes.

[ ] Using the performance submittal, fill out the components (walls, windows, doors, floors, ceilings) and their areas and U-values in the table below. In the field, verify that these components were constructed as indicated, or note any changes.

Component	#	Description	Area	U-value	Verify
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]
					[ ]

__________ Building Identification Number

Performance Path Summary, pg 2

[ ] Compare the take-offs in the submittal to the take-offs developed from the permit set. Discuss any discrepancies or variations below.

____

____

____

____

Compare the take-offs in the submittal to the construction types found in the field. Discuss any discrepancies or variations below. [ ]

____

____

____

____

[ ] Review the component U-values and try to determine why the performance path was used. Check if tradeoffs below are used, or describe others.

- [ ] front door area >24 $ft.^2$ (double entry door)
- [ ] skylight area >2% of HFA
- [ ] efficient windows used
- [ ] other:______________________________

____

____

Appendix C: Interview Protocols

Residential Buildings Energy Code Survey

Building Code Officials Questionnaire

Interviewer Name ______________________________ Date ______________

Jurisdiction Name: ______________________________ Code: ______________

Comments:

A. Initial Contact

Hello, I'm __________ from ECOTOPE, Inc. a energy research firm. We are conducting a survey for the Oregon Department of Energy about the Energy Code for Residential Building. May I speak with the person who is responsible for plans review or field inspection of residential buildings?

Name:

Title:

Phone:

Hello, I'm __________ from ECOTOPE, Inc. a energy research firm. We are conducting a survey for the Oregon Department of Energy about the Energy Code for Residential Building. Although your response is voluntary, we hope you will participate in the interview. Your response is confidential. Any information we collect will be used for statistical purposes. We will not release or disclose this information to anyone, including the Oregon Department of Energy.

A-1. How many years have you been employed within a building department?

________ years.

A-2. What is your primary responsibility in enforcing the energy code for residential buildings?

a. Plans Review

b. Field Inspection

c. Plans Review and Field Inspection

d. Other __________

(If "other," ask for the employee who is responsible for plans review or inspection of residential buildings.)

B. Building Jurisdiction Questions

B-1. What is the total number of staff that primary review residential buildings plans for the Oregon Structural Specialty Code? __________

B-2. What is the total number of staff that inspect residential buildings for the Oregon Structural Speciality Code? __________

B-3. What is the total number of new single-family residential building permits that where issued in 1993 (exclude fabricated homes)? __________

B-4. What would be the average cost of the building permit for an average single-family residential building with 2,000 square feet (no garage or unheated basement)?

____

(If "field inspector," skip to section D.)

C. Plans Review Process

C-1. How many times out of 100 permits does the applicant request training or assistance with the residential energy code? ______

C-2. What type of technical support or training do you provide to builders for energy code questions?

a. Phone support

b. Over the counter (in person)

c. Printed handouts

d. Other ______________________________

C-3. How often do you find the information on the plans or supporting information with the following features?

		Always	**Often**	**Seldom**	**Never**
a.	The Compliance Path (1-9)	[ ]	[ ]	[ ]	[ ]
b.	Insulation R-value for walls	[ ]	[ ]	[ ]	[ ]
c.	Insulation R-value for roofs	[ ]	[ ]	[ ]	[ ]
d.	Insulation R-value for floors	[ ]	[ ]	[ ]	[ ]
e.	Insulation R-value for slabs	[ ]	[ ]	[ ]	[ ]
f.	U-value for windows	[ ]	[ ]	[ ]	[ ]

g.	Moisture barriers	[ ]	[ ]	[ ]	[ ]
h.	Air leakage rate for doors	[ ]	[ ]	[ ]	[ ]
i.	Air leakage rate for windows	[ ]	[ ]	[ ]	[ ]
j.	Position of the slab insulation	[ ]	[ ]	[ ]	[ ]
k.	Wall frame size and spacing	[ ]	[ ]	[ ]	[ ]

C-4. How often do you have time to verify compliance with the following features?

		Always	**Often**	**Seldom**	**Never**
a.	The Compliance Path (1-9)	[ ]	[ ]	[ ]	[ ]
b.	Insulation R-value for walls	[ ]	[ ]	[ ]	[ ]
c.	Insulation R-value for roofs	[ ]	[ ]	[ ]	[ ]
d.	Insulation R-value for floors	[ ]	[ ]	[ ]	[ ]
e.	Insulation R-value for slabs	[ ]	[ ]	[ ]	[ ]
f.	U-value for windows	[ ]	[ ]	[ ]	[ ]
g.	Moisture barriers	[ ]	[ ]	[ ]	[ ]
h.	Air leakage rate for doors	[ ]	[ ]	[ ]	[ ]
i.	Air leakage rate for windows	[ ]	[ ]	[ ]	[ ]
j.	Position of the slab insulation	[ ]	[ ]	[ ]	[ ]
k.	Wall frame size and spacing	[ ]	[ ]	[ ]	[ ]

C-5. How often does your jurisdiction require energy code compliance forms for a residential project to demonstrate energy code compliance? (Circle one)

a. Never.

b. Seldom.

c. Sometime.

d. Always.

e. Unaware of the form.

C-6. (If "Seldom" or "Sometime," ask this question.) Under what condition(s), does your jurisdiction require the energy code compliance forms on the plans? (Circle one or more)

a. When information on the plans is without compliance information.

b. When the track record of a given contractor is unknown.

c. Other ______________________________

C-7. What is the current overall turn around time for code review in your jurisdiction?

____

C-8. What percentage of that is energy code review? __________

C-9. Which compliance paths are most **frequently** submitted? __________

C-10. Which compliance paths are **infrequently** submitted? __________

C-11. What percentage of projects are submitted under the **performance** path? __________

C-12. How are performance path submittals reviewed? Systems analysis?

C-13. How many times out of 100 permits do you see utility-sponsored programs?

____

C-14. (If question C-13 is more than 0) Are these projects handled differently?

C-15. How are plan review energy code corrections followed up?

C-16. What are the most common enforcement or compliance issues which come up during plans examination?

C-17 What part of the energy code are frequently misinterpreted or ignored by designers.

(Skip to Section E)

D. Initial Contact For Field Inspectors

D-1. How often are you able to verify compliance with the following features?

		Always	Often	Seldom	Never
a.	The Compliance Path (1-9)	[ ]	[ ]	[ ]	[ ]
b.	Insulation R-value for walls	[ ]	[ ]	[ ]	[ ]
c.	Insulation R-value for roofs	[ ]	[ ]	[ ]	[ ]
d.	Insulation R-value for floors	[ ]	[ ]	[ ]	[ ]

e.	Insulation R-value for slabs	[ ]	[ ]	[ ]	[ ]
f.	U-value for windows	[ ]	[ ]	[ ]	[ ]
g.	Moisture barriers	[ ]	[ ]	[ ]	[ ]
h.	Air leakage rate for doors	[ ]	[ ]	[ ]	[ ]
i.	Air leakage rate for windows	[ ]	[ ]	[ ]	[ ]
j.	Position of the slab insulation	[ ]	[ ]	[ ]	[ ]
k.	Wall frame size and spacing	[ ]	[ ]	[ ]	[ ]

D-2. How are energy code compliance requirements communicated to the field inspector?

a. Indicating the compliance path on the inspection card.

b. Indicating the compliance path on the plans.

c. Indicating the insulation levels and U-value of the windows on the plans.

d. Compliance forms

e. Other ______________________________

D-3. Do energy code corrections identified in the field require additional inspections, or are they picked up in subsequent inspections?

D-4. What types of energy code compliance issues are most frequently encountered in the field?

D-5. For each of the following energy code issues, pleas discuss at which inspection stage the issue is reviewed. (if any)

a. **Walls**

Insulation R-value

Quality of insulation

Vapor barriers

Advance framing

b. **Roof**

Insulation R-value

Quality of insulation

Vapor barrier

Advance framing

c. **Floor**

Insulation R-value

Quality of insulation

Subcontractor damage

Rim joist insulation

d. **Other**

Window performance

Door performance

Can light IC rating

Weather-stripping, sealant

Duct insulation

Pipe insulation

Low flow fixtures

E. Compliance Issues

E-1. On a scale of 1 to 5, please rate how significantly the following issues affect energy code enforcement.

[ ] Energy code enforcement has have a low priority (if so discuss)

[ ] Obscure or unenforceable code language

[ ] Lack of enforcement resources

[ ] Consistency and availability of technical backup from code support agencies

[ ] Technical difficulty in meeting code requirements

[ ] Lack of printed material (technical support)

[ ] Changes to projects in the field

[ ] Insufficient information in project submittals

[ ] Insufficient/nonexistent product labeling in field

[ ] Other: ______________________________

E-2. For the following groups, describe the most frequent problem areas with regard to the requirements of the energy code.

a. Builders

b. Developers

c. Architects/Designers

d. Code Enforcement Officials

E-3. What kinds of problems come up under various compliance paths?

a. Prescriptive Paths

b. Performance Path

E-4. What percent of projects are required to be modified for energy code compliance?_______

E-4. What percentage of projects have energy code compliance problems in the field inspections? ________

E-5. What errors or ambiguities have you encountered in the code which complicate energy code enforcement?

E-6. What percent of new residential projects would you estimate comply with energy code requirements? _______

F. Training

F-1. Do you get technical support from the following agencies for energy code enforcement?

a. OBOA

b. BCA

c. ODOE

d. OSU Extension Energy Program

F-2. How responsive or reliable is this support?

F-3. How are energy code officials trained in the energy code?

F-4. Are there currently enough training resources available to you and your staff?

F-5. How effective is the training at covering the issues you encounter with the energy code?

G. Follow up

G-1. What do you feel is the overall impact of the energy code?

G-2. How well is the energy code currently accepted by:

- a. Builders
- b. Building department staff
- c. Designers

G-3. How would you go about improving energy code compliance levels?

G-4. Would additional enforcement resources affect energy code compliance?

G-5. What would be the most effective use of resources to improve energy code compliance levels?

- a. Education for builders
- b. Education for code officials
- c. Improved code language
- d. More inspectors
- e. More time/inspection
- f. More inspections

G-6. Do you have any other comments or suggestions

(Thanks for your time)

H. Use this table to record specific comments about energy code measures

H-1. Walls

a. insulation levels

b. quality of installation

c. framing

d. vapor barrier

H-2. Windows

a. glazing area

b. performance rating (plans vs. field)

c. single glazing

H-3. Doors

a. performance

b. limits on area of solid wood

c. glass

H-4. Floors

a. insulation levels

b. installation

c. subcontractor damage

d. perimeter insulation

H-5. Roofs

a. insulation

b. depth

c. R-values

d. fluffing

e. gaps (can lights, ducts, etc)

f. skylights

H-6. Mechanical Systems

a. pipes and ducts

b. equipment sizing and efficiencies

General Information

Interviewer: ____________________
Date: ____________________

Name of Interviewee: ____________________
Title: ____________________
Firm Name: ____________________
Type of Firm: ____________________
Size of Firm (employees): ____________________
Address: ____________________
____
____
Phone Number: ____________________

Profession: ____________________

How many residential projects do you complete annually. _____

What is the price range of your residential construction projects.

____

In which jurisdictions are you active.

Do you participate in utility sponsored incentive programs? (discuss)

Process

Which energy code path are your residential projects most frequently submitted under?

Do you have a standard process for developing energy code submittals?

What form do they usually take? (specific format; general notes on plans, schedules; none)

Impacts

Does the energy code have an affect on your projects? **[y]** **[n]**

How does the energy code affect the following phases of your projects?

Design and planning

Construction phase

Project cost

Describe **specific** aspects of the code which have significant impacts to project cost?

Does the energy code affect the length of time it takes to complete a project?

How frequently (% of projects) does energy code enforcement result in modifications to your project in the following phases:

Design/planning phase	______
Permitting	______
Construction	______

What percentage of residential projects would you estimate comply with energy code requirements? (all projects, not just your own)

______

General Code Impressions

Describe your general impressions on the energy code.

What are the energy conservation impacts of the Oregon Residential Energy Code?

Code Enforcement and Building Department Interactions

Do you encounter variations in enforcement between jurisdictions?

List specific measures which seem to be interpreted or enforced in a variety of ways, or which you most frequently disagree with the building department over.

Describe specific problems you find with energy code requirements for the categories listed.

On a scale of 1 to 5, please rate how significantly the following issues affect energy code enforcement.

General

[ ] Obscure or unenforceable code language
[ ] Lack of resources at enforcement jurisdictions
[ ] Resistance to code requirements by building community
[ ] Limited understanding of code requirements
[ ] among builders
[ ] among code officials
[ ] Lack of technical backup
[ ] Cost of energy code compliance to builders
[ ] Inconsistent interpretation of energy code requirements
[ ] Time involved to assure energy code compliance
[ ] Other ____

Technical

[ ] Technical difficulty in understanding code requirements
[ ] Technical difficulty in meeting code requirements
[ ] Availability of window performance data
[ ] Availability of other performance data (insulation, construction type, etc)
[ ] Other ____
____

What type of training or technical support is currently available to you for energy code questions?

Have you participated in any of the available training?

Are additional energy code training or technical support resources needed?

Would you participate in energy code training in the future?

Improvements you suggest to energy code:

Use this table to record specific comments about energy code measures

[ ]	**Walls**
[ ]	insulation levels
[ ]	quality of installation
[ ]	framing
[ ]	vapor barrier
[ ]	**Windows**
[ ]	glazing area
[ ]	performance rating (plans vs. field)
[ ]	single glazing
[ ]	**Doors**
[ ]	performance
[ ]	limits on area of solid wood
[ ]	glass
[ ]	**Floors**
[ ]	insulation levels
[ ]	installation
[ ]	subcontractor damage
[ ]	perimeter insulation
[ ]	**Roofs**
[ ]	insulation
[ ]	depth
[ ]	R-values
[ ]	fluffing
[ ]	gaps (can lights, ducts, etc)
[ ]	skylights
[ ]	**Mechanical Systems**
[ ]	pipes and ducts
[ ]	equipment sizing and efficiencies