How Do We Know Commercial Codes Deliver Energy Savings? Designing and Testing a New Methodology for Assessing Commercial Code Compliance

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Abstract

Energy codes are identified as a key strategy for meeting a number of energy planning and policy goals. For example, integrated resource plans; aggressive regional, state, and municipal carbon reduction goals; and renewable and efficiency portfolio standards increasingly depend on dramatic energy reductions in new building construction. In addition, many dense urban areas are rapidly adding new commercial and mid- to high-rise multifamily buildings. To meet policy goals and avoid the lost opportunities for deep energy savings in new buildings, energy codes must be more stringent, buildings must comply with these codes, and the codes must actually deliver the increased efficiency that policies are counting on. Although fairly reliable methods exist for assessing residential code compliance, the commercial sector lacks a reliable, repeatable methodology for measuring code compliance. This paper explores the goals, challenges, and structure of an alternative new methodology and mindset for assessing compliance and energy impacts in order to ultimately apply the methodology to a multi-state commercial building code compliance pilot in the Northwest.

Introduction and Background

Energy codes are identified as a key strategy for meeting a number of energy planning and policy goals. For example, integrated resource plans; aggressive regional, state, and municipal carbon reduction goals; renewable and efficiency portfolio standards; and the Architecture 2030 Challenge increasingly depend on dramatic energy reductions in new buildings constructed. In addition, many dense urban areas are rapidly adding new commercial and mid- to high-rise multifamily buildings. To meet policy goals and avoid the lost opportunities for deep energy savings in new buildings, energy codes must be more stringent, buildings must comply with these codes, and the codes must actually deliver the increased efficiency that policies are counting on. Although fairly reliable methods exist for assessing residential code compliance, the commercial sector lacks a reliable, repeatable methodology for measuring code compliance.

This paper explores the goals, challenges, and structure of an alternative methodology and mindset for assessing commercial building code compliance and energy impacts in the Northwest, including Idaho, Montana, Oregon, and Washington. Rather than relying on modeling or interviews with jurisdictions and market actors to assess compliance, the Commercial Building Code Compliance Pilot (Pilot) methodology is based on empirical building characteristics collected onsite and billing data. The compliance assessment method does not attempt to determine compliance on a measure-by-measure basis. Instead it focuses on key determinants of energy use such as UA[1], lighting power density (LPD), and specific mechanical and controls components to identify compliance and compare compliance with the actual energy performance using monthly billing data. The objective of this methodology is to get a better sense of how new commercial buildings are actually being built, the level of code compliance, and how that compliance influences energy savings.

It is important to understand that the commercial codes in virtually all Northwest jurisdictions are actually an amalgam of three prescriptive codes each aimed at different parts of the building

[1] UA is building heat loss expressed as U-value times area.

(envelope, mechanical systems, and lighting systems). Within each code the designer is allowed (even encouraged) to trade-off requirements within the design context. In some cases this tradeoff is obvious and traceable (e.g., heat loss rate of building envelope components and glazing area, lighting power in one part of the building against decreased lighting power in another part of the building). This feature complicates most decisions on compliance. It also suggests that the underlying structure of a compliance review should be subdivided into these three major commercial building code systems.

This conclusion is supported by the fact that in all but the simplest or smallest commercial buildings, code compliance decisions are made by different people. The architect typically controls the building envelope and decides on tradeoffs of building component performance that would allow the design of the building to be executed; the mechanical engineer has complete control over the mechanical system and compliance with that section of the code; and the lighting designer develops the lighting system to meet the code LPD requirements and the lighting control requirements. Each of these areas can and should be evaluated separately.

Generally there is little or no relationship between mechanical system compliance and lighting system compliance. Thus, assessing building wide compliance, without differentiating the compliance of the major systems, misleads the code compliance assessment by assigning non-compliance to systems that comply because some other building system failed.

The complexity of the commercial codes is further increased by a fourth code path embedded in most energy codes: the energy performance path. This approach allows the designer to use an energy simulation approach to tradeoff code components across the three major code sections. For example, a large improvement in lighting efficiency (beyond code) can be traded off against larger glazing areas and reduced envelope performance. Like all buildings, however, their performance depends not on the simulation results but the actual components and controls installed in the building. Thus the meaning of compliance with any section of the code may be ambiguous but the nature of the systems in the building can still be evaluated.

There are no easy solutions to these complex issues when assessing compliance in the new commercial building market using traditional approaches to measuring compliance. This is due to a couple of interrelated issues: sampling and the "behavioral" or "control" aspect found in key aspects of commercial building energy code.

On the sampling side, difficulties arise from several factors. Commercial buildings vary widely in their use, materials, systems and time-to-build. The challenges posed by this heterogeneity are compounded by the fact that anecdotal evidence suggests compliance may vary by building type, building complexity, and jurisdiction. These issues are further compounded by the fact that there may not be enough buildings of particular type/complexity under construction at any given time to allow a researcher to make statistically reliable projections from the sample to the whole market.

Even if the sampling issues could be adequately addressed, system controls and implementation present another set of challenges to relying on the typical approach to compliance assessment. The effectiveness of many key code elements requires controls to be in place and have optimal settings (e.g., temperature setbacks, resets, and deadbands). Estimates vary, but significant amounts of energy savings anticipated to flow from mechanical and lighting code requirements are dependent on the implementation of controls. This means to understand a building's compliance by noting the presence of a compliant piece of equipment is not sufficient; in addition, it is necessary to identify the presence of controls and the behavior that optimizes the equipment in order to get an accurate "measure" of compliance.

In order to design and test a new methodology for assessing commercial code compliance, the Pilot will require the study team to focus on several components to address these challenges. Since it is a Pilot study and essentially an experiment to test assumptions and methods, the sample is not representative and is not intended to summarize compliance in any particular jurisdiction.

This paper describes the research questions and proposed methods for the Pilot. As a pilot study the methodology will be tested on small sample of buildings. The purpose of the Pilot will be

to provide insight into the sample size required for a more generalized sample. The paper emphasizes methodological findings and recommendations with particular focus on the reliability of plan reviews versus building audits. Onsite audits are conducted after the building is complete so there will be limitations on what they can observe (especially building envelope and control specifications). The Pilot study will offer guidance in the appropriate application and interpretation of the as-built and field reviews.

Mental Models for Understanding Code Impacts

The Pilot methodology was designed to test ideas for a large scale code evaluation in the Northwest. In developing this approach, the project team had several working sessions to refine goals and confirm various strategies for the overall code compliance methodology that would be tested on a smaller scale in the Pilot. In attempting to grapple with the challenges inherent in designing a meaningful and cost-effective methodology for assessing commercial code compliance, it became clear that framing the study as a "code compliance study" constrained the uses of the data to a very narrow, potentially misleading assessment of commercial buildings.

When assessing compliance for states with prescriptive commercial codes such as those in the Northwest, reflexively looking for a compliance rate does not get at deeper objectives such as energy impacts, the relationship between enforcement and compliance, or the underlying configurations of complying and non-complying buildings. Without these deeper insights it is difficult to determine where to focus attention when improving codes. One alternative to a prescriptive assessment is to review models of energy use in buildings. However, only a few buildings are modeled as part of the code compliance process in the Northwest so no detailed modeling for code compliance is available. As a result, the project team does not expect that the energy modeling would be helpful in assessing compliance in the context of the code structure and enforcement in any of the states or jurisdictions in the Northwest.

On the other hand, simplified models will be a used to aid in assessing the observed building performance. These models are essentially billing analysis tools that use "change point" analysis to disaggregate major building end uses (e.g., lighting, heating, cooling, etc.). While such an approach may not assess compliance per se, it can provide valuable evaluative information by assigning energy consumption to the same major components that form the basis for the compliance assessment.

In Pilot design process the project team identified four main categories of interest that the team then further refined:

- **Standard compliance**
  - What percentage of buildings is complying with the major components of the energy code?
    - Envelope
    - HVAC Systems
    - Lighting Systems
  - What are the elements of compliance that can be adequately measured in each code section?
- **Energy savings**
  - What is the overall energy use of the building (EUI)?
  - What are the major end uses of the building and their energy use?
    - Emphasis on code sections

        - Estimate process loads outside of the code regulations (such as servers, refrigeration, etc.)
        - Can compliance to individual code sections be correlated to energy use estimates in these end uses?
        - How much energy is left on the table for non-complying code elements?
        - Which code elements are likely delivering the highest savings at the measure and aggregate level?

- **Forensics**
    - What is the impact of enforcement efforts on code compliance?
    - Which measures are being enforced and how do these efforts relate to compliance and savings?
    - Does the enforcement process deliver the expected configurations of systems or are compliance negotiations delivering an alternative result?

- **Building Characteristics**
    - How do the underlying configurations of commercial buildings affect compliance?
    - Aside from code compliance, what are the typical configurations and approaches in designing building systems?
    - The need for modeling inputs for analyzing energy use and energy savings in the code development and initial evaluation process, such as:
        - HVAC system characterization;
        - Saturation of system types and levels of compliance for those systems;
        - Fuel saturations;
        - Lighting Controls

A general observation during the working sessions was that the stakeholder goals fall more under the larger rubric of "code evaluation" rather than just "code compliance study" (which is a subset of code evaluation). Accordingly, the mental model of what type of study we were designing had to shift and the four lenses described above were reframed with an evaluation perspective in the following ways:

- **"Standard Compliance"** aligns with the verification part of an evaluation (which often includes paper and/or field verification). This is a useful step but was not determined to be broad enough to provide stakeholders with an actionable sense of the impact of the commercial code or of the changes that might be necessary to ensure energy performance from code complying buildings.
- **"Energy Savings"** aligns with the focus of an impact evaluation (which often includes billing analysis and modeling for commercial buildings).
- **"Forensics"** or enforcement assessment, aligns with the focus of a process evaluation.
- **"Characteristics"** isn't really a lens but rather the data that must be collected to implement the verification, impact, and process components of the overall evaluation of regional code efforts.

  In addition, characteristics data serve as a new construction baseline that can be used for code related analysis such as potential assessments and the development of utility programs aimed at new commercial construction,

Pilot Objectives

The primary focus of the Commercial Code Compliance Pilot Study is to develop a methodology to evaluate the efficacy of code efforts in the commercial building sector. The final goals of the Pilot include: developing an actionable definition of code compliance based on the fact that we face real limitations in observing the presence of code elements determining the impact of controls, which are difficult to assess, on compliance and energy savings; determining how well code is enforced and if enforcement and training can affect code presence; determining and assessing code impact via energy performance measurement (benchmarking) once buildings are occupied; and using findings to guide future code development and training.

The protocol for this assessment is to be based on the collection of building, system, and component characteristics. The assessment of code compliance will come from an assessment of the characteristics observed in the individual buildings based on a combination of as-built drawings and onsite audits. This Pilot is designed to provide a review of code compliance procedures that can be generalized to a larger population of new commercial buildings.

The Pilot was ultimately designed to accomplish the following objectives:

- Define energy code compliance in terms of building systems. This will include building envelope, mechanical systems, service water heating, and lighting. For each of these areas a definition of compliance will be developed based on the principal requirements of these code sections. Thus for every building a minimum of three separate compliance rates (one for each system) will be developed.
- Develop a compliance protocol based on system design and control requirements assessed after the building is completed and occupied.[2] The code language provides a variety of paths and options meant to maximize the flexibility of designs. It does not provide a single path or even a consistent path through the code. This approach allows the analysis to ignore requirements that are spurious to overall performance and to focus on the aggregate design of each system.
- Conduct building assessments based on plan reviews using "as-built" records at the building and submittals and documentation made during the construction process and commissioning manuals (as available). This approach will be supplemented by field review and verification of components identified in the plan review and for controls. Code submittals will be used when they are available.
- Establish a procedure for developing a representative sample of commercial buildings that can be applied to each state when the large-scale code evaluation is conducted. For the Pilot a small, convenience sample will be used to test the effectiveness of this protocol and to test the limitations of the building level sampling protocol. The convenience sample will be recruited from a representative list of eligible buildings in a select number of counties in Washington State, but will not seek to represent a particular geography.
- Develop and test an approach to assessing attitudes and procedures for energy code enforcement among building officials.
- Assess the relationship between code enforcement activities and compliance. Since this is a compliance study, the baseline is the code itself and will be used to identify a correlation between enforcement activities and building compliance.
- Establish the Energy Use Intensity (EUI) performance for a selection of buildings reviewed using a consistent approach to utility bill collection and calculation of the overall building energy performance. A billing analysis will be used to disaggregate between major building end uses.

[2] The Pilot will include completed and occupied buildings in order to constrain onsite audit work to one site visit, and to allow for an assessment of all building systems in their completed form. In addition, an energy performance assessment that will be conducted on each building will require a year of occupancy.

- Summarize compliance by building system aggregating key components within these building systems.

Pilot Strategies and Limitations

As part of the methodology design process the project team clarified the following main strategies, methods, and limitations.

Strategy 1: Identify major compliance gaps in code implementation and enforcement.

Methods: Conduct paper and onsite review of major system characteristics and compliance, including mechanical systems, envelope, lighting, and building service water. Envelope compliance will be based on a UA comparison with overall building envelope specifications. Lighting compliance will be based on an LPD comparison and controls specified at the lighting zone, but not at the operational level. HVAC compliance will be calculated at the major component level. All compliance rates will be the ratio of complying systems to all systems reviewed. For the larger study after the Pilot, these results can be combined (using appropriate sampling weights) and summarized by state and for the region. This approach better approximates the major contributors to compliance, the architect (building envelope), the mechanical engineer (mechanical systems), and the electric engineer (lighting). Each of these professionals assumes the responsibility to get compliance in their particular specialties.

Limitations: No measure level compliance assessment will be developed for each code requirement, so the compliance summaries will not provide insight into the cause of the compliance rate for the major systems, e.g., walls vs. glazing for envelope compliance. However, the characteristics dataset will enable some more detailed compliance reviews in each case.

Some characteristics may be difficult to obtain from documents or onsite (e.g., glazing specifications) and this may influence the reliability of the compliance ratio. However, the purpose of the Pilot is to get a better understanding of the limitations of the proposed data collection approach and, therefore, the limitations of the methodology for compliance assessment based on a review of major systems.

Strategy 2: Inform commercial code and program development.

Methods: Collect building characteristics necessary to identify future opportunities for refining and improving code.

Limitations: Some resources will be spent collecting characteristics that support other analytical requirements, e.g., modeling, and may not be directly related to compliance assessment. For example, HVAC system size is not regulated by zone but it would be important to characterize the efficiency of the system. Similarly, characterization of the HVAC system would be important in assessing code impacts or measure impacts but system selection is not directly regulated by the energy code. The development of a system baseline would be useful in designing utility programs and future code measures.

Strategy 3: Inform enforcement efforts.

Methods: Interview jurisdictions to gather data on enforcement practices. The interviews will also address areas where officials had trouble enforcing the code and applicants were consistently confused about code interpretation and compliance. Compare results with compliance levels from building reviews and recommend enforcement priorities and refinements.

Limitations: The current study design will not provide measure level compliance rates, which limits the amount of detailed feedback that will be available for improving regional and jurisdictional enforcement efforts.

Strategy 4: Provide feedback on the efficacy of industry efforts.

Methods: This strategy will be accomplished in part through the jurisdiction interviews

which will assess enforcement efforts and environment. In addition, the compliance rates developed via the building reviews will provide some verification-level insight into the efficacy of the codes. For example, with the detailed LPD, the relationship between minimum code compliance and actual installed lighting systems can also be assessed. Interviews in the jurisdictions can provide an assessment of the level of LPD compliance typical of applicants in their areas.

Limitations: Although, compliance rates will be provided on the verification level, the current approach does not include a detailed assessment of as-built energy impacts of the code. Only overall performance and relatively coarse end-use estimates are anticipated. Basic EUIs will be developed from utility bills for as many buildings as possible. This approach will benchmark commercial building performance. If successful the analysis can be extended to major end uses. This approach cannot disaggregate beyond the level of major code areas. The overall effect would be to identify targets for enhanced code language or enhanced enforcement efforts. The Pilot will develop analysis techniques and use the jurisdictional interviews to address the difference between code effects and enforcement effects.

Strategy 5: Provide an improved approach to estimating compliance and demonstrating the value of codes.

Methods: Develop an overall approach to meeting multiple goals for conducting code evaluation in the Northwest. Structure the approach to include a number of strategies to resolve ongoing methodological challenges to implementing cost-effective code evaluations specific to the commercial sector. Test the strategies and provide recommendations for future refinements.

Limitations: As mentioned in the limitations in Strategy 4 above, the current approach does not focus explicitly on energy use linked to energy code requirements or compliance. It is a goal of this methodology to establish a link between energy use and code compliance but in this analysis we will depend on correlations that can be observed between the overall system characteristics (and compliance) and the energy use observed. To the degree that the value of commercial energy codes is fundamentally tied to reduced energy use, the current approach does not fully meet the goal of "demonstrating the value of codes," since it will not distinguish between system effects and code effects.

Final Pilot Methodology

This section discusses the final Pilot methodology developed as part of an iterative process for identifying goals, objectives, strategies, and limitations. The final Pilot methodology includes the three main study elements described below.

Study Element 1: Field Review & Compliance Assessment

Sampling Plan & Sample Frame Development

The sample will be designed to characterize the entire population of new commercial buildings in the Northwest region. The sample design is not intended for use in the Pilot study, but rather a goal of the Pilot study is to develop and test a methodology that can be used for a large scale code evaluation. The sample frame will be screened to include only new buildings.

- The sample frame will be based on a window of construction starts for 2011 through 2013 to capture buildings built to the 2009 Washington State Energy Code and completed at least 12 months prior to launch of the Pilot.
- A stratified sample will be developed using a stratification based on size of building.
- Supplemental sampling procedures will be developed to illustrate potential approaches to building types, supplemental samples and/or utility oversamples.
- Recruit 12 Washington state buildings for inclusion in the Pilot. These buildings will be drawn from the sample but no effort will be made to complete a representative sample of the buildings in this construction window.

Field & Plan Review Protocols

The selected buildings will be audited using a detailed commercial building characteristics protocol with a focus on the sections of the code review (building envelope, mechanical systems, service water heating, and lighting). The protocol will be based on use of "as-built" drawings, commissioning reports, onsite audits, as well as other data sources such as code submittals for building envelope, mechanical systems, lighting system as available from construction records. The field review and verification will include each major system, including:

- Building Envelope
- Mechanical System
- Service Water Heating System
- Lighting System

Data for the pilot protocol will be collected using paper forms. The forms will include fields for building characteristics and checklist items. Plan reviews will include take-offs of component areas (to assess envelope compliance), lighting power and associated building areas (to assess LPD for lighting compliance), mechanical equipment schedules and operation notes (to assess compliance with mechanical sections), and key components of building service water heating (to assess compliance with these code sections).

Plan Reviews, Onsite Audits & Quality Control

As described above, the review of selected buildings under this protocol will be conducted using plans and records from as-built files. These will generally be available at the building sites about a year after the occupancy permit is issued. The approach calls for recruiting buildings that are occupied and using these records to evaluate the buildings with respect to code compliance and characteristics of energy related building components. This review will include three distinct phases:

- Recruitment from F.W. Dodge contacts as well as leads from architectural firms working in the Washington market.
- As-built drawing review
  - Area and component takeoffs
  - Review of functional testing requirements in commissioning documents
  - Review of mechanical equipment schedules and specifications
  - Review of code submittal files as available, particularly as they are relate to compliance calculations
  - Review of lighting fixture submittals and overall fixture in each major building space
- Field review
  - Confirm correspondence with drawings and equipment submittals. This will allow an assessment of the utility of the plan review format in establishing the compliance and characteristics.
  - Confirm correspondence with code submittals

Building & Compliance Summaries

The compilation and analysis of the Pilot building sample will summarize the overall compliance assessments for each building system independently. While the list of measures reviewed will extend across many components, the compliance summary will transcend the many details of such an assessment. The analysis will establish compliance based on the audits and on the as-built drawing reviews. For example, for the building envelope, the assessment of compliance will be based on two key aspects: the overall UA and, the overall solar heat gain coefficient (SHGC). These metrics will be reviewed for compliance with code language but would probably be the dominate factors in assessing envelope compliance.

The compliance will be assembled by each major system using the characteristics developed in the plan and field review. Thus, the envelope compliance will include full compliance with the building target UA and the overall SHGC performance of the envelope, but only the overall envelope compliance will be summarized and reported in the Pilot study. However, since the pilot study protocol is designed to collect data relevant to the underlying components driving compliance for the four major systems, more granular analysis will be possible for a full-scale study in the future.

Compliance will be summarized by building system:

- Building Envelope (overall UA, overall SHGC)
- Mechanical System (equipment efficiency, energy recovery, fan power, controls)
- Service Water Heating System (equipment efficiency)
- Lighting System (interior lighting power, interior lighting controls, exterior lighting power, exterior lighting controls)

Study Element 2: Code Enforcement Assessment

A key factor in assessing compliance with the commercial energy code is the impact of direct building department review apart from the activities of design professionals. In the Pilot we will use interviews with building officials to explore the attitudes and resources that jurisdictions bring to the energy code review. This step will help determine whether interviews with code officials can be used to develop insights into the relationship between code compliance and enforcement.

Since construction of the buildings themselves will have already been completed and the certificate of occupancy issued, it is our intent to gather information on the general approach to energy code enforcement. To this end, up to eight jurisdictions will be selected (four in Washington state, two in Oregon, and two in Montana). Building departments will be interviewed as to their general energy code review and enforcement procedures. Depending on the number and availability of code officials, one to three interviews will be conducted in each department (the head building official, a plans examiner, and a building inspector). These interviews will be structured to characterize the building department and will include open-ended questions designed to solicit the enforcement activities used in the energy code:

- Compliance review procedures
- Resources required/available for energy code assessment
- Compliance to energy code among permitted buildings
- Use of code compliance options (prescriptive or total building performance)

Structured Interview Questionnaire

The structured interview will be developed around several key areas:

- Building Department Characterization
  - Number of commercial permits
  - Total square footage of commercial permits issued annually
  - Total staff, including the number and percent that are commercial inspection certified
  - Size of in-house staff, number of examiners and inspectors involved in energy code compliance
  - Level of staff energy code training
- Energy Code Enforcement Activities
  - Time spent on energy code as a fraction of total review
  - Distribution of code pathways (prescriptive, trade-off, performance)
  - Documentation, retention, and availability of permitting data and plans
  - Particular aspects of the code that the jurisdiction finds difficult to enforce

- Which plan review or inspection items generally don't comply
- Are "red marks" used as part of energy code compliance review, does failure to comply result in construction delays or delays in certificate of occupancy

- Overall Attitudes Toward Energy Code Review and Compliance in the Jurisdictions
  - Department priorities for energy code review
  - Awareness and use of technical support

Sampling Plan & Recruiting

The primary jurisdictions selected for interviews will correspond to the areas where buildings are also recruited for compliance review. Secondary jurisdictions will be selected from states or jurisdictions where no field reviews are conducted in this Pilot. At least two counties in each state will be selected. A total of eight jurisdictions will be recruited.

Individual building departments will be recruited through the head building official. Note that the pilot study enforcement assessment sample will include some rural and urban jurisdictions; however, this split will not be as fully realized as it can be in the large scale compliance study.

Data Collection & Interview Summaries

Most of the interviews will be conducted by phone. Two jurisdictions will be interviewed onsite in order to test the relative value of onsite interviews vs. phone interviews. The onsite interviews will be scheduled in Washington. The clarity and usefulness of the data collected in the enforcement interviews will be assessed not to determine overall performance on the energy codes but to determine what energy code review approaches are used including the perspective of the building officials. Due to the limited nature of the Pilot sample, the analysis of the interview data will use a case study approach in which interview results for each building department are summarized. These case studies will:

- Summarize energy code review procedures
- Summarize attitudes and enforcement procedures based on interview results
  - Amount of resources used
  - Use of redlines and other enforcement for energy code enforcement
- Summarize attitudes to energy code structure
  - Use of alternative paths by applicants
  - Potential for use of performance based paths
- Qualitative test of the relationship between enforcement and compliance in Washington

Study Element 3: Energy Performance Assessment

The final phase of the energy code compliance review will be an energy performance review of the buildings assessed in the field. The goal of this effort is to develop energy use indices (EUIs) that can be compared to performance benchmarks to establish the impact of energy codes on the continued improvement of building energy efficiency. A high-level end use assessment will be used to disaggregate the main end uses from the overall EUI. There are several key outputs from this limited review of new building energy performance:

- Develop and test procedures for assessing whole building performance through the use of billing analysis and overall EUIs.

- Use procedures consistent with the Commercial Building Energy Consumption Survey CBECS[3] and other national databases
- Develop consistent building type to be compatible with the Northwest Power and Conservation Council, CBECS, and EStar Portfolio

- Develop and test a procedure for consistent utility energy reporting
  - Fraction of bills available and timing of energy use assessment
  - Occupancy and vacancy timing to get useful performance assessment
- Develop and test estimates of sample sizes and benchmarking procedure that will allow large scale development of energy performance ratings.
- Assess the ability of "change point" billing analysis to credibly disaggregate the major end uses.
  - This step will be reported as a finding in the Pilot, including the usability of the results in linking end use performance to major code sections.
  - Results will be compared with a larger sample from the Northwest (Baylon et al, 2008) and the California Commercial End-Use Survey (CEUS) data base (Itron 2006).

Reflections on the Final Pilot Study Methodology

The Pilot study will be implemented in the second half of 2015. Results will inform the design of a larger study on a representative sample of commercial buildings in the Northwest. This Pilot is based on the assessment of actual design and construction practices as much as the compliance with particular code provisions. It has long been recognized that the design of high performance buildings in the commercial sector has been heavily influenced by decisions in the design and construction process which can lead to high performance (or significantly poorer performance). It is the intent of the energy code to encourage innovation in these designs on the assumption that more flexibility would lead to more efficient buildings. It is also the intent of the energy code to restrict designs that lead to poorly performing buildings. This tension could lead to a more effective code or result in an overly complicated and ineffective code.

The Pilot study is designed around a methodology intended to assess the success of modern energy codes on both dimensions. We expect to observe and document the improved design practices that have led to better performance. Conversely, the study will document design approaches, including system selection and commissioning, that will be informed by observed performance. While the direct link to building energy use efficiency may be tenuous when dealing with the prescriptive codes in Northwest states, very large impacts will be apparent as will a performance level that represents no particular improvement in building design or performances in spite of code compliance or design flexibility. The methodology developed in the Pilot will not be sufficient to address individual measure savings regardless of sample size but with modest samples large trends can be recognized. The Pilot will test the key data collection and analysis techniques required to meet these goals. The overall purpose is to refocus the evaluation of energy codes around their outcomes in completed, occupied buildings rather than a narrow assessment of individual code provisions using modeling or measure-level compliance checklists.

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[3] The Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey that collects information on the stock of U.S. commercial buildings, including their energy-related building characteristics and energy usage data (consumption and expenditures). For more information go to http://www.eia.gov/consumption/commercial/about.cfm.

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