



U.S. DEPARTMENT OF
ENERGY

PNNL- 18587 Brief 6

Prepared for the U.S. Department of Energy
Under Contract DE-AC05-76RL01830

Topic Brief 6: Evaluation Checklists

Updated 12/1/2009

DRAFT



Pacific Northwest
NATIONAL LABORATORY

The American Recovery and Reinvestment Act (Recovery Act) requires the governors to notify the Secretary of Energy that the governor has obtained assurances that the state or applicable units of local government will implement a plan for achieving compliance with the state or local government building energy code(s) in at least 90% of the new and renovated residential and commercial building space. As part of this effort, the Department of Energy's (DOE's) Building Energy Codes Program (BECP) is developing guidelines and materials to assist states in performing onsite building audits to evaluate compliance based on a randomly selected sample of residential and commercial buildings. The materials being developed include checklists of energy code requirements that can be used by evaluators to gather relevant data. Checklists will include instructions for their proper use and for recording the results, and graphics to assist in identifying complying and non-complying items. These may be made available as paper forms, excel spreadsheets, or online for direct input into a database and/or for use with PDAs. Paper onsite audit checklists will be developed to allow automated reading into an electronic format.

This document defines the checklist contents and how they will be completed so that a final compliance metric for residential and commercial buildings in each state can be developed. The following questions, consolidated from stake holder feedback, are addressed:

1. How will the checklists support various compliance approaches (prescriptive, trade-off, and performance)?
2. How will the checklists address code requirements only visible during certain phases of building construction?
3. What strata will be supported by the checklists (e.g., different building occupancies and uses, renovations vs. new construction, different climate zones)?
4. Will the checklists be used to capture values corresponding to code requirements, as opposed to simply assigning a pass/fail to each measure?
5. Will the checklists include all code requirements or a subset of the requirements?
6. How will the checklists be used to compute a rate of compliance for a particular building?
 - o Will the final metric be weighted by building size?
 - o Will checklist items be weighted based on their impact on energy use?

1.0 Compliance Approaches

A building might comply by any of three approaches:

- Prescriptive
- Trade-off¹
- Performance

The checklists will be generic enough to be used with any of these compliance approaches. Evaluators will be instructed to review the energy code compliance documentation submitted with the plans. If documentation supporting a trade-off or performance approach is not available, the evaluation of the building will be based on the prescriptive compliance path. If there is documentation supporting a trade-off or performance approach, the evaluator will be instructed to evaluate the building construction based on the documentation provided with the plans and specifications for that non-prescriptive compliance approach.

For example, a building may have windows more efficient than the prescriptive requirements in the code. These windows may offset a ceiling design that does not satisfy the minimum thermal requirements of the code. If compliance documentation demonstrating this trade-off was submitted and approved, the evaluator will need to verify that the window U-factors and areas, and installed ceiling construction type and R-values match the trade-off documentation. If no documentation is submitted, the building will fail the ceiling prescriptive R-value

¹ The 2009 International Energy Conservation Code (IECC) contains both a U-factor alternative (Section 402.1.2) and a total UA alternative (Section 4.2.1.4). The reference to a trade-off approach in this document includes both of these alternatives, as well as the trade-off approach defined in the ANSI/ASHRAE/IESNA Standard 90.1–2007.

requirement, even if it can be shown that it meets the code requirements based on a trade-off approach. While this approach might penalize buildings that *do* comply but haven't documented that compliance, it is a justified penalty in that the code requires such documentation be submitted. There are two different scenarios that could apply to this example:

- 1) The ceiling insulation R-value(s) are marked on the plans and match those installed in the field, but no trade-off documentation is submitted. Under this scenario, the building fails one code requirement for not meeting the prescriptive ceiling R-value requirements.
- 2) The ceiling insulation R-value(s) are not marked on any submitted plans or other documentation, nor is trade-off documentation submitted. Under this scenario, the building will fail two code requirements: not identifying insulation R-values on plans and not meeting the prescriptive ceiling R-value requirements.

2.0 Using Multiple Buildings for a Single Sample

Many energy code requirements can only be inspected at specific times during the building's construction. There may be difficulties gathering data on all code requirements for a single building during the appropriate stage of construction. This would require timely and repeated visits to the construction site over a period of time, which may not always be feasible. Moreover, knowing from initial foundation inspection that a single building would be the subject of data gathering on code compliance during the entire course of construction could adversely affect the intended random nature of the compliance evaluations. The following two approaches can be used to help address these issues by evaluating different aspects of multiple buildings to generate a single sample.

2.1 Construction Phases Approach

The checklist items will be grouped in sections corresponding to the phase of construction where the checklist item is typically inspected. The residential checklist requirements are grouped into the following phases. The commercial checklists will be grouped similarly, with an additional inspection for electrical/lighting.

- Plan Review
- Foundation
- Framing/Rough-In
- Insulation
- Final

The checklists can be used to gather data during different stages of construction on different buildings that have the same general attributes in order to yield a resulting single composite building compliance evaluation in lieu of evaluating a single building throughout construction. This is commonly done in residential studies, where evaluators may visit a site where multiple buildings are being simultaneously constructed (e.g., housing subdivision, condominium or apartment complex, or commercial office park) with construction in varying stages occurring at the same time. The evaluators may do a foundation inspection on one building, an insulation inspection on another building, and a lighting inspection on a completed building. Where multiple buildings are used for a single evaluation, the buildings must come from the same jurisdiction. Where multiple commercial buildings are used for a single sample, the buildings must also fall in the same size stratum, which are defined below based on the conditioned floor area of the building:

- Small: 1-2 stories, single zone, up to 25,000 ft²
- Medium: Larger than 25,000 ft² but smaller than 60,000 ft²
- Large: Larger than 60,000 ft² but smaller than 250,000 ft²
- X-Large: Larger than 250,000 ft² but smaller than 400,000 ft²
- XX-Large: Larger than 400,000 ft²

Where multiple residential buildings are used for a single sample, the buildings must be of similar types, defined as:

-
- One- or two-family
 - Townhouse
 - Apartment
 - Condominium

Much of the code compliance evaluation is performed during plan review (e.g., validation that all information needed to determine compliance is available on the approved plans and specifications). A subsequent onsite inspection ensures that what was built matches the approved plans and specifications. Where multiple buildings are used for a single sample, a plan check may be done on just one of the buildings, thus completing the plan check portion of the evaluation. For additional buildings used for a single evaluation, the plans and compliance approach should be reviewed, but not recorded in the “Plan Review” section of the checklist. There is the possibility that one or more of the additional buildings being evaluated submitted documentation showing compliance by the trade-off or performance approach. Such a building may fail a checklist item on a prescriptive basis, but could actually comply as documented on the plans and specifications. Reviewing the plans and performance approach for each building will ensure that such a checklist item is not incorrectly marked as non-compliant.

Each checklist has general information inputs at the top of the first page which should be completed (including the conditioned floor area of the building, the compliance approach assumed by the evaluator, etc.). Some of these inputs are repeated at the beginning of each construction stage. Where a single building is being evaluated for each stage of construction, these duplicate inputs can be ignored. Where multiple buildings are used for a single evaluation, the top portion of each checklist stage must be completed for each different building evaluated.

2.2 Primary Building Approach

Where a single building can be evaluated for a large majority of, but not all of the checklist items, an alternative approach can be used. The majority of checklist items can be evaluated for the single, “primary” building, and another similar building can be used to complete the items that could not be evaluated. As an example, all of the checklist items are evaluated for a single building except for the foundation insulation, which is covered during the field visit. In this case, the checklist items pertaining to the foundation insulation can be evaluated for a different but similar building. The general information at the top of the checklist should be completed for the primary building. The general information at the top of each additional phase of construction should be left blank, since most of the checklist items were evaluated based on the primary building. The evaluator, however, should document those checklist items that were evaluated on the second building. This can be done in the comments fields corresponding to each of those checklist items.

As with the construction phases approach described in Section 2.1, the multiple buildings must come from the same jurisdiction. Where multiple commercial buildings are used, the buildings must also fall in the same size stratum. Where multiple residential buildings are used, the buildings must be of similar types. Also as described in Section 2.1, the plans and compliance approach of each building being evaluated should be reviewed.

3.0 Building Attributes Included

Checklists could be customized according to several criteria that impact which requirements are applicable. Different requirements may apply to different building occupancies and designs. For example, systems serving multiple dwelling units in multifamily residential buildings can have different requirements than those for single-family dwellings. Commercial buildings with vestibules have a requirement that does not apply to buildings without vestibules. Sunroom and pool heater/cover requirements are only applicable to buildings with those features. Perhaps even more relevant are the differences in code requirements pertinent to the following:

- Different commercial building uses and types have different lighting requirements

-
- Commercial building mechanical requirements are different depending on whether or not the mechanical systems are deemed simple or complex, as defined in Section 6.3.1 in the ANSI/ASHRAE/IESNA Standard 90.1–2007 (90.1-2007)
 - Building envelope and commercial building economizer requirements vary by climate zone

An effort to create different checklists that accommodate all of these criteria would result in a large number of different checklists, which might make it difficult for evaluators to ensure they have the correct checklist for each building being evaluated. Instead, evaluators will be able to select ‘not applicable’ for any checklist item that is not applicable to the building being evaluated. The same checklists will be used for new construction, additions, and renovations. For renovations and additions, this might result in a large number of items being deemed ‘not applicable.’ The main difference between complex and simple mechanical system code requirements is that complex system requirements cover a much larger number of systems. Simple system requirements are simply a subset of the complex system requirements. Therefore, for buildings with simple systems, many of the checklist items related to mechanical equipment might be marked ‘not applicable.’

Different checklists will be developed for each climate zone, however, and the code requirement for that climate zone will be incorporated directly into the checklist item (e.g., a checklist item for inspecting the wall insulation R-value will include the prescriptive wall R-value for that climate zone). For lighting, the requirements for each building use will be included in the checklist instructions and will be readily available to the evaluator, but the checklist item will be more generic and the evaluator will have to look up the requirements for the specific building use type.

4.0 Requirements Values

The building evaluations proposed to meet Recovery Act requirements provide an opportunity to collect a great deal of previously unavailable data on real buildings in real world situations. As an example, very little information exists that can answer questions such as:

- What percentage of buildings comply with each of the three compliance approaches (prescriptive, trade-off, and performance)?
- Do large commercial buildings tend to have better or worse compliance than small commercial buildings?
- Do differences in building types show differences in energy code compliance rates?

The checklists are being developed to collect as much information as possible without providing a great deal of additional burden on the evaluator’s time. The checklists will require making a notation of the R-values of insulation installed in the building envelope assemblies; fenestration U-factors and SHGC values; commercial building equipment efficiencies; heating and cooling equipment capacities; infiltration and duct leakage test results; commercial building lighting system controls and connected lighting loads; and generic information about the building being evaluated, such as the compliance approach and the conditioned floor area of the building.

5.0 Code Requirements Included

Not all code requirements have the same impact. In an effort to focus on the most important code requirements, the checklist items have been clustered into multiple tiers, and each tier is given a different weight in determining the overall building metric (see Section 6.0 of this document). The residential code checklist requirements will be clustered into two tiers – the commercial code checklist requirements will be clustered into three tiers. In both cases, Tier 1 requirements are those deemed to be ‘high-impact’ according to the following criteria:

- 1) Items that impact design energy efficiency
- 2) Items that impact long-term operational energy efficiency

Previously the BECP considered recommending only the Tier 1 items in the checklist. Subsequent feedback has indicated that Tier 2 and Tier 3 items may often be quickly inspected, and so the BECP has decided to initially include all code items in the checklists except a few requirements that are deemed administrative and/or without any impact. Initial use of the checklists in anticipated pilot studies will provide additional feedback about the checklists, including a better understanding of the length of time required to evaluate a building and if any of the checklist items are particularly problematic in doing the evaluation.

5.1 Building Evaluation Time

The code compliance pilot studies may also provide more accurate information about the level of effort required to evaluate residential and commercial buildings. These pilots will include tracking evaluators' time spent evaluating buildings. Additional insight might be gained from a recent Building Codes Assistance Project (BCAP) publication, [Residential Building Energy Codes – Enforcement & Compliance Study](#)², which states “The average time to consider energy in a residential plan review can range from 15 to 45 minutes depending on the level of competency of the code official. The average duration of an energy residential building inspection could range from 30 minutes to 1 hour, for each visit.” For the Recovery Act effort, the higher end of this range might be expected due to the fact that an existing, fully trained workforce does not exist for performing this additional scope of work and many of the evaluators may be newly trained. Additionally, the evaluations may not be done by jurisdictional staff in conjunction with other job duties (e.g., inspecting the insulation while already onsite to inspect structural code requirements).

The checklists being developed will include onsite inspection during the following stages of construction (in addition to plan review), all of which may require separate visits to the building:

- Foundation Inspection
- Framing/Rough-In Inspection
- Insulation Inspection
- Final Inspection

Plan review and four field visits, at the higher end of estimated time, could result in close to 5 hours per building. This assumes that the evaluator is located relatively close to the building site, which may not always be the case. This assumption applies to residential buildings – commercial buildings can be significantly more complex, require more visits, and therefore take longer to evaluate. Evaluation times will also vary by the size and complexity of the building being evaluated and the process used for documenting compliance. There may be opportunities to reduce these times. For example, an evaluator may visit a site where multiple buildings are being simultaneously constructed, with construction in varying stages occurring at the same time (e.g., housing subdivisions, condominium or apartment complexes, or commercial office parks). As another example, where a commercial building consists of multiple stories that are identical, inspection of some of the stories as opposed to all of the stories could be considered.

6.0 Derivation of the Building Metric

A building (or multiple buildings comprising a single evaluation) which meets all of the code requirements listed on the appropriate checklist will be deemed to comply with the code and will receive a compliance rating of 100%. Failure to meet one or more items on the checklist will result in a compliance rate below 100%. The requirements in each tier will be weighted differently, with Tier 1 items receiving 3 points, Tier 2 items receiving 2 points, and Tier 3 items receiving 1 point. The building metric is determined by summing the points received, and dividing by the possible points. For example, a building evaluated against 10 Tier 1 requirements, 5 Tier 2

² Residential Building Energy Codes – Enforcement & Compliance Study. 2008. Building Codes Assistance Project. <http://bcap-energy.org/files/Residential_Survey_Report_Oct08.pdf>

requirements, and 5 Tier 3 requirements, passes 8, 4, and 5 requirements respectively. Its compliance rate would be 82%, as computed by Equation 1.

Table 1. Example Building Evaluation

	Checklist Requirements	Possible Points	Requirements Passed	Points Received
Tier 1 Requirements	10	30	8	24
Tier 2 Requirements	5	10	4	8
Tier 3 Requirements	5	5	5	5

Equation 1

$$compliance_percentage = \frac{points_received}{possible_points} \times 100 = \frac{37}{45} \times 100 = 82\%$$

The overall state metric will be derived by averaging all individual building scores. For commercial buildings, the average individual scores will be weighted by building size strata. The weighting will be accomplished at the state level and does not affect the individual checklist scores. The discussion about how the individual scores are weighted by building size can be found in Section 2.3 of Topic Brief 5: *Sample Distribution and Make-Up*.