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Topic Brief 8: Renovations

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Pacific Northwest
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1.0 Introduction.

The American Recovery and Reinvestment Act (Recovery Act) requires the Governor of each state 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 building energy codes in at least 90% of the new and renovated residential and commercial building space in their state. The compliance measurement is to be determined against the 2009 International Energy Conservation Code (2009 IECC) for residential buildings and the ANSI/ASHRAE/IESNA Standard 90.1–2007 (90.1-2007) for commercial buildings, or equivalent codes (referred to as the target codes). This topic brief provides a methodology for measuring compliance against these target codes in commercial and residential building renovated spaces.

Since the target energy codes apply to additions, alterations, and repairs to existing buildings, and since renovations are specifically called out in the Recovery Act, a representative sample of buildings throughout the state should include sampling of renovations in addition to new construction. Three previous topic briefs addressed sampling and evaluation of new construction:

- *Topic Brief 2: Sample Size*, discusses the derivation of a minimal sample of new residential and commercial buildings.
- *Topic Brief 5: Sample Distribution and Makeup* provides additional information about how the residential and commercial samples for new construction should be distributed across the state, and what types of buildings should be included in order to assure a representative evaluation.
- *Topic Brief 6: Evaluation Checklist*, defines evaluation checklists that were developed by the Building Energy Codes Program (BECP) and their recommended use for generating a compliance metric for each new residential and commercial building.

This topic brief provides a corresponding sampling methodology for renovations. In addressing the Recovery Act legislation, the BECP is recommending the reporting of renovations separately from new construction, resulting in the following four distinct compliance metrics:

- New commercial construction
- New residential construction
- Renovations to existing commercial construction
- Renovations to existing residential construction

The BECP does not recommend that the state attempt to combine the four specific compliance metrics for an overall state compliance score, but instead recommends that the state report these compliance results separately. It is quite possible that a state will find that their compliance rate is above 90% in one metric (e.g. new residential construction), but does not attain 90% in another (e.g. commercial renovations). This provides some value in determining where activities that affect compliance may need to be strengthened.

2.0 Definition of Renovation

There are many different and often conflicting definitions for ‘building renovation,’ several of which are described here for context. The two target building energy codes address renovations as follows:

- Section 101.4.3 of the 2009 IECC includes requirements for additions, alterations, renovations and repairs. Addition, alteration, and repair are defined in the 2009 IECC, but renovation is not. Section 202 of the IECC defines alteration as “*Any construction or renovation to an existing structure other than repair or addition that requires a permit. Also, a change in a mechanical system that involves an extension, addition or change to the arrangement, type or purpose of the original installation that requires a permit.*”¹

¹ International Energy Conservation Code, 2009. International Code Council (ICC). www.iccsafe.org.

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- 90.1-2007 addresses additions and alterations only. The terms are both defined with addition subsumed in alterations, and explicitly exempting “*routine maintenance, repair, or service*”.²

The Department of Defense’s Unified Facilities Criteria document for Energy Conservation requires an entire building to be brought into compliance with code requirements for new construction if the renovation cost is 25% or more of the replacement cost of the building³. This definition adds a level of complexity to the issue by factoring in building valuation.

For the purposes of addressing the Recovery Act, the BECP recommends the following definition of renovations based on the above definitions, how building permits are typically issued and classified within a jurisdiction, and the need for a simple and accurate distinction between construction of new buildings and renovations to or within existing buildings.

- **Commercial Renovations:** Any work on or in existing commercial buildings where all or part of the work being performed is required to meet code and for which a permit was issued, including additions, alterations, and repairs.
- **Residential Renovations:** Any work on or in existing residential buildings where all or part of the work being performed is required to meet code and for which a permit was issued, including additions, alterations, and repairs.

While one approach for determining compliance for renovations would be to include them with new construction, this creates an inequity in the derivation of a state metric. The energy impact of a minor alteration or small addition is not comparable to the energy impact of a new building. The evaluation methodology for new construction is based on evaluations of whole building samples, with each building receiving a compliance score. The evaluation of a subset of that building (such as a new mechanical system) would not be directly comparable. Even among renovations, there exists a wide disparity in the impact that different renovations will have (e.g. a lighting retrofit vs. gutting the entire building shell). For these reasons, the BECP recommends that renovations be sampled independently of new construction, and that the state metric be derived differently than for new construction. The methodology proposed in the following sections does not recommend assigning a compliance measurement to each individual renovation. Instead, the renovation samples will be evaluated as a group of observations (e.g. inspected code requirements), where some renovations will contribute only a few observations and some will contribute substantially more.

There are two types of renovations that could have been included with new construction; additions and gutting the entire building shell (e.g. where the building modifications are extensive enough that the entire building becomes subject to the existing energy code). Additions, however, can be small (such as a single bedroom addition) and thus pose a similar problem in comparing their impact to that of a new building. Therefore, the BECP recommends a simple split in evaluation methodology which separates all renovations that are permitted (including additions and those gutting the entire building shell) from new construction. This limits the data collection to two distinct categories, new construction and renovations, and simplifies identification of project type for the data collectors.

3.0 Compliance Checklists for Renovations

The checklists being developed by the BECP for evaluation of new construction can also be used for evaluating renovations (see *Topic Brief 6: Evaluation Checklist*). The number of checklist items that are applicable to a given renovation will vary, and those checklist items that are not applicable can be marked as “N/A” by the individual collecting building field data. The checklists will include two inputs that are not used directly in computing the

² ANSI/ASHRAE/IESNA Standard 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings, 2007. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

³Unified Facilities Criteria (UFC) Energy Conservation. Department of Defense. <http://65.204.17.188/report/doc_ufc.html>

overall state compliance rate for renovations; the square footage of the renovation and the monetary valuation of the renovation.

For new commercial construction, the conditioned floor area of the building being evaluated *WILL* impact the final state metric, as described in *Topic Brief 5: Sample Distribution and Makeup*. While this input will not impact the state metric for residential new construction, nor for renovations, it is still a recommended input on the checklists as there may be value in having this information in future evaluations of data collected as part of this effort. For renovations, the checklist instructions will include the following guidance on how square footage for renovations can be estimated:

- Additions – the area of the additional space being added to the building that is within the scope of the energy code
- Mechanical Systems - the area served by any new system or additions to an existing system
- Lighting Systems - the area served by the lighting retrofit(s)
- Envelope Modifications - the floor area served by and associated with the alterations.

Many data sources report the monetary valuation of a renovation. The codes themselves occasionally use this metric in determining whether or not the entire building must be brought up to all or portions of the code as if the building were new. Therefore, the BECP is also recommending that this information be estimated and recorded on the checklists when evaluating renovations. This information may be available on the permit issued for the renovation.

4.0 Derivation of State Metrics

As stated above, the checklists being developed for new construction can also be used for evaluating renovations, where checklist items that are not applicable are marked “N/A” and will not contribute to the state metric. The variation in the number and type of code requirements being evaluated for each renovated building makes the sample size and state compliance rate more difficult to accurately estimate and determine than for new construction.

For the compliance score calculations associated with new buildings, the BECP assumed that each building within the residential and commercial grouping would generally have to meet the same code requirements (e.g. the number of checklist items evaluated for each building in the sample would be comparable). This assumption does not hold for the sample of renovated buildings, which can vary greatly in the number and type of code items that must be evaluated. The scoring methodology proposed in this document assumes a primary goal of attaining a statewide compliance score for renovations as a whole for residential and for commercial buildings. It does not provide enough observations to make rigorous statistical conclusions about any sub-population within renovations.

The compliance metric for renovations will be derived by taking the total number of checklist items that are evaluated for each building as the divisor and the number of those items that are in compliance as the numerator, multiplied by 100. This calculation will not result in an individual metric being assigned to each building as was suggested for new construction, but it will provide a state-wide metric that takes into account the varied number of code requirements that each observed renovation will be evaluated against.

For example, if three different residential renovations were evaluated, where the first had 8 items checked, the second had 15 items checked, and the third had 3 items checked, then the total number of checklist items evaluated would be 26. Of the checklist items evaluated, the number of items in compliance for each building was 8, 13, and 2, respectively. Thus the numerator would be 23 with a denominator of 26 that gives a proportion of 0.885 and a compliance rate for residential renovations of 88.5%.

This process is equivalent to calculating a compliance metric for each building and then calculating a weighted state compliance metric of renovations where the weights are based on the number of checklist items evaluated for each building. Using the above example data the calculation based on weights would be the following:

$$\frac{1.0 \times 8 + 0.867 \times 15 + 0.667 \times 3}{8 + 15 + 3} = 0.885 .$$

Where 8, 15, and 3 are the weights based on the number of checklist items observed at each building and 1.0, 0.867, and 0.667 are the compliance rates for each renovation. When multiplied by 100, this gives same compliance rate as described in the previous paragraph (88.5%).

There are different methods that could be used to estimate the standard deviation associated with an estimated renovation compliance rate from a state sample. These estimates can differ if there is a believed correlation of compliant checklist items within an observed renovation and the number of items evaluated for each renovation varies. If this correlation does exist then calculating the compliance rate for each renovation (i.e. a building compliance score) and then calculating a standard deviation between renovations in a state's sample of renovations will provide a more accurate standard deviation estimate for use in calculating an upper confidence level. This proposed method is also identical to the recommended method to estimate the standard deviation for new construction, which is beneficial for simplicity as well.

3.1 Sample Size

The necessary number of renovations required for an estimate of the compliance rate within a tolerable margin of error for renovations is dependent on an understanding of the correlation between checklist items within the buildings sampled as well as the variability in the number of checklist items being evaluated for each building. While the standard deviation assumptions for renovations may not be the same as new construction, the BECP believes that the parameters assumed for new construction are reasonable for renovations. Thus, the BECP is proposing a minimum number of buildings evaluated to be 44 for residential renovations and 44 for commercial renovations (see the derived sample size in *Topic Brief 2: Sample Size*). An additional stipulation associated with renovations is that any renovation included in the sample of 44 must have at least 10% of the checklist items evaluated. This will protect against extreme variations in the number of checklist items being evaluated for each building in the sample.

As with new construction, it is understood that the standard deviation from a state's sample of buildings is an estimate and the actual deviation may alter the number of samples required. The result of a state's sample standard deviation can be as high as 0.16 and be acceptable. If the standard deviation estimate resulting from the state sample is above 0.16 and the upper confidence bound is above 0.9, then additional samples based on the estimated standard deviation will be necessary to ensure a valid sample.

4.0 Distribution of Samples

The procedure for distributing the renovation samples across the state is identical to the procedure recommended for new residential construction (see *Topic Brief 5: Sample Distribution and Makeup*). Where commercial new construction included the distribution of samples by building size, sample distributions for residential new construction and both commercial and residential renovations is somewhat simpler and does not take into account the building size. The following two sections provide an example distribution of renovations across Washington State by first distributing across climate zones, and then across counties.

4.1 Distribution Across Climate Zones

If a state has multiple climate zones, the 44 renovation samples should be distributed across climate zones based on evaluating the number of renovations in each climate zone over the three previous years (commercial and residential renovations are estimated separately). The samples within each of the climate zones should be allocated according to the following routine:

1. Calculate the average number of renovations for the prior three years in each climate zone within the state.
2. Calculate the proportion of renovations in each climate zone and remove any climate zones with a proportion smaller than 0.02 (i.e. 2%). Note that a climate zone could be excluded from commercial but not for residential, and vice versa.
3. Calculate the number of samples for each included climate zone, excluding the most densely populated climate zone, by multiplying each proportion by the total number of samples (n) and round up to the nearest integer.
4. The number of samples for the most densely populated climate zone is 44 minus the sum of the numbers calculated in Step 3.

The following example demonstrates this approach for commercial renovations in the state of Washington. Table 1 shows the expected number of commercial renovations within each climate zone. This is the information that would be obtained from Steps 1 and 2 above. Note that Climate Zone 6 is removed from consideration because the building renovations are less than 2%.

Table 1. Estimated commercial renovations by climate zone, for Washington State.

Climate Zone	Average Building Renovations per year	Proportion of Statewide Average	State Sample Size (n)	Climate Zone Sample Size
4	924	0.823	44	36
5	187	0.17	44	8
6	8	0.007	44	Removed

4.2 Distribution Across Counties

The second stage of the sample distribution will identify which counties and how many building renovations within the selected counties must be evaluated. The following process will sample more heavily in counties that are expected to have the most building renovations in the upcoming year:

1. Identify the counties in each climate zone and apply steps 2-4 for each included climate zone.
2. Using the expected renovation data based on the previous three years, identify the number of renovations for each county.
3. Remove any counties with an expected renovation count value less than 2.
4. Create a list of counties, where each county is included in the list as many times as the number of building renovations calculated in Step 2.
5. Randomly select the number of buildings needed from the list created in Step 4, and summarize how many samples were chosen from each county. Random selection can be from an automated process, using functions in a spreadsheet, or simply by pulling county names from a hat.

The state of Washington will again be used as an example of this process. Figure 1 depicts the three climate zones in Washington and an example of estimated building renovations in each county. In this figure, colored regions identify the three climate zones, and the red dots identify the largest cities in Washington, with the size of the dot representing the number of building renovations in that city.

The detailed process for Climate Zone 5 (the green region in Figure 1) follows and the same procedure was followed for Climate Zone 4. An example of the locations of a final sample of 44 commercial renovations is summarized at the end of this section. As listed in Table 2, Climate Zone 5 has an expected total of 187

commercial building renovations spread throughout the 17 counties. The information from Table 2 is used to create the list of counties shown in Table 3. Finally, a random sample of eight counties is selected from the list, identifying the number of commercial building renovations to be evaluated in each county. This process was repeated for each climate zone and the final results are shown in Table 4.

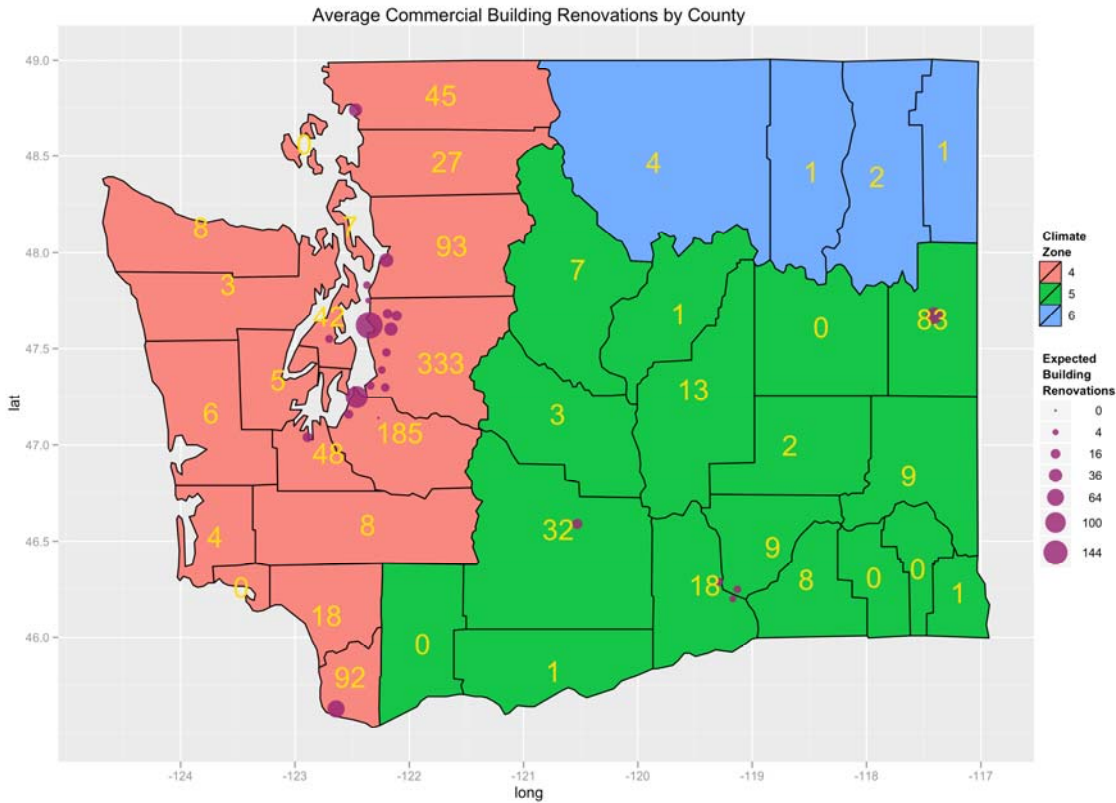


Figure 1. Expected building renovations by county for the state of Washington.

Table 2. Climate Zone 5 counties and the expected number of renovations based on data from previous years. Red strike-out values identify counties that were excluded from the sample.

	Adams	Asotin	Benton	Chelan	Columbia	Douglas	Franklin	Garfield	
Building Renovations	2	+	18	7	0	+	9	0	
	Grant	Kittitas	Klickitat	Lincoln	Skamania	Spokane	Walla Walla	Whitman	Yakima
Building Renovations	13	3	+	0	0	83	8	9	32

Table 3. List of counties where each included county is repeated based on the numbers shown in Table 2.

List of County Names										
Adams	Benton	Franklin	Kittitas	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Adams	Benton	Franklin	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Benton	Benton	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima

Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Chelan	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Franklin	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Franklin	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Franklin	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Franklin	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	Yakima
Benton	Franklin	Grant	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	
Benton	Franklin	Kittitas	Spokane	Spokane	Spokane	Spokane	Spokane	Whitman	Yakima	
Benton	Franklin	Kittitas	Spokane	Spokane	Spokane	Spokane	Walla Walla	Yakima	Yakima	

Table 4. Final random selection of counties from each climate zone (left) and the final summary of the number of buildings identified to be sampled in each selected county (right).

List Of 44 Counties				Building Sample Allocation		
Climate Zone	County	Climate Zone	County	Climate Zone	County	Total Buildings
5	Benton	4	King	5	Benton	1
5	Grant	4	King	5	Grant	1
5	Spokane	4	King	5	Spokane	5
5	Spokane	4	King	5	Yakima	1
5	Spokane	4	Kitsap	4	Clallam	1
5	Spokane	4	Kitsap	4	Clark	5
5	Spokane	4	Lewis	4	King	12
5	Yakima	4	Mason	4	Kitsap	2
4	Clallam	4	Pierce	4	Lewis	1
4	Clark	4	Pierce	4	Mason	1
4	Clark	4	Pierce	4	Pierce	8
4	Clark	4	Pierce	4	Skagit	1
4	Clark	4	Pierce	4	Snohomish	2
4	Clark	4	Pierce	4	Thurston	1
4	King	4	Pierce	4	Whatcom	2
4	King	4	Pierce			
4	King	4	Skagit			
4	King	4	Snohomish			
4	King	4	Snohomish			
4	King	4	Thurston			
4	King	4	Whatcom			
4	King	4	Whatcom			

4.0 Sample Make-Up

For new construction, the BECP provided recommendations that buildings within the sample set vary based on attributes such as building use and ownership scenarios. Similarly, the renovations sample set should be comprised of a variety of renovation types. A varied sampling of renovation projects should include buildings where:

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1. All of the following systems are replaced, or become subject to the current energy code (such as a change in occupancy or an entirely gutted building):
 - Building envelope insulation
 - Horizontal and vertical fenestration
 - HVAC system
 - Lighting system
 - Service water heater system
 2. Conditioned space/structure was added
 3. Unconditioned space was added to conditioned space, such as the conversion of a portion of an unconditioned warehouse to an office, or an attic space to a bedroom
 4. A complete HVAC system was added or replaced
 5. Ductwork was added or replaced
 6. HVAC controls on an existing system were replaced
 7. 50% or more of the lighting systems were replaced or lights were added to an existing system
 8. Lighting controls on an existing system were replaced
 9. Floor to ceiling partitions were constructed to create new spaces within a building and lighting controls were added to meet the switching requirements
 10. Lighting fixtures on the exterior of a commercial building were changed out.

Minor repairs, replacements in kind, and similar items as listed in the IECC and 90.1 should not be included in the renovations samples. In some cases these are items where a permit is not required and as a result are not subject to the energy code. In other cases, the repair or replacement is clearly not significant in relation to the remainder of the building and as such, while it must satisfy the code, non-compliance would have a nominal impact on the compliance rating of the state.