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Montana Residential Energy Code Compliance

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Final Report

Montana Residential Energy Code Compliance

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Project Background

As part of its mission, the Northwest Energy Efficiency Alliance (NEEA) is committed to achieving energy savings by strengthening building energy codes in the Northwest and, as such, it has assumed a leadership role in advocating for compliance with the new energy code.

To benchmark statewide compliance, NEEA contracted with The Cadmus Group, Inc., (Cadmus) to conduct a study of residential energy code compliance in the state of Montana. Additionally, the National Center for Appropriate Technology (NCAT) was contracted to conduct site visits in the field.

This report describes the compliance of residential new construction in Montana with the revised state energy code, an amended version of the 2009 International Energy Conservation Code (2009 IECC). This effort to measure compliance has its roots in the 2009 American Recovery and Reinvestment Act (ARRA), which provided funding to states contingent upon a commitment to adopt the latest model energy codes and achieving 90% compliance with these codes by the year 2017.

As the governors of all 50 states pledged to meet the 90% compliance target, there are ongoing efforts across the country to conduct compliance studies. To support these efforts, the U.S. Department of Energy (DOE)[1] requested that the Pacific Northwest National Laboratory (PNNL) develop a common methodology for assessing compliance.[2] The PNNL methodology provided the basis for the approach used in this study.

In Montana, building codes fall under the jurisdiction of the Montana Building Codes Bureau by default. However, local city and county governments may choose to enforce state building codes, including the energy code, using their own building officials through the state's Certified Local Government Program (CLGP). In areas outside of these certified local jurisdictions, homebuilders are required to self-certify that homes meet the energy code[3]. During the study period, there were 46 local jurisdictions in the CLGP.[4] For consistency in this report, these two types of code enforcement areas will be referred to as "local code jurisdictions" and "self-certifying areas."

Due to concerns that code compliance in self-certifying areas might be less than in local code jurisdictions, this project not only assessed compliance overall, but also examined differences in compliance rates between the two enforcement approaches. Additionally, NorthWestern Energy (NWE) —Montana's largest electric utility—requested an estimate of compliance within its service area and the study was expanded to accommodate this.

[1] www.energycodes.gov

[2] http://www.energycodes.gov/arra/documents/MeasuringStateCompliance.pdf

[3] Note that code enforcement for commercial buildings is still the responsibility of the state in these areas.

[4] The list of local jurisdictions has been updated since the study period began. The cities of Chinook and Deer Lodge no longer participate in the Certified Local Government Program. The current list is available at: http://bsd.dli.mt.gov/bc/pdf/CertCityList.pdf

Sample Creation and Selection

This section describes Cadmus' process for developing an evaluation sample for the project.

Data Sources for New Construction Activity

To select an appropriate sample of new construction projects, Cadmus first characterized the population of newly constructed homes in Montana required to meet the 2009 IECC. To aid in this process, we started with a sample generator[5] created by PNNL; which designates the number of sites to be visited in each county by randomly selecting from the number of newly completed construction projects in that county.

As part of our quality assurance process, we investigated the data sources used in the sample generator and found that the residential data were based on building permit data made available by the U.S. Census Bureau.[6] As these data are provided to the Census Bureau by local code jurisdictions, we determined that it was not representative of the stock of buildings in Montana, where a significant portion of the homes are built in self-certifying areas. The Census Bureau recognizes this limitation and asserts that nationwide less than 5% of homes are built outside of permit-issuing jurisdictions.[7] However, stakeholders in Montana believed about half the home construction in the state was occurring in self-certifying areas. Consequently, we investigated the situation further.

Estimating Montana's Residential Building Population

To construct an independent and more accurate estimate of the Montana residential building population, Cadmus used data available from the Montana Building Industry Association (MBIA),[8] an industry trade group that tracks housing starts. These data, which are collected from municipal governments and the Montana Department of Labor, are believed to provide close to full coverage.[9] However, a small number of municipalities are not included in the MBIA data.

To create a comprehensive dataset, Cadmus combined the two available data sources, using MBIA as a primary source for housing starts and supplementing the Census Bureau's building permit data in the areas for which MBIA data were not available. These data were aggregated at the county level for both local code jurisdictions and self-certifying areas.

Table 1 describes the resulting estimate of annual housing starts in Montana. Consistent with the PNNL methodology, Cadmus calculated the estimate as the average of the three most recent years of available data. As the table shows, the average number of homes constructed annually in Montana from 2008 through 2010 was more than 3,000, although the annual number has decreased notably since the economic downturn that began in late 2008. Approximately two-

[5] http://energycode.pnl.gov/SampleGen/

[6] http://censtats.census.gov/bldg/bldgprmt.shtml

[7] http://censtats.census.gov/bldg/bldginfo.shtml

[8] http://www.montanabia.com/index.php?option=com_content&view=frontpageplus&Itemid=59

[9] Communication with MBIA staff.

thirds of new construction in the state occurs within self-certifying areas, much more than had been anticipated.

Table 1. Statewide Population of Housing Starts

Housing Starts by Area	2008	2009	2010	Average
Local Code Jurisdictions	1,364	976	1,050	1,130
Self-Certifying Areas	2,738	2,006	1,878	2,207
Statewide Total	4,102	2,982	2,928	3,337
% within Local Jurisdictions	33%	33%	36%	34%

Determining Housing Starts within NWE Territory

To determine the appropriate sample of homes to target within NorthWestern Energy (NWE) service territory, Cadmus estimated the proportion of newly built homes within each county that are served by NWE. To complete this task, we obtained data from the U.S. Energy Information Administration that showed the statewide number of residential customers served by each Montana utility, as well as the counties that each utility serves.[10]

Due to the lack of more specific data, Cadmus assumed the portion of newly constructed homes served by NWE would approximate the portion of existing residential customers. As shown in Table 2, NWE serves 58% of Montana's residential customers.

Table 2. Residential Utility Customers in Montana by Utility Category

Utility Type	Residential Customers	Percent
NorthWestern Energy	268,321	58%
Other IOU	18,657	4%
Coop/Gov	177,539	38%

Next, Cadmus looked at the spread of NWE's residential customers across counties. No Montana counties are served exclusively by NWE; 36 of the state's 56 counties are served both by NWE and another utility; and these 36 counties account for 77% of the building starts described in the previous section. Because all of NWE's customers are located within these counties, the utility serves 75% of homes in these 36 counties, as shown in Table 3[11].

Table 3. Montana Residential Utility Customers by Utility Type and County Category

<table>
<tr><th>Area</th><th>Utility Type</th><th>Residential Customers</th><th>Percentage of Customers Statewide</th><th>Percentage of Customers in NWE Counties</th></tr>
<tr><td rowspan="2">NWE Counties</td><td>NorthWestern Energy</td><td>268,321</td><td rowspan="2">77%</td><td>75%</td></tr>
<tr><td>Other</td><td>90,061</td><td>25%</td></tr>
<tr><td>Non-NWE Counties</td><td>Other</td><td>106,135</td><td>23%</td><td>-</td></tr>
</table>

10 http://www.eia.gov/cneaf/electricity/page/eia861.html

11 Percentage of customers in each NWE county located within NWE service territory calculated as: 58% of statewide customers within NWE territory x 77% of statewide customers located in counties served by NWE = 75% of customers in counties with NWE presence served by NWE.

Since no data were available on the number of customers served by each utility in each individual county, Cadmus assumed that the portion of homes served by NWE would be constant across these counties, with the understanding that the sample may need to be revisited if no NWE-served homes could be located in specific counties during the site visit phase. Therefore, we assumed in each of the 36 counties where NWE provided service that 75% of building starts were within NWE's service area.

Sample Selection

After calculating building start estimates at the county level for the local code jurisdictions, self-certifying areas, and within NWE service area, Cadmus implemented a sampling procedure to determine the number of homes to visit in the specific counties for compliance analysis. The methodology for this is described in *Measure State Energy Code Compliance*, the common methodology developed by PNNL.[12] Because the PNNL sample generator was based on the incomplete census data, we implemented the basic procedure using the housing data we had developed.

PNNL suggests sampling 44 homes, the minimum number required to test 90% compliance based on a one-sided 95% confidence interval (and the variance assumed by PNNL). Because this study is limited to residential new construction—and all of Montana is located within a single climate zone—the sample selection process was fairly straightforward.

After omitting counties with fewer than two new homes, per PNNL's protocol, Cadmus used a random number generator to select 44 sites within local code jurisdictions and another 44 in self-certifying areas. We marked each site as being either inside or outside of NWE's service area. In NWE's service area, we required 44 sites in local code jurisdictions and another 44 in self-certifying areas. To meet these quotas, we added sites in the NWE service territory as needed.

After generating the initial sample, NCAT noted that some sites would be difficult to visit due to their remote location. To address this concern, Cadmus removed sites in seven hard-to-reach counties and redrew the sample. We recognized this as a departure from the PNNL methodology, but felt it was a reasonable accommodation to the reality of performing site visits in a state as vast and sparsely populated as Montana. Given that the number of homes affected was relatively small, and the replacement sample was selected randomly, we do not believe that this adjustment had any meaningful impact on the study results and it improved the data collection efficiency significantly. Overall, the sample included 125 sites. Table 4 lists the 61 within local code jurisdictions. Table 5 lists the 65 within self-certifying areas.

[12] http://www.energycodes.gov/arra/documents/MeasuringStateCompliance.pdf, See Chapter 5.2

Table 4. Site Visits in Areas With Local Building Official Oversight

County	Average Annual Housing Starts	Site Visits Required		
		Main Sample	Additional NWE Sites	Total
Yellowstone	257	11	5	16
Missoula	259	10	2	12
Gallatin	138	6	6	12
Cascade	93	5	2	7
Flathead	168	6	0	6
Lewis and Clark	68	2	1	3
Carbon	10	1	1	2
Silver Bow	52	1	0	1
Deer Lodge	19	1	0	1
Lake	10	1	0	1
Total	**1,130**[13]	**44**	**17**	**61**

Table 5. Site Visits Required in Self-Certifying Areas

County	Average Annual Housing Starts	Site Visits Required		
		Main Sample	Additional NWE Sites	Total
Flathead	257	9	0	9
Lewis and Clark	223	5	3	8
Gallatin	218	4	4	8
Ravalli	139	3	5	8
Cascade	95	3	2	5
Carbon	64	3	1	4
Yellowstone	196	3	0	3
Madison	80	2	1	3
Park	80	2	1	3
Lincoln	152	2	0	2
Stillwater	57	2	0	2
Beaverhead	37	1	1	2
Musselshell	24	1	1	2
Lake	113	1	0	1
Broadwater	33	1	0	1
Mineral	33	0	1	1
Powell	21	1	0	1
Glacier	6	1	0	1
Total	**2,207**[14]	**44**	**20**	**64**

[13] Total Average Annual Housing Starts refers to statewide total, not sum of the counties selected in the sample.

[14] Total Average Annual Housing Starts refers to statewide total, not sum of the counties selected in the sample.

Data Collection

After the sample design was established, Cadmus worked to provide NCAT with a roster of ongoing construction projects to use for potential site visits. As the industry construction data used to estimate Montana's population of housing starts were available only in aggregate, project-level contact information had to be collected through a variety of other sources. This was made difficult by the fact that there is no central depository for building permits in self-certifying areas, which necessitated different approaches to collecting data both inside and outside jurisdictional areas.

Locating Information on New Construction Projects

Local Code Jurisdictions

In local code jurisdictions, Cadmus obtained permit information from building departments. There are 19 certified local governments in the sample discussed above, and we attempted to contact the building department in each one via telephone. Several obstacles made it challenging to obtain permit data in this manner:

- Even though this is officially public information, convincing building officials to provide permitting information proved to be very difficult. However, the 17 departments we were able to contact did eventually agree to provide some information.
- Since most building departments did not maintain permit information electronically, an in-person visit was required to either request or examine permit data.
- Most counties reported they had not permitted as many new construction projects as Cadmus expected based on the housing data used to create the sample design.
- One building department reported it had not yet formally adopted the new energy code, and many others reported that, so far, they had permitted few or no new residential buildings under the IECC 2009.

Based on the housing start data that Cadmus collected to develop the sample design, over 1,000 new homes were expected to be built annually in Montana's local code jurisdictions. However, the building departments that provided information reported issuing a total of 364 new permits. Compared to our sample design, the distribution of these permits differed from what was expected across the counties. There are at least two factors that account for these differences. First, we requested that building departments provide only permits that had been issued under the 2009 IECC. As the code was phased in over the summer of 2010 and several departments reported delays in implementing the energy code, we ended up collecting less than a year of data from each building department. Second, due to the obstacles we encountered in collecting permit information, we do not believe that the distribution of the reported permits represents the actual distribution of permits issued by local code jurisdictions. Though this second factor limited the permitted homes from which we could draw a sample in underreporting jurisdictions, we do not believe it introduced any significant bias in the results since we applied appropriate weights to each of the homes included in the site visits.

Table 6 displays the building permit data that had been received from local building departments before NCAT began the field work. Once field work had started, it became clear that more data were needed that could not be collected via telephone. NCAT therefore made in-person visits to many code jurisdictions. At many of these, they found that the permit information was inadequately stored or poorly filed, and that staff members were reluctant to assist with searching through old files. One jurisdiction even reported discarding permit documents once home inspections were complete. The lack of available data also made it difficult to obtain RESCheck files, which were required to inspect homes that chose to comply with the energy code using the component trade-off path.

Table 6. Description of Building Permit Data Collected Before Site Visits

County	Site Visits Needed	Number of Jurisdictions	Permits Received from Jurisdictions	Expected Permits per Year
Yellowstone	16	2	155	257
Gallatin	12	4	127	138
Missoula	12	2	45	259
Cascade	7	1	17	93
Flathead	6	3	20	168
Lewis and Clark	3	2	-	68
Carbon	2	1	-	10
Silver Bow	1	1	-	52
Deer Lodge	1	1	-	19
Lake	1	2	-	10
Total	**61**	**19**	**364**	**1,074**

Self-Certifying Areas

To develop a list of new homes located in self-certifying areas, Cadmus created an inventory of likely projects from a database of electrical permits maintained by the Montana Department of Labor and Industry.[15] Even in areas that allow self-certifying to the energy code, a state inspection is required for the electrical code, and the department's database provides information on all electrical inspections, including those for new homes. We identified 155 likely new home construction projects across the 18 counties included in the self-certifying areas sample and provided these to NCAT.

Completing Site Visits

PNNL provides a series of checklists for measuring the compliance of residential new construction with the 2009 IECC.[16] The checklist used in this study is a modified version of the Climate Zone 6 Residential Checklist that takes into account amendments specific to Montana.

A complete assessment using the checklist requires inspecting homes and construction documents to determine compliance with each of 63 criteria organized into five distinct stages of construction:

- Pre-Inspection/Plan Review

15 https://buildingpermits.mt.gov

16 http://www.energycodes.gov/arra/compliance_checklists.stm

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

For each item, auditors record one of the following entries:

- Yes (complies)
- No (does not comply)
- N/A (item does not apply to a given house, such as skylights)
- Not Observable (item applies but cannot be verified, often because home could not be visited during all stages of construction)[17]

Complete evaluation requires that a home be visited several times to determine compliance at different stages of construction. For some stages, such as pouring the foundation, it is important to coordinate site visits closely with home builders to ensure that time-sensitive data may be collected.[18]

Demonstration of Compliance

Builders can choose to demonstrate energy code compliance using one of three approaches, or paths. Homes that we visited demonstrated compliance through one of two established code paths: prescriptive or trade-off.[19]

Our team used the modified PNNL checklist to make our compliance determination for each home visited, but the checklist is not used by builders to demonstrate compliance. The checklist provides the flexibility to determine compliance based on the path used by the builder and when we collected compliance information and analyzed the data, we applied the checklist in accordance with the compliance path employed by the builder.

PRESCRIPTIVE PATH

In most homes visited—including all homes in self-certifying areas—we assessed compliance based on the prescriptive path.[20] Compliance for a house was demonstrated when an acceptable number of items on the PNNL checklist was shown to be in compliance with the 2009 IECC.

The evaluation of prescriptive-compliance homes was relatively straightforward. The home was visited and each item on the compliance checklist was completed. When applicable, a visit to the local code jurisdiction office was also required to review permit files.

[17] The "Not Observable" category was added after we started the fieldwork, in part because of our concerns that the existing categories did not adequately cover situations when an item could not be observed at the stage when a site visit occurred.

[18] The PNNL methodology allows for homes being built as a part of the same project (such as multiple homes in a development) to be visited at separate stages and combined. However, as none of the homes that NCAT visited were part of larger construction projects, the data could not be combined.

[19] A third option, Performance-based compliance, is also available, but no homes visited in this project documented compliance in this manner.

[20] In self-certifying areas there was no information on how builders chose to comply with the code, so we assumed that they used the prescriptive path.

TRADE-OFF PATH

In certified local code jurisdictions, most homes also used the prescriptive path, but several demonstrated compliance through the trade-off path, in which compliance is considered on a whole-house basis rather than as the aggregate of a number of individual compliance items. Homes are still determined to comply even if certain building envelope items do not satisfy prescriptive compliance requirements, so long as over-compliance from other building envelope items compensates for this deficiency in terms of whole-house energy use. Builders who choose to comply using this method generally utilize the RESCheck software provided by DOE[21] to demonstrate compliance at the whole-house level.

When evaluating a home using the trade-off path, NCAT's field staff obtained RESCheck materials from the local permit-issuing office. When completing the site visit checklist, items were checked against the RESCheck values rather than against the prescriptive requirements. In this manner, the PNNL checklist could be used for both prescriptive and trade-off homes.

Description of Data

NCAT collected data from 130 homes, as listed in Table 7. Because homes within the jurisdiction of certified local governments were easier to locate and visit, they are included in greater numbers in the completed data than homes from self-certifying areas. Additionally, the majority of visited homes were located within NWE's service territory.

Table 7. Distribution of Site Visits across Jurisdictions and Within NWE Service Area

Area	All Site Visits	NWE Service Territory
Certified Local Governments	81	71
Self-Certifying Areas	49	19
Total	**130**	**90**

Table 8 shows the distributions of homes by compliance path in the local code jurisdiction and self-certifying areas. The majority of these 130 homes used the prescriptive path, and, as noted above, all homes in the self-certifying areas were assessed using the prescriptive path. The 28 homes that opted for the trade-off path within the local code jurisdictions represented slightly more than one-third of the homes in these jurisdictions.

Table 8. Distribution of Site Visits by Jurisdictional Area and Compliance Approach

Area	Prescriptive Path	Trade-Off Path	Total
Certified Local Governments	53	28	81
Self-Certifying Areas	49	0	49
Total	**102**	**28**	**130**

Because difficulties in the data collection process prevented sites from being visited in accordance with the original sampling plan, there are differences between the distribution of

[21] http://www.energycodes.gov/rescheck/

counties described in the sampling section above and the distribution of site visits that were actually completed. Table 9 and Table 10 compare the distributions.

Table 9. Distribution of Homes in Sample and Completed Site Visits, Local Code Jurisdictions

County	Sampling Plan Site Visits		Completed Site Visits	
	Total	NWE Territory	Total	NWE Territory
Yellowstone	16	14	27	26
Gallatin	12	9	22	22
Missoula	12	9	12	12
Cascade	7	5	5	5
Flathead	6	0	7	1
Lewis and Clark	3	3	2	2
Carbon	2	2	3	0
Silver Bow	1	1	3	3
Deer Lodge	1	1	0	0
Lake	1	0	0	0
Total	**61**	**44**	**81**	**71**

Table 10. Distribution of Homes in Sample and Completed Site Visits, Self-Certifying Areas

County	Sampling Plan Site Visits		Completed Site Visits	
	Total	NWE Territory	Total	NWE Territory
Flathead	9	0	3	0
Gallatin	8	7	6	6
Ravalli	8	8	4	2
Lewis and Clark	8	8	3	3
Cascade	5	4	1	1
Carbon	4	3	2	0
Yellowstone	3	2	9	2
Madison	3	2	4	4
Park	3	3	3	0
Lincoln	2	0	4	0
Beaverhead	2	1	3	0
Stillwater	2	2	1	0
Musselshell	2	1	0	0
Lake	1	0	5	0
Mineral	1	1	1	1
Broadwater	1	1	0	0
Powell	1	1	0	0
Glacier	1	0	0	0
Total	**64**	**44**	**49**	**19**

NCAT also faced difficulties in collecting full data for each home visited. Due to the obstacles discussed above, it proved nearly impossible to visit homes at each necessary stage of construction. In addition, some required construction documents could not be obtained from building departments. As a result, all homes visited include some entries recorded as "Not

Observable." Table 11 shows the average number of compliance items (out of 63) that were recorded.

Table 11. Average Distribution of Compliance Entries by Jurisdictional Areas (63 Total)

Compliance Entry	Local Code Jurisdictions	Self-Certifying Areas	Statewide
Yes	13.1	8.7	11.5
No	4.1	8.3	5.7
N/A	33.1	31.8	32.6
Not Observable	12.7	14.2	13.3

Figure 1 shows the distribution of homes based on how many items from the checklist could be evaluated as either complying or not complying. In a typical home, slightly less than half of the checklist items were not applicable, while another quarter of the items was applicable but could not be observed. This meant that, on average, compliance was determined based on the observation of about half of the applicable items. It is important to note that if an item was not present, but could plausibly be installed in the future, it was categorized as non-observable rather than non-compliant. Compliance was therefore based solely on direct observation of each requirement.

Figure 1. Distribution of Homes by Number of Evaluated Checklist Items

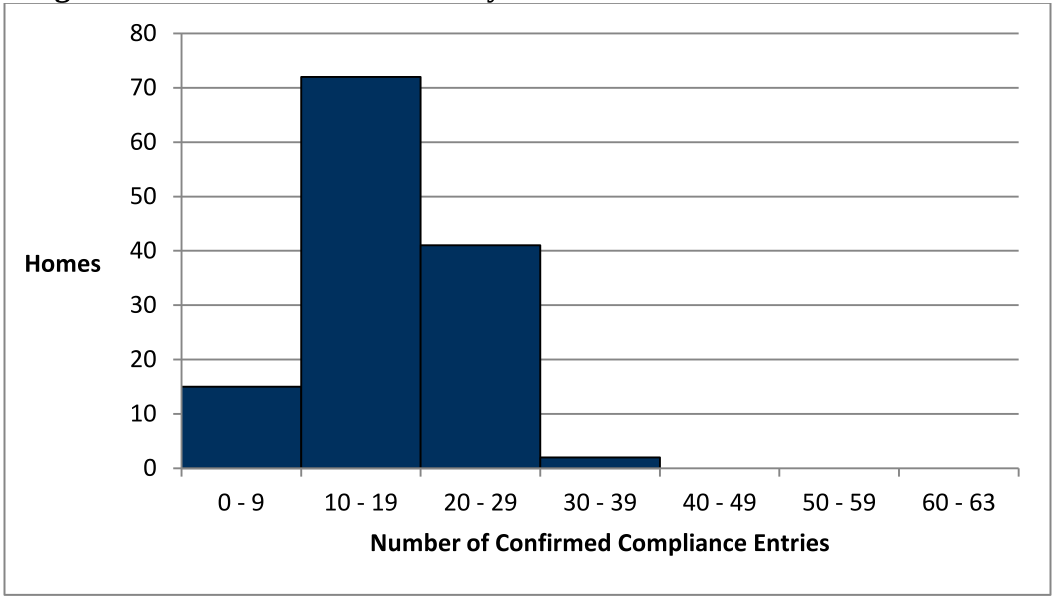


Table 12 shows the number of checklist items by construction stage in a typical home that were relevant to compliance (not recorded as "N/A") as well as those that could be confirmed as either a "Yes" or "No." Overall, just over half of relevant compliance items could be verified as either compliant or non-compliant. The Insulation Inspection stage proved especially difficult to collect data for, with just over a third of relevant data confirmed as compliant or non-compliant. This difficulty is not surprising given the typically short time between when insulation is installed and when it is covered up by drywall.

Table 12. Average Number of Relevant and Evaluated Checklist Items by Construction Stage

Construction Stage	Total Checklist Items	Average Relevant Checklist Items	Average Evaluated Checklist Items	Percent Evaluated
Pre-Inspection/Plan Review	2	2.0	0.9	44%
Foundation Inspection	11	3.0	2.1	70%
Framing/Rough-In Inspection	22	10.8	7.3	68%
Insulation Inspection	16	6.9	2.7	39%
Final Inspection	12	7.7	4.1	54%
Total	**63**	**30.4**	**17.1**	**56%**

Data Collection Challenges and Implications

As noted above, NCAT encountered many challenges in trying to collect the required data. Many of the construction projects identified in the sample selection either had not broken ground or were too far along in the construction process to obtain useful information. Some homes had been fully constructed and were occupied, and many occupants proved unwilling to allow site visits. Also, although we asked building departments to provide permits filed only after the updated building code became effective, NCAT discovered that many projects were being enforced under the old code and, thus, were ineligible for site visits.[22] Perhaps the greatest challenge in completing site visits was the near-unanimous refusal of builders and homeowners to respond to NCAT's phone calls, even with the promise of a $75 incentive.

To respond to these challenges and collect reliable data, NCAT and Cadmus had to adjust the sampling and recruitment process throughout the project. As NCAT encountered difficulties, Cadmus reviewed the sample design and made adjustments to take into account the real world constraints, while trying to maintain randomness and minimize any bias. NCAT had to adjust on the fly when they discovered sample buildings could not be site visited for various reasons. In the end, they had to be very creative in identifying homes that could be visited in lieu of ones that were identified in the specified sample. By building upon existing relationships with building inspectors and utility employees, and by being opportunistic in identifying homes for site visits, NCAT painstakingly recruited additional homes to help expand the original samples for the field work.

We recognize that the data collection process described above departs from the desired randomized sample design. Because site visits were completed at the homes that were available, rather than the homes that were randomly assigned, some degree of bias may have been

[22] If a building permit were applied for after the effective date of the new code, compliance should be based on the new code. However, in prior studies we have encountered difficulties in trying to clarify what date a building department reports and whether it is the date that triggers enforcement of the new code. Technically, if a building department were enforcing the preceding code for buildings that should comply with the new code, the buildings should still be included in the compliance analysis. However, this is likely to be a transition issue, so excluding these buildings from our analysis is not a concern for the longer term.

introduced into the study. However, since the reasons for not being able to complete site visits to sample homes varied, we do not believe there was any systematic bias in the data collected.

It is important to recall that the sample was designed to allow calculating an overall compliance rate by taking the simple average of the values for each home visited. However, if the overall rate is calculated by weighting each observation based on the population distribution, then the difference between the sample plan distribution and actual distribution is not an issue. We calculated compliance rates with and without weighting and these results are presented later.

It is informative to review how our completed site visits compare with the sample designs. Table 9 compares the desired sample and completed site visits in local code jurisdictions. The completed site visits (81) exceed the number in the sample design (61), primarily because we conducted more site visits in the counties with the largest desired sample. No site visits were completed in two counties, but the design was to conduct only one site visit in each so the impact was minimal. The difference between the sample design and completed site visits affects the simple average compliance rate, but weighting by the population distribution should largely eliminate any effect of the difference.

Table 10 shows that the number of completed site visits to homes in the self-certifying areas (49) was less than the number required by the sample plan (64). However, we were able to conduct site visits to several homes in each of the counties where the desired sample was largest. No site visits were completed in four counties, but, as with the local code jurisdictions, the number of sites in the sample plan for these counties was small (either one or two). The biggest gap between the sample design and completed site visits occurred in the case of self-certifying areas served by NWE—our site visits covered less than half the desired number in the sample plan. As shown later, the impact of this was primarily to produce less precise estimates of the compliance rates in these areas. Again, the unweighted average compliance rate will be affected by the difference between the sample design and completed site visits, but the weighted average will be affected minimally.

Without far more support from local building departments and state electrical inspectors, it would be very difficult and resource-intensive to complete this project in the field according to the directions specified by PNNL. As the first foray into completing a project of this kind in Montana, we feel the steps taken were appropriate and necessary, and that they provide valuable lessons for similar efforts that must occur in advance of the 2017 compliance deadline. Also, while the differences between our sample design and the completed site visits affect some of the compliance rate estimates (particularly the unweighted ones), we have no empirical or logical basis for believing that systematic bias was introduced that affected the results.

From these metrics, it is clear that data collection issues exist and improved methods for identifying and visiting potential sites must be developed. However, the large number of visited sites allows for the generation of meaningful statistics in aggregate, even if the data are not very complete on a per-home basis. The next section discusses several possible approaches to analyzing the data and determining compliance.

Analysis Methodology

To provide a common thread for compliance studies across the nation, PNNL has developed a methodology to analyze checklist data.[23] Although states are not required to adhere to the recommended methodology, it provides a strong analytical foundation from which to explore issues of compliance.

PNNL Methodology

In the PNNL method, a compliance score is developed for each home based on the site visit checklists developed by PNNL. Based on PNNL's assessment of the relative importance of 63 specific compliance items, each item is assigned a value of one, two, or three points. There is a total of 130 points available. To determine building-level compliance, the total points for all items marked as compliant are divided by the total points associated with all of the items marked either as compliant or non-compliant. Any items marked as Not Applicable or Not Observable are excluded from the compliance evaluation. If the resulting percentage is greater than or equal to 90%, then the home is determined to meet the minimum compliance threshold and is referred to as compliant for reporting purposes.

For determining statewide compliance, PNNL discusses two possibilities:

- Determine the percentage of compliant homes (those having a checklist score greater than or equal to 90%).
- Take a simple average of the house-level compliance scores.

PNNL states a preference for the second method, as it provides a finer level of detail in the progress of a state in reaching 90% compliance. Cadmus agrees with this, but feels that both metrics are instructive; consequently, we report both.

Adapting the PNNL Methodology for this Study

Two aspects of the data collection process required Cadmus to modify how we analyzed the data. First, since the distribution of completed site visits did not match the sampling plan, we developed a weighting that trued up the data with geographic distribution of housing starts in Montana. Within each county, we calculated a weight for both the local code jurisdictions and self-certifying areas. The weight was the percent of all housing starts within each of these categories that were expected in the selected county, divided by the percent of all site visits in that category that took place in the county. We multiplied the compliance scores for individual homes by the weight value associated with their county and category. For example, if 10% of the self-certifying area site visits occurred in a county that represented 50% of the expected housing starts for self-certifying areas, the compliance score for each observation would be multiplied by a factor of 5.

We repeated this basic approach for the sample restricted to NWE service territory. By increasing the weight given to underrepresented counties and by decreasing the influence of areas where data were collected in larger quantities than specified in the sampling plan, this

[23] http://www.energycodes.gov/arra/documents/MeasuringStateCompliance.pdf, Methodology detailed in sections 5.3 and 5.4.

process aligned the collected data with the actual geographic distribution of housing starts in Montana estimated during the sample design.

The second complication to overcome was the incomplete nature of the individual site visits. As shown in Figure 1 and Table 12 in the previous section, only about half the applicable items on the PNNL checklist could be verified during site visits. Additionally, there was wide distribution of the degree of completeness of the site visits. At some sites, one-half or more of the applicable compliance items could be verified. In others, a much smaller percent could be determined to be compliant or non-compliant.

We felt that the great variety in the completeness of the site visit compliance data should be reflected in the analysis and that homes with more complete checklists should have a greater impact on results than homes where minimal data could be collected. Therefore, we introduced a second weight to the analysis. For each home, this weight was calculated as the total possible compliance points for that home (that is, the point value associated with the items that could be determined to be either compliant or non-compliant) divided by the average possible compliance points across all homes in the sample. We multiplied this weight by the compliance percentage of the home. As with the first weighting discussed above, we repeated this process for the two jurisdictional areas both statewide and within NWE's territory.

This second weighting was a logical way to count more heavily the compliance results for those sites having a greater amount of available data.

Alternate Methodologies

In addition to the basic PNNL methodology (with the weighting approaches described above), Cadmus analyzed compliance using the following two alternate approaches to add to the robustness of the study results.

Significant Item Methodology

In the PNNL methodology, each of the 63 compliance items is given a weight value ranging from one to three points. In our experience, this small range is not sufficient to capture the relative effects of the checklist measures on energy consumption, which is the ultimate impact of code compliance. Many items on the checklist have little impact on a home’s energy consumption and some (such as posting a certificate on the home’s electricity panel describing energy features) may be important from a procedural perspective, but do not contribute directly to energy usage at all. To address this issue, we developed an alternate methodology that encompassed only the items having the most significant effect on compliance and energy use.

This alternative method removed the influence of less-important compliance items by restricting the analysis to the eight checklist items we deemed to be the most important in determining energy consumption. This method allowed the analysis to consider whether builders were complying with the most vital components of the 2009 IECC, regardless of whether the builders complied with other requirements of lesser importance. The eight items in this analysis were these:

- Window Glazing U-factor
- Duct sealing

- Ducts located away from building cavities
- Floor insulation R-value[24]
- Wall insulation R-value
- Ceiling insulation R-value
- Air sealing[25]
- High-efficiency lighting

Other than this change, we applied the remainder of the PNNL method as designed (with the completeness weighting). Each of the eight items above was assigned a weight of three points in the PNNL checklist, and so they were weighted equally in this alternate analysis. As with the PNNL method, we calculated a compliance score for each home that reflected the percentage of these items that were deemed to be code-compliant, and averaged these to estimate a statewide compliance level. (We excluded from our analysis any items rated as “Not Applicable” or “Not Observable”, as these were also excluded in the PNNL methodology).

Energy Consumption Methodology

Our second alternative method was designed to address a related issue with the PNNL methodology. We feel that the checklist methodology could be improved by incorporating an understanding of how energy code compliance relates to energy usage. While verified compliance with the legal requirements of the updated energy code is important and provides valuable information, it is also important to view compliance in the context of the implicit goal of achieving energy savings. Thus, we developed another alternate methodology intended to reflect the impact of each compliance item on a home’s energy consumption.

Ideally, an assessment of this type would involve modeling the energy consumption of each individual home; however, the budget and scope of this effort did not allow that. Instead, we researched the relative importance of different code compliance elements to a home’s energy usage. By grouping together building components affecting various energy end-uses and weighting them by the contribution of that component to a home’s energy consumption, we created an initial framework for evaluating compliance in terms of energy impacts. This was intended to be a simplified look at code compliance, accounting to some extent for the reality that some checklist items have more impact on a home’s actual energy consumption than others. We note that this is only a first cut at taking such an approach. Future studies could build upon this approach and develop more sophisticated measures that better reflect the energy implications of code compliance.

[24] As construction requiring floor insulation is rare in Montana, this compliance item was recorded as Not Applicable in the majority of homes. However, we feel that, in the cases where floor insulation is applicable to a home, it is an important element in compliance. Homes where floor insulation was not applicable were not penalized in the house-level compliance score.

[25] Builders have the option of demonstrating compliance with air sealing requirements either through a blower door test or by visual inspection. In the field, in instances where NCAT knew that a blower door test had been used, the home was evaluated for compliance using the results of the test. In homes where visual inspection had been used to demonstrate compliance or where the method was unknown, a home’s compliance was evaluated by visual inspection. In this alternate methodology, the two methods of evaluating air sealing compliance are combined into a single compliance item.

The source for the data used in the second alternative was a Northwest ENERGY STAR® study from 2000 that discussed the contribution of various factors to a typical home's energy use. Data from this study—which analyzed energy consumption by end use and heat loss by shell measure—were combined to calculate the percentage of a home's code-related energy use that would be impacted by each compliance item.[26] The following tables show how these percentages were calculated.

Table 13 shows the typical distribution of energy use of a home by end use. The data used to form these estimates were based on a typical home in NOAA's Climate Zone 1, which includes Montana. Clearly, the distribution of energy consumption across homes will vary widely by home, and will partially depend on the degree to which a given home's construction complied with the energy code. These numbers are intended to provide general estimates of end-use consumption to apply to all homes in the collected data.

Table 13. Percentage of a Typical Home's Energy Usage in Montana Climate Zone by End Use[27]

End Use	% Energy Usage
Space Heating	56%
Other Appliance and Lighting	21%
Water Heating	17%
Refrigerators	4%
Air Conditioning	2%

There is wide range of applicable criteria in the 2009 IECC relating to the performance of a home's envelope. The energy consumption associated with the two end uses, space heating and air conditioning, must be allocated across different shell components. Table 14 shows the relative contribution of several envelope components to a home's heat loss. Due to a lack of data, we applied these percentages to both the air conditioning and the space heating end use.

Table 14. Contribution to Space Heat Loss by Shell Measure[28]

Shell Component	% Heat Loss
Windows	31%
Air Leakage	24%
Ceilings	17%
Floors	15%
Walls	13%

Northwest ENERGY STAR® provides a breakout of the components that contribute to a home's air leakage, as shown in Table 15, so there is another level of granularity within the air leakage shell component.

[26] We note that this approach did not take into account how much a measure deviated from a code requirement, either above or below the requirement.

[27] http://www.northwestenergystar.com/sites/default/files/resources/NZEH_Final__20110425_v3.pdf, Figure 5.6.1

[28] http://www.northwestenergystar.com/sites/default/files/resources/NZEH_Final__20110425_v3.pdf, Figure 5.4.1

Table 15. Contribution to Air Leakage by Component[29]

Air Leakage Component	% Air Leakage
Floors, Walls, Ceilings Air Sealing	33%
Ducts	15%
Fireplace	14%
Plumbing Penetrations	13%
Doors	11%
Window Air Sealing	10%
Fans and Vents	4%

Cadmus combined this information to calculate a percentage of a typical Montana home's energy consumption related to a variety of code compliance components. All consumption from the refrigerator and water heating end uses was excluded from the analysis.[30] As no code criteria are concerned with appliances and the data could not be disaggregated, all consumption from the Other Appliances and Lighting category was attributed to lighting, which is covered by the code. We allocated consumption from the heating and cooling end uses across the various shell and air leakage components and then combined the resulting percentages with appliances and lighting and normalized to equal 100%. The resulting percentages, shown in Table 16, are intended to provide an approximate estimate of the percentages of building code-related energy consumption that are impacted by various components of a home.

Table 16. Calculated Contribution to Code-Related Energy Consumption by Component

Code Compliance Component[31]	% Energy Usage
Lighting and Appliances	27%
Windows	23%
Ceilings	12%
Floors	11%
Walls	10%
Air Sealing	8%
Ducts	3%
Fireplace	2%
Plumbing Penetrations	2%
Doors	2%
Fans and Vents	1%

[29] http://www.northwestenergystar.com/sites/default/files/resources/NZEH_Final__20110425_v3.pdf, Figure 5.4.2

[30] There are no items on the PNNL checklist that relate to refrigerator consumption. There is an item that relates the insulation of circulating hot water pipes, but we determined that allocating the entirety of the water heating end use to this compliance item would dramatically overstate its importance. Consequently, we chose to exclude the end use entirely.

[31] Many of these compliance components (fireplace, floor insulation, etc.) are not applicable to all homes. In these cases, homes were not evaluated for compliance with that particular item, and the absence of a compliance score did not affect the house-level compliance score.

Cadmus' Process

To reflect the impact of code compliance on a home's energy consumption, we followed the following process.

1. We categorized the items on the PNNL checklist by the code compliance component they related to.

2. Any items that did not correspond to a component or that had been given fewer than three points in PNNL's weighting scheme were excluded.[32]

3. For each house, we calculated a compliance percentage for each code compliance component. When compliance components related to multiple items in the PNNL checklist, these were combined and given equal weighting. For example, three compliance items in the PNNL checklist relate to windows and are attributed three points. The proportion of these three items in a given home that was compliant out of those that were verifiable was recorded and treated as that home's windows compliance percentage.

4. Next, we calculated a project-level compliance score by weighting these component-level compliance scores according to the percentages in Table 16. In the same example, the window compliance percentage was multiplied by 0.23 and combined with the compliance percentages of the other code components in that home.

5. We did not count items against a home's compliance score if the checklist items in a given component could not be verified. (This is similar to the treatment of "Not Applicable" or "Not Observable" compliance items in the PNNL checklist.) For example, if none of the three relevant windows criteria could be verified as compliant or non-compliant in a given home, but a compliance percentage could be calculated for all other code components, then the home's compliance score was calculated using 0.77 instead of 1.00 as the denominator in determining energy-related code compliance.

Application of Alternate Methodologies

As with the modified PNNL approach, Cadmus averaged the house-level compliance scores for these alternate methodologies to develop a statewide estimate of compliance. In both alternate analyses, we weighted the compliance scores of the individual homes to account for geographic spread and the relative completeness of the data.

In these methods, the process for weighting by county was the same as that described above for the modified PNNL methodology. Our process for weighting house-level compliance scores was similar to that used in the modified PNNL method, but adapted to reflect the data used in each alternate methodology.

[32] An exception was made for code compliance components that did not relate to any checklist items worth three points. In these cases, items worth less than the maximum value in PNNL's methodology were not excluded from the analysis. Additionally, the PNNL checklist includes three items—worth one point each—that relate to the visual inspection of air sealing. This methodology retained all three of these items as they combine to be worth three points.

In the Significant Item Methodology, each project was weighted by the number of these items that could be verified as either compliant or non-compliant.[33] In the Energy Consumption Methodology, projects were weighted according to the amount of code-related energy consumption that could be verified through site visits as compliant or non-compliant.[34]

Table 17 provides a summary of the basis for compliance and weighting schemes used in this analysis' three methodologies.

Table 17. Summary of the Three Methods for Compliance Analysis

Compliance Methodology	Basis for Project-Level Compliance	Determining Statewide Compliance	
		Geographic Weights	Completeness Weights
Modified PNNL Checklist	63 Compliance Items, valued at 1, 2, or 3 points.	Each project weighted by the degree that the county it is located in was over- or under-sampled in the data collection process.	Each project weighted by the total possible points recorded on the PNNL checklist.
Significant Items	8 Compliance Items determined to be of the most importance to code compliance, weighted equally.		Each project weighted by the number of important compliance items that could be verified.
Energy Consumption	63 Compliance Items, each weighted according to its contribution to a prototypical home's energy usage of the item they apply to.		Each project weighted by the percent of a home's code-related energy consumption that related to verified items in the checklist.

[33] In other words, the compliance score of each home was given a weight of 1 to 8 points depending on how many items could be verified.

[34] Continuing the example above, if no relevant windows code criteria could be verified but all others could be, the home was given a weight of 0.77. If all code components could be verified, the home was given a weight of 1.00.

Analysis Results

Figure 2 through Figure 4 display the distribution of project-level compliance scores without either geographic or completeness weighting. The results are color-coded to show the difference in the distributions between the local code jurisdictions and self-certifying areas, and a separate figure is provided for each compliance methodology. Both alternative methods led to a larger proportion of homes complying at the 90% or higher level than the modified PNNL method did.

Figure 2. Distribution of House-Level Compliance: Modified PNNL Checklist Methodology—Unweighted

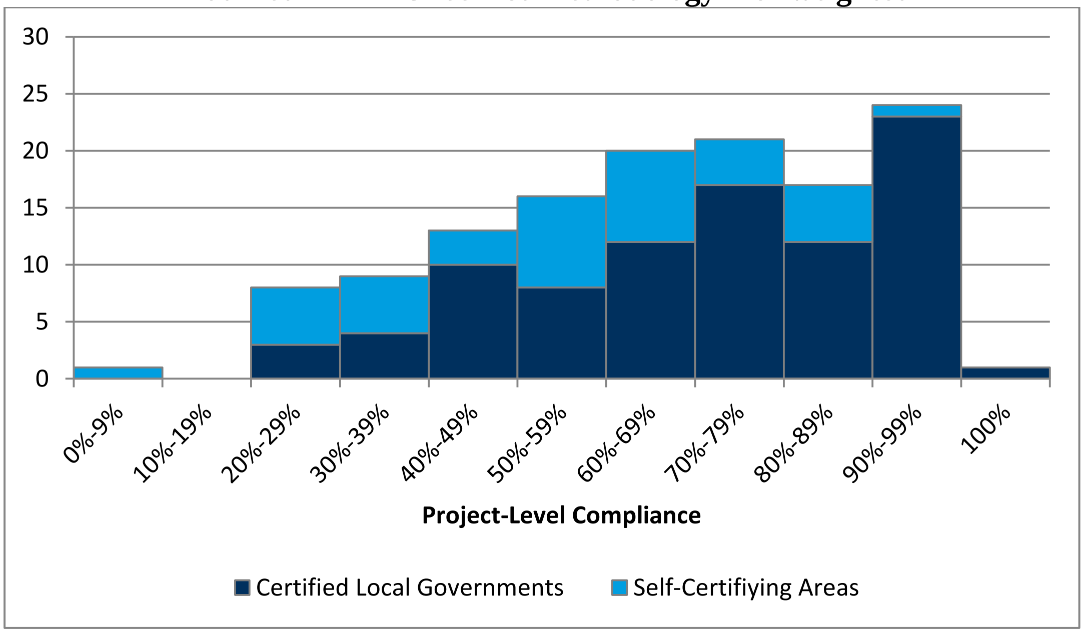


Figure 3. Distribution of House-Level Compliance: Significant Items Methodology—Unweighted

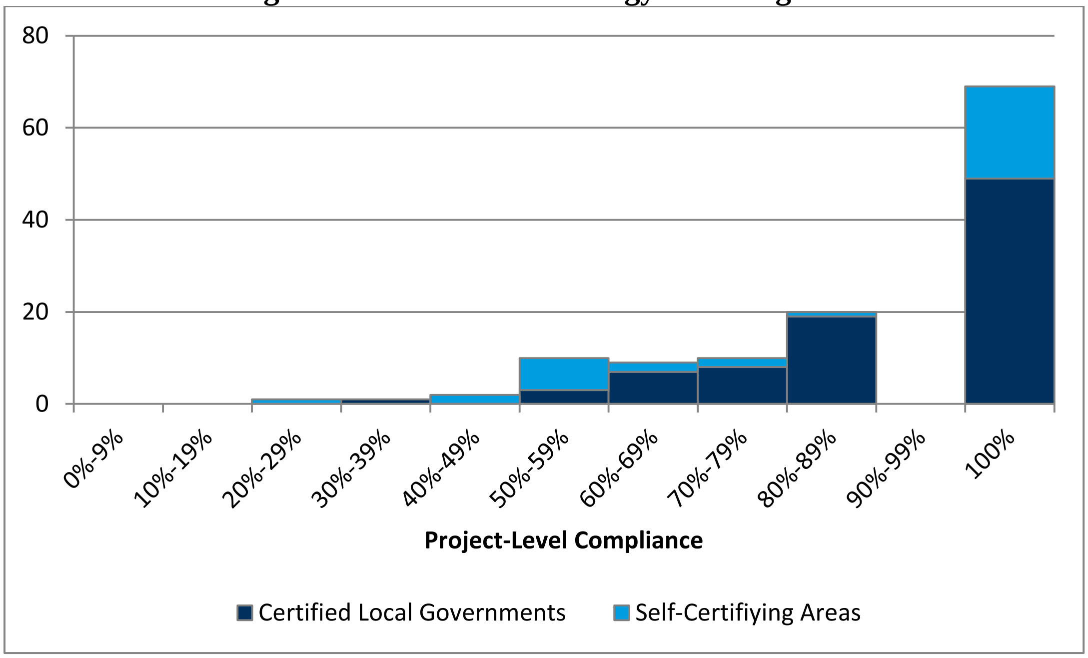
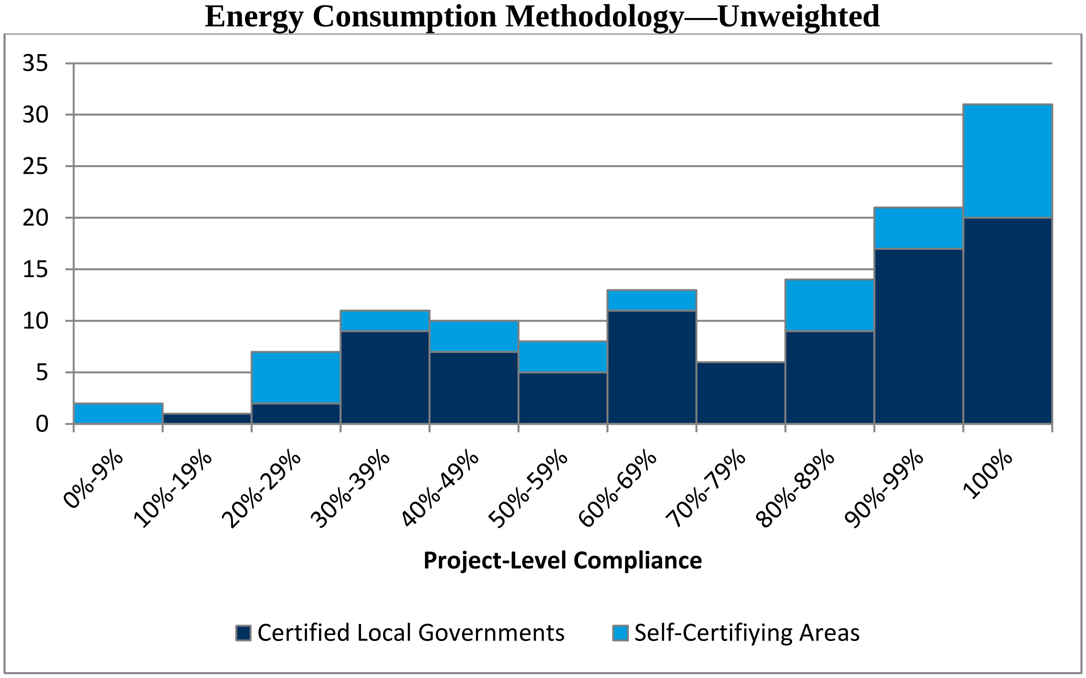


Figure 4. Distribution of Project-Level Compliance: Energy Consumption Methodology—Unweighted



Regarding statewide compliance estimates, there are a variety of ways in which the results of these analyses may be presented. Thus, the number of different compliance estimates presented is quite large. This is due both to the study design (which includes multiple geographic areas of interest) and the use of several methodologies and weights in the analysis. Statewide results are presented as follows:

- Both as the percentage of homes achieving greater than 90% compliance on a project level and as the average of project-level compliance scores. (The latter category is presented four ways: without any weights applied; weighted by county; weighted by the completeness of the checklist; and with both weights applied together.)
- Separately for sites within certified local government and self-certifying jurisdictions. These are combined for a statewide estimate of compliance.[35]
- Separately for the sample of homes located within NWE's service territory.
- In terms of each of the three methodological approaches discussed in the previous section.

Given that this is a baseline compliance assessment, Cadmus views this project as an opportunity to present and compare multiple pathways that might be taken towards evaluating compliance for the 2017 deadline. We do not suggest that any one measure of compliance presented in the following tables is the correct value. Instead, we demonstrate that compliance can be considered in multiple ways, in the hope of beginning a discussion as to how studies such as this should be undertaken and presented, both in Montana and across the nation.

Table 18 summarizes the results from using the different compliance methodologies. These values demonstrate the average house-level compliance—weighted for both geographic area and checklist completeness—in local code jurisdictions, self-certifying areas, and combined.

Table 18. Summary of Results for Compliance Scenarios Statewide

Methodology	Local Code Jurisdictions	Self-Certifying Areas	Combined
Modified PNNL Checklist	78.7%	49.8%	60.5%
Significant Items	95.6%	71.8%	80.6%
Energy Consumption	83.4%	51.8%	63.5%

Table 19 shows the same values, but restricts the analysis to NWE's service territory.

Table 19. Summary of Results for Compliance Scenarios in NWE Service Area

Methodology	Local Code Jurisdictions	Self-Certifying Areas	Combined
Modified PNNL Checklist	81.4%	47.1%	59.8%
Significant Items	97.6%	68.5%	79.3%
Energy Consumption	83.5%	46.2%	60.0%

The remaining results are presented in Table 20, which shows all compliance scenarios calculated using the methodology adapted from PNNL's approach. Table 21 shows compliance

[35] In the statewide estimates, the compliance scores for the local code jurisdictions and self-certifying areas are combined and weighted according to the distribution of Montana housing starts into these areas, which is given in Table 1.

percentages calculated using the Significant Item Methodology. Finally, Table 22 shows values calculated using the Energy Consumption Methodology.

Table 20. Compliance Value Scenarios Calculated Using Modified PNNL Methodology

Sample Area	Compliance Approach	Weighting	Count of Applicable Sites	Percentage of Sites with at Least 90% Compliance	Average of State Compliance Estimates	
					Compliance Value	90% Conf. Int.
Statewide	Local Code Jurisdictions	None	81	29.6%	76.0%	7.8%
		Geographic Area			75.7%	7.8%
		Data Completeness			76.4%	7.7%
		Both			78.7%	7.5%
	Self-Certifying Areas	None	49	2.0%	50.4%	11.7%
		Geographic Area			49.0%	11.7%
		Data Completeness			50.8%	11.7%
		Both			49.8%	11.7%
	Combined	None	130	19.2%	59.9%	7.0%
		Geographic Area			58.9%	7.1%
		Data Completeness			60.2%	7.0%
		Both			60.5%	7.0%
NWE Service Territory	Local Code Jurisdictions	None	71	33.8%	77.7%	8.1%
		Geographic Area			76.6%	8.2%
		Data Completeness			78.8%	8.0%
		Both			81.4%	7.6%
	Self-Certifying Areas	None	19	0.0%	47.1%	18.8%
		Geographic Area			46.9%	18.8%
		Data Completeness			47.1%	18.8%
		Both			47.1%	18.8%
	Combined	None	90	26.7%	58.5%	8.5%
		Geographic Area			57.9%	8.5%
		Data Completeness			58.9%	8.5%
		Both			59.8%	8.5%

Table 21. Compliance Value Scenarios Calculated Using Significant Items Methodology

Sample Area	Compliance Approach	Weighting	Count of Applicable Sites	Percentage of Sites With at Least 90% Compliance	Average of State Compliance Estimates	
					Compliance Value	90% Conf. Int.
Statewide	Local Code Jurisdictions	None	77	70.1%	93.2%	4.7%
		Geographic Area			93.4%	4.6%
		Data Completeness			94.7%	4.2%
		Both			95.6%	3.9%
	Self-Certifying Areas	None	45	33.3%	74.1%	10.7%
		Geographic Area			72.3%	10.9%
		Data Completeness			71.7%	11.0%
		Both			71.8%	11.0%
	Combined	None	122	56.6%	81.2%	5.8%
		Geographic Area			80.1%	5.9%
		Data Completeness			80.2%	5.9%
		Both			80.6%	5.9%
NWE Service Territory	Local Code Jurisdictions	None	69	66.7%	92.4%	5.2%
		Geographic Area			93.0%	5.0%
		Data Completeness			94.6%	4.5%
		Both			97.6%	3.0%
	Self-Certifying Areas	None	18	16.7%	73.4%	17.1%
		Geographic Area			70.4%	17.7%
		Data Completeness			73.1%	17.1%
		Both			68.5%	18.0%
	Combined	None	87	56.3%	80.4%	7.0%
		Geographic Area			78.8%	7.2%
		Data Completeness			81.0%	6.9%
		Both			79.3%	7.1%

Table 22. Compliance Value Scenarios Calculated Using Energy Consumption Methodology

Sample Area	Compliance Approach	Weighting	Count of Applicable Sites	Percentage of Sites with at Least 90% Compliance	Average of State Compliance Estimates	
					Compliance Value	90% Conf. Int.
Statewide	Local Code Jurisdictions	None	78	52.6%	82.8%	7.0%
		Geographic Area			82.8%	7.0%
		Data Completeness			82.1%	7.1%
		Both			83.4%	6.9%
	Self-Certifying Areas	None	46	23.9%	57.8%	11.9%
		Geographic Area			53.4%	12.1%
		Data Completeness			56.0%	12.0%
		Both			51.8%	12.1%
	Combined	None	124	41.9%	67.0%	6.9%
		Geographic Area			64.3%	7.1%
		Data Completeness			65.6%	7.0%
		Both			63.5%	7.1%
NWE Service Territory	Local Code Jurisdictions	None	69	52.2%	82.3%	7.5%
		Geographic Area			82.9%	7.4%
		Data Completeness			84.3%	7.2%
		Both			83.5%	7.3%
	Self-Certifying Areas	None	18	5.6%	49.7%	19.3%
		Geographic Area			47.4%	19.3%
		Data Completeness			51.1%	19.3%
		Both			46.2%	19.3%
	Combined	None	87	42.5%	61.7%	8.5%
		Geographic Area			60.6%	8.6%
		Data Completeness			63.4%	8.5%
		Both			60.0%	8.6%

Component-Level Compliance

To gain some insights into compliance at the component level, we summarized compliance information for specific measures related directly to energy consumption. We determined that 24 of the 63 items on the PNNL checklist related to the energy consumption categories detailed in Table 16. Using the Energy Consumption compliance methodology described earlier, we determined the frequency for which each component was verifiable (i.e., applicable and observable) and the compliance rate. Table 23 shows for each compliance item category the number of items on the checklist that contribute to its compliance level, the percent verifiable, and the compliance percent. The compliance rates are least reliable for those items for which the percent verifiable is low such as floors, walls, fireplace, plumbing penetration, and window air sealing. Though few compliance rates surpass 90%, component-level compliance rates are for the most part fairly high, generally indicating that the elements of code compliance that relate to energy consumption are being addressed well by home builders.

Table 23. Compliance by Component of Energy-Related Code Component

Compliance Item	Number of Items	Percent Verifiable	Percent Compliance
Lighting	1	58%	61%
Windows	3	51%	79%
Ceilings	2	71%	80%
Floors	2	9%	96%
Walls	2	35%	79%
Air Sealing	4	16%	83%
Ducts	5	33%	91%
Fireplace	1	24%	76%
Plumbing Penetrations	1	1%	100%
Doors	2	65%	61%
Fans and Vents	1	95%	100%
Total	**24**	41%	**77%**

Northwest ENERGY STAR® Homes

Eleven (11) of the 130 homes visited have been certified as Northwest ENERGY STAR® homes. Each of these homes was located both within the jurisdiction of a certified local government and in NWE's service territory. Table 24 compares the results for ENERGY STAR® homes with other homes in the local code jurisdictions using the PNNL checklist and the Energy Consumption methods. The average compliance rate of ENERGY STAR® homes is higher than that of the other homes in the local code jurisdictions.

Table 24. Comparison of Northwest ENERGY STAR® Homes and Other Homes Within Local Code Jurisdictions

Home Type	Count	PNNL Checklist Method		Energy Consumption Method	
		Count with at Least 90% Compliance	Average Compliance	Count with at Least 90% Compliance	Average Compliance
Northwest ENERGY STAR® Certified	11	7	87%	10	96%
Other	70	17	74%	31	81%
Total	**81**	**24**	**76%**	**41**	**83%**

It is important to note that the criteria for compliance with the 2009 IECC and for qualification as a Northwest ENERGY STAR® home are different. ENERGY STAR® certification is based on an analysis that compares estimated energy consumption for a home with the estimated consumption for a home that just meets the relevant code. As described in this report, the PNNL method and the Energy Consumption method are based on different metrics. While there is overlap between the ENERGY STAR® approach and the compliance assessment methods we used in this study, there are fundamental differences that make it very possible for an ENERGY

STAR® home to be less than 100% compliant using either the PNNL or Energy Consumption method. As the table shows, the compliance rates are much higher for ENERGY STAR® homes using the Energy Consumption method than the PNNL method, and this is because the former method is closer to a measure of energy performance much like the ENERGY STAR® index.

Appendix: Line Item Compliance

This Appendix presents the results of NCAT's site visits for each of the 63 compliance items on PNNL's checklist. For each criterion, the frequency of homes graded as each response is given, as well as the percent that was verifiable (recorded as either compliant or non-compliant) and the percent of the verifiable homes that complied with this item.

Table 25. Rate of Code Compliance by Compliance Criteria, All Homes

Construction Phase	Compliance Item	Points Allocated in PNNL Checklist	Number Compliant	Number Not Compliant	Number Not Observable	Number Not Applicable	Percent Verified	Percent Compliant
Pre-Inspection/ Plan Review	Construction documentation available and demonstrates energy code compliance.	1	13	53	64	0	51%	20%
	HVAC loads calculations available	2	7	42	81	0	38%	14%
Foundation	Slab edge insulation R-value	1	6	5	16	103	8%	55%
	Slab edge insulation Installed per manufacturer's instructions	1	10	1	16	103	8%	91%
	Slab edge insulation depth/length	1	7	2	18	103	7%	78%
	Basement wall exterior insulation R-value.	1	3	14	6	107	13%	18%
	Basement wall exterior insulation installed per manufacturer's instructions	1	4	13	6	107	13%	24%
	Basement wall exterior insulation depth	1	4	11	8	107	12%	27%
	Crawl space wall insulation R-value	1	62	2	14	52	49%	97%
	Crawl space wall insulation installed per manufacturer's instructions	1	52	12	14	52	49%	81%
	Crawl space continuous vapor retarder	1	31	27	20	52	45%	53%
	Exposed foundation insulation protection	2	8	3	0	119	8%	73%
	Snow melt controls	2	0	1	0	129	1%	0%
Framing / Rough-in	Door U-factor	1	60	18	52	0	60%	77%
	Glazing U-factor	1	76	4	50	0	62%	95%
	Glazing SHGC value, including sunrooms	1	0	0	0	130	0%	-

Construction Phase	Compliance Item	Points Allocated in PNNL Checklist	Number Compliant	Number Not Compliant	Number Not Observable	Number Not Applicable	Percent Verified	Percent Compliant
Framing / Rough-In (Cont'd)	Glazing labeled for U-factor	1	81	38	11	0	92%	68%
	Skylight U-factor	1	1	0	4	125	1%	100%
	Skylight SHGC value	1	0	0	0	130	0%	-
	Skylights labeled for U-factor	1	0	3	2	125	2%	0%
	Sunroom glazing U-factor	1	0	0	1	129	0%	-
	Sunroom skylight U-factor	1	0	0	1	129	0%	-
	Mass wall exterior insulation R-value.	1	1	0	2	127	1%	100%
	Mass wall exterior insulation installed per manufacturer's instructions	1	2	0	1	127	2%	100%
	Duct insulation	1	6	4	14	106	8%	60%
	Duct sealing complies with listed sealing methods	1	91	10	22	7	78%	90%
	Duct tightness evaluated via rough-in test	1	0	0	24	106	0%	-
	Building cavities not used for supply ducts	1	90	5	28	7	73%	95%
	IC-rated recessed lighting fixtures	2	109	3	14	4	86%	97%
	HVAC piping insulation.	2	23	3	15	89	20%	88%
	Circulating hot-water piping insulation	2	1	0	11	118	1%	100%
	Dampers Installed on all outdoor intake and exhaust openings	2	114	0	16	0	88%	100%
	Glazed fenestration air leakage	3	11	34	85	0	35%	24%
	Swinging door air leakage	3	0	42	88	0	32%	0%
	Fenestration and doors labeled for air leakage	3	0	120	10	0	92%	0%
Insulation	Floor insulation R-value	1	11	0	16	103	8%	100%
	Floor insulation installed per manufacturer's instructions	1	12	1	14	103	10%	92%
	Wall insulation R-value	1	42	6	82	0	37%	88%
	Wall insulation installed per manufacturer's instructions	1	27	12	91	0	30%	69%

Construction Phase	Compliance Item	Points Allocated in PNNL Checklist	Number Compliant	Number Not Compliant	Number Not Observable	Number Not Applicable	Percent Verified	Percent Compliant
Insulation (Cont'd)	Basement wall interior insulation R-value	1	20	2	22	86	17%	91%
	Basement wall interior insulation installed per manufacturer's instructions	1	16	5	23	86	16%	76%
	Basement wall interior insulation depth	1	20	2	22	86	17%	91%
	Sunroom wall insulation R-value	1	0	0	2	128	0%	-
	Sunroom wall insulation installed per manufacturer's instructions	1	0	0	2	128	0%	-
	Sunroom ceiling insulation R-value	1	0	0	0	130	0%	-
	Sunroom ceiling insulation installed per manufacturer's instructions	1	0	0	0	130	0%	-
	Air sealing complies via blower door test	1	14	0	21	95	11%	100%
	All installed insulation labeled or R-value provided	2	43	46	41	0	68%	48%
	Air sealing of all openings and penetrations via visual inspection	3	23	2	70	35	19%	92%
	Air sealing of all envelope joints and seams via visual inspection	3	18	4	73	35	17%	82%
	Air sealing of all other sources of infiltration, including air barrier, via visual inspection	3	15	6	74	35	16%	71%
Final	Ceiling insulation R-value	1	80	11	39	0	70%	88%
	Ceiling insulation installed per manufacturer's instructions	1	67	25	38	0	71%	73%
	Attic access hatch and door insulation	1	35	44	33	18	61%	44%
	Duct tightness complies via post-construction test	1	0	0	24	106	0%	-
	Heating and cooling equipment type and capacity as per plans	1	8	25	97	0	25%	24%
	50% of lamps are high efficacy	1	46	29	55	0	58%	61%

Construction Phase	Compliance Item	Points Allocated in PNNL Checklist	Number Compliant	Number Not Compliant	Number Not Observable	Number Not Applicable	Percent Verified	Percent Compliant
Final (Cont'd)	Energy certificate posted	2	52	30	48	0	63%	63%
	Wood burning fireplace	2	22	7	23	78	22%	76%
	Programmable thermostats installed on forced air furnaces	2	44	8	76	2	40%	85%
	Heat pump thermostat installed on heat pumps	2	2	1	17	110	2%	67%
	Circulating service hot water systems have automatic or accessible manual controls	2	1	0	8	121	1%	100%
	Pool heaters, covers, and automatic or accessible manual controls	2	0	0	4	126	0%	-