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Montana 2018 Commercial New Construction Code Compliance Evaluation

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Executive Summary

This report presents the results of a commercial building code compliance study conducted in the state of Montana for the Northwest Energy Efficiency Alliance (NEEA) by Michaels Energy. This study is the third compliance study in a series covering the Northwest states.[1]

This study assessed the paths by which, and degree to which, code compliance is achieved with the amended 2018 International Energy Conservation Code (IECC) in newly constructed commercial buildings in Montana. The study focused on commercial buildings constructed in Montana under its version of the 2018 IECC, which was in effect from February 13, 2021 through June 10, 2022.

The key research objectives for this study were to 1) catalog the major current design and engineering practices in Montana, with focus on primary building systems including envelope, mechanical systems, lighting, and service water heating; 2) assess compliance of new commercial buildings in Montana constructed under 2018 IECC; and 3) assess this study's methodological efficacy and replicability.

1.1 Sample Design

The sampling frame for this study includes all commercial and multifamily[2] (5+ units) buildings constructed in Montana under the 2018 IECC which was in effect from February 13, 2021 to June 10, 2022, when 2021 IECC became effective in Montana. NEEA and Michaels used data from the Dodge Construction Network to identify newly constructed buildings in Montana during this period.

In consultation with NEEA, Michaels adjusted the sampling period to exclude projects permitted within six months of the code's effective date that were not designed to 2018 IECC[3], providing a grace period through August 13, 2021, for buildings designed to 2012 IECC. The intent of this grace period was to exclude projects that were intentionally allowed to proceed under the previous code due to narrowly missing the deadline, while including projects where it was more likely that 2018 IECC was possible and practical but not achieved.

Due to the low number of buildings constructed under 2018 IECC, Michaels and NEEA determined that it was appropriate to shift from a stratified random sampling approach to a census attempt in which Michaels reviewed all eligible buildings. Despite this shift, Michaels incorporated the stratification protocols from prior Washington and Oregon Commercial Code

[1] The first two studies were the *2019 Oregon New Commercial Construction Code Evaluation Study* prepared by Ecotope in 2019 and the *Washington 2015 New Commercial Construction Code Evaluation Study* prepared by Cadmus in 2022.
[2] The study includes both low-rise (1 to 3 stories) and mid- and high-rise buildings (4 or more stories) with five or more units. Although low-rise multifamily buildings do not fall under commercial building code, they were included in this study because the population data did not include the number of stories for all buildings.
[3] If the permit date was unknown, Michaels excluded projects whose building plans were not more than one week after the effective date of the code.

Compliance studies to maximize comparability among studies. Specifically, the study team stratified the population by building type and size.

The study team also used the plan reviews to refine the population of buildings constructed under 2018 IECC. Among the 133 buildings determined to likely be constructed under 2018 IECC based on the Dodge data, further investigation revealed that approximately half were outside the scope of the study. In three-quarters of these cases, the project was outside of the study timeframe after accounting for the permit grace period, while others were not commercial buildings or were not constructed.

After assessing the received plans and removing all out-of-scope sites, Michaels was able to review plans from a total of 28 of the 65 buildings determined to be constructed under 2018 IECC and fully within the scope of the study on all other parameters.

1.2 Building and System Characteristics Analysis

Michaels analyzed the data collected from the building plan reviews and on-site assessments to develop estimates of building and equipment characteristics of buildings constructed under 2018 IECC. These characteristics included building type and square footage and equipment type, efficiency, size/capacity, and fuel type. The study team used these characteristics to determine the building's or equipment's compliance with code and also presented them in the aggregate.

1.3 Code Compliance Analysis

Using the information collected through the Building and Systems Characterization task, Michaels assessed the buildings' compliance with 2018 IECC using two methods, similar to those used in NEEA's prior Washington Commercial Code Compliance Evaluation study. In both approaches, the study team applied weights to account for building type and size so that the results are representative of the population of buildings constructed under 2018 IECC.

- **Binary Compliance** - In this approach, the study team focused on key code requirements for each building system and used the prescriptive code to determine if each requirement was met. If any one requirement was not met, the team flagged the system as noncompliant; likewise, if any system in a building did not comply with code, then the building was considered noncompliant.
- **Weighted Compliance** - The second method takes into consideration the level of compliance to provide a qualitative indication of lost energy savings. Michaels calculated a percentage compliance level for each system instead of a pass/fail determination. The compliance level may be calculated as either the share of compliant floor area or the share of compliant systems. For example, if a building had four furnaces of equal capacity and Michaels found that three of them met the applicable code requirements but one did not, the team would apply a compliance value of 0.75 to the building.

1.3.1 Overall Compliance

Figure 1 shows the overall compliance with 2018 IECC by building and system type. The compliance of each building system is discussed in the following subsections. The figure below shows the binary compliance for each system, where if any subcomponent did not meet code, then the overall system did not meet code. Similarly, if Michaels was not able to assess any subcomponent (and no subcomponent was not compliant), then the entire system was marked as "could not assess." This approach is the most strict, especially for systems that are not easily assessed on building plans, such as lighting and building envelope. In many cases the system was largely compliant except for one subcomponent that could not be assessed using building plans, such as lighting controls and the insulation of doors.

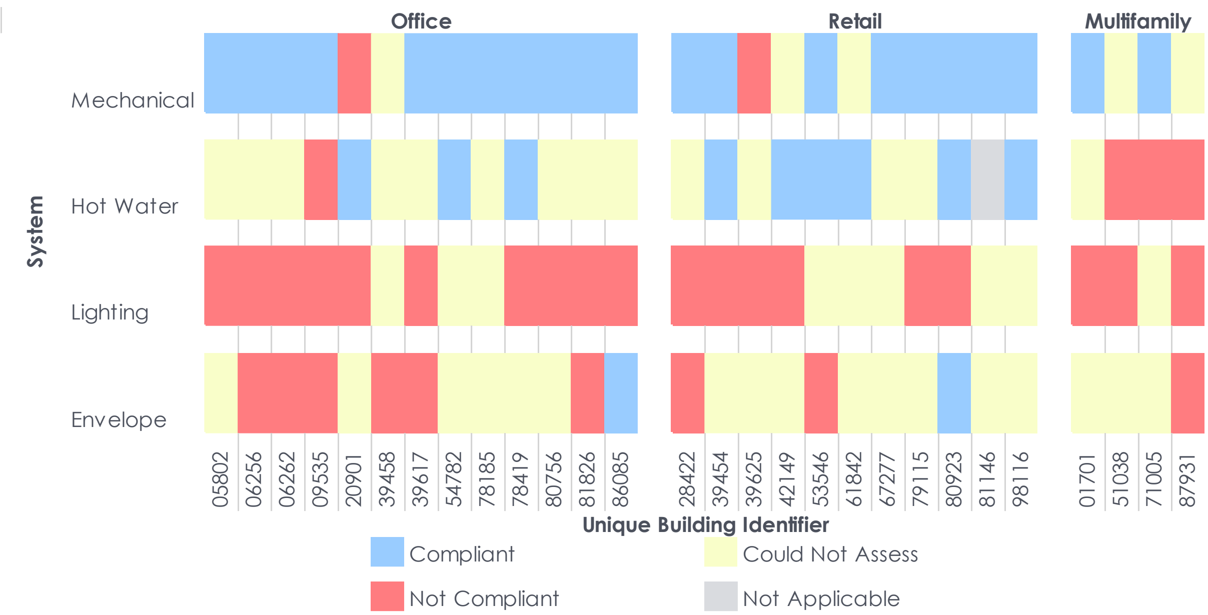

Figure 1. Overall Compliance with 2018 IECC

Michaels also assessed the binary and weighted compliance of key building systems, shown in the table below. The compliance of many buildings was indeterminate, but buildings for which system information was available on plans generally complied with code, especially using the less stringent weighted method.

Table 1. Binary and Weighted Compliance of Key Building Systems (n=28)

System	Subsystem	Binary Compliance			Weighted Compliance		
		Pass	Fail	Could Not Assess	Pass	Fail	Could Not Assess
Envelope	R-Value	38%	7%	54%	48%	2%	49%
	Fenestration U-Factor	15%	--	85%	15%	--	85%
	Fenestration SHGC	11%	1%	88%	11%	1%	88%

System	Subsystem	Binary Compliance			Weighted Compliance		
		Pass	Fail	Could Not Assess	Pass	Fail	Could Not Assess
Lighting	Lighting Power Density	49%	14%	38%	40%	6%	53%
Mechanical Systems	Cooling Equipment	79%	2%	20%	96%	1%	4%
	Heating Equipment	78%	2%	20%	96%	1%	4%
Water Heating	All	32%	57%	11%	35%	55%	10%

1.4 Efficacy and Replicability of Study Methods

Michaels assessed whether the methodology selected for this study is effective in generating reliable information about decisions made by builders seeking compliance with the commercial code, and whether this methodology is replicable over time and across states.

Due to the low response rate of building contacts, Michaels also identified and contacted applicable city or county building departments to request the MEP plans of buildings constructed in their jurisdiction. Many of the contacted building departments were very helpful and provided plans if possible. Requesting building plans from city or county building departments and from public sources was much more successful than contacting individual building representatives and future code evaluation studies should consider this approach.

The study team found that, when available, building plans provided sufficient details to determine compliance with most energy code requirements. Some requirements, such as those related to windows and controls, are not easily determined through building plans. The study found that the code requirements for some buildings or equipment could not be assessed due to lack of information on the plans, but this is also true for on-site assessments for different reasons (e.g., lack of roof access). Due to the small sample sizes for both building plan reviews and site visits in this study, Michaels could not make any statistically representative conclusions about the degree of variance between the two approaches. NEEA may consider using a hybrid approach of building plan reviews and on-site verification in future studies to better understand the efficacy of using building plans as a principal data source for code compliance studies.

2 Introduction

This report presents the results of a commercial building code compliance study conducted in the state of Montana for the Northwest Energy Efficiency Alliance (NEEA) by Michaels Energy. This study is the third in a series covering the Northwest states.[4]

This study assessed the paths by which, and degree to which, code compliance is achieved with the amended 2018 International Energy Conservation Code (IECC) in newly constructed commercial buildings in Montana. The study focused on commercial buildings constructed in Montana under its version of the 2018 IECC, which was in effect from February 13, 2021 through June 10, 2022.

2.1 Study Objectives

The two key research objectives for this study are as follows:

Objective 1: Assess Compliance Pathways and Achievement

The study's first objective was to identify the path(s) to compliance taken by designers and builders and evaluate system and building compliance with Montana's 2018 IECC commercial new construction code. Michaels accomplished this objective through:

- Cataloguing the major current design and engineering practices by building type, with focus on primary building systems including envelope, mechanical systems, lighting, and service water heating.
- Assessing compliance of new commercial buildings in Montana constructed under 2018 IECC. The analysis focused on the major systems (envelope, mechanical systems, lighting, and service water heating) but also included whole building compliance.

Objective 2: Assess This Study's Methodological Efficacy and Replicability

The study's second objective was to assess whether the methodology selected for this study is effective in generating reliable information about decisions made by builders seeking compliance with the commercial code, and whether this methodology is replicable over time and across states.

Other Objectives

The study also had an objective to analyze the energy performance and energy savings of a subsample of buildings through the use of billing data which was summarized, normalized, and disaggregated by end use. However, due to the small number of total buildings constructed under 2018 IECC and the low participation rate of eligible buildings in opt-in components of the study (i.e., comparative site visits and billing data analysis), this objective could not be met.

[4] The first two studies were the *2019 Oregon New Commercial Construction Code Evaluation Study* prepared by Ecotope in 2019 and the *Washington 2015 New Commercial Construction Code Evaluation Study* prepared by Cadmus in 2022.

Given the lack of statistically representative data available for this analysis, NEEA and Michaels elected to exclude the planned energy use analysis from this study.

3 Methodology

3.1 Overall Approach

Michaels' original sample design was based on the protocols developed for NEEA's prior Washington and Oregon Commercial Code Evaluation Studies with the support of study-specific working groups. The study team initially planned to use a stratified random sampling approach to achieve ±10% relative precision at the 90% confidence level based on building floor area.[5] This approach also would ensure coverage of all important groups as well as contain the greatest share of total newly constructed commercial building area. Appendix A. Sample Design Memo describes the initial sample frame development.

As described below, the number of commercial and multifamily buildings constructed under the 2018 International Energy Conservation Code (IECC) was much lower than originally estimated. As a result, Michaels shifted from a stratified random sampling approach to a census approach in which the team attempted to review all eligible commercial buildings.

3.2 Study Scope

The sampling frame for this study includes all commercial and multifamily[6] (5+ units) buildings constructed in Montana under the 2018 IECC which was in effect from February 13, 2021 to June 10, 2022, when 2021 IECC became effective in Montana. NEEA and Michaels used data from the Dodge Construction Network to identify newly constructed buildings in Montana during this period.

In consultation with NEEA, Michaels adjusted the sampling period to exclude projects permitted within six months of the code's effective date that were not designed to 2018 IECC,[7] providing a grace period through August 13, 2021, for buildings designed to 2012 IECC. The intent of this grace period was to exclude projects that were intentionally allowed to proceed under the previous code due to narrowly missing the deadline, while including projects where it was more likely that 2018 IECC was possible and practical but not achieved. NEEA believes that a six-month grace period is justifiable because Montana only had three months between the code adoption date and the effective date (compared to the six- to twelve-month concurrency periods in other states) and because local building departments are likely more lenient in allowing commercial buildings to comply with the code they were originally designed to, given the lengthy design timeframes associated with commercial construction.

[5] A building's square footage is correlated to other features of interest, including energy use, lighting power, and types and sizes of HVAC equipment.
[6] The study includes both low-rise (1 to 3 stories) and mid- and high-rise buildings (4 or more stories) with five or more units. Although low-rise multifamily buildings do not fall under commercial building code, they were included in this study because the population data did not include the number of stories for all buildings.
[7] If the permit date was unknown, Michaels excluded projects whose building plans were not more than one week after the effective date of the code.

3.3 Population and Sampling Frame Development

The initial sampling frame was based on Dodge Construction Network "building starts" from February 13, 2021 to May 31, 2022.[8] Using this dataset, Michaels identified 418 commercial buildings believed to be constructed under 2018 IECC. Beginning with this initial list of buildings, Michaels closely reviewed the Dodge data to determine if the building was likely constructed under 2018 IECC. Using fields in the database including "Action Stage(s)," "Target Start Date," "Target Completion Date," and "Status," Michaels identified 133 commercial new construction sites with high probability of being constructed under 2018 IECC.

Due to the low number of buildings constructed under 2018 IECC, Michaels and NEEA determined that it was appropriate to shift from a stratified random sampling approach to a census attempt in which Michaels reviewed all eligible buildings. Despite this shift, Michaels incorporated the stratification protocols from prior Washington and Oregon Commercial Code Compliance studies to maximize comparability among studies. Specifically, the study team stratified the population by two dimensions:

- **Building type:** Similar to the OR and WA studies, the study team stratified the population by five key building types: Office, Retail, Education, Multifamily[9], and Other buildings.
- **Building Size:** The study team stratified the population by building square footage using NEEA's recommended definition of each size category: Small (under 20,000 SF), Medium (20,000 to 99,999 SF), and Large (100,000 SF or greater).

Table 2 defines the five building types included in the study by types of buildings from the Dodge data that made up each category.

Table 2. Building Type Definitions

Building Type	Project Types Included from Dodge Data
Office	- Office and Bank Buildings
Retail	- Stores and Restaurants
Education	- Schools, Libraries, and Labs (non-manufacturing) - Dormitories
Multifamily	- Apartments 5+ Units, 1-3 Stories - Apartments 5+ Units, 4+ Stories
Other	- Amusement, Social and Recreational Buildings - Government Service Buildings - Hotels and Motels - Hospitals and Other Health Treatment - Manufacturing Plants, Warehouses, Labs - Miscellaneous Nonresidential Buildings - Parking Garages and Automotive Services - Religious Buildings

[8] The Dodge data available at the time of the sampling plan development included projects started until the end of the second quarter of 2022. Because 2018 IECC was in effect in Montana until June 10, 2022, the sample frame did not contain buildings constructed in the first 10 days of June 2022.

[9] The study includes both low-rise (1 to 3 stories) and mid- and high-rise buildings (4 or more stories) with five or more units. Although low-rise multifamily buildings do not fall under commercial building code, they were included in this study because the population data did not include the number of stories for all buildings.

Building Type	Project Types Included from Dodge Data
	- Warehouses (excluding manufacturer-owned)

Michaels stratified the sample by building area on the basis of building information identified through a combination of the Dodge database and building plans. In 15 cases, the study team estimated building area using Google Earth or online real estate listings. In one case, the team estimated the square footage of the building using the estimated value of the project.[10]

Table 3 presents the initial and revised population of Montana commercial buildings constructed under 2018 IECC.

Table 3. Population of Montana Commercial Buildings Constructed Under 2018 IECC through May 31, 2022

Building Type	Building Size	Initial Population from Dodge	Revised Population (Likely 2018 IECC)
Office	Small (<20,000 SF)	22	40
	Medium (20,000-99,999 SF)	6	5
	Large (100,000+ SF)	0	1
	Unknown	12	28
	Subtotal	*40*	*74*
Retail	Small (<20,000 SF)	15	27
	Medium (20,000-99,999 SF)	1	2
	Large (100,000+ SF)	0	0
	Unknown	0	13
	Subtotal	*11*	*42*
Education	Small (<20,000 SF)	5	0
	Medium (20,000-99,999 SF)	5	0
	Large (100,000+ SF)	1	0
	Unknown	0	0
	Subtotal	11	0
Multifamily	Small (<20,000 SF)	12	2
	Medium (20,000-99,999 SF)	7	4
	Large (100,000+ SF)	1	6
	Unknown	188	3
	Subtotal	*208*	*15*
Other	Small (<20,000 SF)	59	0
	Medium (20,000-99,999 SF)	29	0
	Large (100,000+ SF)	2	0
	Unknown	43	2
	Subtotal	*133*	*1*
Total	Small (<20,000 SF)	113	69
	Medium (20,000-99,999 SF)	48	11
	Large (100,000+ SF)	4	7
	Unknown	253	46
	Total	**418**	**133**

[10] In this case, the study team created an average value per square foot using the estimated value of the project from Dodge data for all buildings in the sample with known building areas.

3.4 Data Collection

3.4.1 Recruitment and Building Plan Collection

After identifying the buildings likely constructed under 2018 IECC, Michaels sought to collect mechanical, electrical, and plumbing (MEP) plans for each site to review. To reduce burden on site contacts, the study team first gathered all available public plans from the Montana Department of Labor & Industry website. When public plans were not available, the team attempted to contact the appropriate party for each building to request the needed building plans, seek consent for utility usage data, and recruit for potential site visits.

Michaels engaged in a multi-mode outreach effort to collect information about each building included in the study. First, the team mailed invitation letters to building owners in July 2023 using the contact information contained in the Dodge data, followed by phone and email outreach to each building owner. In cases where there was no listed contact information or the original contact was unresponsive, Michaels conducted secondary research to identify and attempt recruitment of other contacts affiliated with the building. Michaels often contacted multiple parties involved in the construction of a given building to locate and attempt to secure building plans. The study team conducted recruiting outreach over the summer, fall, and winter of 2023 and into early 2024. In February 2024, Michaels sent another invitation letter to unresponsive contacts in a final attempt to gather the needed information. This was followed up with a final round of email and phone outreach.

Due to the low response rate of building contacts, Michaels also identified and contacted applicable city or county building departments to request the MEP plans of buildings constructed in their jurisdiction. Many of the contacted building departments were very helpful and provided plans if possible. In some cases, the building department was responsive but could not provide building plans to third parties without permission from the building owner. Overall, this method of outreach was much more successful than contacting individual building representatives and should be considered for future studies.

3.4.2 Data Collection Tool

To facilitate the collection of information about buildings constructed under 2018 IECC, Michaels created an Excel-based data collection tool. This tool was adapted from the Commercial Building Energy Code Field Study data collection forms developed by the US Department of Energy, Pacific Northwest National Lab, and the Institute for Market Transformation.[11]

The tool consists of multiple tabs grouped by major building system (building envelope, HVAC and water heating, and lighting) and building characteristics. Each tab contains multiple tables

[11] https://www.energycodes.gov/commercial-energy-code-field-study

designed to document the characteristics of buildings' equipment and systems collected both through building plan reviews and onsite.

3.4.3 Plan Reviews

Using the collected information about the buildings within the sample frame, Michaels conducted desk reviews of existing documentation to catalog the design and engineering practices for major building systems and building types.

For each building, the study team reviewed applicable permit and building plan documentation to identify information about the building and catalogue its systems. Reviewed documents included any architectural and mechanical, electrical, and plumbing (MEP) plans. The team's review focused on the key components of the primary building systems, including envelope, mechanical systems, lighting, and service water heating, concentrating on the elements that drive energy use for each building system and tie into the major components targeted in the code compliance assessment, described in Section 3.6 Code Compliance Analysis.

The study team also used the plan reviews to refine the population of buildings constructed under 2018 IECC. Among the 133 buildings determined to likely be constructed under 2018 IECC, further investigation revealed that approximately half were outside the scope of the study. In three-quarters of these cases, the project was outside of the study timeframe after accounting for the grace period described in Section 3.2, while others were not commercial buildings or were not constructed. Michaels was able to collect either full or partial plans from more than half of the projects initially identified as falling within the scope of the study.

Figure 2The following figures illustrate the dispositions of the 133 buildings determined likely to be constructed under 2018 IECC (Figure 2) and the reasons why 68 of the 133 reviewed buildings were not in the project scope (Figure 3).

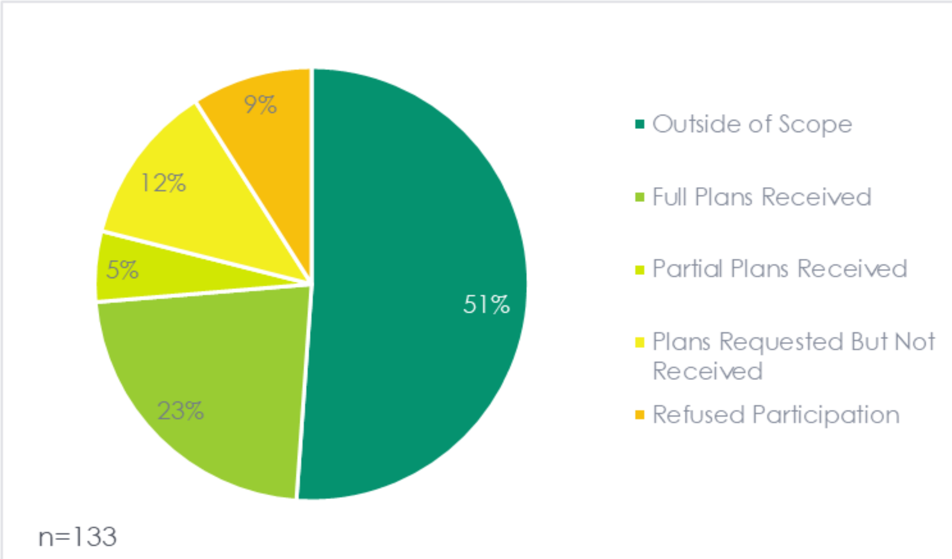

Figure 2. Dispositions of Buildings Determined Likely to be Constructed Under 2018 IECC (Share of Buildings)

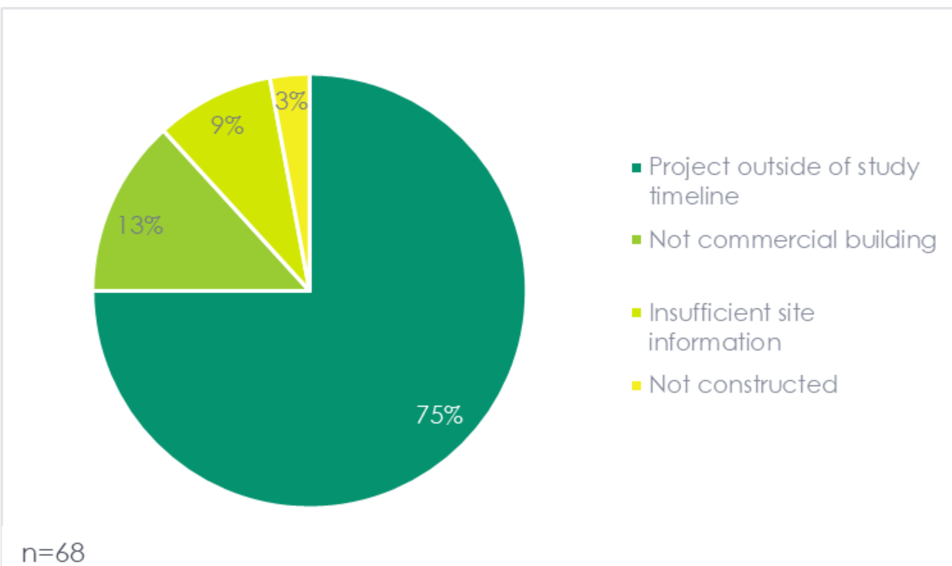

Figure 3. Reasons for Building Being Out of Project Scope (Share of Ineligible Buildings)

After assessing the received plans and removing all out-of-scope sites, Michaels was able to review plans from a total of 28 of the 65 buildings determined to be constructed under 2018 IECC and fully within the scope of the study on all other parameters. Table 4 shows the counts of projects by building type and size in each phase of the sample development, from the initial population estimate from Dodge to the final number of reviewed 2018 IECC projects.

Table 4. Final Study Population and Sample

Building Type	Building Size	Initial Population from Dodge	Revised Population (Likely 2018 IECC)	Population of Buildings in Scope	2018 IECC Plan Reviews
Office	Small (<20,000 SF)	22	40	19	12
	Medium (20,000-99,999 SF)	6	5	2	1
	Large (100,000+ SF)	0	1	1	0
	Unknown	12	28	13	0
	Subtotal	*40*	*74*	*35*	*13*
Retail	Small (<20,000 SF)	15	27	16	8
	Medium (20,000-99,999 SF)	1	2	3	3
	Large (100,000+ SF)	0	0	0	0
	Unknown	0	13	2	2
	Subtotal	*11*	*42*	*21*	*11*
Education	Small (<20,000 SF)	5	0	0	0
	Medium (20,000-99,999 SF)	5	0	0	0
	Large (100,000+ SF)	1	0	0	0
	Unknown	0	0	0	0
	Subtotal	11	0	0	0
Multifamily	Small (<20,000 SF)	12	2	2	2
	Medium (20,000-99,999 SF)	7	4	2	1
	Large (100,000+ SF)	1	6	3	1
	Unknown	188	3	2	0
	Subtotal	*208*	*15*	*9*	*4*
Other	Small (<20,000 SF)	59	0	0	0
	Medium (20,000-99,999 SF)	29	0	0	0
	Large (100,000+ SF)	2	0	0	0
	Unknown	43	2	0	0
	Subtotal	*133*	*1*	*0*	*0*
Total	Small (<20,000 SF)	113	69	37	22
	Medium (20,000-99,999 SF)	48	11	7	5
	Large (100,000+ SF)	4	7	4	1
	Unknown	253	46	17	0
	Total	**418**	**133**	**65**	**28**

3.4.4 On-Site Assessments

To verify the as-built condition and to understand the degree of variance, Michaels sought to supplement the desk reviews with on-site inspections of a subset of buildings. Building plans typically provide a reasonably accurate representation of the actual construction, but some variation from the plans may occur during construction. The study team planned to use information gathered on-site to verify and, if needed, adjust the results from the desk review.

Similar to the very limited success recruiting building contacts to provide building plans, Michaels also had extreme difficulty recruiting buildings for on-site assessments. After extended recruiting efforts mirroring those described in Section 3.4.1, only three buildings agreed to a site visit, two of which had the same owner.

Given the lack of statistically representative data from the site visits, Michaels did not conduct any population-level analysis using the on-site assessments or make any population-level adjustments. However, the study team did use information from the three on-site assessments when determining compliance for those buildings. Additionally, the study team included findings from the limited number of site visits in the equipment-specific sections where appropriate.

3.5 Building and System Characteristics Analysis

Michaels analyzed the data collected from the building plan reviews and on-site assessments to develop estimates of building and equipment characteristics of buildings constructed under Montana's amended 2018 IECC. These characteristics included building type and square footage and equipment type, efficiency, size/capacity, and fuel type. The study team used these characteristics to determine the building's or equipment's compliance with code and also presented them in the aggregate.

3.6 Code Compliance Analysis

Using the information collected through the Building and Systems Characterization task, Michaels assessed the buildings' compliance with 2018 IECC using two methods, similar to those used in NEEA's prior Washington Commercial Code Compliance Evaluation study. In both approaches, the study team applied weights to account for building type and size so that the results are representative of the population of buildings constructed under 2018 IECC.

3.6.1 Binary Compliance

The first approach used a binary method similar to NEEA's prior Oregon and Washington Commercial Code Compliance Evaluation studies. In this approach, the study team focused on key code requirements for each building system and used the prescriptive code to determine if each requirement was met. If any one requirement was not met, the team flagged the system as noncompliant; likewise, if any system in a building did not comply with code, then the building was considered noncompliant. Although this is a very strict test of compliance, it allows NEEA to compare results to other studies. Michaels also weighted the results back to the population.

3.6.2 Weighted Compliance

The second method takes into consideration the level of compliance to provide a qualitative indication of lost energy savings. Using the approach employed in the prior Washington Commercial Code Compliance Evaluation study, Michaels calculated a percentage compliance level for each system instead of a pass/fail determination. The compliance level may be calculated as either the share of compliant floor area or the share of compliant systems. For example, if a building had four furnaces of equal capacity and Michaels found that three of them met the applicable code requirements but one did not, the team would apply a compliance value of 0.75 to the building. This approach reduces the bias toward zero if a single requirement is not met and provides a more representative view of the building's overall compliance with code requirements.

3.7 Energy Use Analysis

The original scope of the study also called for an analysis of the energy performance of a subsample of buildings through the use of utility billing data and the information gathered in the Building Systems Characterization task. Michaels sought to calculate the energy use intensity (EUI) for each building and disaggregate it by major end use category.

After extended recruiting efforts mirroring those described earlier for the building plans and on-site assessments, only three buildings agreed to provide their utility data. Given the lack of statistically representative data available for this analysis, NEEA and Michaels elected to exclude the planned energy use analysis from this study.

3.8 Study Limitations

While Michaels used best practices to maximize the accuracy and precision of the research, it is important to note two limitations of the study.

The primary limitation of this study is the small number of buildings included in the analysis. Because the 2018 version of IECC was only in effect in Montana for 15 months (from February 13, 2021 to June 10, 2022) and because the overall level of commercial new construction in the state is relatively low, the total number of buildings constructed under this code version is correspondingly small. In addition, as described earlier, the study employed a six-month grace period for buildings permitted near when the code went into effect, further limiting the number of buildings in the study's scope. Despite Michaels' best efforts, the cooperation rate for buildings was also low, both for utility data access and comparative site visits and, importantly, for provision of building plans not available through public records offices. As a result, the analysis includes 28 of the 65 buildings determined to be in the scope of the study. Twenty-eight buildings would be considered very low for most code evaluations, but in this case, the number represents nearly half of the population of buildings in the study's scope. Additionally, because Michaels employed a census sampling approach, there is no sampling error in the study's results. Despite this, the small number of analyzed buildings limited the study team's ability to present results in meaningful segments, such as by building size, segment, or town incorporation.

Related to this, the sampling frame for the study was likely smaller than the true population of buildings constructed under 2018 IECC for two reasons. First, the study team used Dodge data as the primary source of information about construction during this period and only included data through the end of the second quarter of 2022. Because 2018 IECC was in effect in Montana until June 10, 2022, the sample frame did not contain buildings constructed in the first 10 days of June 2022. Additionally, the study team did not apply a six-month grace period after 2018 IECC was no longer in effect due to project timeline constraints. This means that there were likely some buildings constructed under this code that were not included in the study. However, given the small number of buildings in the study's sampling frame and the short period of time not covered, it is not likely that the number of buildings not captured in the study would significantly change the study's findings.

Another limitation of the study is the use of building plans as the primary source of data. NEEA sought to understand whether future commercial code compliance evaluations could use building plan reviews instead of on-site data collection. This approach resulted in cost savings compared to on-site assessments as well as a higher number of included buildings. However, some building systems and code items, such as insulation levels and equipment control strategies, are not easily assessed through building plans. This led to a high share of buildings for which some code elements could not be assessed compared to other studies.

4 Building-Level Findings

4.1 Building Characteristics

Based on our review of Dodge data and applicable building plans, Michaels estimates that a total of 65 commercial buildings representing approximately 1.75 million square feet were constructed in Montana under 2018 IECC.[12] Office buildings represented almost half of the buildings but only 25% of the total floor area. Only 10 multifamily buildings were built under this code but they were over 100,000 square feet on average.[13]

Table 5. Floor Area of Buildings Permitted Under 2018 IECC

Type	Quantity	Total Floor Area	Mean Floor Area
Office	33	471,762	14,296
Retail	22	237,130	10,779
Multifamily	10	1,066,535	106,654
Total	**65**	**1,775,427**	**27,314**

Table 6 shows the floor area of sampled buildings. The sample made up 33% of the total floor area of all known buildings permitted under 2018 IECC. The mean floor areas of the sampled buildings of different types were comparable to the mean floor areas of buildings in the population, but there were some differences. To account for this, the study team employed a weighting strategy to ensure the results were representative of the population.[14]

Table 6. Floor Area of Sampled Buildings

Type	Quantity	Total Floor Area	Mean Floor Area
Office	13	147,901	11,377
Retail	11	178,809	16,255
Multifamily	4	264,733	66,183
Total	**28**	**591,443**	**21,123**

Small buildings, defined as under 20,000 square feet, made up most of the commercial buildings constructed under Montana 2018 IECC, as shown in Figure 4. The figure also shows the distribution of sampled projects by building type and size.

[12] This excludes buildings that were constructed during the grace period (described in Section 2.2) of the first six months of the time period in which 2018 IECC was in effect.
[13] Note that while the original sample frame included "Education" and "Other" building type categories, the final sample of 65 buildings did not include any sites falling into these categories.
[14] Appendix C describes the study's weighting approach.

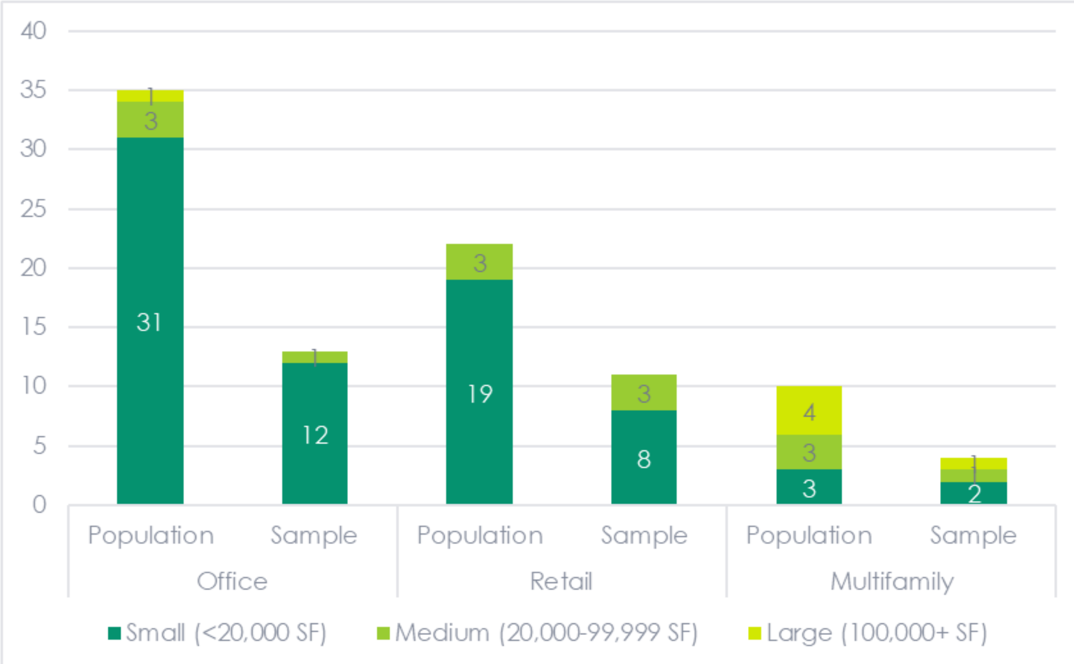

Figure 4. Distribution of Buildings Permitted Under 2018 IECC by Size and Building Type

In the limited site visits conducted, the study team found minor differences in the square footage of the overall building and for some building spaces. These discrepancies were under 10% and likely would not materially affect the buildings' compliance with energy code in most cases. However, changes in square footage of individual spaces could affect some compliance thresholds, such as lighting power density, or change the primary use of a mixed-use building, which could have other implications.

4.2 Building-Level Compliance Findings

4.2.1 Overall Compliance

Figure 5 shows the overall compliance with 2018 IECC by building and system type. The compliance of each building system is discussed in the following subsections. The figure below shows the binary compliance for each system, where if any subcomponent did not meet code, then the overall system did not meet code. Similarly, if Michaels was not able to assess any subcomponent (and no subcomponent was not compliant), then the entire system was marked as "could not assess." This approach is the most strict, especially for systems that are not easily assessed on building plans, such as lighting and building envelope. As discussed in the following subsections, in many cases the system was largely compliant except for one subcomponent that could not be assessed using building plans, such as lighting controls and the insulation of doors.

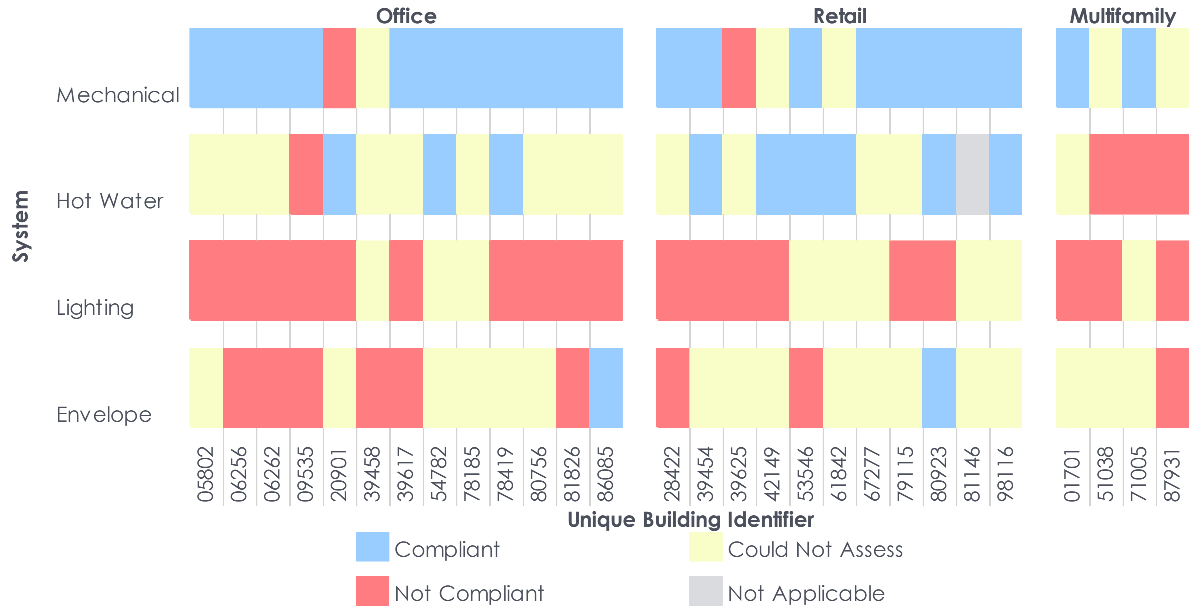

Figure 5. Overall Compliance with 2018 IECC

Table 7 shows the share of sampled buildings complying with 2018 IECC using the binary compliance method. Based on building plan reviews, mechanical systems had the highest level of compliance (75% of sampled sites) while no sampled buildings were fully compliant for their lighting systems. Note that these shares include buildings with indeterminate compliance, which can account for a large share of sampled sites.

Table 7. Share of Sampled Buildings Complying with 2018 IECC by Type (n=28)

Building Type	Mechanical	Hot Water	Lighting	Envelope
Office	85%	23%	0%	8%
Retail	73%	55%	0%	9%
Multifamily	50%	0%	0%	0%
Total	75%	32%	0%	7%

4.2.2 Compliance Pathways

Commercial buildings in Monana can comply with 2018 IECC using either the prescriptive or performance pathway. To comply with the energy code, projects following the prescriptive pathway must meet or exceed each individually listed code element. For less complex commercial (and residential) new construction projects, using the prescriptive path can be as simple as verifying requirements on a checklist. Design teams of more complex buildings can follow the performance pathway method of energy code compliance. Performance-based compliance requires that the annual energy cost of the proposed building design is less than or equal to the annual energy cost of a baseline model building, as demonstrated through building performance simulations. This approach provides design teams with more flexibility for components and features that are integrated into the design.

Due to the small sample size for this study, Michaels was not able to determine the share of buildings using the two compliance pathways. The study team did not find any documentation that any of the sampled buildings used the performance pathway and consequently assessed all sampled buildings using the prescriptive pathway.

5 Building Envelope Findings

5.1 Building Envelope Characteristics

Michaels assessed the building envelope characteristics of all reviewed building plans. In many cases, the building plans did not contain the required information to assess the characteristics of the envelope components under study.

Table 8 shows the mean value of key envelope characteristics of buildings where this information was available compared to their code requirement. These included the R-value of insulation, the U-factor of windows and doors, and the solar heat gain coefficient (SHGC) of windows and glazed doors. In most cases, the mean value of the building envelope characteristic met the code requirement, with the exception of the insulation of mass walls (i.e., walls made of concrete or brick).

Table 8. Building Envelope Characteristics

System Type	Subsystem Type	Unit	Code Requirement	Mean Value	Does Mean Value Meet Code?
Roof	Insulation Entirely Above Deck	R-Value	30.0	31.0	Yes
	Metal Building	R-Value	25.0	46.0	Yes
	Attic and Other	R-Value	49.0	49.1	Yes
Walls	Mass	R-Value	50.0	19.0	No
	Metal Building	R-Value	13.3	19.2	Yes
	Metal Framed	R-Value	13.0	21.8	Yes
	Wood Framed (Option #1)	R-Value	13.0	19.0	Yes
	Wood Framed (Option #2)	R-Value	20.0	21.0	Yes
Floors	Joist/Framing	R-Value	30.0	30.3	Yes
	Slab on Grade (Heated)	R-Value	5.0	10.0	Yes
	Slab on Grade (Unheated)	R-Value	10.0	10.2	Yes
Windows & Glazed Doors	Fixed Fenestration	U-Factor	0.36	0.32	Yes
	SEW, PF <0.2	SHGC	0.4	0.30	Yes
Opaque Doors	Entrance Doors	U-Factor	0.77	0.36	Yes

5.2 Building Envelope Compliance

Figure 6 shows the compliance of different building envelope components. For several components, Michaels could not assess the majority of buildings' compliance because the building plans did not contain enough information. However, most buildings' building envelope components were compliant with 2018 IECC if the plans contained the appropriate information. In a small number of cases, the study team classified a building's compliance as "lenient pass" if there was compelling evidence that the building was likely compliant. For example, one building's wall passed using the U-value method of compliance but failed using the R-factor method.

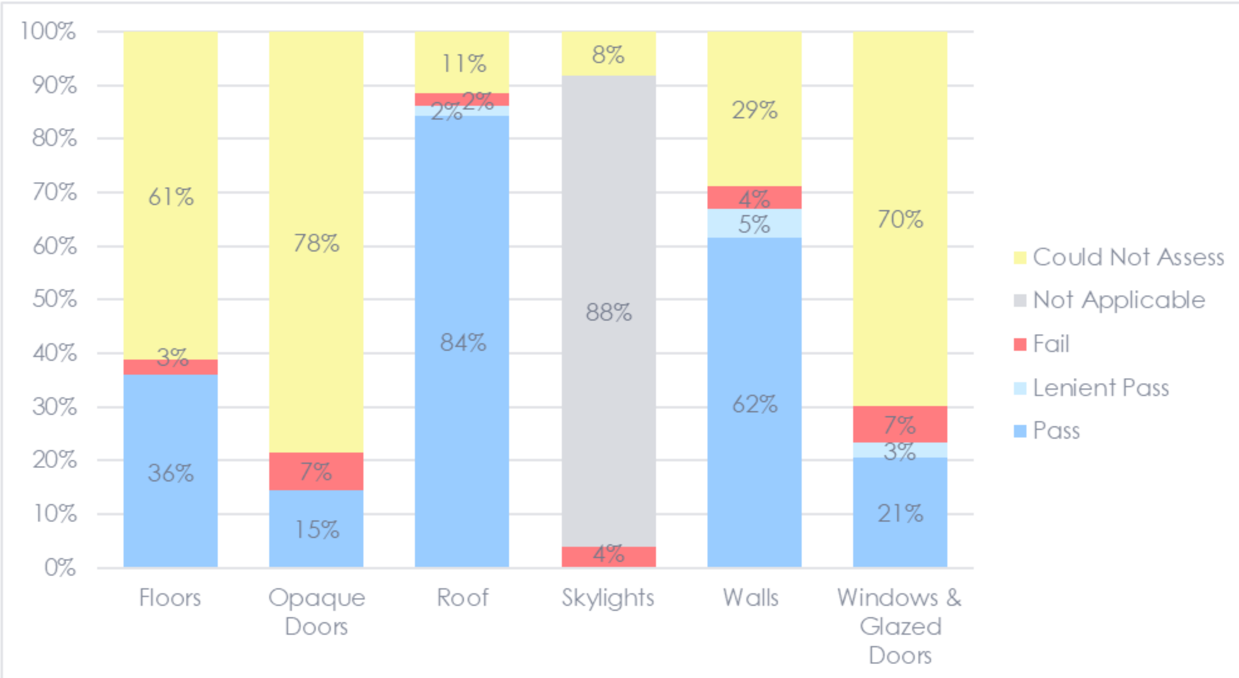

Figure 6. Compliance by Building Envelope Component

Michaels also assessed the binary and weighted compliance of key building envelope metrics, shown in Figure 7 below. Similar to the component-level analysis, the compliance of many sites was indeterminate, but buildings for which envelope information was available on plans generally complied with code, especially using the less stringent weighted method.

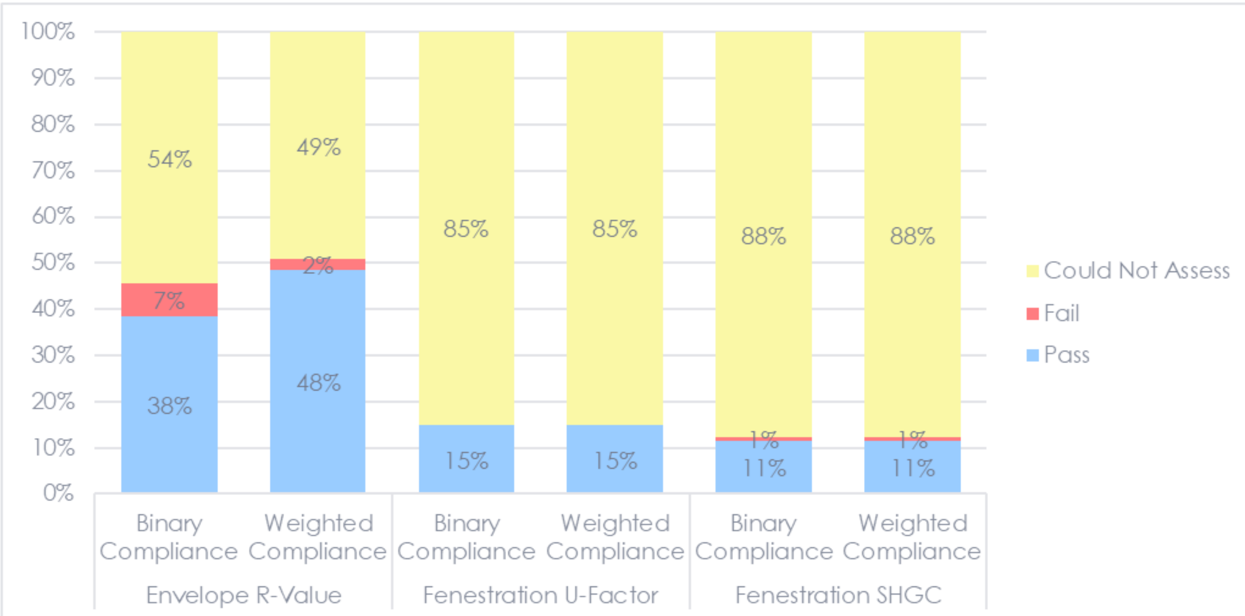

Figure 7. Binary and Weighted Compliance of Building Envelope Components

6 Lighting System Findings

6.1 Lighting Power Density

Michaels reviewed the available building plans for details on each site's interior and exterior lighting, focusing on the building's lighting power density (LPD) as well as its control strategies.

Table 9. Interior Lighting Power Density for Select Building Areas

Building Area Type	Sample Size	Code LPD Allowance	Mean LPD
Office	8	0.79	0.53
Retail	6	1.06	0.60
Multifamily	3	0.62	0.59

Michaels conducted three compliance assessments of buildings' interior lighting efficiency outlined in Montana 2018 IECC: a space-by-space method and two building area methods. As shown in Figure 8, the three methods all result in nearly identical compliance levels, with approximately 50% of the buildings (78% of those able to be assessed) passing the compliance check. The figure also shows the exterior lighting power density compliance. Roughly one-third of buildings did not have exterior lighting on their building plans.

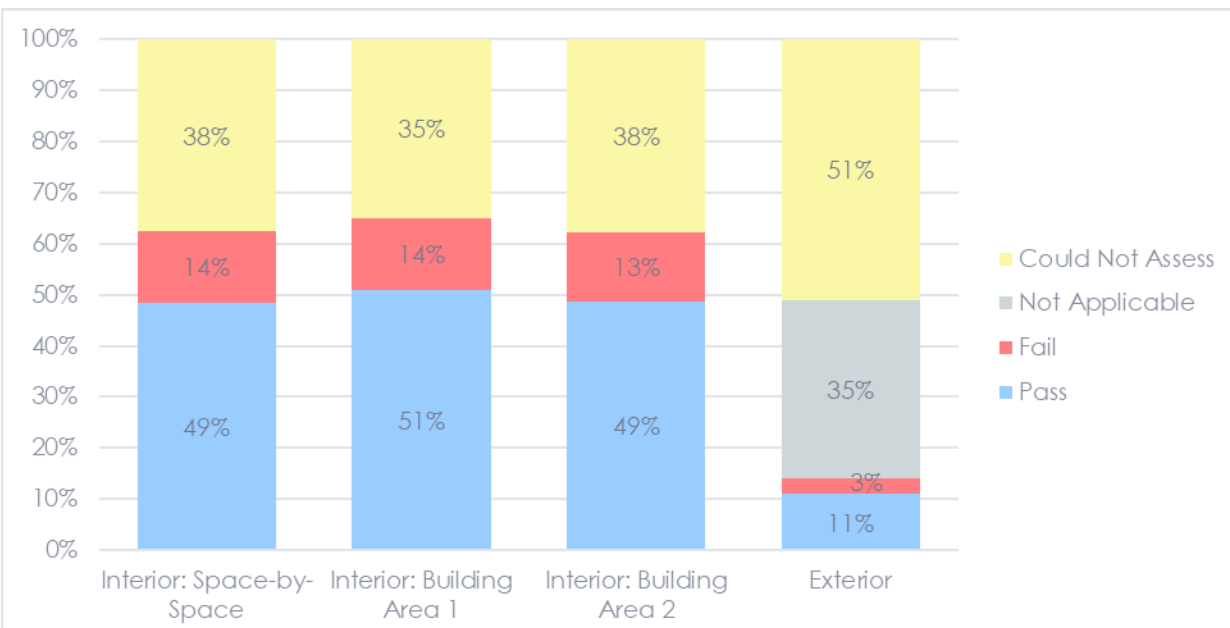

Figure 8. Lighting Power Density Compliance by Building

6.2 Lighting Controls

Michaels also reviewed building plans to determine their lighting control strategies and compliance with 2018 IECC. Based on the 481 spaces reviewed in the 25 buildings, only 6% of spaces had lighting controls that complied with code. The most common reasons for non-compliance were missing controls, such as time switches, daylight-responsive controls, and occupancy sensors. It should be noted that lighting control strategies indicated in building plans may differ than those actually included in the building. The large discrepancy between the compliance of lighting controls in this study compared to other studies in the Northwest suggests that low compliance rate in Montana may be a result of poor documentation in the building plans rather than actual non-compliance.[15] Further site visits are recommended to investigate this.

[15] Other studies found that 88% of buildings in Washington and 96% of buildings in Oregon complied with the relevant lighting control code requirements.

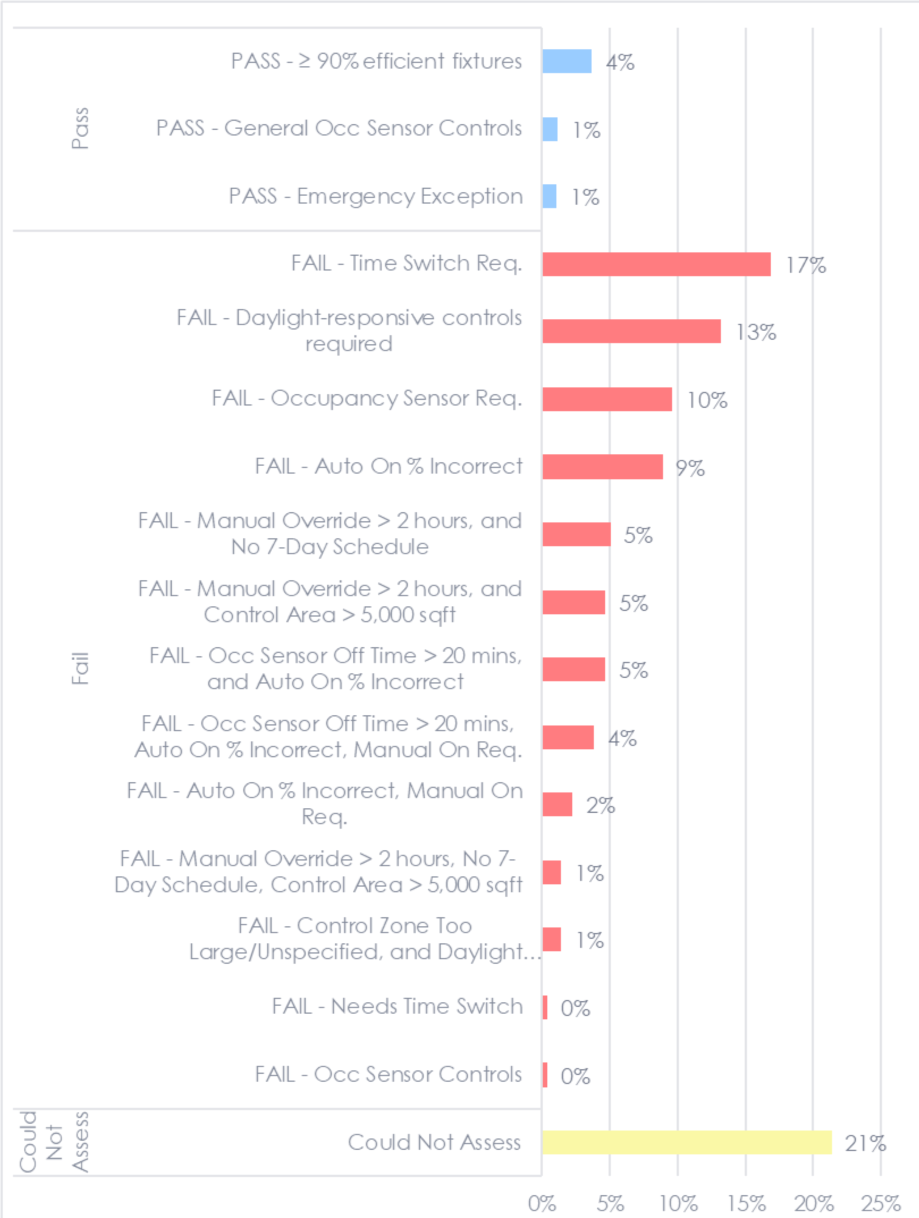

Figure 9. Lighting Control Compliance (Share of Building Spaces)

During the limited site visits, Michaels found that some space types differed slightly from the building plans. For example, approximately 30 square feet in one building appeared to be part of a mechanical storage room in the plans but was actually part of a restroom. Space type attributions and correct area measurements are important when determining lighting power density. Potential misclassification of space types or square footage can change the allowable wattage calculation for space-by-space LPD compliance methods. The site visits also found minor differences in the number of light fixtures and their wattages, but these were rare and did not affect the building's compliance.

7 Mechanical Systems Findings

7.1 HVAC System Characteristics

7.1.1 Cooling Systems

Unitary air conditioners accounted for the largest share of cooling systems in Montana commercial buildings constructed under 2018 IECC, in terms of both number of systems and cooling capacity. As shown in Figure 10, approximately one-quarter of cooling systems in new commercial buildings were heat pumps, but these accounted for a relatively small share of total cooling capacity. Conversely, few chillers were installed, but they made up a disproportionately large share of cooling capacity.

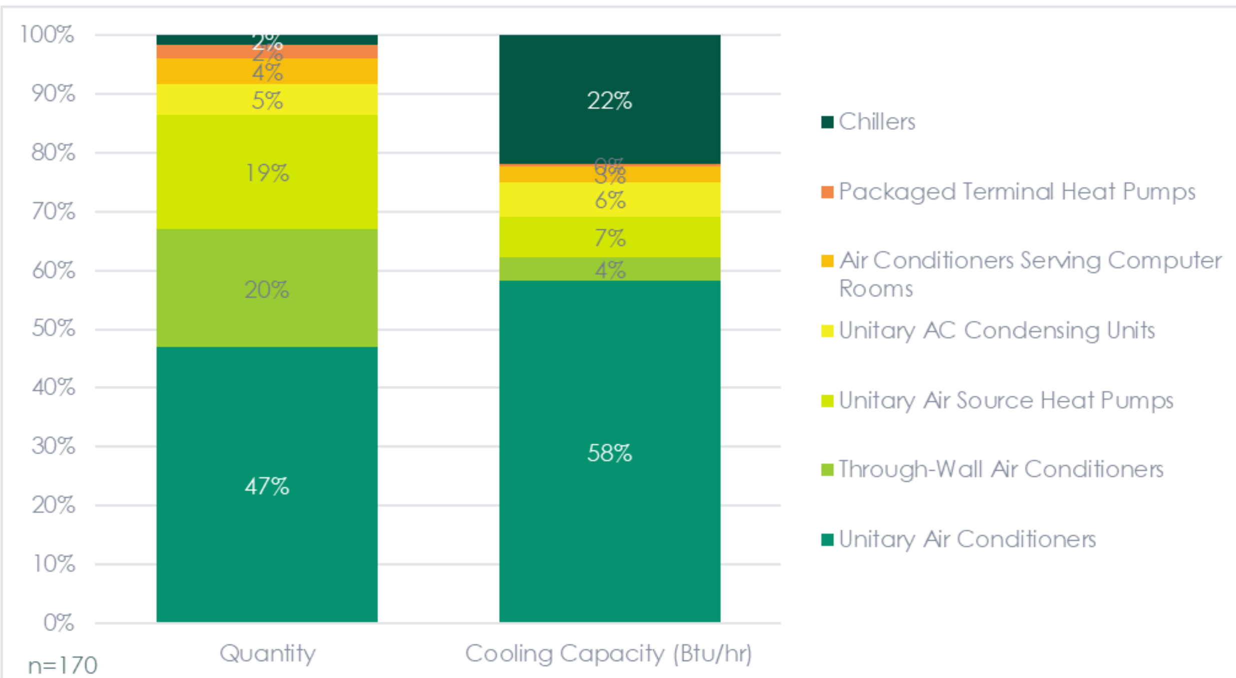

Figure 10. Distribution of Primary Cooling Equipment by Quantity and Heating Capacity

Figure 11 shows the efficiencies of the cooling systems installed in Montana commercial buildings constructed under 2018 IECC. The results are presented both in the mean efficiency weighted by building size and type and by system capacity. Overall, larger systems tended to have slightly lower efficiencies than smaller systems.

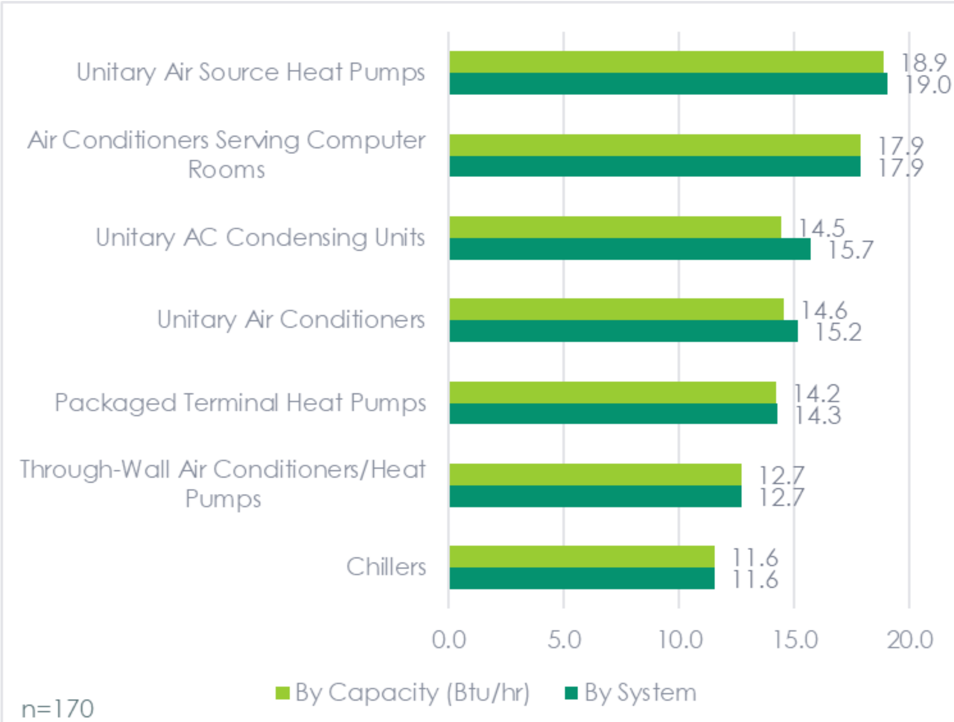

Figure 11. Mean Cooling System Efficiencies (SEER)

7.1.2 Heating Systems

Figure 12 shows the distribution of heating systems by quantity and heating capacity. Furnaces and duct furnaces combine to account for 46% of units and 44% of capacity.[16] While boilers account for only 9% of total systems, they make up more than half of total heating capacity. Heat pumps make up nearly half (45%) of systems but only 5% of capacity.

[16] In the building plans and code compliance analysis, warm-air furnaces include all components (burner, blower, control board, etc.) in one unit, while warm-air duct furnaces include only the burner and are separate from the blower component (and AC coil) which is combined to create a system in the installation process. These types of equipment are listed separately because the code specifies different efficiency requirements by size for each.

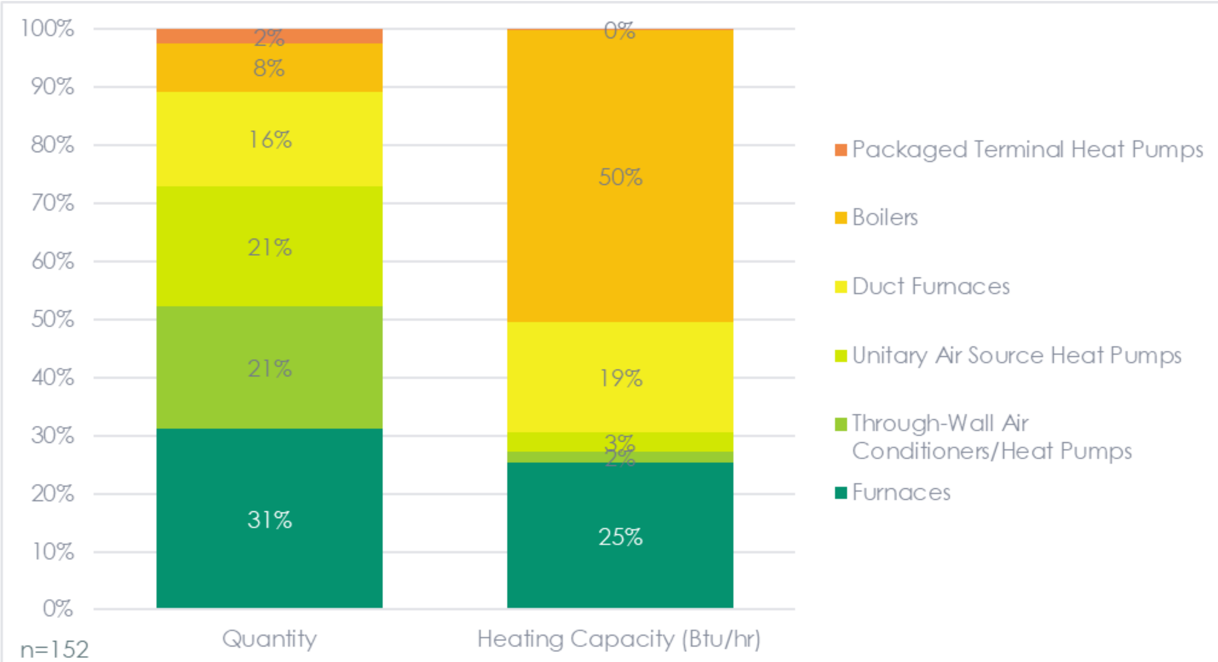

Figure 12. Distribution of Primary Heating Equipment by Quantity and Heating Capacity

Reviews of building plans found that 79% of furnaces (83% of capacity) used natural gas as a fuel. The remainder used propane. All boilers listed in the building plans used natural gas.

Table 10 shows the mean efficiencies of heating systems installed in Montana commercial new construction under 2018 IECC. The table shows the average efficiencies both in terms of installed systems and installed heating capacity. Similar to cooling systems, larger systems tend to be slightly less efficient than smaller systems, resulting in a lower mean efficiency when weighted by capacity.

Table 10. Mean Heating System Efficiencies

System Type	By Quantity	By Capacity	Unit
Furnaces	81.6%	76.8%	Thermal Efficiency
Through-Wall Air Conditioners/Heat Pumps	3.23	3.23	COP
Unitary Air Source Heat Pumps	10.4	10.3	HSPF
Duct Furnaces	80.9%	78.1%	Thermal Efficiency
Boilers	93.1%	86.4%	Thermal Efficiency
Packaged Terminal Heat Pumps	3.65	3.64	COP

In the limited site visits conducted, Michaels found mixed verification results for the mechanical systems. The study team found that one building's installed heating and cooling equipment was consistent with the building plans. On the second site, the make and model of all units differed from the equipment specified in the mechanical plans but were still code compliant. The study team was not able to assess the equipment at the third site.

7.2 Code Compliance

7.2.1 Cooling Equipment

As shown in

Figure 13, code compliance of cooling equipment in Montana commercial buildings was very high for all equipment types. Michaels found no evidence of noncompliance in the building plan review, although compliance could not be assessed for nearly one-quarter of unitary air conditioners and a small share of air source heat pumps.

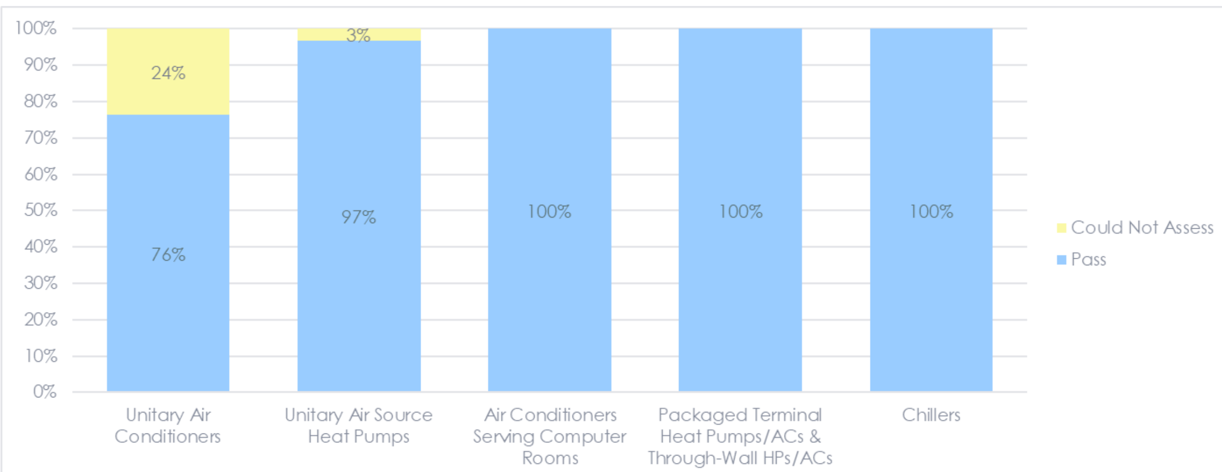

Figure 13. Cooling Equipment Compliance by Equipment Type

Figure 14 shows the binary and weighted compliance of cooling equipment. The vast majority of buildings constructed using 2018 IECC met the efficiencies specified by code.

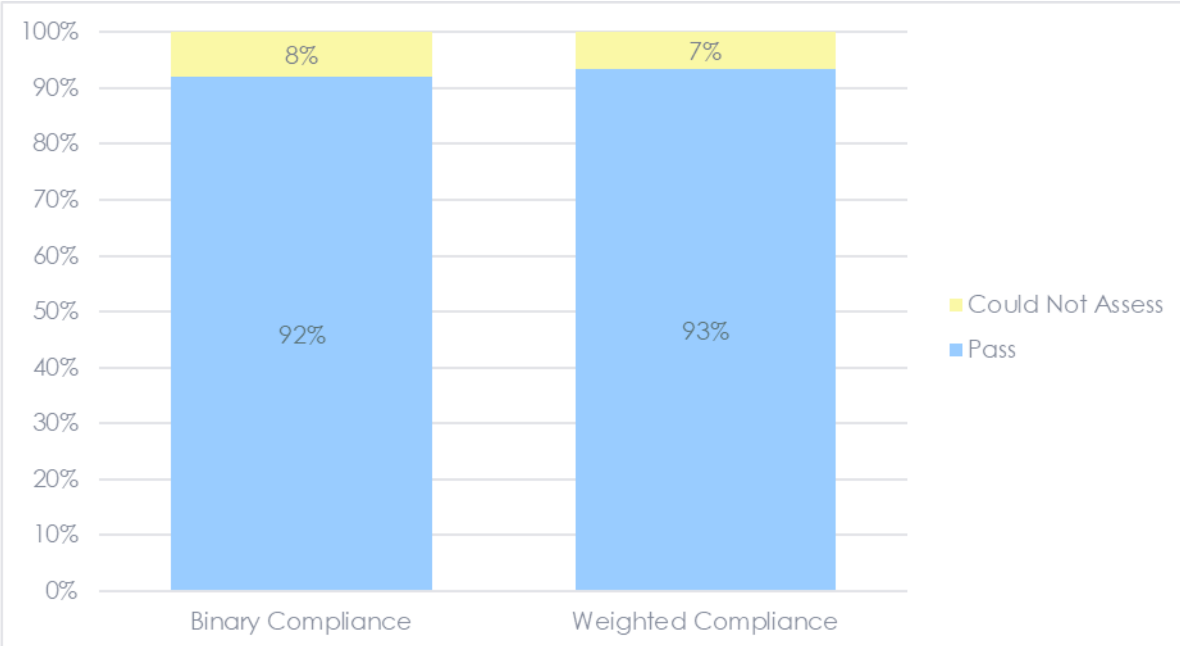

Figure 14. Binary and Weighted Compliance of Cooling Equipment

7.2.2 Heating Equipment

Figure 15 shows the compliance of different types of heating equipment installed in Montana under 2018 IECC. Similar to cooling equipment, most building plans specified equipment that met the efficiency levels required by code. A small share of furnaces were not compliant, and compliance could not be assessed for 27% of furnaces.

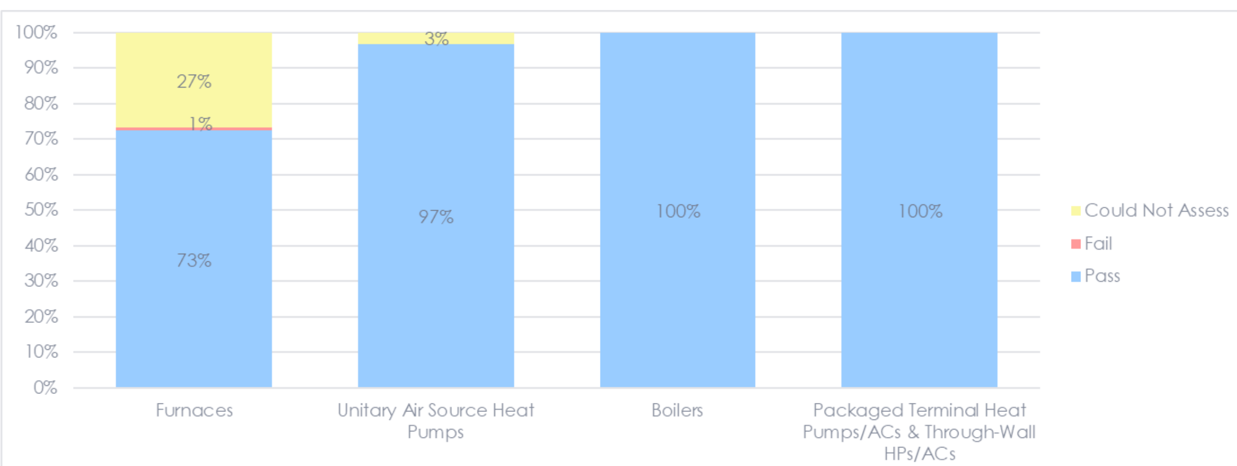

Figure 15. Heating Equipment Compliance by Equipment Type

Figure 16 shows the binary and weighted compliance of cooling equipment. When using the more stringent binary compliance method, Michaels could confirm code compliance of heating systems in only 78% of buildings because it could not be assessed for 20% of buildings.

However, in many cases, sufficient equipment in those buildings could be assessed, resulting in a weighted compliance rate of 96%.

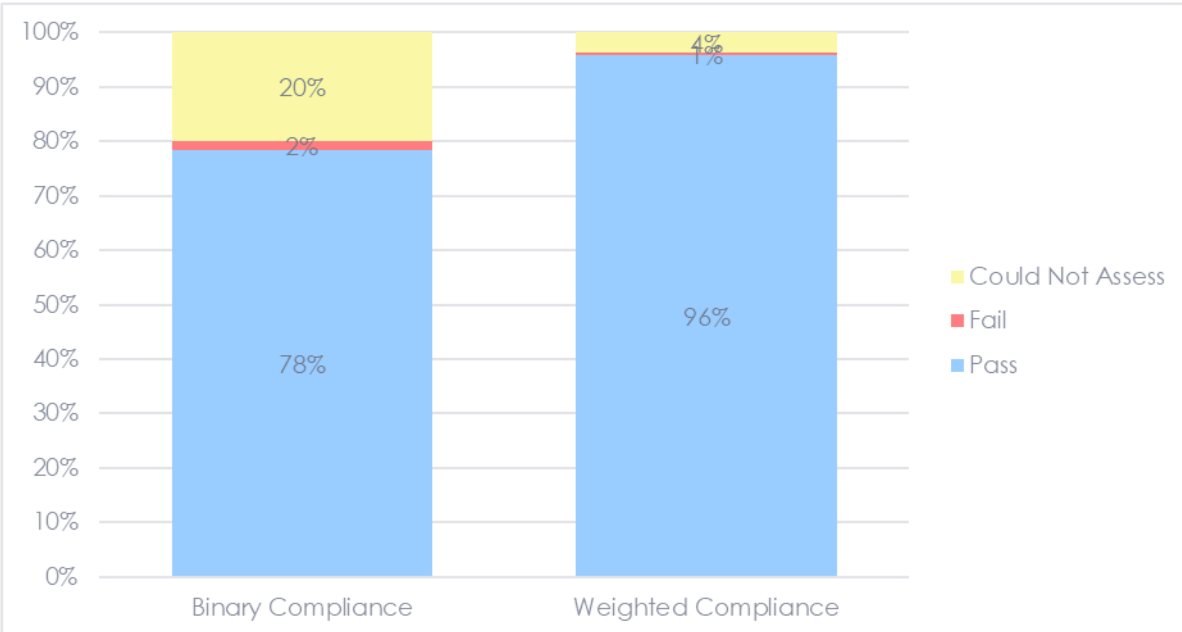

Figure 16. Binary and Weighted Compliance of Heating Equipment

8 Water Heating Systems

8.1 Water Heating System Characteristics

Figure 17 shows the quantity and capacity of water heating systems installed in Montana commercial buildings constructed under 2018 IECC. Storage water heaters accounted for the large majority of systems, with instantaneous water heaters combining to make up only 12% of systems. Although storage water heaters are split roughly evenly between electric and natural gas systems, natural gas storage water heaters accounted for 85% of total water heating capacity in Btu/hr.

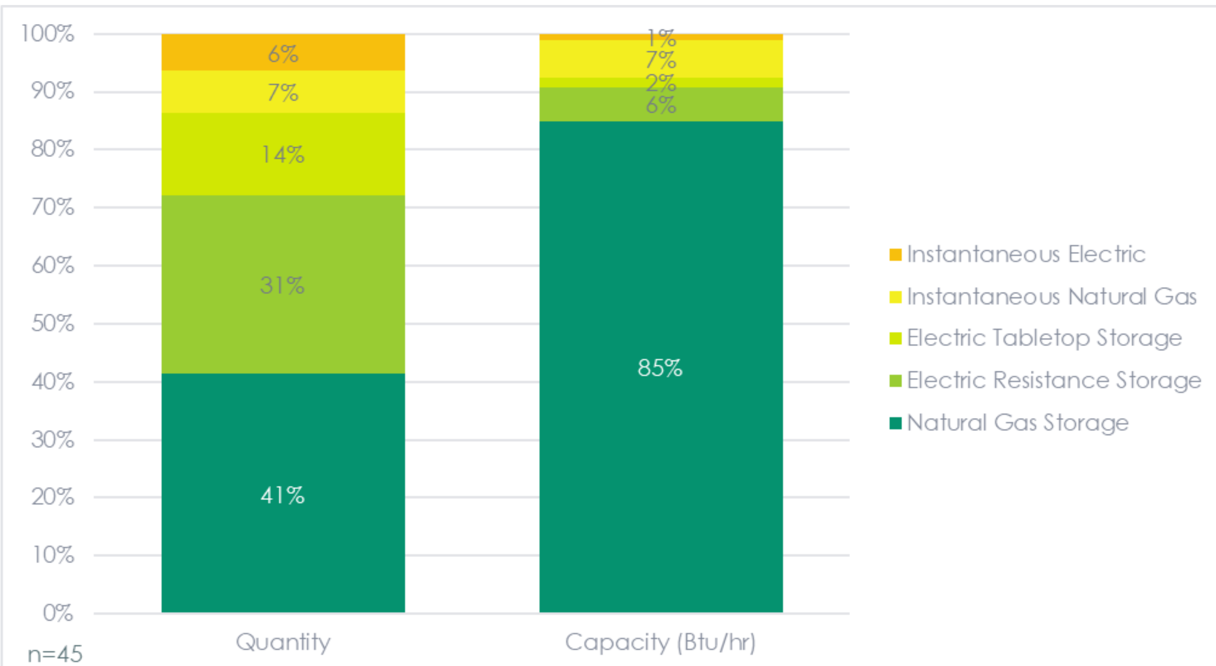

Figure 17. Water Heating Equipment

Figure 18 shows the average water heating system efficiency, in thermal efficiency, by system type, weighted by capacity.

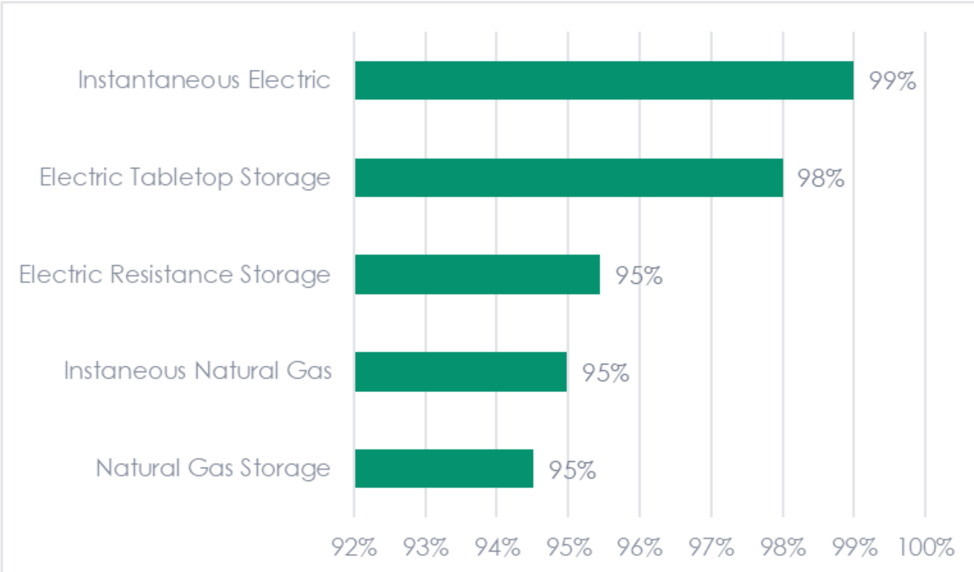

Figure 18. Mean Water Heating System Efficiencies (Thermal Efficiency)

As shown in Figure 19, more than half of storage water heaters did not meet the efficiencies specified by 2018 IECC. Notably, nearly all natural gas storage water heaters (96%) met code while only a small share (7%) of electric storage water heaters did so. Although the compliance of 82% of instantaneous water heaters could not be assessed, this is a result of the small sample size (n=6) of these systems.

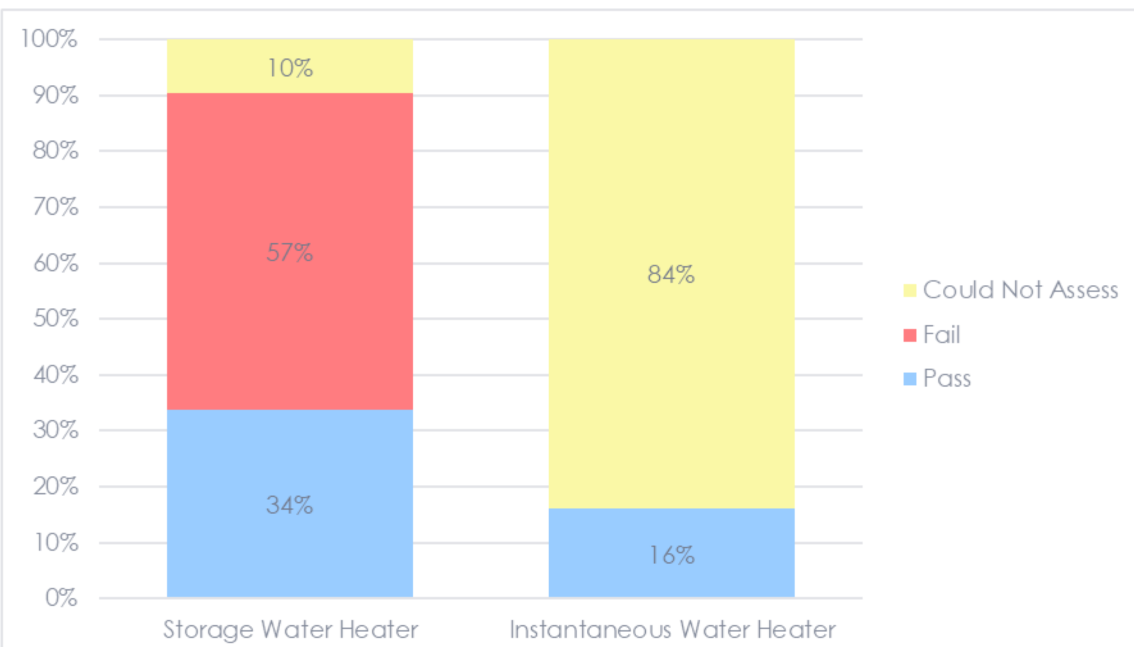

Figure 19. Compliance by Water Heater System Type

Figure 20 shows the binary and weighted compliance of water heating equipment. Because there are relatively few water heating systems in each building, the results from both analyses are similar, with approximately one-third of buildings meeting code for this system type.

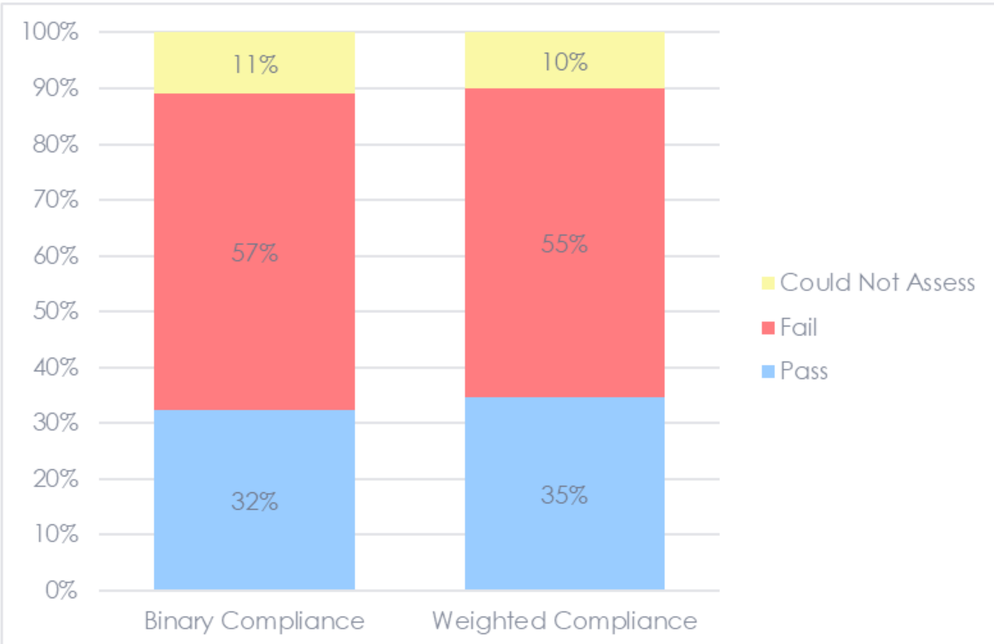

Figure 20. Binary and Weighted Compliance of Water Heating Equipment

In the limited site visits conducted, the study team found mixed verification results for water heating equipment. For one building, the study team verified that the installed water heating equipment was consistent with the building plans, but the installed equipment for the other two buildings differed from the plans. For one of these sites, the water heaters still complied with 2018 IECC despite the different specifications. However, for the other building, the site visit revealed that the UEF values were too low to be compliant whereas the equipment listed in the building plans fell outside of the electric water heater volume and input capacity ranges for 2018 IECC.

9 Conclusions and Recommendations

The Montana Commercial New Construction Code Evaluation Study's primary objectives were to assess compliance pathways, achievement, and energy savings; and to assess the study's methodological efficacy and replicability.

Finding 1. Based on building plan reviews, Michaels found that no sampled building was fully compliant with 2018 IECC using the strict compliance methodology. Mechanical systems had the highest level of compliance (75% of sampled sites), while compliance was low for service hot water (32%) and envelope (7%). No sampled buildings were fully compliant for their lighting systems. Note that these shares include buildings with indeterminate compliance, which often accounted for a large share of sampled sites. Michaels found higher compliance using the weighted compliance method, which reduces the bias toward zero if a single requirement is not met.

> **Recommendation 1.** NEEA may consider using the weighted compliance method as the primary compliance metric for future studies. Instead of a simple pass/fail determination, this approach takes into consideration the level of compliance and provides a more representative view of the state's overall compliance with code requirements.

Finding 2. 2018 IECC was only in effect in Montana for 16 months, limiting the number of commercial buildings designed during that time. Additionally, despite multiple outreach attempts by mail, email, and phone, the study team observed a very low response rate among eligible buildings. Taken together, after assessing the received plans and removing all out-of-scope sites, Michaels was able to review plans from a total of 28 of the 65 buildings determined to be constructed under 2018 IECC and fully within the scope of the study on all other parameters.

> **Recommendation 2.** While 2018 IECC was likely an outlier for its short duration in Montana, NEEA may consider conducting future studies only on code cycles that last a more typical three to six years. This will allow a larger population of eligible buildings to be designed and constructed as well as architects, engineers, builders, and contractors time to properly learn and implement code requirements. Waiting for a larger population will also allow further studies to better explore items of interest such as compliance pathways and geographic differences.

Finding 3. Due to the low response rate of building contacts, Michaels also identified and contacted applicable city or county building departments to request the MEP plans of buildings constructed in their jurisdiction. Many of the contacted building departments were very helpful and provided plans if possible. In some cases, the building department was responsive but could not provide building plans to third parties without permission from the building owner. Additionally, Michaels was also able to gather some plans through public sources, including county websites and the Montana Department of Labor & Industry website.

> **Recommendation 3.** Requesting building plans from city or county building departments and from public sources was much more successful than contacting individual building

representatives. Future code evaluation studies should consider these approaches to maximize the number of plans to review as well as efficiency. Additionally, NEEA may consider periodically reaching out to participating building departments to determine if sufficient plans are available for a full compliance study, at which time NEEA could undertake a more comprehensive sampling strategy.

Finding 4. The study team found that, when available, building plans provided sufficient details to determine compliance with most energy code requirements. Some requirements, such as those related to windows and controls, are not easily determined through building plans. The study found that the code requirements for some buildings or equipment could not be assessed due to lack of information on the plans, but this is also true for on-site assessments for different reasons (e.g., lack of roof access). Due to the small sample sizes for both building plan reviews and site visits in this study, Michaels could not make any statistically representative conclusions about the degree of variance between the two approaches.

Recommendation 4. NEEA may consider using a hybrid approach of building plan reviews and on-site verification in future studies to better understand the efficacy of using building plans as a principal data source for code compliance studies.

Appendix A. Sample Design Memo

This memo presents the initial sampling strategy developed by Michaels Energy for the NEEA Montana New Commercial Construction Code Evaluation. It documents the goals, considerations, and key decisions for the sample design. As described below, Michaels will finalize sample design and draw the sample after gathering supplemental information on the population of buildings and input from NEEA.

9.1 Overall Approach

NEEA has developed sampling protocols for code evaluations as part of the Washington and Oregon Commercial Code Evaluation Studies with the support of study-specific working groups. Whenever reasonable, Michaels will incorporate those protocols into this study to maximize comparability among studies. The sampling approach described below may be refined after gathering supplemental information on the population of buildings.

Similar to the Oregon and Washington studies, Michaels' sampling plan is designed to achieve ±10% relative precision at the 90% confidence level based on building floor area. A building's square footage is correlated to other features of interest, including energy use, lighting power, and types and sizes of HVAC equipment.

We will use a stratified random sample approach and ensure coverage of all important groups as well as contain the greatest share of total newly constructed commercial building area. Stratification improves the precision of the results by breaking the overall sample into more homogenous groups (minimizing variance in floor area), helps target specific areas of interest, and ensures that the final results are representative of the population. We will use the simplest sampling strategy that provides the required level of detail. We plan to stratify by the following two dimensions:

- **Building type:** Similar to the Washington and Oregon studies, we stratified the population by five key building types: Office, Retail, Education, Multifamily[17], and Other buildings.
- **Building Size:** We stratified the population by building square footage. We used NEEA's definition of each size category: Small (under 20,000 SF), Medium (20,000 to 99,999 SF), and Large (100,000 SF or greater).

If possible, Michaels will also stratify by municipality incorporation (i.e., incorporated v. unincorporated communities) to account for potential geographic differences in code compliance.

After stratifying the sample frame, Michaels randomly selected the appropriate number of buildings within each stratum. Recognizing that other NEEA code evaluations have had difficulty recruiting projects to review and that the required information may not be available for some sampled projects, we may supplement the random sample with convenience sampling if low response rates prevent meeting our desired quota for each stratum. If required, we will work with

[17] For this study, we define multifamily buildings as those with 5 or more units. The sampling frame currently includes both low-rise (1 to 3 stories) and mid- and high-rise buildings (4 or more stories).

NEEA's stakeholder relationships to identify additional buildings for potential recruitment. Moving away from the random selection of buildings introduces potential bias into the results and Michaels will mitigate this by comparing the selected sample to the population and developing post hoc weights if needed.

9.2 Sampling Frame

The sampling frame for this study includes all commercial and multifamily (5+ units) buildings constructed in Montana under the 2018 International Energy Conservation Code (IECC) which was in effect from February 13, 2021 to June 10, 2022, when 2021 IECC became effective. The initial sampling frame is based on Dodge dataset "building starts" from February 13, 2021 to May 31, 2022.[18] The total number of projects in the sampling frame is 418 commercial buildings constructed under 2018 IECC.

Table 11 defines the five building types included in the study by types of projects from the Dodge data that made up each category.

Table 11. Building Type Definitions

Building Type	Project Types Included from Dodge Data
Office	- Office and Bank Buildings
Retail	- Stores and Restaurants
Education	- Schools, Libraries, and Labs (non-manufacturing) - Dormitories
Multifamily	- Apartments 5+ Units, 1-3 Stories - Apartments 5+ Units, 4+ Stories
Other	- Amusement, Social and Recreational Buildings - Government Service Buildings - Hotels and Motels - Hospitals and Other Health Treatment - Manufacturing Plants, Warehouses, Labs - Miscellaneous Nonresidential Buildings - Parking Garages and Automotive Services - Religious Buildings - Warehouses (excluding manufacturer-owned)

Michaels plans to stratify the sample by building area. However, due to the setup of the Dodge dataset, the square footage is not shown for all buildings.[19] If this is the case, we will supplement this information using information from the permit information on the Montana Department of Labor & Industry website or information from county code officials. If the square footage is still missing, we will impute an estimated square footage value based on estimated value of project

[18] The Dodge data available at the time of the sampling plan development included project started until the end of the second quarter of 2022.
[19] The square footage is unknown for 90% of multifamily buildings and 31% of non-multifamily commercial buildings.

or other variable. Table 12 shows the counts of projects constructed under 2018 by building type and size, based on the information available in the Dodge data extract.

Table 12. Count of Projects Constructed Under 2018 IECC by Building Type and Size

Building Type	Small (<20,000 SF)	Medium (20,000 – 99,999 SF)	Large (100,000+ SF)	Unknown Size	Total
Office	22	6	0	12	40
Retail	15	1	0	10	26
Education	5	5	1	0	11
Multifamily	12	7	1	188	108
Other	59	29	2	43	133
Total	113	48	4	253	418

To be able to stratify the sampling frame by municipality incorporation (i.e., incorporated v. unincorporated communities), Michaels will need to conduct additional research. The Dodge data identifies the county for each project, but not the town in which it was built, and this information will need to be added to the sampling frame.[20]

After supplementing the Dodge data with other information for buildings with unknown area, Michaels will have a dataset of all commercial buildings constructed under 2018 IECC and the major characteristics of each building to draw a sample.

9.3 Sample Selection

Once the sampling frame and stratification are developed and approved by NEEA, Michaels will draw the sample of buildings to review. Similar to the Oregon and Washington studies, Michaels sample is designed achieve ±10% relative precision at the 90% confidence level based on building floor area. We plan to review 90 buildings and will conduct site visits with a subset of 20.[21] This sample size would meet the 90/10 confidence/precision threshold for key metrics, assuming a population of 418 buildings and a coefficient of variation (CV) of 0.5.[22]

While Michaels will strive to achieve the traditional industry 90/10 confidence/precision standard for key metrics, not all buildings will have each equipment type. The actual precision for specific building characteristics and building types may vary widely based on the number of observations and the variance of the data. We also note that the 90% compliance approach that used to be promoted by PNNL, the number of sites to achieve 10% precision at the 90% confidence level was 44 buildings.

[20] Montana has a total of 669 communities, of which 128 are incorporated, in 57 counties. However, only 22 counties had commercial new construction starts within the study timeframe.
[21] We will randomly select the buildings to visit based on those that have expressed interest in the on-site inspection in the interview.
[22] We understand that the Oregon Commercial New Construction Code Evaluation achieved CVs of 0.76 to 1.00 for building floor area but found less variance in other important metrics. Michaels also assumes that further stratification by building size in addition to building type will improve precision.

Table 13 presents the preliminary sample for this evaluation. Michaels will develop a final sample that will include supplemental building area data and information about municipality incorporation.

Table 13. Preliminary Sample

Building Type	Building Size	Population	Sample	Total Population SF (000)	% of Population SF (000)
Office	Small (<20,000 SF)	22	5	210.4	3%
	Medium (20,000-99,999 SF)	6	2	198.0	2%
	Large (100,000+ SF)	0	0	0	0%
	Unknown	12	3	106.0	1%
	Subtotal	*40*	*10*	*514.4*	*6%*
Retail	Small (<20,000 SF)	15	4	130.6	0%
	Medium (20,000-99,999 SF)	1	1	22.4	3%
	Large (100,000+ SF)	0	0	0	2%
	Unknown	0	0	129.3	0%
	Subtotal	*11*	*5*	*282.3*	*5%*
Education	Small (<20,000 SF)	5	1	20.6	2%
	Medium (20,000-99,999 SF)	5	3	254.5	0%
	Large (100,000+ SF)	1	1	135.0	0%
	Unknown	0	0	0	2%
	Subtotal	11	5	410.1	4%
Multifamily	Small (<20,000 SF)	12	2	129.7	2%
	Medium (20,000-99,999 SF)	7	3	311.4	4%
	Large (100,000+ SF)	1	1	169.4	2%
	Unknown	188	30	3,726.1	46%
	Subtotal	*208*	*36*	*4,336.0*	*54%*
Other	Small (<20,000 SF)	59	8	448.2	6%
	Medium (20,000-99,999 SF)	29	12	1,080.7	13%
	Large (100,000+ SF)	2	2	261.0	3%
	Unknown	43	9	720.7	9%
	Subtotal	*133*	*31*	*2.510.6*	*31%*
Total	Small (<20,000 SF)	113	20	939.5	12%
	Medium (20,000-99,999 SF)	48	21	1,867	23%
	Large (100,000+ SF)	4	4	565.4	7%
	Unknown	253	45	4,682.1	58%
	Total	**418**	**90**	**8,054.0**	**100%**

Appendix B. Weighting

Michaels Energy weighted the results presented in this report to be representative of the population of buildings constructed under 2018 IECC. The study team developed and applied weights to account for the difference in the distribution of buildings by type and size within the sample compared to the population. To account for the relative impact of code compliance on the population, the study team also weighted the results by buildings' square footage and equipment capacity as needed.

Table 14. Sampling Weighting

Building Type	Building Size	Population	Sample	Weight
Office	Small (<20,000 SF)	30	12	1.0796
	Medium (20,000-99,999 SF)	4	1	
	Large (100,000+ SF)			1.6716
	Subtotal	*34*	*13*	--
Retail	Small (<20,000 SF)	19	8	0.9925
	Medium (20,000-99,999 SF)	3	3	0.4179
	Large (100,000+ SF)	0	0	--
	Subtotal	*22*	*11*	--
Multifamily	Small (<20,000 SF)	3	2	0.6269
	Medium (20,000-99,999 SF)	3	1	1.2537
	Large (100,000+ SF)	4	1	1.6716
	Subtotal	*10*	*4*	--
Total	Small (<20,000 SF)	52	22	--
	Medium (20,000-99,999 SF)	9	5	--
	Large (100,000+ SF)	5	1	--
	Total	**67**	**28**	**--**