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Commissioning Long-Term Monitoring and Tracking—2016 Square Footage Update

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1 Executive Summary

As part of the Northwest Energy Efficiency Alliance's (NEEA's) long-term monitoring and tracking (LTMT) efforts on commercial building commissioning, the Cadmus Group collected data on commissioning market activities and trends in the Northwest for 2016.

Through an online survey of 27 commissioning providers (representing 25 firms) active in the Northwest and analysis of Dodge and NEEA's 2014 Commercial Building Stock Assessment (CBSA) data, Cadmus estimated the following for new and existing building commissioning:

- Market size in square feet,
- Market activity (area of commissioned space), and
- Market penetration as a percentage of market size.

Table 1 provides the 2016 estimates for new building commissioning (Cx). The Northwest's new building market size grew slightly in 2016, and Cx market penetration grew significantly, from a region-wide market penetration rate of 49% in 2015 to 71% in 2016. Washington and Oregon continue to show higher Cx market penetration rates than Idaho and Montana. Notably, Washington had a very high Cx market penetration rate compared to the other three states, due to the Washington State Energy Code (WSEC) 2015 updates, which require commissioning to be conducted in new buildings. The changes took effect in 2016. Idaho was the only state for which market penetration did not climb in 2016. However, commercial new construction has grown considerably for the past several years in that state.

Table 1. 2016 LTMT Estimates for New Building Commissioning

State	Commissioned Space (sq. ft.)	Commercial New Construction Floor Area (sq. ft.)	Market Penetration
Idaho	1,241,321	8,654,525	14%
Montana	1,038,165	2,935,250	35%
Oregon	9,740,592	13,003,750	75%
Washington	27,608,184	31,103,975	89%
Total	39,628,261	55,697,500	71%

Sources: Dodge; Cadmus analysis of 2016 data.

Table 2 provides the existing building commissioning estimates broken down by the three commissioning types:

- Retrocommissioning (RCx) – Commissioning existing buildings that have been never been commissioned
- Recommissioning (ReCx) – Commissioning buildings that have been commissioned during the construction phase
- Ongoing commissioning (OCx) – Fine tuning commissioned buildings repeatedly over time

On the whole, existing building commissioning activity decreased compared to 2015, for the second year in a row. However, all types of existing building commissioning in the Oregon market grew, as did OCx in Washington.

Table 2. 2016 LTMT Estimates for Existing Building Commissioning

	State	Commissioned Space (sq. ft.)	Commercial Existing Building Floor Area (sq. ft.)	Market Penetration
Retrocommissioning	Idaho	111,286	285,616,121	0.04%
	Montana	620,702	245,330,092	0.25%
	Oregon	15,537,577	923,165,449	1.68%
	Washington	7,710,523	1,606,779,887	0.48%
	Total	23,980,068	3,060,891,549	0.78%
Recommissioning	Idaho	276,159	285,616,121	0.10%
	Montana	21,429	245,330,092	0.01%
	Oregon	1,934,324	923,165,449	0.21%
	Washington	1,663,518	1,606,779,887	0.10%
	Total	3,895,430	3,060,891,549	0.13%
Ongoing commissioning	Idaho	246,377	285,616,121	0.09%
	Montana	30,612	245,330,092	0.01%
	Oregon	5,909,100	923,165,449	0.64%
	Washington	1,901,991	1,606,779,887	0.12%
	Total	8,088,080	3,060,891,549	0.26%
	Overall Total*	35,963,571	3,060,891,549	1.17%

*Totals may not equal the sum of column due to rounding.
Sources: NEEA 2014 (CBSA); Cadmus analysis of 2016 data.

1.1 Discussion and Recommendations for Future Research

1. Despite similarities in methods and outreach studies, this year's LTMT study only garnered responses from 25 commissioning firms, a notable dip in responsiveness compared to last year's 35 unique firms.

   Because findings from the survey are extrapolated to the population (an estimated 77 firms) to determine overall market activity in the region, a robust sample size is necessary to produce reliable results. For future efforts, Cadmus recommends the following:
   - In advance of the next survey, attend chapter meetings at various certification and professional organizations to encourage survey participation.
   - In advance of the next survey, collaborate with professional organizations to help them highlight the survey in their publications and newsletter and to encourage participation.

- Update the population with fresh secondary research. For firms that participated in the survey this year, conduct a preliminary online search to determine whether the respondents still work at the firm. If not, attempt to find a new contact at that firm to invite to participate.

2. Based on the number of survey respondents, there is only a small number of firms providing commissioning services in Idaho, where the rate of new building commissioning has not kept pace with new construction despite the adoption of the 2012 International Energy Conservation Code (IECC). However, Cx firms are also predicting their activity will increase in that state. Considering the strong growth in new construction there, Cadmus recommends NEEA consider ways to support awareness-building in Idaho on the benefits of commissioning, through its support of the Building Commissioning Association (BCA) or other industry efforts.

3. Regarding existing building commissioning, the downward trend in RCx is concerning, especially in a large market like Washington. Cadmus recommends NEEA explore reasons for this trend in future surveys. It could also consider conducting in-depth qualitative research, such as interviews or focus groups, with a small number of commissioning providers to explore market trends and barriers. It could also consider research activities with end users such as building owners or property managers, to explore market barriers to commissioning.

4. Cadmus discovered in this year's study that industrial and manufacturing buildings comprised 7% of the commissioned floor space in 2016 for Cx, 11% of RCx, and 3% of ReCx. Cadmus recommends NEEA consider changes to the survey to further explore the trends in industrial facility commissioning and enhance the confidence in the extrapolated results. For example, next year NEEA could consider adding questions to assess the location of the commissioning work[1] and manufacturing segment.

[1] The current survey asks the percentage of work that was conducted for industrial and manufacturing buildings in general for the region, and did not ask respondents to report the percentage for each state. Cadmus estimated the state proportions during analysis.

2 Introduction

From 1998 to 2004, the Northwest Energy Efficiency Alliance (NEEA) administered an initiative to transform the building commissioning market in the Pacific Northwest. NEEA's goal was to make commissioning standard practice in public buildings and to create a standardized professional certification body for commissioning providers. Through the initiative, NEEA supported the adoption of state and local commissioning policies for public buildings, and it created and fostered the Building Commissioning Association (BCA). To assess the outcomes of the initiative, NEEA began tracking market activities and trends related to commissioning in 2005 through its long-term monitoring and tracking (LTMT) efforts. Past LTMT efforts included primary and secondary data collection on market characterization, commissioning providers, and policy.

NEEA uses the data collected to review and update the key assumptions that underlie the Alliance Cost-Effectiveness (ACE) Model for commissioning. NEEA selected Cadmus to update square footage estimates of the following types of space commissioning in the Northwest, using 2016 data:

- Commissioning (Cx) – Commissioning new buildings during the construction phase
- Retrocommissioning (RCx) – Commissioning buildings that have been never been commissioned
- Recommissioning (ReCx) – Commissioning buildings that have been commissioned during the construction phase
- Ongoing commissioning (OCx) – Fine tuning commissioned buildings repeatedly over time

This is the fourth year that Cadmus has conducted this study. Each year the methods have remained consistent to provide a reliable measure of market change, although NEEA and Cadmus have made refinements based on the study's findings, NEEA's priorities, and best available information.

2.1 Notable 2016 Methodological and Scope Updates

For the 2015 report, Cadmus provided NEEA with an estimate of baseline market share, or the percentage of commissioned floor space that would have been commissioned without NEEA intervention. Cadmus generated a forecast of the baseline market share through 2020. The scope of this report (2016) was limited to collecting square footage data and calculating market penetration for use in NEEA's ACE Model updates.

In 2015, Cadmus added survey questions to investigate the percentage of commissioning occurring in the industrial and manufacturing (I&M) sector. Cadmus and NEEA made a minor improvement to the survey question wording in 2016 to clarify that the data being collected was for square footage of I&M *building* commissioning, not I&M *equipment* commissioning. Cadmus netted out I&M square footage from the total commissioning square footage reported in this LTMT report (discussed further in Section 4.4.3). This is consistent with the methods for calculating square footage in 2015, with minor improvements.[2] To inform future methodologies for calculating I&M commissioning activity and potential savings for NEEA's ACE Model updates, Cadmus also completed the following:

1. Reviewed available data sources and estimated I&M market size in the Northwest (see Appendix 7.3)

2. Recommended a savings rate for commissioning and retrocommissioning in I&M facilities (see Appendix 7.4)

3. Recommended refinements to the LTMT survey instrument to gather more precise data on commissioning activities in the I&M sector

[2] In 2015, because the percentage was small and the associated savings were relatively inconsequential, NEEA and Cadmus did not net out I&M square footage from new building commissioning activity. However, in 2016, the adjustment was made for all commissioning types (new and existing).

3 Methodology

NEEA had four major objectives for the 2016 LTMT study:

- Update the total floor area of commissioned space (square footage) by state and by each type of commissioning
- Determine the total market size of new and existing commercial buildings
- Calculate market penetration and determine how market penetration has changed over time
- Update the number of certified and uncertified commissioning providers by state

Table 3 provides a summary of the methodology and sources used for meeting each of these objectives. The next section describes the methodology for the online survey. In later sections of this report, Cadmus discusses detailed steps taken to arrive at the 2016 estimates.
Cadmus calculated precision for the square footage results at 80% confidence with ±42% precision for new building commissioning, and 80% confidence with ±23% precision for existing building commissioning.[3] The low level of precision for the new building commissioning results was primarily driven by the small sample size and the high variability of each of the reported square footage values, which impacted the standard error. Specifically, the inclusion of one large outlier value of 4.9 million square feet drove down precision.[4] If the outlier was excluded from the standard error calculation, confidence and precision would be 80/24 for new building commissioning.

[3] Cadmus calculated one measurement of confidence and precision for all types of existing building commissioning combined (80/23). Sample sizes were too small to provide meaningful precision results for OCx and ReCx separately.

[4] Cadmus included this record in the final estimated square footage because we verified the reported number with the respondent via a follow-up phone call. But because this value is over 10 times the average reported square footage from the other respondents, it adds significant variance to the sample and greatly reduces the precision in drawing inferences to the population.

Table 3. Data Collection Methodology

Objectives	Method	Population[1]	Target Sample Size	Achieved Sample Size	Data Source for Task
Square footage of commissioned building space	Online Survey of Providers	77 firms	37 firms	25 firms	Sample frame constructed from public data from certification bodies (see note 1) and internet search
Market size: square footage of new and existing buildings	Secondary sources	N/A	N/A	N/A	Dodge Report and Commercial Building Stock Assessment data provided by NEEA
Market penetration	Square footage of commissioned building space in 2016 by state divided by market size	N/A	N/A	N/A	Dodge Report and Commercial Building Stock Assessment data provided by NEEA; square footage obtained through online survey
Number of certified and uncertified commissioning providers by state	Online Survey of Providers	77 firms (125 profes-sionals)	N/A	27 respondents[2]	Sample frame constructed from public data from certification bodies (see note 1) and internet search; number of uncertified providers obtained from survey

Notes:
[1] Population is based on number of professionals certified with one or more of the following: BCA, AABC Commissioning Group (ACG), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Association of Energy Engineers (AEE), and the National Environmental Balancing Bureau (NEBB).
[2] 27 individual respondents completed the survey. They represented 25 firms.

3.1 Online Survey

Cadmus used an online survey, designed and administered through the Qualtrics platform, to collect square footage values for commissioning activity. Appendix 7.2 contains the online survey instrument. Cadmus contacted all members of the commissioning provider population, targeting 37 responses from unique firms.[5] Cadmus excluded providers whose emails bounced back during the previous commissioning study. Cadmus included California-based providers to investigate whether their firms serviced the Northwest in 2016. Four California providers who completed the survey reported servicing the Northwest; thus, Cadmus counted them in the final population. Altogether, 27 providers completed the survey (representing 25 firms), 23 in the Northwest and four in California.

Despite similarities in methods and outreach studies, this year's LTMT study only garnered responses from 25 firms, a notable dip in responsiveness compared to last year's sample size of

[5] Assuming a coefficient of variation of 0.5, responses from 37 commissioning firms would elicit results with 10% precision at the 90% confidence level. Observed variability in square footage of firms was calculated using the standard deviation of square footage within each state and commissioning type, their respective sample sizes, and a finite population correction.

35 unique firms. All 39 providers who completed the survey last year indicated interest in participating again. Yet, out of last year's 35 firms, only 21 participated in this year's survey (and four new firms participated). Of the 13 participants who dropped out in 2016, we found that for five firms the contact person had moved on to a new job. The remaining six firms that participated in 2015 and not 2016 were primarily smaller companies, with gross revenue of at most $250,000. In these cases, limited staff capacity to complete our survey may have played a role in participation.

4 Findings

In this section, Cadmus presents the results of the four research objectives shown in section 3 (Methodology).

4.1 Number of Commissioning Providers

In 2016, Cadmus and NEEA decided not to conduct new internet research to update the population of commissioning providers (or agents) and instead relied on the 2015 sample. This list was a collection of 77 unique firms representing 125 providers. As in 2015, Cadmus included some California-based engineering firms in the sample and inquired whether they had completed any projects in the Northwest. Four California respondents reported doing so and are therefore included in our population of 77.

Cadmus constructed the original population of certified commissioning providers in the Northwest and California using providers listed on the following commissioning certification organizations' websites:

- BCA
- AABC Commissioning Group (ACG)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Association of Energy Engineers (AEE)
- National Environmental Balancing Bureau (NEBB).

4.1.1 Certified Providers

The estimated population of certified commissioning providers servicing the Northwest in 2016 was 125, representing 77 unique firms. As in 2015, Cadmus included providers from California in the population estimation. Of the 125 providers and 77 unique firms, four California providers representing four California-based firms serviced the Northwest in 2016. The number of certified providers decreased slightly from 137 in 2015 to 125 in 2016 because several providers on that list no longer had valid e-mail addresses.

4.1.2 Uncertified Providers

The estimated population of uncertified commissioning providers servicing the Northwest in 2016 was 82. To find the number of uncertified providers, Cadmus used the data reported by providers in the online survey (n = 26).[6] On average, survey respondents reported that 61% of their firms' commissioning employees held a professional certification. By assuming the 125 certified providers represent 61% of the total number of commissioning providers, Cadmus calculated the total number of commissioning providers in the population, arriving at the number of uncertified providers by subtracting certified providers from the total. Table 4 shows the estimated population of certified and uncertified providers.

[6] One respondent did not answer this question.

Table 4. Population of Certified and Uncertified Providers

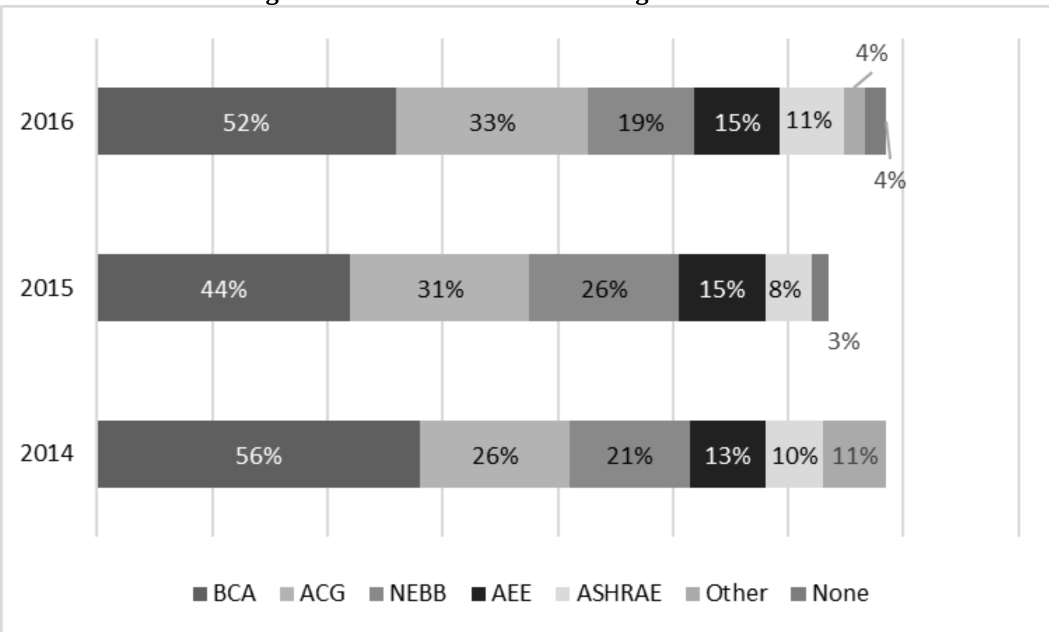
Population of Certified Providers	Population of Uncertified Providers	Total Population of Providers
125	82	207
61%	39%	100%

Sources: Internet research; Cadmus analysis of 2016 (n = 26) data, *QD3. How many people does your firm employ who work a significant amount of time on commissioning projects?*; (n = 26), *QD4. Of this group, how many people hold individual professional commissioning certifications?*

4.1.3 Commissioning Certification Type

Out of the 27 individuals who participated in the online survey, all but one held a commissioning certification. BCA (52%) and ACG (33%) were the top two certifying organizations among the respondent pool. This was consistent with the 2014 and 2015 survey findings. As Figure 1 demonstrates, the proportion of providers holding a BCA certification increased from 44% in 2015 to 52% in 2016, approaching 2014 levels (see Figure 1). On the other hand, the NEBB certification share decreased from 26% in 2015 to 19% in 2016. The shares of providers with other certifications are consistent with results from prior years.

Figure 1. 2014-2016 Commissioning Certifications



Sources: Cadmus analysis of 2014 (*n* = 39) and 2015 (*n* = 39) data (Cadmus 2015 and Cadmus 2016), and Cadmus analysis of 2016 (*n* = 27) data, *QC2. From which of the following do you hold a current commissioning certification?*

Notes: Multiple responses allowed, percentages might add up to more than 100%.

Cadmus also asked providers about firm-level commissioning certifications. About 63% of respondents reported that their firms hold a commissioning certification, which demonstrates a continuous increase from 54% in 2015 and 51% in 2014. Among firms that hold an organizational commissioning certification, respondents cited BCA's (48%) and NEBB's Building Systems Commissioning (22%) certifications.

4.2 Market Size

NEEA measures market penetration of new and existing building commissioning activity using the total new and existing commercial building floor area by state. New commercial building square footage is the metric for Cx market size. Existing commercial building square footage is the metric for RCx, ReCx, and OCx market size.

Cadmus used the same data source as was used in previous years to determine new commercial building space in each state. NEEA provided Cadmus new construction square footage from Dodge Data and Analytics (Dodge) for 2015 and 2016, as both years are necessary to arrive at the most accurate 2016 market size for new building commissioning. To be consistent with prior year methods, Cadmus lagged the construction start data by nine months to account for the long duration between construction start and completion. For example, the 2016 new building square footage estimate consists of 75% of the new construction starts' square footage from 2015 and 25% from 2016. Cadmus removed the square footage of parking garages from this estimate because these structures typically do not undergo commissioning.

To determine the existing commercial building space in each state, Cadmus used NEEA's CBSA data from 2014. Last year, Cadmus updated the data to arrive at an estimate for the 2015 building stock by simply adding on 2014 new construction square footage,[7] and this year we followed the same methodology to arrive at a 2016 estimate for the existing building stock.

Table 5 shows the market size for new and existing commercial buildings. Idaho, Montana, and Oregon experienced growth in commercial new construction in 2016, with Idaho experiencing 54% growth in new building market size compared to last year. Although this growth exceeds all other states by a large margin, it is consistent with the growth patterns the state has experienced since 2014. Only Washington's new building market size contracted in 2016, by 7% from 2015, representing a slight slowdown in new commercial building construction. Oregon's growth was moderate at 3% over last year. Appendix 7.1 shows historical market size by year.

[7] Lagged by nine months.

Table 5. 2016 Estimated Market Size by State

State	New Construction Floor Area (sq. ft.)	Existing Building Floor Area (sq. ft.)
Idaho	8,654,525	285,616,121
Montana	2,935,250	245,330,092
Oregon	13,003,750	923,165,449
Washington	31,103,975	1,609,038,937
Total	55,697,500	3,060,891,549

Sources: Dodge; NEEA 2014 (CBSA).

4.3 Square Footage of Demolitions

NEEA requires estimates of demolished building space for the ACE Model. To calculate the square footage of demolished building space, Cadmus applied the 2013 LTMT study's established demolition rate of 0.63% to 2016's existing building square footage for each state. Table 6 reports the square footage of demolished building space for 2016.

Table 6. Demolished Square Footage

State	2016 Existing Building Sq. Ft.	Demolition Rate	Demolished Sq. Ft.
Idaho	285,616,121	0.63%	1,799,382
Montana	245,330,092	0.63%	1,545,580
Oregon	923,165,449	0.63%	5,815,942
Washington	1,609,038,937	0.63%	10,136,945

Sources: NEEA 2014; Cadmus 2014.

4.4 Market Penetration

Cadmus determined commissioning market penetration by collecting commissioning firms' estimates of the area (in square feet) commissioned in 2016, by state and commissioning type.

Cadmus' market penetration methodology involved the following steps:

1. Collect commissioning square footage from providers through the online survey.
2. Estimate the population of commissioning firms by state and commissioning type.
3. Adjust for commissioning in manufacturing and industrial facilities.
4. Extrapolate the sample data collected to the firm population to arrive at total square feet of commissioned space.

5. Calculate market penetration by state and commissioning type.

4.4.1 Online Survey

The online survey asked respondents to report the size (in square feet) of the Cx, RCx, ReCx, and OCx projects that their firms completed in 2016 for each state in the Northwest.[8] All four California providers who participated in the online survey provided square footage data in at least one state in the Northwest in 2016, thus their square footage data were included in the results.

Cadmus found some inconsistencies in firms that submitted square footage data. Two firms, each with two respondents, submitted conflicting data as part of the survey. In each case, the two respondents reported differing square footage values for their firms. In these instances, Cadmus contacted the respondents by e-mail, inquired about which values to use, and made adjustments according to respondents' instructions. In another case, the square footage data for two different firms were identical. Cadmus researched this issue and found that one individual had reported commissioning activity twice under two different organization names after becoming a sole proprietor. To avoid double-counting, Cadmus only included square footage data from one of the firms.

4.4.2 Estimated Firm Population by State and Commissioning Type

Cadmus estimated that 77 unique firms with certified professionals performed commissioning in the Northwest in 2016. However, not all of the firms performed commissioning in each of the four states, and not all of the firms performed each of the four types of commissioning. Detail on location of and types of commissioning is necessary to extrapolate square footage values obtained through the survey to the population and to generate total estimates of the square feet of commissioned space by *state* and *type*.

Cadmus counted the number of firms that provided square footage data for each state and commissioning type in the online survey (Table 7). Next, Cadmus converted these counts to percentages of the total sample (*n* = 25 firms).

Table 7. Count and Percentage of Firms Responding to Online Survey by State and Commissioning Type

State	Cx Firms		RCx Firms		ReCx Firms		OCx Firms	
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
Idaho	2	8%	1	4%	1	4%	1	4%
Montana	6	24%	5	20%	1	4%	1	4%
Oregon	9	36%	8	32%	1	4%	4	16%
Washington	16	64%	8	32%	3	12%	4	16%

Notes: Respondents could submit data on more than one commissioning type and state; therefore, totals exceed the sample size (*n* = 25 firms).

[8] The survey also gave an option for respondents to report zero square feet.

To generate an estimate of the population of firms by state and commissioning type, Cadmus applied the percentages listed in Table 7 to the population of unique firms (*N* = 77). For example, to arrive at the estimate of two firms that provided new building commissioning services in the state of Idaho in 2016, we multiplied 8% by 77 firms. Though the total number of commissioning firms in the region may only vary slightly over time, these particular results change each year according to the actual data collected in the survey.

Table 8 contains the final estimated population of firms by state and commissioning type. In this case, "service population" means the number of firms that Cadmus estimates *serviced end users in that state*, for each specific commissioning type. We used these population estimates as a multiplier to generate the total square footage values for the ACE model (see next section).

Table 8. Total Estimated Population of Commissioning Firms by State and Commissioning Type

State	Cx Service Population	RCx Service Population	ReCx Service Population	OCx Service Population
Idaho	6	3	3	3
Montana	18	15	3	3
Oregon	28	25	3	12
Washington	49	25	9	12

Source: Cadmus 2016 analysis

4.4.3 Adjustments

NEEA's commissioning initiative focused on the commercial building market. Although the survey focused on commercial building commissioning, respondents may have counted I&M buildings in their reported commissioned square footage. To measure this trend, Cadmus included questions in the survey to inform the square footage of commissioned floor space that was from I&M buildings for each of the four types of commissioning and adjusted the final square footage to remove the square footage for these buildings.

As shown in Table 9, I&M buildings comprised 7% of Cx square footage, 11% of RCx, and 3% of ReCx square footage. These results are fairly similar to results of the 2015 study.

Table 9. Proportion of Commissioned Space Consisting of Industrial and Manufacturing Buildings

State	Cx	RCx	ReCx	OCx
Idaho	24,734	23,874	338	8
Montana	29,574	6,874	3,042	61
Oregon	232,063	652,682	21,973	1,461
Washington	657,746	323,894	18,897	470
Total I&M*	944,116	1,007,324	44,250	2,000
As a Percentage of Total Commissioned Space	7%	11%	3%	0.1%

Note: Square footage represents data from the survey sample prior to extrapolating to the population.
*Totals may not equal the sum of column due to rounding.

Table 10 displays the survey sample's total commissioning square footage, excluding the I&M square footage in Table 9.

Table 10. Adjusted Sample Commissioning Square Footage Values

State	Cx	RCx	ReCx	OCx
Idaho	403,026	36,126	89,662	79,992
Montana	337,066	201,526	6,958	9,939
Oregon	3,162,530	5,044,668	628,027	1,918,539
Washington	8,963,696	2,503,416	540,103	617,530
Total*	12,866,319	7,785,737	1,264,750	2,626,000

*Totals may not equal the sum of column due to rounding.

4.4.4 Extrapolation of Sample Data to Population

To extrapolate the sample square footage to the population of firms in each state and commissioning type, Cadmus applied the following formula:

Equation 1. Extrapolation

$$NCxSqFt_{\text{s,t}} = \frac{\sum_{f=1}^{n} CxSqFt_{\text{s,t}}}{n_{\text{s,t}}} \times N_{\text{s,t}}$$

Where

s = State (ID, MT, OR, or WA);

t = Commissioning type (Cx, RCx, ReCx, or OCx);

f = Commissioning firm;

$N_{s,t}$ = Number of firms in the population in state (*s*) and commissioning type (*t*) (from Table 8);

$n_{s,t}$ = Number of firms in the sample in state (*s*) and commissioning type (*t*) (from Table 7);

$CxSqFt_{s,t}$ = Adjusted commissioning square feet reported by firm (*f*) for state (*s*) and commissioning type (*t*) (from Table 10); and

$NCxSqFt_{s,t}$ = Total commissioning square feet for state (*s*) and commissioning type (*t*) (in Table 11).

Table 11.Total Commissioning Square Footage

State	Cx	RCx	ReCx	OCx
Idaho	1,241,321	111,268	276,159	246,377
Montana	1,038,165	620,702	21,429	30,612
Oregon	9,740,592	15,537,577	1,934,324	5,909,100
Washington	27,608,184	7,710,523	1,663,518	1,901,991
Total*	39,628,261	23,980,068	3,895,430	8,088,080

*Totals may not equal the sum of column due to rounding.

4.4.5 Market Penetration by State and Commissioning Type

4.4.5.1 New Building Commissioning

Cadmus calculated Cx market penetration by dividing Cx activity by new building market size. Table 12 shows the Cx market size, activity, and penetration by state. Cadmus sourced market size data from Dodge, as discussed in Section 4.2. The Cx activity represents square footage that Cadmus calculated using the method and formula described in the previous sections. Total Cx market penetration for the region in 2016 was 71%.

Table 12. New Building Commissioning Square Footage, Market Size, and Market Penetration

State	Commercial New Construction Floor Area (sq. ft.)	Commissioned Space (sq. ft.)	Market Penetration
Idaho	8,654,525	1,241,321	14%
Montana	2,935,250	1,038,165	35%
Oregon	13,003,750	9,740,592	75%
Washington	31,103,975	27,608,184	89%
Total	55,697,500	39,628,261	71%

Sources: Dodge; Cadmus analysis of 2016 data.

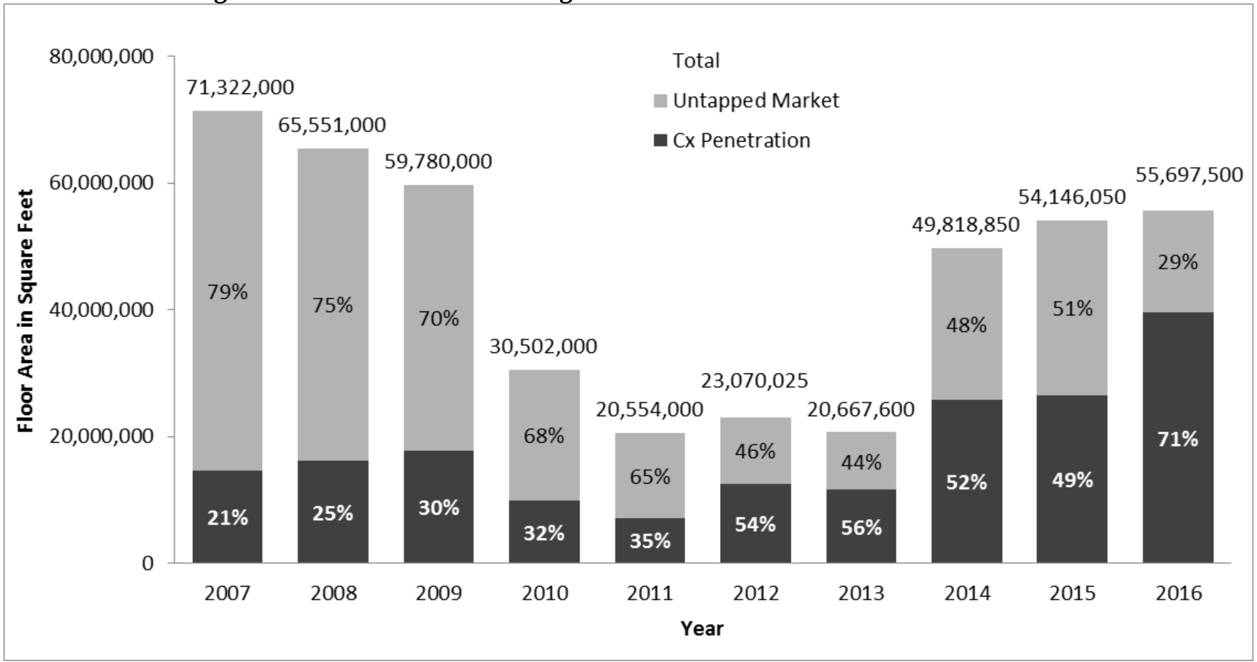
*Totals may not equal the sum of column due to rounding.

In line with previous years' results, Oregon and Washington showed higher Cx market penetration rates than Idaho and Montana. Montana's Cx market penetration slightly increased from 30% in 2015 to 35% in 2016. On the other hand, Idaho's Cx market penetration dropped from 35% in 2015 to 14% in 2016. Although Idaho's new construction market has grown at a similar rate compared to 2015 (about a 50% year-over-year increase in new construction), its commissioned space decreased by almost 40% compared to 2015, a sharp drop compared to prior year growth. Appendix 7.1 contains tables for each commissioning type with 2012–2016 market activity estimates by state.

Oregon's Cx market penetration remained at 2015 levels, or 75%. In contrast, Washington's Cx market penetration increased significantly, from 43% in 2015 to 89% in 2016. This increase is due to a 7% decrease in new building market size and a near doubling of new building commissioning square footage. This increase in new building commissioning activity most likely resulted from the 2015 WSEC, which requires new building commissioning and went into effect in 2016.

Figure 2 shows how new building market size and Cx market penetration have changed over time, at the regional level. Total new building market size grew slightly in 2016 from 2015, while Cx market penetration increased from 49% to 71%.

Figure 2. Historical New Building Market Size and Cx Penetration Estimates



Sources: Summit Blue Consulting, 2007-2008; Navigant, 2009-2011, Cadmus 2012-2016

4.4.5.2 Existing Building Commissioning

Table 13 contains market size, activity, and penetration for all types of existing building commissioning: RCx, ReCx, and OCx. Similar to 2015 results, Oregon had the largest market activity in existing building commissioning in 2016. For each type of commissioning, its existing building commissioning market penetration was at least two times the market penetration in Washington. Oregon's RCx market penetration (1.68%) is similar to its 2015 rate (1.62%).

Table 13. 2016 Existing Building Commissioning Square Footage, Market Size, and Market Penetration

	State	Commercial Existing Building Floor Area (sq. ft.)	Commissioned Space (sq. ft.)	Market Penetration
Retrocommissioning	Idaho	285,616,121	111,268	0.04%
	Montana	245,330,092	620,702	0.25%
	Oregon	923,165,449	15,537,577	1.68%
	Washington	1,609,038,937	7,710,523	0.48%
	Total	3,063,150,599	23,980,068	0.78%
Recommissioning	Idaho	285,616,121	276,159	0.10%
	Montana	245,330,092	21,429	0.01%
	Oregon	923,165,449	1,934,324	0.21%
	Washington	1,609,038,937	1,663,518	0.10%
	Total	3,063,150,599	3,895,430	0.13%
Ongoing commissioning	Idaho	285,616,121	246,377	0.09%
	Montana	245,330,092	30,612	0.01%
	Oregon	923,165,449	5,909,100	0.64%
	Washington	1,609,038,937	1,901,991	0.12%
	Total	3,063,150,599	8,088,080	0.26%
	Overall Total*	**3,063,150,599**	**35,963,578**	**1.17%**

Sources: NEEA 2014 (CBSA); Cadmus analysis of 2016 data.
*Totals may not equal the sum of column due to rounding.

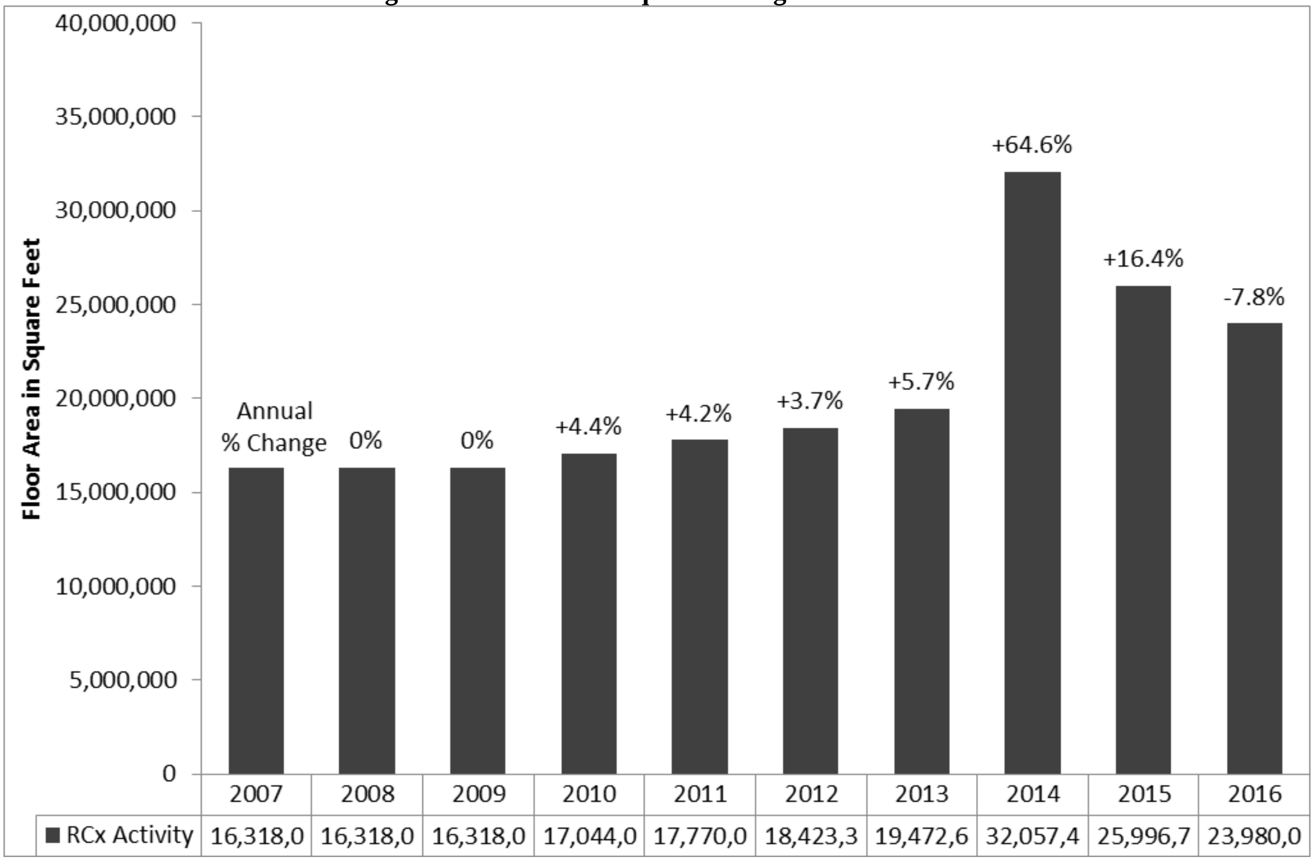
While Idaho had no ReCx or OCx activity in 2015, its ReCx and OCx market penetration rates in 2016 were 0.10% and 0.09%, respectively.

On the other hand, all types of Montana's existing building commissioning decreased in 2016; its 2016 ReCx and OCx market penetration rates were both 0.01%.

4.4.5.2.1 Historical Retrocommissioning (RCx) Trends

Figure 3 shows 2016 estimates of RCx square footage compared to previous LTMT estimates. Based on total square footage, RCx market activity in the Northwest decreased in 2016 by 7.8% from 2015. However, the total 2016 RCx market penetration (0.78%) did not change much compared to 2015 (0.86%) (see Table 15 in Appendix 7.1).

Figure 3. RCx Annual Square Footage Growth

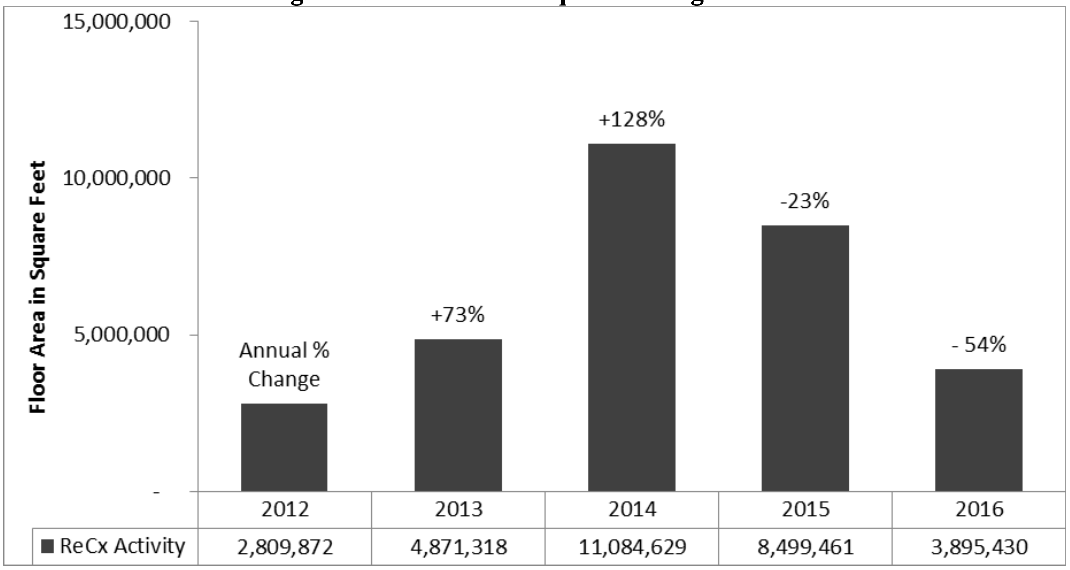


Sources: Summit Blue Consulting, 2007-2008; Navigant, 2009-2011, Cadmus 2012-2016

4.4.5.2.2 Historical Recommissioning (ReCx) Trends

ReCx square footage decreased in 2016 by 54% from 2015, continuing the downward trend from 2014 and 2015. Figure 4 compares the 2016 estimate of recommissioned space to past LTMT estimates. The Northwest's overall ReCx market penetration rate is also on a decreasing trend, from 0.37% in 2014 and 0.28% in 2015, to 0.13% in 2016 (see Table 16 in Appendix 7.1). All states saw a decrease in ReCx market penetration in 2016 except Idaho.

Figure 4. ReCx Annual Square Footage Growth

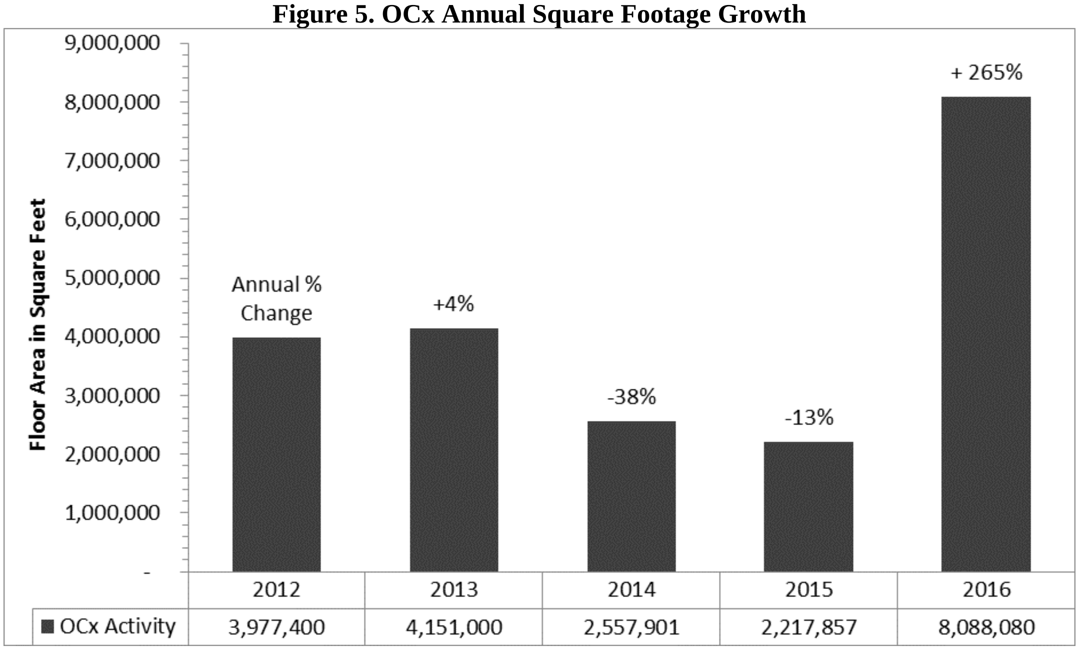


Sources: Cadmus 2012-2016

4.4.5.2.3 Historical Ongoing Commissioning (OCx) Trends

Figure 5 compares OCx market activity over time. OCx activity, as measured in square feet, decreased by 46% from 2013 to 2015. In 2016, OCx square footage more than tripled compared to 2015. OCx market penetration also more than tripled from 0.07% in 2015 to 0.26% in 2016 (see Table 17 in Appendix 7.1). This drastic increase in OCx market penetration is mainly due to the increase in OCx market activity, since the existing building market size grew by merely 2% in 2016. The next section of this report discusses some trends in commissioning offerings, which may offer some explanation for the market activity growth.

Figure 5. OCx Annual Square Footage Growth



Sources: Cadmus 2012-2016

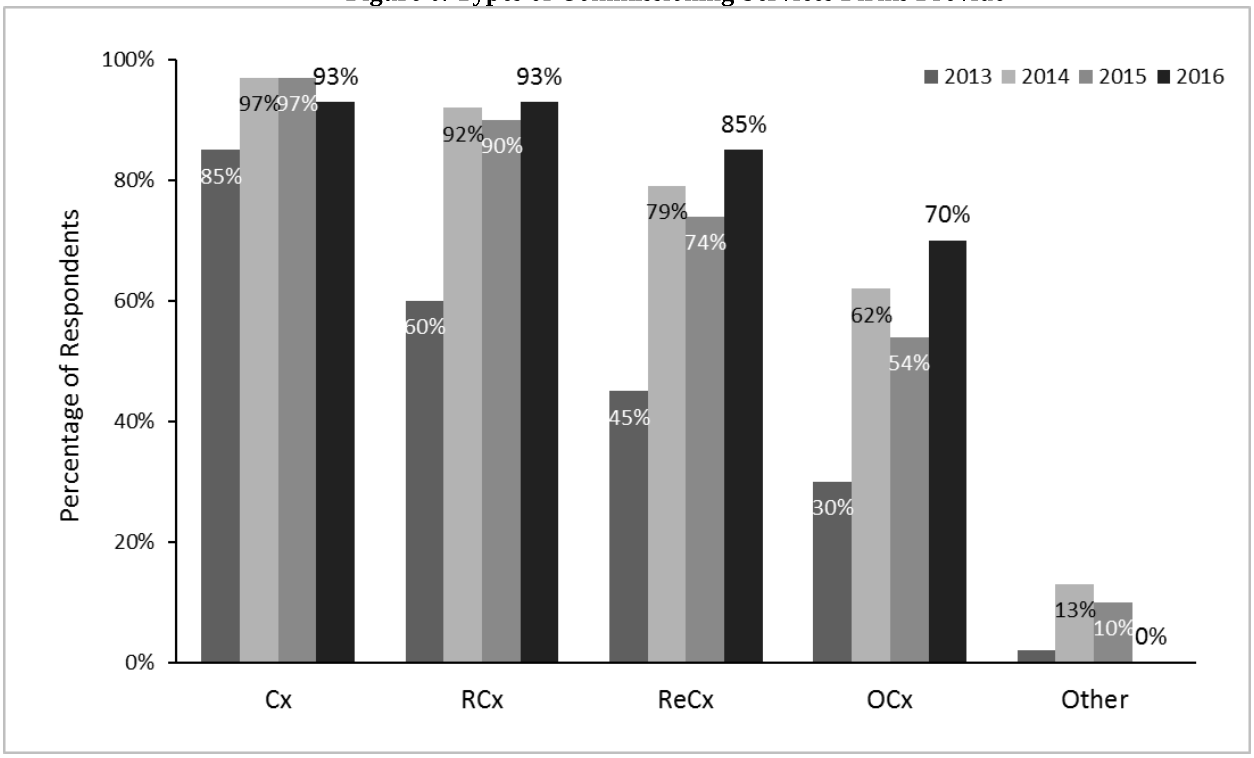
4.5 Market Trends

4.5.1 Commissioning Service Offerings

The survey asked providers about the types of commissioning services their firms provided. As shown in Figure 6, the proportion of firms providing Cx and RCx commissioning services in 2016 was similar to the last two years.

More noticeably, there was an increase in the proportion of firms providing ReCx and OCx services. The increase in the proportion of firms providing OCx services corresponds with the increase in the OCx market penetration rate. On the other hand, although a larger proportion of firms are providing ReCx services, 2016 saw a decrease in ReCx market penetration.

Figure 6. Types of Commissioning Services Firms Provide



Sources: Cadmus analysis of 2013 (*n* = 40), 2014 (*n* = 39), and 2015 (*n* = 39) data (Cadmus 2014, Cadmus 2015, and Cadmus 2016), and Cadmus analysis of 2017 (n = 27) data, *QD4. What types of commissioning services does your firm provide?*

Notes: Multiple responses allowed, percentages may add to more than 100%.

In addition, Cadmus asked providers whether their firms provide commissioning as the main service or provide commissioning as one of many services. A majority of respondents (67%) reported that their firms provide commissioning as one of many services, which is similar to 2015 results.

Cadmus further explored OCx practices by asking providers about the types of buildings that undergo OCx and the frequency with which they conduct OCx. Of the nine respondents who conduct OCx, four reported conducting OCx on existing buildings that had been retrocommissioned and two reported conducting OCx on new buildings that had been commissioned during the final construction phase; two reported conducting OCx on both types of buildings. In 2015, more respondents reported conducting OCx on new buildings than existing buildings. But similar to 2015 results, respondents were evenly split on the frequency with which they conducted OCx, from once a year to twice a year to continuously through automated systems.

4.5.2 Revenue

As in the 2015 survey, Cadmus asked providers for their firms' total new and existing building commissioning revenue in 2016. Just 13 respondents provided their firms' revenue. For each reported revenue, Cadmus separated the total revenue into new commissioning revenue and existing commissioning revenue, based on the ratio of the reported new commissioning square footage to existing commissioning square footage. On average, the respondents reported about $1.55 million of new building commissioning revenue and $0.39 million of existing building commissioning revenue, per firm. Dividing these dollar amounts by the respondents' reported square footage of commissioned space yields an estimate of $1.84 per square foot of new building commissioning and $0.38 per square foot of existing building commissioning.

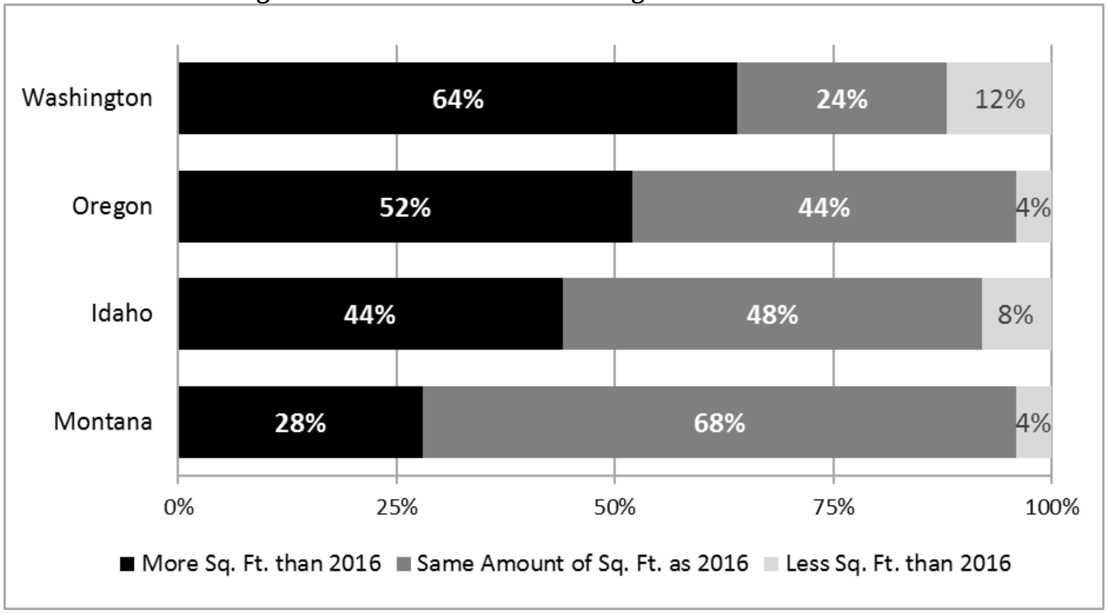
4.5.3 Market Growth Predictions

Figure 7 shows providers' commissioning growth predictions for the next five years. Consistent with 2015's findings, most providers predict that their firms will conduct more new and existing building commissioning in the next five years in Washington and Oregon.

However, the majority of providers continue to predict that their firms will conduct about the same amount of commissioning in the next five years in Montana and Idaho. For Idaho, there is a relative increase in market growth predictions: almost half of the respondents predict that their firms will increase commissioning in Idaho in the next five years, while in 2015 only 34% of respondents made this prediction.

Out of the 21 respondents who predicted an increase in commissioning activity in at least one state over the next five years, 29% cited general growth in the market as the top reason for predicting an increase.

Figure 7. Providers' Commissioning Growth Predictions



Sources: Cadmus analysis of 2016 (n=25) data, *QG4. In five years, do you predict your company will commission the same amount of square feet of building space as it did in 2016, more square feet, or less square feet? Consider all types of commissioning.*

4.5.4 LEED Projects

The survey asked providers about the percentage of Cx projects completed as part of a new LEED building.[9] On average, providers whose firms provide new building commissioning services (n = 24) estimated that 49% of the Cx square footage they completed in 2016 was commissioned as part of LEED certification. This estimate is in line with results from 2014 and 2015: 46% and 48%, respectively.

[9] LEED for Building Design Construction (LEED BD+C) and LEED for Interior Design Construction (ID+C) are certifications focused on design and construction that have two commissioning components: "Fundamental Cx" is a prerequisite for certification (so all projects must complete it) and "Enhanced Cx" is an optional credit. Our survey asked about projects completed as part of LEED BD+C certification.

5 Discussion

This year's LTMT study garnered a smaller number of survey responses than anticipated. This, combined with the high variability in reported square footage among respondents, reduces the precision of the overall results. Nonetheless, Cadmus found many overall market trends to be generally consistent with prior year findings, which are discussed in this section, followed by recommendations for future research.

5.1 New Buildings

In 2016, the Northwest saw some interesting trends in building commissioning. New building commissioning is at an all-time high in Washington, due to changes in the commercial building code adopted by the state. This study found a remarkably high market penetration rate of 89%. Commissioning in Montana also experienced its first major growth in several years. In Oregon, commissioning activity grew slowly, steadily, and predictably along with the rate of growth for new commercial buildings, yet commissioning in Idaho did not match the strong growth in the new construction sector. In Idaho, commercial new construction has experienced a year-over-year growth rate of 40% to 54% for the past three years.

Idaho will be interesting to watch in the next several years for new building commissioning. Recently, Idaho adopted the 2012 IECC, and it became effective in 2015. This version of the code includes a mandatory commissioning component for large, new commercial buildings of more than 20,000 square feet, yet this study found Cx activity decreased in 2016. Because of the long timeframe associated with commercial new construction, the market may still be responding to this regulatory change. It is likely that an increase in availability of services, along with enhanced end-user awareness and demand for commissioning services, will be a driving force of market activity in the future. Based on the survey sample, Cadmus estimated just six firms are providing commissioning services in Idaho. However, firms are also predicting their activity will increase in that state: almost half of the respondents predicted an increase in commissioning in Idaho *for their firm* in the next five years, while in 2015, only 34% of respondents made that prediction. This indicates practitioners are aware of the growth in new construction and the policy shifts in the state.

5.2 Existing Buildings

Commissioning in existing buildings has experienced a slow-down region-wide. When data on all types of existing building commissioning are combined, it becomes apparent that market penetration has dipped slightly for the past two years. Oregon is the only state in the region that has experienced a solid rate of growth consistently for the past four years. In 2016, OCx activity grew substantially, particularly in the Washington and Oregon markets. However, a general slow-down in RCx, the most widespread existing building commissioning practice, is concerning, especially in large markets like Washington where RCx market activity and penetration have dropped each year for the past three years. In Washington, it could be that engineering and commissioning firms are shifting their focus to meet the growing demand for new building commissioning--due to policy advancements over the past several years--leaving less industry focus on the existing stock. This may be a useful research topic to explore in the future.

5.3 Industrial and Manufacturing Sector

NEEA's commissioning initiative aimed to transform the commercial building market, which does not include I&M buildings. Cadmus found in this year's study that commissioned floor area included I&M buildings: 7% of the Cx square footage, 11% of RCx, and 3% of ReCx square footage. However, the survey only asked respondents to report the percentage of total commissioning conducted for I&M buildings. Cadmus completed the analysis to allocate the totals proportionally by state. Recently, Cadmus provided NEEA with a suggested adjustment on a savings rate (kWh/square foot) for I&M facilities (see Appendix 7.4). Should NEEA seek to apply the savings rate, it may wish to consider improving the rigor of square footage calculations for the sector.

5.4 Recommendations for Future Research

- Because findings from the survey are extrapolated to the population (an estimated 77 firms) to determine overall market activity in the region, a robust sample size is necessary for credibility of the results. For future efforts, Cadmus recommends the following:
    - In advance of the next survey, attend chapter meetings of various certification and professional organizations to encourage survey participation.
    - In advance of the next survey, collaborate with professional organizations to help them highlight the survey in their publications and newsletter to encourage participation.
    - Update the population with fresh internet research. For firms that participated in the survey this year, conduct a preliminary online search to determine whether the respondents still work at the firm. If not, attempt to find a new contact at that firm to invite to participate.
- Continue to monitor the Idaho market for changes in new building commissioning activity as the market size for commercial new construction grows, and consider ways to support efforts in the state to raise awareness, through support of BCA or other industry efforts.
- Consider adding new questions to the survey to explore reasons for the downward trend in RCx, particularly in Washington. Alternatively, NEEA could also consider conducting in-depth qualitative research, such as in-depth interviews or focus groups with a small number of commissioning providers, to explore market trends and barriers more fully. It could also consider research activities with end users such as building owners or property managers, to explore market barriers to commissioning.
- Consider changes to the survey to further explore the trends in industrial facility commissioning and enhance the reliability of the extrapolated results. For example, next year, consider adding questions to assess the location of the commissioning work and manufacturing segment.

6 References

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7 Appendix

7.1 Historical Data

Table 14. Cx 2012–2016 Market Size, Activity, and Penetration Estimates

State	Year	New Building Market Size (sq. ft.)	Cx Activity (sq. ft.)	Market Penetration
Idaho	**2016**	**8,654,525.00**	**1,241,321**	**14%**
Idaho	2015	5,626,275	1,971,336	35%
Idaho	2014	3,756,200	856,308	23%
Idaho	2013	2,659,925	376,000	14%
Idaho	2012	3,348,850	385,755	12%
Montana	**2016**	**2,935,250.00**	**1,038,165**	**35%**
Montana	2015	2,556,625	768,214	30%
Montana	2014	2,060,825	794,779	39%
Montana	2013	1,401,725	499,021	36%
Montana	2012	995,300	576,183	58%
Oregon	**2016**	**13,003,750.00**	**9,740,592**	**75%**
Oregon	2015	12,600,125	9,421,714	75%
Oregon	2014	13,959,850	7,199,634	52%
Oregon	2013	5,842,325	3,192,334	55%
Oregon	2012	6,498,525	2,918,564	45%
Washington	**2016**	**31,103,975.00**	**27,608,184**	**89%**
Washington	2015	33,363,025	14,344,043	43%
Washington	2014	30,041,975	16,950,747	56%
Washington	2013	10,763,625	7,562,522	70%
Washington	2012	12,227,350	8,617,914	70%
Total	**2016**	**55,697,500**	**39,628,261**	**71%**
Total	2015	54,146,050	26,505,308	49%
Total	2014	49,818,850	25,801,468	52%
Total	2013	20,667,600	11,629,876	56%
Total	2012	23,070,025	12,498,416	54%

Sources: Dodge; Cadmus analysis of 2012, 2013, 2014, and 2015 data (Cadmus 2014, Cadmus 2015, and Cadmus 2016) and Cadmus analysis of 2016 data.

Table 15. RCx 2012–2016 Market Size, Activity, and Penetration Estimates

State	Year	Existing Building Market Size (sq. ft.)	RCx Activity (sq. ft.)	Market Penetration
Idaho	**2016**	**285,616,121**	**111,268**	**0.04%**
Idaho	2015	279,993,579	449,365	0.16%
Idaho	2014	277,520,204	1,310,676	0.47%
Idaho	2013	251,819,745	231,000	0.09%
Idaho	2012	250,628,640	513,333	0.20%
Montana	**2016**	**245,330,092**	**620,702**	**0.25%**
Montana	2015	242,774,686	1,922,118	0.79%
Montana	2014	241,278,586	2,895,373	1.20%
Montana	2013	73,404,096	1,256,700	1.71%
Montana	2012	73,726,888	621,000	0.84%
Oregon	**2016**	**923,165,449**	**15,537,577**	**1.68%**
Oregon	2015	910,569,540	14,787,244	1.62%
Oregon	2014	902,390,465	8,041,145	0.89%
Oregon	2013	700,587,203	5,490,747	0.78%
Oregon	2012	698,772,815	9,682,095	1.39%
Washington	**2016**	**1,609,038,937**	**7,710,523**	**0.48%**
Washington	2015	1,575,691,205	8,838,009	0.56%
Washington	2014	1,558,742,105	19,810,255	1.27%
Washington	2013	1,175,723,736	12,494,182	1.06%
Washington	2012	1,168,381,594	7,606,938	0.65%
Total	**2016**	**3,063,150,599**	**23,980,068**	**0.78%**
Total	2015	3,009,029,010	25,996,736	0.86%
Total	2014	2,979,931,360	32,057,449	1.08%
Total	2013	2,201,534,780	19,472,629	0.88%
Total	2012	2,191,509,936	18,423,367	0.84%

Sources: NEEA 2014; Cadmus analysis of 2012, 2013, 2014, and 2015 data (Cadmus 2014, Cadmus 2015, and Cadmus 2016), and Cadmus analysis of 2016 data.

Table 16. ReCx 2012–2016 Market Size, Activity, and Penetration Estimates

State	Year	Existing Building Market Size (sq. ft.)	ReCx Activity (sq. ft.)	Market Penetration
Idaho	**2016**	**285,616,121**	**276,159**	**0.10%**
Idaho	2015	279,993,579	-	0.00%
Idaho	2014	277,520,204	523,243	0.19%
Idaho	2013	251,819,745	-	0.00%
Idaho	2012	250,628,640	4,400	0.00%
Montana	**2016**	**245,330,092**	**21,429**	**0.01%**
Montana	2015	242,774,686	313,820	0.13%
Montana	2014	241,278,586	350,071	0.15%
Montana	2013	73,404,096	-	0.00%
Montana	2012	73,726,888	37,500	0.05%
Oregon	**2016**	**923,165,449**	**1,934,324**	**0.21%**
Oregon	2015	910,569,540	6,025,351	0.66%
Oregon	2014	902,390,465	3,897,020	0.43%
Oregon	2013	700,587,203	1,046,318	0.15%
Oregon	2012	698,772,815	717,972	0.10%
Washington	**2016**	**1,609,038,937**	**1,663,518**	**0.10%**
Washington	2015	1,575,691,205	2,160,289	0.14%
Washington	2014	1,558,742,105	6,314,294	0.41%
Washington	2013	1,175,723,736	3,825,000	0.33%
Washington	2012	1,168,381,594	2,050,000	0.18%
Total	**2016**	**3,063,150,599**	**3,895,430**	**0.13%**
Total	2015	3,009,029,010	8,499,461	0.28%
Total	2014	2,979,931,360	11,084,628	0.37%
Total	2013	2,201,534,780	4,871,318	0.22%
Total	2012	2,191,509,936	2,809,872	0.13%

Sources: NEEA 2014; Cadmus analysis of 2012, 2013, 2014, and 2015 data (Cadmus 2014, Cadmus 2015, and Cadmus 2016), and Cadmus analysis of 2016 data.

Table 17. OCx 2012–2016 Market Size, Activity, and Penetration Estimates

State	Year	Existing Building Market Size (sq. ft.)	OCx Activity (sq. ft.)	Market Penetration
Idaho	**2016**	**285,616,121**	**246,377**	**0.09%**
Idaho	2015	279,993,579	10,714	0.00%
Idaho	2014	277,520,204	246,947	0.09%
Idaho	2013	251,819,745	-	0.00%
Idaho	2012	250,628,640	-	0.00%
Montana	**2016**	**245,330,092**	**30,612**	**0.01%**
Montana	2015	242,774,686	321,429	0.13%
Montana	2014	241,278,586	86,171	0.04%
Montana	2013	73,404,096	-	0.00%
Montana	2012	73,726,888	-	0.00%
Oregon	**2016**	**923,165,449**	**5,909,100**	**0.64%**
Oregon	2015	910,569,540	1,114,286	0.12%
Oregon	2014	902,390,465	1,766,511	0.20%
Oregon	2013	700,587,203	1,806,000	0.26%
Oregon	2012	698,772,815	1,806,000	0.26%
Washington	**2016**	**1,609,038,937**	**1,901,991**	**0.12%**
Washington	2015	1,575,691,205	771,429	0.05%
Washington	2014	1,558,742,105	458,271	0.03%
Washington	2013	1,175,723,736	2,345,000	0.20%
Washington	2012	1,168,381,594	2,171,400	0.19%
Total	**2016**	**3,063,150,599**	**8,088,080**	**0.26%**
Total	2015	3,009,029,010	2,217,857	0.07%
Total	2014	2,979,931,360	2,557,901	0.09%
Total	2013	2,201,534,780	4,151,000	0.19%
Total	2012	2,191,509,936	3,977,400	0.18%

Sources: NEEA 2014; Cadmus analysis of 2012, 2013, 2014, and 2015 data (Cadmus 2014, Cadmus 2015, and Cadmus 2016), and Cadmus analysis of 2016 data.

7.2 Survey Instrument

NEEA Commissioning LTMT Survey
For Commissioning Service Providers
December 2016

B. Screener

[DISPLAY NEEA LOGO]

B0. In 2016, did your firm provide commissioning services in the Northwest (Washington, Oregon, Idaho, or Montana)?
1. Yes [CONTINUE]
2. No [TERMINATE]
3. Don't know [TERMINATE]

[TERMINATION MESSAGE: "Only commissioning providers who have worked in the Northwest in 2016 are eligible for this study. Thank you for your interest. To learn more about NEEA, please visit www.neea.org"]
[SURVEY CONTINUES IF B0=1]

Welcome! The Northwest Energy Efficiency Alliance (NEEA) is conducting its annual study on new building and existing building commissioning markets. Your responses are very important to us and we will keep them confidential. Complete the survey by December 16, 2016 to receive a $150 Visa gift card. The survey will take you about 20 minutes.
This survey saves your responses automatically and responses will be submitted when you complete the survey. You can return to the survey at any time by clicking on the survey link provided to you in the email. Please access the survey from the same device.
More about this study: The survey will ask you to gather the square footage of your commissioning or retrocommissioning projects completed in 2016. The purpose of the research is to help NEEA understand more about the building commissioning industry and market trends. Your responses will remain confidential, we will aggregate them with others, and you will not be asked to report your clients' names or information.

[DISPLAY BEGIN SURVEY BUTTON]

C. Introduction

C1. Name:
Firm Name:
Job Title:
Phone Number:

C2. From which of the following do you hold a current commissioning certification? (Select all that apply)
1. ACG (AABC Commissioning Group)
2. AEE (Associations of Energy Engineers)

3. ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers)
4. BCA (Building Commissioning Association)
5. NEBB (National Environmental Balancing Bureau)
6. TABB (Testing, Adjusting and Balancing Bureau)
7. UWM (University of Wisconsin-Madison)
8. Other, please specify
9. None
98. Don’t know

D. About Your Firm

[DISPLAY COMMISSIONING DEFINITION GRAPHIC WITH DESCRIPTIONS FROM D1]

D1. What types of commissioning services does your firm provide? For the purposes of this study, please note the definitions of the various commissioning types above. (Select all that apply)

1. New building commissioning (Cx is the process of commissioning new buildings during the construction phase.)
2. Retrocommissioning (RCx is the commissioning of existing buildings that have not previously been commissioned.)
3. Re-commissioning (ReCx is the commissioning of existing buildings that have previously been commissioned.)
4. Ongoing/continuous commissioning (OCx, sometimes referred to as *continuous commissioning*, is the process of monitoring and fine-tuning commissioned buildings repeatedly over time).
5. Other, please specify
98. Don’t know

D2. Which best describes your firm?

1. My firm specializes in commissioning and that is the main service we offer.
2. My firm provides commissioning as one of many services.
98. Don’t know

D3. How many people does your firm employ who work a significant amount of time on commissioning projects? Only count employees who spend at least 25% of their time on commissioning projects.

D4. Of this group, how many people hold individual professional commissioning certifications? Use your best guess.

D5. Does your firm hold any firm-level commissioning certifications?

1. Yes
2. No
98. Don’t know

[ASK IF D5=1]

D6. Which firm-level commissioning certifications does your firm hold? (Select all that apply)

1. BCA’s Certified Commissioning Firm

2. AEE's Certified Building Commissioning Firm
3. NEBB's Building Systems Commissioning Firm
4. Other, please specify
98. Don't know

E. Project Square Footage

In this section, we will ask you to enter square footage data for commissioning projects your firm completed in 2016. We are seeking data by state and by project type. If you do not have square-footage data available now, please collect the information at your convenience and come back to this survey. Clicking on the survey link provided to you in the email will resume this survey.

[ASK IF D1=1]

E1. Please enter the total square footage of new building commissioning* projects your firm completed in 2016 for each state. Use whole numbers. Enter "0" if you did not complete projects in that state.
*New building commissioning is the process of commissioning new buildings during the construction phase.
Washington
Oregon
Idaho
Montana

[ASK IF D1=1]

E2. If any of the square footage you just entered for new building commissioning was estimated, help us understand how much variance there may be from the actual square feet. Please estimate how accurate the value that you provided is. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK] [Note: If respondent enters "zero" in one of the states above, it will not show here.]
Washington
Oregon
Idaho
Montana

[ASK IF D1=1]

E3. About what percentage of the new building commissioning projects were major renovations?
Washington
Oregon
Idaho
Montana

[ASK IF D1=1]

E4. About what percentage of the total square footage of new building space your firm commissioned in 2016 were industrial or manufacturing facilities, if any? Please only consider square footage for industrial or manufacturing **building** commissioning, not industrial or manufacturing **equipment** commissioning. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

[ASK IF D1=2]

E5. Please enter the total square footage of retrocommissioning projects your firm completed in 2016 for each state. Use whole numbers. Enter “0” if you did not complete projects in that state.
*Retrocommissioning is the commissioning of existing buildings that have not previously been commissioned.
Washington
Oregon
Idaho
Montana

[ASK IF D1=2]

E6. If any of the square footage you just entered for retrocommissioning was estimated, help us understand how much variance there may be from the actual square feet. Please estimate how accurate the value that you provided is. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK] [Note: If respondent enters “zero” in one of the states above, it will not show here.]
Washington
Oregon
Idaho
Montana

[ASK IF D1=2]

E7. About what percentage of the total square footage of retrocommissioned space your firm completed were industrial or manufacturing facilities, if any? Please only consider square footage for industrial or manufacturing **building** retro-commissioning, not industrial or manufacturing **equipment** retro-commissioning. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

[ASK IF D1=3]

E8. Please enter the total square footage for recommissioning projects your firm completed in 2016 for each state. Use whole numbers. Enter “0” if you did not complete projects in that state.
*Re-commissioning is the commissioning of existing buildings that have previously been commissioned.
Washington
Oregon
Idaho
Montana

[ASK IF D1=3]

E9. If any of the square footage you just entered for recommissioning was estimated, help us understand how much variance there may be from the actual square feet. Please estimate how accurate the value that you provided is. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK] [Note: If respondent enters “zero” in one of the states above, it will not show here.]

Washington
Oregon
Idaho
Montana

[ASK IF D1=3]

E10. About what percentage of the [TOTAL FROM E8] sq. ft. of recommissioned space your firm completed were industrial or manufacturing facilities, if any? Please only consider square footage for industrial or manufacturing **building** re-commissioning, not industrial or manufacturing **equipment** re-commissioning. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

[ASK IF D1=4]

E11. Please enter the total square footage for ongoing/continuous commissioning projects your firm completed in 2016 for each state. Use whole numbers. Enter “0” if you did not complete projects in that state.
*Ongoing commissioning, sometimes referred to as *continuous commissioning*, is the process of monitoring and fine-tuning commissioned buildings repeatedly over time.

Washington
Oregon
Idaho
Montana

[ASK IF D1=4]

E12. If any of the square footage you just entered for ongoing/continuous commissioning was estimated, help us understand how much variance there may be from the actual square feet. Please estimate how accurate the value that you provided is. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK] [Note: If respondent enters “zero” in one of the states above, it will not show here.]

Washington
Oregon
Idaho
Montana

[ASK IF D1=4]

E13. About what percentage of the square footage of ongoing commissioned space your firm completed were industrial or manufacturing facilities, if any? Please only consider square footage for industrial or manufacturing **building** ongoing commissioning, not industrial or manufacturing **equipment** ongoing commissioning. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

[ASK IF D1=4]
E14. For ongoing/continuous commissioning projects your firm completed in 2016, were these projects mostly for…

1. New buildings that had been commissioned during the final construction phase, or
2. Existing buildings that had been retrocommissioned and are now undergoing continuous commissioning
3. Both

98. Don't know

[ASK IF D1=4]
E15. On average, how often is ongoing/continuous commissioning conducted?

1. Annually (once a year)
2. Semi-annually (twice a year)
3. Quarterly (three to four times a year)
4. Continual through automated systems
5. Other, please specify

98. Don't know

F. Market Drivers

F1. Using a scale from 1 to 5 where 1 means "extremely important" and 5 means "not at all important," please rate the level of importance you believe the following factors have on the overall market for new building commissioning in the Northwest. [RANDOMIZE ORDER] [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 1-5, plus DK]

A. LEED
B. Utility programs/incentives
C. Trade associations (such as BCA, ACG, ASHRAE) that publish guidelines, offer education, and legitimize the practice through professional certifications
D. Public policies/procurement policies/government buildings
E. Code requirements
F. Overall awareness of the benefits of commissioning among building owners/decision-makers

F2. Are there any other drivers of new building commissioning in the Northwest? These other drivers can be minor or major.

1. Yes, please specify:
2. No

98. Don't know

[ASK IF F2=1]
F3. Using a scale from 1 to 5 where 1 means "extremely important" and 5 means "not at all important," please rate the level of importance this other driver has on your firm's new building commissioning business.

F4. Using a scale from 1 to 5 where 1 means "extremely important" and 5 means "not at all important," please rate the level of importance you believe the following factors have on the overall market for existing building commissioning in the Northwest. [RANDOMIZE ORDER] [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 1-5, plus DK]

A. LEED
B. Utility programs/incentives
C. Trade associations (such as BCA, ACG, ASHRAE) that publish guidelines, offer education, and legitimize the practice through professional certifications
D. Public policies/procurement policies/government buildings
E. Overall awareness of the benefits of retrocommissioning or recommissioning among building owners/decision-makers

F5. Are there any other drivers of existing building commissioning in the Northwest? These other drivers can be minor or major.

1. Yes, please specify
2. No
98. Don't know

[ASK IF F5=1]
F6. Using a scale from 1 to 5 where 1 means "extremely important" and 5 means "not at all important," please rate the level of importance this other driver has on your firm's existing building commissioning business.

G. Market Trends

This is the final section of the survey. Please continue to the end to enter your address to receive a gift card.

[ASK IF D1=1]
G1. Using your best estimate, about what percentage of your firm's new building commissioning projects were conducted as part of LEED BD+C certification? Please estimate as a percentage of total square feet. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

[ASK IF D1=1]
G2. For 2016, what is your estimate of the percent of all new building square footage that was commissioned in the Northwest? Consider not just your firm's projects but all square footage. Use your best guess. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

Washington
Oregon
Idaho
Montana

[ASK IF D1=2]
G3. For 2016, what is your estimate of the percent of all existing building square footage that was retrocommissioned in the Northwest? Consider not just your firm's projects but all

square footage. Use your best guess. [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 0-100%, in 5% increments, plus DK]

Washington
Oregon
Idaho
Montana

G4. In 5 years, do you predict your company will commission the same amount of square feet of building space as it did in 2016, more square feet, or less square feet? Consider all types of commissioning. [MATRIX TABLE WITH RESPONSE CHOICES: LESS SQUARE FEET, SAME AMOUNT OF SQUARE FEET, AND MORE SQUARE FEET]

Washington
Oregon
Idaho
Montana

[ASK IF ANY FROM G4= "less"]
G5. For the following state(s), you predicted that your company will commission fewer square feet of building space in 5 years than 2016. By what percentage do you predict the decrease will be? [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 5-100%, in 5% increments, plus DK] [Note that only the states that were indicated as "less" in G4 will be displayed.]

Washington
Oregon
Idaho
Montana

[ASK IF ANY FROM G4= "less"]
G6. For which type of building are you predicting a decrease in commissioning?

1. New buildings
2. Existing buildings
3. Both
98. Don't know

[ASK IF ANY FROM G4= "less"]
G7. Is there any particular reason why you are predicting this decrease? [OPEN END]

[ASK IF ANY FROM G4= "more"]
G8. For the following state(s), you predicted that your company will commission more square feet of building space in 5 years than 2016. By what percentage do you predict the increase will be? [DROP DOWN SELECTION MENU WITH RESPONSE CHOICES: 5-100%, in 5% increments, plus DK] [Note that only the states that were indicated as "more" in G4 will be displayed.]

Washington

Oregon
Idaho
Montana

[ASK IF ANY FROM G4= “more”]
G9. For which type of building are you predicting an increase in commissioning?
1. New buildings
2. Existing buildings
3. Both
98. Don’t know

[ASK IF ANY FROM G4= “more”]
G10. Is there any particular reason why you are predicting this increase? [OPEN END]

G11. In 2016, what was your company’s total commissioning revenue in dollars? Please consider new and existing building commissioning.
1. Prefer not to specify
98. Don’t know

H. Thank You!

H1. Please provide your mailing address to receive the $150 Visa gift card.
Name
Street Address
City
State
Zip Code

H2. Are you interested in being contacted for future annual research on this topic? Participants are eligible for a $150 gift card for each year of data they provide.
Yes
No

[END OF SURVEY SCRIPT] Your responses have been submitted. Thank you for participating. Your gift card will be mailed out in a few weeks. Please be on the lookout for a business-size envelope from CADMUS. To learn more about NEEA, please visit www.neea.org

7.3 Memo: Industrial Sector Market Size

To: Jennifer Stout, NEEA
From: Cadmus
Subject: Market Size (Square Footage) of Industrial Facilities in the Northwest
Date: 1/6/2017

This memo summarizes Cadmus' findings and considerations for estimating the market size of industrial facilities in NEEA's region, as measured by square footage. These findings will serve as inputs into future long-term monitoring and tracking activities for the Commissioning Initiative as it relates to the industrial sector.

Methodology and Data Sources

Cadmus researched three possible secondary data sources that could be used to estimate industrial market size. These were:

- NEEA Industrial Facility Stock Assessment (IFSA)
- DOE Manufacturing Energy Consumption Survey (MECS)
- Manufacturing News, Inc. (MNI) subscription database

After reviewing available data, we found that MNI was the most comprehensive and recommend using this source to estimate industrial market size. The MNI Dec. 2016 data tracks various characteristics for over 9,300 facilities in Idaho, Montana, Oregon and Washington broken into 19 SIC codes. Though MNI did not collect square footage information for all facilities, their sample size is sufficient enough to generate reasonable estimates of total square footage at a state-by-state level.

MNI contains square footage data for facilities in the NW that fall into the following industry classifications:[10]

Food and Kindred Products
Textile Mill Products
Apparel and Other Finished Products
Lumber and Wood Products
Furniture and Fixtures
Paper and Allied Products
Printing, Publishing, and Allied Industries
Chemicals and Allied Products
Petroleum Refining and Related
Rubber and Miscellaneous Plastics
Leather and Leather Products
Stone, Clay, Glass and Concrete
Primary Metal Industries

[10] MNI also identified one facility in the Tobacco Products SIC category in Washington, but did not report square footage for this facility.

Fabricated Metal Products, except Machinery and Transportation Equipment
Industrial and Commercial Machinery and Computer Equipment
Electronic and other Electrical Equipment and Components
Transportation Equipment
Miscellaneous Manufacturing Industries

MNI defines square footage as: "*The building or space that a company occupies. Only the physical premises. Or 'Building Envelope' as it is referred to.*"

Table 1 contains the sample size of industries with square footage data that MNI has for each state.

Table 18. Sample Size by State

	ID	MT	OR	WA	All States
No. of Facilities with Square Footage Information	369	212	1,213	1,532	3,326

Using this sample, Cadmus calculated a weighted average of per-facility square footage by industry type (SIC classification) for each state. The weighting leads to more precise estimates than an overall mean, as some industries make up a greater proportion of the industrial footprint than others. For example, in Idaho, facilities in the Lumber and Wood Products category represent approximately 15% of the total number of facilities. Although facilities in the Transportation Equipment category have the largest square footage per facility, they only represent 6% of the facilities in Idaho. The average square footage for each state accounts for these proportional differences in the market.

Next, we multiplied the weighted average square footage by the total number of facilities in each state, to arrive at total market size in square feet.

Results

Table 19 contains the market size, in square feet, by state.

Table 19. Market Size by State

	Average Square Ft per Facility*	Total Facilities (N)	Market Size (Square Feet)
ID	46,658	1,213	56,595,720
MT	25,084	757	18,988,442
OR	47,981	3,305	158,577,726
WA	76,936	4,118	316,821,085
		9,393	550,982,973

*Weighted by SIC classification

Limitations

Cadmus noticed average square footage for the SIC classification of Petroleum Refining seemed low. Examining the data further, we found no actual refineries listed square footage. Though there are only a few of these facilities in NEEA territory, their physical size is likely enough to shift this average significantly. Based on this observation, as well as possible other gaps in the MNI data, the market size we reported here is most likely a conservative estimate.

7.4 Memo: Industrial Facility Savings Rate

To: Jennifer Stout, NEEA
From: Cadmus
Subject: Industrial Building Commissioning (RCx and Cx) Savings Rates
Date: 02/22/2017

Executive Summary

This memorandum summarizes research that was part of the Northwest Energy Efficiency Alliance's (NEEA) 2016 Long-Term Monitoring and Tracking Study for building commissioning.

This memo is an overview of the steps, assumptions, and sources used to determine the savings rates for new *industrial* building commissioning (Cx) and existing *industrial* building retro-commissioning (RCx). This research adds to Cadmus' research on Cx and RCx in commercial buildings.

For this industrial building research, per the direction of NEEA's planning group, Cadmus limited their analysis to the Cx and RCx savings rates for industrial *buildings*. Cadmus did not estimate savings rates for industrial equipment within buildings (e.g. motors, fans, compressed air). Further, also per the direction of NEEA's planning group, Cadmus only analyzed savings rates for HVAC systems.[11]

The resulting savings rates for HVAC systems in industrial buildings in the NEEA region were as follows:

NEEA Region Parameter	Quantity	Unit
Market Size	582,484,438	Ft^2
Baseline Consumption (all end uses)	23,575	GWh/yr
Baseline Intensity (all end uses)	40.47	kWh/ft^2
HVAC Cx Savings Rate	0.48	kWh/ft^2
HVAC Cx Savings Rate Portion of Baseline	1.18%	-
HVAC RCx Savings Rate	0.59	kWh/ft^2
HVAC RCx Savings Rate Portion of Baseline	1.45%	-

Methodology

Cadmus found that industrial facility square footage comprised approximately 7% of the commissioned square footage for Cx, 11% for RCx, and 3% for recommissioning (ReCx).[12] NEEA tasked Cadmus with establishing a savings rate for commissioning (Cx and RCx) in industrial buildings.

[11] Savings from lighting systems were not included to avoid double-counting across other initiatives.
[12] See draft 2016 square footage table delivered to NEEA on Feb. 15, 2017.

To develop a savings algorithm for electricity consumption per square foot of industrial facilities, Cadmus quantified the following inputs using trusted secondary data sources:

- The market size for industrial facilities in square feet in Idaho, Montana, Oregon and Washington,
- Baseline energy use intensity (EUI) in kWh per square foot for industrial facilities,
- Distribution of electricity use across sub-systems in industrial facilities,
- Cx and RCx savings rates for sub-systems that overlap with commercial building commissioning,
- Cx and RCx kWh per square foot savings rate for industrial facilities

Table 1 provides a summary of the methodology used by the Cadmus team to determine building Cx and RCx in industrial facilities. In the next sections of this memo Cadmus discusses detailed steps taken to arrive at the facility Cx and RCx kWh per square foot savings rate.

Table 1. Savings Rate Methodology

Objectives	Task	Data Source for Task
1.1 NEEA Region Industrial Market size in square feet	Secondary research	Manufacturers News, Inc (MNI) subscription database[13]
1.2 Baseline kWh per square foot for industrial facilities for all systems and equipment	Secondary research	Manufacturing Electrical Consumption Survey (MECS)[14] and United States Industrial Electric Motor Systems Market Opportunities Assessment (MOA)[15]
1.3 Distribution of electricity use across sub-systems in industrial facilities	Secondary research	MECS and MOA
1.4 Cx and RCx savings rates for systems that overlap with building commissioning	Secondary research	Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions. Lawrence Berkeley National Laboratory[16]
1.5 Cx and RCx kWh per square foot savings rate for industrial facilities	N/A	N/A

NEEA Region Market Size

Cadmus found the MNI subscription provided the most comprehensive database for manufacturer listings and recommended using this source to estimate industrial market size. The MNI December 2016 data tracked various characteristics for over 9,393 facilities in Idaho, Montana, Oregon and Washington broken into 21 NAICS codes.

[13] https://mni.net/
[14] https://www.eia.gov/consumption/manufacturing/data/2010/
[15] https://energy.gov/sites/prod/files/2014/04/f15/mtrmkt.pdf
[16] http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf

Though it was the most comprehensive, the MNI dataset only had facility square footage information for a portion of records (about 35% of records). Table 2 contains the sample size of facilities with square footage data in the MNI for each state, which Cadmus used to extrapolate to the population.

Table 2. Sample Size by State

	ID	MT	OR	WA	All States
Number of Industrial Facilities s with Square Footage Information	369	212	1,213	1,532	3,326

Using the sample of industrial facilities with available square footage data, Cadmus calculated the average square feet per facility in each of the 21 NAICS codes. We then extrapolated these averages across the 9,393 sites listed in the MNI database in accordance with their respective NAICS codes to calculate the total market size for the NEEA region in square feet. Cadmus estimated that the total industrial market size in the region is 582,484,439 square feet.[17]

Table 3. Market Size of NEEA Region

	Average Square Ft per Facility*	Total Facilities (N)	Market Size (Square Feet)
Total	62,013*	9,393	582,484,439

*Average Square Ft per Facility weighted by NAICS Code

For more information about estimating market size, see the memo submitted to NEEA on 01/06/2017. [18]

Baseline Energy Use Intensity

Cadmus calculated baseline EUI using the total industrial market size calculated in Section 1.1 and the total electricity consumption in kWh calculated using data from MECS.
As shown in Table 4, in the review of the market size data, Cadmus found that industrial facilities in Idaho, Montana, Oregon and Washington represent approximately 3.1% of the total number of industrial facilities in the U.S.[19]

Table 4. NEEA Facility Count as a Percent of National Count

Industry	National Count	NEEA Count	NEEA Portion of National by Count
All Manufacturing	100,456	3,160	3.1%

[17] MNI defines square footage as: "*The building or space that a company occupies. Only the physical premises. Or 'Building Envelope' as it is referred to.*"
[18] Cadmus originally weighted the average square footage by state by SIC code. However, because MECS breaks down it findings by NAICS, the market size analysis was updated to NAICS classification, resulting in slightly different market size for each state, and a regional total larger than what Cadmus originally presented in the January memo.
[19] Source: MNI. The proportion is based on facility count, not floor area.

In calculating baseline electricity consumption, we assumed the proportion of total national electricity consumption represented by industrial facilities in the NEEA region would be equal to the proportion of the number of industrial facilities in the NEEA region (3.1%). Therefore, to calculate the NEEA region baseline electricity consumption, the Cadmus team multiplied the national electricity consumption provided by MECS by 3.1%. This is illustrated in Table 5:

Table 5. Baseline Industrial/Manufacturing GWh/year in NEEA Region

Parameter	Metric	Source
National Baseline Consumption Industrial Facilities (GWh/year)	845,727	MECS
Proportion of Facilities in NEEA Region	3.1%	MNI
NEEA Baseline Consumption in Industrial Facilities (GWh/year)	23,575	Calculated

The resulting baseline EUI is as follows:

$$\text{Baseline}\ \frac{\text{kWh}}{ft^2} = \frac{NEEA\ Energy\ Consumption\ (GWh) \times 1{,}000{,}000}{NEEA\ Market\ Size\ (ft^2)}$$

$$\text{Baseline}\ \frac{\text{kWh}}{ft^2} = \frac{23{,}575{,}000{,}000}{582{,}484{,}439}$$

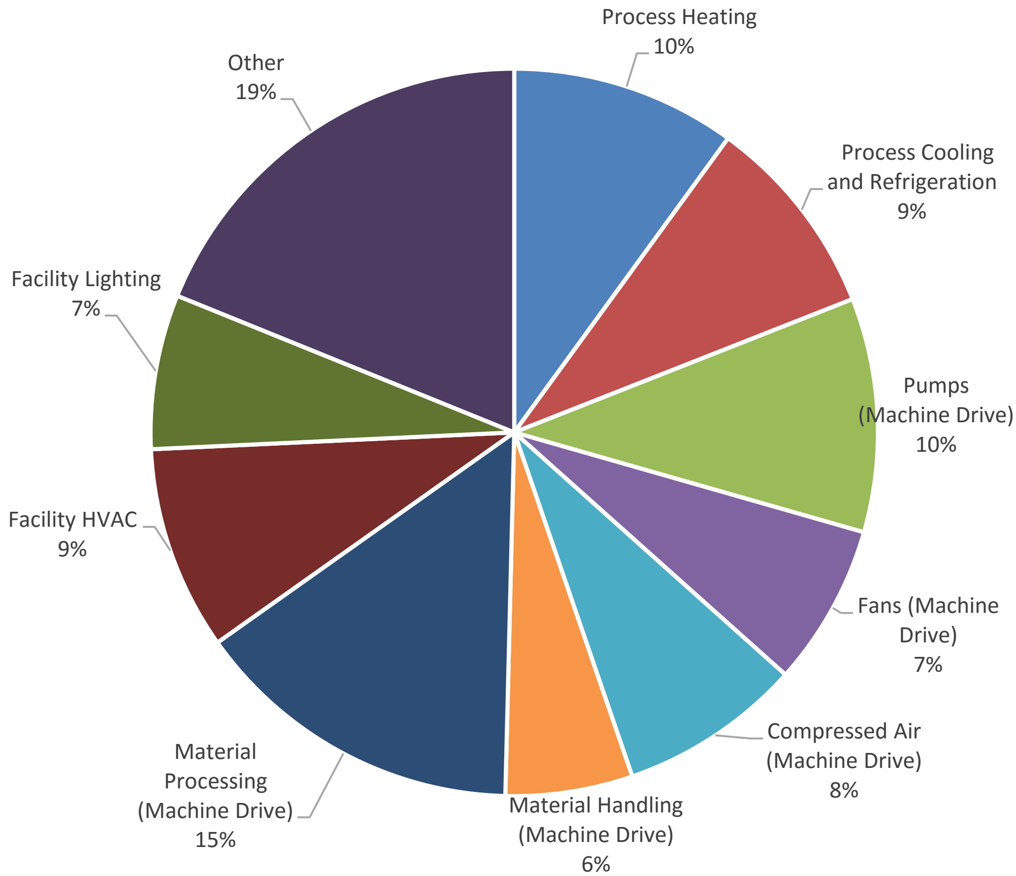
$$\text{Baseline}\ \frac{\text{kWh}}{ft^2} = \mathbf{40.47}$$

System Electricity Distribution

To determine the Cx and RCx savings rate Cadmus first determined the distribution of electricity use across sub-systems in industrial facilities in the NEEA region. Cadmus used MECS and MOA data to determine system electricity use distribution. Cadmus weighted the distribution using industries representative of the NEEA region. Using the sub-system electricity distribution, Cadmus determined the percent of baseline electrical use in industrial facilities dedicated to HVAC, which is applied in step 1.5 to determine the savings rate. For this scope, only HVAC facility energy use is considered in the final savings rate, per direction from NEEA.[20]
Figure 1 shows the distribution of electricity consumption across sub-systems in industrial facilities in the NEEA region. As shown, HVAC constitutes 9.1% (equal to 2,138 GWh).

[20] NEEA is only tracking industrial savings related to building commissioning, not equipment commissioning (e.g., motors, fans, compressors).

Figure 1. NEEA Baseline Sub-System Electricity Consumption (in Industrial Facilities)



HVAC Commissioning and Retrocommissioning Savings Rate

After reviewing secondary sources on Cx and RCx savings opportunities in industry, the Cadmus team determined it was most appropriate to use the savings rates identified in the Lawrence Berkeley National Laboratory building commissioning report published in a 2009, because of the narrow scope of only considering whole-facility energy consumption and resulting savings.[21] Cadmus used the LBNL published savings rates of 13% for Cx and 16% for RCx for commercial buildings. We believe this is best fit for several reasons:

a. The top issues causing energy inefficiencies in commercial buildings discussed in the 2009 LBNL report are similar issues experienced in HVAC systems in industrial facilities.
b. Based on observations and first-hand experience visiting industrial facilities, we see similar HVAC systems across both commercial and industrial spaces.
c. A considerable portion of HVAC electricity use in industrial space goes to office space which is similar to commercial HVAC use. Note that there are many industrial spaces in

[21] Mills, Evan, et al., Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas
Emissions, LBNL, July 21, 2009.

the NEEA region that only use HVAC for their office space (and our methodology of applying a weighted savings based on sub-system energy use accounts for this).

d. The MECS dataset distinguished between process cooling and heating, refrigeration, and HVAC, which allowed Cadmus to isolate the HVAC portion of industrial building energy use that was similar to commercial buildings.

Commissioning and Retrocommissioning Savings per Square Foot

Cadmus calculated the Cx and RCx electricity savings per square foot by multiplying the weight of the HVAC sub-system identified in section 1.3 (9.1%), by the HVAC savings rates for Cx (13%) and RCx (16%) identified in section 1.4, by the baseline electricity consumption per square foot (40.47 kwh/ft^2) identified in section 1.2.

The resulting savings rates is as follows:

$$HVAC\ Savings\ Rate = Baseline\frac{kWh}{ft^2} \times HVAC\ SubSystem\ Weight\ (9.1\%) \times HVAC\ System\ Savings$$

$$Cx\ HVAC\ Savings = 40.47\frac{kWh}{ft^2} \times 9.1\% \times 13\%$$

$$Cx\ HVAC\ Savings\ Rate = \mathbf{0.48}\boldsymbol{\frac{kWh}{ft^2}}$$

$$RCx\ HVAC\ Savings = 40.47\frac{kWh}{Sqft^2} \times 9.1\% \times 16\%$$

$$RCx\ HVAC\ Savings\ Rate = \mathbf{0.59}\boldsymbol{\frac{kWh}{ft^2}}$$

Assumptions and Limitations

In this section Cadmus discusses the assumptions and limitations of this study.

- Cadmus assumed electricity consumption derived from the MECS data to be proportional to number of facilities across U.S derived from the MNI data. The number of facilities in the NEEA region (3.1%) is used to proportionally determine the portion of total electricity consumption (using MECS data) in the NEEA region.
- Cadmus assumed that industry in the U.S as a whole is the same as in the NEEA region (e.g., lumber and wood processing facilities in other states have similar electricity consumption characteristics as wood processing facilities in NEEA’s region).
- Cadmus noticed average square footage for NAICS classification of Petroleum Refining seemed low. Examining the data further, Cadmus did not find any actual refineries that listed square footage. Though there are only a few of these facilities in NEEA territory, their physical size is likely sufficient to increase the average square footage. Based on these observations, as well as possible other gaps in the MNI data, the market size we reported here is most likely a conservative estimate. However, Cadmus’ experience with refineries has found only a small portion of their total area includes conditioned space. So, while an increase in market size to account for refineries would slightly reduce the average baseline energy consumption per square foot (leaving the potential for slightly

smaller savings), we do not view this as a significant concern, because the HVAC energy use from refineries is also likely lower than average.

- It is important to note that compared to commercial spaces, industrial spaces served by HVAC are more dynamic and less predictable which can result in additional savings from Cx and RCx.

Summary Results and Future Considerations

The resulting savings rates for building Cx and RCx in industrial facilities is 0.48 kWh/ft2 or 1.18% and 0.59 kWh/ft2 or 1.45% respectively. The low Cx and RCx savings rates percent are due to the low proportion of HVAC electricity use (9.1%) as a sub-system in industrial buildings versus commercial buildings. However, this is counteracted by the high baseline electricity intensity (40.47 kWh/ft2) of industrial buildings, as discussed in section 1.1.
Table 6 summarizes the findings and savings rates for the NEEA region:

Table 6. Cx and RCx Savings Rate Summary

NEEA Region Parameter	Quantity	Unit
Market Size	582,484,438	Ft^2
Baseline Consumption (all end uses)	23,575	GWh/yr
Baseline Intensity (all end uses)	40.47	kWh/ft^2
HVAC Cx Savings Rate	0.48	kWh/ft^2
HVAC Cx Savings Rate Portion of Baseline	1.18%	-
HVAC RCx Savings Rate	0.59	kWh/ft^2
HVAC RCx Savings Rate Portion of Baseline	1.45%	-

The opportunity for savings through commissioning and retro-commissioning is significant even though HVAC accounts for only 9.1% of total electricity use in industrial facilities.
It should be noted that the savings algorithm is presented in a way that all numbers including the system weights and the sub-system savings rates can be updated as new research and studies are published. Cadmus is currently conducting field work for the new nationwide Motor System Market Assessment study (MOA) funded by the U.S. Department of Energy. The data from that study updates the information from the previous MOA, and the results could provide updated electricity distribution data for HVAC systems. Cadmus could provide these rates to NEEA once the study is complete.

Although it was not NEEA's primary interest for the LTMT commissioning study, Cadmus also determined that there remains a large opportunity for Cx and RCx savings across all sub-systems in industrial facilities. For informational purposes only, we estimate the savings rates for Cx and RCx when considering all sub-systems to be 0.569 kWh/ft2 or 1.41%, and 3.073 kWh/ft2 or 7.59%, respectively. The large discrepancy in Cx and RCx savings when considering all sub-systems is because Cadmus sees commissioning of new sub-systems directly related to production equipment as standard practice. This is done to ensure design specifications are met. These sub-systems will eventually shift from their ideal set-points resulting in a large opportunity for RCx.