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2014 INDUSTRIAL FACILITIES SITE ASSESSMENT: REPORT & ANALYTIC RESULTS

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Table of Contents

Executive Summary ... 1
IFSA Study Protocols ... 1
Sample Design ... 1
Data Collection ... 2
Data Security ... 3
Customer Contact ... 3
Study Implementation ... 4
Study Analysis and Results ... 5
Conclusions and Recommendations ... 8
Study Design ... 8
Study Implementation ... 9
SEM Adoption Level ... 11
1 Introduction ... 12
2 Sample Design ... 14
2.1 Sample Frame ... 14
2.2 Sample Design ... 14
2.2.1 Precision and Reporting Domains ... 14
3 Data Collection ... 18
3.1 Collect End-Use Consumption Data ... 18
3.1.1 Motor Systems (Machine Drive) ... 20
3.1.2 Refrigeration (Process Cooling and Refrigeration) ... 20
3.1.3 Steam/Hot Water End Uses (Conventional Boiler Use) ... 21
3.1.4 Process Heating (Process Heating) ... 21
3.1.5 Space Conditioning (Facility HVAC) ... 22
3.1.6 Lighting (Facility Lighting) ... 22
3.2 Data Security ... 22
3.2.1 Data Security Methods ... 22
3.2.2 Confidentiality ... 23
3.3 Operational Practices Survey ... 24
3.3.1 Measuring SEM Adoption ... 25
3.3.2 Survey Instrument ... 25
3.3.3 SEM Scoring ... 26

4 Utility and Participant Outreach ... 28
4.1 Utility/Stakeholder Engagement and Coordination ... 28
4.2 IFSA Value Proposition ... 29
4.3 Utility and Participant Contact ... 30
5 Study Implementation ... 34
5.1 Pre-Test ... 34
5.1.1 Pre-Test Process ... 34
5.1.2 Pre-Test Results ... 34
5.1.3 Pre-Test Findings and Recommendations ... 37
5.2 Full IFSA Study Implementation ... 38
5.3 Final Sample Disposition ... 38
5.4 Final Sample by NAICS and Stratum ... 41
5.4.1 Oversampling ... 42
5.4.2 Variance between Sample Frame and Verified Employment ... 42
5.5 Analysis and Normalization ... 44
5.6 Site-Specific Report ... 45
6 Analysis and Results ... 46
6.1 NAICS 311 – Food Manufacturing ... 50
6.2 NAICS 321 - Wood Products Manufacturing ... 55
6.3 NAICS 322 – Paper Manufacturing ... 66
6.4 NAICS 324 - Petroleum and Coal Products Manufacturing ... 74
6.5 NAICS 325 - Chemical Manufacturing ... 78
6.6 NAICS 326 - Plastics and Rubber Products Manufacturing ... 83
6.7 NAICS 327 - Nonmetallic Mineral Products Manufacturing ... 87
6.8 NAICS 331 - Primary Metal Manufacturing ... 92
6.9 NAICS 332 - Fabricated Metal Products Manufacturing ... 97
6.10 NAICS 334 - Computer and Electronic Products Manufacturing ... 102
6.11 NAICS 336 - Transportation Equipment Manufacturing ... 106
6.12 NAICS 493 - Refrigerated Warehousing and Storage ... 111
6.13 SEM Adoption Level Findings ... 114
7 Conclusions and Recommendations ... 122
7.1 Study Design ... 123
7.2 Study Implementation ... 123
7.3 SEM Adoption Level ... 126

8 References 127

Executive Summary

In March 2013, the Northwest Energy Efficiency Alliance (NEEA) commissioned Cadmus and subcontractors Energy350 and Nexant (hereafter known as the Cadmus team) to conduct the Industrial Facility Site Assessment (IFSA). The primary goal of the IFSA was to obtain end-use energy consumption data for the Northwest industrial population. The IFSA was intended to provide: (1) a comprehensive and regionally representative account of energy usage characteristics in Northwest industrial facilities; and (2) a comprehensive analysis of the levels, use, and management of industrial energy. To the best of our knowledge, the IFSA was the first study in the United States to collect this type of comprehensive information on this level. Because of the unprecedented nature of this work, the project experienced a variety of challenges related to outreach, recruitment, and analysis, which are detailed throughout the report.

To facilitate the IFSA, NEEA assigned each major study task to be reviewed and refined by one of four working groups made of regional stakeholders from utilities and related organizations. This approach allowed the Cadmus team to gather feedback on outstanding issues related to the methodology to complete each task. The working groups analyzed the following study components:

- Sample Design
- Data Collection
- Data Security
- Customer Contact

IFSA Study Protocols

Sample Design

The Cadmus team developed the sample using the *Database of Northwest Manufacturers, Nurseries, and Wineries*, produced by Evergreen Economics,[1]which lists 18,000 records for industrial facilities across twenty-four, three-digit NAICS[2] codes in Idaho, Montana, Oregon, and Washington. The original source of this information comes from InfoGroup, a provider of lists containing known business establishments, similar to Dun & Bradstreeet. Evergreen also modeled estimates for each facility's annual electricity consumption based on employee counts from these lists coupled with data from the Energy Information Administration (EIA). The final sample design encompassed 120 sites spread across the twelve industrial sectors deemed most relevant to the future of Northwest industry, as shown in Table 1.

[1] Available online: http://neea.org/docs/default-source/reports/report-on-database-of-northwest-manufacturers-nurseries-and-wineries.pdf?sfvrsn=7
[2]North American Industry Classification System (NAICS), https://www.census.gov/eos/www/naics/

The Cadmus team allocated larger sample sizes to those sectors with the highest estimated electricity consumption and those the working group deemed of highest interest to the Northwest. The working group recognized that samples this small were unlikely to achieve reasonable levels of confidence and precision to extrapolate back to the full population, but would nonetheless provide some valuable insights.

Table 1. Sample Design by NAICS Code

NAICS Code	Industry Sector	Total
311	Food Manufacturing	15
321	Wood Products Manufacturing	15
322	Paper Manufacturing	18
324	Petroleum and Coal Products Manufacturing	7
325	Chemical Manufacturing	10
326	Plastics and Rubber Products Manufacturing	6
327	Nonmetallic Mineral Products Manufacturing	10
331	Primary Metal Manufacturing	7
332	Fabricated Metal Products Manufacturing	8
334	Computer and Electronic Products Manufacturing	8
336	Transportation Equipment Manufacturing	8
493	Refrigerated Warehousing and Storage	8
	Total	120

Data Collection

Through the IFSA, the Cadmus team categorized consumption for the major end uses at each facility, focusing end-use data collection on motor systems (compressed air, materials processing, material handling, pumps, and fans), refrigeration, process heating systems, steam systems, and cogeneration, as these typically represented the majority of energy consumption at each site. We varied the type of data collected at each site according to the industrial sector, fuels used, and end-use systems that represent the majority of the energy consumption.

The Cadmus team mapped the final end-use consumption estimates to end uses from the 2010 Manufacturing Energy Consumption Survey (MECS).[3]The MECS provides a standard, widely used classification system for equipment end uses, which matched the intent of this study. However, MECS data relies on self-reported surveys, while the intent of the IFSA was to collect on-site data in Northwest facilities, calibrating the end-use consumption estimates to actual utility consumption data. The Cadmus team outlined general data collection methods for each end use and developed Microsoft Excel data collection forms to input information obtained through the on-site assessments, which were limited to one day or less of data collection. The team relied heavily on data provided by facility contacts, such as motor logs, production data,

[3]The MECS is a national sample survey of collected information on the stock of the U.S. manufacturing establishment, their energy-related building characteristics, and their energy consumption and expenditures.(http://www.eia.gov/consumption/manufacturing/).

and submetering data, where available. We did not conduct comprehensive submetering on equipment end uses, as that level of effort was outside the scope of the IFSA.

The Cadmus team obtained information on energy management strategies, high-efficiency equipment, and operational practices related to energy use. We developed a brief survey to conduct on-site in order to obtain these details, which can be used to quantify the potential for deployment of strategic energy management (SEM). Through this survey, the Cadmus team also measured the persistence of energy management practices for facilities that have already implemented SEM.

Data Security

The Cadmus team developed data security and client confidentiality procedures to protect the privacy of data collected as part of the IFSA. We treated any data received from utilities and participants as highly sensitive and kept it safeguarded both digitally and physically.

Customer Contact

The Cadmus team and working group members recognized that one of the most critical aspects of the study revolved around participant outreach. The key first step in the outreach process involved notifying and educating utility representatives and other regional stakeholders, such as staff associated with the Bonneville Power Administration, Energy Trust of Oregon, and Northwest Power and Conservation Council (NPCC). Some of these stakeholders participated in the protocol development working groups and assisted with outreach for pre-test assessments. After the working group meetings concluded, NEEA convened a regional webinar for representatives from utilities with facilities in the sample, where it provided more detail on the final protocols and outlined expectations of support from utility representatives.

Participation in the IFSA study was optional, but NEEA attempted to encourage one hundred percent utility participation. NEEA staff directly contacted representatives of each utility in the sample and provided a list of sites in their service territory, asking for their support in verifying and contacting those sites.

The Cadmus team, NEEA, and the working group members suggested various approaches to create a meaningful value proposition to motivate potential participants. The Cadmus team condensed the proposed approaches into the following list, which was conveyed to potential participants through a Frequently Asked Questions (FAQ) document.

- Each participating facility would receive a site-specific report containing results of the analysis. Participants could use this to gain a better understanding of how energy is used within their facility and as a comparison to their specific industrial sector.

- Participants would have an opportunity to discuss potential energy efficiency improvements with an independent engineer (not a vendor promoting a particular type of equipment). A list of identified energy efficiency opportunities would be included with the site-specific report.

- The end-use consumption analyses would provide ideas of better methods for utilities to serve their industrial facility customers with more targeted efficiency opportunities based on specific industrial sectors.

- The information could include more region-specific equipment and load data to support future power planning efforts by utilities and regional organizations. This could allow the region to more effectively characterize current energy loads, plan to meet future loads, and ideally avoid expensive new power generation facilities that raise utility rates.

The Cadmus team developed a detailed decision tree for utility and site recruitment, as well as a comprehensive scheduling process. After scheduling a site visit, the Cadmus team scheduler provided the participant with contextual documentation on the IFSA study, and with the full FAQ document summarizing the IFSA details presented in this report. The Cadmus team also provided the participant with a proposed agenda of on-site activities, the titles of various facility staff the Cadmus team hoped to meet with, and a list of data the team would try to obtain.

Study Implementation

The Cadmus team tested and implemented the working group protocols on two facilities. The pre-test results then informed the final protocols, which the Cadmus team applied to the full population of sample sites.

Some participants were resistant to allowing on-site assessments without additional incentives. NEEA staff approved additional budget to provide a $250 gift card for each participating facility. Potential participants displayed mixed reactions to the gift cards. Some appreciated the gesture and thought it appropriate to reward their employees for supporting the study. Others said that $250 was a minor amount compared to their annual revenues and was not appropriately large enough.

The Cadmus team conducted three additional sample draws because of the unexpectedly large number of sites removed due to inaccuracies in the sample frame, unreachable sites, and refusals. From the full sample draw of 506 sites, the Cadmus team completed eighty-two assessments out of the initially established goal of 120.

The Cadmus team calculated end-use energy consumption using the data collected on-site and calibrating utility bills. For reporting purposes, the Cadmus team normalized the end-use consumption for each stratum and NAICS code by dividing the end-use consumption by the number of employees at the facility. The Cadmus team and the working group determined that this process was necessary to maintain the anonymity (and associated competitive details) of each facility’s consumption, although it was possible that the normalization process could distort per-site end-use consumption estimates.

The Cadmus team completed a site-specific assessment report for each facility that allowed on-site data collection and authorized us to obtain utility billing data. An example report can be found in Appendix G. The Cadmus team provided each site-specific report to both the participant and the utility. The report provided information about analysis results, energy-efficiency opportunities, and utility energy-efficiency program details.

Study Analysis and Results

The final analyses by NAICS code revealed results that were largely expected. For example, the primary driver of energy consumption in sawmills was machine drive systems, specifically material processing motors. The normalized results between strata often featured significant variance, often due to different manufacturing and process requirements between four-digit NAICS codes (e.g., aerospace manufacturing and shipbuilding). Variations in employment between sites in the same NAICS codes, particularly between strata, also introduced significant differences in the final normalized consumption.

The Cadmus team then compared weighted average energy consumption distributions against those from MECS. We often found the results to be similar in terms of proportion, although with some variation between IFSA and MECS. For example, the predominant end use for NAICS 336 (Transportation Equipment Manufacturing) for both IFSA and MECS was Machine Drive. While the next three largest end uses were the same as well, their proportions of total consumption varied, as shown below in Table 2.

Table 2. Comparison of IFSA and MECS Consumption Data for NAICS 336

End Use	IFSA Portion of Total Consumption	MECS Portion of Total Consumption
Machine Drive	52%	37%
Process Heating	18%	14%
Facility Lighting	17%	15%
Facility HVAC	9%	19%

However, the differences between IFSA and MECS tended to be larger with very small sample sizes. For example, the Cadmus team could only recruit two medium strata NAICS 324 (Petroleum and Coal Products Manufacturing) facilities. These two sites were similar in nature, but had different consumption patterns from petroleum refineries and other major electricity consumers for this NAICS code. The comparison for the top end uses is shown in Table 3.As a result of the limited sample size, the IFSA end-use proportions were likely not representative of the NAICS 324population.

Table 3. Comparison of IFSA and MECS Consumption Data for NAICS 324

End Use	IFSA Portion of Total Consumption	MECS Portion of Total Consumption
Machine Drive	21%	80%
Process Heating	66%	3%
Facility Lighting	13%	3%
Facility HVAC	0%	4%
Process Cooling and Refrigeration	0%	5%

Table 4 on the following page shows the weighted average end-use consumption estimates. The Cadmus team normalized the values by dividing energy consumption by the number of employees per facility.

Table 4. Normalized End Use Consumption Estimates by NAICS Code

			Weighted Average Consumption by NAICS Code														
Indirect Uses-Boiler Fuel	Fuel Type	Unit	311	3211	3212	3219	3221	3222	324	325	326	327	331	332	334	336	493
Conventional Boiler Use	Natural Gas	MMBtu	90	0	133	0	4,508	0	0	50	0	116	5,616	0	11	23	0
	Electricity	MMBtu	5	18	16	0	77	0	0	1	0	6	0	0	0	1	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Uses-Total Process																	
Process Heating	Natural Gas	MMBtu	19	0	148	0	0	0	63	19	36	186	564	284	6	46	0
	Electricity	MMBtu	0	0	0	0	101	1	20	12	9	5	207	14	8	9	0
	Propane	MMBtu	0	0	0	0	0	12	0	0	0	0	0	0	0	37	0
Process Cooling and Refrigeration	Electricity	MMBtu	31	1	0	0	0	0	0	4	50	0	128	7	0	0	70
Machine Drive	Electricity	MMBtu	156	342	470	469	2,745	56	6	59	327	128	436	76	59	25	22
Pumps	*Electricity/MD*	*MMBtu*	10	47	51	44	995	0	1	13	2	37	169	8	6	2	0
Fans	*Electricity/MD*	*MMBtu*	60	35	174	6	193	3	1	8	2	14	93	4	9	3	0
Compressed Air	*Electricity/MD*	*MMBtu*	13	18	40	30	154	10	1	10	197	6	62	13	10	4	6
Material Handling	*Electricity/MD*	*MMBtu*	40	65	57	327	270	25	1	8	1	25	59	5	2	2	6
Material Processing	*Electricity/MD*	*MMBtu*	34	177	146	58	967	17	3	20	125	45	53	45	32	13	7
Other Systems	*Electricity/MD*	*MMBtu*	0	0	3	3	165	0	0	0	0	0	0	1	1	0	4
Electro-Chemical Processes	Electricity	MMBtu	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Process Use	Electricity	MMBtu	1	0	0	0	128	0	0	0	0	0	0	0	0	1	8
Direct Uses-Total Nonprocess																	
Facility HVAC	Natural Gas	MMBtu	21	0	0	10	0	93	0	23	4	5	2	56	31	18	8
	Electricity	MMBtu	2	0	0	0	8	1	0	1	6	0	87	13	15	4	1
Facility Lighting	Electricity	MMBtu	11	5	38	65	82	9	4	7	9	17	81	13	6	8	22
Other Facility Support	Electricity	MMBtu	0	0	0	0	0	0	0	0	0	1	0	3	1	0	0
Onsite Transportation	Electricity	MMBtu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBtu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Nonprocess Use	Electricity	MMBtu	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total Consumption																	
	Electricity	MMBtu	212	367	524	534	3,041	67	30	84	401	156	938	126	90	48	123
	Natural Gas	MMBtu	131	0	281	10	4,508	93	63	93	40	307	6,182	340	49	50	8
	Propane	MMBtu	0	0	0	0	0		0	0	0	0	0	0	0	37	0
	Total Energy	MMBtu	342	367	805	545	7,549	160	93	177	441	463	7,121	466	139	135	132

Note: *Electricity/MD* in the Fuel Type column represents the electric consumption for various machine drive applications. These are broken out separately to provide more granularity on energy consumption within this major end use.

Conclusions and Recommendations

The Cadmus team found that the study's implementation protocols functioned reasonably well. The IFSA analysis results as compared to MECS point to some potential regional differences for those NAICS codes with a sample of five or more facilities. The team could not draw definitive conclusions from those NAICS codes with smaller sample sizes. However, the Cadmus team identified the following challenges and opportunities to inform future IFSA efforts, broken out by area for improvement.

Study Design

The working groups improved the study's methodology and utility participation. The working groups, composed of utility representatives and regional stakeholders, were enabled to weigh in on critical study design issues and provide feedback on the methodology. This enabled stakeholders to achieve a higher comfort level in presenting the IFSA to their customers. It also enabled the protocols to more effectively achieve the study goals in ways that addressed the needs and concerns of utilities and stakeholders.

- **Recommendation:** NEEA should apply the working group structure to re-examine the study protocols and recommend further improvement during future industrial market research efforts.

The InfoUSA sample frame limitations made recruitment more difficult and inhibited the extrapolation of sample results to the overall population. During sample draws, the Cadmus team found many facilities that were not manufacturing, misclassified by NAICS code, or inactive. Also, the sample frame included contact names and information that was generally inappropriate for recruitment purposes. The Cadmus team found sufficient discrepancies between modeled and actual electricity consumption and employment that indicated extrapolation of the results to the overall population could not be performed with reasonable accuracy.

- **Recommendation:** NEEA should investigate developing a truly regional sample frame that is more accurate and better represents the industrial population.

A lack of general awareness inhibited study recruitment. Several utilities, and most facilities, were generally unaware of the IFSA study and of NEEA. The Cadmus team found it more difficult to educate staff at those utilities and facilities about the study, its potential benefits to the region, and the importance of participation.

- **Recommendation:** NEEA should consider increasing general awareness of the IFSA among utilities and industrial facilities throughout the region to encourage higher levels of participation in future studies. One possibility for raising awareness could be through trade or industry associations.

Study Implementation

The pre-test provided a useful method for testing the working group protocols and assessing the viability of the sample frame. The pre-test allowed the Cadmus team to identify any deficiencies in the various protocols and coordinate with the working groups to address those issues. The Cadmus team found that the protocols worked effectively, although the focus of the data collection approach needed to be on systems instead of on equipment. This would be more time-efficient and less burdensome to facility staff.

- **Recommendation:** NEEA should perform a pre-test on a small sample in future studies to determine the viability of protocols.

The Cadmus team found it more difficult to recruit large facilities because they were more likely to have previously engaged in detailed energy-efficiency audits. Larger facilities are frequently targeted for utility energy-efficiency programs due to their large consumption and associated opportunities. Therefore, many have already been intensively studied, some had been extensive submetered, and most large facility personnel were already aware of how their energy consumption is broken out among various end uses. Several facility contacts doubted the value proposition based on the limited nature of the IFSA on-site assessment (one day or less without metering).

- **Recommendation:** NEEA should consider funding the IFSA as an ongoing effort in conjunction with utility energy-efficiency programs throughout the region, rather than as an intermittent study every five years. Many of these large facilities will continue to receive detailed audits through utility energy-efficiency programs before the next round of the IFSA. These audits represent the best opportunity to gain detailed metering and submetering data the IFSA lacked, while also allowing NEEA to track a wider scope of end-use consumption variables. NEEA could then focus the next round of IFSA primarily on small to medium facilities that have not yet been studied in detail, and which can be more easily assessed in a limited time period without metering.

The study budget provided sufficient depth to develop and test assessment protocols, but was insufficient for a statistically valid analysis of industrial end-use consumption. The 2014 IFSA provided a good start to understanding the challenges and possibilities associated with industrial market characterization. In conjunction with the working groups, the Cadmus team developed viable protocols that effectively allowed us to gather data to estimate end-use consumption. However, the sample size by sector was too small to extrapolate results to the larger population with any statistical validity. In addition, on-site verification without metering represented the only viable data collection method within the budget constraints.

- **Recommendation:** NEEA should consider expanding the IFSA budget to allow the study contractor to conduct assessments on a larger sample to ensure statistical validity. In particular, the sample could be expanded to achieve more granularity at the four-digit NAICS level for those NAICS codes with a relatively high level of participation. The budget could support enhanced data collection through short-term metering and multi-day assessments. The additional budget could also be used to provide incentives for industrial audit contractors to complete data collection based on IFSA protocols, provided to NEEA as interim data.

Analysis results may be inconsistent among three-digit NAICS codes due to variances among facility types. For the IFSA, the Cadmus team generally focused on three-digit NAICS codes due to the limited sample. This could result in wide variance between facility end-use consumption estimates due to the wide variation in types of manufacturing facilities in each three-digit NAICS code. For example, NAICS 336 covers transportation equipment manufacturing, which included facilities the Cadmus team visited that manufactured products as various as light aircraft, automotive equipment, helicopter components, and ships. However, the Cadmus team did examine samples for 321 (Wood Products) and 322 (Paper) at the four-digit NAICS level.

- **Recommendation:** NEEA should expand future sample sizes to achieve statistically valid confidence and precision for more industrial subsectors deemed to be of the highest importance to the Northwest region.

The attempt to collect data with a lower level of uncertainty could jeopardize a successful site assessment. As outlined in the Data Collection Methodology section, SCADA trends and facility equipment inventories represent data sources with lower levels of uncertainty in end use consumption estimates. Some facility contacts offered to send the team low uncertainty data to supplement the analysis so that the field engineer would not need to perform an on-site equipment inventory. However, in some cases the facility contact did not provide the data and could not be reach for follow-up. The team therefore could not complete the full analysis and omitted the site from final results.

- **Recommendation:** Field engineers should clearly outline data collection requirements in advance to the extent possible. The field engineers should try to work with facility contacts to ensure the SCADA data, digital equipment inventories, etc. are available to download to a secure laptop at the time of the assessment, or uploaded to a secure FTP server. If this low uncertainty data cannot be obtained in advance or during the assessment, the field engineer should consider conducting an on-site equipment inventory supplemented with equipment operator interviews.

Utility staff are supportive of the IFSA and increased study participation. In many cases, utility staff (either key account managers or energy managers) recognized the importance of the IFSA value proposition for their customers who appeared in the sample draw. The Customer Contact protocols provided utility contacts with the first right of refusal to notify the potential participants about the study. Some utility staff members actively sought to contact and recruit their customers to participate in the study. This was particularly true for facilities that had not previously received energy-efficiency audits, and were therefore expected to possess potentially numerous opportunities for improvement. The Cadmus team found it easier to identify the appropriate contacts and recruit sites in coordination with supportive utility staff than through cold calls or with limited utility support.

- **Recommendation:** For future IFSA efforts, NEEA should continue to engage utility staff members through working groups, webinars, and monthly update meetings.

Example site reports from the previous IFSA should be shared with staff to highlight the value proposition for their customers. An expanded scope and depth of assessment and analysis may also improve utility staff members' perception of the value proposition.

Bonus incentives helped to increase participation. The Energy Trust of Oregon offered IFSA participants an additional ten percent incentive if they installed an energy-efficiency measure identified through the study's on-site assessment. This provision increased the value proposition for participants, and several said this incentive was their primary motivation for participating in the IFSA. Both the Cadmus team subcontractors served as program delivery contractors for the Energy Trust's Production Efficiency Program. The bonus incentive provided additional motivation for them to recruit potential participants within their geographic service territories. The field engineers were generally able to identify cost-effective energy-efficiency opportunities to pursue through the Energy Trust program.

- **Recommendation:** For future IFSA efforts, NEEA should coordinate with supportive utilities that may consider offering a similar bonus incentive. These incentives can spur additional participation in the IFSA study, as well as participation in the utility's energy-efficiency programs.

SEM Adoption Level

The SEM adoption level in the industrial market is low; however, the market potential for adopting this system for managing energy as a controllable expense is high. Four percent of the sites visited had adopted *full* SEM; however, sixty-six percent of respondents reported interest in participating in a SEM program. Interest was mixed among facility sizes and facility types.

1 Introduction

The Northwest Energy Efficiency Alliance (NEEA) is supported by and works in collaboration with the Bonneville Power Administration (BPA), the Energy Trust of Oregon, and more than 100 utilities on behalf of more than twelve million energy consumers in the Northwest (Idaho, Oregon, Washington, and parts of Montana). NEEA has previously conducted stock assessments of residential and commercial buildings[4,5]that provide information on the age, characterization, and energy-efficiency potential of each population within the Pacific Northwest. NEEA observed that the industrial population represents one of the largest consumers of energy resources in the Northwest. The U.S. Energy Information Administration estimated that fifty-one gigawatt-hours of electricity are sold annually to support the region's industrial processes.[6] The scale of energy consumption for this population indicates significant opportunities for the region to achieve energy savings.

Currently, users of the region's energy consumption data have access to a great deal of information about how the industry uses energy to drive production. Nevertheless, these data have some limitations; principally that there is no centralized, comprehensive source of recently collected energy consumption data that represents Northwest industrial sites. For instance, though regional electric motor data collected by Oregon State University can be found in the Northwest Industrial Motor Database,[7] the database does not contain information about how energy is used in non-motor applications; there is little information on the management environment in which the energy is used; and there is no information on gas-based energy usage. In addition, the data are, in some cases, quite old: having been collected more than twenty years ago.

From 2013 to 2014, NEEA commissioned Cadmus and subcontractors Energy350 and Nexant to conduct the Industrial Facility Site Assessment (IFSA) to obtain equipment end-use consumption and energy management data for the industrial population. The IFSA should provide: (1) a comprehensive and regionally representative account of energy usage characteristics in Northwest industrial facilities; and (2) a comprehensive analysis of the levels, use, and management of industrial energy.

The IFSA is intended to provide the region with information useful to a variety of stakeholders. The data will be reported anonymously, in a manner that will not compromise the proprietary information or operations of any facility. Stakeholders include:

- Businesses: to better understand the average/typical energy consumption and how it compare to peers;

- Utilities: for use in program planning;

[4]http://neea.org/resource-center/regional-data-resources/residential-building-stock-assessment
[5]http://neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment
[6]http://www.eia.gov/electricity/state/pdf/sep2010.pdf
[7]http://rtf.nwcouncil.org//meetings/2009/03/NW_Motor_Database_Summary_20090116.pdf

- Researchers: for use in energy use characterization;
- The Northwest Power and Conservation Council (NPCC): for key inputs into regional planning efforts such as the Regional Power Plan.

To facilitate the IFSA, NEEA assigned each major study task to be reviewed and refined by one of four working groups made up of regional stakeholders from utilities and related organizations. This approach allowed the Cadmus team to gather input and feedback on issues related to the methodology to complete each task. The working groups were:

- Sampling: This working group helped the Cadmus team develop a sampling plan and a dataset of sampled facilities for IFSA assessment and verification.
- Data Security: This working group developed data security and client confidentiality procedures to protect the privacy of data collected as part of the IFSA.
- Participant Contact: This working group developed protocols to contact the industrial customers and address questions or concerns regarding the site assessment process.
- Data Collection: This working group developed protocols for two critical portions of the IFSA effort:
    - Collecting end-use consumption data
    - Conducting an operational practices survey

Each working group met at least three times during the early stages of the study (generally every two to four weeks) to assist with study design and planning. The NEEA project manager organized and hosted these meetings, which took place by webinar and conference call. Prior to each working group session, the Cadmus team compiled a PowerPoint presentation showing the status of protocols specific to that working group, as well as a list of outstanding issues to resolve. At the final working group meetings, the Cadmus team was able to achieve consensus among the working group members for each of the proposed protocols.

Following the working group meetings, the Cadmus team finalized memos containing protocols for conducting the IFSA study (see Appendices). The Cadmus team then conducted a pre-test on two facilities to determine how the protocols functioned in the field and whether any adjustments were needed.

2 Sample Design

In conjunction with the Sample Design Working Group, the Cadmus team developed a sampling plan and a dataset of sampled facilities for IFSA assessment and verification. The Sample Design Protocols developed through the working group sessions are provided in Appendix A.

2.1 Sample Frame

The basis for the sample design came from a sample frame produced by Evergreen Economics entitled *Database of Northwest Manufacturers, Nurseries, and Wineries* (herein known as Industrial Database). As the report for the database notes, "The database is composed of information on business facilities obtained through InfoGroup[8] and augmented with information on additional business facilities collected through trade associations." The Industrial Database contains data from more than 18,000 facilities in twenty-four industry sectors throughout Idaho, Montana, Oregon, and Washington. The data include the site name, address, NAICS code, facility contact information, number of employees and value of sales. Evergreen also developed models to estimate annual electricity consumption from a subset of these variables.

2.2 Sample Design

In its initial request for proposals, NEEA expressed interest in having a sample developed for each industrial sector with proportional representation by state. The Cadmus team determined that the study budget was insufficient to achieve a sample at that level. We proposed that the sampling design take the industry sectors into account, and that we concentrate on the most relevant sectors as determined by the working groups.

2.2.1 Precision and Reporting Domains

The Cadmus team recommended treating each industrial sector as a unique population, as it was unlikely there would be any relationship of energy use across sectors. The Cadmus team conducted a limited Delphi study[9] by providing the list of industrial sectors to the working group members and requesting that they rank the importance of each sector to Northwest energy planning efforts, from 1 (no importance) to 5 (high importance).

The Cadmus team removed several sectors from consideration due to their low contribution to overall electric consumption and the lack of perceived relevance to the industrial population as a whole. The sectors from the Industrial Database and their estimated electricity consumption are shown in Table 5.

[8]InfoGroup collects data on businesses and consumers from a variety of sources, including business directories, annual reports, phone books, county courthouse filings, SEC filings, and other sources(http://www.infogroup.com/).

[9]http://betterevaluation.org/evaluation-options/delphitechnique

Table 5. Northwest Industrial Sectors and Electricity Consumption

NAICS	Industry Sector	Total Electricity (GWh)	Pct. of Total Consumption
322	Paper Manufacturing	10,423.0	27.3%
321	Wood Products Manufacturing	4,243.0	11.1%
311	Food Manufacturing	4,171.6	10.9%
327	Nonmetallic Mineral Products Manufacturing	3,556.1	9.3%
325	Chemical Manufacturing	2,973.0	7.8%
332	Fabricated Metal Products Manufacturing	1,947.0	5.1%
336	Transportation Equipment Manufacturing	1,818.0	4.8%
493	Refrigerated Warehousing and Storage	1,424.0	3.7%
324	Petroleum and Coal Products Manufacturing	1,408.0	3.7%
334	Computer and Electronic Products Manufacturing	1,362.0	3.6%
331	Primary Metal Manufacturing	1,007.0	2.6%
333	Machinery Manufacturing	919.5	2.4%
326	Plastics and Rubber Products Manufacturing	715.2	1.9%
312	Beverage and Tobacco Product Manufacturing	546.4	1.4%
339	Miscellaneous Manufacturing	439.2	1.2%
424	Farm, Flower, Nursery, and Florist Supply Wholesale	256.9	0.7%
444220	Nursery, Garden, and Farm Supply Stores	229.8	0.6%
335	Electrical Equip, Appliance/Component Manufacturing	226.7	0.6%
313	Textile Mills	178.2	0.5%
337	Furniture and Related Products Manufacturing	163.0	0.4%
111421	Nursery and Tree Production	91.2	0.2%
314	Textile Product Mills	19.9	0.1%
315	Apparel Manufacturing	7.4	0.0%
316	Leather and Allied Product Manufacturing	5.8	0.0%

Based on the feedback from the Delphi study and subsequent discussion, the Cadmus team targeted twelve sectors as candidates for sampling, shown in Table 6. The team split the sample across census (very large), large, medium, and small consumption facilities. The strata levels are shown by sector in Table 7.

Table 6. IFSA Industrial Sectors and Strata

NAICS	Industry Sector	Strata Quantity Census (n)	Large (n)	Medium (n)	Small (n)	Total (n)
311	Food Manufacturing	0	3	7	5	15
321	Wood Products Manufacturing	1	4	5	5	15
322	Paper Manufacturing	0	5	6	7	18
324	Petroleum and Coal Products Manufacturing	0	2	3	2	7
325	Chemical Manufacturing	1	2	4	3	10
326	Plastics and Rubber Products Manufacturing	0	2	2	2	6
327	Nonmetallic Mineral Products Manufacturing	0	3	4	3	10
331	Primary Metal Manufacturing	2	2	2	1	7
332	Fabricated Metal Products Manufacturing	0	2	4	2	8
334	Computer and Electronic Products Manufacturing	0	2	4	2	8
336	Transportation Equipment Manufacturing	0	2	4	2	8
493	Refrigerated Warehousing and Storage	2	2	2	2	8
	Total					120

Table 7. Strata Definitions – Modeled Electricity Consumption by Sector (MWh)

NAICS	Industry Sector	Census	Large	Medium	Small
311	Food Manufacturing	N/A	> 50,000	5,000-50,000	< 5,000
321	Wood Products Manufacturing	> 100,000	50,000 - 100,000	5,000-50,000	< 5,000
322	Paper Manufacturing	N/A	> 500,000	50,000 - 500,000	< 50,000
324	Petroleum and Coal Products Manufacturing	N/A	> 100,000	10,000 - 50,000	< 5,000
325	Chemical Manufacturing	> 500,000	50,000 - 500,000	5,000-50,000	< 5,000
326	Plastics and Rubber Products Manufacturing	N/A	>10,000	500 - 10,000	< 500
327	Nonmetallic Mineral Products Manufacturing	N/A	> 100,000	10,000 - 100,000	< 5,000
331	Primary Metal Manufacturing	> 100,000	10,000 - 100,000	1,000-10,000	< 1,000
332	Fabricated Metal Products Manufacturing	N/A	> 100,000	5,000-100,000	< 5,000
334	Computer and Electronic Products Manufacturing	N/A	> 100,000	5,000-100,000	< 5,000
336	Transportation Equipment Manufacturing	N/A	> 100,000	5,000-100,000	< 5,000
493	Refrigerated Warehousing and Storage	> 100,000	50,000 - 100,000	5,000-50,000	< 5,000

The sample of sites included 120 primary sites and 240 back-up sites. The Cadmus team drew the back-up sites using the same sample design components as we used to select the primary sites. The team assumed it would be unlikely to achieve a 100 percent response rate on the 120 primary sites, and selected two backup sites for each primary site. There may not be a 2:1 ratio of back-up to primary sample for every utility organization.

The drawn sample included sites for nine investor-owned utilities and fifty-six publicly owned utilities throughout Idaho, Montana, Oregon, and Washington. To maintain participant anonymity, this report does not identify specific utilities or participants.

During the pre-test and initial sample review, the Cadmus team and the working group noted several areas of concern related to the sampling population:

- The Cadmus team provided the working group with the Industrial Database's energy consumption (kWh) and employee modeling data. The team considered this as an example of how to normalize the final data to report to the NPCC. However, we noted numerous inconsistencies in the data, which limited its use for normalization purposes. For example, the database listed only one employee for a medium-sized pulping facility that the Cadmus team noted had several employees during a previously visit as part of a utility program energy-efficiency evaluation.

- A working group member identified one large industrial site in their service territory that had not been included in the sample frame.

- The modeled energy consumption may not correlate effectively to actual energy consumption at each facility. Inconsistencies and omissions may prevent extrapolation of end-use consumption findings to each sector's overall population with any degree of confidence.

The Cadmus team's original intent was to extrapolate IFSA assessment analysis results from the sample to the overall population based on NAICS code and stratum using the number of employees. After identifying the limitations of the sampling frame, we determined that this extrapolation would not be feasible. The IFSA analysis results are generally representative of various industry subsector populations, but cannot be extrapolated proportionally by employment numbers.

3 Data Collection

The Cadmus team worked with the Data Collection working group to identify the most important data to obtain through the study, as well as the most effective methods to collect those data. The working group reviewed and approved the forms and surveys for collecting end-use consumption and operational practices data. In addition, the Data Security working group met in parallel with the Data Collection working group to specify methods for ensuring the confidentiality of any collected data.

The resulting Data Collection Protocols from the working group sessions are shown in Appendix B. The Data Security Protocols are shown in Appendix C.

3.1 Collect End-Use Consumption Data

Through the IFSA, the Cadmus team estimated consumption for major end uses at each facility, focusing on motor systems (compressed air, material processing, material handling, pumps, and fans), refrigeration, process heating systems, steam systems, and cogeneration, as these measures typically represented the majority of energy consumption at each site. The team varied the type of data collect at each site according to the industrial sector, fuels used, and end-use systems that represent the majority of the energy consumption. In general when collecting the on-site data, the team relied on SCADA (Supervisory Control and Data Acquisition)[10]trend data, logs, and other secondary sources rather than primary measurements.

The following table presents the various data collection methods employed in the study, as well as the relative uncertainty associated with calculating energy consumption through each method. Within each NAICS code, assessments for the various sites relied on a mixture of these data collection methods.

Table 8. Relative Uncertainty of Consumption Estimates by Data Collection Method

Data Collection Method	Hours of Operation Method	Relative Uncertainty
Equipment schedule from facility operator	Data logging	Low
Equipment schedule from facility operator	SCADA / trend data	Low
Equipment schedule from facility operator	Operator interview	Medium
On-site nameplate inventory	Data logging	Medium
On-site nameplate inventory	SCADA / trend data	Medium
On-site nameplate inventory	Operator interview	High

[10]http://en.wikipedia.org/wiki/SCADA

The Cadmus team mapped the final end-use consumption estimates to end uses from the 2010 Manufacturing Energy Consumption Survey (MECS). MECS is a self-reported, sample-based assessment of end-use energy consumption. The MECS provides a standard, widely used classification system for the equipment end-use types under consideration in the IFSA. Using it allowed the Cadmus team to organize end uses in a consistent manner that will be readily understood by many Northwest regional stakeholders, many of whom are already familiar with MECS. The MECS end uses are:

- Indirect Uses-Boiler Fuel
    - Conventional Boiler Use
    - CHP and/or Cogeneration Process
- Direct Uses-Total Process
    - Process Heating
    - Process Cooling and Refrigeration
    - Machine Drive
        - Pumps
        - Fans
        - Compressed Air
        - Material Handling
        - Material Processing
        - Other Systems
    - Electro-Chemical Processes
    - Other Process Use
- Direct Uses-Total Nonprocess
    - Facility HVAC
    - Facility Lighting
    - Other Facility Support
    - Onsite Transportation
    - Conventional Electricity Generation
    - Other Nonprocess Use

In some cases, we had multiple options for mapping the data back to an MECS end use. For example, machine drives (such as pumps) are an integral component of many other systems (such as boiler systems). In those cases, the Cadmus team assigned the energy consumption for the pumps (or other drives) to the appropriate end use it serves. The general data collection methods for the expected major end uses are outlined below, along with the appropriately mapped MECS category.

3.1.1 Motor Systems (Machine Drive)

The Cadmus team estimated the end-use consumption of motor systems by motor size, efficiency, load factor, and hours of operation. During the assessment, Cadmus team field engineers collected nameplate data on as many motors as practical,[11] prioritizing the largest motors first. In some cases, the engineers obtained this information from motor logs provided by the facility contact.

Engineers compared motor efficiencies against existing databases, including manufacturer data and MotorMaster+.[12] The engineers also applied the average load factors by motor size, as calculated by Cascade Energy in *Standard Savings Estimation Protocol for Premium Efficiency Motors*, Table 4.[13]

The motor operating hours represented the parameter of greatest variability and significance for data collection. The Cadmus team followed standard methods to obtain operating hours, as outlined in the Cascade Energy study, such as using SCADA trend data, manual logs, and asking questions of facility personnel; these methods are appropriate for most motor applications.

The scope of the study restricted the budget for on-site metering. The lack of metered data likely impacted the data quality, as most data is based on secondary sources. In one case, the Cadmus team installed run-time loggers to estimate operating hours on motors, which could not be obtained through a SCADA system. The Cadmus team used the UX90 series run-time loggers from Onset Computer Corporation, which do not require the additional time and expense of installing true power loggers. While this approach required an additional site visit to remove the loggers, it improved the accuracy of end-use consumption estimates for motors that have the potential for a large impact on consumption.

3.1.2 Refrigeration (Process Cooling and Refrigeration)

The amount of energy used by refrigeration equipment is affected by outside (condensing) temperatures, production levels (often the mass of product cooled),how the refrigeration components are controlled, and the production hours. During the site visit, Cadmus team field engineers interviewed facility production managers or maintenance engineers to understand the operational load profile. For on-site data collection, the engineers obtained operating parameters such as temperature, thermal characteristics, and power demand.

Because the entire system can affect the consumption and opportunities for improvement, the engineers looked at all the system elements, investigating the type of condensers, floating head

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[11] The scope of work and budget restricted on-site work to no more than eight hours, or as much time as the facility staff would allow. Field engineers collected as much data as they reasonably could within the time limits established by the facility contact.

[12] http://www1.eere.energy.gov/manufacturing/tech_assistance/software_motormaster.html

[13] http://www.nwcouncil.org/energy/rtf/meetings/2012/10/Premium%20Efficiency%20Motors%20Standard%20Protocol%20DRAFT%2010-19-12.docx

versus suction controls, types of fan motors on the evaporator coils (shaded pole, PSC, or ECM),evaporator controls, and type of refrigerant.

3.1.3 Steam/Hot Water End Uses (Conventional Boiler Use)

In each case, the engineer first determined whether the boiler is the only (or predominant) source of gas consumption on a single gas meter (or facility).If so, the engineer used the gas utility bills to determine the total system energy consumption. If there were multiple gas uses on the same meter, the engineer calculated boiler energy consumption by determining boiler(s) size by checking the nameplate, recent inspection/maintenance documents, and as-built plans. When needed, the engineer obtained the horsepower or capacity rating using the make and model number of the boiler.

To estimate how much energy is being transferred into the distribution system as opposed to being lost to the environment, the engineer assessed the boiler(s) efficiency using the following methods (listed in order from ideal to adequate):

- Check SCADA system for gas input and steam output values.
- Check for flow meters showing instantaneous readings on gas input and steam output (ensure this is undertaken during the production process).
- Check maintenance logs to see if the facility recently conducted a tuning/combustion analysis that measured efficiency.

Once the engineer estimated the total energy in the distribution system, they used the following methods to calculate the energy distribution between production equipment and system losses caused by leaks, heat loss, etc. (listed in order from ideal to adequate):

- Check SCADA system for flow trends to all equipment.
- Check for flow meters on each branch of the system showing instantaneous flow readings and compare to equipment operating conditions. The engineer recorded heat exchanger efficiencies to account for waste heat.
- Check production equipment or heat exchangers for flow requirements.

Finally, the engineer assigned a standard system loss factor (ranging from five percent to fifteen percent based on engineering judgment of the condition of insulation, leaks, and other visual inspection) to account for leaks and other distribution losses.

3.1.4 Process Heating (Process Heating)

Process efficiency is commonly rated by the fuel used/product made. The engineer first attempted to obtain annual production data from the facility (if personnel were willing to provide). If this could not be obtained, the engineer would: (1) check the SCADA system for relevant input power consumption; (2) obtain equipment specifications (size, efficiency, etc.); and (3) estimate consumption patterns based on equipment operator interviews.

3.1.5 Space Conditioning (Facility HVAC)

Conventional HVAC loads typically represent a small portion of an industrial facility's energy consumption.[14] Typically, only a small portion of a facility site is conditioned (such as the administrative and/or operations offices). The field engineers obtained nameplate data for HVAC equipment, where accessible, and gathered operational schedules and setpoints for conditioning. The analysis consisted of a simplified bin analysis to estimate equivalent full load hours, which the engineer then multiplied by each unit's heating or cooling capacity to estimate total consumption. The engineer also reviewed each facility's utility billing data to estimate whether there are out-sized seasonal impacts not reflected in the HVAC consumption calculations.

3.1.6 Lighting (Facility Lighting)

Typically, lighting represents a small portion of industrial facility energy consumption,[15] so field engineers first determined the lighting power density for each representative space in the facility, then extrapolated that value to similar spaces. This entailed calculating the facility space area with a laser range-finder, recording the lamp and ballast information for each fixture, counting the number of fixtures installed, and determining whether fixtures are affected by lighting controls. The engineers also estimated lighting hours of operation for each site based on site interviews, monitoring, or data obtained through the SCADA system.

3.2 Data Security

In conjunction with the working group process, the Cadmus team also developed data security and client confidentiality procedures to protect the privacy of data collected as part of the IFSA. The Cadmus team treated any data received from either utilities or participants as highly sensitive and kept it safeguarded.

3.2.1 Data Security Methods

The Cadmus team used a standardized process for sharing electronic data in a secure manner. We used a secure-FTP to transport data to and from the team's highly secure data center. The overall data structure was limited to the four members of Cadmus' Data Security team and the NEEA project manager. All members signed non-disclosure agreements with NEEA to protect the security of the information.

[14] As shown in MECS data: http://www.eia.gov/consumption/manufacturing/data/2010/
[15] As shown in MECS data.

The Cadmus team conducted criminal background checks on every field engineer. The team also used the following procedures to maintain the physical security of any data received:

- Field engineers did not store any site data on a flash drive.
- Field engineers did not leave laptops or hard copies of site data unsecured in their vehicle. If the field engineer needed to bring this material along, they either kept it in their physical possession or locked it in the trunk.
- Field engineers left sensitive materials locked in a safe in their hotel room, if a safe was available.
- If a field engineer stored site data on a laptop computer, they password-protected that laptop.
- Field engineers password protected any cell phone that received site data through an e-mail account.

3.2.2 Confidentiality

The Cadmus team collected facility-level data from utilities and, where necessary, assumed responsibility for coordinating with utilities and compiling consumption histories. This information was an essential component of the data collection effort and a critical element of the database.

In addition, because many industrial facilities had proprietary processes and intellectual property they wished to protect, the Cadmus team negotiated a non-disclosure agreement with any facility that requested it, although this was rare. In conjunction with and based on feedback from the Data Security/Confidentiality Protocols working group, the Cadmus team determined which specific individuals should have access to this information through the database, and how the assessment data would be disseminated.

The Cadmus team is providing data for future planning efforts in aggregate, without specific identifying information for any facilities, such as state, production data, or product. The Cadmus team has not and will not make any raw IFSA data or information publicly available at any point: this includes any end-use consumption data that has not been normalized by the number of employees.

The Cadmus team will release site data fields for planning efforts by groups such as the NPCC that include:

- NAICS code
- Estimated annual energy consumption by end use in kWh per employee (or unit of production) for electric consumption and in MMBtu[16] per employee (or unit of production) for gas consumption
- Whether the facility is served by a public power entity or investor-owned utility

Utility organizations will receive customized site reports for individual facilities within their service territory. These site reports will contain un-normalized consumption data based on annual billing data the utility provided to the Cadmus team.

3.3 Operational Practices Survey

The Cadmus team obtained information on energy management strategies, high-efficiency equipment, and operational practices related to energy use. The team developed a brief on-site survey to obtain these details, using the survey to quantify the potential for SEM. Through this survey, the Cadmus team also measured the persistence of energy management practices for facilities that have already implemented SEM. The survey was not intended to identify or measure a relationship between the presence of energy management and energy savings.

[16] MMBtu = millions of British thermal units

3.3.1 Measuring SEM Adoption

The Cadmus team worked with NEEA and the Data Collection working group to develop the survey instrument and a methodology to score the survey results in terms of measuring SEM adoption. At the time of survey instrument development, NEEA's definition of SEM included three major categories:[17]

1. **Customer commitment.** These activities include SEM support and communication from top management, proper resources allocated to SEM, regular review of the SEM program, and staff awareness of SEM.

2. **Planning and implementation.** These activities include conducting a facility energy audit, tracking energy consumption, setting goals for energy performance improvement, developing an energy management plan (and regularly assessing or revising the plan), engaging employees in energy-efficiency activities, and implementing energy projects.

3. **Measurement, tracking, and reporting (MT&R).**These activities include regularly measuring energy performance and tracking progress toward energy performance goals.

3.3.2 Survey Instrument

The survey instrument asked respondents about the following topics:

- Current or previous participation in a SEM program
- Extent of current energy management practices
- Management support with SEM
- Allocation of resources toward SEM activities
- Motivation behind energy-efficiency projects
- Tracking of energy consumption
- Review of progress toward the energy performance goal
- Existence of an energy management plan
- Interest in SEM adoption

The survey instrument can be found in Appendix D. Cadmus team engineers conducted the surveys during the on-site visit or in a follow-up phone conversation.

[17] This was NEEA's definition at the time of survey development in 2013. Recently, the Consortium for Energy Efficiency released its definition of minimum elements for SEM (CEE 2014). This guidance document was not available at the time Cadmus developed the survey instrument and scoring methodology. However, the two definitions are sufficiently similar to allow analysis based on the CEE definition to be conducted on data collected from a questionnaire based on the NEEA definition (see Table 9 below).

3.3.3 SEM Scoring

The Cadmus team developed the SEM scoring methodology based on the Consortium for Energy Efficiency SEM Minimum Elements. The methodology was developed in collaboration with NEEA and BPA staff. An overview of the scoring approach is shown in Table 9.
We grouped the questions in three categories as Customer Commitment, Planning and Implementation and MT&R as described in Section 3.3.1. The Cadmus team categorized SEM adoption for each category as "Full", "Some" and "None" based on respondent's answers on the IFSA Operational Practices Survey.

Table 9. SEM Adoption Scoring Overview

SEM Category	Corresponding Question(s)	Full	Some	None
1. Customer Commitment				
Policy and Goals	EM16	EM16 = 1	Any other response combination	EM16 = 2 or -99
Resources	EM5, EM6, EM7, EM8	(EM5 > 1 OR EM6 > 1) AND (EM7 < 4 OR EM8 < 3)		(EM5 = 1 AND EM6 = 1) AND (EM7 = 4 or -99 AND EM8 = 3 or -99)
2. Planning and Implementation				
EM Assessment	EM9	EM9 = 1 or 2	Any other response combination	EM9 = 3 or -99
Energy Map	EM15	EM15 = 1, 2, or 3		EM15 = 4 or -99
Metrics & Goals	EM16	EM16 = 1		EM16 = 2 or -99
Project Register	EM17	EM17 = 1 or 2		EM17 = 3 or -99
Employee Engagement	EM10	EM10 = 1, 2, 3, or -77		EM10 = -98 or -99
Implementation	None			
Reassessment	EM17a, EM19	(EM17a = 1, 2, or 3) AND (EM19 = 1 or 2)		EM17a = 4 or -99 AND EM19 = -99
3. Measurement, Tracking, and Reporting (MT&R)				
Measurement	EM15, EM15a, EM15b, EM18	EM15 = 1, 2, or 3 AND EM15b = 1, 2, 3, or 4	Any other response combination	EM15 = 4 or -99
Data Collection & Availability				
Analysis				
Reporting	EM20	EM20 = 1		EM20 = 3 or -99

In addition, the survey included questions about a respondent's willingness to adopt SEM in order to assess the market potential for SEM. The Cadmus team asked if respondents were interested in doing more to manage energy and whether they would be interested in participating in a program that offered long-term technical support to develop and implement a SEM plan. The Cadmus team didn’t include the questions related to respondent’s willingness in SEM adoption scoring; however, this information is useful for future regional energy-savings potential studies.

4 Utility and Participant Outreach

The Cadmus team and working group members recognized that one of the most critical aspects of the study revolved around participant outreach. The likelihood of establishing a good response rate among industrial customers of NEEA's utility partners was predicated upon ensuring utility partners had complete visibility over this process and that customers understood the following details:

- What (if any) benefits they might derive from the study;
- How much of their staff time was being requested to facilitate the study;
- Why the Cadmus team was collecting the relevant data;
- How that data would ultimately be used; and
- Who would have access to that data.

The Customer Contact Protocols developed through the working group sessions can be found in Appendix F.

4.1 Utility/Stakeholder Engagement and Coordination

The key first step in the outreach process involved notification and education for utility representatives and other regional stakeholders, such as staff associated with the Bonneville Power Administration, Energy Trust of Oregon, and Northwest Power and Conservation Council. NEEA staff provided early notification to regional stakeholders during the study's solicitation process to highlight that the study would be occurring in the near future. In February 2013, NEEA staff conducted a webinar and provided information on the scope of the IFSA, the purpose of the study, and expected outcomes to regional stakeholders. In addition, a Q&A period provided time for stakeholders to ask specific questions. Several of these stakeholders assisted in evaluating proposals submitted by contractor teams and participated in best-and-final interviews with potential contractors. Many more stakeholders participated in the protocol development working groups to shape the study's scope and methodology. A select group of utility representatives assisted in conducting outreach for pre-test assessments to ensure that the draft protocols functioned as expected.

After the working group meetings concluded, NEEA convened a regional webinar for representatives from utilities with facilities in the final sample to provide more detail on the final protocols and to outline expectations of support from utility representatives. Participation in the IFSA study was optional for each utility, but NEEA attempted to encourage 100 percent utility participation. NEEA staff noted that all building stock assessments, including those involving industrial sites, are based upon ensuring a representative sample across the Northwest. From a research design standpoint, allowing entire service territories within the region to opt out would diminish the ability to collect data from a truly representative sample. The working group agreed that exceptions should include facilities engaged in ongoing litigation with their utility, or facilities that had previously been visited multiple times for energy-efficiency audits.

NEEA staff provided representatives from each utility with a list of sample sites in their service territory. NEEA requested that each representative confirm the following details for each site:

- Was the site in their territory?
- Was the site still active?
- Did the utility have a key account manager or other staff member with knowledge of the site?
- Would the utility or the Cadmus team perform the initial contact with the site?

NEEA staff provided weekly updates on the process to interested stakeholders through weekly e-mail updates. NEEA also facilitated monthly update meetings to keep stakeholders apprised of study progress, findings, and issues. For example, the first monthly update meeting provided a summary of pre-test results and resulting recommendations. NEEA staff also maintained ongoing communication and coordination with utilities to address utility or participant concerns and questions, pass on data requests from the Cadmus team, and track study progress. Through ConduitNW.org, NEEA made all monthly meeting notes or other relevant materials available to stakeholders.

4.2 IFSA Value Proposition

A major focus of the working group discussion revolved around the value proposition for both the utilities and potential participants. The utility representatives and regional stakeholders on the working group affirmed that the study results can provide valuable data to the region on industrial consumption patterns. However, they acknowledged that most industrial facilities may not be motivated by that knowledge.

The Cadmus team, NEEA, and the working group members suggested various approaches to create a meaningful value proposition to motivate potential participants. Cadmus condensed the proposed approaches into the following list, which was conveyed to potential participants through the FAQ document.

- Each participating facility would receive a site-specific report containing results of the analysis. This could be used by the participant to gain a better understanding of how energy is used within their facility, as well as how it compares to their specific industrial sector.
- Participants would have an opportunity to discuss potential energy efficiency improvements with an independent engineer who was not a vendor promoting a particular type of equipment. A list of identified energy efficiency opportunities would be included with the site-specific report.

- The end use consumption analyses could provide better methods for utilities to serve their industrial facility base with more targeted efficiency opportunities based on specific industrial sectors.

- The information could also allow the region to more effectively characterize current energy loads, plan to meet future loads, and ideally avoid expensive new power generation facilities that raise utility rates.

Energy Trust of Oregon introduced a financial incentive plan to further improve the value proposition for participants. Energy Trust of Oregon agreed to provide an additional ten percent incentive for participants to implement any one energy-efficiency measure that was identified as part of the IFSA on-site assessment.

The working group did not recommend additional financial incentives as part of the protocol. However, during the initial stages of IFSA implementation, NEEA added a $250 incentive for each site to participate in the study. NEEA made this retroactive for facilities that agreed to an assessment prior to the incentive's introduction.

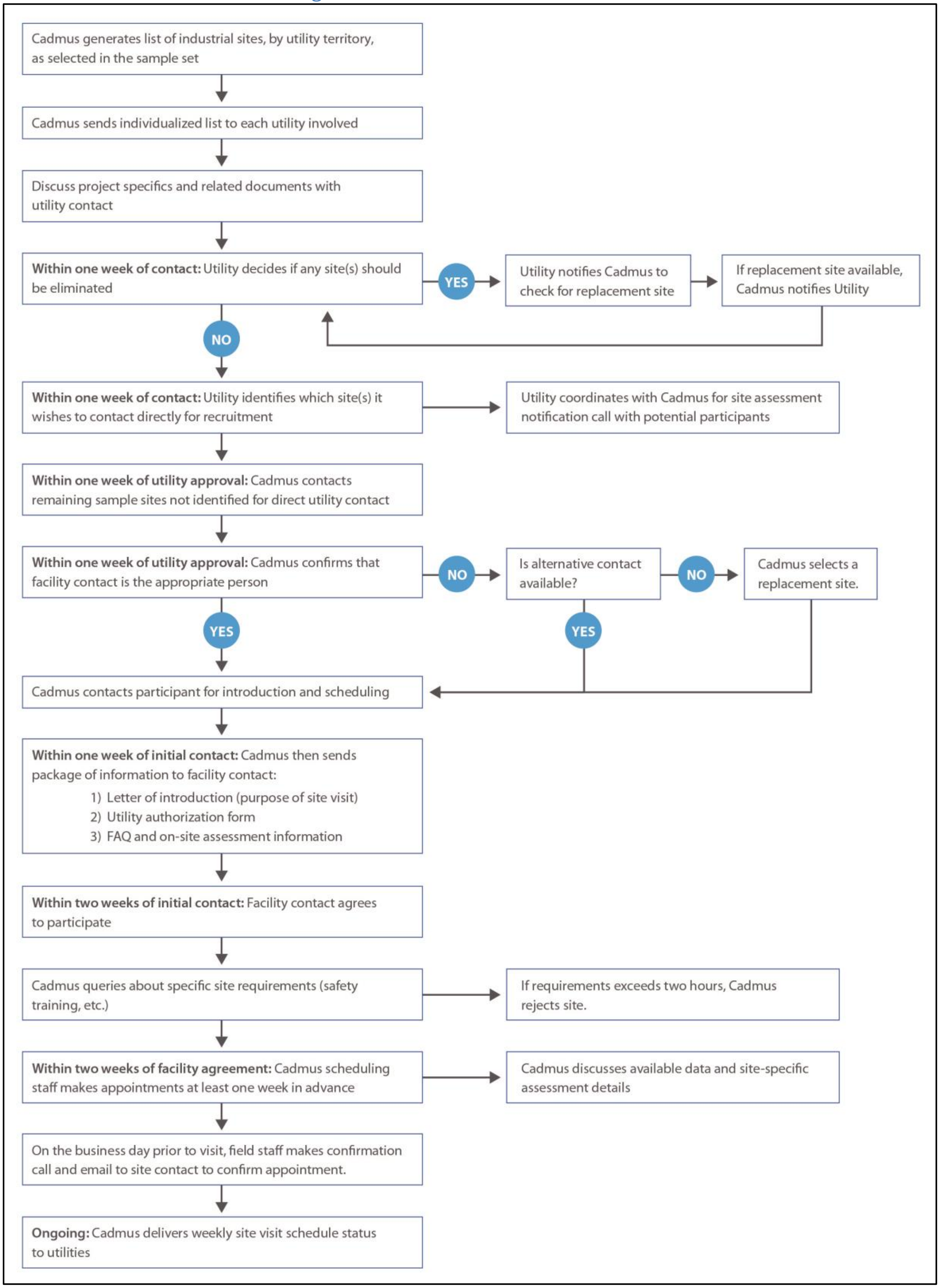
4.3 Utility and Participant Contact

The Cadmus team attempted to engage utility support to reach potential participants and recruit them for the study. The sample sites included data from the Industrial Database that listed the relevant utility serving the site. NEEA attempted to contact each utility to, ideally, connect the Cadmus team to the facility's account executive or energy efficiency representative, if one had been assigned. This process varied based on each utility.

In the Cadmus team's experience, utility customer-facing staff often possesses detailed knowledge of the facilities they work with, particularly among large industrial sites. This information can include the best contact with whom to arrange an on-site visit, as well as some of the preliminary assessment data (such as the facility's management structure, approach to energy management, and participation in utility incentive programs). At a minimum, the Cadmus team expected the utility to provide facility contact information sufficient to arrange an on-site visit.

The resulting utility and participant contact process is outlined in the decision tree on the following page.

Figure 1. Decision Tree for Outreach Process



The Cadmus team refined the following site visit scheduling guidelines with the working group:

1. Site-visit recruiting calls made by the Cadmus team to facilities based on the coordination process described below.

2. The Cadmus team provided information on sampled sites to the corresponding utilities as far in advance as possible. This list contained information as collected from within the Industrial Database, including firm/company name, address, facility contact information and title, as well as basic consumption information.

3. The utility was provided the first option to make the initial customer contact. If the utility chose this option, the utility then identified for the Cadmus team which sites they wished to contact. For those customers agreeing to participate, the utility coordinated site visit scheduling with the Cadmus team. Cadmus team scheduling personnel contacted those sites not identified for direct utility contact.

4. The person making the initial customer contact to schedule the visit confirmed that the facility contact was familiar with the facility and the end-use operational parameters to be verified. If the initial contact did not have this knowledge, the Cadmus team sought an alternative contact.

5. Upon agreement to participate, Cadmus asked the contact about specific site requirements to be satisfied prior to walking on site such as a safety briefing, background check, special clothing, etc.

6. At the time of scheduling, ,the Cadmus team exchanged contact information (such as name, telephone number—including cell phone—and e-mail address) so each party had the needed information if rescheduling the visit became necessary.

7. To give the customer adequate notice, schedulers attempted to make appointments at least one week in advance, providing more advance time if possible. On the business day before the visit, field engineers made confirmation calls, as necessary, to the site contact to confirm the appointment.

8. The Cadmus team requested from the participant any available data on energy-using systems, their efficiency, operating hours, and operating patterns throughout the year. The Cadmus team also requested copies of previous energy studies performed, as well as the status of energy efficiency upgrades. The Cadmus team's lead engineer worked with the participant to refine an appropriate on-site scope based on participant availability and time requirements.

9. The Cadmus team provided a utility data authorization form to be signed by the participant for the purpose of obtaining utility billing history in support of the energy use analysis.

After scheduling a site, the Cadmus team scheduler also provided the participant with contextual documentation on the IFSA study. The full FAQ document summarized the IFSA details presented in this report. The Cadmus team also provided the participant with a proposed agenda of on-site activities, the titles of various staff the team hoped to meet with, and a list of data the team hoped to obtain. These documents can be found in Appendix F.

5 Study Implementation

After developing protocols through the working group process, the Cadmus team tested and implemented those protocols. The pre-test results then informed the final protocols, which the Cadmus team applied to the full population of sample sites. The Cadmus team had to perform several additional sample draws due to dwindling available sample sites resulting from issues with the sample frame, participant and utility refusals, and difficulties in connecting with site contacts. As a result, the Cadmus team completed eighty-seven assessments out of the expected 120.

5.1 Pre-Test

At NEEA's request, the Cadmus team conducted a pre-test of the IFSA protocols starting mid-July through a limited number of initial assessments. The intent of the pre-test was to evaluate the contact protocols and general data collection processes, identify potential gaps in the processes, and use the results to incorporate any necessary modifications into the full study.

5.1.1 Pre-Test Process

The Cadmus team reached out to several utilities with representatives who participated in the working groups, and were therefore familiar with IFSA scope and process. The Cadmus team identified several sites from the primary sample draw for each utility. The Cadmus team outlined for the utility representatives the relevant details of the pre-test and expectations, and asked them to help recruit sites. NEEA convened a regional kick-off webinar for all sampled utilities for early September. The Cadmus team determined that all initial recruitment and field work would need to be completed by mid-August to allow sufficient time for analysis prior to the kick-off. The Cadmus team was able to recruit two study participants by the deadline. Several of the participants initially contacted for the pre-test later had assessments completed during the full study roll-out.

5.1.2 Pre-Test Results

The Cadmus team provided to utilities and stakeholders information relevant to the results of the pre-test and potential suggested changes to the protocols. In general, Cadmus determined the protocols functioned as expected. Key findings are noted below.

5.1.2.1 Sample Frame Limitations

The pre-test enabled the Cadmus team to identify several limitations with the sample frame that required removal of more than half of the pre-test sample projects. Out of the initial pre-test sample of eighteen projects, the team found:

- The sample frame listed incorrect NAICS codes for three projects. The correct codes did not fall within the twelve NAICS codes in the IFSA study.

- The utilities reported that four facilities were "inactive."

- Cadmus' research and contact attempts found that another three facilities were no longer in operation.

The Cadmus team found that the sample frame significantly overstated the number of employees at the two sites where the team conducted pre-test assessments. Evergreen modeled the facility's electricity consumption based on the employment data reported by InfoUSA, so those data were also overstated.

- For the first pre-test site, the sample frame listed 300 employees. The site actually employed 40 people.

- The second site listed 3,600 employees; there were actually 450.

A full comparison of sample frame and verified employment for all assessed facilities can be found in section 5.4.2.

5.1.2.2 Customer Contact

The response and coordination support varied among the small selection of initial utilities. Most utilities were able to arrange initial conference calls and discussions with key facility staff to introduce the IFSA and discuss next steps. Key account managers at utilities who expressed strong support for the IFSA were particularly helpful in moving the process forward.

The Cadmus team found the FAQ and On-Site Assessment documents were very helpful in providing context up-front for the participants, particularly when the documents were sent to participants for review prior to the conference call.

The Cadmus team spoke with five facilities, with the following results.

- Two contacts agreed to assessment

- One contact initially agreed but was overruled by his facility's plant manager, who said the study would not be an effective use of staff time.

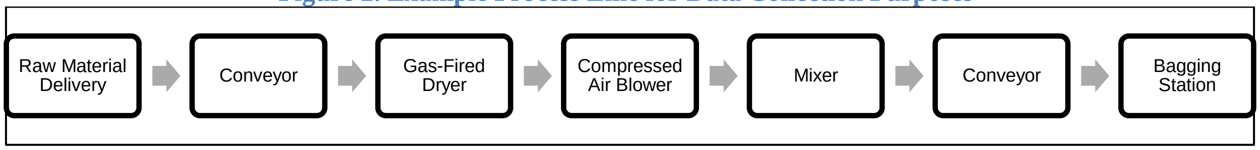
- Another was not interested in the value proposition. His facility already performed significant submetering and had detailed data on energy use. This contact was non-responsive after the conference call.

- The last site contact expressed concern that the Cadmus team would not conduct metering. He doubted the value of study data without metering and was non-responsive following the conference call. However, he later did allow the Cadmus team to conduct an assessment.

5.1.2.3 Data Collection

Based on working group review and feedback, the Cadmus team created detailed data collection instruments. The pre-test identified some efficiency issues with data collection forms. The original data collection forms requested data for one specific equipment end use. The forms proved to be impractical to apply in the field. While in the field, the Cadmus team determined the actual on-site assessment process should be focused on systems rather than end uses. As an example, Figure 2 shows an example process line.

Figure 2. Example Process Line for Data Collection Purposes



Each stage of this process line involved different equipment end uses, but all experienced the same number of operating hours. The team found it was more time-efficient and less burdensome on facilities to track equipment type, size, efficiency, etc., on a pad of paper as the team mapped out systems, rather than enter equipment data on the different sheets.

The Cadmus team received excellent cooperation from on-site facility staff on both assessments. The first site had both plant managers for the full tour and assessment process. The second site provided knowledgeable staff for each of four on-site field engineers from the Cadmus team. Both sites readily provided the previous year's production data. The assessments also proved to be less time-intensive than expected for both facilities. Cadmus completed the first site in half a day with three engineers and the second site in half a day with four engineers. It proved to be relatively easy to identify the most significant loads during the plant tour and focus data collection efforts on those end uses. In general, a full audit with end use metering would provide more accurate data, but the working group members determined that the level of detail obtained through the assessment was reasonable for the available budget.

The field engineers identified numerous measures to highlight the value proposition for the participant facilities. A full list of measures identified for each NAICS code can be found in Appendix H.

For the first site, the potential opportunities identified by the Cadmus team included:

- Provide insulation for uninsulated pipes on steam system;
- Conduct compressed air system audit to reduce pressure from a relatively high level (130 psi);
- Convert from air cooling to water cooling for air compressor to preheat steam system.

This participant noted additional opportunities they had been considering. The utility key account manager had accompanied the assessment team, and arranged to send an implementation engineer to establish baselines and quantify some of the identified opportunities.

On the second site, Cadmus identified the following potential opportunities:

- Install inverters on duty welders;
- Install variable frequency drives (VFDs) on vacuum pumps;
- Upgrade lighting systems in various buildings that have not yet received upgrades;
- Rebalance dust collection systems and possibly reduce speed with a VFD;
- Replace hydraulic presses with electric.

5.1.3 Pre-Test Findings and Recommendations

In general, the pre-test confirmed that the IFSA protocols functioned as intended and could result in significant value to the study, the participant facility, and the utility. Based on the pre-test results, the Cadmus team developed the following recommendations to adjust protocols.

5.1.3.1 Customer Contact

Utility account representative engagement and support was a critical factor in overcoming potential initial resistance. It is preferable for the utility representative to be supportive of the IFSA rather than neutral. A financial incentive could help overcome resistance to the time required by facility staff to support the assessment. Some facilities wanted more than the proposed value proposition.

5.1.3.2 Data Collection

The Cadmus team and the working group agreed there should be less emphasis on data collection forms. The plan for future assessments would involve tracking system-level equipment impacts. The analysis workbook would still require data entry using the format of the original data collection forms.

5.2 Full IFSA Study Implementation

Following the pre-test and minor protocol adjustments, the Cadmus team commenced full implementation of the IFSA study. NEEA and the Cadmus team coordinated to provide each utility with the list of primary and back-up sample sites in their service territory.

In many cases, utilities were able to provide facility contact information, arrange conference calls with potential participants, or arrange e-mail introductions. In the case of some sampled sites, the facility's annual energy consumption was too low for the utility to define it as an industrial facility, and the utility did not have staff members who were directly familiar with the site. In other cases, the utility did not have staff available to conduct initial contact. In both of those cases, the utility provided consent for the Cadmus team to reach out directly to potential participants.

Some participants were resistant to allowing on-site assessments without additional incentives. NEEA staff approved additional budget to provide a $250 gift card for each participating facility. The Cadmus team informed the facilities that the gift card was intended to be used to provide a team meal, purchase new tools or equipment, or provide some other reward for facility employees. However, there were no restrictions on how the card could be used. Some facilities became creative with the gift cards. For example, right before Christmas, one facility raffled off the gift card among its employees.

Potential participants displayed mixed reactions to the gift cards. Some appreciated the gesture and thought it appropriate to reward employees for their support of the study. Others said that $250 was a minor amount compared to their annual revenues and was not an appropriately large incentive. While some sites continued to refuse assessments, many still participated even though they did not consider the gift card to be meaningful compensation. One facility even refused the gift card, which they felt was inappropriate. The Cadmus team donated that facility's gift card to charity.

As noted previously, Energy Trust provided a coupon for an additional ten percent incentive to implement any measures identified as part of the IFSA on-site assessment. Several Energy Trust sites still refused to respond or declined to participate, but a large number stated the additional incentive did motivate them to participate. Anecdotally, the coupon did provide a strong value proposition to increase study participation.

5.3 Final Sample Disposition

The Cadmus team conducted three additional sample draws because of the unexpectedly large number of sites removed due to inaccuracies in the sample frame, sites which the team was unable to reach, and refusals. During each draw, the Cadmus team identified the specific outstanding stratum and NAICS code combinations for which the team needed additional sample sites. Where possible, the team randomly selected additional sites to fill those gaps. The Cadmus team only selected sites from utilities that had been previously contacted as part of the IFSA study due to the significant level of education and coordination required to bring a new utility into the study. The final sample draw included a total of 506 sites. Table 10 shows the disposition for each site.

Table 10. Final Disposition of IFSA Sample Draw

Site Disposition	Quantity of Sites
Completed assessment	82
Partial assessment	6
Completed stratum and NAICS	90
Declined to participate	89
No response to contact attempts	80
Not industrial facility	77
Inactive facility	27
Incorrect NAICS code	12
Not a NEEA funder	10
Removed for miscellaneous reasons	999
Duplicate entry	4
Utility asked not to contact facility	3
Utility declined to participate	15
Site refused to provide account data	2
Total Sites in Sample Draw	506

Explanations for each disposition type are as follows:

- Completed assessment: The Cadmus team conducted the on-site assessment and gathered sufficient data to develop annual end-use energy consumption estimates.

- Partial assessment: The Cadmus team conducted the on-site assessment, but either did not achieve access to the entire facility or did not receive sufficient information from the participant to develop annual end-use energy consumption estimates. As noted in the Data Collection Methodology section, SCADA trends and facility equipment inventories represent data sources with lower levels of uncertainty in end use consumption estimates. The facility contact at most of the partial assessment sites offered to send the team low uncertainty data to supplement the analysis so that the field engineer would not need to perform an on-site equipment inventory. However, in these cases the facility contact did not provide the data and could not be reach for follow-up. The team therefore could not complete the full analysis and omitted the site from final results.

- Completed stratum and NAICS: The Cadmus team developed samples specific to the various strata within each NAICS code. Each NAICS/stratum combination (e.g., 327 Large) had a set number of sites on which to conduct assessments. The team sought to avoid over-representation in any NAICS/stratum combination. Therefore, after all sites had been scheduled in a particular NAICS/stratum combination, Cadmus removed any additional sites in that combination from the sample.

- Declined to participate: Participants refused participation for a wide variety of reasons. Some of the most frequent reasons are listed below.
    - The assessment would require too much time or effort from the facility's staff.
    - The facility was involved in time-sensitive activities that would not be complete until the study's recruitment period ended.
    - The facility had had a number of energy efficiency audits performed previously, and did not think the assessment would add value beyond that.
    - A higher-level decision-maker than the Cadmus team's contact vetoed participation in the study.
    - The value proposition and gift card did not represent sufficient incentive to convince them to participate.
- No response: In many cases, participants did not respond to contact attempts through voice-mail and e-mail. The Cadmus team often found it difficult to identify the appropriate site contact for sites at which the utility could not provide an introduction.
- Not an industrial facility: The sample frame included more than 18,000 records for individual sites that were supposed to represent industrial facilities. In the sample of 506 sites, at least fifteen percent of those were not actually industrial. The non-industrial sites varied from residences to retail establishments to former industrial sites that had been converted to other uses.
- Inactive facility: The Cadmus team identified sites that were no longer in business based on feedback from utility staff or Internet research.
- Not a NEEA funder: The sample frame included one utility from outside the geographic region that NEEA represents. The Cadmus team removed these sites from the sample because they were not intended to be part of the IFSA population.
- Duplicate entry: The sample frame included several duplicate sites.
- Utility asked not to contact facility: Several utilities identified a facility in their territory that had either been studied intensively previously or was considered too sensitive to approach. At the utility's request, the Cadmus team removed each site from the sample.

- Utility refused to participate: Three publicly owned utilities with one site each and one investor-owned utility with twelve sites declined to participate in the IFSA study and requested no contact be made with any customers within their service territory. Cadmus removed these sites from the sample.

- Site refused to submit account data: Two sites agreed to allow field engineers to perform an assessment. Afterward, the Cadmus team sent the utility authorization form to the participants. However, the participants refused to provide their utility account number. The utilities involved could not provide the utility billing data to the Cadmus team until the participant released the account number. After several contact attempts, the utilities asked the Cadmus team not to contact the participants again.

5.4 Final Sample by NAICS and Stratum

The final sample achieved is shown in Table 11 below.

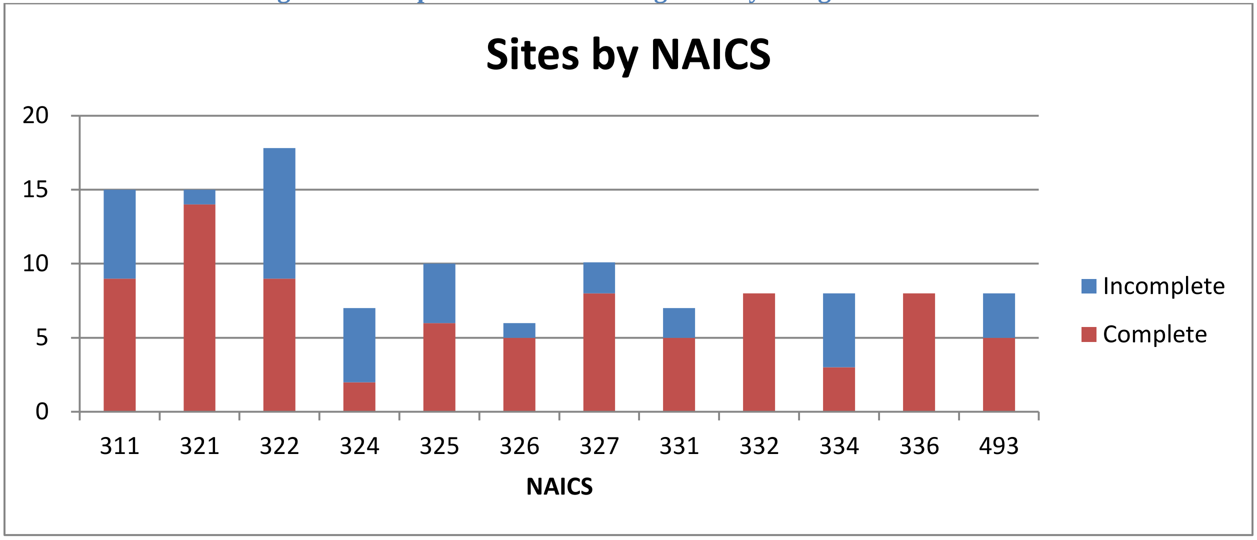
Table 11. Final Sample by 3-Digit NAICS Code and Stratum

NAICS	Industry Sector	Census	Large	Medium	Small	Total
311	Food Manufacturing		2	7	2	11
321	Wood Products Manufacturing	1	5	4	5	15
322	Paper Manufacturing		1	3	5	9
324	Petroleum and Coal Products Manufacturing			2		2
325	Chemical Manufacturing		1	3	2	6
326	Plastics and Rubber Products Manufacturing		2	2	1	5
327	Nonmetallic Mineral Products Manufacturing		1	5	2	8
331	Primary Metal Manufacturing	1	2	2	1	6
332	Fabricated Metal Products Manufacturing		3	3	2	8
334	Computer and Electronic Products Manufacturing		1	2		3
336	Transportation Equipment Manufacturing		2	5	1	8
493	Refrigerated Warehousing and Storage	2	2	1	1	6
	Total	4	22	39	22	88

ts section for each NAICS code.

Figure 3 shows the comparison between the completed sample and original goal by three-digit NAICS code. The Cadmus team was able to complete the full set of assessments for 321 (Wood Products), 332 (Fabricated Metal Products), and 336 (Transportation Equipment). Cadmus experienced varying levels of success on most other NAICS codes, with particularly difficulty in recruiting and completing assessments for 322 (Paper), 324 (Petroleum and Coal Products), 325 (Chemical), and 334 (Computer and Electronics). The challenges associated with achieving the full sample for these codes are outlined further in the Analysis and Results section for each NAICS code.

Figure 3. Completed and Remaining Sites by 3-Digit NAICS Code



5.4.1 Oversampling

In some cases, participants from completed strata replied to the Cadmus team weeks or months after the initial contact attempt. These participants generally expressed enthusiasm for the opportunity to conduct an assessment of their energy consumption and potential efficiency opportunities. In consultation with NEEA, the Cadmus team determined it would be best to conduct those assessments for the sake of customer service, even if it resulted in oversampling in a specific NAICS / size stratum. Where possible, the Cadmus team would remove a sample point from a lower-size stratum in the same NAICS code to ensure a consistent sample size for each NAICS code.

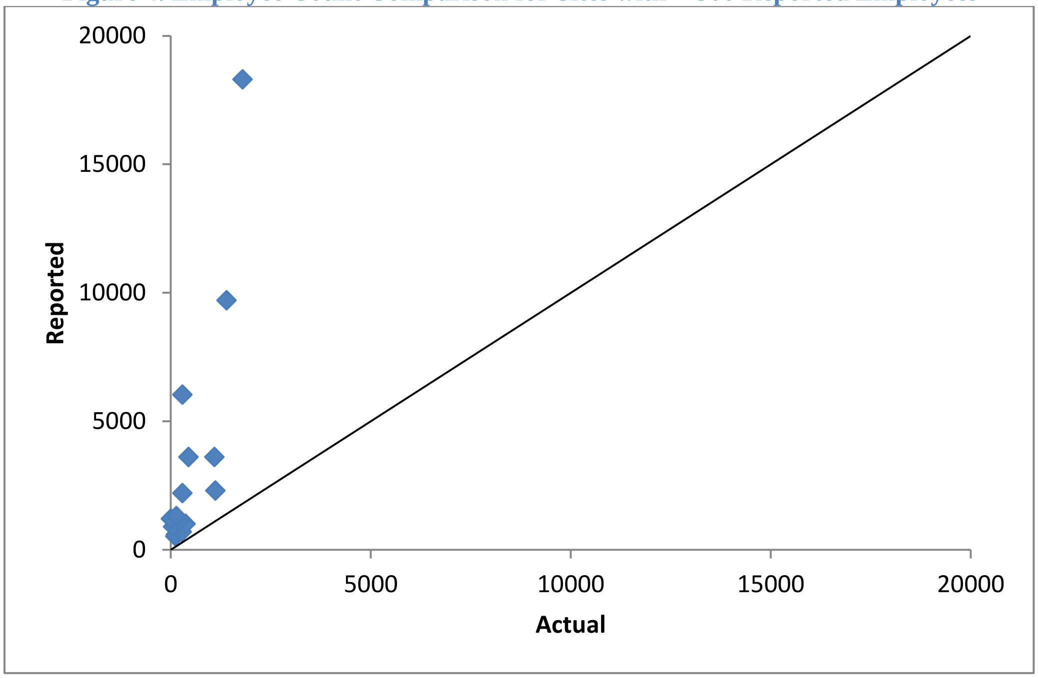
As an example, a Large 332 NAICS participant was contacted and eventually reached out to the Cadmus team, indicating they wanted to conduct the assessment and receive the Energy Trust ten percent incentive bonus. By this time, Cadmus had already completed the sample for this stratum/NAICS combination. The Cadmus team chose not to create a customer service issue and allowed the assessment. The team then removed one of the Small 332 sites from the sample.

Cadmus found the sample frame used to draw sites may not be reliable for the NAICS and size distribution. Therefore, Cadmus believed it was important to keep the sample within the same NAICS code, but the stratum was less important. The Cadmus team also attempted to include larger facilities as replacement, rather than small facilities, for the oversampling, which should add more detail to the analysis.

5.4.2 Variance between Sample Frame and Verified Employment

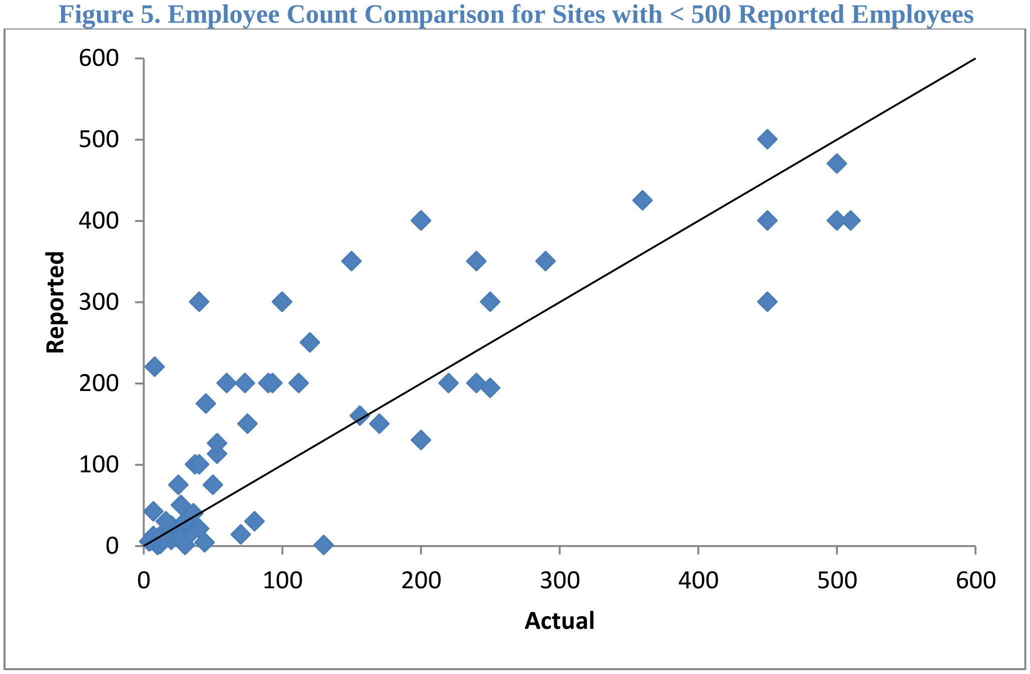
As noted in the pretest section, the Cadmus team found a large degree of variance between the assumed employment numbers in the InfoUSA sample frame and the actual employment reported by each site. The variance was particularly pronounced at sites for which the sample frame reported more than 500 employees (eighteen percent of the total sample frame), as shown in Figure 4. The actual employment figures were generally ten to twenty percent of the reported value. The solid line indicates the hypothetical case in which the reported value equaled the verified value.

Figure 4. Employee Count Comparison for Sites with > 500 Reported Employees



The variance was less pronounced at sites for which the sample frame reported fewer than 500 employees (eighty-two percent of the sample frame). The comparison is shown in Figure 5.

Figure 5. Employee Count Comparison for Sites with < 500 Reported Employees



These results raised concerns for the Cadmus team on the reliability of the sample frame employment and energy consumption projections. The employment projections were one input used to develop the sample frame energy consumption estimates, which also varied by similar margins as the employment estimates.

5.5 Analysis and Normalization

The Cadmus team calculated end-use energy consumption through the data collection process and utility bill calibration. For reporting purposes, the team normalized the end use consumption for each stratum and NAICS code by dividing the end use consumption by the number of employees at the facility. The Cadmus team and the working group determined this process was necessary to maintain the anonymity (and associated competitive details) of each facility's consumption, although the team accepted that the normalization process could distort per site end use consumption estimates.

To start, the Cadmus team redefined the NAICS code strata based on actual utility billing data, rather than the modeled estimates from the sample frame. Overall facility energy consumption was generally smaller than in the sample frame, but most of sites stayed in the same stratum within which they had originally been placed. Occasionally the team found it necessary to reassign a stratum based on site's actual consumption.

For each NAICS code, the Cadmus team then calculated a weighted average end use consumption for each stratum based on the following calculations. Cadmus multiplied the calculated consumption by number of employees for the various end uses for each facility within a stratum. The team summed the resulting values for each end use, and divided that value by the total number of employees for facilities in the stratum. This resulted in a weighted average consumption for each end use in each stratum.

Cadmus also calculated the weighted average end use consumption for the entire NAICS code using the same process for all facilities in the NAICS code. The team further weighted each sampled facility's consumption by its representation in the overall population. For example, if the team sampled four Medium 332 sites out of a total population of twenty Medium 332 sites, each sample point would represent five more sites in the population. The team therefore multiplied the impact of the sample by its weight in the population to develop a true weighted average.

5.6 Site-Specific Report

The Cadmus team completed a site-specific assessment report for each facility that allowed on-site data collection and authorized obtaining utility billing data. Cadmus provided each site-specific report to both the participant and its utility. The site report included the following sections to enhance the study's value to the participant and the utility:

- IFSA description and scope;
- Graphical depiction of facility utility billing data over time;
- Energy mapping based on MECS end uses;
- Comparison between facility end use consumption and MECS self-report survey data for the specific industrial subsector;
- Site observation and energy efficiency opportunities;
- Information on utility energy-efficiency programs and utility contact information.

6 Analysis and Results

The following section provides the analysis results by three-digit NAICS code for each industrial sector. The Cadmus team first provides context on the final sample achieved relative to the initial proposed sample, as well as a qualitative discussion of the results. The team lists data on the normalized end-use energy consumption by stratum and a weighted average. A comparison of normalized end use consumption estimates by NAICS code can be found in Table 15 on the following page. Finally, the Cadmus team includes a comparison on the proportion of consumption for each end use between the on-site assessment and MECS self-report surveys.

The number of sites assessed for each NAICS code is important, as it informs the reliability of consistency level between sites that are assessed. While the results are not statistically valid, a larger number of assessed sites with relatively consistent end use consumptions implied the estimates were more reliable. For instance, the Cadmus team considers the reliability for a NAICS code that has only two sites assessed is lower than the reliability for a NAICS code with eight sites assessed.

The Cadmus team provided an analysis of the relative consistency of results within each three- or four-digit NAICS code within the sample. The team also provided estimates of the relative level of discrepancy compared with 2010 MECS data. The team proposed three relative consistency levels between sites that were assessed for each NAICS code, as well as three levels of discrepancy between IFSA and 2010 MECS results. These levels were "high", "medium", and "low." The combination of these factors allowed the Cadmus team to assess the relative reliability of results from both IFSA and MECS, and make recommendations on which data source would be most relevant to the Pacific Northwest. These estimates are shown in Table 12.

Table 12. Relative Reliability of Data Sources by NAICS Code

NAICS	Sites Assessed	Consistency Level within Sites Assessed	Discrepancy Level between IFSA Sites and MECS	Most Reliable Data Source
311	9	Medium	Medium	IFSA
324	2	Medium	High	MECS
325	6	Low	Medium	MECS
326	5	High	Medium	IFSA
327	8	Low	Medium	MECS
331	5	Medium	Medium	IFSA
332	8	High	Low	IFSA
334	3	Low	Medium	MECS
336	8	Low	Low	Neither
493	5	High	N/A	IFSA
3211	3	Medium	Low	IFSA
3212	6	Low	Medium	MECS
3219	5	Medium	Medium	IFSA
3221	6	High	Low	IFSA
3222	3	Medium	Low	IFSA

In general, the team recommends applying IFSA results because the consumption data represented analyses informed by on-site observations and primary or secondary data on specific end uses from the facility. However, in cases of small sample size or low consistency between facility end use consumption estimates, the team recommends deferring to the MECS data.
To illustrate the determination of consistency levels, the data for sites for two NAICS codes with "high" and "low" consistency levels are illustrated below in Table and table.

Table 13. End Use Consumption by Employee for Sites with Relatively High Consistency

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Site A	Site B	Site C	Site D
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distilate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	171
Process Cooling and Refrigeration	Electricity	kWh	5,376	26,837	20,929	17,343
Machine Drive	Electricity	kWh	187	8,829	13,187	3,880
Pumps	*Electricity/MD*	*kWh*	30	163	402	0
Fans	*Electricity/MD*	*kWh*	32	0	0	0
Compressed Air	*Electricity/MD*	*kWh*	123	2,971	754	0
Material Handling	*Electricity/MD*	*kWh*	2	1,741	3,362	3,880
Material Processing	*Electricity/MD*	*kWh*	0	2,165	7,118	0
Other Systems	*Electricity/MD*	*kWh*	0	1,790	1,550	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	4,364	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	16	0	0	46
	Electricity	kWh	286	98	151	400
Facility Lighting	Electricity	kWh	1,283	9,378	8,710	1,876

The data from these four sites within one NAICS code show there was no boiler use or process heating (with the exception of one site with minimal electric heating). The majority of electricity consumption for all four sites was due to process cooling and refrigeration. All sites had material handling in common and non-process uses showed similar trends. The results indicate the consumption distribution for these four sites has a relatively high consistency.

Table 14. End Use Consumption by Employee for Sites with Relatively Low Consistency

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Site A	Site B	Site C	Site D
Conventional Boiler Use	Natural Gas	MMBTU	0	0	332	10
	Electricity	kWh	0	0	2,246	237
CHP and/or Cogeneration Process	Diesel or Distilate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	544	0	0
	Electricity	kWh	0	0	0	7,156
Process Cooling and Refrigeration	Electricity	kWh	0	30,549	1,841	371
Machine Drive	Electricity	kWh	36,970	49,235	174,356	5,967
Pumps	*Electricity/MD*	*kWh*	17,733	16,336	1,389	886
Fans	*Electricity/MD*	*kWh*	0	8,917	24,739	17
Compressed Air	*Electricity/MD*	*kWh*	14,297	16,206	16,233	1,359
Material Handling	*Electricity/MD*	*kWh*	2,774	7,775	42,493	0
Material Processing	*Electricity/MD*	*kWh*	2,166	0	89,502	3,705
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	298	50	0	1
	Electricity	kWh	1,714	462	3,287	323
Facility Lighting	Electricity	kWh	7,530	2,995	12,508	1,041
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	190	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	524	0

The data from these four sites within one NAICS code show that half of the sites had boiler use while the other half did not. There are two sites with process heating: one natural gas (no boiler use on site) and one electric (also with a natural gas fired boiler on site). Three out of four sites also had process cooling and refrigeration. The machine drive electricity consumption and distribution was relatively inconsistent. These results indicate the consumption distribution between the sites assessed for this NAICS code has a relatively low level of consistency.

Table 15. Energy Use per Employee by NAICS Code

			Weighted Average Consumption by NAICS Code														
Indirect Uses-Boiler Fuel	Fuel Type	Unit	311	3211	3212	3219	3221	3222	324	325	326	327	331	332	334	336	493
Conventional Boiler Use	Natural Gas	MMBtu	90	0	133	0	4,508	0	0	50	0	116	5,616	0	11	23	0
	Electricity	MMBtu	5	18	16	0	77	0	0	1	0	6	0	0	0	1	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Uses-Total Process																	
Process Heating	Natural Gas	MMBtu	19	0	148	0	0	0	63	19	36	186	564	284	6	46	0
	Electricity	MMBtu	0	0	0	0	101	1	20	12	9	5	207	14	8	9	0
	Propane	MMBtu	0	0	0	0	0	12	0	0	0	0	0	0	0	37	0
Process Cooling and Refrigeration	Electricity	MMBtu	31	1	0	0	0	0	0	4	50	0	128	7	0	0	70
Machine Drive	Electricity	MMBtu	156	342	470	469	2,745	56	6	59	327	128	436	76	59	25	22
Pumps	*Electricity/MD*	*MMBtu*	10	47	51	44	995	0	1	13	2	37	169	8	6	2	0
Fans	*Electricity/MD*	*MMBtu*	60	35	174	6	193	3	1	8	2	14	93	4	9	3	0
Compressed Air	*Electricity/MD*	*MMBtu*	13	18	40	30	154	10	1	10	197	6	62	13	10	4	6
Material Handling	*Electricity/MD*	*MMBtu*	40	65	57	327	270	25	1	8	1	25	59	5	2	2	6
Material Processing	*Electricity/MD*	*MMBtu*	34	177	146	58	967	17	3	20	125	45	53	45	32	13	7
Other Systems	*Electricity/MD*	*MMBtu*	0	0	3	3	165	0	0	0	0	0	0	1	1	0	4
Electro-Chemical Processes	Electricity	MMBtu	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Process Use	Electricity	MMBtu	1	0	0	0	128	0	0	0	0	0	0	0	0	1	8
Direct Uses-Total Nonprocess																	
Facility HVAC	Natural Gas	MMBtu	21	0	0	10	0	93	0	23	4	5	2	56	31	18	8
	Electricity	MMBtu	2	0	0	0	8	1	0	1	6	0	87	13	15	4	1
Facility Lighting	Electricity	MMBtu	11	5	38	65	82	9	4	7	9	17	81	13	6	8	22
Other Facility Support	Electricity	MMBtu	0	0	0	0	0	0	0	0	0	1	0	3	1	0	0
Onsite Transportation	Electricity	MMBtu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBtu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Nonprocess Use	Electricity	MMBtu	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total Consumption																	
	Electricity	MMBtu	212	367	524	534	3,041	67	30	84	401	156	938	126	90	48	123
	Natural Gas	MMBtu	131	0	281	10	4,508	93	63	93	40	307	6,182	340	49	50	8
	Propane	MMBtu	0	0	0	0	0		0	0	0	0	0	0	0	37	0
	Total Energy	MMBtu	342	367	805	545	7,549	160	93	177	441	463	7,121	466	139	135	132

6.1 NAICS 311 – Food Manufacturing

The Cadmus team initially planned to conduct fifteen assessments on 311 NAICS facilities and completed eleven assessments. Thirty-three sites the team attempted to recruit declined the assessment, were not actually industrial facilities, or could not be reached despite repeated contact attempts. The team found it particularly difficult to identify and recruit Small stratum sites due to misidentification issues. The Industrial Database included many retail bakeries as industrial sites, but the team determined these were not appropriate for the IFSA study.

The actual electricity consumption data varied considerably from the modeled estimates in the sample frame. The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Medium stratum site as Large. The revised stratum definitions and number of sites for the 311 NAICS code are shown in Table 16.

Table 16. Revised 311 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 5,000 MWh	4
Medium	500 MWh - 5,000 MWh	3
Small	< 500 MWh	2

The nine assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3112: Grain and Oilseed Milling
- 3114: Fruit and Vegetable Preserving and Specialty Food Manufacturing
- 3115: Dairy Product Manufacturing
- 3119: Other Food Manufacturing

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in

Table 17. This table also shows the end-use energy consumption across all strata for the 311 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 311 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame the number of employees per stratum was:

- Large: 3,512
- Medium: 86,490
- Small: 23,205

The final weighted average consumption reflects the larger proportion of employees in the Medium and Small strata in the sample frame. The actual number of employees per site was significantly less than the original reported values, but the relative proportions were somewhat consistent with the sample frame. Without actual employment numbers for the full sample frame, the Cadmus team had to rely on the original sample frame for employment proportions with which to weight the average across the 311 NAICS code.

The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 311 NAICS sites. The team found some variance between sites, likely due to different consumption requirements for each four-digit NAICS code. However, the larger sample size and medium level of consistency indicate the IFSA results can be considered relatively reliable.

The data show that consumption for 311 NAICS facilities is predominantly driven by electric loads for fans, material handling, material processing, and process cooling and refrigeration for the food products. Natural gas loads for boilers and process heating represented approximately one third of energy consumption. Six of the nine sites analyzed used a natural-gas-fired conventional boiler to support processes, while two of the remaining three sites used electric boilers for this purpose.

Table 17. 311 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	311 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	221	106	10	90
	Electricity	kWh	39,597	462	40	1,589
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	17	29	19
	Electricity	kWh	0	129	0	98
Process Cooling and Refrigeration	Electricity	kWh	24,196	10,540	1,077	9,024
Machine Drive	Electricity	kWh	32,853	58,344	894	45,778
Pumps	*Electricity/MD*	*kWh*	6,260	3,426	59	2,824
Fans	*Electricity/MD*	*kWh*	1,644	22,958	0	17,591
Compressed Air	*Electricity/MD*	*kWh*	7,940	4,510	210	3,735
Material Handling	*Electricity/MD*	*kWh*	2,278	15,190	531	11,784
Material Processing	*Electricity/MD*	*kWh*	14,457	12,261	95	9,835
Other Systems	*Electricity/MD*	*kWh*	272	0	0	8
Electro-Chemical Processes	Electricity	kWh	0	472	0	360
Other Process Use	Electricity	kWh	0	443	0	339
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	25	11	21
	Electricity	kWh	4,553	103	1,750	578
Facility Lighting	Electricity	kWh	2,152	3,914	1,265	3,316
Other Facility Support	Electricity	kWh	258	0	0	8
Onsite Transportation	Electricity	kWh	192	0	182	43
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	1,200	893	1,100
Total Consumption						
	Electricity	kWh	103,694	75,606	6,101	62,230
	Natural Gas	MMBTU	221	148	51	131
	Total Energy	MMBTU	574	405	72	342

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities than the Cadmus team assessed. However, both IFSA and MECS featured machine drive as the largest and process cooling and refrigeration as the second largest electric end use. There was significant variance in the natural gas end-use distribution as none of the facilities the Cadmus team assessed used CHP or cogeneration while it represented nearly one third of the MECS data consumption. Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically collected from Northwest sites rather than self-report data.

Figure 6. Comparison of IFSA Weighted Electricity End-Use Distribution with MECS Data

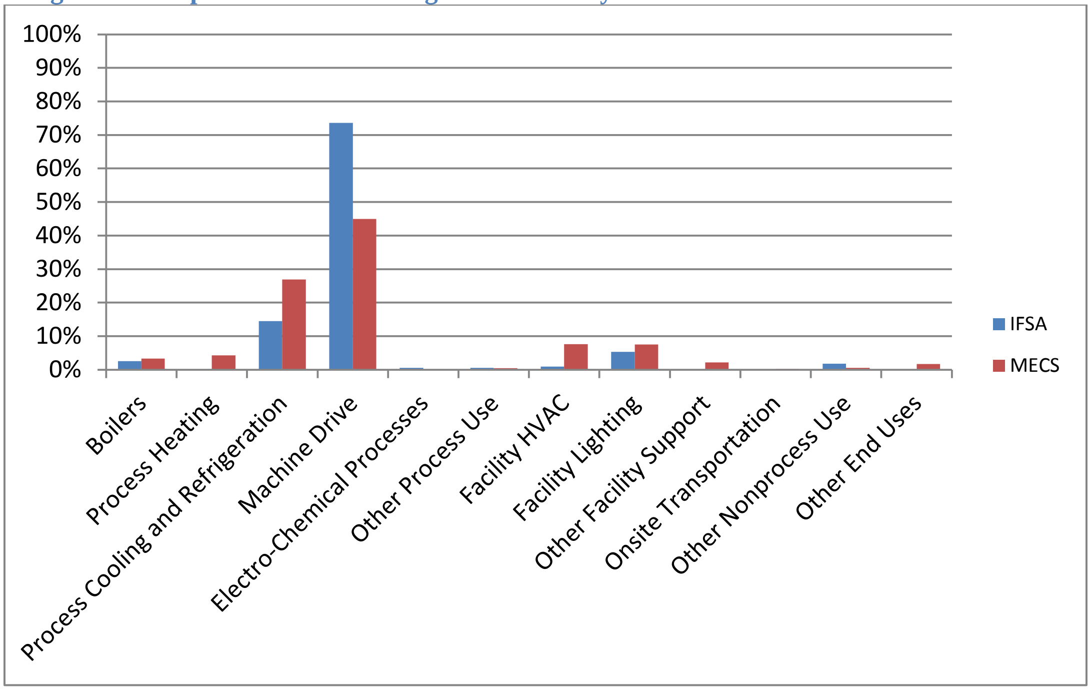


Figure 7. IFSA Machine Drive Electricity Distribution

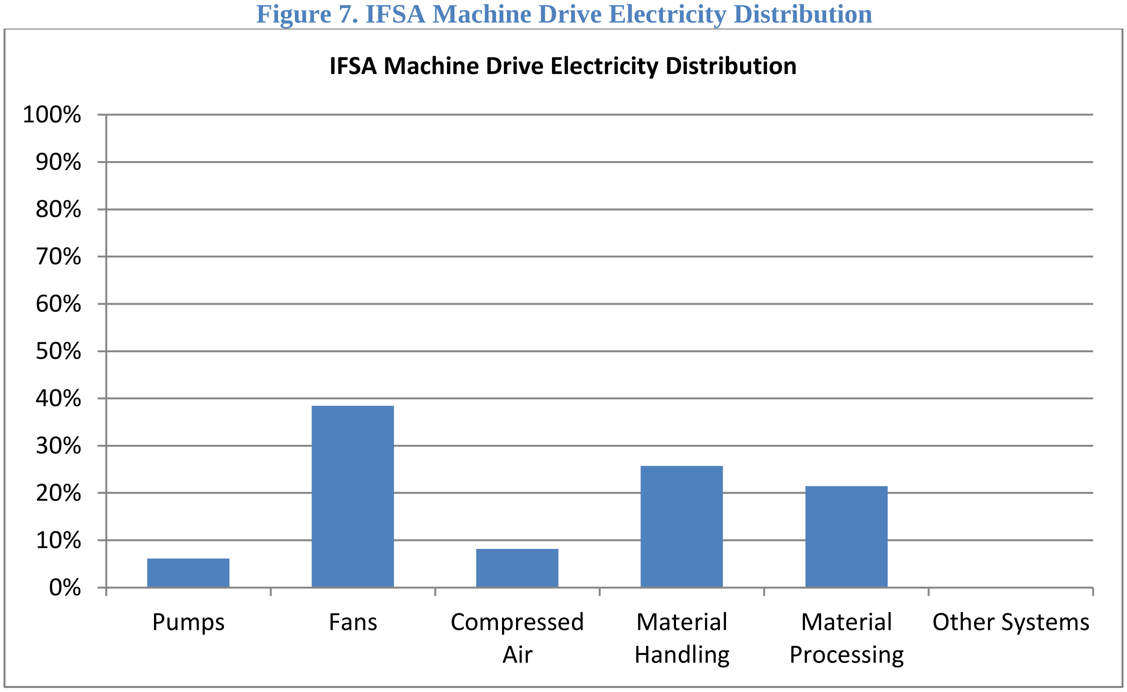
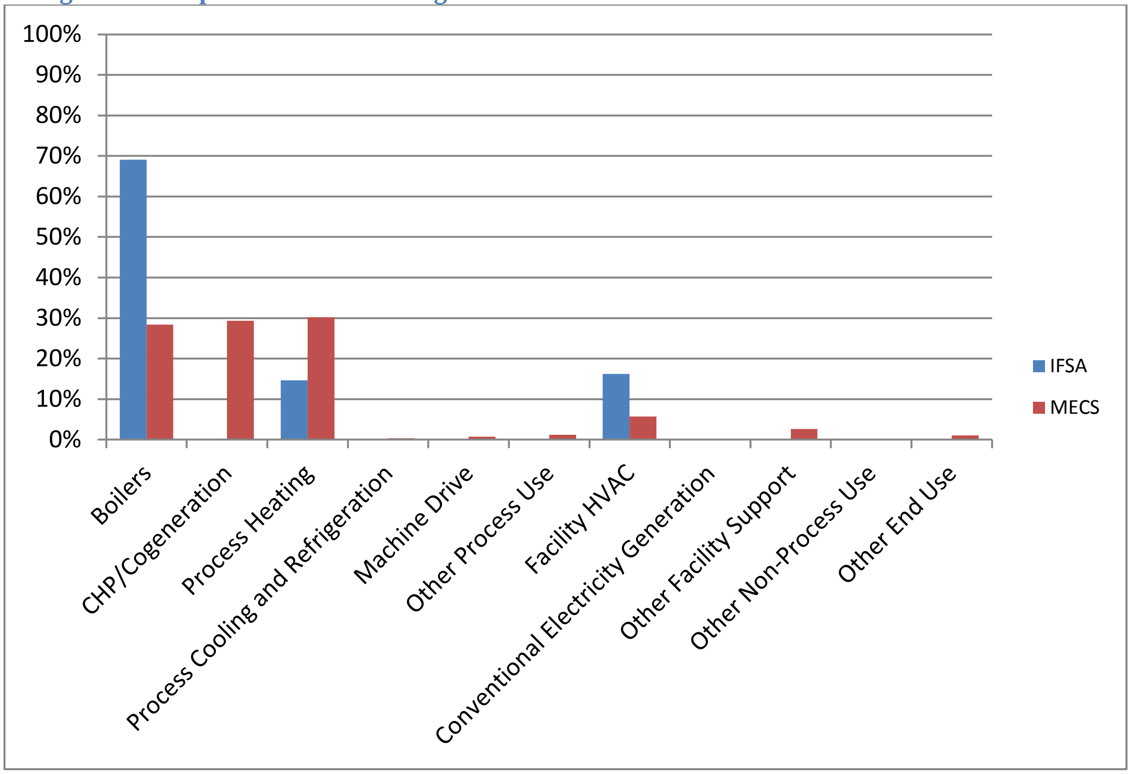


Figure 8. Comparison of IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.2 NAICS 321 - Wood Products Manufacturing

The Cadmus team sampled the 321 NAICS at the four-digit level due to the importance of wood products manufacturing to the Northwest. The four-digit NAICS definitions are:

- 3211: Sawmills and Wood Preservation
- 3212: Veneer, Plywood, and Engineered Wood Product Manufacturing
- 3219: Other Wood Product Manufacturing

As planned, the team conducted fifteen total assessments for the 321 NAICS. Table 18 shows the initial plan and final number of assessments completed for each four-digit code.

Table 18. Planned and Achieved Assessments for Wood Products Manufacturing

NAICS Code	Planned Assessments	Achieved Assessments
3211	5	3
3212	5	6
3219	5	5
Total	15	14

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Medium stratum site as Large. The revised stratum definitions and number of sites for the 321 NAICS code are shown in Table 19.

Table 19. Revised 321 NAICS Strata Definitions

NAICS Code	Stratum	Definition	Number of Facilities
3211	Large	> 15,000 MWh	0
	Medium	1,000 MWh - 15,000 MWh	2
	Small	< 1,000 MWh	1
3212	Large	> 15,000 MWh	3
	Medium	1,000 MWh - 15,000 MWh	0
	Small	< 1,000 MWh	3
3219	Large	> 15,000 MWh	0
	Medium	1,000 MWh - 15,000 MWh	2
	Small	< 1,000 MWh	3

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 20.. These tables also show the end-use energy consumption across all strata for the 321 NAICS codes, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 321 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. Table 20 shows the number of employees per stratum from the original sample frame.

The final weighted average consumption reflects the proportion of employees in the various strata in the sample frame.

Table 20. Sample Frame Employees by Four-Digit NAICS and Strata

NAICS Code	Stratum	Number of Total Employees
3211	Census	250
	Large	2,577
	Medium	1,918
	Small	526
3212	Large	2,885
	Medium	1,729
	Small	436
3219	Medium	49,912
	Small	9,113

The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 3211 NAICS (sawmills) sites. The team found some variance between sites, but the sample size was relatively small at three sites. The data in Table 21 show that consumption for sawmills is driven primarily by machine drive end uses, as might be expected. The material processing end use represents forty-eight percent of the total weighted average facility consumption. The 3211 sites that the Cadmus team assessed did not have any natural gas loads.

Table 21. 3211 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	3211 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	6,684	501	5,353
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
Process Cooling and Refrigeration	Electricity	kWh	0	0	1,465	315
Machine Drive	Electricity	kWh	0	126,739	4,181	100,362
Pumps	*Electricity/MD*	*kWh*	0	17,719	0	13,906
Fans	*Electricity/MD*	*kWh*	0	12,950	393	10,247
Compressed Air	*Electricity/MD*	*kWh*	0	6,367	1,284	5,273
Material Handling	*Electricity/MD*	*kWh*	0	23,719	1,500	18,937
Material Processing	*Electricity/MD*	*kWh*	0	65,984	1,003	51,998
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
Facility Lighting	Electricity	kWh	0	1,916	108	1,527
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	0	135,338	6,255	107,557
	Natural Gas	MMBTU	0	0	0	0
	Total Energy	MMBTU	0	462	21	367

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS for 3211. As noted previously, the MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. For example, the IFSA 3211 facilities did not employ natural gas for production or space conditioning, while the MECS participants did apply some natural gas for those end uses. In the IFSA sites, machine drive represented a much larger portion of overall electricity consumption than in the MECS data.

Overall, the Cadmus team estimated a low level of variance between the IFSA and MECS data. Despite the relatively small sample size, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically

collected from Northwest sites and is fairly consistent with MECS data on major end use distributions.

Figure 9. Comparison of 3211 IFSA Weighted Electricity End-Use Distribution with MECS Data

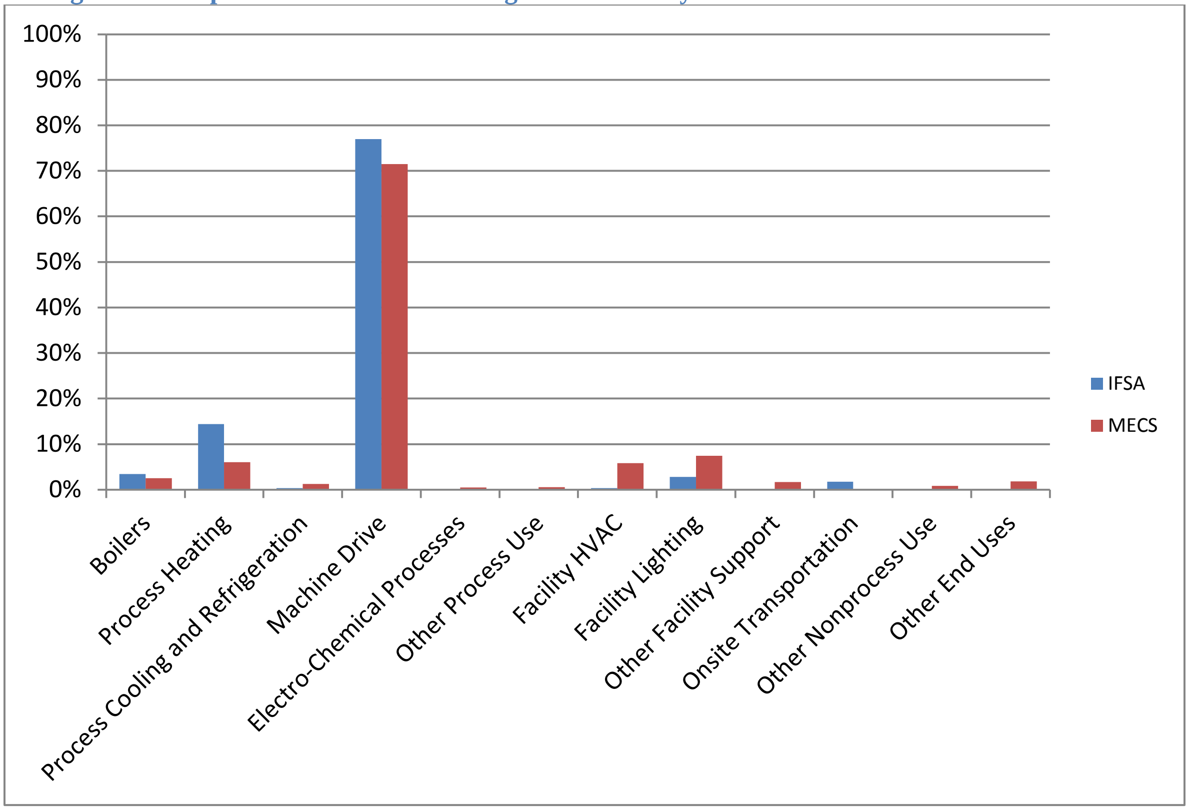


Figure 10. IFSA Machine Drive Electricity Distribution for 3211

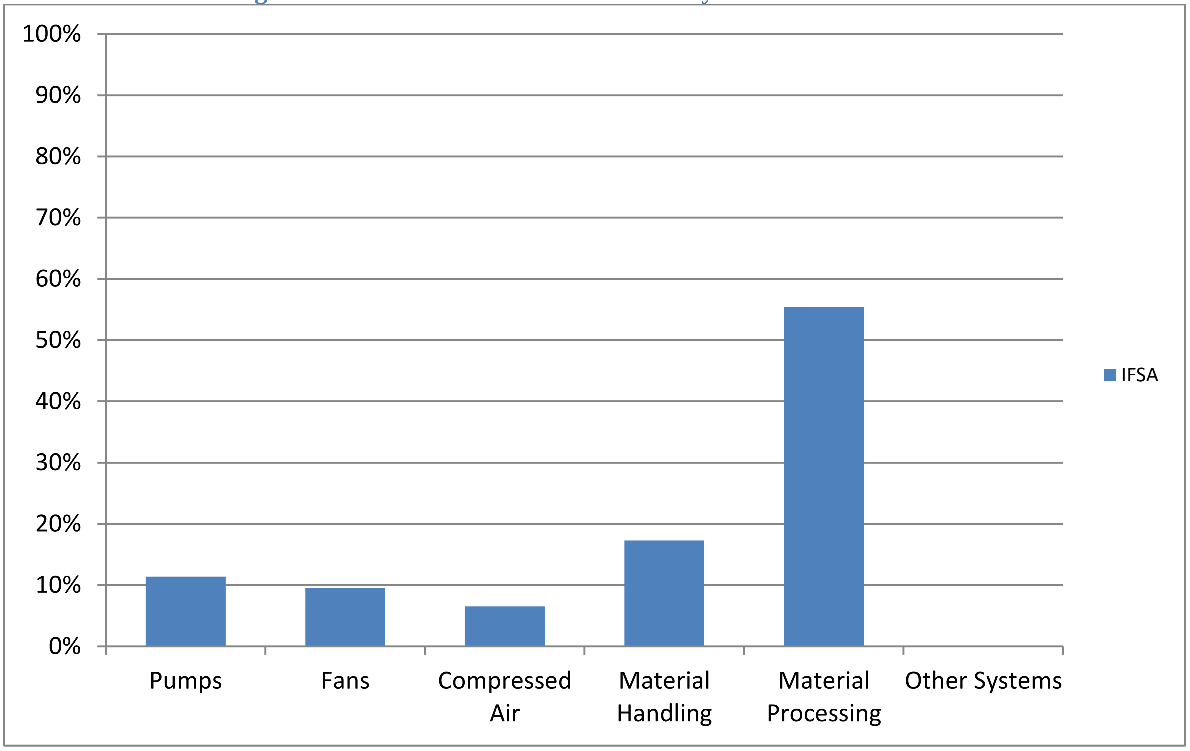
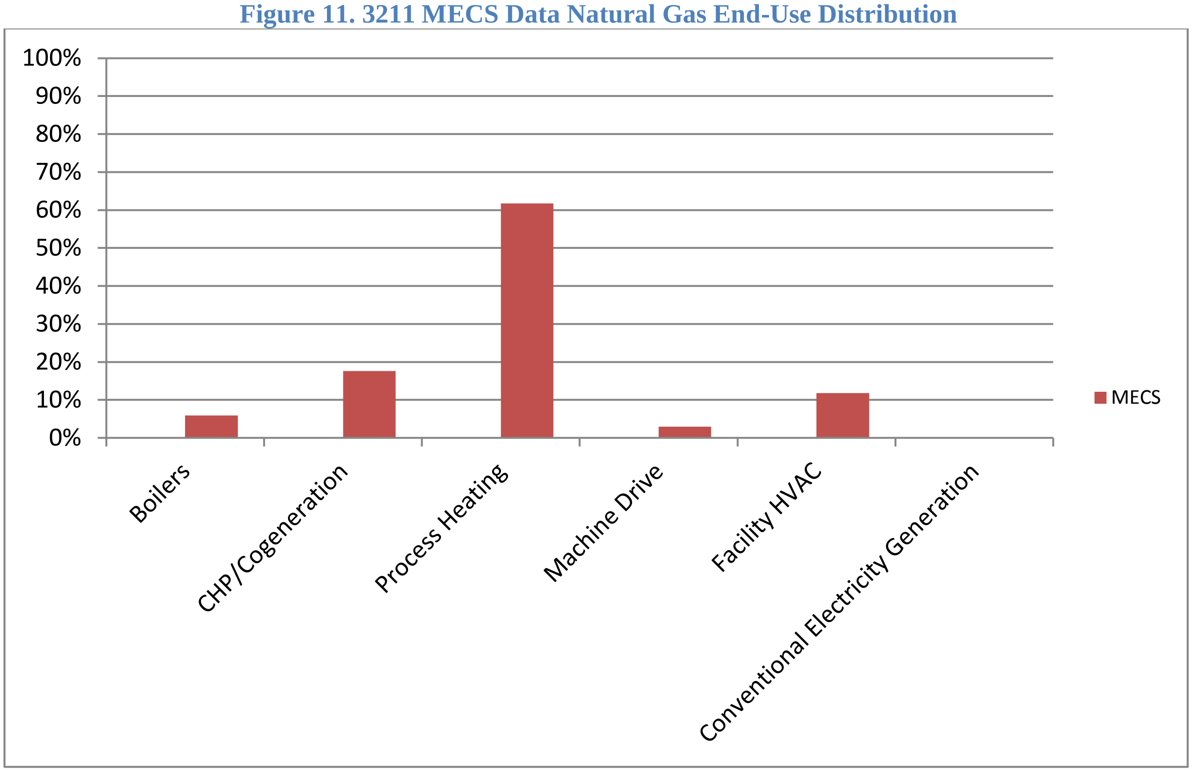


Figure 11. 3211 MECS Data Natural Gas End-Use Distribution



The Cadmus team estimated there was a low level of consistency between end use consumption estimates for the 3212 NAICS (engineered wood products) sites. The team found relatively high variance between end use consumption distributions between sites, likely due to different consumption requirements at each site.

The results in Table 22 show that consumption for 3212 NAICS is primarily driven by machine drive end uses, particularly fans and material processing. The larger facilities used large amount of natural gas for boiler and process heating applications, although the medium and small sites did not have process heating.

Table 22. 3212 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	3212 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	153	0	0	133
	Electricity	kWh	5,289	0	0	4,594
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	171	0	0	148
	Electricity	kWh	0	0	0	0
Process Cooling and Refrigeration	Electricity	kWh	0	0	0	0
Machine Drive	Electricity	kWh	158,301	0	1,812	137,756
Pumps	*Electricity/MD*	*kWh*	17,087	0	0	14,844
Fans	*Electricity/MD*	*kWh*	58,617	0	0	50,921
Compressed Air	*Electricity/MD*	*kWh*	13,453	0	515	11,754
Material Handling	*Electricity/MD*	*kWh*	19,107	0	178	16,622
Material Processing	*Electricity/MD*	*kWh*	49,047	0	1,119	42,755
Other Systems	*Electricity/MD*	*kWh*	991	0	0	861
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	0	2	0
	Electricity	kWh	0	0	230	30
Facility Lighting	Electricity	kWh	12,747	0	1,276	11,241
Other Facility Support	Electricity	kWh	0	0	20	3
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	176,337	0	3,338	153,625
	Natural Gas	MMBTU	323	0	2	281
	Total Energy	MMBTU	925	0	13	805

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS for 3212.The results showed relative similarity, in that both IFSA and MECS electricity consumption is driven by machine drive with a large number of smaller end uses.

For natural gas, the IFSA consumption came entirely from process loads through boilers and process heating. These represented sixty-four percent of the MECS gas consumption, but the remaining load was split among a variety of smaller end uses.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends MECS data as the more reliable source for the Northwest, primarily due to relatively low consistency between end use consumption distributions in the IFSA sample.

Figure 12. Comparison of 3212 IFSA Weighted Electricity End-Use Distribution with MECS Data

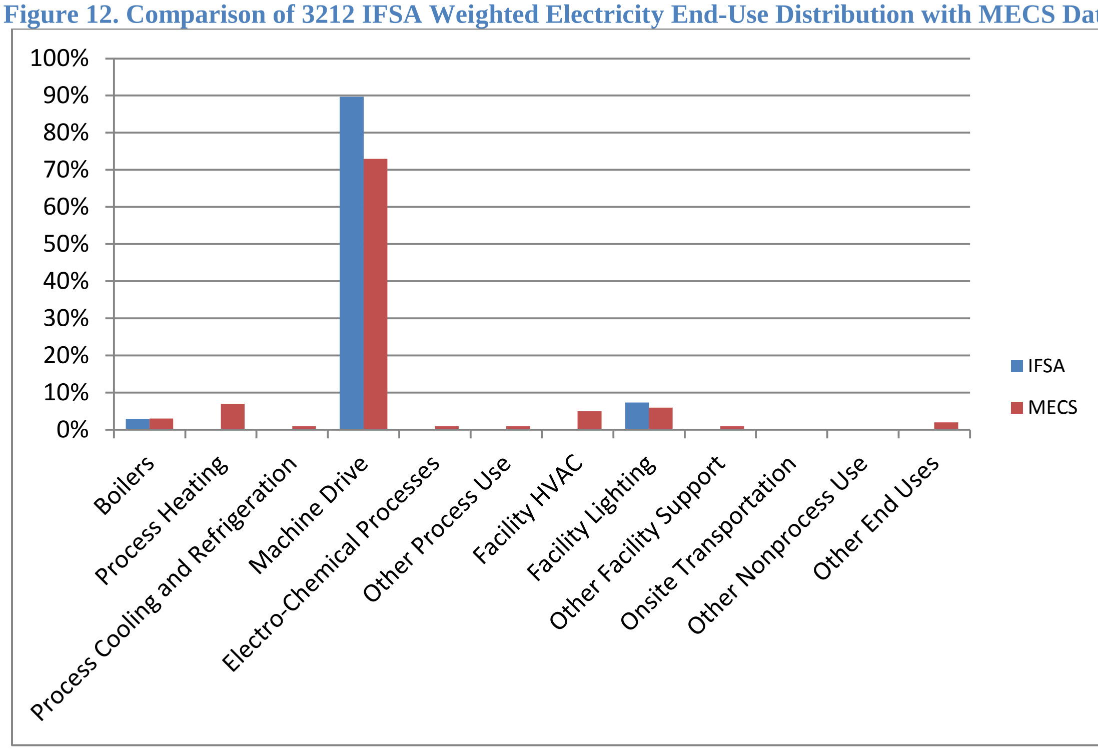


Figure 13. 3212 IFSA Machine Drive Electricity Distribution

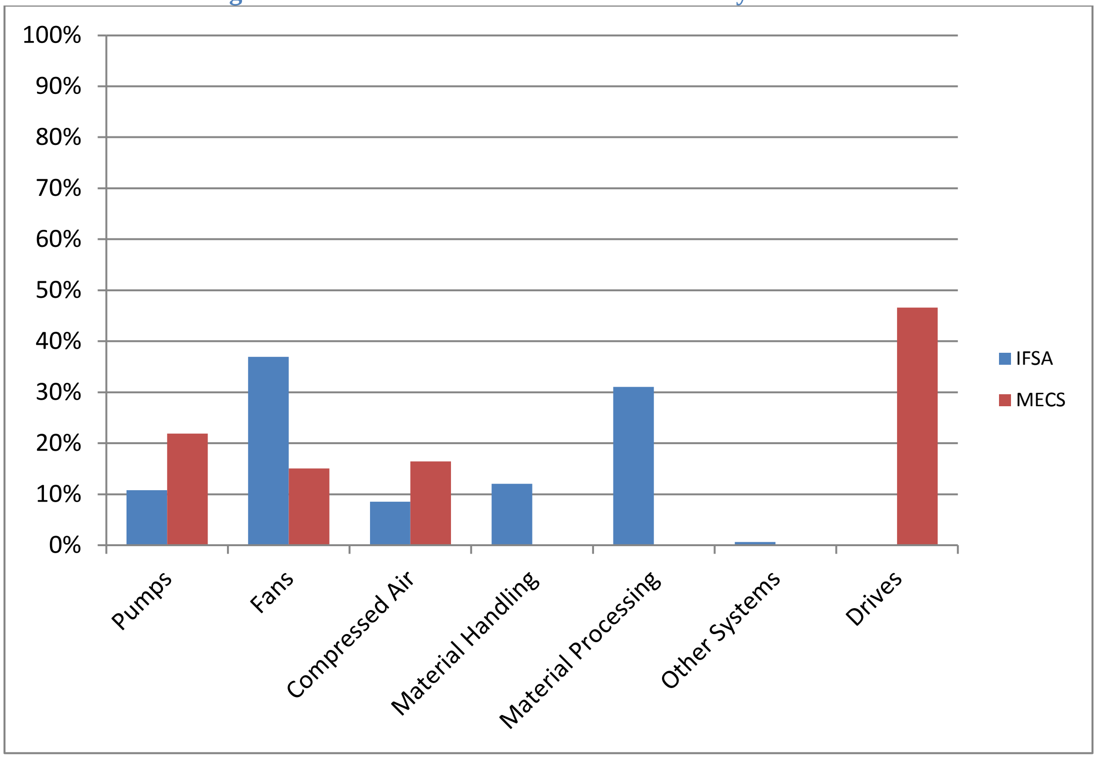
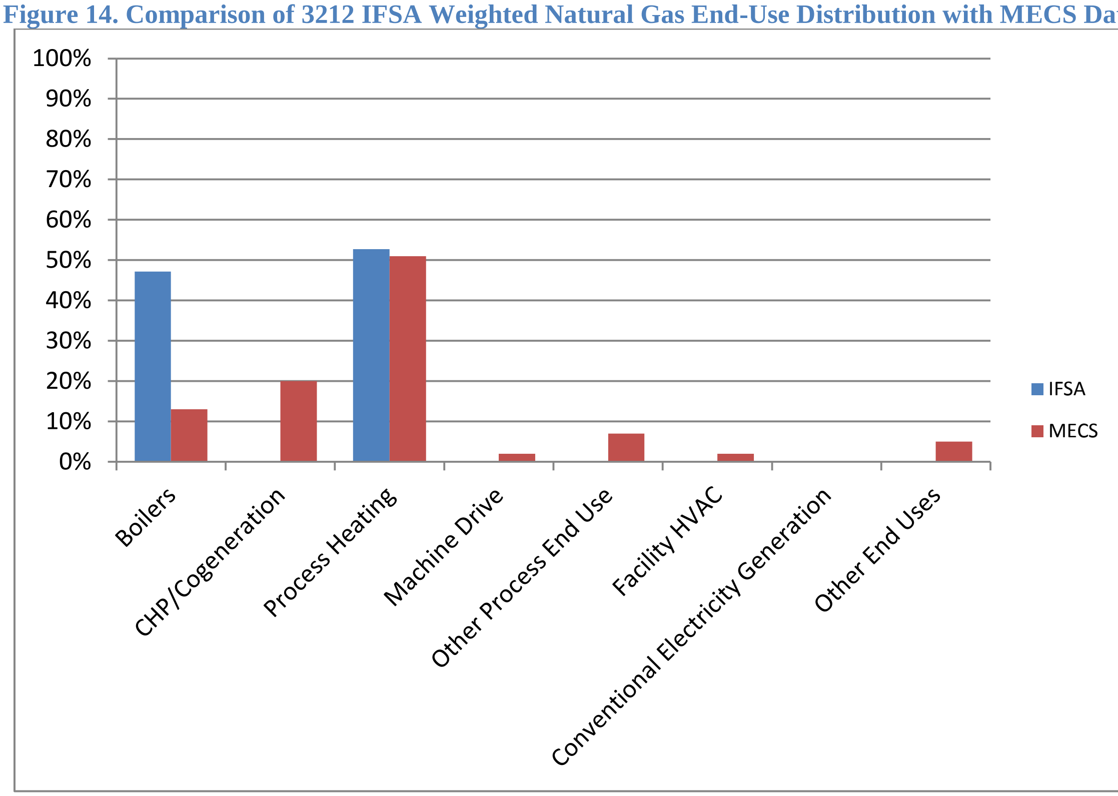


Figure 14. Comparison of 3212 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 3219 NAICS (miscellaneous wood products) sites. The team found some variance between sites, likely due to different consumption requirements for each site.

The results in Table 23 indicate consumption in 3219 NAICS manufacturing facilities is also driven primarily by machine drive. In this case, the material handling represents the major source of energy consumption.

Table 23. 3219 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	3219 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	5	1
Process Cooling and Refrigeration	Electricity	kWh	0	0	288	44
Machine Drive	Electricity	kWh	0	161,083	7,632	137,391
Pumps	*Electricity/MD*	*kWh*	0	15,352	0	12,982
Fans	*Electricity/MD*	*kWh*	0	2,135	155	1,829
Compressed Air	*Electricity/MD*	*kWh*	0	10,004	1,304	8,660
Material Handling	*Electricity/MD*	*kWh*	0	112,886	3,176	95,948
Material Processing	*Electricity/MD*	*kWh*	0	19,639	2,997	17,070
Other Systems	*Electricity/MD*	*kWh*	0	1,067	0	902
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	0	67	10
	Electricity	kWh	0	0	851	131
Facility Lighting	Electricity	kWh	0	21,973	3,128	19,064
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	23	3
Total Consumption						
	Electricity	kWh	0	183,056	11,926	156,635
	Natural Gas	MMBTU	0	0	67	10
	Total Energy	MMBTU	0	625	107	545

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS for 3219. The electric comparison shows a large portion of machine drive consumption for both IFSA and

MECS, although the IFSA machine drive represented a considerably larger portion of consumption. The next largest load for IFSA sites was lighting, while MECS was split among a variety of other end uses, with lighting representing a more minor one.

The IFSA sites only used natural gas for space conditioning. The MECS sites consumed natural gas primarily for process loads, although more than one-third of gas consumption involved space conditioning.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically collected from Northwest sites rather than self-report data.

Figure 15. Comparison of 3219 IFSA Weighted Electricity End-Use Distribution with MECS Data

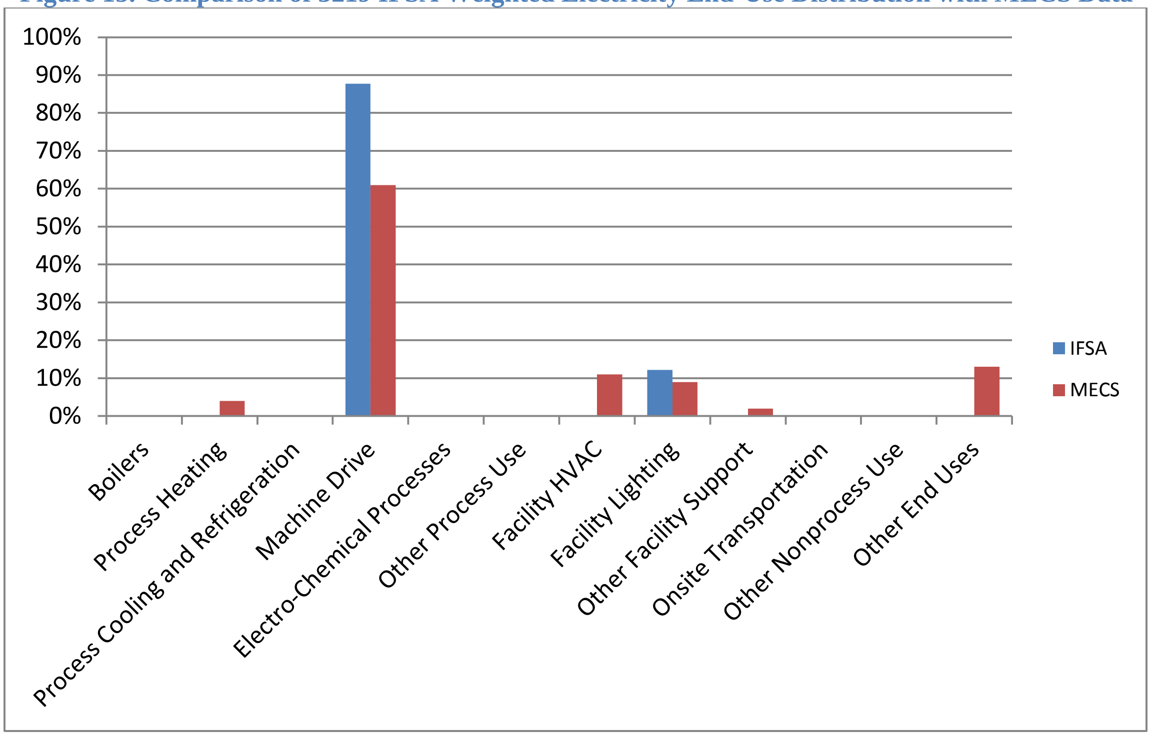


Figure 16. 3219 IFSA Machine Drive Electricity Distribution

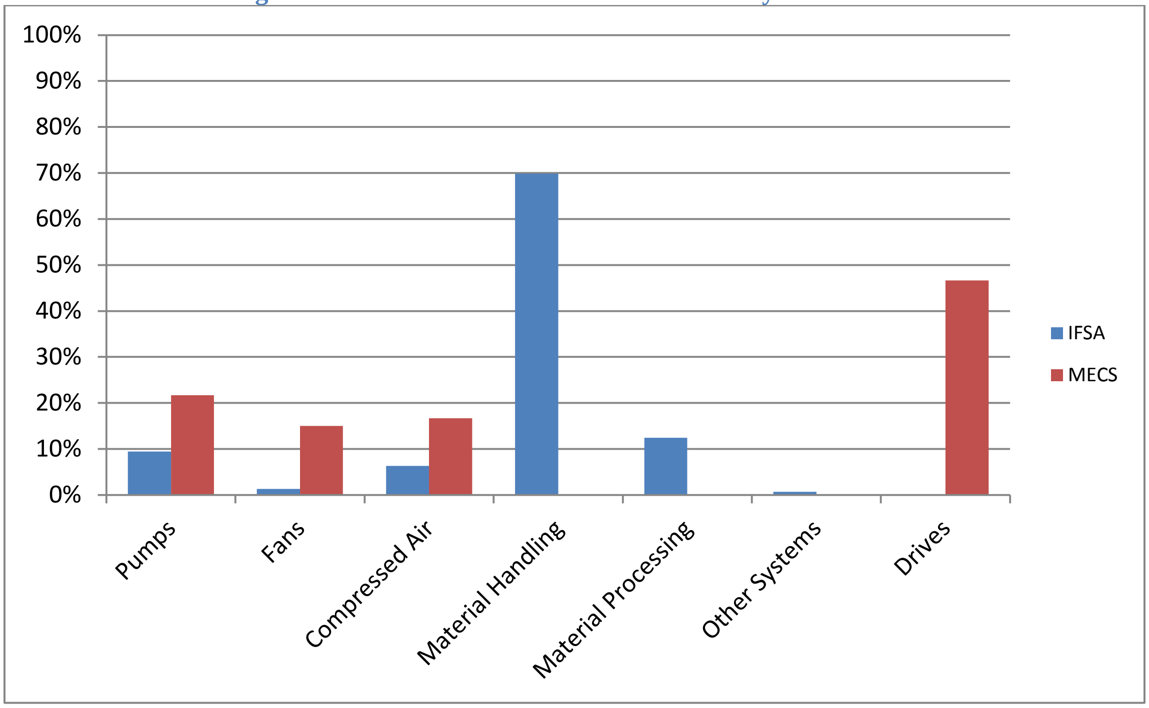
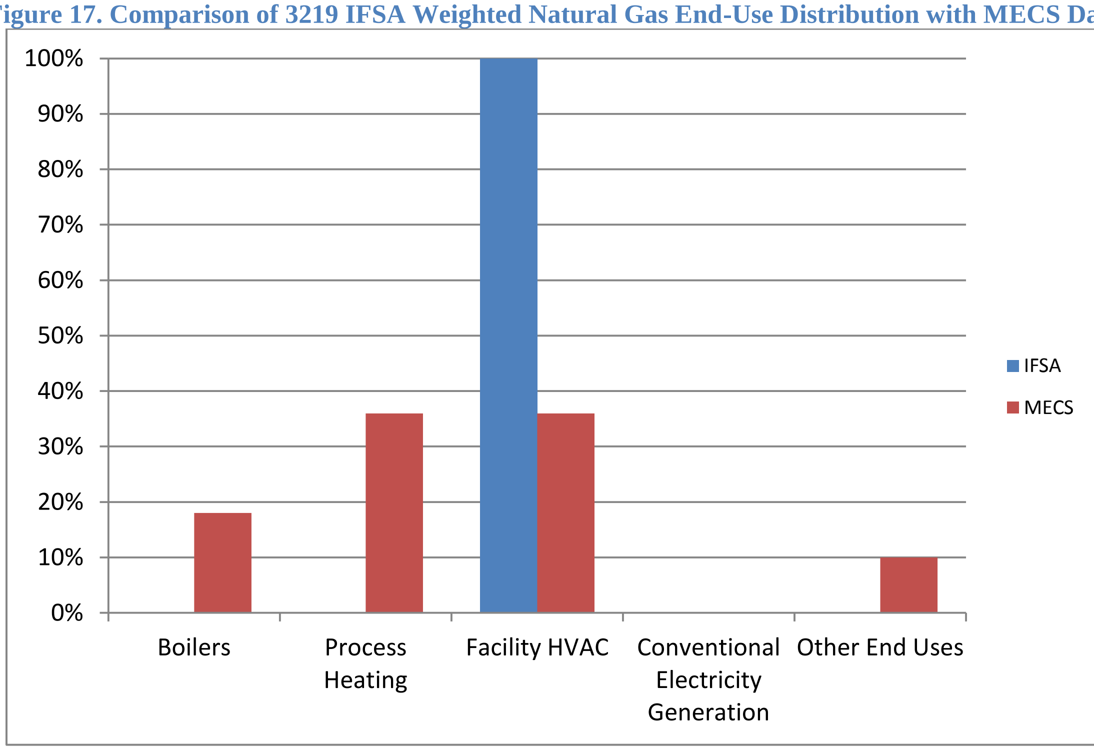


Figure 17. Comparison of 3219 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.3 NAICS 322 – Paper Manufacturing

The Cadmus team sampled the 322 NAICS at the four-digit level due to the importance of paper manufacturing to the Northwest. The four-digit NAICS definitions are:

- 3221: Pulp, Paper, and Paperboard Mills
- 3222: Converted Paper Product Manufacturing

The team initially planned to conduct eighteen assessments on 322 NAICS facilities and completed nine assessments. Table 24 shows the initial plan and final number of assessments completed for each four-digit code.

Table 24. Planned and Achieved Assessments for Paper Manufacturing

NAICS Code	Planned Assessments	Achieved Assessments
3221	12	6
3222	6	3
Total	18	9

Beyond the nine completed assessments, the Cadmus team attempted to recruit participants from a population of fifty-seven additional sites. In general, these sites declined the assessment, were not actually industrial facilities, or could not be reached despite repeated contact attempts. The Cadmus team found it particularly difficult to recruit the large pulp and paper mills. The facilities consume so much energy that they represent particularly sensitive accounts for utilities, whose account managers may be reluctant to allow outside contractors to initiate contact. Due to their level of consumption, these facilities have frequently been a target for energy-efficiency audits, reducing their willingness to engage in further study. Their facility contacts were also often extremely busy with various projects and therefore less likely to be responsive to contact attempts.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Small and both Medium 3221 strata sites as Large due their large electricity consumption (all greater than 100,000,000 kWh per year). The team also reclassified one Small 3222 site as Medium. The revised stratum definitions and number of sites for the 322 NAICS code are shown in Table 25.

Table 25. Revised 322 NAICS Strata Definitions

NAICS Code	Stratum	Definition	Number of Facilities
3221	Large	> 100,000 MWh	4
	Medium	1,000 MWh - 100,000 MWh	0
	Small	< 1,000 MWh	2
3222	Large	> 100,000 MWh	0
	Medium	1,000 MWh - 100,000 MWh	2
	Small	< 1,000 MWh	1

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 26. These tables also show the end-use energy consumption across all strata for the 322 NAICS codes, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 322 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. Table 26 shows the number of employees per stratum from the original sample frame. The final weighted average consumption reflects the proportion of employees in the various strata in the sample frame.

Table 26. Sample Frame Employees by Four-Digit NAICS and Strata

NAICS Code	Stratum	Number of Total Employees
3221	Large	16,645
	Medium	2,953
	Small	1,037
3222	Large	4,960
	Medium	350
	Small	4,728

The Cadmus team estimated there was a high level of consistency between end use consumption estimates for the 3221 NAICS (pulp and paper mills) sites. The team found little variance in end use consumption distribution between sites. The data in Table 27 show that consumption for 3221 NAICS is driven primarily by natural gas loads for boilers that support various process applications. The largest machine drive end uses include pumps for water and slurry, as well as various material processing applications.

Table 27. 3221 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	3221 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	4,789	0	0	4,508
	Electricity	kWh	23,850	0	0	22,451
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	31,336	0	0	29,499
Process Cooling and Refrigeration	Electricity	kWh	0	0	0	0
Machine Drive	Electricity	kWh	850,069	0	72,427	804,463
Pumps	*Electricity/MD*	*kWh*	309,708	0	3,434	291,746
Fans	*Electricity/MD*	*kWh*	59,801	0	4,700	56,570
Compressed Air	*Electricity/MD*	*kWh*	47,550	0	4,907	45,049
Material Handling	*Electricity/MD*	*kWh*	83,498	0	9,704	79,171
Material Processing	*Electricity/MD*	*kWh*	298,126	0	49,683	283,556
Other Systems	*Electricity/MD*	*kWh*	51,385	0	0	48,372
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	39,934	0	0	37,592
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	0	3	0
	Electricity	kWh	2,615	0	23	2,463
Facility Lighting	Electricity	kWh	25,655	0	347	24,171
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	463	27
Total Consumption						
	Electricity	kWh	942,123	0	73,261	891,167
	Natural Gas	MMBTU	4,789	0	3	4,508
	Total Energy	MMBTU	8,004	0	253	7,549

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS for 3221.The results are fairly similar, in that both found the electricity use is dominated by machine drive loads with a mix of other, much smaller end uses.

The natural gas comparison highlights major differences between MECS and the IFSA. The IFSA gas loads result entirely from boiler consumption, while MECS is split among several end uses. Nearly half of the MECS natural gas consumption is for CHP or cogeneration. The IFSA found that paper manufacturing sites often used waste wood products for these end uses rather than natural gas.

Overall, the Cadmus team estimated a low level of variance between the IFSA and MECS data. The Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically collected from Northwest sites and is fairly consistent with MECS data on major end use distributions.

Figure 18. Comparison of 3221 IFSA Weighted Electricity End-Use Distribution with MECS Data

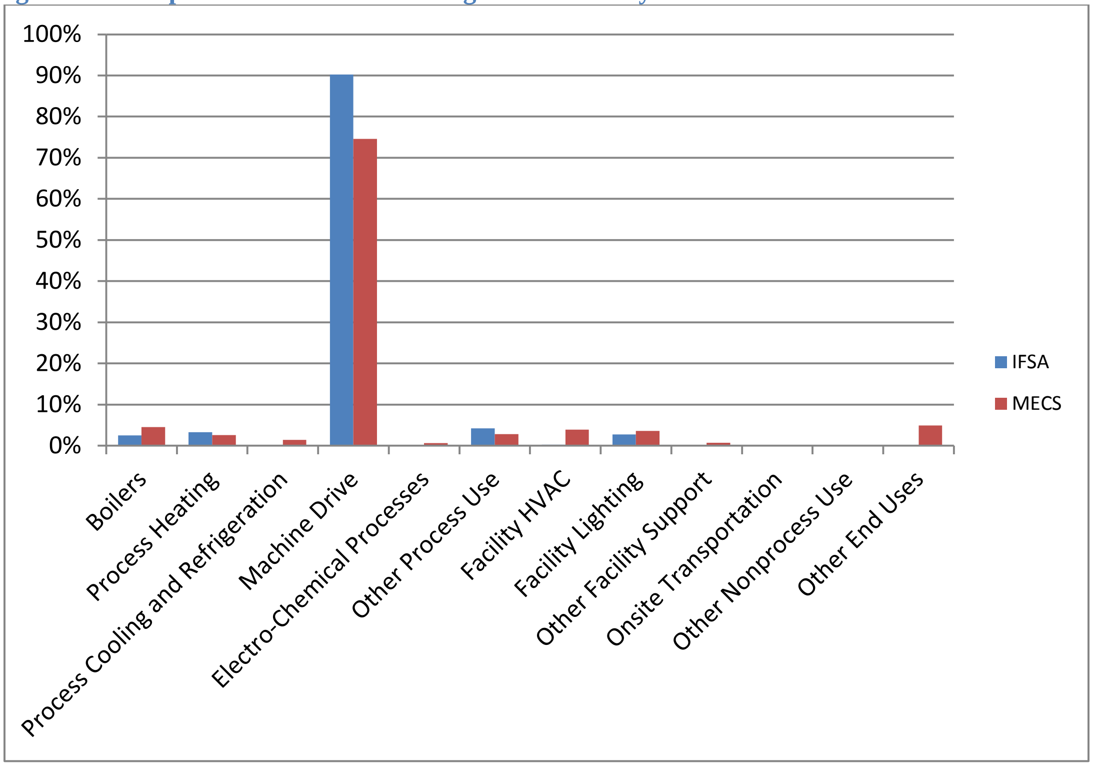


Figure 19. 3221 IFSA Machine Drive Electricity Distribution

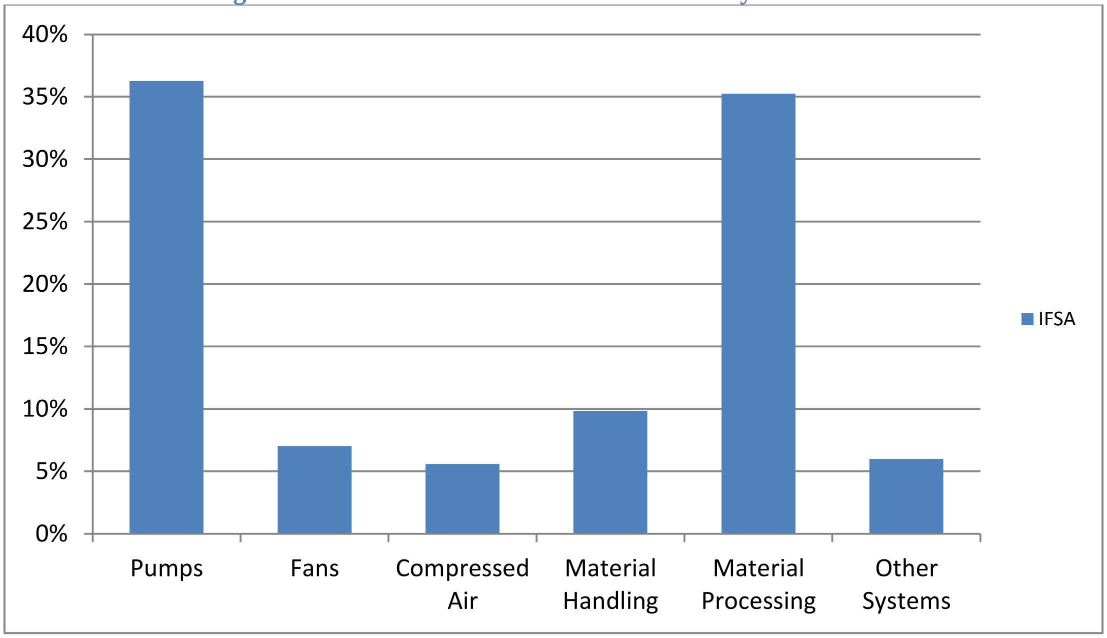
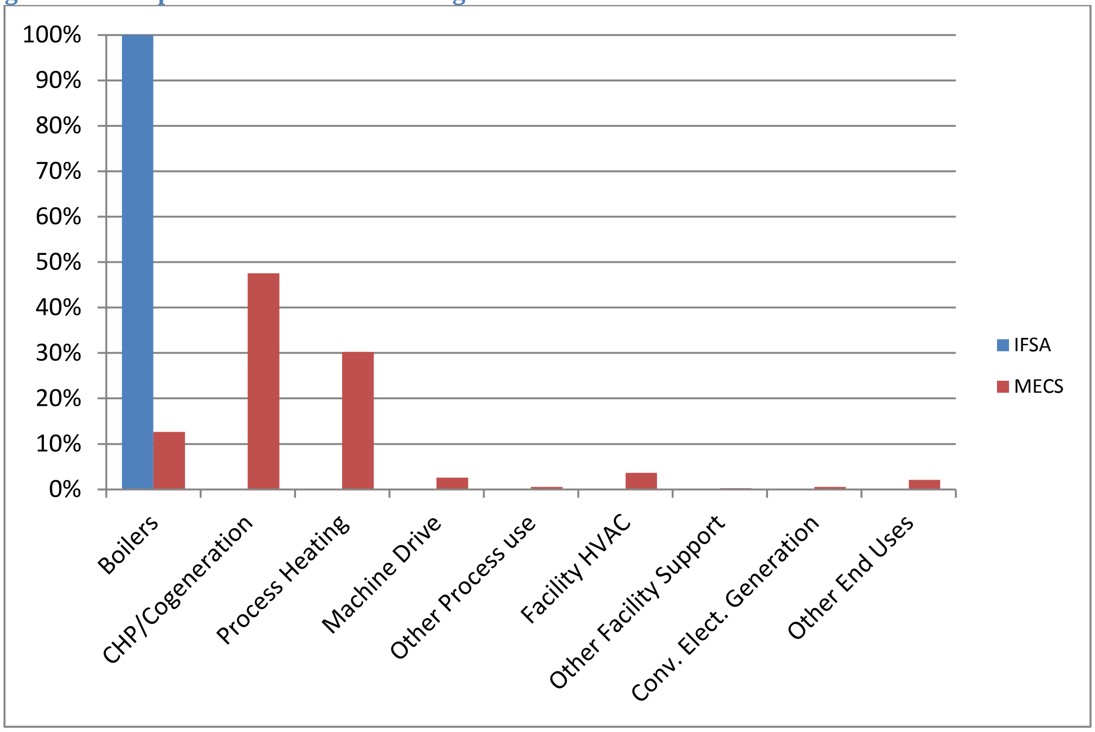


Figure 20. Comparison of 3221 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 3222 NAICS (converted paper product manufacturing) sites. The team found some variance between sites, likely due to different consumption requirements for each facility.

The results in Table 28 show that consumption for 3222 NAICS is primarily driven by machine drive end uses, distributed among fans, material processing, material handling, and compressed air. These facilities did not use natural gas for process heating applications.

Table 28. 3222 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	3222 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	2,554	0	2,554
Process Cooling and Refrigeration	Electricity	kWh	0	169	0	169
Machine Drive	Electricity	kWh	0	21,807	0	21,807
Pumps	*Electricity/MD*	*kWh*	0	311	0	311
Fans	*Electricity/MD*	*kWh*	0	7,359	0	7,359
Compressed Air	*Electricity/MD*	*kWh*	0	3,720	0	3,720
Material Handling	*Electricity/MD*	*kWh*	0	3,826	0	3,826
Material Processing	*Electricity/MD*	*kWh*	0	6,591	0	6,591
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	9	0	9
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	74	0	74
	Electricity	kWh	0	1,885	0	1,885
Facility Lighting	Electricity	kWh	0	2,272	0	2,272
Other Facility Support	Electricity	kWh	0	18	0	18
Onsite Transportation	Electricity	kWh	0	108	0	108
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	0	28,823	0	28,823
	Natural Gas	MMBTU	0	74	0	74
	Total Energy	MMBTU	0	173	0	173

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS for 3222. AS with 3221, the results are fairly similar. Both IFSA and MECS found the electricity use is dominated by machine drive loads with a mix of other, much smaller end uses.

The natural gas comparison highlights more differences between IFSA and MECS. The IFSA sites only used natural gas for space conditioning. The MECS sites consumed natural gas for a wide array of end uses, with space conditioning only representing a minor load.

Overall, the Cadmus team estimated a low level of variance between the IFSA and MECS data. Despite the relatively small sample size, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically

collected from Northwest sites and is fairly consistent with MECS data on major end use distributions.

Figure 21. Comparison of 3222 IFSA Weighted Electricity End-Use Distribution with MECS Data

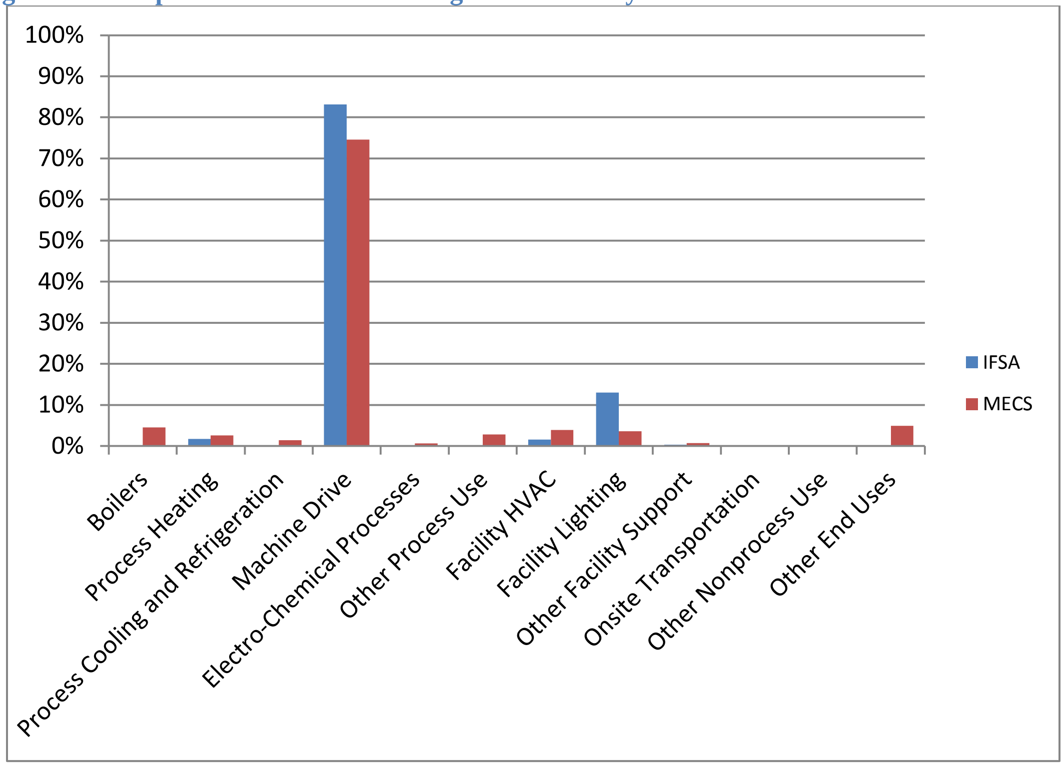


Figure 22. 3222 IFSA Machine Drive Electricity Distribution

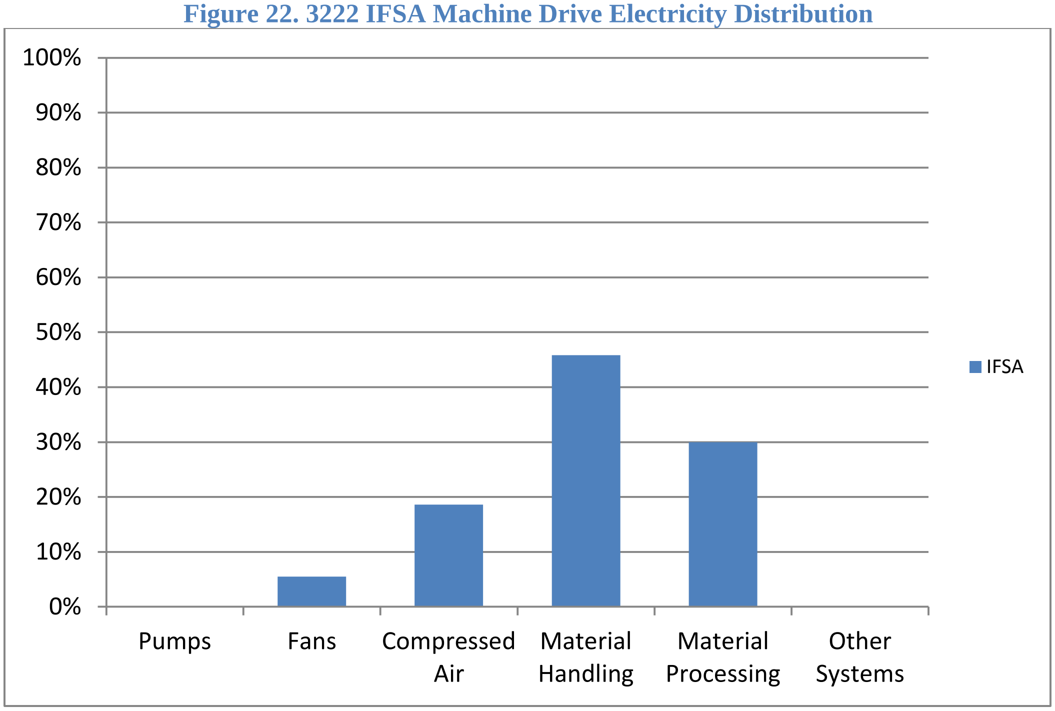
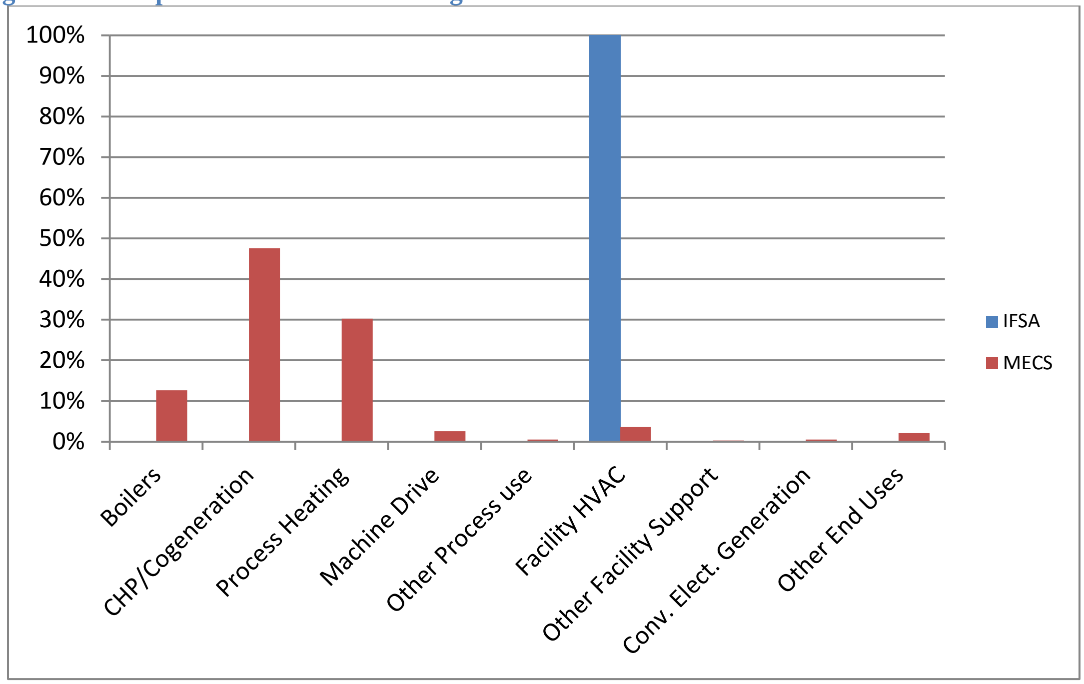


Figure 23. Comparison of 3222 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.4 NAICS 324 - Petroleum and Coal Products Manufacturing

The Cadmus team initially planned to conduct seven assessments on 324 NAICS facilities and completed two assessments. Sixteen sites that the Cadmus team attempted to recruit declined the assessment, were not actually industrial facilities, or could not be reached despite repeated contact attempts. The team experienced particular difficulty recruiting the very large oil refineries that were the primary subject of interest in this NAICS code. Of the three refineries the team attempted to recruit, one declined, one was unresponsive, and another initially committed to the assessment but would not set a date for that to occur.

The Cadmus team revised the stratum definitions based on the actual consumption data. The revised stratum definitions and number of sites for the 324 NAICS code are shown in Table 29.

Table 29. Revised 324 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 5,000 MWh	-
Medium	250 MWh - 5,000 MWh	2
Small	< 250 MWh	-

Both of the assessed sites represented the following four-digit NAICS code.

- 3241: Petroleum and Coal Products Manufacturing

The Cadmus team normalized the end-use energy consumption for the Medium stratum by number of employees, as shown in Table 30.

The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 324 NAICS sites. The data show that most energy consumption for medium 324 NAICS facilities involves natural gas for process heating. The majority of electric loads involved process heating for petroleum and coal products. One of the two sites used both electricity and natural gas for process heating. Process heating was followed by machine drive systems and lighting, which was the only non-process-related end use in the assessed 324 facilities. The sites did not have HVAC loads because they were open to the elements and did not require conditioned spaces.

Table 30. 324 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	324 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	63	0	63
	Electricity	kWh	0	5,754	0	5,754
Process Cooling and Refrigeration	Electricity	kWh	0	0	0	0
Machine Drive	Electricity	kWh	0	1,850	0	1,850
Pumps	*Electricity/MD*	*kWh*	0	282	0	282
Fans	*Electricity/MD*	*kWh*	0	242	0	242
Compressed Air	*Electricity/MD*	*kWh*	0	290	0	290
Material Handling	*Electricity/MD*	*kWh*	0	269	0	269
Material Processing	*Electricity/MD*	*kWh*	0	767	0	767
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
Facility Lighting	Electricity	kWh	0	1,177	0	1,177
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	0	8,781	0	8,781
	Natural Gas	MMBTU	0	63	0	63
	Total Energy	MMBTU	0	93	0	93

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. For example, neither of the two medium 324 NAICS sites in the IFSA used process cooling and refrigeration. Also, IFSA featured process heating as the largest electric end use, while machine drive was presented the largest electric end use with 80% share in the MECS data. This is likely due to significant differences between the populations represented in the two studies. There was also significant variance in the natural gas end-use distribution as IFSA identified process heating as the only end use for natural gas, while only about half of the natural gas load was represented as process heating in MECS data.

Overall, the Cadmus team estimated a high level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends MECS data as the more reliable source for the Northwest, primarily due to the small IFSA sample size, which did not include refineries.

Figure 24. Comparison of 324 IFSA Weighted Electricity End-Use Distribution with MECS Data

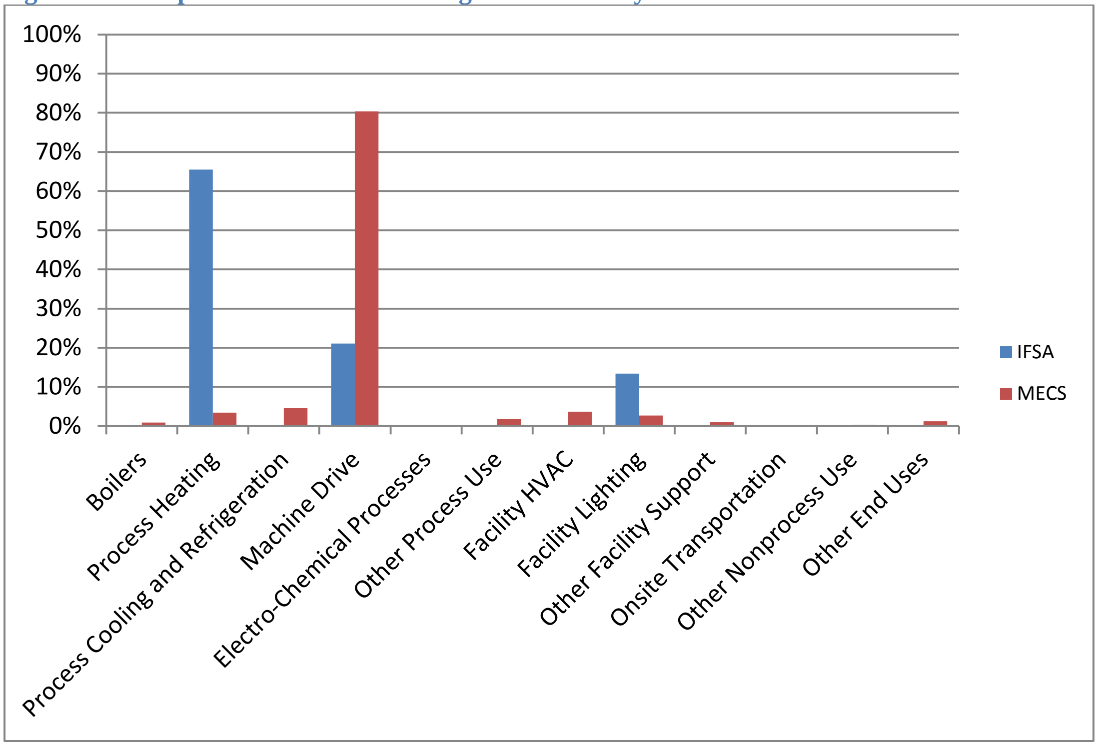


Figure 25. 324 IFSA Machine Drive Electricity Distribution

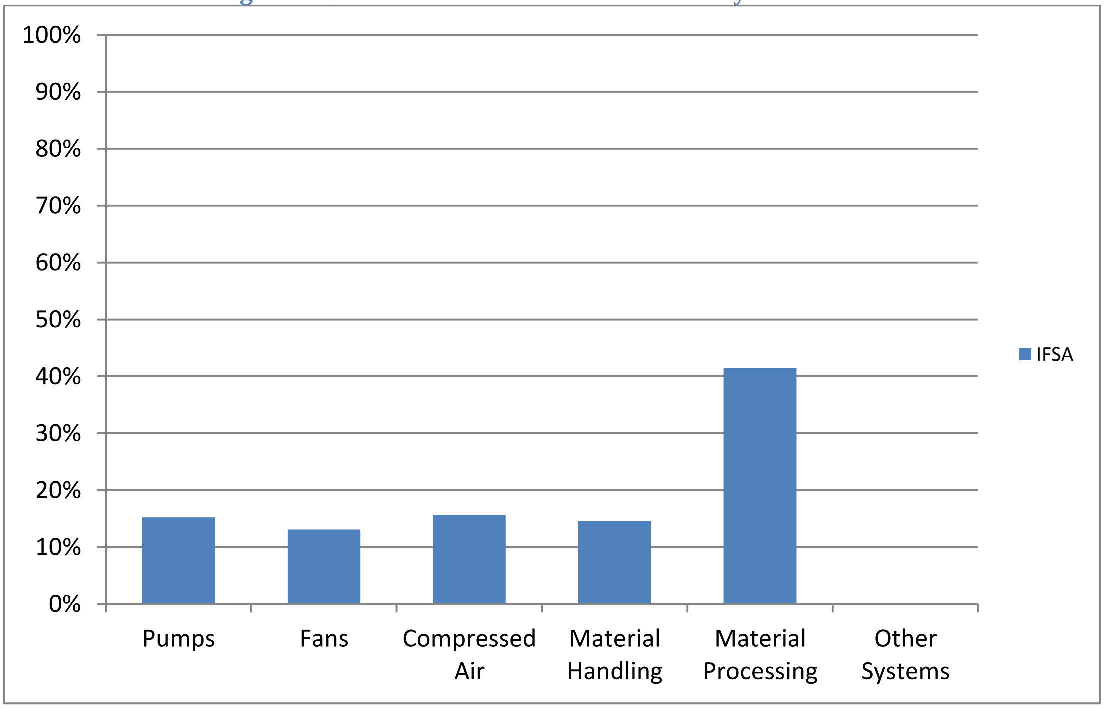
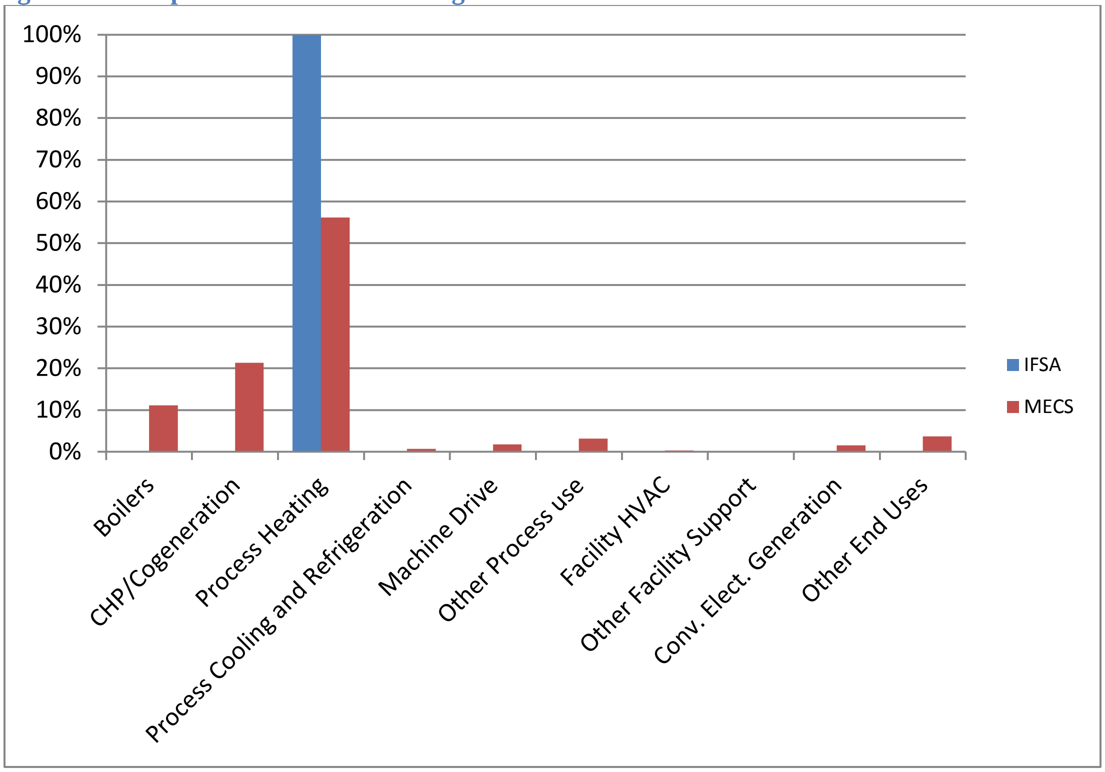


Figure 26. Comparison of 324 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.5 NAICS 325 - Chemical Manufacturing

The Cadmus team initially planned to conduct ten assessments on 325 NAICS facilities and completed six assessments. Twenty-eight sites that the Cadmus team attempted to recruit declined the assessment, were not actually industrial facilities, or could not be reached despite repeated contact attempts.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Large stratum site as Medium. The revised stratum definitions and number of sites for the 325 NAICS code are shown in Table 31.

Table 31. Revised 325 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 5,000 MWh	-
Medium	500 MWh - 5,000 MWh	4
Small	< 500 MWh	2

The six assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3251: Basic Chemical Manufacturing
- 3252: Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing
- 3253: Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing
- 3259: Other Chemical Product and Preparation Manufacturing

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in

Table 32. This table also shows the end-use energy consumption across all strata for the 325 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 325 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame, the number of employees per stratum was:

- Large: 2,304
- Medium: 6,308
- Small: 3,589

The final weighted average consumption reflects the larger proportion of employees in the Medium and Small strata in the sample frame.

The Cadmus team estimated there was a low level of consistency between end use consumption estimates for the 325 NAICS sites. The team found a large level of variance between sites, likely due to different consumption requirements for each four-digit NAICS code, as well as varying consumption patterns between each facility's processes.

The data show that consumption for 325 NAICS facilities is driven by electricity and natural gas loads nearly equally. The majority of electric loads involved machine drive systems, more specifically material processing and pumps. Only one of the six sites used electricity for Process Heating. The analysis normalized this consumption across the entire NAICS code, although this particular site may be an outlier in its application of process heating using electricity.

The weighted average analysis results indicate a moderate natural gas load for primarily conventional boiler use. Three of the six sites used a natural gas fired conventional boiler to support processes.

Table 32. 325 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	325 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	79	0	50
	Electricity	kWh	0	386	0	246
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	30	0	19
	Electricity	kWh	0	5,520	0	3,518
Process Cooling and Refrigeration	Electricity	kWh	0	2,035	0	1,297
Machine Drive	Electricity	kWh	0	19,828	12,486	17,166
Pumps	*Electricity/MD*	*kWh*	0	3,979	3,411	3,773
Fans	*Electricity/MD*	*kWh*	0	3,051	827	2,244
Compressed Air	*Electricity/MD*	*kWh*	0	2,911	2,954	2,926
Material Handling	*Electricity/MD*	*kWh*	0	2,223	2,570	2,349
Material Processing	*Electricity/MD*	*kWh*	0	7,664	2,724	5,873
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	5	56	23
	Electricity	kWh	0	432	324	393
Facility Lighting	Electricity	kWh	0	2,025	2,019	2,023
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	7	0	4
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	19	0	12
Total Consumption						
	Electricity	kWh	0	30,253	14,830	24,660
	Natural Gas	MMBTU	0	114	56	93
	Total Energy	MMBTU	0	217	107	177

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. For example, none of the 325 NAICS sites in the IFSA used electrochemical processes. However, both IFSA and MECS featured machine drive as the largest electric end use. There was significant variance in the natural gas end-use distribution as CHP / cogeneration was presented as the largest end use for natural gas in the MECS data, while it was not identified in any sites assessed by IFSA. There was also significant variance in the proportions of consumption for the smaller end uses for both fuels.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends MECS data as the more reliable source for the Northwest, primarily due to relatively low consistency between end use consumption distributions in the IFSA sample.

Figure 27. Comparison of 325 IFSA Weighted Electricity End-Use Distribution with MECS Data

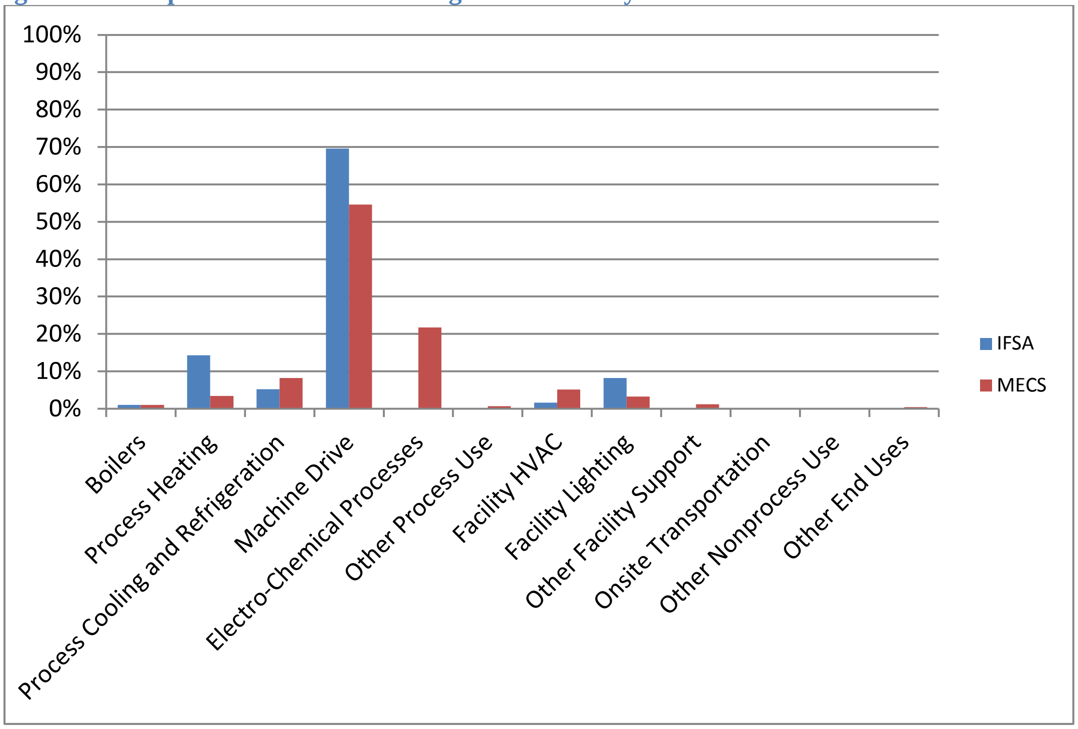


Figure 28. 325 IFSA Machine Drive Electricity Distribution

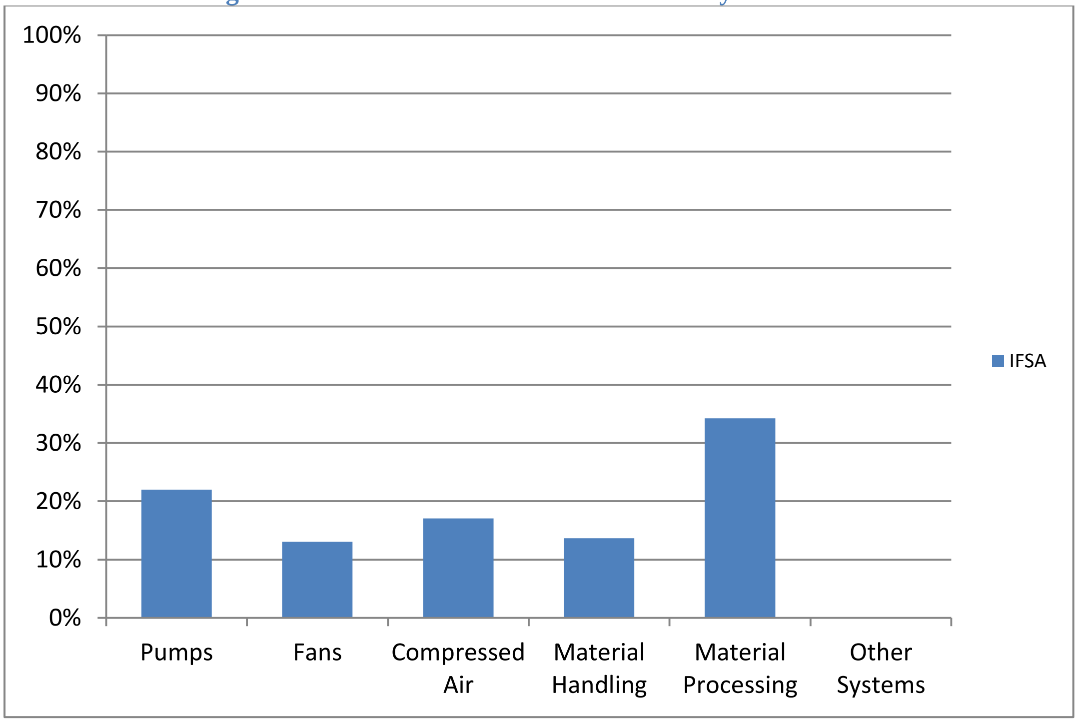
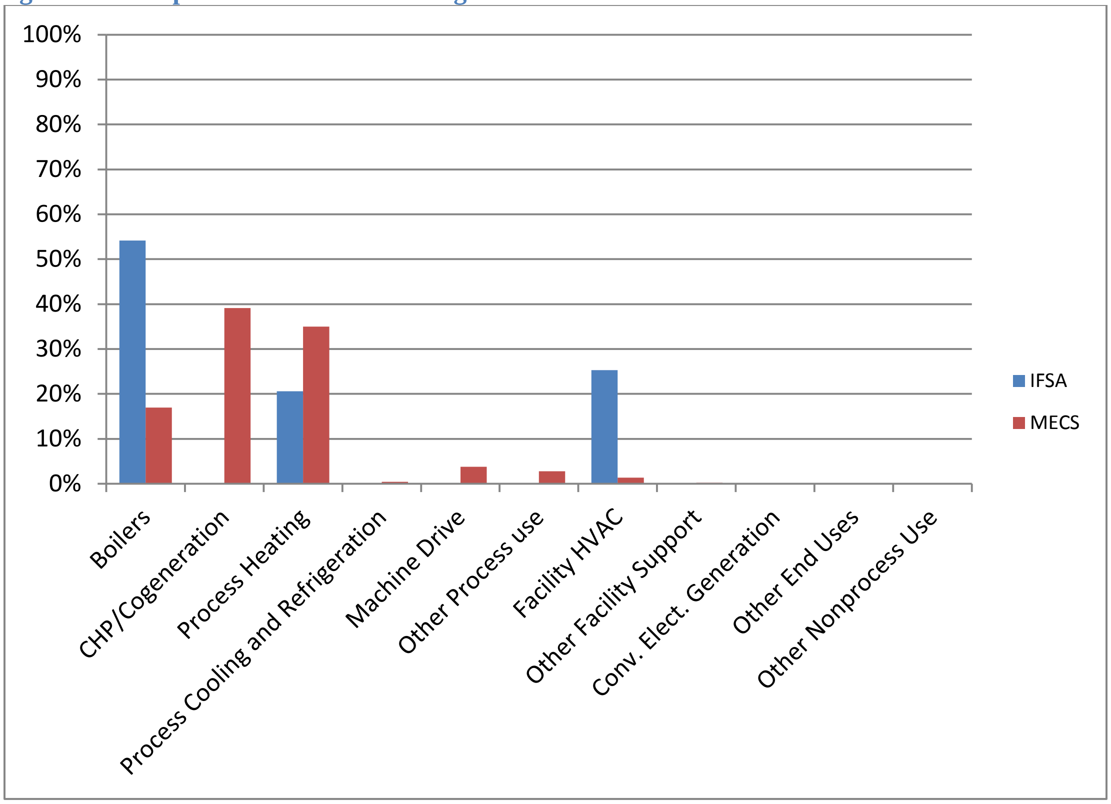


Figure 29. Comparison of 325 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.6 NAICS 326 - Plastics and Rubber Products Manufacturing

The Cadmus team initially planned to conduct six assessments on 326 NAICS facilities and completed five assessments. The team was unable to recruit the last Small stratum site despite outreach attempts to eighteen potential participants. Most of these sites either declined the assessment or were determined to not actually be industrial facilities.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Large stratum site as Medium and one Medium site as Small. The revised stratum definitions and number of sites for the 326 NAICS code are shown in Table 33.

Table 33. Revised 326 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	>10,000 MWh	1
Medium	500 MWh - 10,000 MWh	2
Small	< 500 MWh	2

The five assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3261: Plastic Products Manufacturing
- 3262: Rubber Products Manufacturing

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 34. This table also shows the end-use energy consumption across all strata for the 326 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 326 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame, the number of employees per stratum was:

- Large: 2,924
- Medium: 5,309
- Small: 475

The final weighted average consumption reflects the larger proportion of employees in the Medium stratum in the sample frame.

The Cadmus team estimated there was a high level of consistency between end use consumption estimates for the 326 NAICS sites. The team found little variance in end use consumption distribution between sites.

The results show that consumption for 326 NAICS facilities is driven by electricity primarily by machine drive systems, with an emphasis on compressed air and material processing. Most sites used either electricity or natural gas for process heating loads and several required process cooling as well.

Table 34. 326 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	326 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	107	0	0	36
	Electricity	kWh	0	4,334	109	2,649
Process Cooling and Refrigeration	Electricity	kWh	42,675	334	0	14,533
Machine Drive	Electricity	kWh	271,593	7,330	5,219	95,950
Pumps	*Electricity/MD*	*kWh*	0	915	958	610
Fans	*Electricity/MD*	*kWh*	0	935	234	583
Compressed Air	*Electricity/MD*	*kWh*	169,260	1,365	1,406	57,744
Material Handling	*Electricity/MD*	*kWh*	0	390	95	243
Material Processing	*Electricity/MD*	*kWh*	102,333	3,724	2,527	36,770
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	1	1	52	4
	Electricity	kWh	1,470	1,852	980	1,676
Facility Lighting	Electricity	kWh	4,236	1,893	1,426	2,655
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	63	3
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	34	2
Total Consumption						
	Electricity	kWh	319,975	15,744	7,831	117,468
	Natural Gas	MMBTU	109	1	52	40
	Total Energy	MMBTU	1,200	54	79	441

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. Both IFSA and MECS identified machine drive as the largest electric end use, although the IFSA portion of overall consumption for machine drive was much larger. Both studies also identified process heating and boilers as the dominant end uses, followed by facility space conditioning.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically collected from Northwest sites rather than self-report data. The IFSA data also showed a relatively high level of consistency between site end use consumption distributions.

Figure 30. Comparison of 326 IFSA Weighted Electricity End-Use Distribution with MECS Data

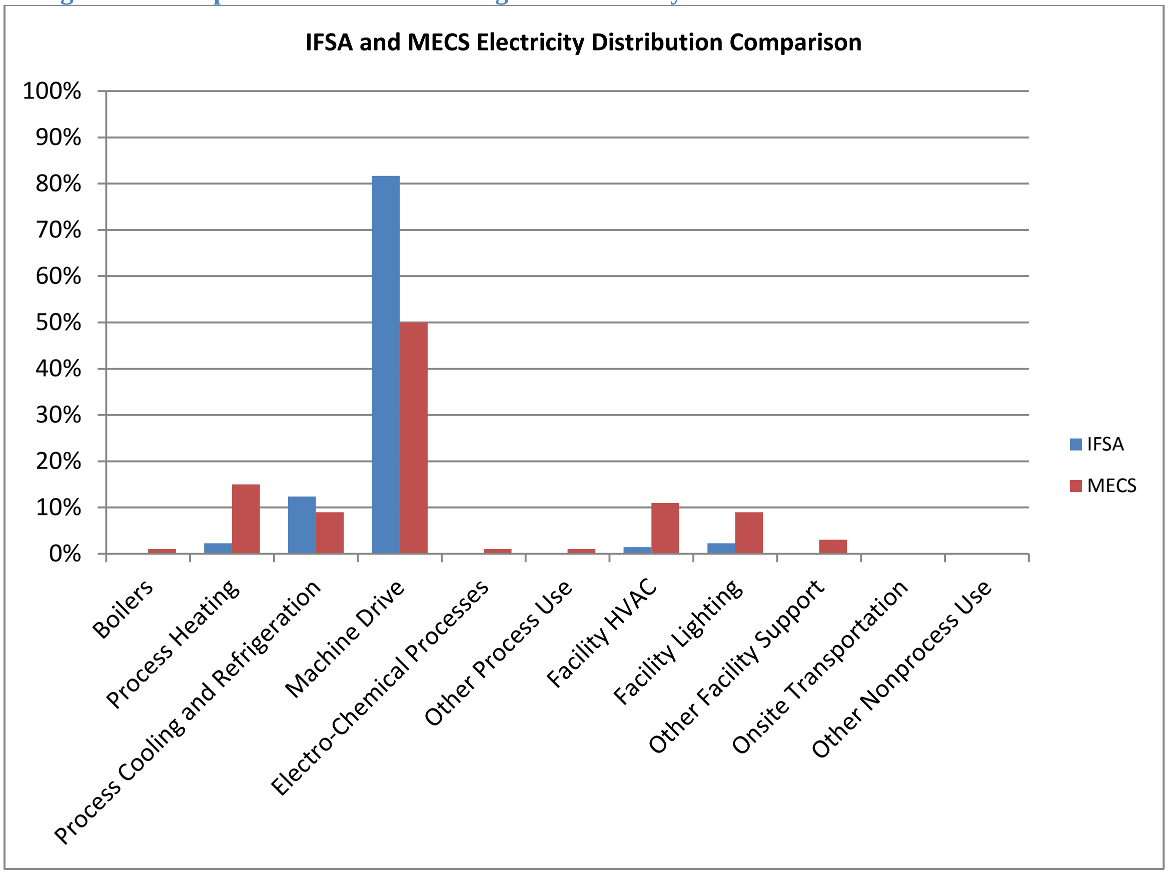


Figure 31. 326 IFSA Machine Drive Electricity Distribution

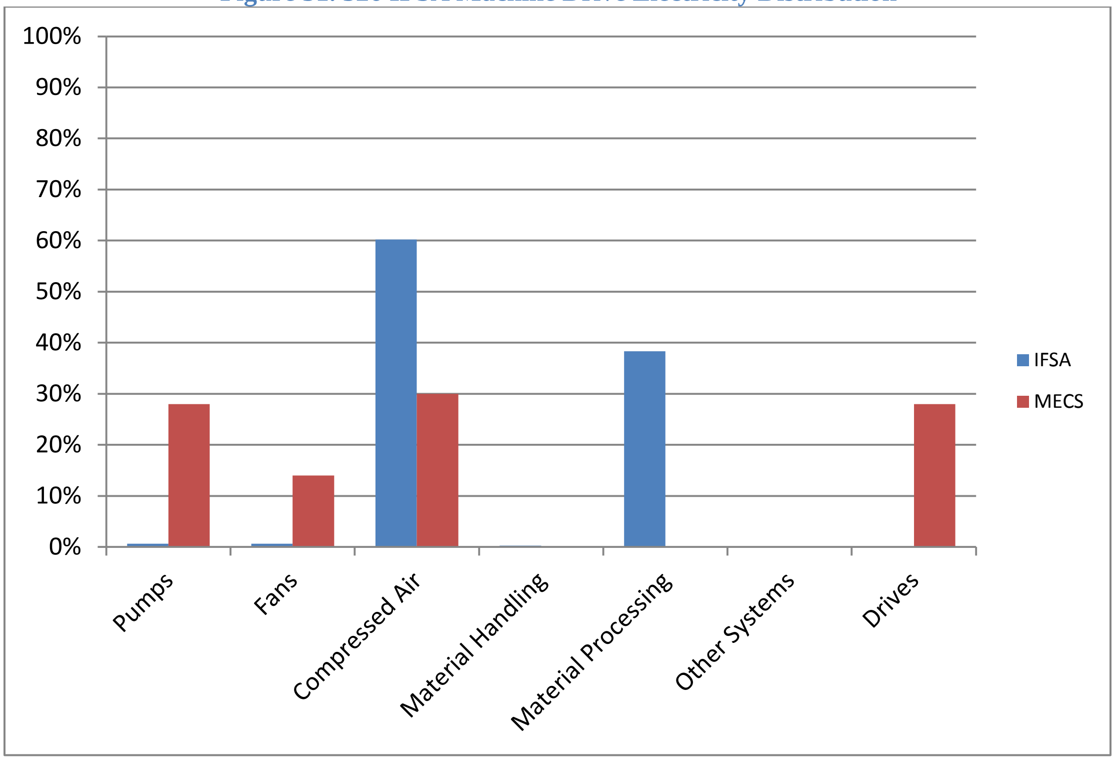
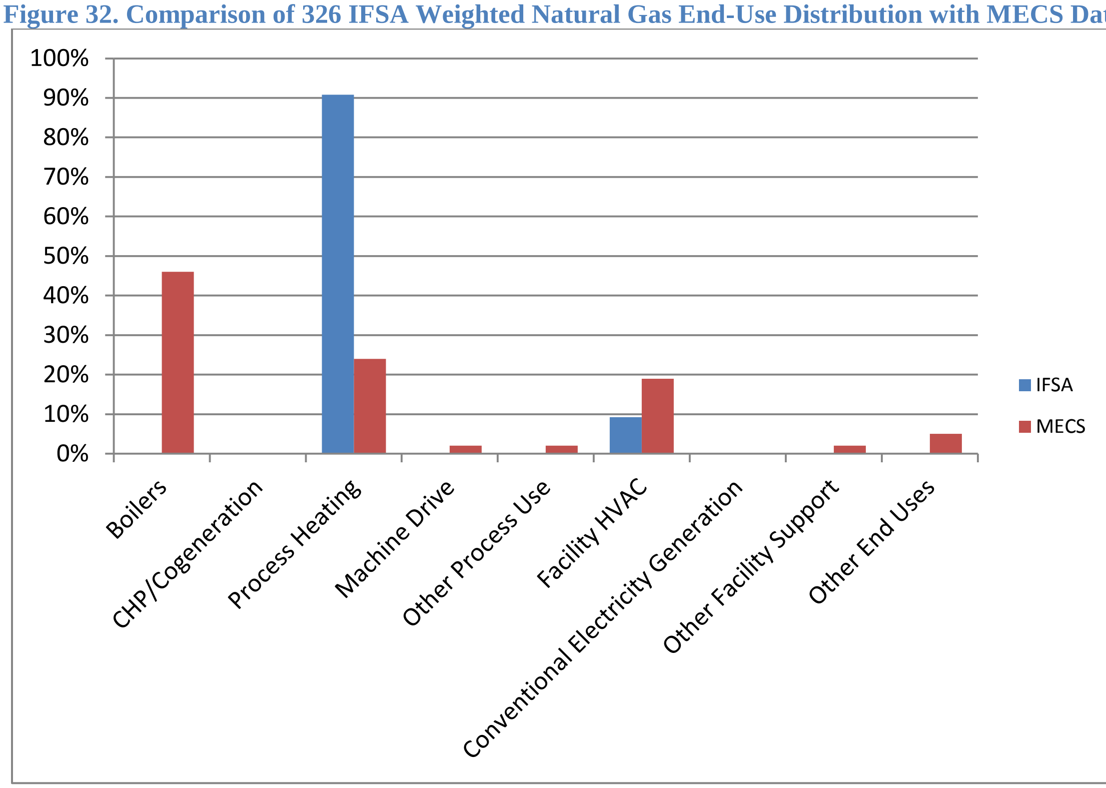


Figure 32. Comparison of 326 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.7 NAICS 327 - Nonmetallic Mineral Products Manufacturing

The Cadmus team initially planned to conduct ten assessments on 327 NAICS facilities and completed eight assessments. Nineteen sites that the Cadmus team attempted to recruit declined the assessment, were not actually industrial facilities, or could not be reached despite repeated contact attempts.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Medium stratum site as Large. The revised stratum definitions and number of sites for the 327 NAICS code are shown in Table 35.

Table 35. Revised 327 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 5,000 MWh	2
Medium	500 MWh - 5,000 MWh	4
Small	< 500 MWh	2

The eight assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3271: Clay Product and Refractory
- 3272: Glass and Glass Product
- 3273: Cement and Concrete Product
- 3274: Lime and Gypsum Product

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 36. This table also shows the end-use energy consumption across all strata for the 327 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 327 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame, the number of employees per stratum was:

- Large: 1,560
- Medium: 15,081
- Small: 4,356

The final weighted average consumption reflects the larger proportion of employees in the Medium and Small strata in the sample frame.

The Cadmus team estimated there was a low level of consistency between end use consumption estimates for the 327 NAICS sites. The team found a large level of variance between sites, likely due to different consumption requirements for each four-digit NAICS code, as well as varying consumption patterns between each facility's processes.

The data show that consumption for 327 NAICS facilities is predominantly driven by natural gas loads for process heating and boilers. The majority of electric loads involved machine drive systems to process and transport nonmetallic mineral products. However, the overall electric consumption for facilities in this industrial sector was sufficiently low that facility lighting represented a non-trivial portion of total consumption.

The weighted average analysis results indicate a moderate natural gas load for conventional boiler use. Only one of the eight sites used a conventional boiler to support process heating. The analysis normalized this consumption across the entire NAICS code, although this particular site may be an outlier in its application of boiler use.

Table 36. 327 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	327 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	162	0	116
	Electricity	kWh	0	2,560	0	1,839
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	48	253	0	186
	Electricity	kWh	0	1,763	376	1,344
Process Cooling and Refrigeration	Electricity	kWh	0	0	0	0
Machine Drive	Electricity	kWh	75,740	43,871	1,651	37,480
Pumps	*Electricity/MD*	*kWh*	1,079	14,787	225	10,748
Fans	*Electricity/MD*	*kWh*	30,771	2,695	0	4,222
Compressed Air	*Electricity/MD*	*kWh*	5,126	1,939	149	1,804
Material Handling	*Electricity/MD*	*kWh*	17,574	8,270	815	7,415
Material Processing	*Electricity/MD*	*kWh*	21,189	16,180	462	13,291
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	20	3	7	5
	Electricity	kWh	54	140	0	105
Facility Lighting	Electricity	kWh	3,230	6,297	719	4,912
Other Facility Support	Electricity	kWh	0	15	701	156
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	79,024	54,646	3,447	45,836
	Natural Gas	MMBTU	68	418	7	307
	Total Energy	MMBTU	337	605	19	463

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use with the corresponding data from MECS. The MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. For example, none of the 327 NAICS sites in the IFSA used process cooling or electrochemical processes. However, both IFSA and MECS featured Machine Drive as the largest electric end use and Process Heating as the largest natural gas end use. There was significant variance in the proportions of consumption for the smaller end uses for both fuels.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends MECS data as the more reliable source for the Northwest, primarily due to relatively low consistency between end use consumption distributions in the IFSA sample.

Figure 33. Comparison of 327 IFSA Weighted Electricity End-Use Distribution with MECS Data

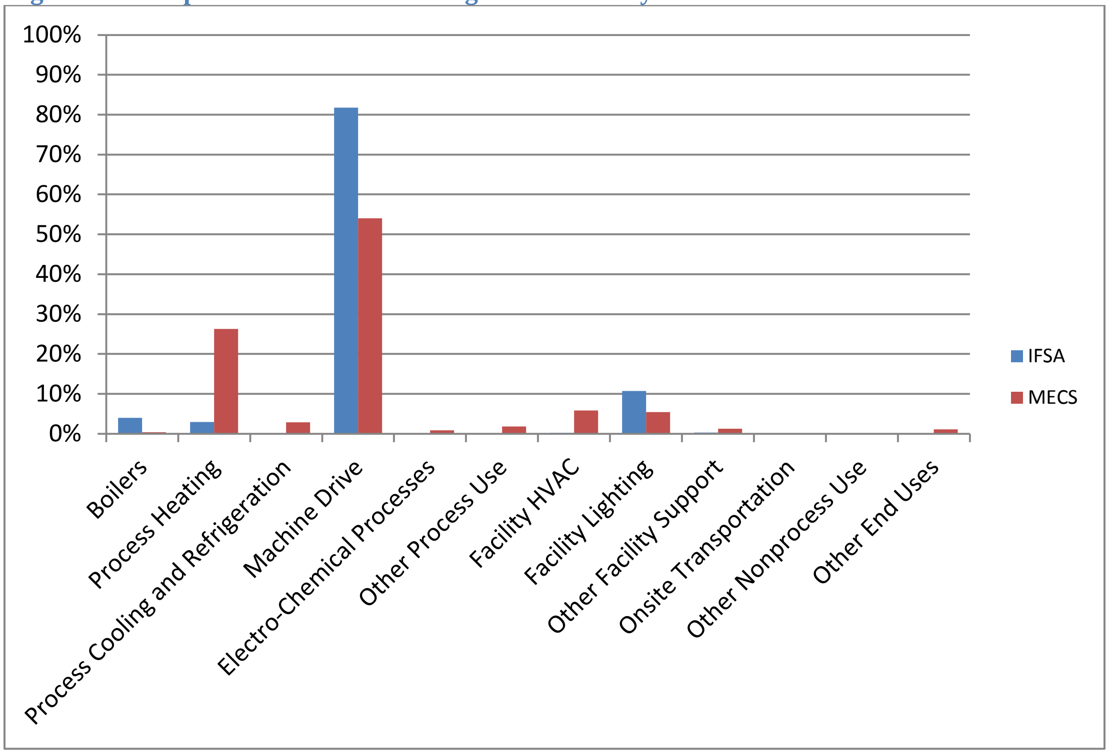


Figure 34. 327 IFSA Machine Drive Electricity Distribution

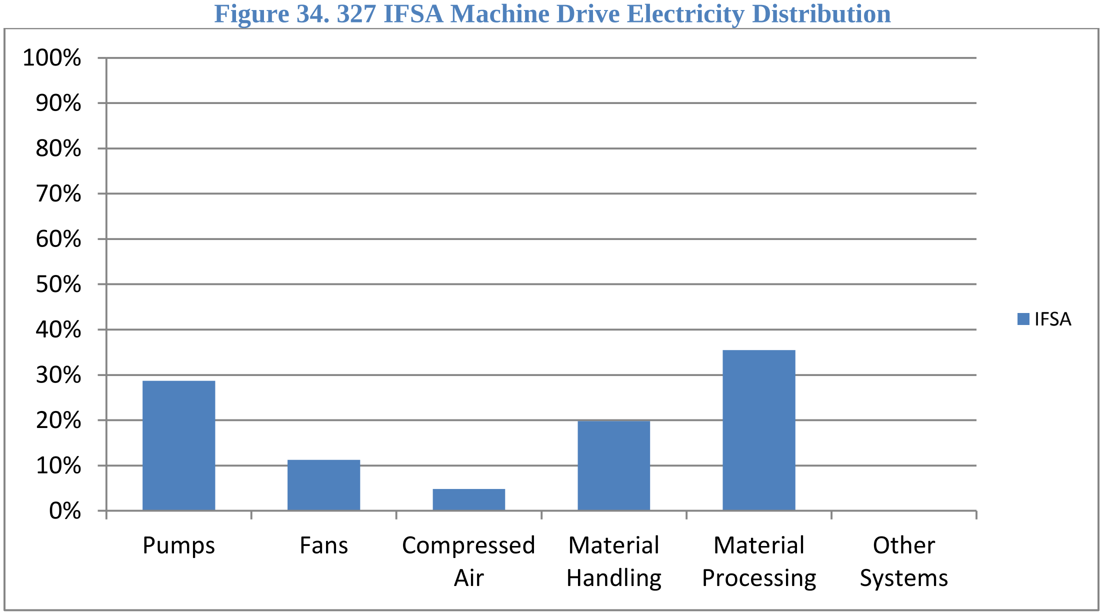
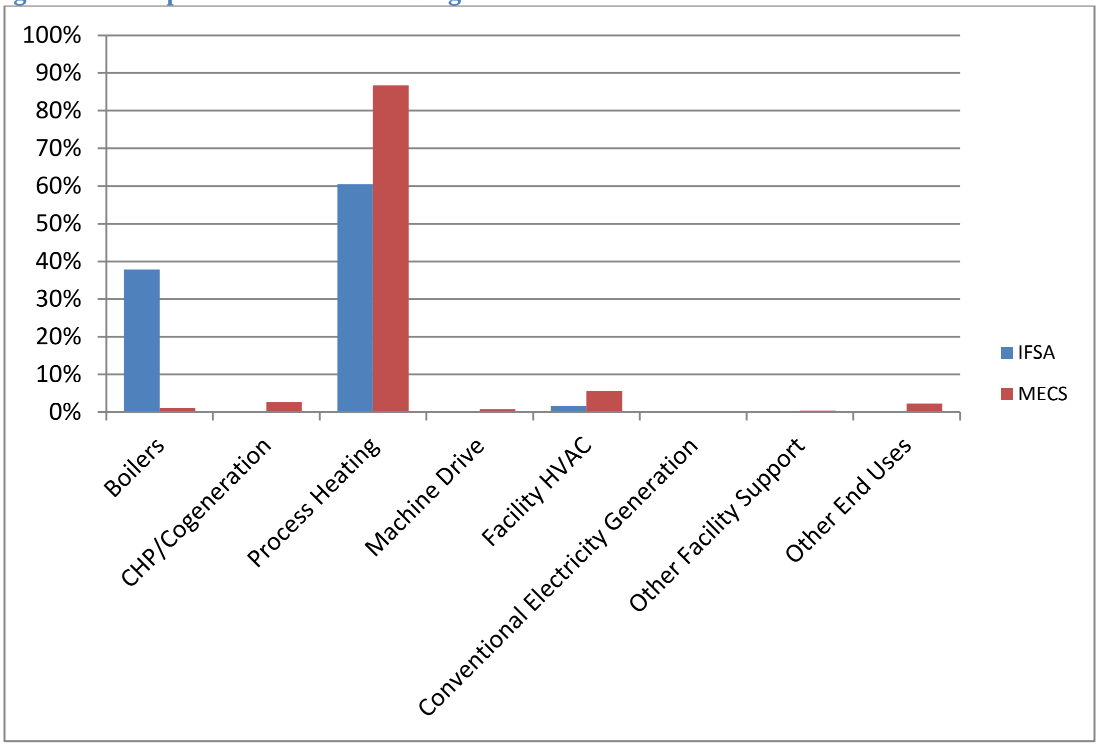


Figure 35. Comparison of 327 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.8 NAICS 331 - Primary Metal Manufacturing

The Cadmus team initially planned to conduct seven assessments on 331 NAICS facilities and completed six assessments. The team originally planned to conduct assessments on two Census sites, but determined one site was an aluminum smelter. The Sample Design working group indicated aluminum smelters were not a major focus of the effort, and the facility contact did not respond to repeated contact attempts. The Cadmus team attempted to recruit a replacement site from a population of seven Large facilities. Most of these sites either declined the assessment or were unresponsive. A utility representative reported that one Large 331 site in his service territory was no longer active.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Large stratum site as Medium and one Medium site as Small. The revised stratum definitions and number of sites for the 331 NAICS code are shown in Table 37.

Table 37. Revised 331 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Census	>50,000 MWh	1
Large	10,000 MWh - 50,000 MWh	1
Medium	500 MWh - 10,000 MWh	1
Small	< 500 MWh	2

The six assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3311: Iron and Steel Mills and Ferroalloy Manufacturing
- 3313: Alumina and Aluminum Production and Processing
- 3314: Nonferrous Metal (except Aluminum) Production and Processing
- 3315: Foundries

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 38. This table also shows the end-use energy consumption across all strata for the 331 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 331 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame, the number of employees per stratum was:

- Census: 19,500
- Large: 1,916

- Medium: 2,485
- Small: 1,891

The final weighted average consumption was dominated by the larger number of employees in the Census stratum in the sample frame. The actual number of employees per site was significantly less than the original reported values, but the relative proportions were somewhat consistent with the sample frame. Without actual employment numbers for the full sample frame, the Cadmus team had to rely on the original sample frame for employment proportions with which to weight the average across the 331 NAICS code.

The Cadmus team estimated there was a medium level of consistency between end use consumption estimates for the 311 NAICS sites. The team found some variance between sites, likely due to different consumption requirements for each four-digit NAICS code and between individual site process requirements.

The analysis data show that consumption for 331 NAICS facilities is driven by natural gas loads for boiler use and process heating, primarily to melt, shape, and process the primary metals. Machine drives represented the major electricity load, particularly for pumping, along with secondary loads contributed by electric process heating and cooling.

Table 38. 331 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Census	Large	Medium	Small	331 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	7,428	0	0	0	5,616
	Electricity	kWh	0	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0	0
Direct Uses-Total Process							
Process Heating	Natural Gas	MMBTU	729	110	40	15	564
	Electricity	kWh	72,927	73,277	978	123	60,683
Process Cooling and Refrigeration	Electricity	kWh	47,746	15,994	3,781	0	37,651
Machine Drive	Electricity	kWh	160,481	43,896	25,477	8,320	127,657
Pumps	*Electricity/MD*	*kWh*	64,844	6,512	1,002	0	49,606
Fans	*Electricity/MD*	*kWh*	33,968	7,235	8,103	1,868	27,137
Compressed Air	*Electricity/MD*	*kWh*	22,205	11,250	4,858	1,719	18,218
Material Handling	*Electricity/MD*	*kWh*	22,128	5,284	183	123	17,149
Material Processing	*Electricity/MD*	*kWh*	17,336	13,615	11,331	4,610	15,548
Other Systems	*Electricity/MD*	*kWh*	0	0	0	0	0
Electro-Chemical Processes	Electricity	kWh	0	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0	0
Direct Uses-Total Nonprocess							
Facility HVAC	Natural Gas	MMBTU	0	3	5	16	2
	Electricity	kWh	31,106	24,155	316	441	25,375
Facility Lighting	Electricity	kWh	29,328	9,533	5,304	3,763	23,669
Other Facility Support	Electricity	kWh	0	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0	0
Total Consumption							
	Electricity	kWh	341,589	166,855	35,856	12,647	275,035
	Natural Gas	MMBTU	8,157	114	45	32	6,182
	Total Energy	MMBTU	9,323	683	167	75	7,121

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. However, both IFSA and MECS reported significant electric load for machine drive and process heating. There was significant variance in the proportions of consumption for the natural gas end uses.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically collected from Northwest sites rather than self-report data.

Figure 36. Comparison of 331 IFSA Weighted Electricity End-Use Distribution with MECS Data

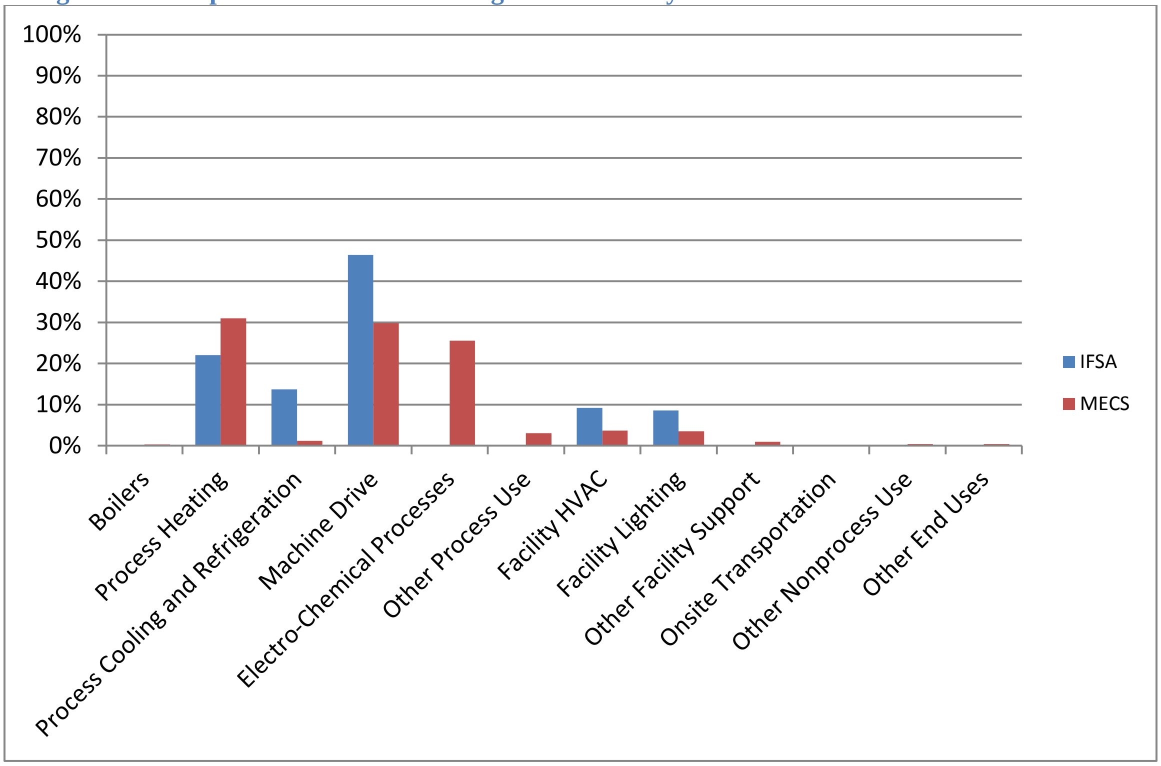


Figure 37. 331 IFSA Machine Drive Electricity Distribution

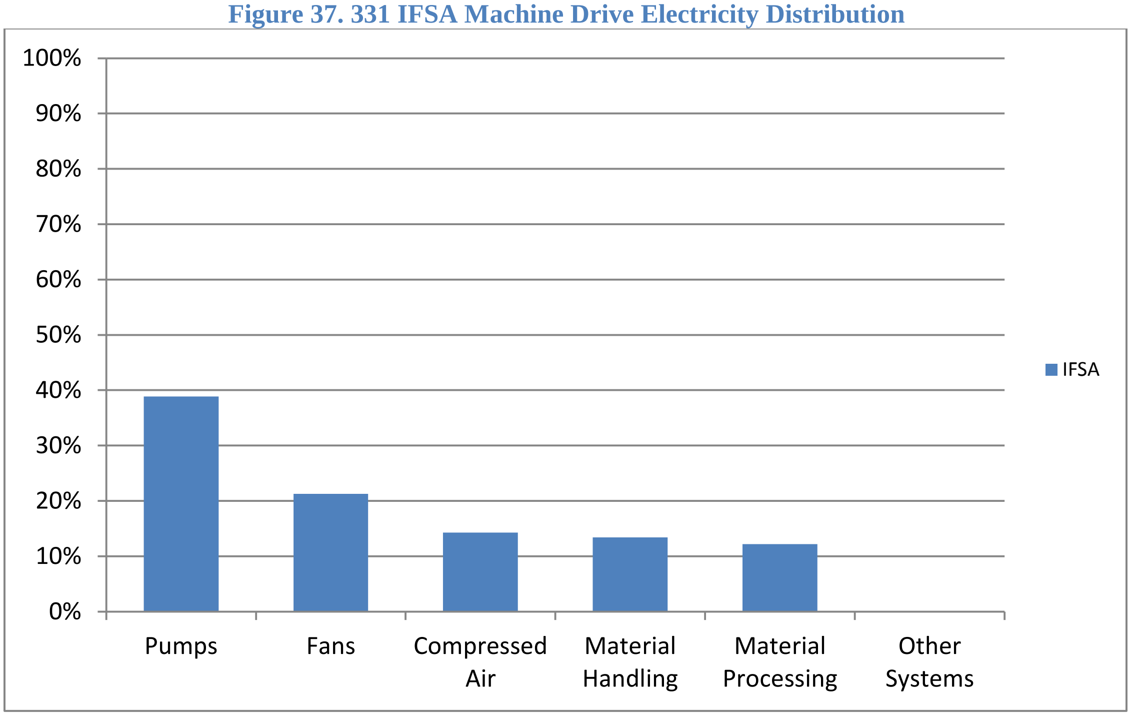
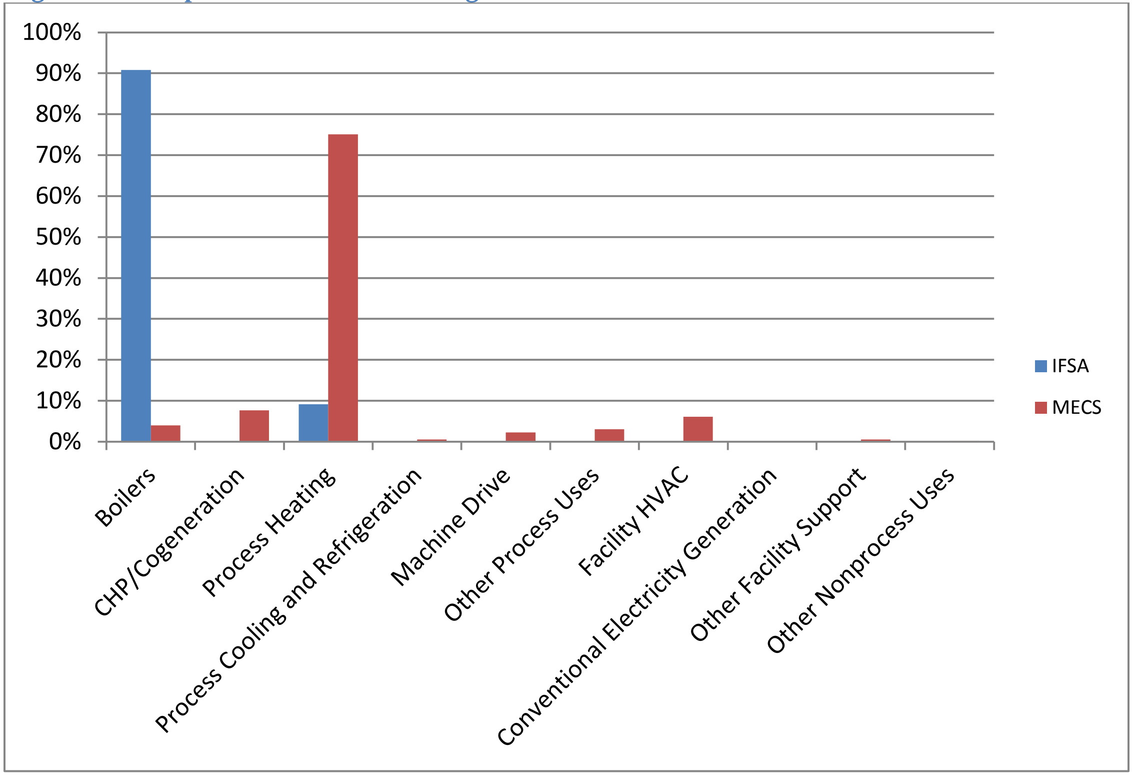


Figure 38. Comparison of 331 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.9 NAICS 332 - Fabricated Metal Products Manufacturing

The Cadmus team planned and conducted eight assessments on 332 NAICS facilities. The team originally planned to conduct assessments on two Large and four Medium strata sites. After completing the two Large site assessments, a previously contacted Large site responded to the Cadmus team and requested an assessment. The team determined it would be appropriate to conduct the assessment since the site had been recruited and to avoid customer service issues for the relevant utility, even though the NAICS/combination had been completed. The Cadmus team removed one site from the Medium stratum to result in three Large and three Medium assessments completed.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Large stratum site as Medium and one Medium site as Large, so the number in each stratum stayed consistent. The revised stratum definitions and number of sites for the 332 NAICS code are shown in Table 39..

Table 39. Revised 332 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 10,000 MWh	3
Medium	500 MWh - 10,000 MWh	3
Small	< 500 MWh	2

The eight assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility’s process requirements.

- 3321: Forging and Stamping
- 3322: Cutlery and Handtool Manufacturing
- 3323: Architectural and Structural Metals Manufacturing
- 3325: Hardware Manufacturing
- 3327: Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 40. This table also shows the end-use energy consumption across all strata for the 332 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 332 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame the number of employees per stratum was:

- Large: 16,900
- Medium: 3,815
- Small: 33,503

The final weighted average consumption reflects the larger proportion of employees in the Large and Small strata in the sample frame.

The Cadmus team estimated there was a high level of consistency between end use consumption estimates for the 332 NAICS sites. The team found little variance in end use consumption distribution between sites.

The data indicate that the majority of 332 NAICS facilities results from natural gas loads for process heating. Like with Primary Metals, the process heating is used to melt and mold metals for fabrication. Machine drives also represent the largest portion of electricity consumption, with the majority of that from material processing applications.

Table 40. 332 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	332 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	242	0	0	75
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	986	0	0	307
	Electricity	kWh	5,034	2,198	0	1,724
Process Cooling and Refrigeration	Electricity	kWh	7,216	442	0	2,281
Machine Drive	Electricity	kWh	56,796	7,510	317	18,428
Pumps	*Electricity/MD*	*kWh*	7,862	75	0	2,456
Fans	*Electricity/MD*	*kWh*	3,722	180	0	1,173
Compressed Air	*Electricity/MD*	*kWh*	7,344	1,868	99	2,481
Material Handling	*Electricity/MD*	*kWh*	2,572	353	2	827
Material Processing	*Electricity/MD*	*kWh*	34,224	5,035	217	11,156
Other Systems	*Electricity/MD*	*kWh*	1,072	0	0	334
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	94	3	2	31
	Electricity	kWh	12,092	2,776	13	3,972
Facility Lighting	Electricity	kWh	8,964	2,788	74	3,036
Other Facility Support	Electricity	kWh	3,113	19	0	972
Onsite Transportation	Electricity	kWh	245	0	0	76
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	12	7
Total Consumption						
	Electricity	kWh	93,703	15,735	416	30,572
	Natural Gas	MMBTU	1,080	3	2	338
	Total Energy	MMBTU	1,400	57	4	443

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities with more variety in the end-use equipment than the Cadmus team found in the limited Northwest sample. Process heating was the largest electric end use in the IFSA results, while it was only $1/5^{th}$ of the total electric load according to MECS. However, both IFSA and MECS featured process heating as the largest natural gas end use. There was slight variance in the proportions of consumption for the smaller end uses for both fuels.

Overall, the Cadmus team estimated a low level of variance between the IFSA and MECS data. Despite the relatively small sample size, the Cadmus team recommends IFSA data as the more reliable source for the Northwest since it relies on engineering analysis based on data physically

collected from Northwest sites and is fairly consistent with MECS data on major end use distributions.

Figure 39. Comparison of 332 IFSA Weighted Electricity End-Use Distribution with MECS Data

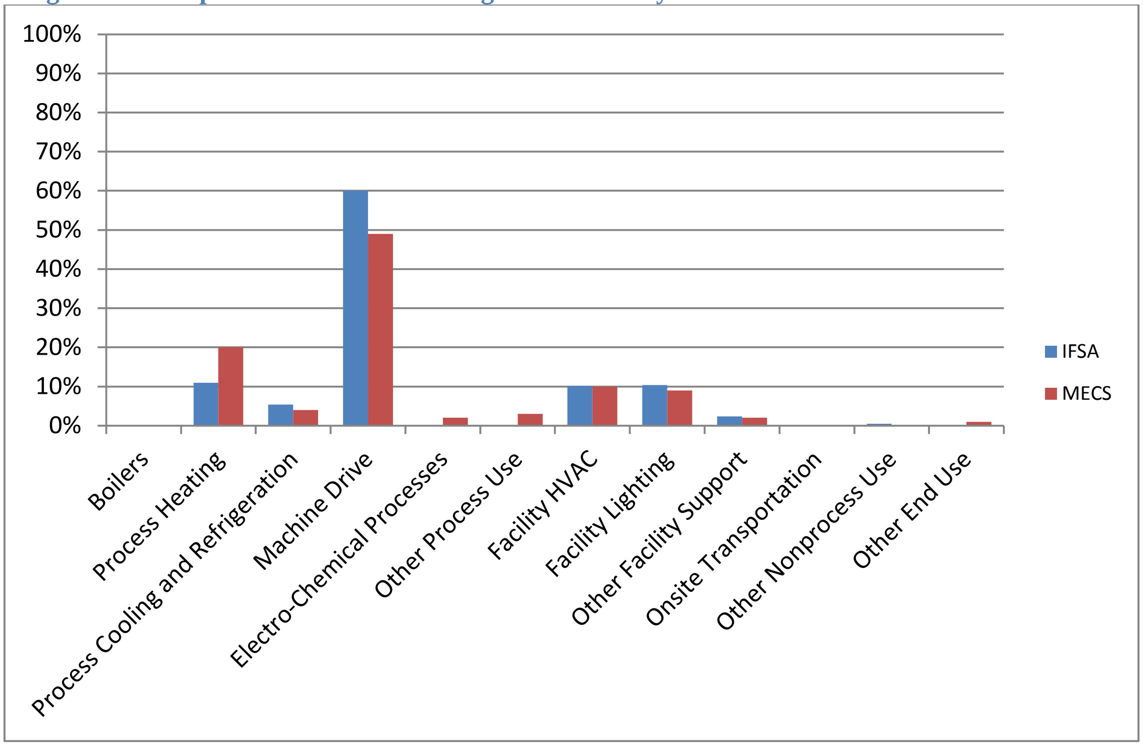


Figure 40. Comparison of 332 IFSA Machine Drive Electricity Distribution with MECS Data

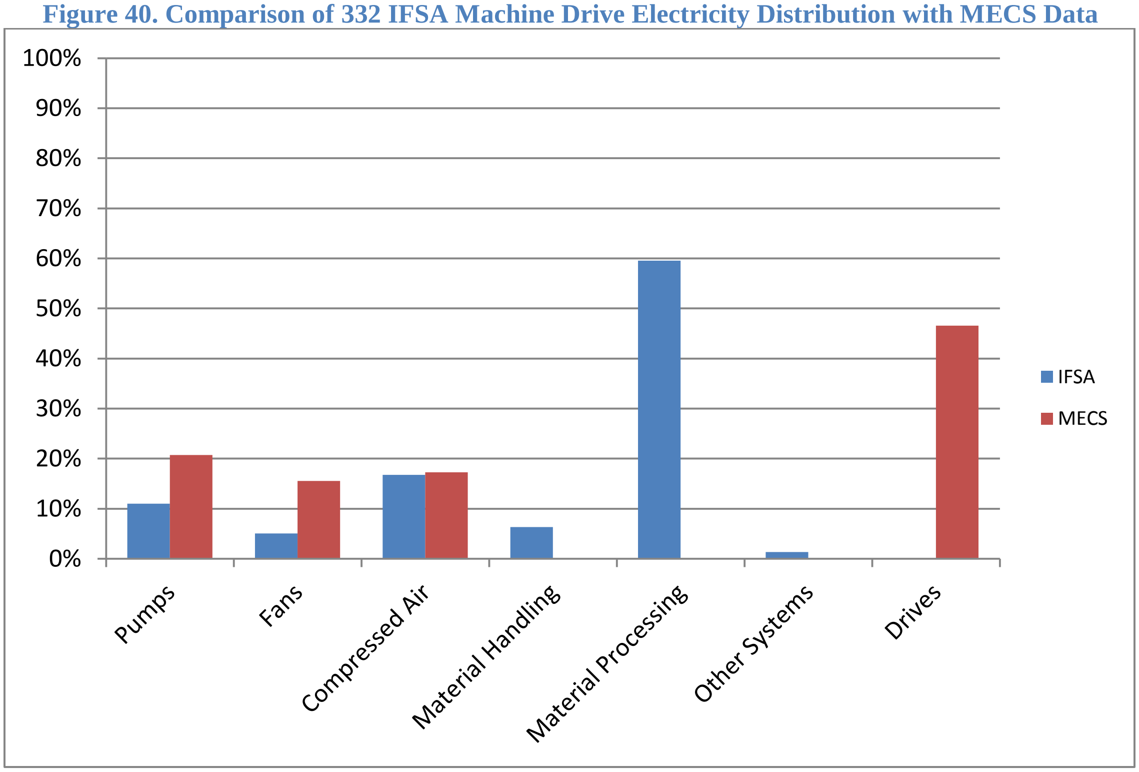
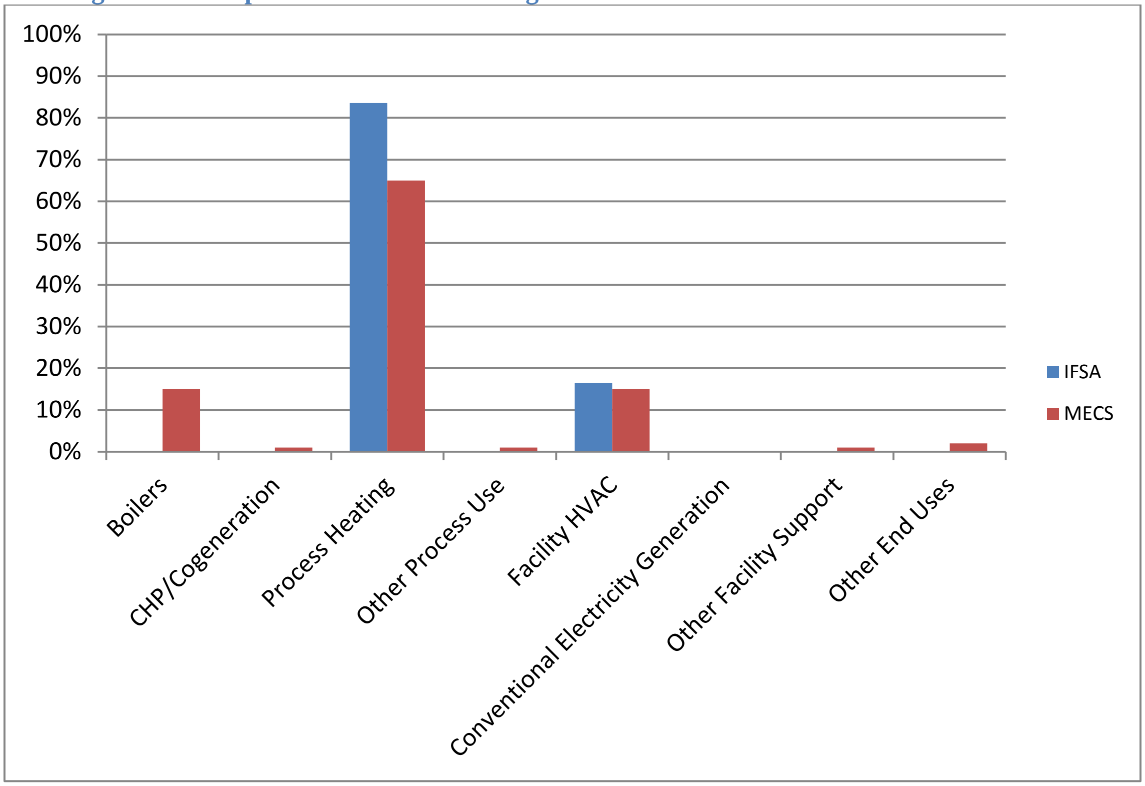


Figure 41. Comparison of 332 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.10 NAICS 334 - Computer and Electronic Products Manufacturing

The Cadmus team initially planned to conduct eight assessments on 334 NAICS facilities and completed three assessments. Computer and Electronics Manufacturing represents a growing, highly competitive industry in the Northwest. The team was unable to recruit the remaining sites despite outreach attempts to thirty potential participants. These sites were nearly evenly split among those that declined the assessment, were unresponsive, or were determined to not actually be industrial facilities.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. All three projects matched their previous strata. The stratum definitions and number of sites for the 334 NAICS code are shown in Table 41.

Table 41. Revised 334 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	> 10,000 MWh	1
Medium	500 MWh - 10,000 MWh	2
Small	< 500 MWh	0

The three assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3344: Semiconductor and Other Electronic Component Manufacturing
- 3345: Navigational, Measuring, Electromedical, and Control Instruments Manufacturing

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 42. This table also shows the end-use energy consumption across all strata for the 334 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 334 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame the number of employees per stratum was:

- Large: 6,177
- Medium: 29,288

The final weighted average consumption reflects the larger proportion of employees in the Medium stratum in the sample frame.

The Cadmus team estimated there was a low level of consistency between end use consumption estimates for the 325 NAICS sites. The team found a large level of variance between sites, likely due to different consumption requirements for each four-digit NAICS code, as well as varying consumption patterns between each facility's processes.

The results show that consumption for 334 NAICS facilities is driven by electricity primarily by machine drive systems. Material processing represents the majority of machine drive consumption. Facility HVAC represents a relatively large portion of overall electricity consumption (seventeen percent) and natural gas consumption (sixty-four percent) perhaps due to the precise temperature controls often required in electronics manufacturing.

Table 42. 334 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	334 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	19	0	11
	Electricity	kWh	0	18	0	11
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	10	0	6
	Electricity	kWh	0	3,874	0	2,367
Process Cooling and Refrigeration	Electricity	kWh	0	109	0	67
Machine Drive	Electricity	kWh	107,302	5,529	0	17,208
Pumps	*Electricity/MD*	*kWh*	12,087	303	0	1,743
Fans	*Electricity/MD*	*kWh*	18,392	206	0	2,496
Compressed Air	*Electricity/MD*	*kWh*	18,670	753	0	2,867
Material Handling	*Electricity/MD*	*kWh*	0	765	0	467
Material Processing	*Electricity/MD*	*kWh*	56,842	3,502	0	9,466
Other Systems	*Electricity/MD*	*kWh*	1,311	0	0	169
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	0
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	177	14	0	31
	Electricity	kWh	28,721	1,370	0	4,539
Facility Lighting	Electricity	kWh	3,227	2,341	0	1,847
Other Facility Support	Electricity	kWh	3,085	0	0	398
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	142,335	13,242	0	26,436
	Natural Gas	MMBTU	177	43	0	49
	Total Energy	MMBTU	662	88	0	139

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities than the Cadmus team assessed. IFSA featured machine drive as the largest electric end use, while facility HVAC represented the largest electric load in the MECS data. However, facility HVAC was the second largest electric end use in the IFSA results. There was also a slight variance in the natural gas end-use distribution as the largest two end uses were the same but in the opposite order.

Overall, the Cadmus team estimated a medium level of variance between the IFSA and MECS data. In this case, the Cadmus team recommends MECS data as the more reliable source for the Northwest, primarily due to the relatively small size and low consistency in the IFSA sample.

Figure 42. Comparison of 334 IFSA Weighted Electricity End-Use Distribution with MECS Data

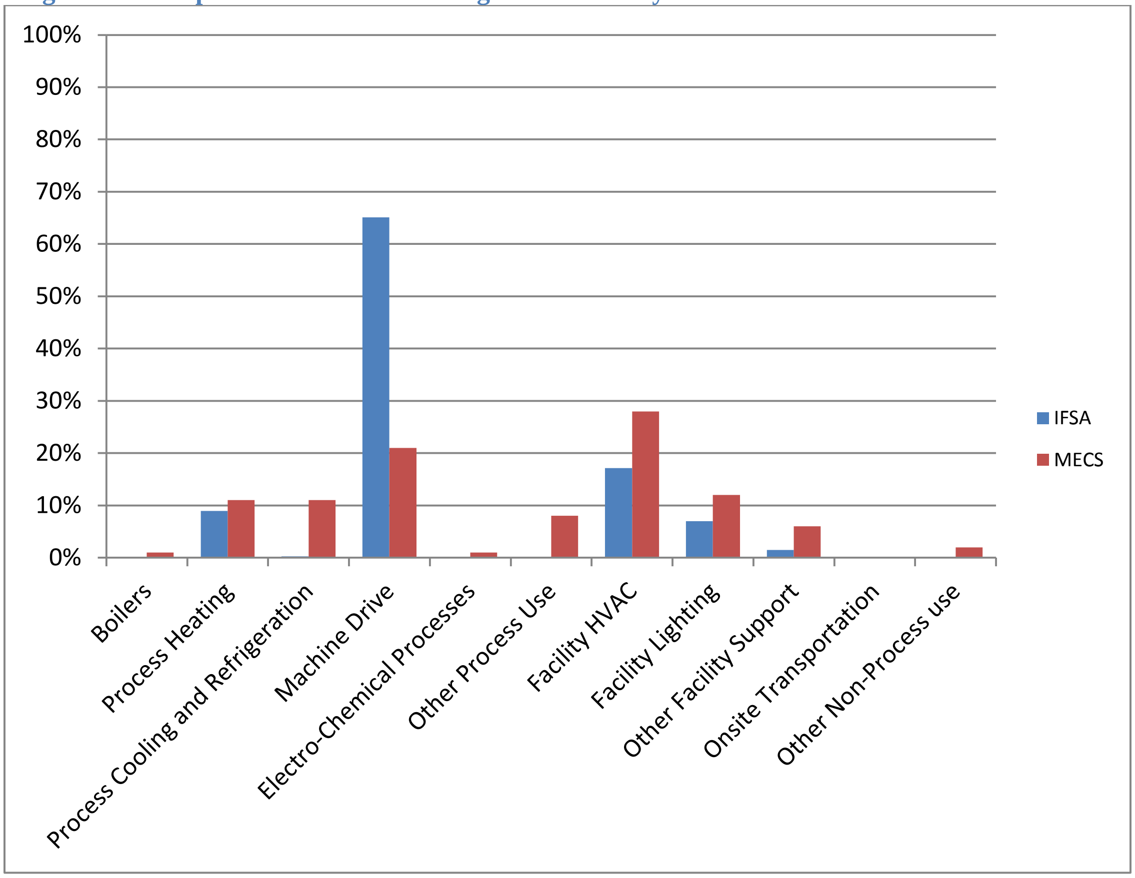


Figure 43. Comparison of 334 IFSA Machine Drive Electricity Distribution with MECS

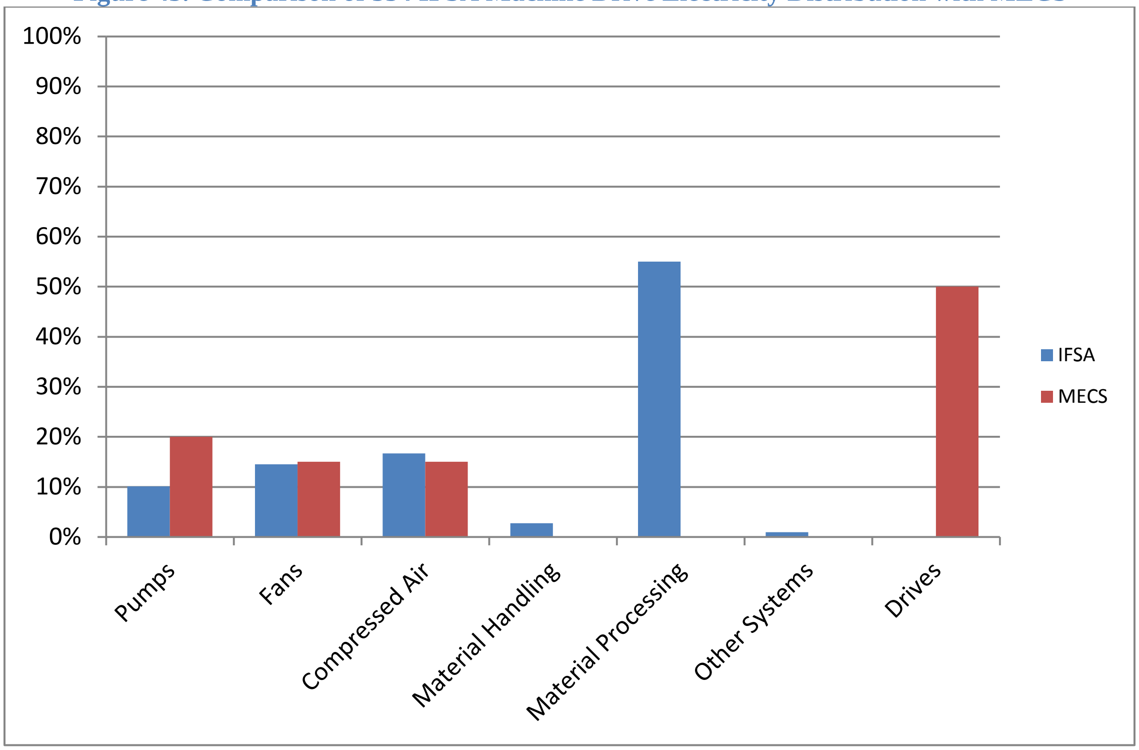
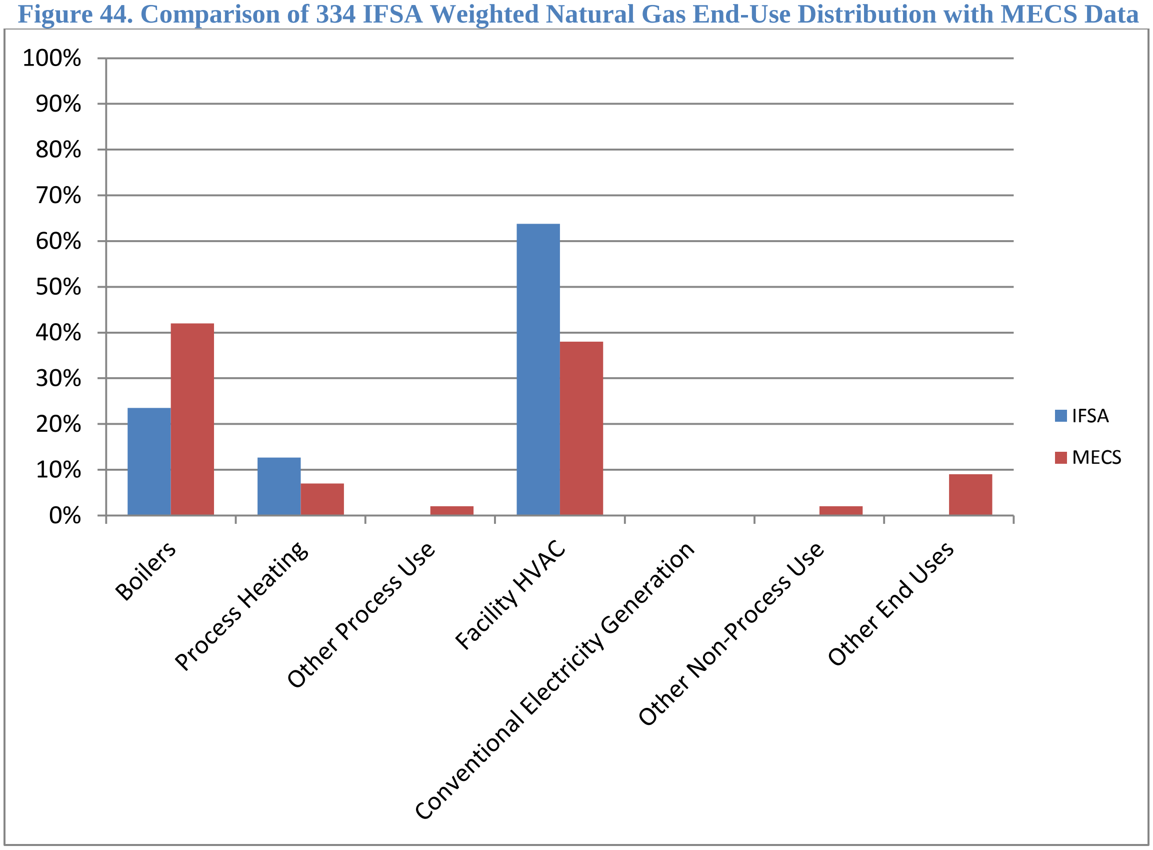


Figure 44. Comparison of 334 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.11 NAICS 336 - Transportation Equipment Manufacturing

The Cadmus team planned and conducted eight assessments on 336 NAICS facilities. The team originally planned to conduct assessments on four Medium and two Small strata sites. After completing the four Medium site assessments, a previously contacted Medium site responded to the Cadmus team and requested an assessment. The team determined it would be appropriate to conduct the assessment since the site had been recruited and to avoid customer service issues for the relevant utility, even though the NAICS/combination had been completed. The Cadmus team removed one site from the Small stratum to result in five Medium assessments and one Small completed.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Large stratum site as Medium and one Medium site as Small. The revised stratum definitions and number of sites for the 336 NAICS code are shown in Table 43..

Table 43. Revised 336 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Large	>5,000 MWh	1
Medium	500 MWh - 5,000 MWh	5
Small	< 500 MWh	2

The eight assessed sites represented the following four-digit NAICS codes. The different four-digit codes resulted in variance in energy consumption for end uses based on each facility's process requirements.

- 3362: Motor Vehicle Body and Trailer Manufacturing
- 3363: Motor Vehicle Parts Manufacturing
- 3364: Aerospace Product and Parts Manufacturing
- 3366: Ship and Boat Building

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 44. This table also shows the end-use energy consumption across all strata for the 336 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 336 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame, the number of employees per stratum was:

- Large: 2,819
- Medium: 55,321
- Small: 7,116

The final weighted average consumption reflects the larger proportion of employees in the Medium stratum in the sample frame.

The Cadmus team estimated there was a low level of consistency between end use consumption estimates for the 336 NAICS sites. The team found a large level of variance between sites, likely due to different consumption requirements for each four-digit NAICS code, as well as varying consumption patterns between each facility’s processes.

The results show that consumption for 336 NAICS facilities is driven by electricity primarily by machine drive systems, with the majority due to material processing applications. Other machine drive systems are nearly even split among the remainder. The 336 NAICS facilities have a relatively low energy consumption per employee compared with other NAICS codes assessed through the IFSA.

Table 44. 336 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	336 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	27	0	23
	Electricity	kWh	0	242	0	205
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	54	0	46
	Electricity	kWh	0	2,883	996	2,553
	Propane	MMBTU	0	44	0	37
Process Cooling and Refrigeration	Electricity	kWh	0	145	0	123
Machine Drive	Electricity	kWh	50,711	5,436	5,209	7,367
Pumps	*Electricity/MD*	*kWh*	0	741	156	646
Fans	*Electricity/MD*	*kWh*	4,270	958	0	997
Compressed Air	*Electricity/MD*	*kWh*	6,673	1,097	770	1,302
Material Handling	*Electricity/MD*	*kWh*	4,328	370	0	501
Material Processing	*Electricity/MD*	*kWh*	35,440	2,257	4,282	3,911
Other Systems	*Electricity/MD*	*kWh*	0	12	0	10
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	363	0	308
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	42	19	0	18
	Electricity	kWh	0	1,381	385	1,213
Facility Lighting	Electricity	kWh	8,806	2,095	1,698	2,341
Other Facility Support	Electricity	kWh	0	47	0	40
Onsite Transportation	Electricity	kWh	0	0	18	2
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	327	34	0	43
Total Consumption						
	Electricity	kWh	59,844	12,644	8,306	14,194
	Natural Gas	MMBTU	42	100	0	87
	Propane	MMBTU	0	18	0	37
	Total Energy	MMBTU	247	143	28	135

The following figures provide a graphical comparison between the IFSA results for weighted average energy consumption by end use and the corresponding data from MECS. The MECS data included results from a larger sample of facilities than the Cadmus team assessed. However, both IFSA and MECS featured machine drive as the largest electric end use. Results of the next three largest electric end-uses were also similar. Although the largest natural gas end-use was different between IFSA and MECS, there was not significant variance in the natural gas end-use distribution.

Overall, the Cadmus team estimated a low level of variance between the IFSA and MECS data. Since the 336 NAICS site data showed relatively little consistency, the Cadmus team does not believe the IFSA data is reliable. However, since the MECS data has few discrepancies from IFSA in the end use consumption distributions, it's possible that these data sources are equally reliable (or unreliable) for Northwest energy consumption estimates.

Figure 45. Comparison of 336 IFSA Weighted Electricity End-Use Distribution with MECS Data

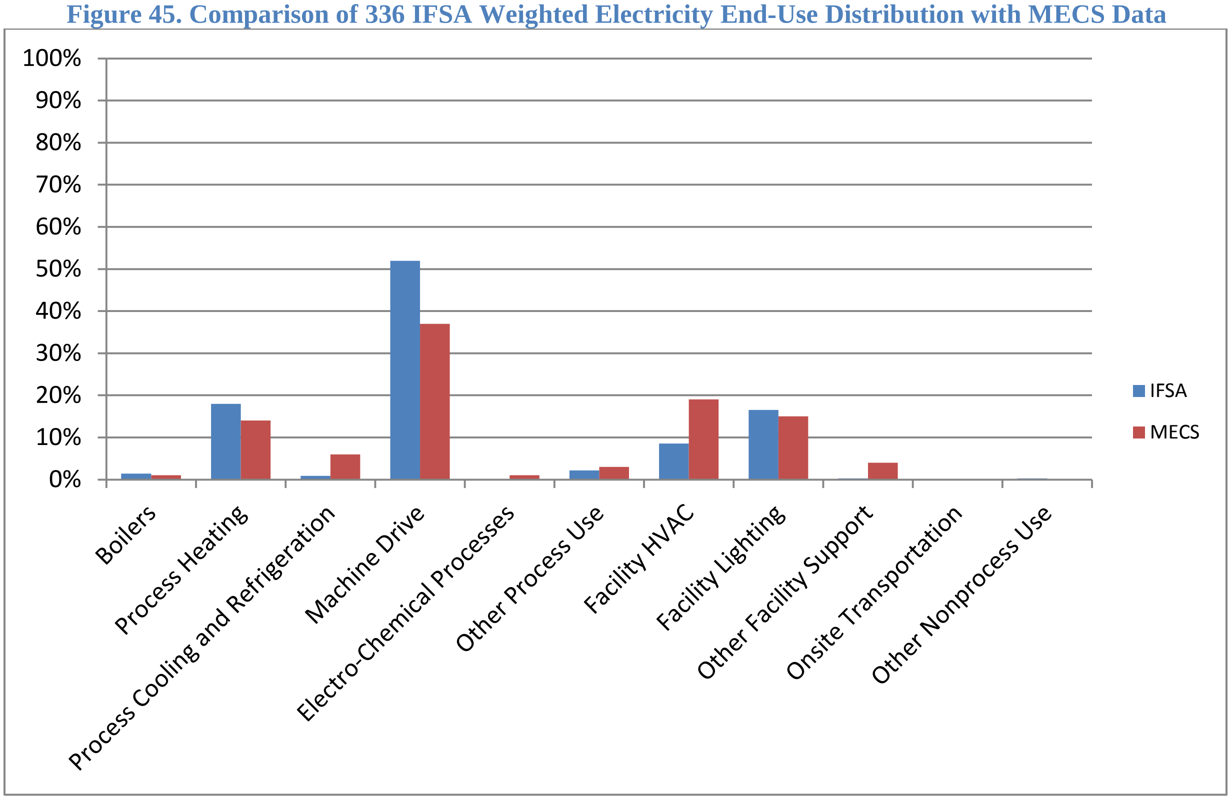


Figure 46. Comparison of 336 IFSA Machine Drive Electricity Distribution with MECS

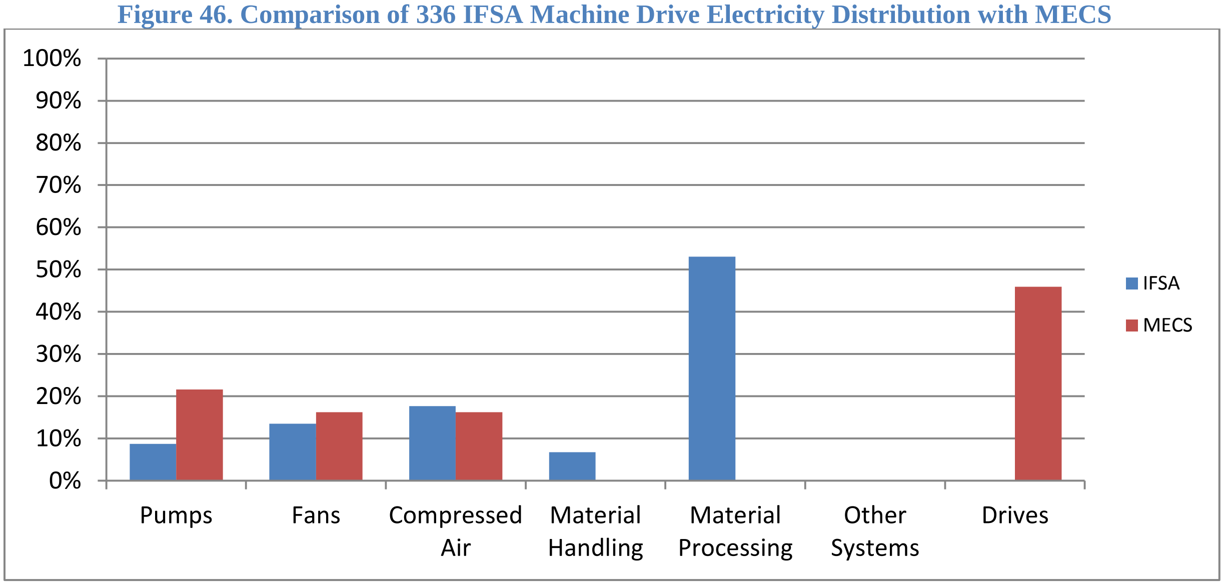
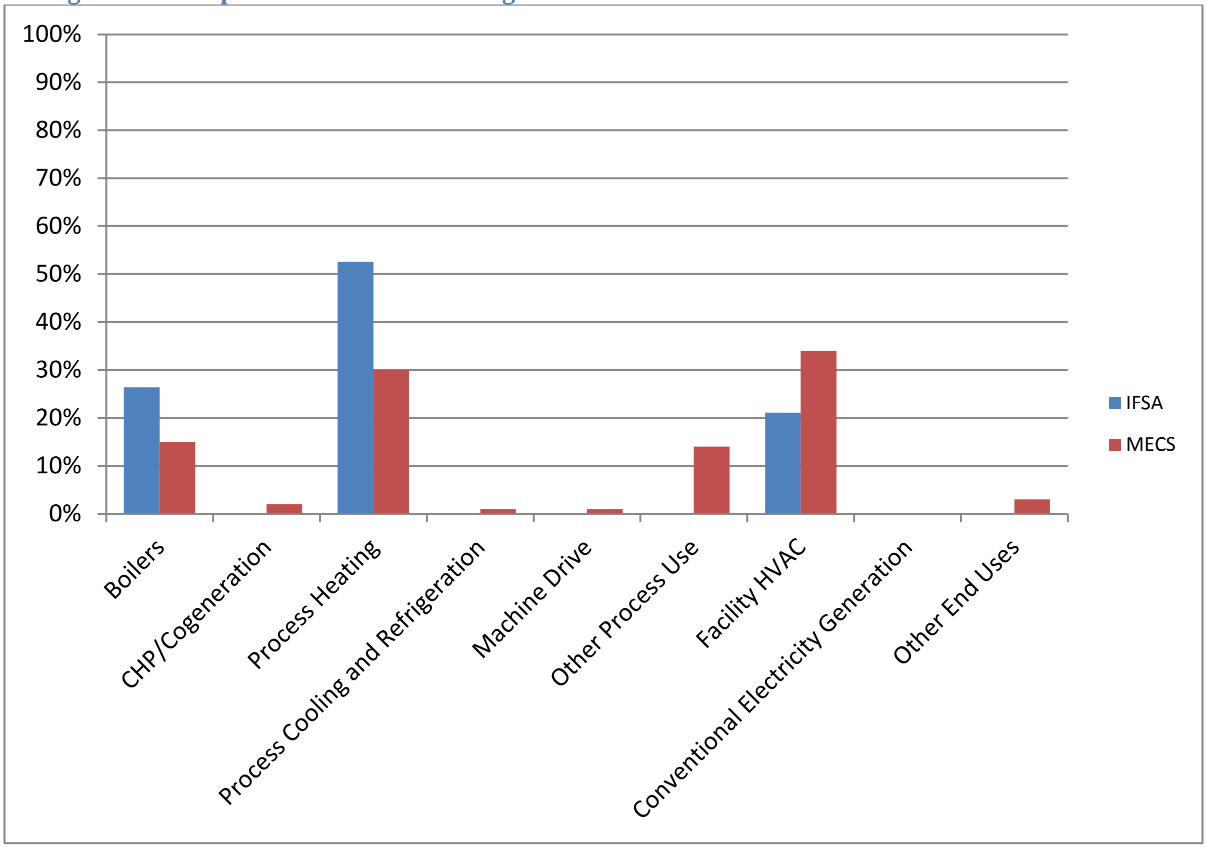


Figure 47. Comparison of 336 IFSA Weighted Natural Gas End-Use Distribution with MECS Data



6.12 NAICS 493 - Refrigerated Warehousing and Storage

The Cadmus team initially planned to conduct eight assessments on 493 NAICS facilities and completed seven assessments. The team was unable to recruit the last Small stratum site despite outreach attempts to twelve potential participants. Most of these sites either could not be reached or had been misclassified. One Large site offered to provide the field engineer with equipment operating data to reduce the analysis uncertainty, but ultimately did not provide the data. The field engineer had not collected sufficient data on-site to complete the data analysis. In addition, one Medium site refused to release its utility billing data after the assessment was completed, resulting in a final total of five completed 493 assessments.

The Cadmus team revised the stratum definitions based on the actual consumption data and reallocated the facilities accordingly. Based on the new stratum definitions, the Cadmus team reclassified one Census stratum site as Large, one Large site as Medium, and one Small site as Medium. The revised stratum definitions and number of sites for the 493 NAICS code are shown in Table 45. All 493 sites have the same four-digit NAICS code, 4931.

Table 45. Revised 493 NAICS Strata Definitions

Stratum	Definition	Number of Facilities
Census	> 10,000 MWh	1
Large	5,000 MWh - 10,000 MWh	1
Medium	500 MWh - 5,000 MWh	3
Small	< 500 MWh	0

The Cadmus team normalized the end-use energy consumption for each stratum by number of employees, as shown in Table 46. This table also shows the end-use energy consumption across all strata for the 493 NAICS code, weighted by number of employees. The Cadmus team also estimated the weighted average consumption across all 493 NAICS sites in the Northwest population based on the relative proportion of employees per stratum from the original sample frame. In the original sample frame the number of employees per stratum was:

- Census: 2,600
- Large: 600
- Medium: 1,852
- Small: 480

The Cadmus team estimated there was a high level of consistency between end use consumption estimates for the 493 NAICS sites. The team found little variance in end use consumption distribution between sites.

The final weighted average consumption reflects the larger proportion of employees in the Medium stratum in the sample frame. As expected, the data show that consumption for 493 NAICS facilities is driven by electricity for process cooling and refrigeration.

Table 46. 493 NAICS Weighted End-Use Energy Consumption per Employee

Indirect Uses-Boiler Fuel	Fuel Type	Unit	Large	Medium	Small	493 NAICS Weighted Average
Conventional Boiler Use	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	0	0	0
CHP and/or Cogeneration Process	Diesel or Distillate	Gallons	0	0	0	0
Direct Uses-Total Process						
Process Heating	Natural Gas	MMBTU	0	0	0	0
	Electricity	kWh	0	42	0	15
Process Cooling and Refrigeration	Electricity	kWh	20,929	11,840	0	20,637
Machine Drive	Electricity	kWh	13,187	1,252	0	6,569
Pumps	*Electricity/MD*	*kWh*	402	22	0	140
Fans	*Electricity/MD*	*kWh*	0	24	0	9
Compressed Air	*Electricity/MD*	*kWh*	754	91	0	1,652
Material Handling	*Electricity/MD*	*kWh*	3,362	1,116	0	1,705
Material Processing	*Electricity/MD*	*kWh*	7,118	0	0	1,960
Other Systems	*Electricity/MD*	*kWh*	1,550	0	0	1,105
Electro-Chemical Processes	Electricity	kWh	0	0	0	0
Other Process Use	Electricity	kWh	0	0	0	2,246
Direct Uses-Total Nonprocess						
Facility HVAC	Natural Gas	MMBTU	0	23	0	8
	Electricity	kWh	151	308	0	181
Facility Lighting	Electricity	kWh	8,710	1,649	0	6,466
Other Facility Support	Electricity	kWh	0	0	0	0
Onsite Transportation	Electricity	kWh	0	0	0	0
Conventional Electricity Generation	Natural Gas	MMBTU	0	0	0	0
Other Nonprocess Use	Electricity	kWh	0	0	0	0
Total Consumption						
	Electricity	kWh	42,977	15,091	0	36,115
	Natural Gas	MMBTU	0	23	0	8
	Total Energy	MMBTU	147	74	0	132

The following figures provide a graphical comparison for the IFSA results. MECS does not provide data for the 493 NAICS, so the team could not provide a comparison. Cadmus considers this data to be reliable since the end use consumption distribution data was relative consistent between sites.

Figure 48. 493 IFSA Weighted Electricity End-Use Distribution

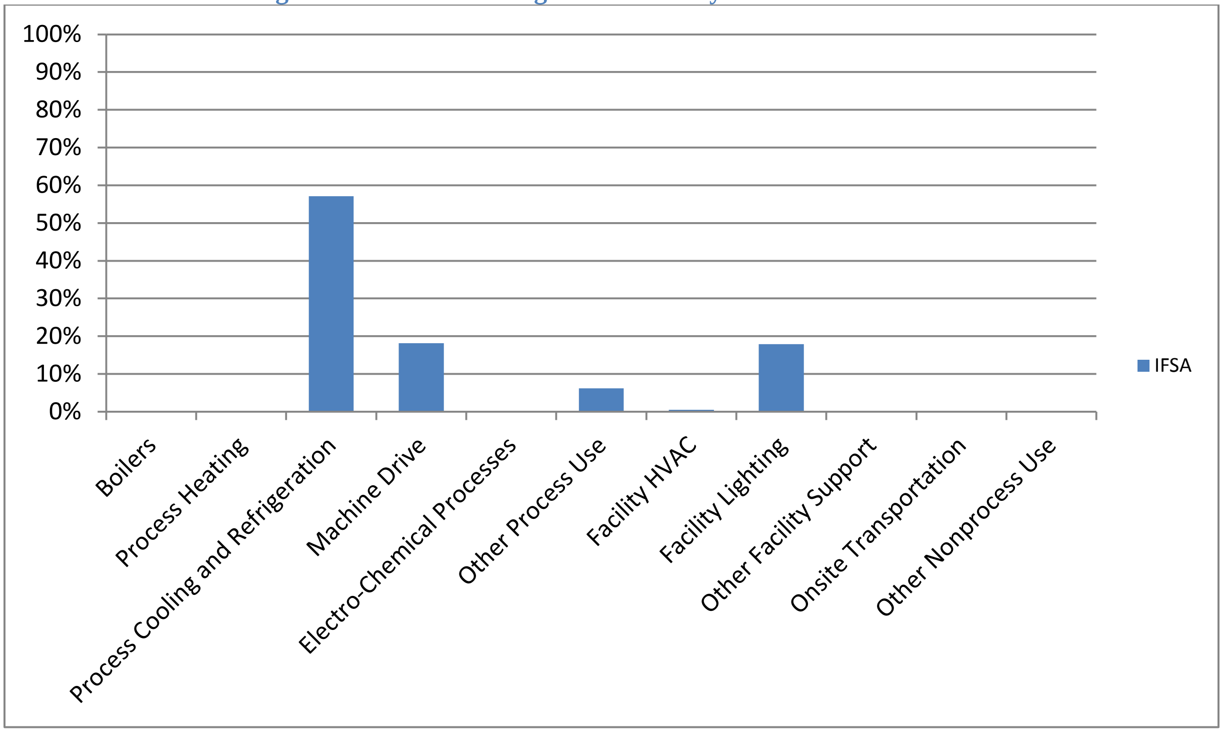
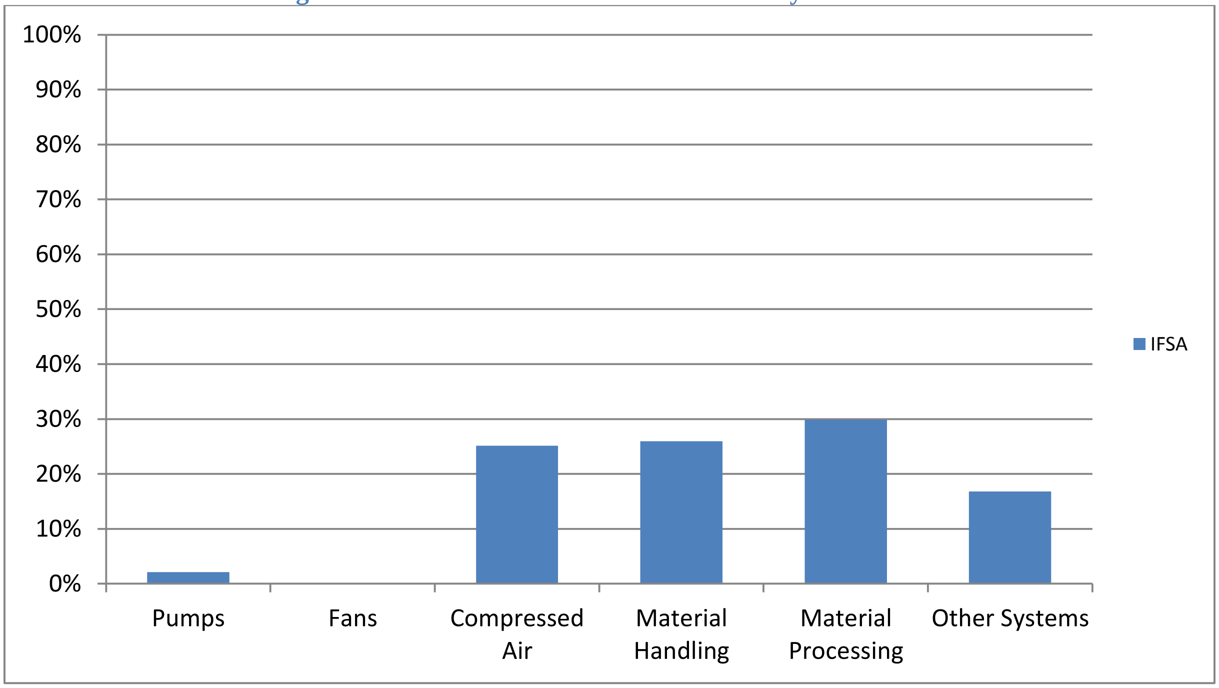


Figure 49. 493 IFSA Machine Drive Electricity Distribution



6.13 SEM Adoption Level Findings

As part of the site assessment, the Cadmus team also surveyed facility managers about the strategic energy management activities in place. The intent was to learn more about how industrial facilities manage their energy consumption and whether this varies by facility size or facility type. This information is useful for regional utilities and program administrators to determine which energy efficiency services may be most valuable, and whether to target certain facility types

The Cadmus team conducted the assessment of SEM adoption based on three major categories:[18]

1. **Customer commitment:** including SEM support and communication from top management, proper resources allocated to SEM, regular review of the SEM program, and staff awareness of SEM.

2. **Planning and implementation:** including conducting a facility energy audit, tracking energy consumption, setting goals for energy performance improvement, developing an energy management plan (and regularly assessing or revising the plan), engaging employees in energy-efficiency activities, and implementing energy projects.

3. **Measurement, tracking, and reporting (MT&R):** including regularly measuring energy performance and tracking progress toward energy performance goals.

As discussed earlier in the report, our team analyzed the corresponding questions for each SEM category and scored SEM adoption under each category as “Full”, “Some” or “None” for each facility based on the survey data.

[18] This was NEEA’s definition at the time of survey development in 2013. Recently, the Consortium for Energy Efficiency released its definition of minimum elements for SEM (CEE 2014). This guidance document was not available at the time Cadmus developed the survey instrument and scoring methodology.

Table 47. SEM Adoption Scoring Overview

SEM Category	Corresponding Question(s)	Full	Some	None
1. Customer Commitment				
Policy and Goals	EM16	EM16 = 1	Any other response combination	EM16 = 2 or -99
Resources	EM5, EM6, EM7, EM8	(EM5 > 1 OR EM6 > 1) AND (EM7 < 4 OR EM8 < 3)		(EM5 = 1 AND EM6 = 1) AND (EM7 = 4 or -99 AND EM8 = 3 or -99)
2. Planning and Implementation				
EM Assessment	EM9	EM9 = 1 or 2	Any other response combination	EM9 = 3 or -99
Energy Map	EM15	EM15 = 1, 2, or 3		EM15 = 4 or -99
Metrics & Goals	EM16	EM16 = 1		EM16 = 2 or -99
Project Register	EM17	EM17 = 1 or 2		EM17 = 3 or -99
Employee Engagement	EM10	EM10 = 1, 2, 3, or -77		EM10 = -98 or -99
Implementation	None			
Reassessment	EM17a, EM19	(EM17a = 1, 2, or 3) AND (EM19 = 1 or 2)		EM17a = 4 or -99 AND EM19 = -99
3. Measurement, Tracking, and Reporting (MT&R)				
Measurement	EM15, EM15a, EM15b, EM18	EM15 = 1, 2, or 3 AND EM15b = 1, 2, 3, or 4	Any other response combination	EM15 = 4 or -99
Data Collection & Availability				
Analysis				
Reporting	EM20	EM20 = 1		EM20 = 3 or -99

Based on these three major categories, the Cadmus team examined complete surveys conducted in eighty industrial facilities. About fifty percent of these industrial facilities are medium size, twenty-five percent are small size and the remaining twenty-five percent are large facilities. Based on the Operational Practices Survey analysis, the Cadmus team found that four percent of the facilities had fully implemented SEM. Remaining ninety-six percent of the industrial facilities had *some* SEM adoption. Results are in Table 48.

Table 48. SEM Adoption Level

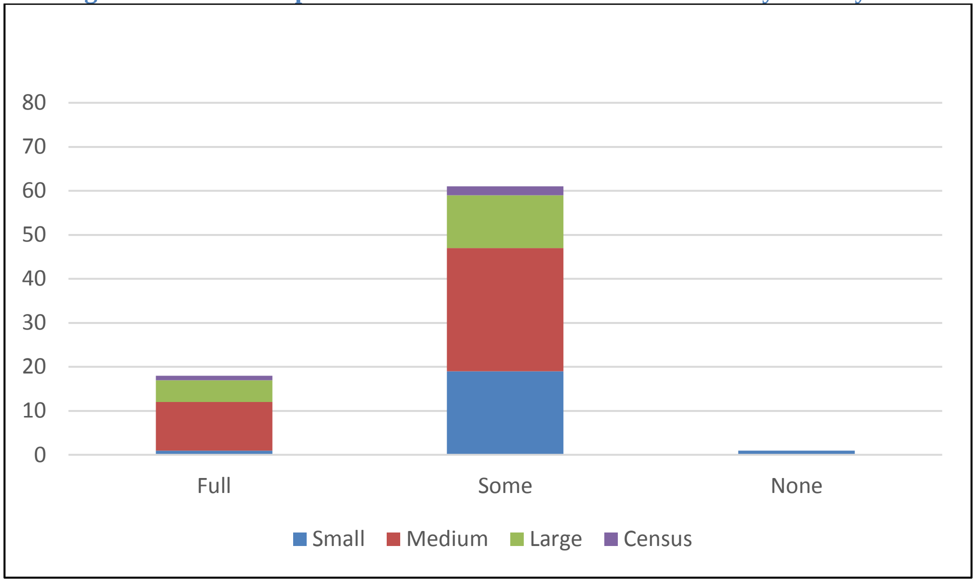
	Number of Respondents	
	n=80	Percentage
Full	3	4%
Some	77	96%
No	0	0%
Total	80	100%

Note: The Cadmus team did not include results from 12 incomplete surveys

SEM adoption by the industrial facilities seems relatively better in individual SEM categories than for overall adoption of all three categories. The Cadmus team found that among eighty industrial facilities, eighteen industrial facilities had fully implemented activities in Customer Commitment category as shown in Figure 50. Sixty-one industrial facilities had *some* adoption and only one industrial facility had no adoption in Customer Commitment category.

In the Customer Commitment category, medium size industrial facilities had higher adoption levels. Although medium size industrial facilities represent about fifty percent of the sample, sixty-one percent of the facilities that had fully implemented activities in Customer Commitment category are medium size facilities. Only one small size facility had full adoption in this category. Moreover, food manufacturing (four facilities) and computer and electronic products manufacturing (three facilities) facilities succeeded well and represent about fifty percent of the facilities that had fully implemented the activities in this category.

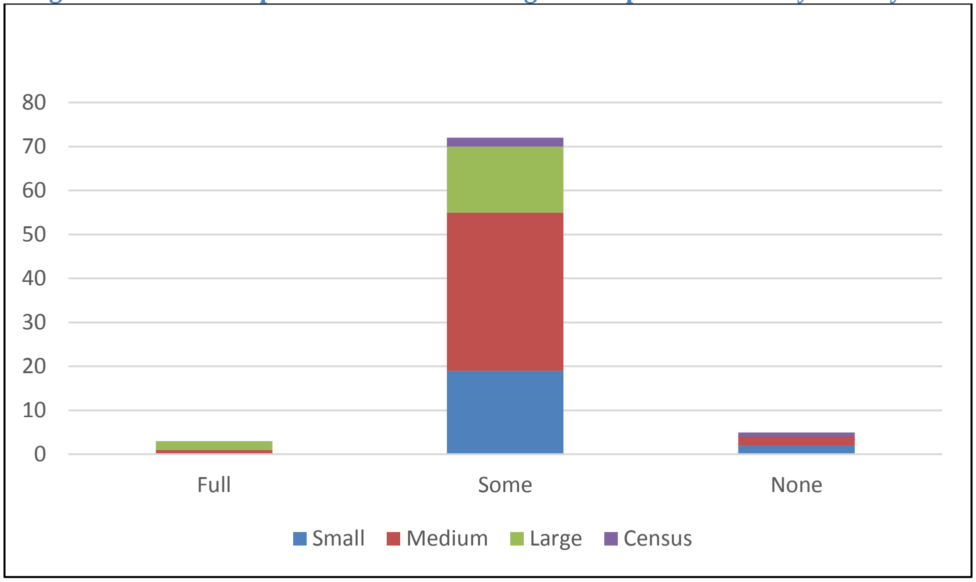
Figure 50. SEM Adoption Level for Customer Commitment by Facility Size



The Planning and Implementation category is the most challenging one among all SEM categories because it requires a many different activities for full adoption. The Cadmus team found that only three industrial facilities had fully implemented Planning and Implementation related SEM activities as shown in Figure 51. Seventy-two industrial facilities had *some* adoption and five industrial facilities had no adoption in Planning and Implementation.

In Planning and Implementation category, there is not significant correlation between the size or type of the facilities and full adoption rate since the full adoption rate is very low. However, we can note that no small size facility had full adoption in this category.

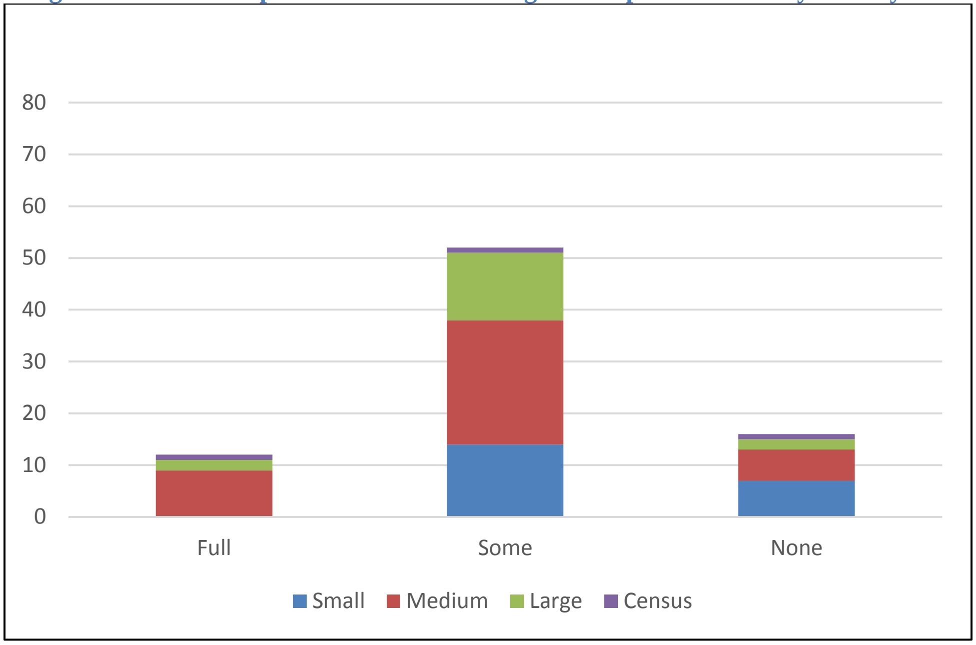
Figure 51. SEM Adoption Level for Planning and Implementation by Facility Size



Industrial facilities also had low adoption levels for the Measurement, Tracking, and Reporting (MT&R) category. As shown in Figure 52, twelve industrial facilities had fully implemented SEM activities in MT&R category and fifty-two industrial facilities had *some* adoption. Sixteen industrial facilities had no adoption in MT&R category.

In MT&R category, medium size industrial facilities had higher adoption levels than other size facilities. Seventy-five percent of the facilities that had fully implemented activities in MT&R category are medium size facilities. No small size facility had full adoption in this category. Again, food manufacturing (four facilities) facilities succeeded well and represent thirty-three percent of the facilities that had fully implemented the activities in this category.

Figure 52. SEM Adoption Level for Planning and Implementation by Facility Size



The survey questions that are not included in SEM scoring also provided interesting results. Figure 53 shows seventy-five percent of the facilities did not participate in a strategic energy management program in the past three years. Only twenty percent of the facilities are either currently participating in an SEM program or participated in the past and no longer participating.

Figure 53. Participation in SEM Program in the Past Three Years

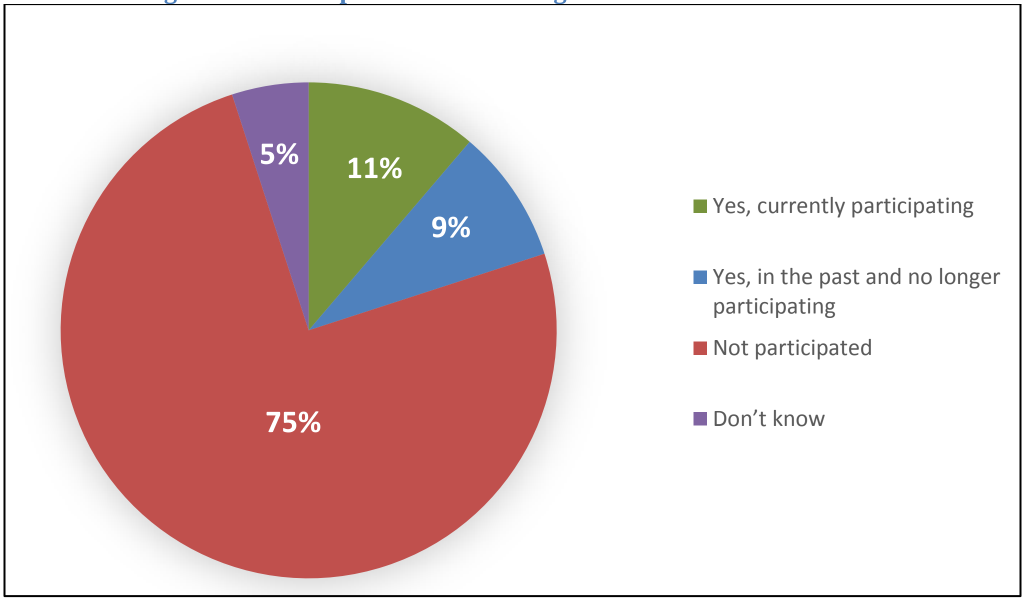


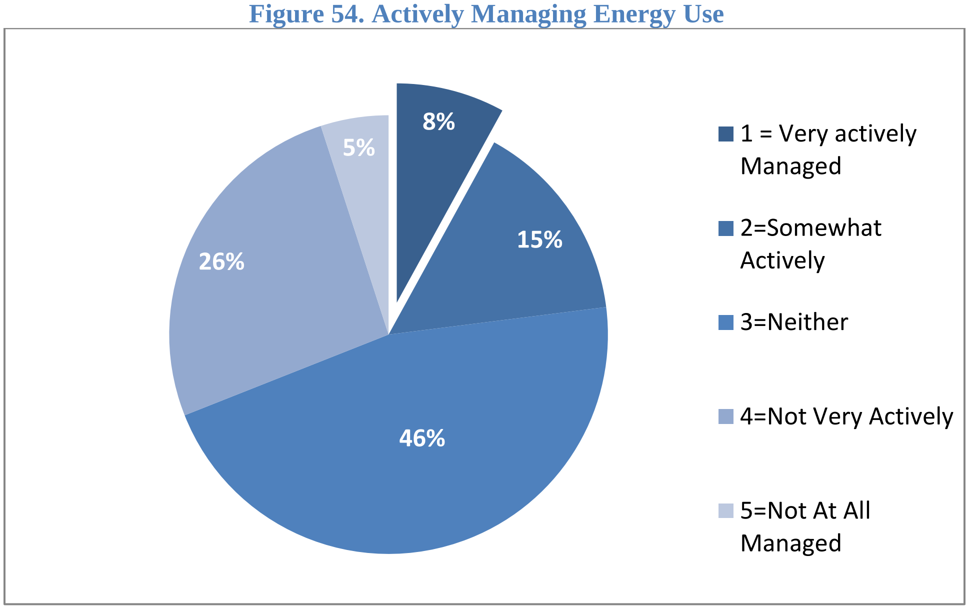
Table 49 shows the number of facilities that participated in a SEM program and their SEM adoption levels. Nine of 80 facilities were currently participating in a SEM program and had *some* SEM adoption. Seven of 80 facilities had participated in a SEM program in the past. Of those, one had *full* SEM adoption and six had *some* SEM adoption. Two facilities had not participated in a SEM program, but had *full* SEM adoption.

Table 49. Overall SEM Adoption Level and Participation in a SEM Program

Facility participated in a SEM program in the past three years	Full	Some	None
Yes, currently participating	0	9	0
Yes, in the past and no longer participating	1	6	0
No, have not participated	2	58	0
Don't know	0	0	4
Total	3	73	4

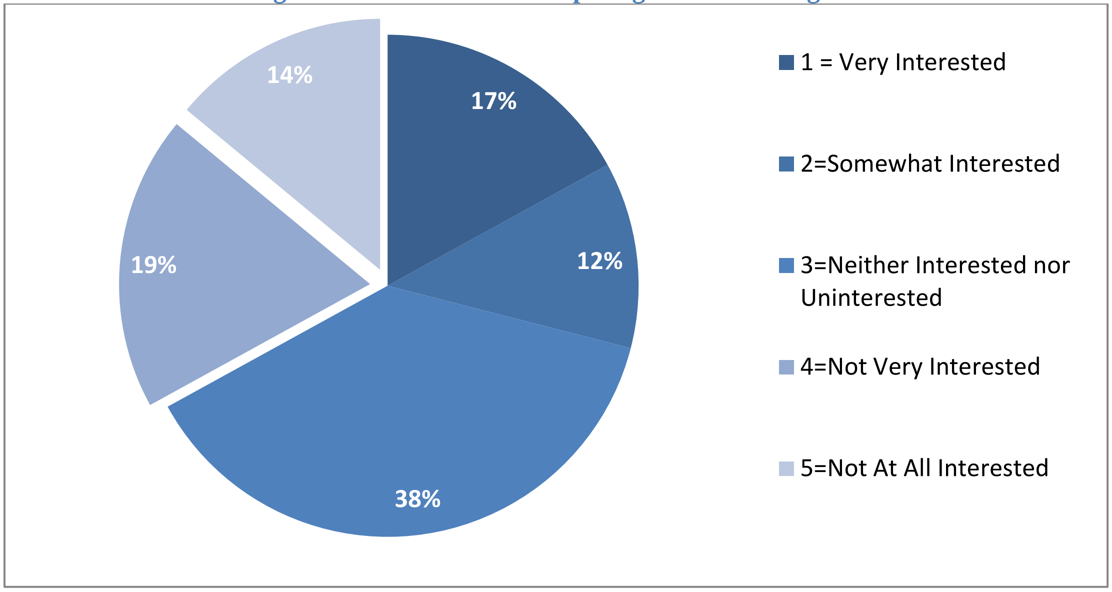
The majority of the facilities have not participated in SEM program, which is born out by the degree of active energy management facilities say they engage in; only 8 % manage energy very closely, as shown in Figure 54.

Figure 54. Actively Managing Energy Use



Finally, as shown in Figure 55, only 33% (the sum of "Not at all Interested" plus" Not Very Interested") of facilities surveyed indicated they would not be very interested in participating in a program that provides long-term technical support to develop and implement a strategic energy management strategy.

Figure 55. Interest in Participating in a SEM Program



all

Table 50 shows respondents' interest in participating in a SEM program in the future, by facility size. Overall, the level of interest among all sizes of facilities was mixed, with the majority of respondents saying they were moderately interested.

Table 50. Interest in Participating in a SEM Program by Facility Size

Facility Size	Level of Interest				
	1	**2**	**3**	**4**	**5**
Small	2	1	8	4	6
Medium	74	6	14	6	4
Large	41	2	6	4	1
Census	0	0	1	1	0
Total	13	9	29	15	11

**1 indicating participant is very interested and 5 indicating participant is not interested at all*

Table 51 shows respondents' interest in participating in a SEM program in the future, by facility type. Interest levels were mixed within sectors. The sectors that were most interested in SEM were food manufacturing and fabricated metal products manufacturing.

Table 51. Interest in Participating in a SEM Program by Facility Type

Facility Type	Level of Interest				
	1	**2**	**3**	**4**	**5**
Food Manufacturing	0	1	2	3	4
Wood Products Manufacturing	2	4	3	0	2
Paper Manufacturing	2	2	5	0	0
Petroleum and Coal Products Manufacturing	0	0	1	1	0
Chemical Manufacturing	0	2	1	1	1
Plastics and Rubber Products Manufacturing	2	1	1	0	0
Nonmetallic Mineral Products Manufacturing	1	0	5	0	0
Primary Metal Manufacturing	1	1	2	1	0
Fabricated Metal Products Manufacturing	1	0	2	0	5
Computer and Electronic Products Manufacturing	0	1	2	2	0
Transportation Equipment Manufacturing	2	1	3	1	1
Refrigerated Warehousing and Storage	0	2	2	0	0
Total	11	15	29	9	13

**1 indicating participant is not interested at all and 5 indicating participant is extremely interested*

7 Conclusions and Recommendations

The Industrial Facility Site Assessment represented an initial attempt to characterize the industrial sector in a manner similar to the Commercial Building Stock Assessment and Residential Building Stock Assessment. The IFSA provided an opportunity to inform regional power planning efforts by the Northwest Power and Conservation Council, allow participants to identify their end-use energy consumption patterns and high-level energy efficiency opportunities, and provide utilities with more data on how their customers use energy.

Through the study, the Cadmus team completed eighty-two assessments out of the original goal of 120. The team found the study's implementation protocols functioned reasonably well.

The final analyses by NAICS code found results that were largely to be expected. For example, the primary driver of energy consumption in sawmills was machine drive systems, specifically material processing motors. The normalized results between strata often featured significant variance, often due to different manufacturing and process requirements between four-digit NAICS codes (e.g., aerospace manufacturing and shipbuilding). Variations in employment between sites in the same NAICS codes, particularly between strata, also introduced significant differences in the final normalized consumption.

The Cadmus team also compared weighted average energy consumption distributions against those from MECS. We often found the results to be similar in terms of proportion, although it varied according to the size of the IFSA sample for each NAICS codes. In general, the MECS data provided average consumption across a larger number of sites with a wider array of end uses. For example, many MECS distributions listed consumption for combined heat and power (CHP), cogeneration, and electrochemical processing. In the IFSA study, Cadmus found several sites employing CHP/cogeneration, but those processes used waste wood products rather than natural gas (as in the MECS data). None of the IFSA sites used electrochemical processing.

The Cadmus team found that the study's implementation protocols functioned reasonably well. The IFSA analysis results as compared to MECS point to some potential regional differences for those NAICS codes with a sample of five or more facilities. The team could not draw definitive conclusions from those NAICS codes with smaller sample sizes. However, the Cadmus team identified the following challenges and opportunities to inform future IFSA efforts, broken out by area for improvement.

7.1 Study Design

The working groups improved the study's methodology and utility participation. The working groups, composed of utility representatives and regional stakeholders, were enabled to weigh in on critical study design issues and provide feedback on the methodology. This enabled stakeholders to achieve a higher comfort level in presenting the IFSA to their customers. It also enabled the protocols to more effectively achieve the study goals in ways that addressed the needs and concerns of utilities and stakeholders.

- **Recommendation:** NEEA should apply the working group structure to re-examine the study protocols and recommend further improvement during future industrial market research efforts.

The InfoUSA sample frame limitations made recruitment more difficult and inhibited the extrapolation of sample results to the overall population. During sample draws, the Cadmus team found many facilities that were not manufacturing, misclassified by NAICS code, or inactive. Also, the sample frame included contact names and information that was generally inappropriate for recruitment purposes. The Cadmus team found sufficient discrepancies between modeled and actual electricity consumption and employment that indicated extrapolation of the results to the overall population could not be performed with reasonable accuracy.

- **Recommendation:** NEEA should investigate developing a truly regional sample frame that is more accurate and better represents the industrial population.

A lack of general awareness inhibited study recruitment. Several utilities, and most facilities, were generally unaware of the IFSA study and of NEEA. The Cadmus team found it more difficult to educate staff at those utilities and facilities about the study, its potential benefits to the region, and the importance of participation.

- **Recommendation:** NEEA should consider increasing general awareness of the IFSA among utilities and industrial facilities throughout the region to encourage higher levels of participation in future studies. One possibility for raising awareness could be through trade or industry associations.

7.2 Study Implementation

The pre-test provided a useful method for testing the working group protocols and assessing the viability of the sample frame. The pre-test allowed the Cadmus team to identify any deficiencies in the various protocols and coordinate with the working groups to address those issues. The Cadmus team found that the protocols worked effectively, although the focus of the data collection approach needed to be on systems instead of on equipment. This would be more time-efficient and less burdensome to facility staff.

- **Recommendation:** NEEA should perform a pre-test on a small sample in future studies to determine the viability of protocols.

The Cadmus team found it more difficult to recruit large facilities because they were more likely to have previously engaged in detailed energy-efficiency audits. Larger facilities are frequently targeted for utility energy-efficiency programs due to their large consumption and associated opportunities. Therefore, many have already been intensively studied, some had been extensive submetered, and most large facility personnel were already aware of how their energy consumption is broken out among various end uses. Several facility contacts doubted the value proposition based on the limited nature of the IFSA on-site assessment (one day or less without metering).

- **Recommendation:** NEEA should consider funding the IFSA as an ongoing effort in conjunction with utility energy-efficiency programs throughout the region, rather than as an intermittent study every five years. Many of these large facilities will continue to receive detailed audits through utility energy-efficiency programs before the next round of the IFSA. These audits represent the best opportunity to gain detailed metering and submetering data the IFSA lacked, while also allowing NEEA to track a wider scope of end-use consumption variables. NEEA could then focus the next round of IFSA primarily on small to medium facilities that have not yet been studied in detail, and which can be more easily assessed in a limited time period without metering.

The study budget provided sufficient depth to develop and test assessment protocols, but was insufficient for a statistically valid analysis of industrial end-use consumption. The 2014 IFSA provided a good start to understanding the challenges and possibilities associated with industrial market characterization. In conjunction with the working groups, the Cadmus team developed viable protocols that effectively allowed us to gather data to estimate end-use consumption. However, the sample size by sector was too small to extrapolate results to the larger population with any statistical validity. In addition, on-site verification without metering represented the only viable data collection method within the budget constraints.

- **Recommendation:** NEEA should consider expanding the IFSA budget to allow the study contractor to conduct assessments on a larger sample to ensure statistical validity. In particular, the sample could be expanded to achieve more granularity at the four-digit NAICS level for those NAICS codes with a relatively high level of participation. The budget could support enhanced data collection through short-term metering and multi-day assessments. The additional budget could also be used to provide incentives for industrial audit contractors to complete data collection based on IFSA protocols, provided to NEEA as interim data.

Analysis results may be inconsistent among three-digit NAICS codes due to variances among facility types. For the IFSA, the Cadmus team generally focused on three-digit NAICS codes due to the limited sample. This could result in wide variance between facility end-use consumption estimates due to the wide variation in types of manufacturing facilities in each three-digit NAICS code. For example, NAICS 336 covers transportation equipment manufacturing, which included facilities the Cadmus team visited that manufactured products as various as light aircraft, automotive equipment, helicopter components, and ships. However, the

Cadmus team did examine samples for 321 (Wood Products) and 322 (Paper) at the four-digit NAICS level.

- **Recommendation:** NEEA should expand future sample sizes to achieve statistically valid confidence and precision for more industrial subsectors deemed to be of the highest importance to the Northwest region.

The attempt to collect data with a lower level of uncertainty could jeopardize a successful site assessment. As outlined in the Data Collection Methodology section, SCADA trends and facility equipment inventories represent data sources with lower levels of uncertainty in end use consumption estimates. Some facility contacts offered to send the team low uncertainty data to supplement the analysis so that the field engineer would not need to perform an on-site equipment inventory. However, in some cases the facility contact did not provide the data and could not be reach for follow-up. The team therefore could not complete the full analysis and omitted the site from final results.

- **Recommendation:** Field engineers should clearly outline data collection requirements in advance to the extent possible. The field engineers should try to work with facility contacts to ensure the SCADA data, digital equipment inventories, etc. are available to download to a secure laptop at the time of the assessment, or uploaded to a secure FTP server. If this low uncertainty data cannot be obtained in advance or during the assessment, the field engineer should consider conducting an on-site equipment inventory supplemented with equipment operator interviews.

Utility staff are supportive of the IFSA and increased study participation. In many cases, utility staff (either key account managers or energy managers) recognized the importance of the IFSA value proposition for their customers who appeared in the sample draw. The Customer Contact protocols provided utility contacts with the first right of refusal to notify the potential participants about the study. Some utility staff members actively sought to contact and recruit their customers to participate in the study. This was particularly true for facilities that had not previously received energy-efficiency audits, and were therefore expected to possess potentially numerous opportunities for improvement. The Cadmus team found it easier to identify the appropriate contacts and recruit sites in coordination with supportive utility staff than through cold calls or with limited utility support.

- **Recommendation:** For future IFSA efforts, NEEA should continue to engage utility staff members through working groups, webinars, and monthly update meetings. Example site reports from the previous IFSA should be shared with staff to highlight the value proposition for their customers. An expanded scope and depth of assessment and analysis may also improve utility staff members' perception of the value proposition.

Bonus incentives helped to increase participation. The Energy Trust of Oregon offered IFSA participants an additional ten percent incentive if they installed an energy-efficiency measure identified through the study's on-site assessment. This provision increased the value proposition for participants, and several said this incentive was their primary motivation for participating in the IFSA. Both the Cadmus team subcontractors served as program delivery contractors for the Energy Trust's Production Efficiency Program. The bonus incentive provided additional motivation for them to recruit potential participants within their geographic service territories. The field engineers were generally able to identify cost-effective energy-efficiency opportunities to pursue through the Energy Trust program.

- **Recommendation:** For future IFSA efforts, NEEA should coordinate with supportive utilities that may consider offering a similar bonus incentive. These incentives can spur additional participation in the IFSA study, as well as participation in the utility's energy-efficiency programs.

7.3 SEM Adoption Level

The SEM adoption level in the industrial market is low; however, the market potential for adopting this system for managing energy as a controllable expense is high. Four percent of the sites visited had adopted *full* SEM; however, sixty-six percent of respondents reported interest in participating in a SEM program. Interest was mixed among facility sizes and facility types.

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