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2014 COMMERCIAL BUILDING STOCK ASSESSMENT: FINAL REPORT

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Executive Summary

The Commercial Building Stock Assessment (CBSA) of 2014 is a milestone in the history of the Northwest Energy Efficiency Alliance (NEEA) and its evolving relationship of collaboration with its stakeholders. The CBSA featured a renewed emphasis upon regional coordination. Study findings will inform the Northwest Power and Conservation Council's (NPCC) 7th Power Plan conservation targets and provide valuable information for energy efficiency planning and programming across the region.

ES.1 Study Objectives

The 2014 CBSA study sought to:

- Expand the CBSA user group to better define data needs, and ensure maximum utilization of study findings for regional planning purposes.
- Develop an easy-to-use CBSA database with varying security levels to ensure the privacy of customer data, while allowing public access to a rich store of high quality data on commercial buildings.
- Provide detailed “data dictionaries” to orient users on data field definitions, database functionality, and key building characteristics.
- Expand the number of actual facilities visited for the baseline assessment, as previous studies relied extensively on secondary data of varying vintages.

ES.2 Onsite Surveys

In order to provide an accurate and current picture of the commercial building market in the Pacific Northwest, the 2014 CBSA ‘core’ study gathered primary data from 859 commercial sites across twelve building types. Table ES-1 provides the distribution of onsite surveys within each building type category.

Table ES-1. Number of Buildings Surveyed by Type in 2014 Core CBSA²

Building Type	Number of Buildings Surveyed
Assembly	105
Food Service	43
Grocery	74
Hospitals	24
Lodging	72
Office	117
Other	81
Residential Care	70
Retail	132
Schools	75
Universities	23
Warehouse	43
Total	859

ES.3 Key Findings

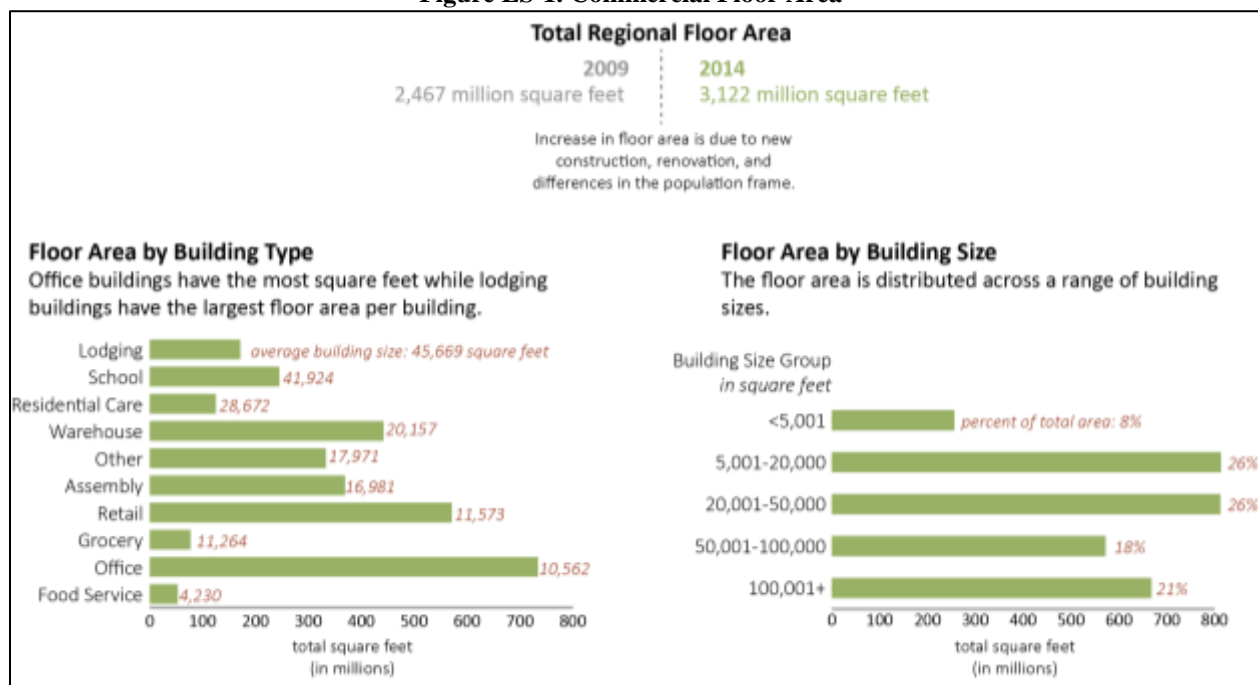
This section summarizes a number of high-level findings. For more detail, see section 3 and Appendix A.

NEEA and the project team removed Hospitals and Universities from the general report findings and analyses due to their unique multi-building, “campus” quality. Separate data and analyses will be included in the Hospitals and Universities Addendum to this report.

² The “Core” CBSA study is differentiated from any utility- or stakeholder-funded oversample efforts currently being conducted at the time of this writing.

As shown in Figure ES-1, the total regional floor area for the Northwest as a whole has increased nearly 27 percent, from 2,467 million square feet in 2009, to 3,122 million square feet in 2014. New commercial construction and differences in the population frames used by the two CBSA studies were the primary contributors to this change.³

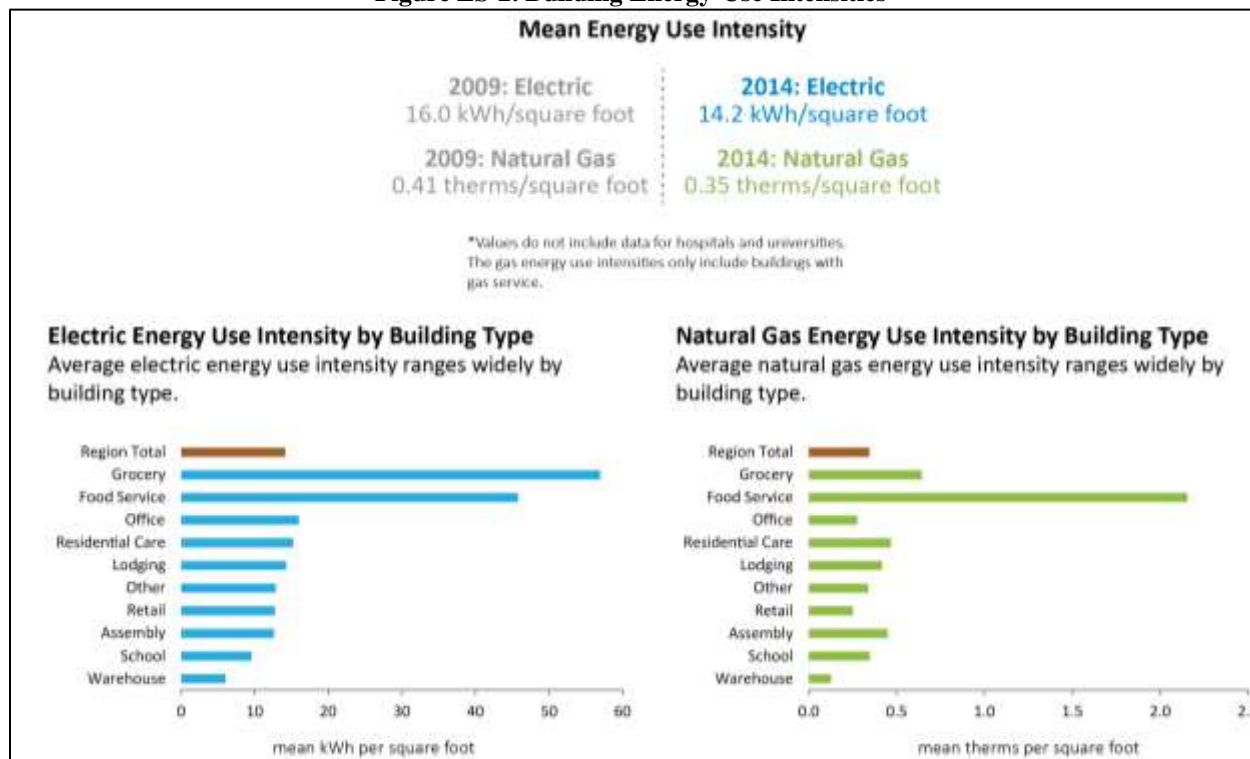
Figure ES-1. Commercial Floor Area



³ Regional floor area does not include Hospitals and Universities. For more information on average building sizes as compared to the 2009 results, see Appendix A.

Figure ES-2 describes the results of the Energy-Use Intensities (EUIs) for both electricity and natural gas. Between 2009 and 2014, electrical energy use per square foot decreased by approximately 11 percent, while gas use decreased by just under 15 percent. These EUI reductions are attributable to a combination of effects, including; naturally occurring conservation, codes & standards, EE program impacts, and differences in the 2009 and 2014 CBSA sample frame and data collection methods. It is difficult to attribute the change accurately among these factors.

Figure ES-2. Building Energy-Use Intensities



ES.4 Recommendations for Future CBSA Studies

An initial population frame was developed in advance of the 2014 CBSA⁴. The population frame was incomplete and was thus expanded upon over the course of the 2014 CBSA sample frame development and data collection process. Recruitment rates were also lower than anticipated, primarily due to incomplete population contact records and the decision to not budget for incentives for building owners/operators to participate.

This experience and lessons learned over the course of the 2014 CBSA study lead to the recommendations for future CBSA efforts:

⁴ SBW Consulting, Inc. 2012. *Northwest Commercial Building Market Characterization*. Portland, OR: Northwest Energy Efficiency Alliance.

1. *Accurately characterize the population of commercial buildings prior to conducting a CBSA update study.* Data cleaning efforts done on the population frame of commercial buildings in the region will greatly increase the efficiency, quality, and success of the sample design, recruitment, and site classification activities.
2. *Expand marketing for future CBSA studies to promote regional awareness of NEEA's efforts and improve recruitment rates.* Collaborating with utilities to actively inform and educate customers about the benefits of the CBSA study will improve recruitment rates by expanding the pool of willing participants.
3. *Incorporate recruitment incentives.* Partway through the 2014 CBSA effort, the project team began offering facilities a 200-dollar incentive to participate in study (in the event that a customer could not accept the gift card, a 200-dollar donation was made to an organization of their choosing). This increased recruitment rates from 5.6 percent to 10.5 percent. Combining a similar incentive structure with the marketing efforts mentioned in #2 above, can reduce difficulties in recruitment for future studies.

Section 4 provides further detail on future CBSA recommendations.

1 Introduction

1.2 Background

This report summarizes the research findings of the 2014 Commercial Building Stock Assessment (CBSA) for the Pacific Northwest. The data collected during this assessment will be used for the following purposes, among others:

- Supporting commercial sector conservation policy, planning, potential analysis, program design, and evaluation in the Pacific Northwest by providing insight into the state of the region's commercial market
- Establishing a baseline to gauge the influence of market transformation efforts, the impact of utility Demand Side Management (DSM) programs, and the extent of naturally occurring conservation in commercial buildings
- Developing a regionally representative commercial building database
- Facilitating building stock energy-use assessment

The CBSA of 2014 is a milestone in the history of the Northwest Energy Efficiency Alliance (NEEA) for several reasons:

1. This is the first time that NEEA's five-year business plan has included funding and expectations specific to the CBSA study;
2. The 2014 CBSA took place within an evolving relationship of collaboration between NEEA and its stakeholders, with a renewed emphasis upon regional coordination;
3. The 2014 CBSA study collected primary onsite data for the largest random sample of commercial buildings in the history of the Northwest;

1.2.1 Previous CBSA Studies

2003 Study

The first CBSA study completed in 2003 was, at the time, a unique effort to characterize the physical and energy-use characteristics of commercial facilities in the Pacific Northwest. The study integrated data from previous regional studies conducted between 1986 and 1999 (e.g., the Pacific Northwest Nonresidential (PNNonRES) Energy Survey (BPA 1987)), and supplemented it using current floor space data from the Dodge database compiled by McGraw Hill. The

original database contained 1,157 commercial facilities⁵ divided into three vintages: pre-1987, 1988–1994, and 1995–2001.

2009 Study

In 2009, The Cadmus Group led an effort to enhance and update the 2003 CBSA study by:

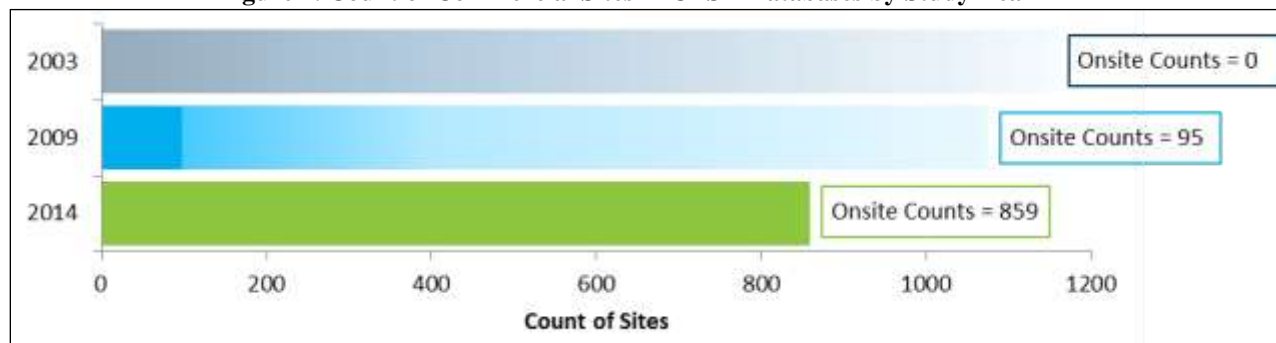
- Expanding the original database using a variety of commercial buildings surveys completed in the region since the year 2000, including the 2007 NEEA New Construction Study, and the 2007 Snohomish County Public Utility District Study;
- Filling in data gaps for approximately 500 existing sites in the 2003 CBSA database using telephone surveys and “drive-by” visits; and
- Visiting and performing onsite surveys for an additional ninety-five commercial facilities.

2014 Study

The current 2014 CSBA study sought to further improve upon the first two studies by drawing a new random sample of regional commercial buildings and conducting highly detailed audits to develop a more accurate and current picture of energy consumption across the region. The sample is comprised of 859 sites, stratified by twelve commercial building types, three size categories, two vintage classifications, and an urban/rural stratification. The Navigant project team designed the sample to achieve 90 percent confidence/10 percent precision by building type, and 80 percent confidence/20 percent precision by each size, vintage, and population density combination.

Figure 1 compares the counts of commercial sites in each CBSA study year. The 2014 CBSA study has fewer total sites in the completed database, though all sites included utilized the same data collection protocol. Data fields populated in the earlier studies reflected the differences in focus of the data combined from various sources. Due to the increased count of actual onsite visits conducted in this current effort, the statistical significant and precision of the data, as well as the “freshness” of the results is much higher than in prior studies. It should also be noted that an oversample effort for other stakeholders and utilities is underway that will increase the 2014 site counts considerably, and is expected to be included in a 2015 update to the database.

⁵ Due to the nature of combining data from a diverse set of studies, the 2003 study included a range of data completeness for each facility, and the number of sites that received an on-site survey was substantially less than this total.

Figure 1. Count of Commercial Sites in CBSA Databases by Study Year⁶

1.2.2 Stakeholders and Working Groups

Effectively capturing stakeholder feedback in a timely manner was critical for understanding and characterizing 2014 CBSA data needs, aligning objectives, and agreeing on project specifications. A series of meetings with the CBSA Advisory Committee, split into topic-specific “working groups,” facilitated this process of project planning.

Each working group, consisting of technical and regional experts, collaborated on various study topics and project objectives. The five working groups established for these tasks included:

- **Sampling Priorities Working Group** - The prioritization of sampling targets based on region, building type, size, and vintage.
- **Building Classification Working Group** - The definition and subsequent prioritization of different building types investigated through the study.
- **Data Collection Protocols and Instruments Working Group** - The refinement of building survey protocols around building characteristics and equipment that yielded complete, consistent, and relevant data. The protocols used by Ecotope in the research for Baseline Characteristics of the 2002-2004 Non-Residential Sector provided the starting point for this discussion.
- **Field Definitions Working Group** - Clarification and consensus on definitions of database fields, particularly for Heating, Ventilation, and Air-Conditioning (HVAC) equipment (e.g., clarify “primary” heating system as shown in the existing database), and develop understandable terminology that can be operationalized and re-measured over time.

⁶ For purposes of this graph, the onsite count values do not include onsite visits that may have occurred within studies outside of the actual CBSA project. For example, the Pacific Northwest Nonresidential (PNNonRES) Energy Survey (BPA 1987) used in the 2003 CBSA study, may have included onsite visits but the 2003 study did not conduct any onsite visits of their own. This is significant in comparing newly gathered data with older out of date data.

- **Special Topics Working Group** - Additional research topics/requests conveyed by stakeholders (e.g., optional studies including plug load assessments and any sub-metering requirements).

The project team used the working group sessions to obtain guidance and NEEA made decisions regarding key factors of the study design and implementation. The working group sessions also provided the chance for NEEA and the project team to communicate decisions and rationale to the attending stakeholder groups.

NEEA and the project team communicated working group decisions and action items to the broader stakeholder Interest Group through monthly update meetings, regular email notifications, and informational postings to www.Conduitnw.org.

Table 1 shows the collaboration objectives and key organization members for each working group.

Table 1. Stakeholder and Working Group Participation in 2014 CBSA

Working Group	Objectives	Organization
Building Classification	Developed the set of building types for sample stratification and design:	NEEA
	• Developed statistical significance and proportional representation	SCL
	• Developed the detailed building classification scheme	NPCC
	• Established variables needed to allow flexible classification of data collection activities by stakeholders	SnoPUD
	• Developed detailed subtypes (i.e. primary, secondary, daycare schools)	BPA
	• Developed rules for classifying ambiguous buildings (e.g., mixed use, dynamic use)	ETO
Sampling Priorities	Established the prioritization of sampling objectives, including:	NEEA
	• Filling data gaps in the 2009 CBSA	
	• Balancing longitudinal / cross-sectional research objectives	
	• Metric-specific precision levels (e.g. lighting power density)	
	Defined the sample population	Idaho Power
Data Collection Protocols	Defined the sample stratification dimensions	
	• Established primary dimensions requiring statistical significance (e.g. building type, vintage, size)	NPCC
	• Established secondary dimensions for proportional representation (e.g., urban/rural, geography, climate zone, natural gas availability)	
	Developed weighting by expected magnitude of square footage, EUI by strata	BPA
Field Definitions	Developed protocols for data collection activities including:	NEEA
	• Participant value proposition, communications, and scheduling	
	• Field staff training	BPA
	• Data collection techniques	
	• Data collection tools	NPCC
Special Topics	• Quality assurance and quality control	
	Developed definitions for data fields to be gathered during onsite visits, including:	NEEA
	• Ensured consistency with other data set definitions	
	• Evaluated/refined existing CBSA definitions and categories	
	• Developed definitions for new data items identified as collection targets by Special Topics Working Group	
Special Topics	Worked with the Data Collection Working Group to	ETO
	• Ensure data to support definition is collectable	
	• Ensure definitions support proposed data structure	
	Identified additional data elements to capture	NPCC
	• Worked with the Data Collection Working Group to determine feasibility of data	
Special Topics	• Provided input on additional items to Special Topics Working Group	
	Addressed topics identified by regional stakeholders not covered by other working groups, including:	NEEA
	• Additional data needs	BPA
Special Topics	• Additional data requests	NPCC
	• Mixed use categorization	

2014 CBSA

1.3 Study Objectives

The stakeholder and working group process provided historical context, feedback on sampling strategies, and lessons learned from previous iterations of the CBSA study. This collaborative input drove the following research objectives established early in the project:

- **Provide consistent data variables and definitions:** The project team documented all study procedures, data collection definitions, and the interpretation of database fields in a number of CBSA “data dictionaries.” See Appendices F, G, H, and I.
- **Involve more users to better define data needs:** The project team expanded the CBSA user group to ensure a broader utilization of study findings for regional planning purposes.
- **Provide an easy-to-use CBSA database:** In the end, the project team built two databases: a simple, publicly available Microsoft Access™ version of the database where all customer identifying information is suppressed, and another web-based version of the database equipped with various security access levels to ensure the privacy of sensitive customer data while providing utilities access to their own customer records.
- **Provide improved, peer-reviewed summary and analysis of building characteristics:** Discussed further in the Key Findings section.
- **Improve data quality and consistency:** The 2014 CBSA emphasized the comprehensive collection of data using the stakeholder approved survey instrument and quality control protocols.
- **Improve representation of rural areas in the region:** Bonneville Power Administration (BPA) and rural areas were under-represented in previous CBSA studies. The 2014 CBSA sampling framework addressed this issue by explicitly stratifying by urban and rural regions in the Pacific Northwest.
- **Define data collection processes, definitions, and representations that will accommodate future scalability:** Stakeholders, NEEA, and the project team recognized the importance of developing a framework for data collection, storage, and analysis to facilitate future commercial sector/CBSA data collection efforts. For example, a number of stakeholder utilities are leading ongoing oversample efforts that meet this objective.
- **Provide granularity on the average size for each building type, and the associated Energy-Use Intensity (EUI):** The 2014 CBSA study collected detailed information on subspaces within each building type and used it to calculate total building EUIs.
- **Provide a description of building types comprising the “Other” category and look to re-classify them wherever possible:** The 2014 CBSA thoroughly investigated the “Other” building types within the population frame and where possible, re-classified sites

into more descriptive building categories. See the Methodology section and Appendix B.1 for further detail.

- **Determine the appropriate level(s) of access and protection of privacy for different users.** A growing concern for utilities and other industries is the protection of customer data. As noted above, the 2014 CBSA database development team defined and created secure user access levels to prevent the public from accessing billing and other sensitive data while simultaneously providing utility stakeholders access to their customers' records. See section 2.4.3 for more information on database access levels.

2 Study Methodology

2.1 Population and Sampling

This section describes the methods for constructing the population frame used during the 2014 CBSA stratification and sample design process.

2.1.1 Population Frame Development

The Navigant project team received an initial population frame of the Pacific Northwest commercial building market, updated through 2011 using information from the Commercial Building Inventory (CBI) and CoStar™ databases. NEEA developed this population frame shortly before the initiation of the 2014 CBSA in order to create a comprehensive starting point for the study.

The project team also compiled additional data regarding Hospitals and Universities, frequently administered as campuses rather than individual buildings, to augment the initial population frame, and substituted them into the population frame to prevent double counting with CBI and CoStar™.

The original population frame was also supplemented part way through the CBSA study with a recent update from the CBI and new construction data from the Dodge database compiled by McGraw Hill.

The combination of these five primary data sources (listed in Table 2) represents, for all practical purposes, the most complete inventory of commercial buildings in the region.

Table 2. Population Frame Sources

Data Source	Description
Commercial Building Inventory™	A database representing buildings by parcel based on tax assessor records for commercial properties
CoStar™	A database reporting records by commercial building
McGraw Hill Construction Dodge	A database of permit applications for new construction and renovation projects
American Hospital Directory	A database of over 6,000 public and private hospitals nationwide
Integrated Postsecondary Education Data System	A compilation of survey data collected from all educational institutions that participate in federal student financial aid programs

Notes: CBI and CoStar™ information compiled by SBW Consulting, Inc. 2012. Other sources compiled by 2014 Navigant project team.

The project team collaborated with the Building Classification Working Group to allocate each record in the population frame to a building-type category for the purposes of building characterization sample design. Many of these definitions aligned with previous CBSA efforts, but the working group identified some discrepancies and inconsistencies in previous classifications, and recommended alterations. Most notably, the following two discrepancies:

- The *Other Health* category from the 2009 CBSA changed to include only *Residential Care* buildings such as nursing homes and assisted living facilities. Medical office buildings previously included in *Other Health*, such as doctor and dental offices moved to the *Office* category.
- Additionally, the project team made a concerted effort to reduce the scope of the *Other* building category. The Building Classification Working Group added a new *Assembly* building type to cover secular, religious, and cultural gathering places and altered the *Lodging* category to include fraternities, convents, dorms, and shelters.

Table 3 shows the distribution of population frame records by building type for sampling purposes.

Table 3. Number of Records by Building Type in Population Frame

Building Type	Number of Records
Assembly	23,057
Food Service	12,652
Grocery	5,136
Hospitals	288
Lodging	6,901
Office	42,113
Other	95,115
Residential Care	2,427
Retail	50,672
Schools	6,581
Universities	113
Unknown	768
Warehouse	24,171
Total	269,994

Notes: Data obtained from CBSA Study population frame

2.1.2 Sample Design

The CBSA Sampling Priorities Working Group developed the sample design methodology with the following objectives in mind:

- Apply lessons learned and recommendations from prior CBSAs;

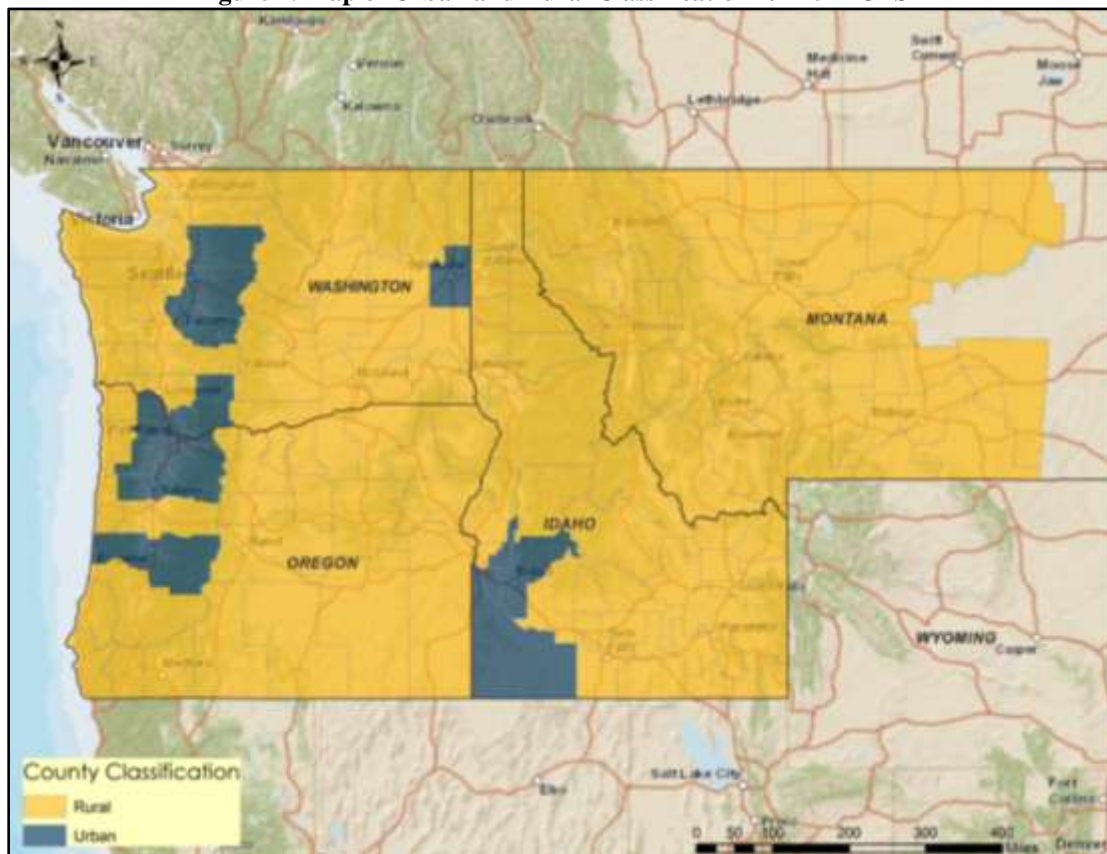
- Fully represent the commercial building market in the Pacific Northwest by stratifying the population frame by primary economic use, square footage, building vintage and urban versus rural classifications (Table 4);
- Achieve an 80 percent confidence/20 percent precision at the intersection of each sample stratification, and an average of 90 percent confidence/10 percent precision by building type;
- Address the low representation of rural buildings surveyed in prior CBSA studies.⁷ Figure 2 shows the urban/rural county designation where rural buildings account for approximately 40.4 percent of commercial square footage in the region, but 48.5 percent of the sampled building square footage.

Table 4. Sample Stratification Definitions

Building Characteristic	Application to the Sample
Building Type (Primary Economic Use)	The primary economic use of a building was determined from a combination of CBI data, North American Industry Classification System (NAICS) codes, and other information sources. The working group mapped these economic uses to twelve building-type categories used for sampling based on the methodology used by the Northwest Power & Conservation Council.
Building Vintage	The Navigant project team split the population into two vintages in order to better ascertain the impacts of recent code changes and construction technology improvements. The team further partitioned buildings into those built prior to 2004 and those built in 2004 or later.
Building Size	The project team applied between one and three building specific size bins to each category, due to the impact building size has on energy-use characteristics for various building types.
Urban/Rural Classification	The sampling priorities working group designated counties by urban or rural based on their Rural-Urban Continuum Code (RUCC). ⁸ The Navigant project team classified counties with a RUCC of 2 or less as urban, and those with a 3 or higher as rural. Figure 2 shows the urban/rural county designation based on this definition.

⁷ BPA provided additional funding to increase the rural representation in the 2014 CBSA sample design.

⁸ Further information available at <http://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>

Figure 2. Map of Urban and Rural Classification for 2014 CBSA

Combining the four sampling stratifications produced the sampling framework (shown in Figure 3) which consists of seventy “cells” that intersect each stratum.⁹ The numbers in each cell are the counts of onsite surveys needed to achieve 20 percent precision with 80 percent confidence in the results. When aggregated to the building-type level, these counts achieve 10 percent precision with 90 percent confidence. For further explanation of the sampling methodology, see Appendix B.2.

⁹ The removal of Hospitals and Universities from the sample framework reduces the number of cells to sixty six.

Figure 3. Sample Framework for the CBSA Study (N=859)

	Vintage	Size (SF)	Retail	Grocery	Office	Food Service	Warehouse	Hospital	Residential Care	Hotel-Motel	School	University	Assembly	Other
Urban	Pre-2004	5,000 or less	16	14	13	12	12	12	12	14	14	12	13	10
		5,001-20,000		12										
		20,001-50,000	12		9									
		50,001-100,000							14		8			
		100,001 & Up												
Rural	Pre-2004	5,000 or less	16	13	16	12	12	12	14	14	12	11	16	14
		5,001-20,000		14										
		20,001-50,000	13		3				8		5			
		50,001-100,000											11	
		100,001 & Up												
All	2004-2013	5,000 or less	25	11	25	19	19		12	18	11		21	12
		5,001-20,000		10										
		20,001-50,000	13		9				7		4			
		50,001-100,000											12	
		100,001 & Up												

Notes: The comparatively small population in the 2004-2013 vintage limited the ability of the project team to achieve statistically significant results in both urban and rural areas. Thus, this dimension was removed from the 2004-2013 vintage. Due to the campus nature of Hospitals and Universities, no vintage dimension was applied to these building types. The sample cells for these two building types include all construction through 2013.

Population Frame Refinement

Recruitment and onsite efforts on the population frame uncovered site-specific detail allowing the reclassification of buildings into more appropriate categories. The Navigant project team maintained these changes in both the sample population and the overall population in order to fill known gaps and improve data quality. For more on this see Appendix B.3.

2.1.3 Case Weight Development

The Navigant project team used “case weight” ratios (indicating the number of buildings in the population represented by each sampled building) to extrapolate collected data to the regional level and characterize the commercial building stock for the entire Pacific Northwest.

The ratios were calculated as the ratio of the total region-wide square footage for each stratification cell in the overall population frame to the total sampled square footage for the corresponding stratification cell in the sample frame.

The team then applied these ratios to the data collected at each site within a stratification cell to extrapolate results across the region. For further detail, see section 2.3.4 and Appendix B.4.

2.2 Data Collection

Collecting high quality data on the buildings of interest required significant planning and coordination to deploy resources effectively. The project team built numerous quality control checks into each stage of the data gathering process to ensure rigorous data review for consistency and accuracy. This section and Figure 4 summarize these processes, and Appendix C provides additional details in the Quality Management Plan.

Figure 4. Data Collection Process Flow



2.2.1 Surveys and Recruitment

NEEA and the Navigant project team developed recruitment process protocols and assigned a dedicated recruitment team to schedule data collection activities that minimized customer inconvenience while maximizing resource efficiency.¹⁰ The CBSA management team met with the recruitment team on a weekly basis to resolve any issues encountered in the field while adhering to sample design requirements, scheduling pace, logistical efficiency, and quality control protocols established in this recruitment process and communications plan.¹¹

This plan included:

- Consistent recruitment protocols including letters from NEEA and the utilities that could be sent to participating sites upon request;
- Protocols for securing customer data;
- Scheduling protocols for the Field Activities and Communication Tracker (FACT) platform to ensure sample design quotas were met; and
- A “Recruiting Progress Report” to communicate with all parties during the team’s weekly meetings, the recruiter hit rate, list burn rate, record list assignment issues, and participant issues.

2.2.2 Site Visits

A team of professional surveyors and engineers performed site surveys at 859 commercial buildings for the 2014 study. Site visit protocols ensured clear work instructions for surveyors, standardized visit procedures, and communication feedback loops to quickly answer questions from onsite surveyors. Other checks included the following:

- The creation of data dictionaries in collaboration with the Data Collection Protocols Working Group and the Field Definitions Working Group;
- Training program for surveyors before data collection began, and *ride-alongs* with new field personnel to provide feedback and clarification on data collection objectives; and
- Pre- and post- site visit checklists to ensure all necessary items were addressed in an appropriate manner.

See Appendices D and E for onsite data collection survey instruments.

¹⁰ Population Research Systems (PRS), a division of Nexant, Inc. coordinated the recruitment work.

¹¹ Appendix C provides the specifics for the 2014 CBSA Quality Management Plan.

2.2.3 Data Management

The Navigant project team established a quality control team to manage the data coming in from the onsite visits. Their main priority was to clean the data at three different intervals or “checkpoints” including the following:

- Initial review of each submitted survey in order to understand:
 - The building as a whole and how the energy systems relate to one another; this helped define appropriate EUIs;
 - The overall lighting scheme to ensure appropriate Lighting Power Densities (LPDs); and
 - Whether the interpretation of data collection fields was appropriate and consistent.
- Feedback loops with surveyors to fill in data gaps and clarify initial survey review questions.
- Automatic data validation checks and adaptive algorithms embedded in the FACT platform, including drop-down menus and standard value parameters to ensure the Navigant project team entered only proper data into the database.
- Final reviews of aggregated output data using Revolution R statistical software in order to catch outliers or oddities in the data.

2.3 Data Analysis

The analysis team used the clean data in the FACT system to summarize site-level results such as building LPD, electric and gas EUI, and building envelope characteristics. The team then extrapolated site-level results up to the region-level using the calculated case weights to provide representative results of the entire commercial building population in the Northwest.

2.3.1 Site-Level Analysis

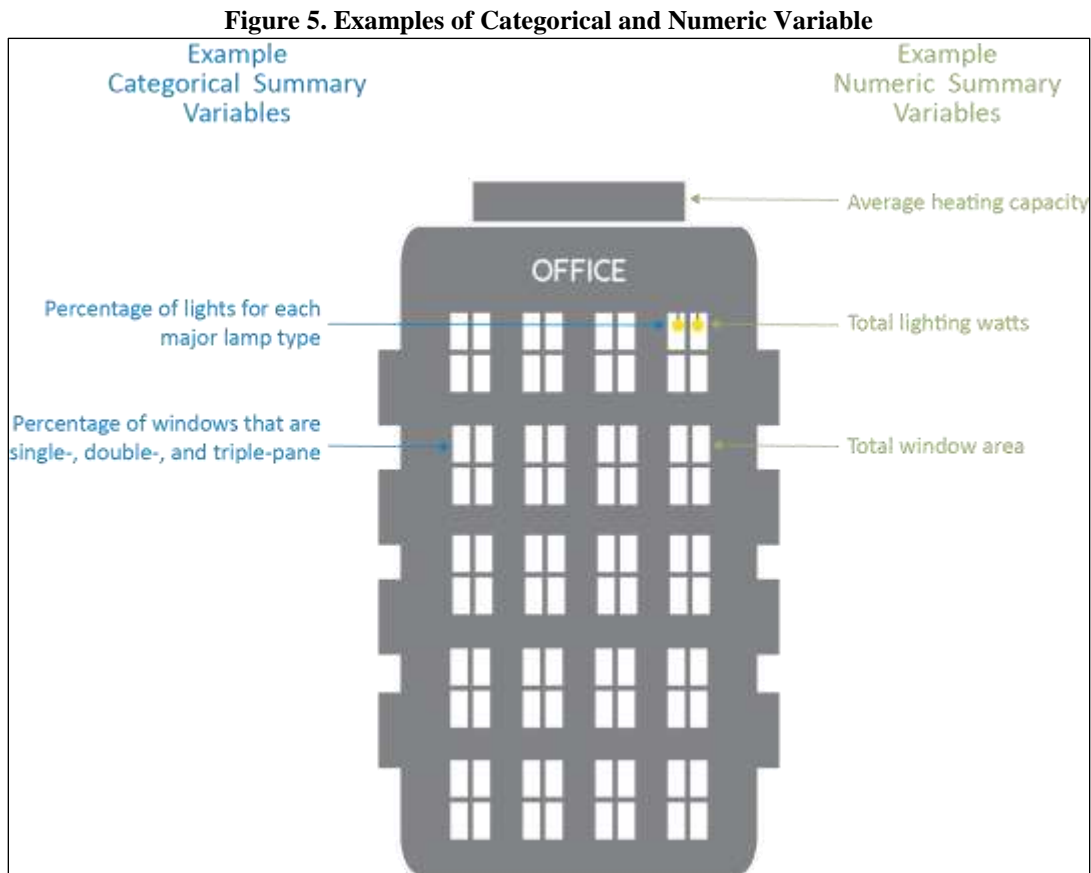
The complexity of the data collected at each site required two different summation calculations depending on the variable type. The Navigant project team generally summarized variables that had a fixed set of responses, or *categorical variables*, by calculating the percentage of the building corresponding to each response.¹² Examples of categorical summary variables include percentage of lights for each major lamp type, and percentage of windows that are single-, double- and triple-pane. The team summarized *numeric variables* on the other hand, by producing either the weighted average or the sum of the values for the site.¹³ Examples of

¹² The metric summarized varied by end use: building floor area (general), wattage (lighting), system input power (HVAC and DHW), or component area (building envelope).

¹³ These calculations utilized the same end-use specific metrics described in footnote 10.

numeric summary variables include total lighting watts, average boiler capacity, and total window area.

Figure 5 shows examples of both *categorical* and *numeric* variables as applied to a typical office building.



2.3.2 Lighting Power Density (LPD) Calculation

LPD, measured in watts per square foot, is an important measure of a building's energy consumption. Due to the size of many of the buildings surveyed however, it was impractical to gather information needed for LPD calculations from all lights in the building. Instead, surveyors sampled representative spaces and the analysis team extrapolated the results to the whole building.

To maximize the value of surveyor time onsite, the project team also created specific criteria for when and where to gather lighting information. Only spaces that met at least one of the following criteria were required to be sampled for LPD calculations:

1. The space was in the list of required spaces by building type,¹⁴ or
2. The space represented more than 20 percent of total building floor area.

Separate LPD values were calculated for indoor, outdoor (outdoor watts/indoor SF), parking garage (parking watts/parking SF), and refrigeration (refrigeration case watts/indoor SF). For specific LPD engineering calculations, see Appendix B.6.

2.3.3 Energy-Use Intensity Calculation and Modeling

The project team collected billing data from the utilities that served the sampled buildings to calculate electric and natural gas energy-use intensities at the site-level (EUI, measured in kWh/sf or therms/sf). First, the Navigant project team acquired signed billing data release forms for as many sites as possible and sent them, along with corresponding information from the FACT database, to the utilities via a secure file transfer protocol (FTP) website. The team requested three years of consumption history (kWh or therms) for each meter, along with dates of service and meter identifying information to link the data back to the individual buildings. Figure 6 summarizes this process.

Figure 6. EUI Calculation Process



The Navigant team compared the calculated EUI values to typical values by building type, and manually checked sites that appeared to be outliers for errors or missing meters. Ultimately, the team dropped any value that did not appear to be credible.¹⁵

¹⁴ See Appendix B.6 for full list of required spaces by building type.

Some sites did not have complete billing histories so the project team used regression models to estimate the corresponding electric and natural gas EUIs. Various building parameters, listed in Table 5, were required to run either a simple or complex regression analysis. Only sites that met the necessary parameters were able to run the complex regressions, while the remaining sites used simple regression models.

Table 5. EUI Regression Model Parameters

	Complex Electric	Simple Electric	Complex Gas	Simple Gas
Square Footage	√	√	√	√
Cooled Percentage	√			
Heated Percentage	√		√	
CDD	√	√		
HDD	√	√	√	√
Building Age	√		√	
Hours of Operation	√		√	
Building Type	√	√	√	√

Figure 7 provides the percent of sample framework sites that received utility billing data for electric EUI calculations. Figure 8 shows these percentages for gas EUIs.¹⁶ As shown, the overall share of sites with appropriate electric billing data was approximately 67 percent, while the overall share of sites with gas present and with appropriate gas billing data was approximately 57 percent. The Navigant team populated the remaining site EUIs with the estimated values from the regression models.

¹⁵ The team flagged data points that were less than 10 percent or greater than 1,000 percent of the median value by building type, except for warehouse data, which were not subject to this screening due to the wide range of possible usage patterns. Flagged data points were dropped if no reasonable explanation for them was found in the site level detail. These cutoff points represent a valid range for including relevant data without including faulty data that may skew results.

¹⁶ The N for each cell in Figure 7 “Percent of Electric Billing Histories Provided by Utilities” and Figure 8 “Percent of Gas Billing Histories Provided by Utilities” is the count of sites defined in the Sample Framework Figure 3 *excluding Hospitals and Universities*.

Figure 7. Percent of Electric Billing Histories Provided by Utilities (N=812)

	Vintage	Size (SF)	Retail	Grocery	Office	Food Service	Warehouse	Residential Care	Hotel-Motel	School	Assembly	Other				
Urban	Pre-2004	5,000 or less	81%	71%	85%	58%	58%	92%	64%	43%	54%	50%				
		5,001-20,000		67%									64%	70%	85%	83%
		20,001-50,000	75%		92%			91%		100%	83%	78%				
		50,001-100,000							57%							
		100,001 & Up														
Rural	Pre-2004	5,000 or less	75%	69%	63%	58%	73%	86%	50%	58%	63%	50%				
		5,001-20,000		57%									58%	33%	50%	38%
		20,001-50,000	46%		100%			80%								
		50,001-100,000							45%	100%	80%					
		100,001 & Up														
All	2004-2013	5,000 or less	64%	73%	68%	37%	60%	75%	78%	64%	81%	75%				
		5,001-20,000		60%									62%	89%	67%	71%
		20,001-50,000	77%		100%			75%								
		50,001-100,000							50%	100%	75%					
		100,001 & Up														

Figure 8. Percent of Natural Gas Billing Histories Provided by Utilities (N=812)

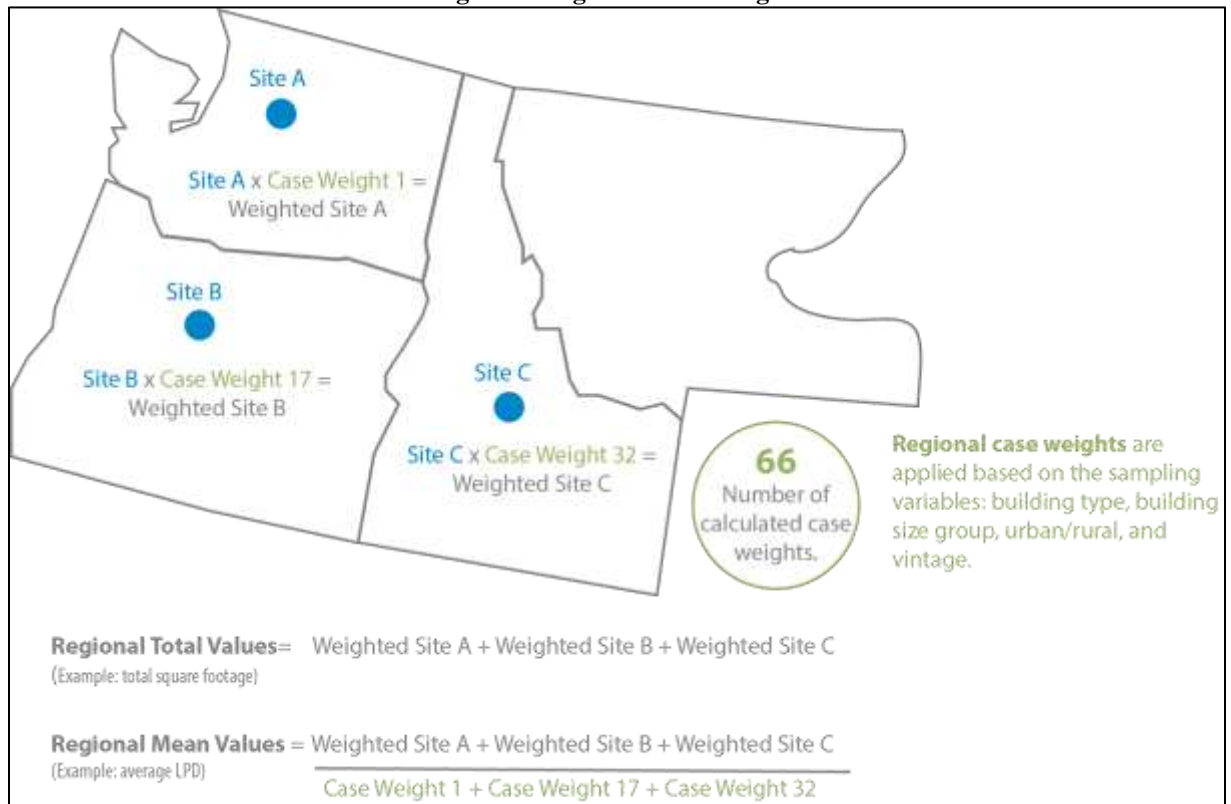
	Vintage	Size (SF)	Retail	Grocery	Office	Food Service	Warehouse	Residential Care	Hotel-Motel	School	Assembly	Other	
Urban	Pre-2004	5,000 or less	64%	50%	71%	67%	67%	64%	62%	50%	40%	67%	
		5,001-20,000		64%									50%
		20,001-50,000	75%		70%			58%			63%	67%	
		50,001-100,000		36%					70%	91%			58%
		100,001 & Up	36%		70%			91%			58%	63%	
Rural	Pre-2004	5,000 or less		78%		63%	33%		9%	67%			79%
		5,001-20,000	50%		27%	40%		38%			54%	85%	
		20,001-50,000		25%			50%						40%
		50,001-100,000	0%		50%	40%		38%			54%	85%	
		100,001 & Up		0%			50%						40%
All	2004-2013	5,000 or less	65%		38%	64%		39%	61%	50%	71%	64%	
		5,001-20,000		44%	55%		64%						57%
		20,001-50,000	77%			88%				64%			
		50,001-100,000		33%	88%		64%				57%	55%	67%
		100,001 & Up	33%			88%				64%			

2.3.4 Region-Level Analysis

The team extrapolated site-level results to the entire Pacific Northwest using the regional case weights developed for each cell in the sample frame as described in section 2.1.3. The team applied these weights to the sites that fell within the corresponding stratification framework. For example, all rural, pre-2004, 100,000+ sqft, Retail sites in the region were weighted by the corresponding rural, pre-2004, 100,000+ sqft, Retail case weight calculated from the sample.

The analysis team applied the case weights slightly differently depending on the data type. Specifically, the team calculated *region totals* (e.g., total window area) by multiplying the site-level values by the appropriate case weight before summing. The team calculated *regional mean values* (e.g., average LPD) by taking the weighted mean of the site-level values, using the case weight as the weighting factor. Figure 9 provides the calculations of total and mean regional values using three example sites across the region.¹⁷

Figure 9. Regional Case Weights



¹⁷ The three sites in Figure 9 fall in different states to show an example of regional representation only. The Navigant team did not perform the stratification between sites at the state level but rather the building type, vintage, size, and urban/rural stratification levels.

2.4 Data Storage

The volume of detailed data collected during this study required several different storage forms to maximize its usefulness to a wide range of database users. The following sections describe these forms.

2.4.1 Relational Database

Data is provided in a relational format consisting of thirty-seven separate tables linked by unique key values. This database contains all individual data points collected, including data on individual building envelope components (windows, walls, etc.), lights, HVAC systems, and refrigeration equipment. The public version of the relational database is constructed in Microsoft Access, and the private version is constructed in Microsoft SQL. Appendices H and I contain the data dictionary of relational database field definitions.

2.4.2 Flat-File Tables

The Navigant team also produced a flat-file site summary table and detailed lighting and HVAC tables to make the data more accessible to certain users. The site summary table contains one row per site, and includes all summary variables calculated for that site (e.g., percentage of lighting watts that are incandescent lamps, average boiler capacity, etc.). These flat-files do not contain customer sensitive data.

2.4.3 SharePoint Web Interface

A SharePoint website provides further access to the data by allowing users to create dashboard reports of region-wide building characteristics including on-the-fly tables and graphs. The website also provides an interface for download of subsets of the flat-file database for further analysis in Excel.

NEEA's goal in this process was to provide the maximum level of data access to each user while protecting the privacy of the study participants. To accomplish this goal, the team created different levels of access by user group, as summarized in Table 6:

Table 6. SharePoint™ Web Interface CBSA Database User Types and Access Levels

User	User Type	Database Access Level	SharePoint™ Access Level
NEEA	Admin/Super Users	Read/write access	Read/write access, with ability to edit users and permissions
Utilities	Conservation Program Administrators, Planners, etc.	Read-only access to all CBSA records, with identifiable customer information for only buildings within their service area	Access to dashboard reports and data download (with identifiable customer info for only their customers)
Other Northwest Organizations & Stakeholders	Agencies, Universities, etc.	Read-only access to all CBSA records – no identifiable customer information	Access to dashboard reports and data download (no identifiable customer info)
Other	Public	No access to the raw data	Access to downloaded stock reports

2.5 Study Challenges

There are inherent challenges and limitations that apply to a study of this scope and scale. This section discusses the most important ones encountered during the 2014 CBSA.

2.5.1 Data Quality

Review of the population framework compiled from the 2011 CBI and CoStar™ revealed numerous gaps in the commercial building data, including missing phone numbers and key building characteristics across the various sampling strata. NEEA's commercial sector population 2012 report acknowledged these and other forewarnings:¹⁸

- “The analyses suggested that both CBI and CoStar™ poorly represented rural and public buildings in the sampled business districts and public agency lists.”
- “...there were a number of Idaho counties with known commercial activity that were not present in the CBI catalogue table. CoStar™'s data was similarly weak in rural representation.”
- “...none of the sampled public agency buildings were matched to CoStar™.”

¹⁸ SBW Consulting, Inc. 2012. *Northwest Commercial Building Market Characterization*. Portland, OR: Northwest Energy Efficiency Alliance.

- “A lack of coverage for rural commercial buildings and publicly owned buildings is a known concern for the CBSA and similar regional research, and a consistent challenge for sampling and sample-precision.”

These gaps resulted in significant challenges in identifying the correct building type for many facilities which in turn impacted the planned CBSA budget and timeline through the cancellation of site visits, reclassification of sites (and the corresponding updating of quota projections), rescheduling and redeploying site surveyors, and related project management activities.

2.5.2 Representation

The 2014 CBSA greatly expanded the representation of commercial buildings across the region; however, the following challenges prevented further accomplishments:

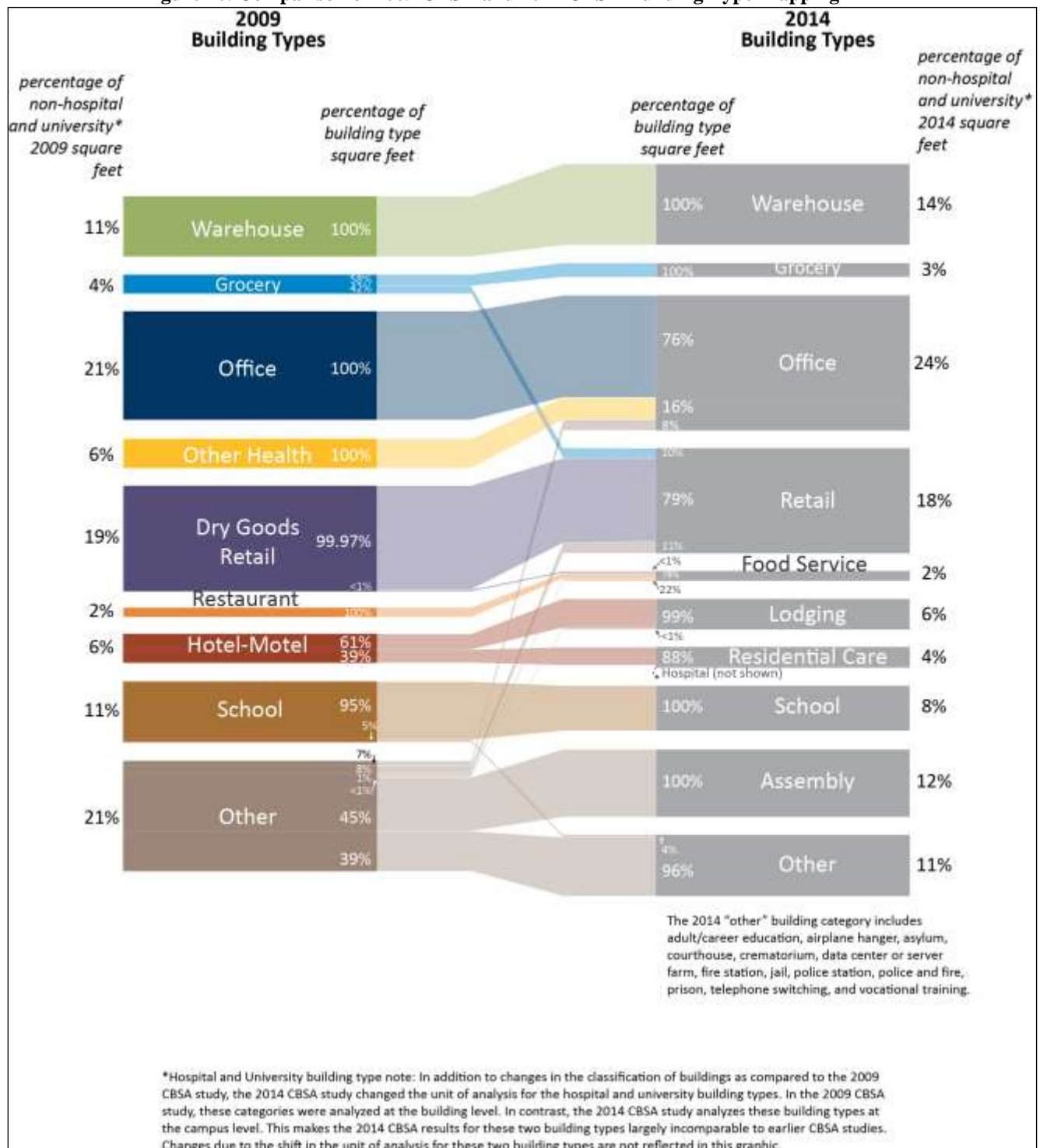
- The quality of data within the population discussed in the previous subsection;
- The consistency of data and building definitions used across the population frame sources (e.g., the CBI reported information by *tax parcel* which could include portions of, or multiple, buildings);
- Gaps within the population frame sources (e.g., a notable gap in coverage for rural commercial buildings and publicly owned buildings was observed in the CBI and CoStar™ populations);
- Inclusion of building types that were excluded from the CBSA (e.g., buildings that were primarily industrial or manufacturing, residential space, etc.); and
- Overlapping records within the population frame sources (e.g., Hospitals buildings were reported in both the American Hospital Directory and the CBI).

2.5.3 Data Mapping

Comparisons between the 2014 CBSA results and earlier CBSA studies are difficult due mainly to the differences in building-type classifications. The Building Classification Working Group altered the classifications in the 2014 study to better reflect energy use between building types, and to attempt to reduce the “Other” building category. Figure 10 provides a side-by-side comparison of building types that were included in the classifications for both the 2009 and 2014 CBSA studies. Appendix B.1 provides further detail on the building type mapping methods.

The 2009 CBSA contains only the results of the 2009 mapping; the sub-classification details are not available by building to re-map the 2009 data into the 2014 building classifications. This limitation means that comparisons can be made by ignoring the differences, or by mapping 2014 buildings into the 2009 classification scheme. This study utilizes the latter approach, but the reader must be careful not to use the 2014 data in these comparison charts and tables for further analysis.

Figure 10. Comparison of 2009 CBSA and 2014 CBSA Building Type Mapping



2.5.4 Data Collection and Recruitment

Both NEEA and the Navigant recognized that the commercial building recruitment needed to fill the quotas defined in the sample framework would be a challenge. In fact, recruitment rates based on the cold-calling efforts of PRS averaged about 6 percent. The following limitations contributed to this low rate:

- Gaps in the population frame:
 - Only 22 percent of buildings in the CoStar™ database included phone numbers (CBI does not include phone numbers). The project team sent a sample frame of 50,000 records to a phone number matching service in an attempt to improve contact information, but the service only had a 50 percent success rate;
 - In the population frame, 19.7 percent of the records had no a street address;
 - An additional 3 percent of buildings had incomplete or suspect addresses; and
 - Of all records, 38.2 percent were missing key building characteristics making them difficult to classify;
- Difficulty finding the correct contacts at a site to allow surveyor access;
- Site security or other corporate requirements limiting surveyor access;
- The inability to leverage possible rapport with customers who participated in previous CBSA studies or utility DSM programs; and
- Lack of incentive for participants during first nine months of the study.¹⁹

2.5.5 Revisions to the CBSA Sampling Methodology

The insufficient cell populations and recruitment challenges mentioned above, led NEEA and the project team to eliminate the urban/rural split for the new building vintage of post-2004. This reduced the necessary sample count required to achieve confidence and precision targets. More importantly, the sampling framework revision increased the population relative to the necessary sample for several key cells of interest in the new vintage, thereby allowing the current CBSA to achieve results with greater statistical precision in these cells.

Originally, the Navigant team designed the urban/rural stratification to ensure that stakeholders from the more remote areas of the Pacific Northwest had adequate representation in the final

¹⁹ NEEA and the project team began offering a 200-dollar gift card as an incentive for participating in the study. In the event that a customer could not accept the gift card, the team donated 200 dollars to an organization of their choosing. This increased recruitment rates from 5.6 percent to 10.5 percent and section 4 discusses this incentive further.

CBSA dataset, and concern was raised that this representation would be jeopardized when removing the distinction from the post-2004 vintage.

However, due to the increasing similarities in overall energy-use characteristics of average urban and rural buildings built within the last ten years, the modification of the urban/rural split within the new building vintage had a minimal impact upon the final results of the CBSA study. For more information, see Appendix B.2.

3 Key Findings

This section describes the key findings from the 2014 CBSA study and provides a high-level summary of the kinds of informative data included in the final database. Additional data representations are contained in Appendix A.

3.1 Building Characteristics

3.1.1 General Building Info – Floor Area

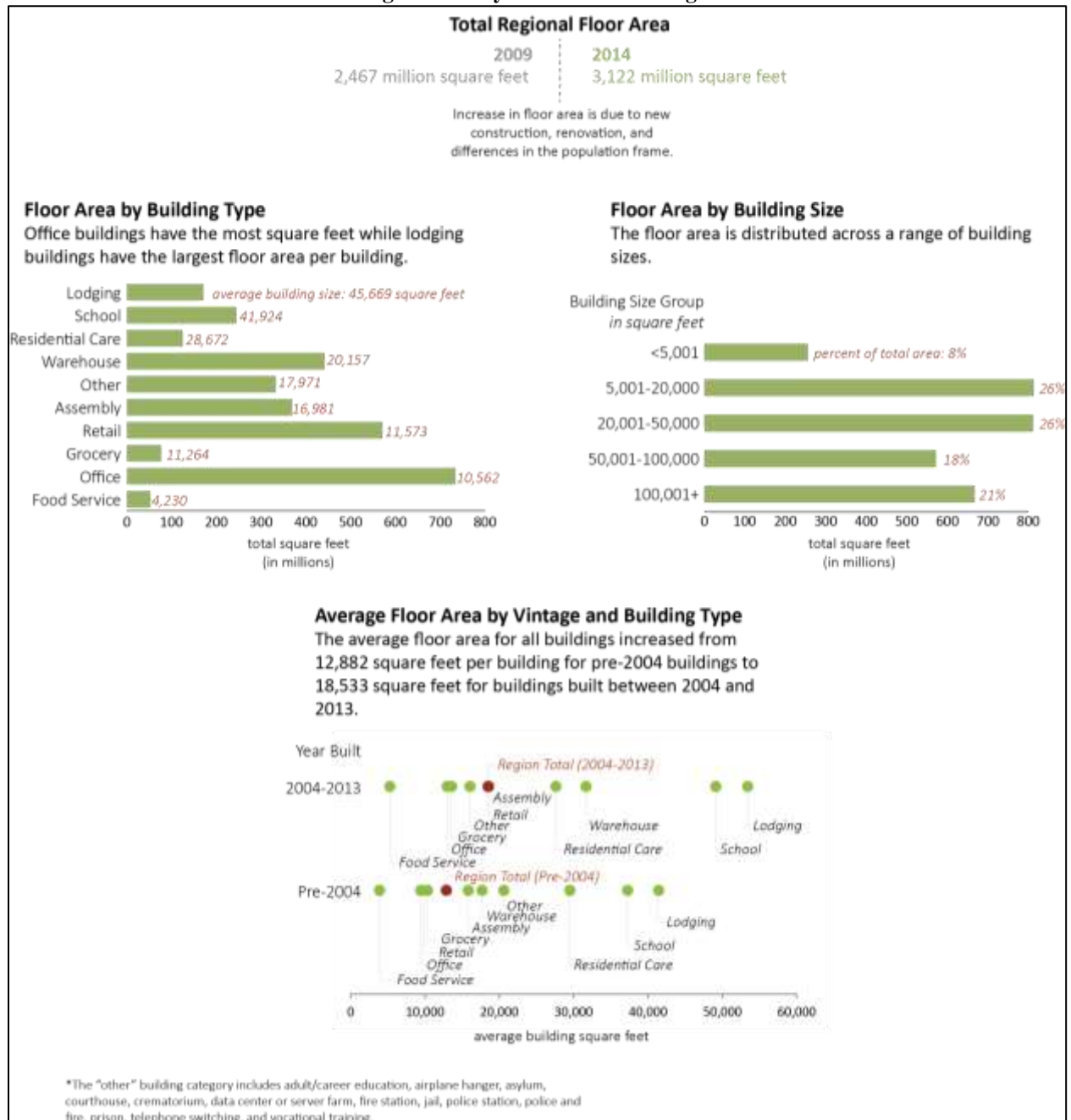
The total regional floor area for the Northwest as a whole has increased nearly 27 percent, from 2,467 million square feet in 2009, to 3,122 million square feet in 2014. The Navigant team attributes this increase to the following factors:

- New building construction – Between 2009 and 2012 commercial new construction increased approximately 8 percent on average nationally.²⁰
- Data quality of population frame and sample design – The 2014 study consists of the most current primary data collected on commercial buildings in the Northwest to date. The comprehensive sample drawn from the updated population frame for the 2014 study represents the region at a 90 percent confidence and 10 percent precision at the building-type level.

Figure 11 below provides graphical breakdowns of floor area by building type, size, and vintage. Key findings include:

- The “Floor Area by Building Type” graph shows the average building size within each category, and the total summed square footage of that building category in millions of square feet (e.g., the average School is 41,924 sqft, and the total School square footage across the region is just over 250 million sqft.).
- 21% of commercial floor area in the region is at sites that are over 100,000 sqft.
- Average floor area per commercial building increased 44 percent from buildings built before 2004 to those built after 2004, as shown in the “Average Floor Area by Vintage and Building Type” graph below.

²⁰ Further information available at <http://www.aia.org/practicing/AIAB090310>

Figure 11. Key Floor Area Findings

3.1.2 General Building Info – Operating Hours

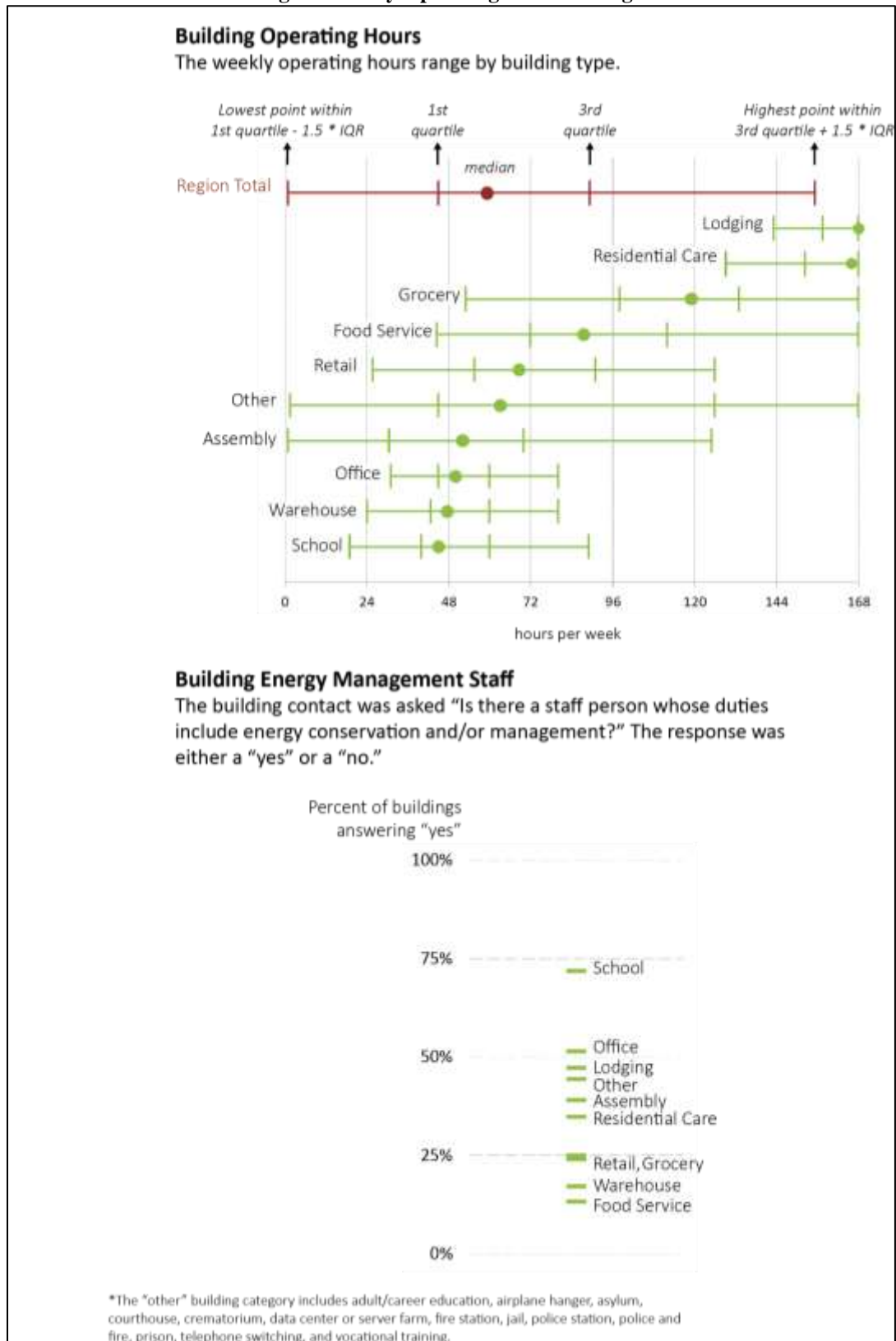
The 2014 CBSA study defines commercial building operating hours as hours per week the building is open for business.

The “Building Operating Hours” graph in Figure 12 below provides both the median, and range around the median, for the hours of operation by building type.²¹ Operating hours are consistent with prior expectations. For example,

- Lodging operates a full 168 hours per week; and
- Grocery stores operate at around 120 hours per week and have very high electricity EUIs due to refrigeration equipment (see section 3.2 for EUI results).

The “Building Energy Management Staff” graph displays the percentage of sites by building type who answered “yes” to having a staff member whose duties include managing energy consumption. Schools topped the list at nearly 75 percent while Food Service establishments came in at a lowly 12 percent.

²¹ IQR refers to the Interquartile Range

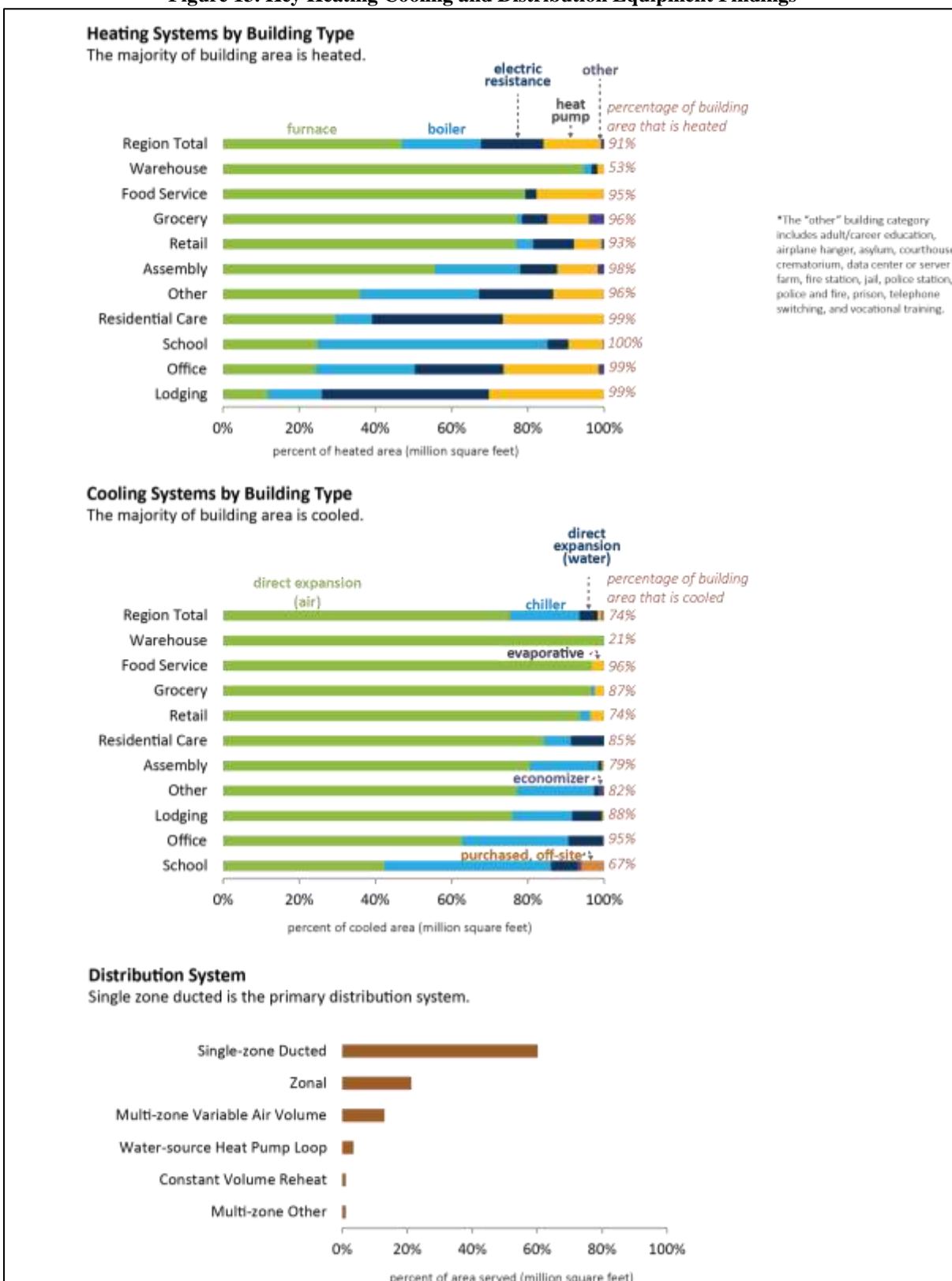
Figure 12. Key Operating Hour Findings

3.1.3 Heating and Cooling Equipment

Figure 13 shows the detailed heating, cooling, and distribution characteristics by building and system types. There is a great deal of diversity in these systems, and several important findings:

- Of commercial building square footage, 91 percent is heated;
- Furnaces heat 47 percent of heated square footage across the region;
- Heat pumps heat only 15 percent of heated square footage across the region;
- Approximately 48 percent of School square footage use boilers for heating;
- Cooling in nearly 75 percent of Pacific Northwest commercial building space; and
- Single-Zone ducted distribution systems make up the majority (60 percent) of cooling load distributed through the region.

Figure 13. Key Heating Cooling and Distribution Equipment Findings

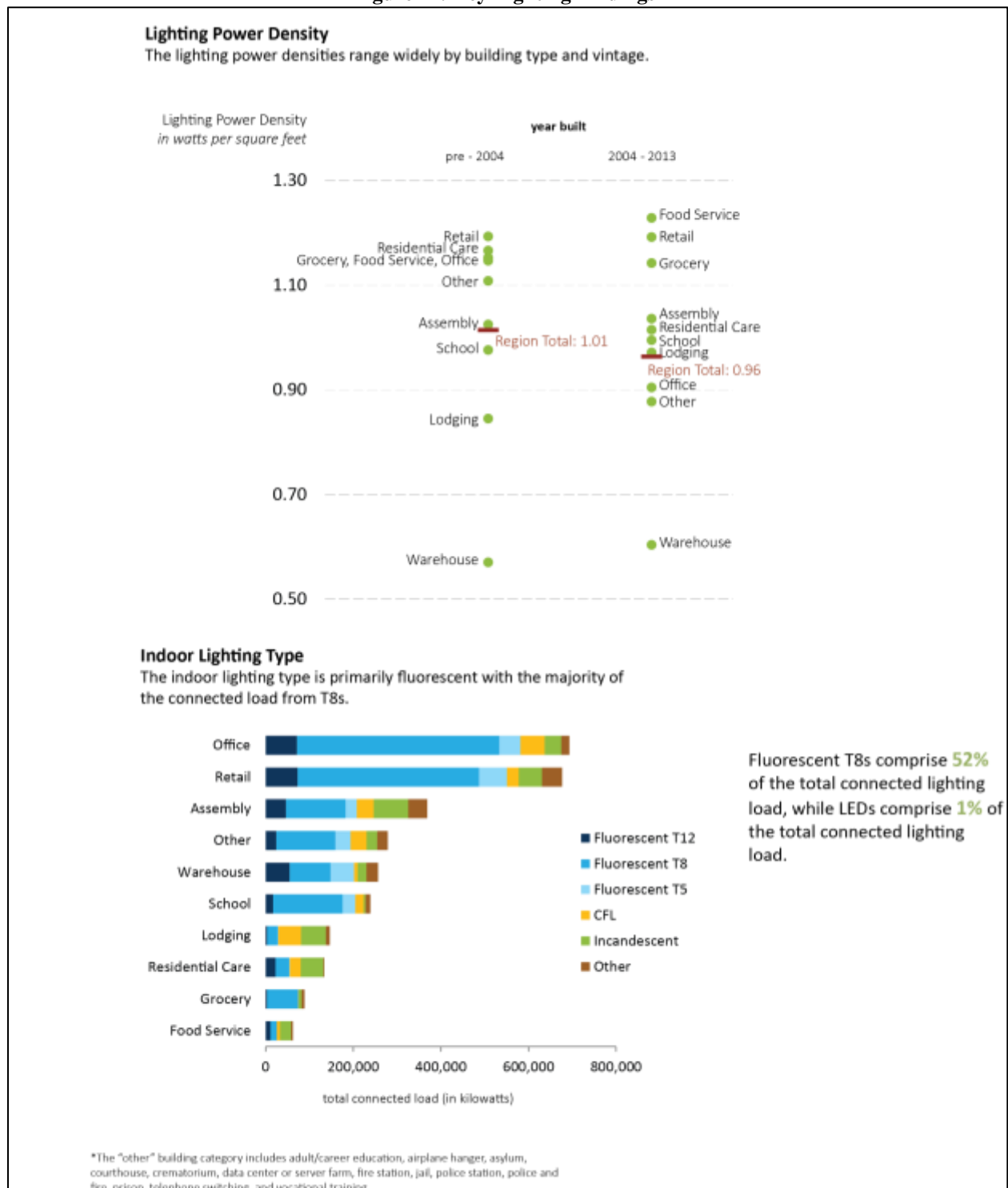


3.1.4 Lighting

The 2014 CBSA study paid particular attention to the state of the commercial building lighting market. Key findings include:

- LPD – A ratio of watts per square foot of building space, that provides valuable indications of power or wattage consumption in various building areas. The “Lighting Power Density” graph in Figure 14 shows:
 - The calculated LPD for each building category by vintage;
 - A downward trend in the average LPD across all commercial buildings in the region, from 1.01 in pre-2004 construction to 0.96 in buildings built between 2004 and 2013; and
 - Food service building LPD increased slightly from 1.15 to 1.25.
- The “Indoor Lighting Type and Control” graph below shows that the Office and Retail building categories make up the bulk of connected lighting load in the region and use primarily T8 lighting fixtures (65 percent and 61 percent, respectively).
- Inefficient incandescent bulbs remain a significant portion of the Assembly, Lodging, and Residential Care lighting load.

Figure 14. Key Lighting Findings

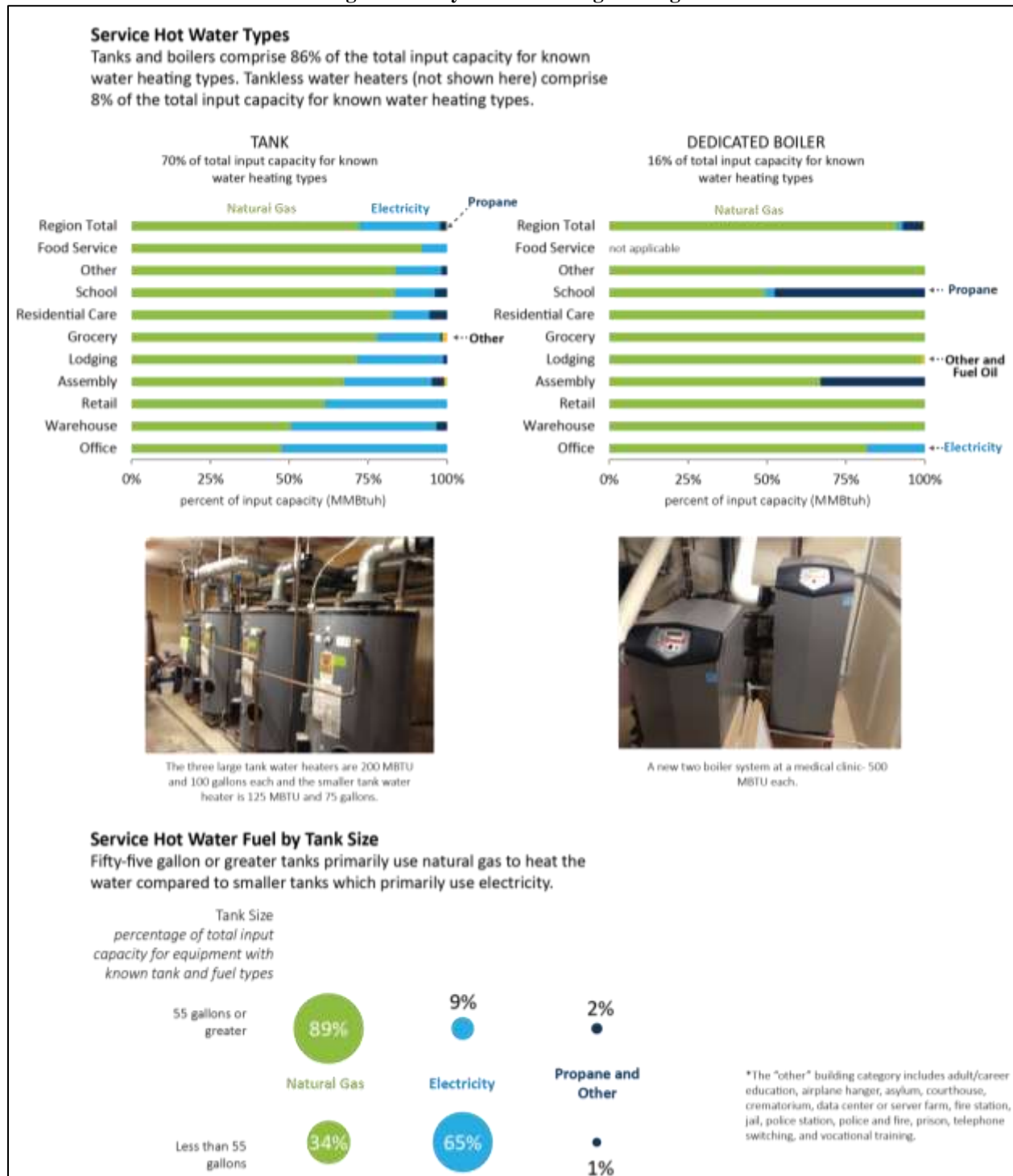


3.1.5 Water Heating

Figure 15 provides high-level findings for Service Water Heating (SWH) characteristics.

- Nearly half of boiler capacity in Schools with dedicated boilers burn propane for fuel;
- The majority of large water heating tanks (greater than fifty-five gallons) and boilers across the region use natural gas as the primary fuel source; and
- Smaller water heating tanks (less than fifty-five gallons) use electricity as the primary fuel source.

Figure 15. Key Water Heating Findings



3.1.6 Building Envelope

The make-up of the building envelope drives the amount of energy required to heat and cool the building space and can affect lighting requirements. Figure 16 provides a high-level summary of findings for the various pieces that make up the building envelope.

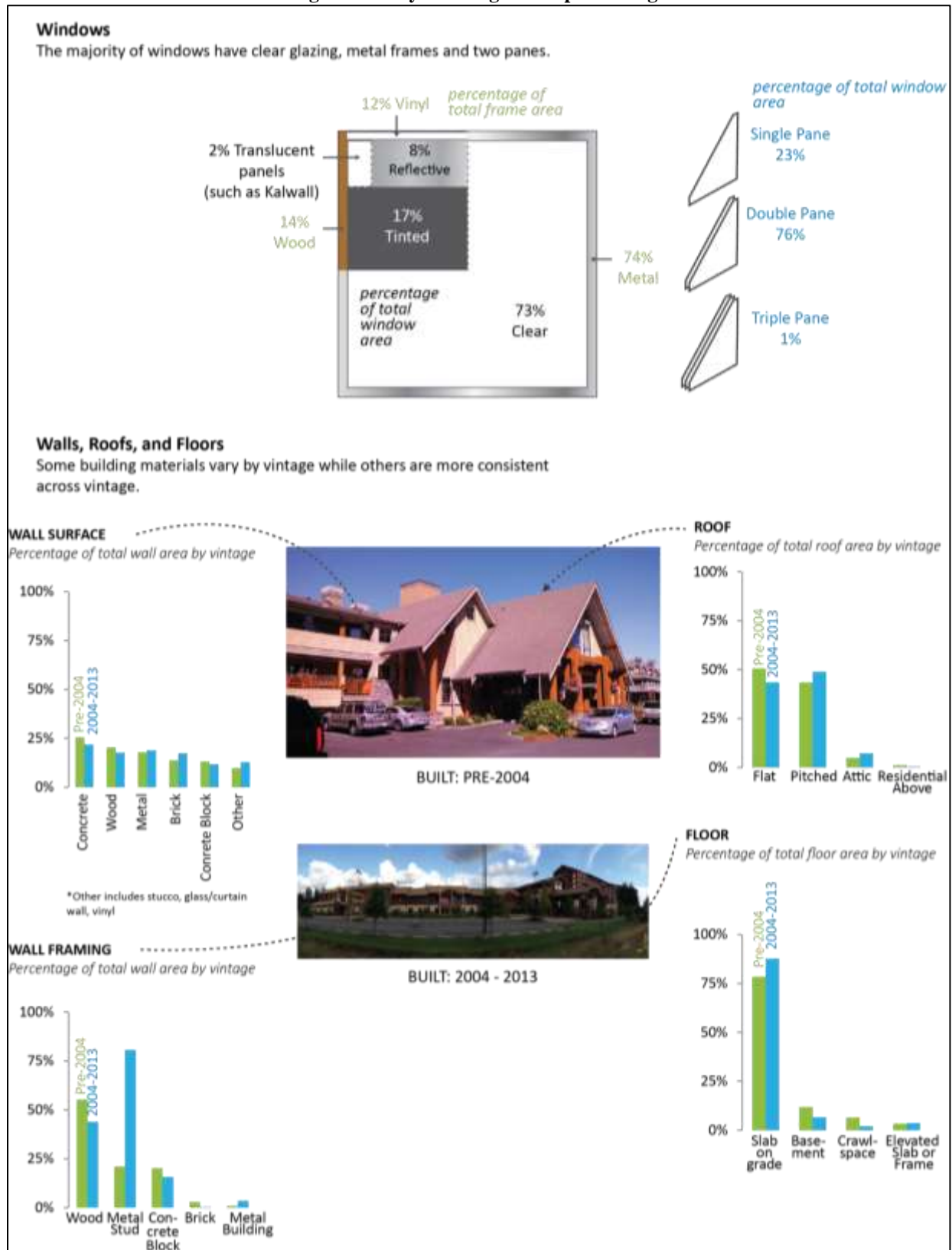
Windows

- The majority of windows in commercial buildings across the region are double pane (76 percent), clear (73 percent), and metal framed (74 percent)
- Inefficient, single pane still makes up 23 percent of window area

Wall, Roof, and Floor

- Building construction comparisons between pre-2004 to 2004-2013 vintages show a significant increase in the use of metal stud framings
- The majority of construction between 2004 and 2013 (85 percent) is slab on grade flooring. Only a slight increase from older pre-2004 buildings at 77 percent

Figure 16. Key Building Envelope Findings



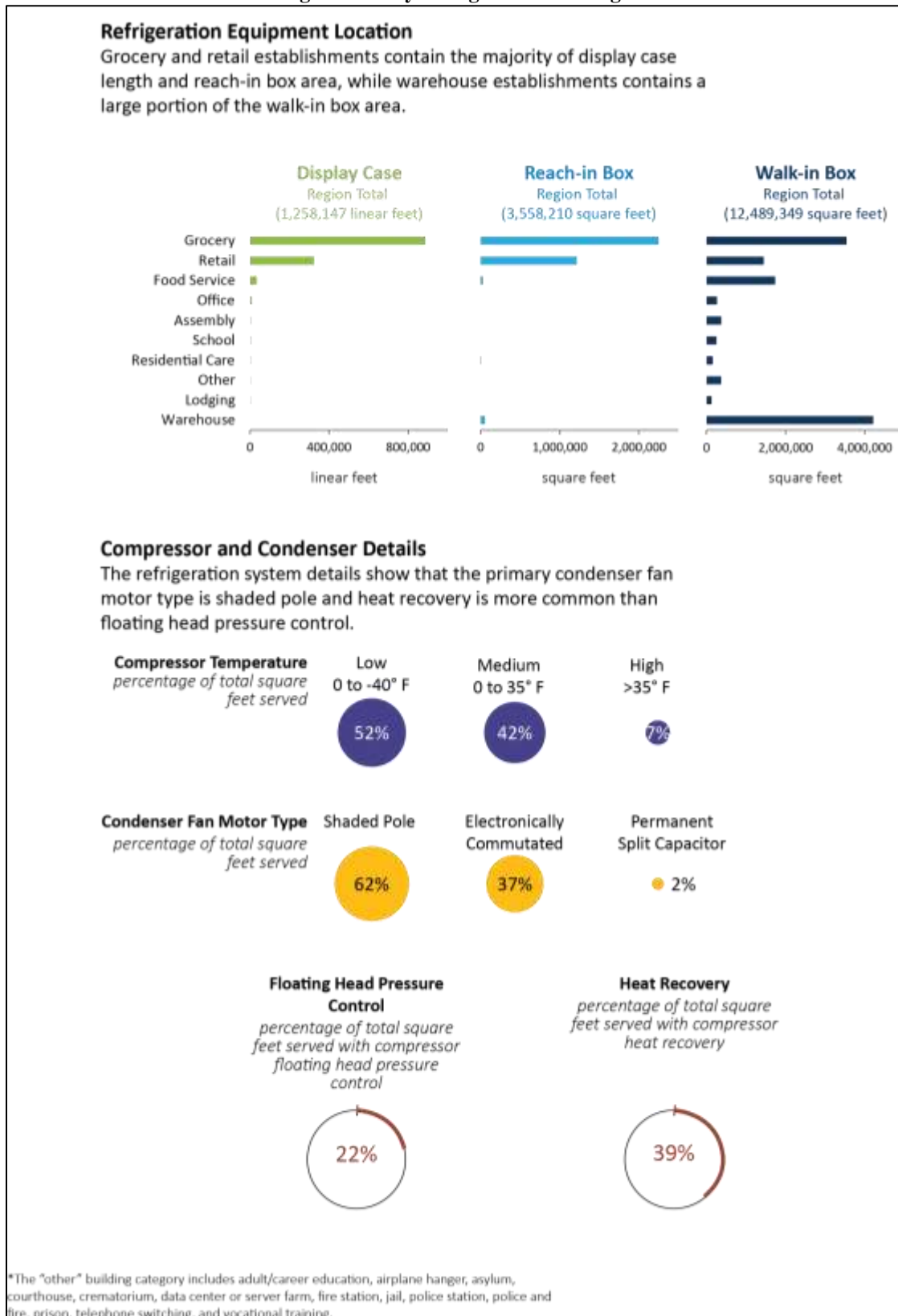
3.1.7 Refrigeration

The Grocery and Food Service industries consume large amount of energy to refrigerate product (represented as the two top ranked building EUIs in section 3.2). Key refrigeration findings include:

- A little over half of all refrigerated square footage is cooled to temperatures below 0° F
- Higher efficiency Electronically Commutated Motors (ECMs) make up only 37 percent of condenser fan area served; and
- Recovering lost heat from refrigeration display cases, reach-ins, and walk-ins occurs on 39 percent of refrigerated square footage.²²

²² As a side note, many smaller grocery and convenience stores in the sample indicated the lack of heating equipment required at the site due to the latent heat provided by display cases and reach-ins.

Figure 17. Key Refrigeration Findings



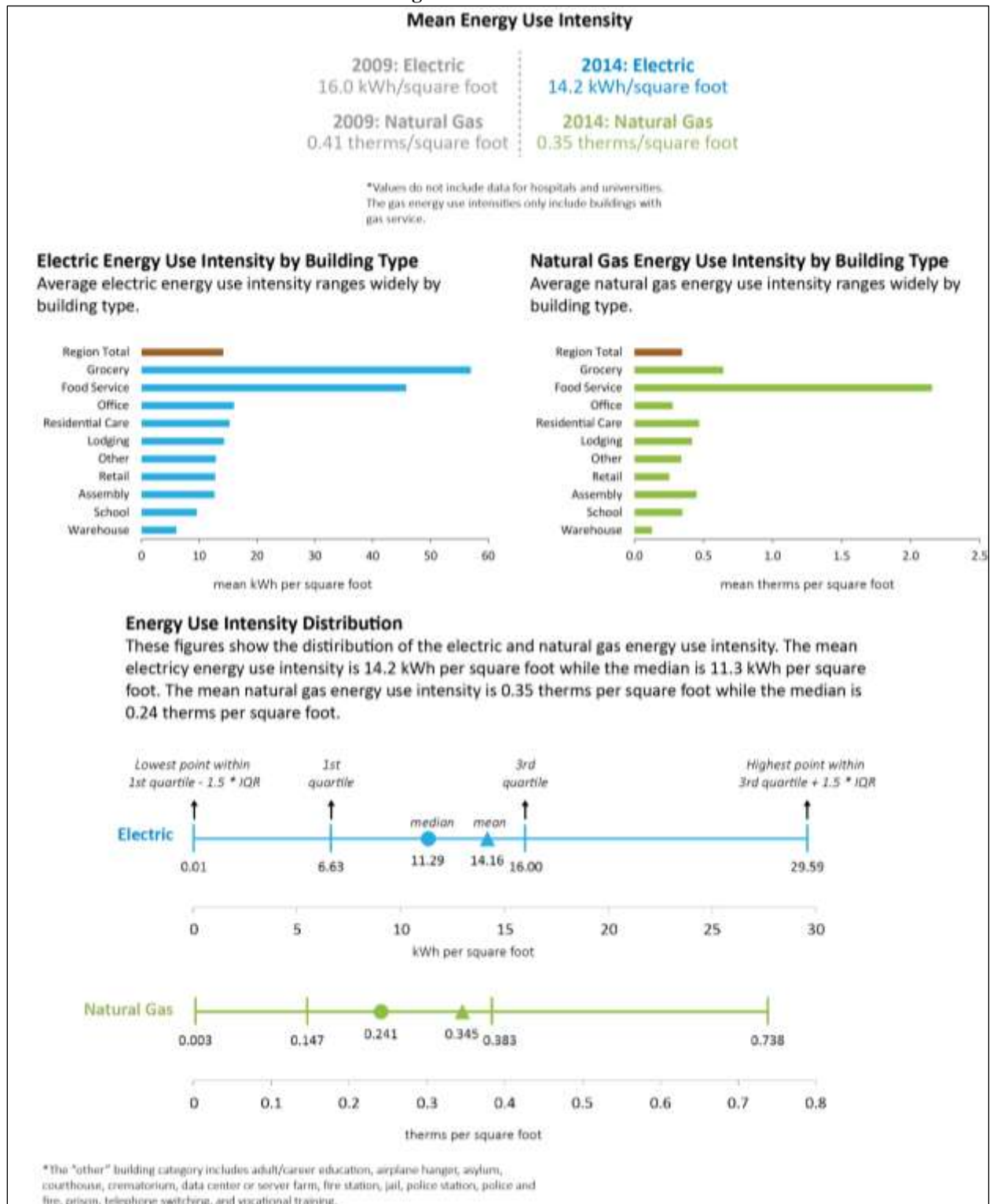
3.2 Energy-Use Intensities

Figure 18 shows average calculated EUI results for electricity and natural gas by total commercial building stock and by individual building category. The analysis reveals:

- Comparisons to the 2009 CBSA study show a decrease of approximately 11 percent in electrical energy intensity and a decrease of just under 15 percent in gas intensity.
- Grocery and Food Service buildings rank first and second in both electric and natural gas use intensity due to product refrigeration.
- The “Energy-Use Intensity Distribution” graph provides the mean, median, and ranges around the mean for all commercial buildings in the region.

The Navigant team attributes a significant portion of these reductions to methodology changes between the 2009 and 2014 CBSA studies, and not entirely to actual reductions in energy use. Appendix B.5 offers more detail on the EUI calculations.

Figure 18. EUI Results



4 Lessons Learned and Recommendations for Future CBSA Updates

Throughout this effort, the project team identified and documented lessons learned to inform future CBSA studies. These include the following:

- **Establishment of collaboration between NEEA and stakeholders to meet regional planning needs:** Effectively capturing stakeholder feedback in a timely manner was critical for understanding and characterizing data needs, aligning objectives, and agreeing on project specifications.
- **Development of a new random sampling framework to accurately characterize the distribution of regional commercial building square footage:** In collaboration with NEEA's stakeholders, the Navigant project team developed the random onsite sample to be representative of commercial buildings in the region according to four building characteristics:
 - Building type, or primary economic use
 - Building square footage
 - Building vintage
 - Urban/rural classification

The final sampling framework achieved 80 percent confidence/20 percent precision at the intersection of building type, size, vintage, and urban/rural dimensions, and an average of 90 percent confidence/10 percent precision by building type.

- **Documentation of *all* CBSA study methodologies, processes and protocols:** The CBSA Data Dictionaries and other appendices are the culmination of all project documentation and will inform future studies about the processes and protocols relied on in the 2014 effort.
- **Implementation of rigorous Quality Assurance/Quality Control (QA/QC) procedures across all data collection and analysis processes:** The project team established a dedicated QA/QC team to review, clarify, and correct each individual survey form, develop automated data validations and adaptive algorithms into the online data collection platform, and review aggregated data sets. Collectively, these efforts improved the accuracy, consistency, and representativeness of CBSA analysis findings.
- **Development of a new relational database:** The 2014 CBSA relational database is scalable and can house data from future CBSA efforts.

4.1 Recommendations

This section provides some general project recommendations to inform future CBSA efforts and recommended solutions to the study limitations identified in section 2.5.

Recommendation 1: Accurately characterize the population of commercial buildings prior to conducting a CBSA update study. Understanding any data gaps that may exist within the population of commercial buildings at the onset of a CBSA study will improve overall data quality and alleviate many of the study limitations listed in section 2.5. These include:

- Building-type classification – knowing key site characteristics will allow for easier classification;
- Representation – understanding key elements such as building type and energy use will improve the sample framework to be much more representative of the overall population;
- Recruitment – having proper phone numbers and site contacts will improve recruitment rates significantly.

Utilizing secondary sources to fill in missing address and key building information and phone number matching services to track down contact numbers as early as possible in the CBSA study, will have a positive impact on project timeline and budget.

Recommendation 2: Expand marketing for future CBSA studies to promote regional awareness of NEEA's efforts and improve recruitment rates. Collaborating with utilities to actively inform and educate customers about the benefits of the CBSA Study will improve recruitment rates and minimize potential recruitment bias in future efforts by expanding the pool of willing participants.

Recommendation 3: Incorporate recruitment incentives into future CBSA update studies. The average CBSA site surveys took between four and eight hours to complete. A significant portion of this time required the participant to be present, creating a major barrier to participation. In fact, the recruitment rate was only 5.6 percent early in the study until NEEA and the project team instituted a 200-dollar incentive for participation, increasing the recruitment rate to nearly 10.5 percent. Recognizing the value of incentives and rewarding participants for their contributions to the CBSA study at the onset of the project will improve recruitment dramatically.

Recommendation 4: Involve funding utilities early in the study to help recruit large customers that may otherwise opt out of the study. Leverage relationships between utility representatives and larger customers (while ensuring random selection) during the recruitment process. The 2014 CBSA requested recruitment support from a number of utilities, which ultimately helped the team achieve its sampling goals.

Recommendation 5: Conduct Hospital and University site surveys using separate data collection protocols. Hospitals and Universities comprised larger and more complex building “campuses” that took additional time and resources to survey. The Navigant project team developed a separate data collection protocol for these building types through the Working Group process, and because survey findings and energy-use estimates were so unique for these campuses, the results were not directly comparable to the other building types included in the study. The project team developed an addendum to the CBSA Report that details survey findings for hospitals and universities, along with the methodologies and lessons learned to inform future update studies.

Recommendation 6: Further reduce the population of “Other” building types by refreshing sample populations. Fill data gaps in the overall population (Recommendation 1 above) to reduce the percent of sites vaguely categorized as “other” when drawing the sample population. Use data gathered during recruitment and onsite visits to further re-classify “other” buildings into existing building-type categories. Refreshing the sample population to incorporate these re-classifications, and reduce the impact of the “other” category on the overall study results.

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February 9, 2015

2014 COMMERCIAL BUILDING STOCK ASSESSMENT:

Final Hospital and University Addendum

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Executive Summary

The Addendum to the 2014 Commercial Building Stock Assessment (CBSA) captures the unique multi-building, “campus” characteristics of the Hospital and University segment across the region. The Northwest Energy Efficiency Alliance (NEEA) and the project team removed Hospitals and Universities¹ from the general report findings and analyses due to their unique data collection methods and analyses, which distinguished these building types from the other categories investigated through the CBSA.

ES.1 Data Collection

To provide an accurate and current picture of the Hospital and University segment in the Pacific Northwest, the 2014 CBSA ‘core’ study gathered primary data from 52 Hospitals and Universities. Table ES-1 provides the distribution of onsite surveys within each building type category.

Table ES-1. Number of Hospitals and Universities Surveyed in 2014 Core CBSA²

Building Type	Number of Buildings Surveyed
Hospitals	31
Universities	21
Total	52

ES.2 Key Findings

This section summarizes a number of high-level Hospital and University findings. For more detail, see section 2 and Appendix A. It should also be noted that the absence of comparative metrics between the 2009 and 2014 Hospital and University findings is deliberate. In addition to changes in the classification of buildings as compared to the 2009 CBSA study, the 2014 CBSA study changed the unit of analysis for the hospital and university building types. The 2009 CBSA study analyzed these categories at the building level. For example, a dormitory might have represented an entire university in 2009 and previous CBSA studies. In contrast, the 2014 CBSA study analyzes these building types at the campus level, making the 2014 CBSA results for these two building types largely incomparable to earlier CBSA studies.

As shown in Figure ES-1, the total regional floor area for Hospitals and Universities is 228 million square feet (104 million square feet and 124 million square feet, respectively). Hospitals and four year colleges with graduate schools comprise 89 percent of the total floor area for these

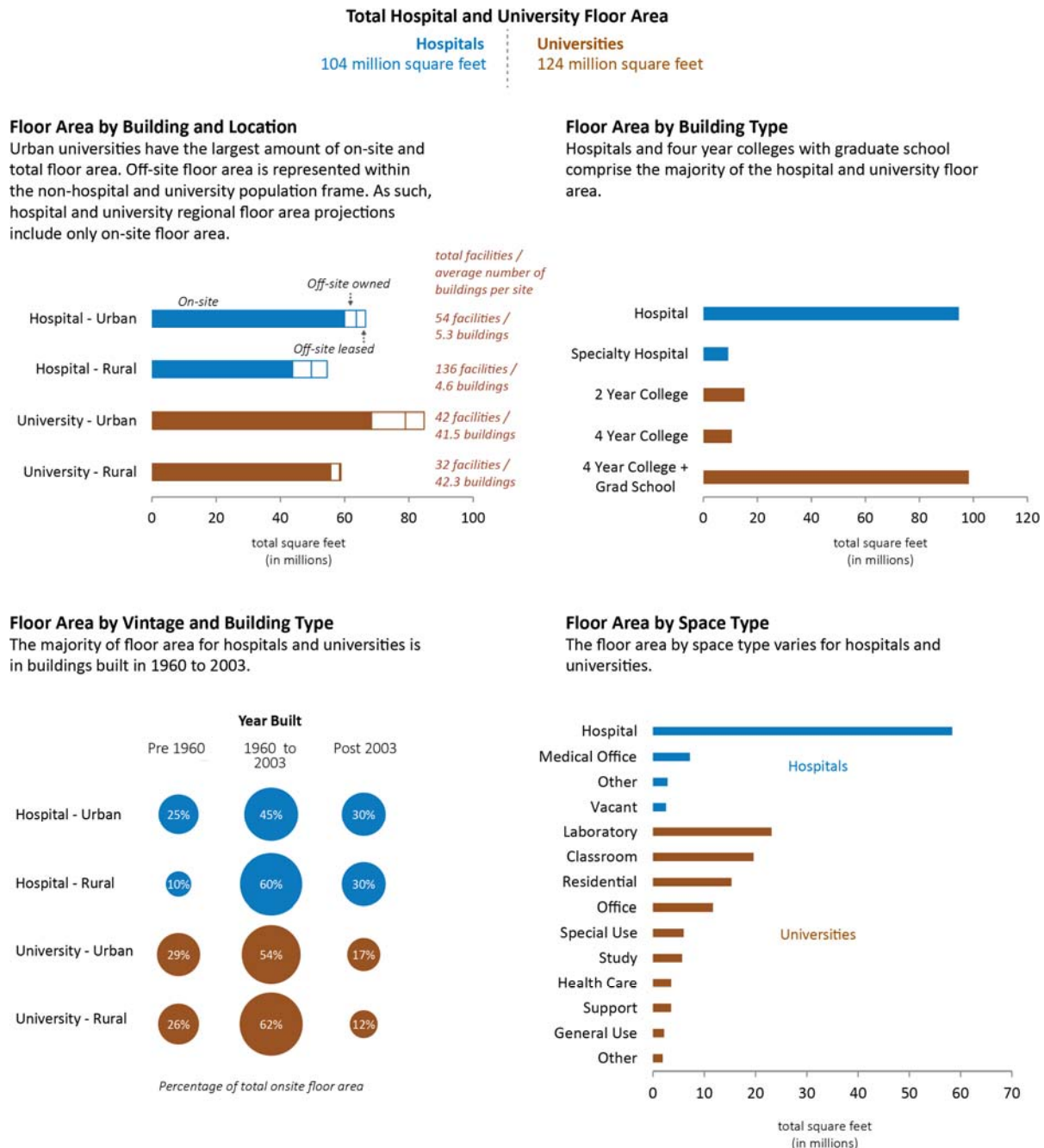
¹ Universities comprised higher education colleges, universities, and non-profit technical and vocational postsecondary institutions.

² The “Core” CBSA study is differentiated from any utility- or stakeholder-funded oversample efforts currently being conducted at the time of this writing.

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building segments, and 54 percent of total Hospital and University floor area was constructed between 1960 and 2003.³

Figure ES-1. Hospital and University Floor Area Characteristics



³ Throughout the study, Hospitals and Universities confirmed an ongoing and continual upgrade process. The vintage splits (pre-1960, 1960 to 2003, etc.) were a product of available data from surveyed sites, and also separated buildings where central air and cooling was a very likely systems from those where it would have been less common.

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Additional Hospital and University observations captured through the data collection process include:

- An increase in leased space across both Hospitals and Universities. The use of leased space ranged from medical offices to main University campuses for some private schools.
- More conservation-oriented improvements in public colleges than private colleges.
- Ongoing LED retrofits, particularly in parking garages for Hospitals and Universities.
- A large portion of Hospitals have eliminated T-12 lighting and a small portion have eliminated incandescent lighting. Roughly half of those with T-12 or incandescent lighting remaining have programs in place to replace existing fixtures with T-8s and LEDs.
- A small portion of Universities have eliminated T-12 and incandescent lighting. Those with T-12 or incandescent lighting remaining have programs in place to address their replacement with T-8 and LEDs in the near future.
- A general shift away from central plants in colleges in favor of implementing building-level equipment.

Figure ES-2 describes the results of the Energy-Use Intensities (EUIs) for both electricity and natural gas in the Hospital and University segment. Differences between the 2009 and 2014 CBSA EUI values are attributable to a combination of effects, including naturally occurring conservation, codes & standards, energy efficiency program impacts, and differences in the 2009 and 2014 CBSA sample frame and data collection methods. Moreover, the 2014 Hospital and University EUIs achieved greater floor area representation than previous efforts, capturing campus-level, instead of building level, characteristics.

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Figure ES-2. Hospital and University Energy-Use Intensities⁴

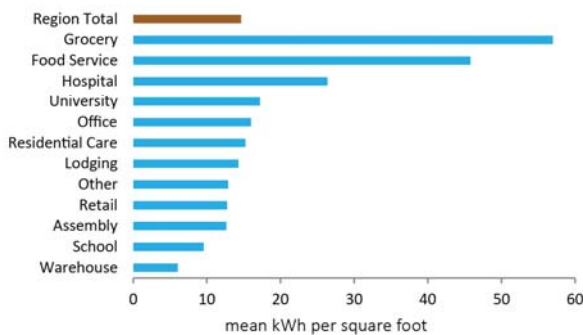
Mean Energy Use Intensity

2009: Electric 16.8 kWh/square foot	2014: Electric 14.6 kWh/square foot
2009: Natural Gas 0.46 therms/square foot	2014: Natural Gas 0.39 therms/square foot

*The gas energy use intensities only include buildings with gas service. All values on this graphic include hospitals and universities.

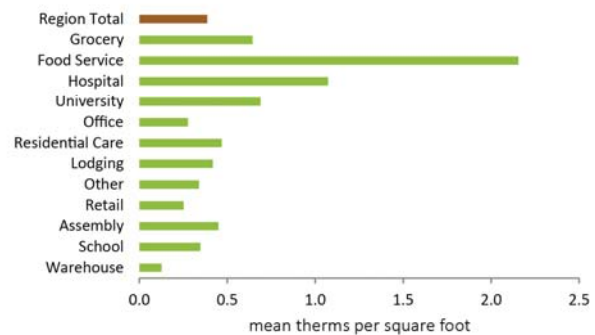
Electric Energy Use Intensity by Building Type

Average electric energy use intensity ranges widely by building type.



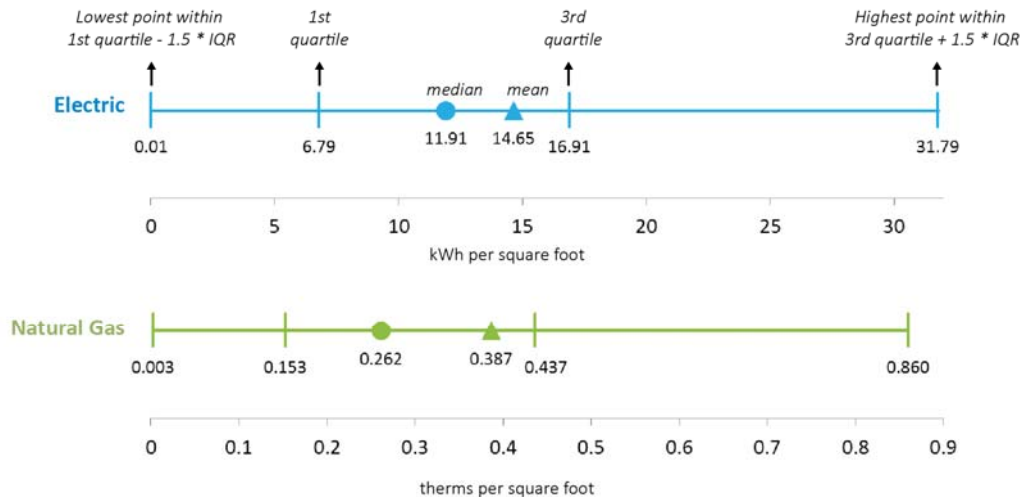
Natural Gas Energy Use Intensity by Building Type

Average natural gas energy use intensity ranges widely by building type.



Energy Use Intensity Distribution

These figures show the distribution of the electric and natural gas energy use intensity. The mean electricity energy use intensity is 14.6 kWh per square foot while the median is 11.9 kWh per square foot. The mean natural gas energy use intensity is 0.39 therms per square foot while the median is 0.26 therms per square foot.



*The "other" building category includes adult/career education, airplane hanger, asylum, courthouse, crematorium, data center or server farm, fire station, jail, police station, police and fire, prison, telephone switching, and vocational training.

⁴ Some Hospitals and Universities used backup fuels (e.g., oil) for which we were unable to capture consumption

ES.3 Recommendations for Future CBSA Studies (Hospital and University)

Recommendations for the Hospital and University segment mirrored the recommendations of the general report. Segment specific recommendations, include:

1. *Expand marketing for future CBSA studies to promote regional awareness of NEEA's efforts and improve recruitment rates.* By collaborating with utilities to actively inform and educate customers about the benefits of the CBSA study, future efforts will improve recruitment rates by expanding the pool of willing participants. This is particularly true of Hospitals and Universities whose facility management staff often could not accept monetary recruitment incentives.
2. *Conduct Hospital and University site surveys using separate data collection protocols.* Hospitals and Universities comprised larger and more complex building “campuses” that took additional time and resources to survey. A unique data collection protocol for these building types was established through the Working Group process, and because survey findings and energy-use estimates were so unique for these campuses, the results were not directly comparable to the other building types included in the study.

1 Hospital and University Study Methodology

1.1 Population and Sampling

This section describes the methods for constructing the Hospital and University population frame used for the 2014 CBSA stratification and sample design process.

1.1.1 Population Frame Development

The project team compiled the population frame for the core CBSA study using multiple sources, most notably the Commercial Building Inventory (CBI) and CoStar databases, and found a high degree of variation in the portrayal of a single Hospital and University campus. Specifically, the population frame broke out some campuses into a collection of entries, each representing an individual building on a college campus, or a wing of a hospital; while representing other entities with one or more tax parcels, which may or may not have had any direct bearing on the number of buildings on the campus. Most importantly, this inconsistency in the unit level for these building types made it nearly impossible to ensure that all hospitals and universities had the same chance of random sample selection. Additional factors affecting Hospital and University representation within the CBI and CoStar databases included:

- The designation of onsite and offsite Hospital and University buildings within the Commercial Building Inventory (CBI) and CoStar population was unclear.
- The Commercial Building Inventory (CBI) and CoStar population represented leased space more accurately than owned Hospital and University buildings.
- The Commercial Building Inventory (CBI) and CoStar population underrepresented public Hospitals and Universities.

To compensate for these discrepancies, the project team constructed new population frames for Hospitals and Universities, and substituted them into the population frame to prevent double counting with the CBI and CoStar™ databases. Table 1 lists the replacement data sources.

Table 1. Hospital and University Population Frame Sources	
Data Source	Description
American Hospital Directory	A database of over 6,000 public and private hospitals nationwide
The United States Department of Education	A federal inventory of educational institutions
Integrated Postsecondary Education Data System	A compilation of survey data collected from all educational institutions that participate in federal student financial aid programs

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The project team “de-duplicated” entries within the Department of Education directory and IPEDS to create a single population for Universities, and moved “for-profit professional/vocational schools” to the “Other” building type category. The Building Classification Working Group determined the University category, and focused on characterizing larger public and private University campuses. The remaining entries served as the Hospital and University population frame for the 2014 CBSA study. Table 2 shows the final number of hospital and university entries in the population frame by sample cell.

Table 2. Number of Hospital and Universities in Population Frame, by Sample Cell			
Building Type	Rural	Urban	Total
Hospital	197	91	288
University	53	60	113
Total	250	151	401

It should be noted, however, that there exists some overlap between the CBI and CoStar constructed population frame, and the newly constructed Hospital and University population frame. This is due to the inconsistency of designated Hospital and University buildings within CBI and CoStar databases and are acknowledged as sources of bias in this addendum.

1.1.2 Extrapolation of Hospital and University Square Footage in the Region

The unique population frame compiled for Hospitals and Universities largely addressed the issues of consistent unit level and equal chance of random selection, however the primary data sources from the Hospital and University population frame did not include square footage estimates for the campus. It was therefore necessary to use the collected survey data to develop an estimate of regional square footage.

The project team used a size proxy in the population dataset to compensate for any deviation between the average sizes of entries in the population versus the sample, in order to account for any bias that may exist in the recruited sample. For hospitals, the proxy metric was number of beds; the project team calculated the average square footage per hospital bed in the sample, and then applied this average to the remaining entries in the population frame to estimate the building square footage of each hospital campus in the region. The team used a similar extrapolation process for universities based on total student enrollment.

For both building types, the project team performed this extrapolation separately for urban and rural entries to reduce the possibility of introducing any bias into the square footage estimate. To further reduce bias, the team also performed this extrapolation separately for public and private universities, where possible. Though the vast majority of entries in the population frame had data for the proxy size metric, approximately 8 percent of records did not. In these instances, the entry was assigned the average extrapolated square footage of all other entries with the same extrapolation criteria.

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Table 3 shows the estimated regional square footage by sample cell after the project team completed the extrapolation process for all entries in the population frame.

Table 3. Square Footage Estimates for Hospitals and Universities			
Building Type	Rural	Urban	Total
Hospital	43,781,681	59,972,354	103,754,035
University	55,641,784	68,347,342	123,989,126
Total	99,423,465	128,319,695	227,743,160

1.2 Data Collection

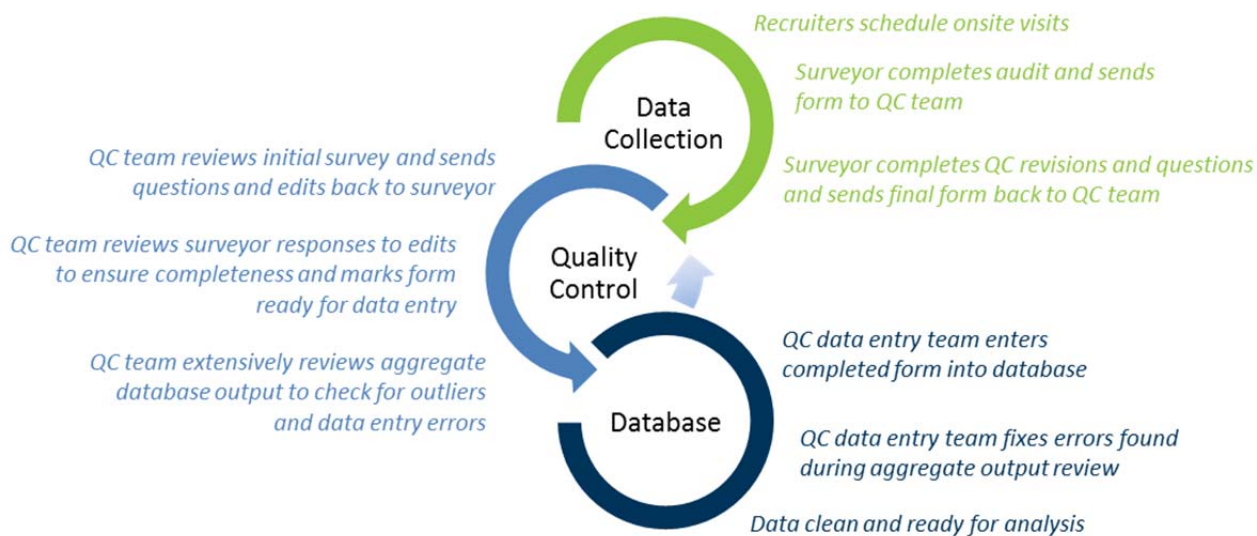
Capturing detailed information across large Hospital and University campuses, which are comprised of numerous buildings, was both time and cost-prohibitive. Moreover, the ongoing commitment required of participating facility managers needed to be balanced against diminishing recruitment rates.

The project team collaborated with the Working Groups to develop a revised data collection protocol consisting of both on-site surveys and telephone interviews that captured the desired campus-level information to support regional planning efforts. The updated data collection protocol also maintained the original 80/20 sampling requirements for the urban / rural split by combining the telephone and site surveys. Table 4 shows the final distribution of Hospital and University data collection efforts.

Table 4. Distribution of Hospital and University Data Collection Efforts		
Building Type	On-Site Surveys	Telephone Surveys
Hospital	10	21
University	8	13
Total	18	34

Hospital and University data collection efforts adhered to the same rigorous quality control checks to ensure the consistency and accuracy of analysis findings. Figure 1 summarizes these processes, and Appendix C provides additional details in the Quality Management Plan.

Figure 1. Data Collection Process Flow



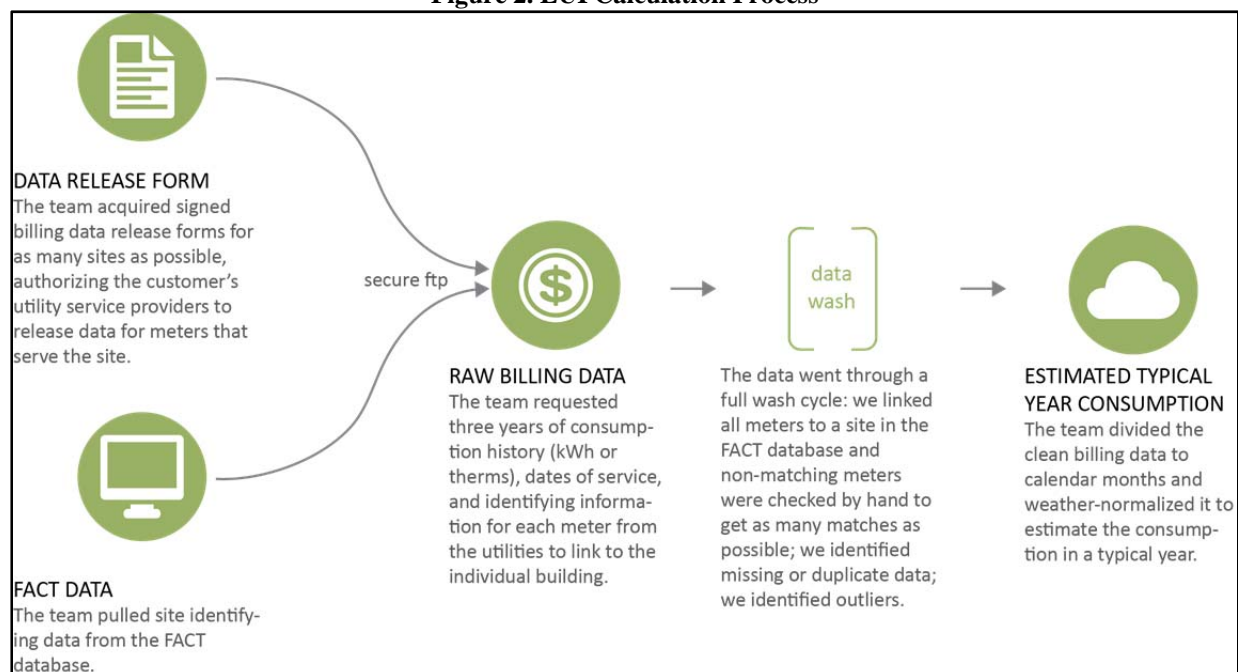
1.3 Data Analysis

The analysis team used the clean data in the FACT system to summarize campus-level results such as electric and gas EUI, and lighting technology characterizes. The team then extrapolated site-level results up to the region-level using the calculated case weights to provide representative results of the entire commercial building population in the Northwest. The campus-centric nature of Hospitals and Universities typically restricted analyses to *categorical variables*.

1.3.1 Energy-Use Intensity Calculation and Modeling

The project team collected billing data from the utilities that served the sampled Hospitals and Universities to calculate electric and natural gas energy-use intensities at the site-level (EUI, measured in kWh/sf or therms/sf). First, the project team acquired signed billing data release forms for as many sites as possible and sent them, along with corresponding information from the FACT database, to the utilities via a secure file transfer protocol (FTP) website. The team requested three years of consumption history (kWh or therms) for each meter, along with dates of service and meter identifying information to link the data back to the individual buildings. Figure 2 summarizes this process.

Figure 2. EUI Calculation Process



The project team compared the calculated EUI values to typical values by building type, and manually checked sites that appeared to be outliers for errors or missing meters. Ultimately, the team dropped any value that did not appear to be credible.⁵ The overall share of Hospitals and Universities with appropriate electric billing data was approximately 48 percent, while the overall share of sites with gas present and with appropriate gas billing data was approximately 41 percent.

2 Key Findings

This section describes the key findings from the 2014 CBSA study and provides a high-level summary of the kinds of informative data included in the final database. Additional data representations are contained in Appendix AA. It should also be noted that the absence of comparative metrics between the 2009 and 2014 Hospital and University findings is deliberate. In addition to changes in the classification of buildings as compared to the 2009 CBSA study, the 2014 CBSA study changed the unit of analysis for the hospital and university building types. The 2009 CBSA study analyzed these categories at the building level. In contrast, the 2014

⁵ The team flagged data points that were less than 10 percent or greater than 1,000 percent of the median value by building type, except for warehouse data, which were not subject to this screening due to the wide range of possible usage patterns. Flagged data points were dropped if no reasonable explanation for them was found in the site level detail. These cutoff points represent a valid range for including relevant data without including faulty data that may skew results.

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CBSA study analyzes these building types at the campus level, making the 2014 CBSA results for these two building types largely incomparable to earlier CBSA studies.

As shown in Figure 3, the total regional floor area for Hospitals and Universities is 228 million square feet (104 million square feet and 124 million square feet, respectively).

- Hospitals and four year colleges with graduate schools comprise nearly 89 percent of the total floor area for these building segments.
- More than 54 percent of total Hospital and University floor area was constructed between 1960 and 2003.

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Figure 3. Hospital and University Floor Area Characteristics

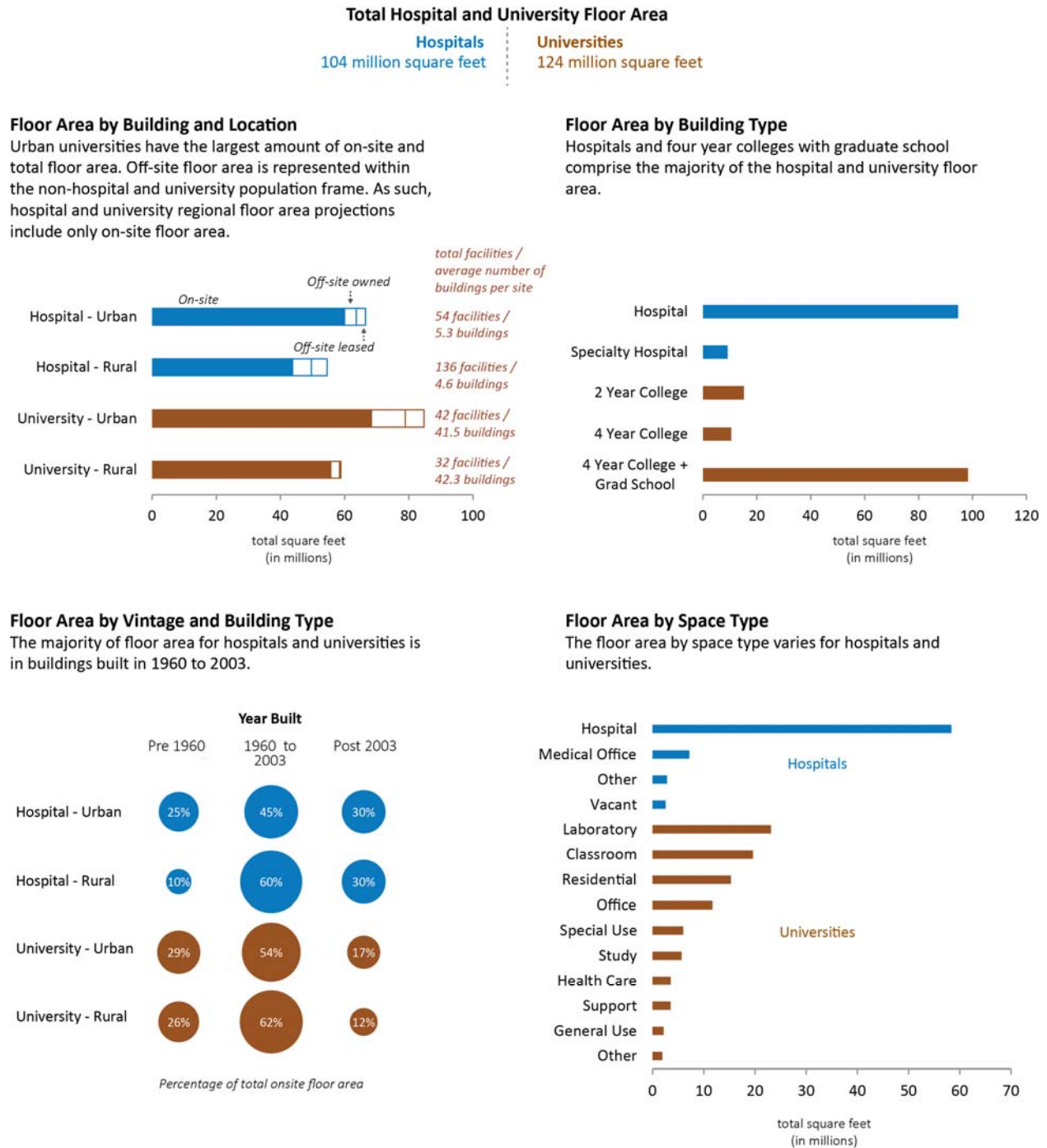


Figure 4 illustrates the distribution of primary heating fuel for Hospitals and Universities, along with the density of server equipment in each building segment.

- Hospitals and Universities almost universally use natural gas as the primary heating fuel (excluding reheat energy).
- Hospitals had nearly twice the server room density of Universities (6.62 square feet of server room per 1,000 square feet versus 3.45 for Universities).

Figure 4. Heating and Server Equipment Characteristics

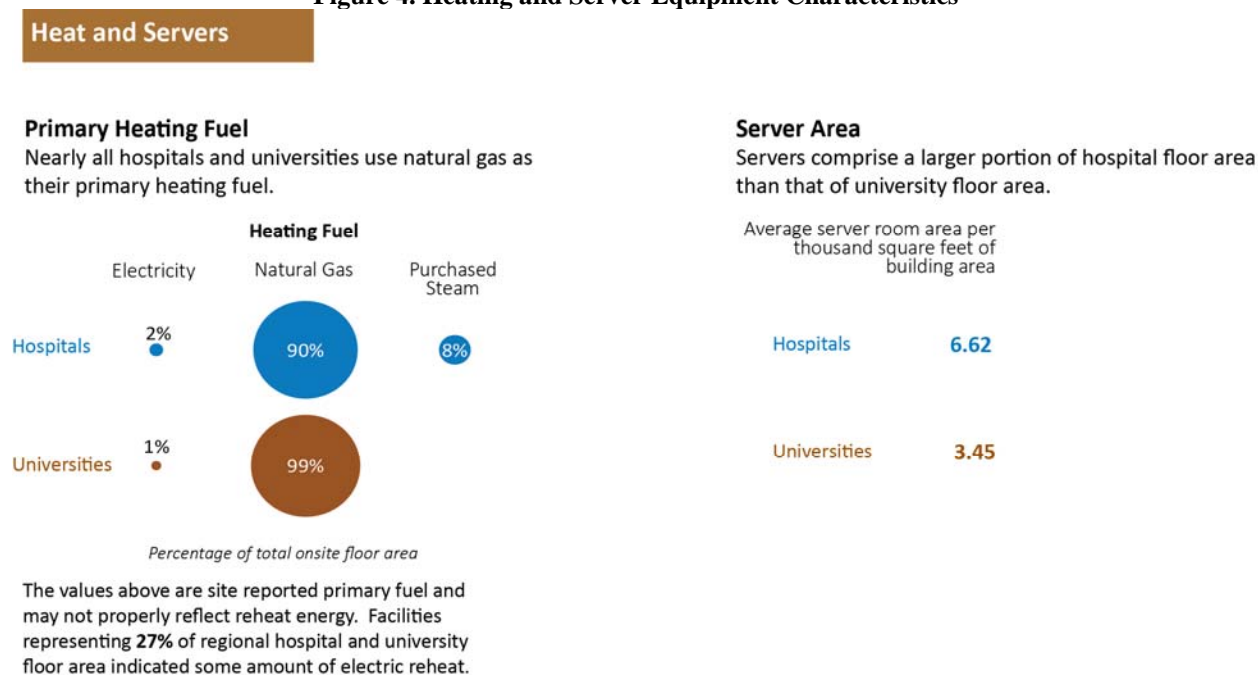


Figure 5 summarizes lighting technology and control characteristics of Hospital and University campuses.

- Facilities representing nearly 85 percent of University floor area report having T-12 lighting; facilities representing approximately 85 percent of University floor area report having incandescent lighting.
- 100 percent of Universities with T-12 or incandescent lighting report having an active policy or program to replace existing lighting with T-8 and LEDs.
- Facilities representing approximately 35 percent of Hospital floor area report having T-12 lighting. Of hospitals with T-12 lighting, approximately 50 percent report having an active policy or program to replace existing lighting with T-8 fixtures.

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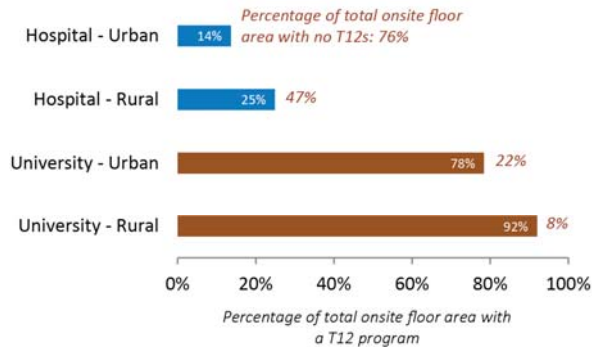
- Facilities representing nearly 15 percent of Hospital floor area report no incandescent lighting. Of hospitals with incandescent lighting, approximately 50 percent report having an active policy or program to replace existing lighting with LEDs.
- Facilities representing 57 percent of Hospital floor area report no sweep controls. Conversely, facilities representing 84 percent of University floor area have some level of sweep control.
- Hospital storage rooms, restrooms, and offices have the highest density of occupancy sensors.
- University offices, conference rooms, and classrooms have the highest density of occupancy sensors.

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Figure 5. Lighting Technology and Control Characteristics

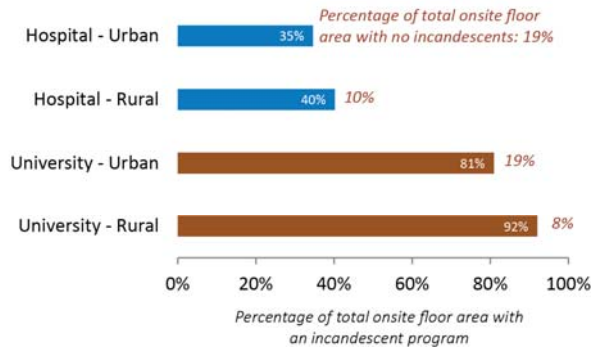
T12 Program

An active program to convert fixtures with T12 lamps is in place for a large percentage of university floor area. In contrast, an active program to convert fixtures with T12 lamps is in place for a small percentage of hospital floor area, likely due to a large percentage of total onsite floor area with no T12s.



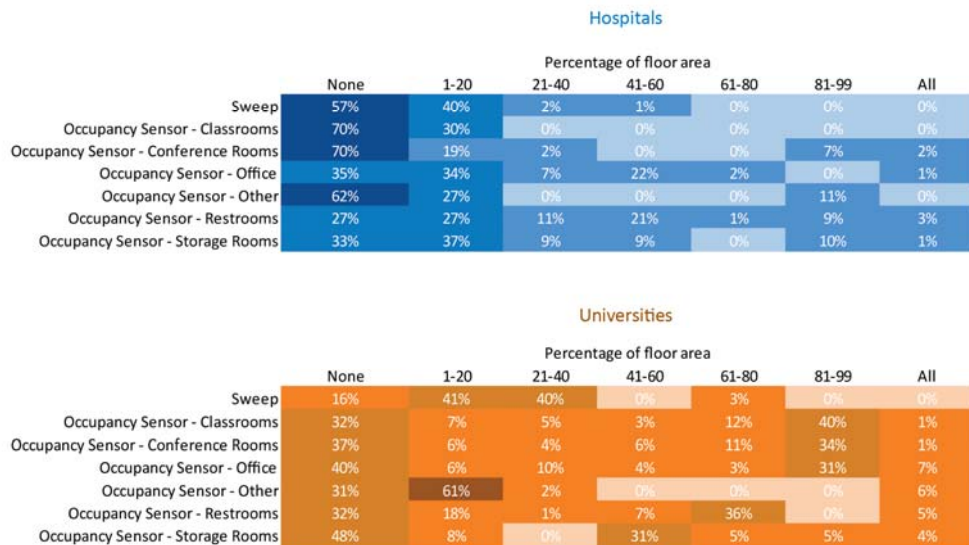
Incandescent Program

An active program to convert fixtures with incandescent lamps is in place for a large percentage of university floor area. In contrast, an active program to convert fixtures with incandescent lamps is in place for a smaller percentage of hospital floor area. The percentage of total onsite floor area with no incandescents is similar for hospitals and universities.



Lighting Control

Hospitals and universities have a range of control by control type and building area. Note that the survey only asked about sweep and occupancy sensor control.



Additional Hospital and University observations captured through the data collection process include:

- An increase in leased space across both Hospitals and Universities. The use of leased space ranged from medical offices to main University campuses for some private schools.
- More conservation-oriented improvements in public colleges than private colleges.
- Ongoing LED retrofits, particularly in parking garages for Hospitals and Universities.
- A large portion of Hospitals have eliminated T-12 lighting and a small portion have eliminated incandescent lighting. Roughly half of those with T-12 or incandescent lighting remaining have programs in place to replace existing fixtures with T-8s and LEDs.
- A small portion of Universities have eliminated T-12 and incandescent lighting. Those with T-12 or incandescent lighting remaining have programs in place to address their replacement with T-8 and LEDs in the near future.
- A general shift away from central plants in colleges in favor of implementing building-level equipment.

2.1.1 Energy-Use Intensity

Figure 6 shows average calculated EUI results for electricity and natural gas for Hospitals and Universities. The analysis reveals:

- Changes in EUI values are attributable to a combination of effects, including; naturally occurring conservation, codes & standards, EE program impacts, and differences in the 2009 and 2014 CBSA sample frame and data collection methods. It is difficult to attribute the change accurately among these factors. Additionally, the 2014 Hospital and University EUIs achieved greater floor area representation than previous efforts - capturing campus-level, instead of building level, characteristics.
- The “Energy-Use Intensity Distribution” graph provides the mean, median, and ranges around the mean for all commercial buildings in the region.

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Figure 6. Hospital and University Energy-Use Intensities⁶

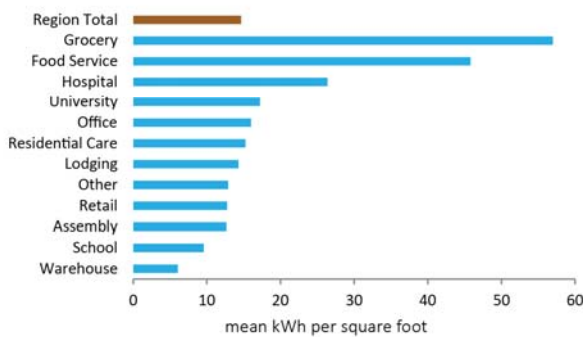
Mean Energy Use Intensity

2009: Electric 16.8 kWh/square foot	2014: Electric 14.6 kWh/square foot
2009: Natural Gas 0.46 therms/square foot	2014: Natural Gas 0.39 therms/square foot

*The gas energy use intensities only include buildings with gas service. All values on this graphic include hospitals and universities.

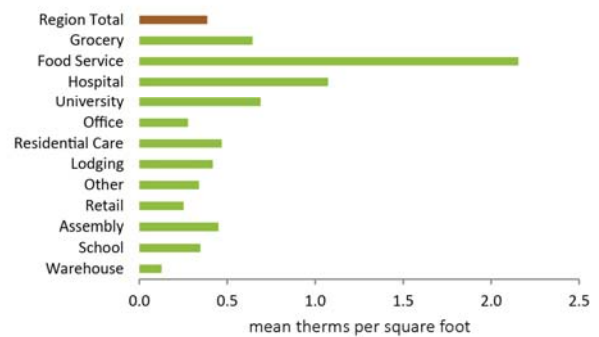
Electric Energy Use Intensity by Building Type

Average electric energy use intensity ranges widely by building type.



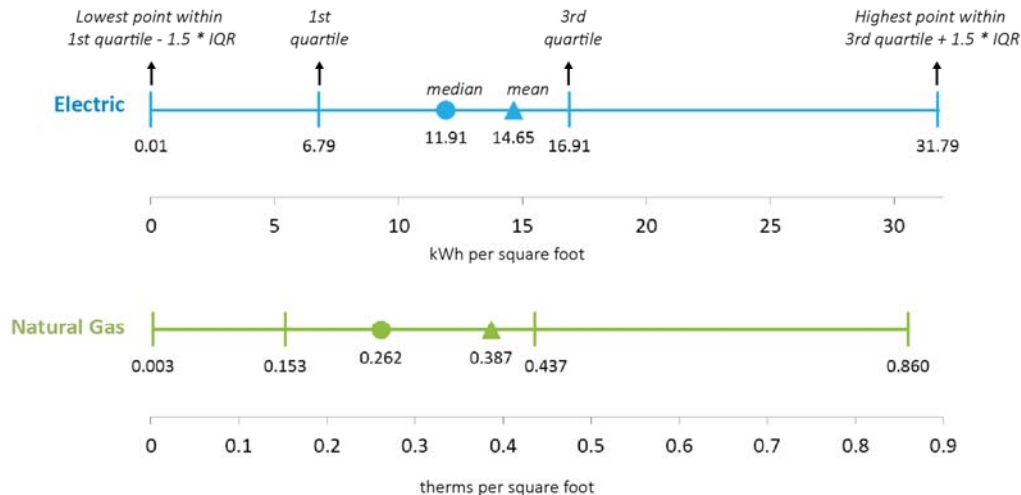
Natural Gas Energy Use Intensity by Building Type

Average natural gas energy use intensity ranges widely by building type.



Energy Use Intensity Distribution

These figures show the distribution of the electric and natural gas energy use intensity. The mean electricity energy use intensity is 14.6 kWh per square foot while the median is 11.9 kWh per square foot. The mean natural gas energy use intensity is 0.39 therms per square foot while the median is 0.26 therms per square foot.



*The "other" building category includes adult/career education, airplane hanger, asylum, courthouse, crematorium, data center or server farm, fire station, jail, police station, police and fire, prison, telephone switching, and vocational training.

⁶ Some Hospitals and Universities used backup fuels (e.g., oil) for which we were unable to capture consumption

3 Recommendations for Future CBSA Updates (Hospital and University)

Recommendations for the Hospital and University segment mirrored the recommendations of the general report. Segment specific recommendations, include:

1. *Expand marketing for future CBSA studies to promote regional awareness of NEEA's efforts and improve recruitment rates.* By collaborating with utilities to actively inform and educate customers about the benefits of the CBSA study, future efforts will improve recruitment rates by expanding the pool of willing participants. This is particularly true of Hospitals and Universities whose facility management staff often could not accept monetary recruitment incentives.
2. *Conduct Hospital and University site surveys using separate data collection protocols.* Hospitals and Universities comprised larger and more complex building “campuses” that took additional time and resources to survey. A unique data collection protocol for these building types was established through the Working Group process, and because survey findings and energy-use estimates were so unique for these campuses, the results were not directly comparable to the other building types included in the study.

data; back-up fuel was not included in the reported natural gas EUIs.

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