BASELINE ENERGY USE INDEX OF THE 2002-2004 NONRESIDENTIAL SECTOR: IDAHO, MONTANA, OREGON, AND WASHINGTON

For the
Northwest Energy Efficiency Alliance

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1. Introduction

The energy uses analyzed in this report were constructed from billing records collected during development of the *Baseline Characteristics of the 2002-2004 Nonresidential Sector: Idaho, Montana, Oregon, and Washington* (2002-04 Baseline Study) (Baylon et al. 2008). The primary purpose of that study was to characterize buildings built in the Pacific Northwest between 2002 and 2004. Results were based on a sample of approximately 350 buildings, stratified by building size, state, and, in some cases, building type. For building characteristics and size the study generally produced high levels of precision. However, energy use, the topic of this report, was more difficult to assess because in many cases the utility billing records do not correspond well to the buildings as surveyed. Resolving these inconsistencies can be complex, time consuming, and often unsuccessful. Of the 350 buildings in the 2002-04 Baseline Study, approximately 190 had energy use information in sufficient detail that an overall energy use index (EUI) could be derived. EUIs are defined as the total energy use (usually drawn from the energy bills assigned to a particular building) divided by the building square footage.

Even within the 190 buildings with usable billing data, the results must be viewed with extreme caution. For the most part, the standard errors of the average EUIs presented here sometimes swamp the chance of a statistically significant comparison among various samples. This is a predictable outcome of using the 2002-04 Baseline Study as the basis of this EUI study. The sample of 350 buildings included in the 2002-04 Baseline Study was designed to provide 90% confidence that the true population mean was within 10% of the study results for the stratifications noted above. By definition then, any analysis based on less than 350 buildings would provide less statistical confidence; basing an analysis on just over half of the original buildings provides far lower confidence levels.

In addition to the impacts of the reduced sample, large standard errors result from factors that are not related to efficiency such as hours of operation, plug load density, and changing business patterns as well as from the natural diversity of stock within the commercial sector, which is comprised of such diverse uses as office buildings, hotels, and simple storage warehouses. One result of the lack of statistical precision is that relatively small differences in EUIs brought on by code initiatives or other mechanisms are likely not identifiable.

As part of this report, we have assembled EUIs generated from other studies for purposes of validating our results and assessing the performance of buildings in the 2002-04 Baseline Study relative to others. The most significant of these comparisons is with the Commercial Building Stock Assessment (CBSA) database that contains records of Pacific Northwest buildings sampled and surveyed between 1986 and 2001. The CBSA database includes approximately 1,200 buildings; wherever possible we tried to use the energy-use information that was roughly comparable between CBSA and the data collected in this 2002-2004 Baseline Study.

The EUIs were also compared to the results of the Commercial Buildings Energy Consumption Survey (CBECS). This is a large survey conducted by the United States Energy Information Administration and includes EUI data for 4.6 million buildings throughout the country. Finally, we looked at the California Commercial End-Use Survey (CEUS), a survey of approximately 2,800 buildings conducted in California in 2005 and published in 2006. CEUS goals were focused more on individual end uses (e.g., space heating, lighting, plug loads, etc.) than on the

overall building EUI, but a summary was available that could be used to compare to the 2002-04 Baseline Study data.

To evaluate the 190 sets of energy bills we obtained from the 2002-04 Baseline Study we employed EZ Sim, which provides a weather normalization of building energy use and a breakdown of the end uses within buildings. This breakdown is derived from both the building characteristics developed in the detailed building survey and patterns observed in the billing data. About 90% of the 190 buildings with useable billing data in the 2002-04 Baseline Study were evaluated using this technique. The end-use breakdowns were then compared to the CEUS results which were derived using a comparable but more elaborate calibration process.

2. EUI Calculation

The traditional metric for summarizing energy use is called the energy use index (EUI). The EUI is typically the total square footage of the building divided into the total annual energy use (in thousands of BTUs) recorded for all fuels and electricity used in the building. The critical step in calculating EUIs is to establish a building area that corresponds to the energy bills for that area. In this study, applicable floor area is taken as the net, human-occupied square footage, exclusive of numerous categories such as outside sales areas, parking areas and garages, tanks, trailers, and exterior storage and mechanical spaces. This is the same definition used in CBECS and was used to guide the data collection in the 2002-04 Baseline Study. Wherever possible, we have used the same definition in all the databases compared in this study.

The bills were requested from the utilities identified in the audit and usually included the meter numbers noted by the auditors in the billing releases. The utility was asked to provide two to three years of billing data ending in March 2007. Generally, the year ending in that year was used for this analysis. In some cases, the bills were not available for 2007, or the year had to be extended into the fall of 2007 to get a complete year of bills. In no case did the bills diverge more than six months from the March 2006 to March 2007 billing period.

Once energy bills were collected an EZ Sim simulation run was conducted on each building. The results of this process are summarized later in this report.

3. Study Limitations

As noted there are several limitations on the type of data collection and analysis presented here. These limitations are inherent in this type of data and suggest the need for much larger samples (and thus smaller standard errors), or larger changes in codes and measures so the change in consumption is more observable.

3.1. Billing Releases

The Baseline Study protocol included a billing release associated with every audit conducted. Auditors were asked to secure a signed release of all the utility bills and fuel sources that were used on the site which could be used to request the data from the serving utility. This process was also mentioned in the recruiting process so in general the building operators had agreed in advance. In spite of this, a certain number of

releases were not collected either because of oversights from the auditor or because of lack of cooperation at the time of the audit. Still, of the 346 separate audited points, 339 billing releases were collected.

3.2. Applicability of Billing Data

It is important to realize that energy bills are created to aid utilities in collecting revenue. It is not generally even a secondary goal that this data be used to assess building performance. From a performance perspective, billing accounts associated with any building are often a bewildering array of meters and overlapping energy use that frequently have a difficult-to-determine relationship to the particular square footage surveyed for detailed engineering characteristics. The situation is further complicated by the complexity of the meter numbers and the fact that the address of the party is not necessarily that of the building but rather is the location of the party responsible for paying the bill.

Auditors were asked to collect the billing releases and meter information of every visible meter on the sight so that both billing accounts and meter numbers would be available. This sometimes included buildings in which the billing release applied to much more square footage than was audited (such as campus energy systems with district heating and cooling). In other cases (especially multi-tenant strip malls) the releases applied only to those tenant's willing to participate in a study of this kind. In numerous cases, this was the result of central plants that were used to provide space heating or space cooling outside the building envelope itself. These types of issues resulted in approximately 83 of the audited points being dropped from bill collection, usually before a billing request was even made.

3.3. Dropped and Missing Data

Of the remaining 256 buildings for which we had bill releases and for which the bill releases were valid, approximately 47 were lost as the result of either missing account data, missing bill data, the presence of propane for which no bills could be secured, bad account numbers, incomplete account numbers, or a variety of issues with utility cooperation in securing the billing records.

3.4. Bill Screening

Even in cases where the utility was cooperative and the releases were obtained, there were numerous instances where the bills received were clearly unrelated to the building that was audited and the errors associated with those releases were never resolved. Bills were reviewed and where the situation was unclear additional requests for information were made to the utilities. After this process was complete, we had a total of 209 buildings with apparently complete energy bills and associated square footage, audits, etc. that would allow an EUI review and the development of an EZ Sim simulation run.

Of the 209 buildings that were submitted for EZ Sim runs, various issues with either the billing record or with the square footage arose and resulted in a reduced confidence in the

EZ Sim results. As a result, approximately 37 EZ Sim runs were abandoned, leaving end use information for 172 buildings. Of these abandoned buildings, in approximately 20 cases an overall EUI was later constructed manually.

Thus, for purposes of evaluating the EUIs in the 2002-04 Baseline Study, 192 buildings were usable. This represented slightly more than half of the original audited sample and about 75% of the buildings for which an EUI could have been constructed.

3.5. Building Types

Throughout this report the buildings have been categorized into common economic use types for purposes of summarizing the EUIs and comparing the energy use among and within the various samples. These building types were developed to summarize the characteristics and sample sizes for the entire baseline report (Baylon et.al, 2008). All the comparisons involved redefining the building types into these same categories. In the case of the CBSA this mapping was reasonably straightforward as the definitions used in that review were developed using the same forecasting and characterization requirements used in the Pacific Northwest. In the case of the CEUS and CBECS data a mapping was developed to relate the building types in those summaries to the building types used in the 2002-04 Baseline Study. All of these transformations, including the assignment of the original building types, have limitations and affect the comparison among the buildings in this and other surveys.

Even with the level of detail implied by the twelve building types there are many anomalies that must be subsumed when the commercial building sector is summarized as twelve idealized building types:

1. The "Retail" sector (especially in the "big box" stores) has gradually integrated grocery operations into more traditional dry goods retail. As a result the base energy use could be expected to rise just because of the advent of large refrigeration case loads. While the impact here is less than would be expected in the "Grocery" sector (since these stores are much bigger than the typical grocery), the effect is to increase the EUIs of these types of stores and of the "Retail" sector. This increase is not necessarily a change in efficiency of the buildings but only the functionality of the particular market positioning.
2. The "Office" building type is probably the most homogenous of any commercial building type but as we see in these summaries the addition of server and communications equipment can increase the apparent EUI by a factor of three. These uses represent a tiny fraction of the spaces in the office building but have connected loads and HVAC loads that are significantly larger than the rest of the building combined.
3. This summary combines several public service building types as "Institutions." This sector has become a catch-all for the institutional buildings such as prisons, jails and fire stations. In addition uses such as courthouses, police stations, and smaller city halls are included in this category. This combination of uses has very different schedules and occupancy making comparisons across different samples for this group

uncertain. The main advantage of this category is that it allows these uses to be combined and defined rather than leave them as part of even more heterogeneous categories such as "Other."

4. "Hospitals" are a significant use but are very diverse in this sort of sample. Almost all new construction in this sector is in the form of additions. These additions sometimes take the form of an entirely new building on a hospital campus, and sometimes take the form of smaller major remodels of existing space to accommodate new uses or technologies. As a result most hospital complexes are in constant state of flux where areas and energy use change every year. Moreover, these complexes are typically supplied by a central heating and cooling loop which is not necessarily tied to any particular building. While a new building is often separately metered the heating and cooling loads are supplied from elsewhere and not part of the apparent EUI of the new building. As a result, it is usually impractical to infer an overall EUI for any one building and equally problematic to assign efficiency to the complex as a whole given the diversity of ages and uses subsumed in the hospital.
5. "Health Services" is similar to the "Institution" sector in that there is a substantial diversity in the sector that subsumes medical clinics and offices as well as assisted living and nursing homes. This sector also includes several laboratory facilities as well. Even though this sector has numerous building types the actual energy uses among these types appears fairly comparable (at least in the samples included here).

The impact of this diversity is particularly challenging as the number of cases is reduced. It is clear in the overall population that the use of these occupancy types reduces the variance in most categories and thus allows comparisons among samples. It is also clear that the accommodation here is imperfect and comparison among building types, while useful, should be regarded with skepticism.

3.6. Statistical Summaries

As mentioned in the Introduction, the sample of 346 buildings included in the 2002-04 Baseline Study was designed to provide 90% confidence that the true population mean was within 10% of the study results. Certain building types and utility areas had enhanced samples that added precision to these estimates and complicated the weighting scheme and the comparison among buildings in the sample. Unfortunately the attrition rate associated with the utility bills seriously compromised the original sample design and sample weights used to summarize the datasets.

After considerable exploration of various alternative strategies we elected to weight the EUI summaries only by building area. This process made the ability to summarize across utility areas or states unworkable (largely because sample sizes in many categories became too small for acceptable summaries). The strategy did, however, allow the maximum precision within each building type and in many cases salvaged the possibility for comparison with other sources and with the regional data collected in the CBSA dataset. Wherever possible, comparison studies are presented un-weighted except by building size. Thus total EUIs are not expressed in any of the summaries and the reader

is encouraged to resist the temptation to assemble such a summary from the data presented.

Table 1 shows the distribution of buildings included in both the 2002-04 Baseline Study and the current EUI study. Note the very small number of sample points in some building types. No extrapolations should be made from related data unless statistically justified.

Table 1: Distribution of Buildings

Building Type	2002-04 Baseline Study	EUI Study
Assembly	8	7
College	9	3
Schools	67	34
Grocery	18	7
Health Services	16	10
Hospital	25	10
Institution	23	20
Office	27	21
Other	9	5
Residential/Lodging	18	8
Restaurant / Bar	8	4
Retail	78	40
Warehouse	40	25
Total	346	194

4. EUI Summaries

EUI summaries were calculated using the sampling information and audit information collected for the 2002-04 Baseline Study. As can be seen in the following table, the mean EUIs have substantial variation among building types. Quite often this variation is difficult to explain from any description of the buildings themselves, and is typically the result of large loads that are not comparable between buildings within a particular building type. Loads of this sort are usually found in restaurants which have large process loads, in warehouses where materials handling or manufacturing processes may be a part of the building area, and in office or institutional structures where server rooms or server facilities can add considerably to the EUI.

Also, we wish to re-emphasize here our many warnings above about the limitations of the data and the inappropriateness of extrapolating results. The main value of these results is to provide the region with some indication and benchmarking for buildings surveyed as part of an overall regional sample.

Table 2 represents the entire sample for which reliable EUIs are available. Table 3 shows the result of screening these buildings that had substantial additions but where the area of the audited addition was not the majority of the structure. In this case the "new" square footage is more representative of the performance of new commercial construction. There are some differences between these two summaries. These differences are focused on the "Warehouse" where various refrigeration and expansions of facilities with large process loads were removed by the "new"

designation. Because of the extra sample size and the similarity between the two summaries in most building types the full sample is included in the subsequent tables in the report.

Table 2: Baseline Study EUIs

Building Type	Mean	Std. Dev.	N
Assembly	83.1	37.1	7
College	62.2	9.1	3
Education	61.4	18.2	34
Grocery	219.8	102.2	7
Health Services	111.8	35.3	10
Hospital	193.5	46.6	10
Institution	75.2	29.7	20
Office	112.5	74.9	21
Other	102.5	76.0	5
Residential/Lodging	64.1	23.1	8
Restaurant/Bar	451.0	249.8	4
Retail	95.5	34.9	40
Warehouse	70.5	58.1	25
Total			194

Table 3: Baseline Study EUIs, New Construction Only

Building Type	Mean	Std. Dev.	N
Assembly	88.1	46.0	6
College	62.2	9.1	3
Education	61.8	19.9	26
Grocery	218.4	105.6	6
Health Services	111.8	35.3	10
Hospital	199.6	53.9	5
Institution	75.2	29.7	20
Office	112.4	75.4	20
Other	127.6	98.3	3
Residential/Lodging	62.8	18.3	7
Restaurant/Bar	451.0	249.8	4
Retail	94.5	35.3	38
Warehouse	59.1	46.0	23
Total			169

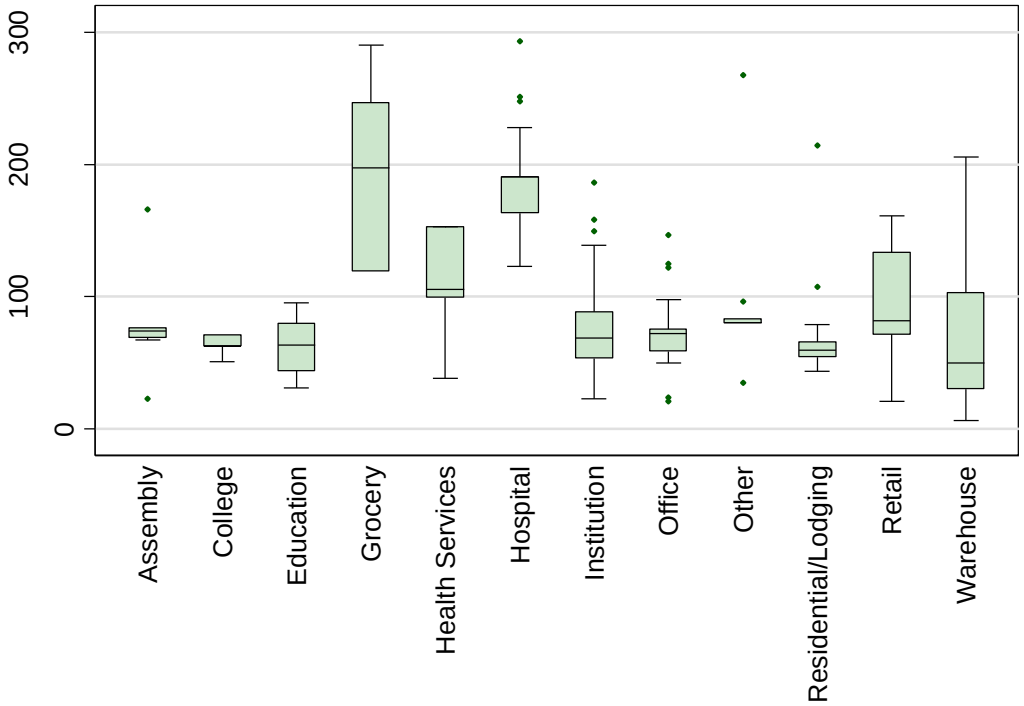
Table 4 shows one further issue in the sample. There are two offices with very large process loads resulting in a skewed summary of the rest of the "Office" sample. Since these cases are large outliers with a disproportion influence on the final summary, we have removed them from the population in this table. For the most part this summary is used in the rest of the comparisons to represent the baseline sample.

Figure 1 shows the distribution of this sample with the Outliers removed and the "Restaurant / Bar" removed to improve the scaling and clarity of the graphic.

Table 4: Final Comparison Sample Baseline 2002-2004

Building Type	Mean	Std. Dev.	N
Assembly	83.1	37.1	7
College	62.2	9.1	3
Education	61.4	18.2	34
Grocery	219.8	102.2	7
Health Services	111.8	35.3	10
Hospital	193.5	46.6	10
Institution	75.2	29.7	20
Office	71.7	26.1	19
Other	102.5	76.0	5
Residential/Lodging	64.1	23.1	8
Restaurant/Bar	451.0	249.8	4
Retail	95.5	34.9	40
Warehouse	70.5	58.1	25
Total			192

Figure 1: EUI Distribution Baseline 2002-2004



Details of the distribution of these EUIs and of the state samples are included in Appendix A. This set often suffers from inadequate sample size and that limitation should be kept in mind as the individual state samples are reviewed.

Because of the efforts to combine or categorize buildings by building type, we believe that the variances in EUIs are captured in the standard deviation as shown in Table 4. It is clear that in some cases, the standard deviation is sufficiently large and the sample size sufficiently small that a robust statistical comparison is not likely even among buildings within this sample.

5. EUI Comparisons

EUIs can be compared to other databases to help establish confidence in the EUI estimates in this study. However, such comparisons are complicated by variations in data collection techniques from study to study, even when similar teams are involved, and especially when the collection methods are neither well-documented nor particularly comparable. For this reason, we have reviewed three databases:

- **CBSA Database.** EUIs for this database were collected and defined in a manner relatively similar to this 2002-04 Baseline Study, although there were some significant differences, noted in the CBSA discussion below.
- **CBECS Database.** A large national database collected from survey information conducted by the Energy Information Administration.
- **CEUS Database.** This data was collected by the State of California and includes EUI information. The collection and EUI calculation method is the least well documented so the comparisons are the most uncertain.

5.1. CBSA Database

The CBSA database was constructed from six different datasets collected in the Pacific Northwest over a period of approximately 20 years. These datasets were then supplemented with additional field review (especially for older buildings) in 2002-2003. Because the goal of the studies incorporated into CBSA varied, the type and amount of information collected also varied. The length of time over which these studies were conducted and the fact that none of those protocols required billing releases for the then current occupants, made it necessary to gather bills and energy use from the utilities directly. The bills were collected in the absence of direct permission or current account information (such as meter and account numbers) for the current building occupants. In spite of this, of the 1200 buildings in CBSA, full electric and gas bills were collected for about 258 and electric-only bills were collected for about 400. Because of the uncertainty of gas usage, the summaries in this report were confined to 257 buildings for which both a gas bill and an electric bill were available.

A second transformation necessary for the CBSA dataset was that some building types had to be redefined as they varied from the definitions used in the 2002-04 Baseline Study. This process resulted in only one building being lost because of lack of direct comparability.

The goal of the CBSA database was to review buildings throughout the sector and be representative of all commercial buildings. For purposes of this comparison we have divided the CBSA data into two groups: one set of buildings representing all the CBSA buildings in the sample, and one set of buildings built after 1989. For the final comparisons with the building stock in the 2002-04 Baseline Study we suggest that the latter category is a more valid comparison. The final comparison includes both groups separately.

To develop the comparison between the CBSA and the 2002-04 Baseline Study populations there were several steps used to transform the CBSA data to make it compatible with the EUIs in this study. Table 5 through Table 7 show the development of these transformations. Table 5 summarizes the EUIs in the CBSA sample as developed from CBSA's definition of

building area. The principal difference between the CBSA building area calculation and the method used in the 2002-04 Baseline Study is the treatment of parking garages. In CBSA, the parking structures or garages are included in the final area while in the 2002-04 Baseline Study these structures are not included in that calculation. The energy associated with the parking garage is treated as a part of the EUI for this smaller area. This feature occurs in less than 5% of the buildings, however, because these buildings tend to be large and their impact on EUIs of the entire population is very noticeable. The CBSA database includes information that allows the building area to be adjusted so that the EUIs developed are comparable to the 2002-04 Baseline Study and to the other EUI summaries used in this comparison. The energy use for the entire building was not altered so the parking garage lighting and ventilation system was included in the total energy use of the building and the total EUI for the building.

Table 5 shows the results of this area correction on this summary. Using this area transformation, the CBSA building categories were redefined to match the 2002-04 Baseline Study categories. The results are shown in Table 6.

Figure 2 shows the CBSA EUI distribution using the 2002-04 Baseline building types.

Figure 3 shows the comparison between the CBSA EUI data and the EUIs collected in the 2002-2004 Baseline.

Table 5: CBSA without Area Adjustments, CBSA Categories, All Cohorts

	Initial Area		Adjusted Area		
Building Type	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**N**
Dry Goods Retail	86.9	42.8	97.2	61.3	51
College	61.1	27.8	67.8	33.6	4
Other	89.5	53.4	119.4	97.6	25
Vacant	26.7	15.4	26.7	15.4	4
Grocery	242.5	69.2	255.5	100.7	14
Office	73.2	36.4	80.8	34.2	69
Restaurant	457.4	252.7	458.4	251.2	26
Warehouse	60.5	43.3	60.5	43.3	30
Hospital	218.2	29.2	218.2	29.2	2
Other Health	84.9	38.7	84.9	38.7	10
Hotel/Lodging	141.2	48.2	141.4	48.1	9
School	58.9	21.6	58.9	21.6	13
Total	89.8	64.2	97.5	71.9	257

Table 6: CBSA EUIs with Adjusted Areas and Baseline Categories, all Cohorts

Building Type	Mean	Std. Dev.	N
Assembly	61.6	31.2	9
College	67.8	33.6	4
Education	58.9	21.6	13
Grocery	255.5	100.7	14
Health Services	84.9	38.7	10
Hospital	218.2	29.2	2
Institution	141.8	30.7	3
Office	80.8	34.2	69
Other	106.2	162.2	14
Residential/Lodging	141.4	48.1	9
Restaurant/Bar	435.6	261.6	27
Retail	96.5	61.2	52
Warehouse	60.5	43.3	30
Total	97.5	71.9	256

Figure 2: CBSA EUI Distribution All Cohorts

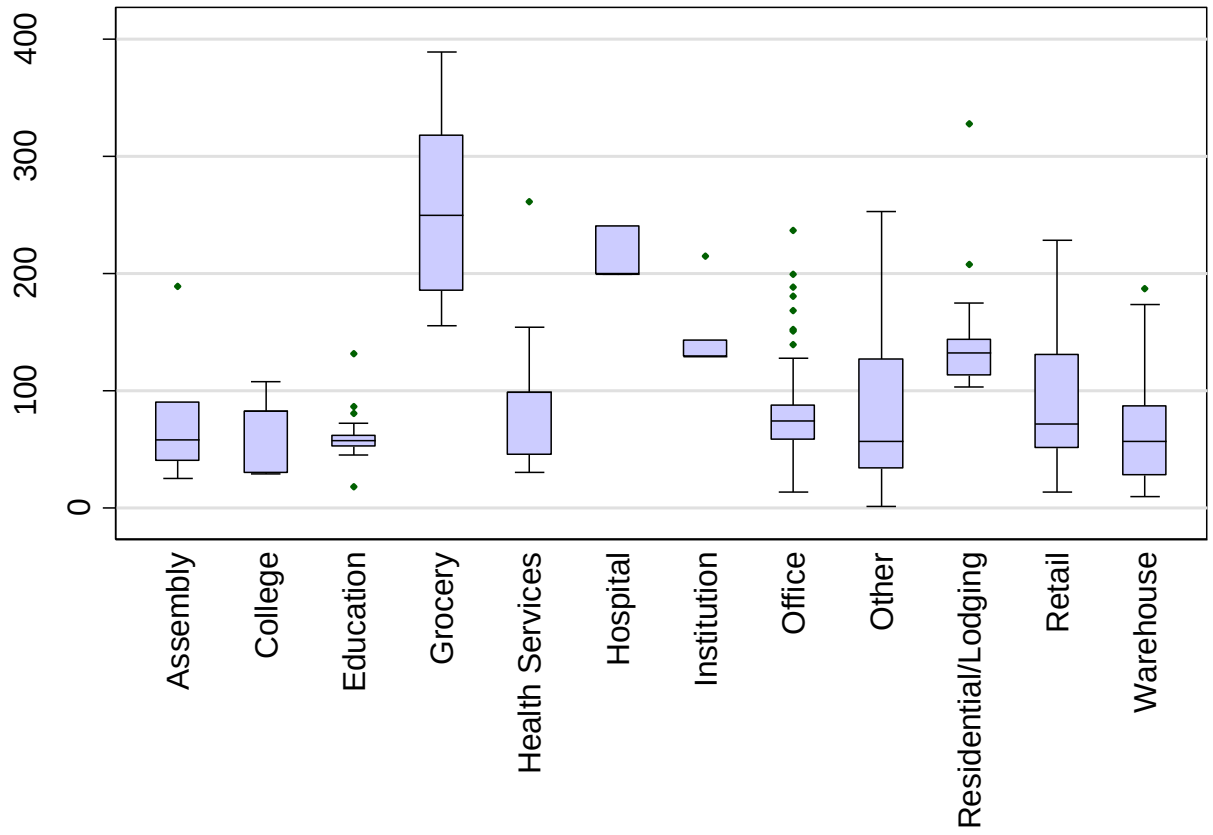
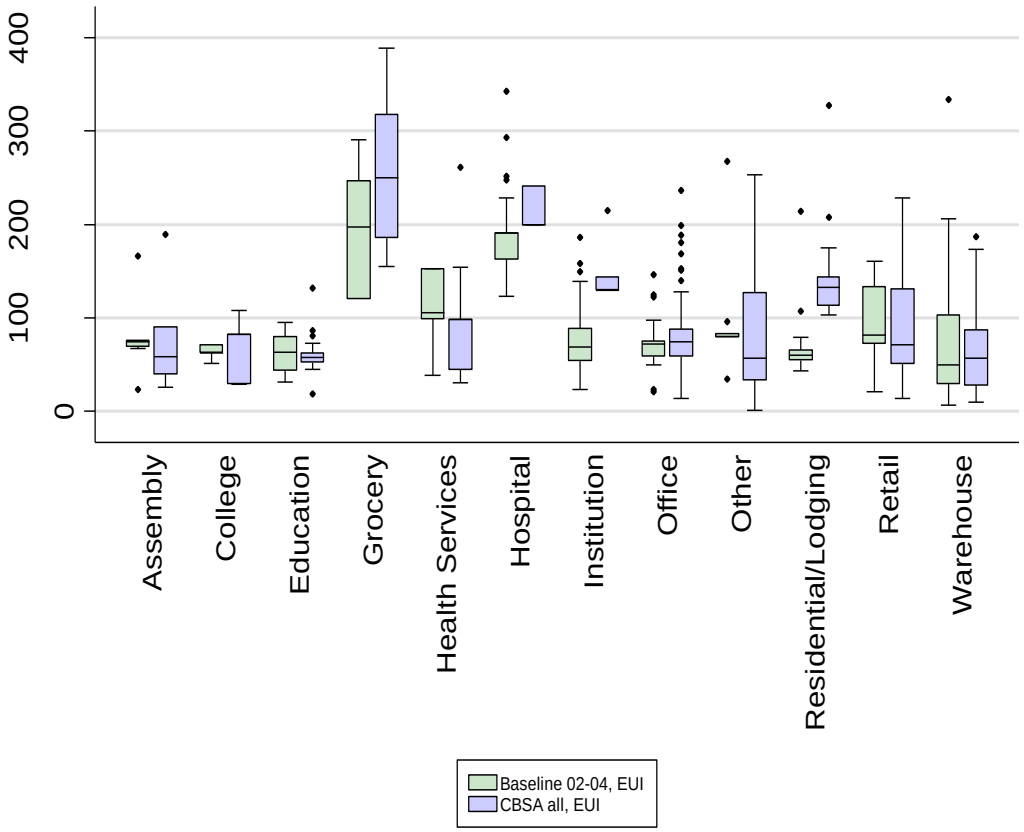


Table 7 includes only those buildings in the CBSA sample that are in the newer building cohorts. When this summary is compared to the entire CBSA sample the results suggest that there is relatively little advantage in restricting the comparisons in this way. Thus the comparison between the CBSA sample and the Baseline (shown in Figure 3) are based on the entire sample of both groups.

Table 7: CBSA EUIs, Adjusted Area, Baseline Categories, 1990-Plus Cohorts

Building Type	Mean	Std. Dev.	N
Assembly	69.3	58.2	3
College	63.5	54.5	2
Education	59.5	14.3	6
Grocery	249.5	109.5	10
Health Services	76.5	48.4	8
Hospital			
Institution	161.5	44.0	2
Office	83.8	47.1	46
Other	248.3	393.8	4
Residential/Lodging	103.3		1
Restaurant / Bar	507.1	293.8	13
Retail	120.3	65.3	33
Warehouse	83.0	46.2	11

Figure 3: CBSA and Baseline EUI Comparison All Cohorts, Full Sample



5.2. CBECS Database

The Commercial Building Energy Consumption Survey (CBECS) database is constructed approximately every four years by the Energy Information Administration. CBECS is constructed from surveys conducted throughout the country and provides a large sample of buildings. Participation in this sample is largely voluntary and EUIs and energy use are constructed from questionnaire data. The current database was constructed in 2003 and includes 4.6 million buildings from throughout the country.

The comparison of both regional samples to CBECS should be reasonably robust since the definition of building area used in constructing the EUIs is identical. Individual survey respondents are given instructions to separate parking garages and other uses (outdoor sales, mechanical penthouses, etc.). These are then separated from the main building area when constructing the building area summaries and EUIs.

As with CBSA, building type definitions vary between CBECS and the 2002-04 Baseline Study. In most cases, these can be resolved relatively easily; in a few cases it is considerably less clear and the EUI comparisons are more uncertain (e.g., the Assembly categories are consolidated for the 2002-04 Baseline Study). As with the CBSA, however, the most significant and largest building types (retail, office, grocery, warehouse, etc.) are reasonably unambiguous and can provide a direct comparison.

Since we do not have direct access to the CBECS database, we have used the CBECS data as a given even though we suspect that there are substantial components of this database that are not strictly comparable to either CBSA or to the 2002-04 Baseline Study. The database is published with Relative Standard Errors (RSE) for each summary published; however, because of the sample size and the distribution of the population these are not very helpful in our comparison. For the comparison with the 2002-04 Baseline Study and the CBSA we have used the mean calculated from the most recent cohort as well as the means calculated for the entire sample.

Another significant factor in CBECS, is its use in developing target performance values for buildings throughout the country. These target performance values are used by various rating organizations including the "2030 Challenge," the LEED certification process, USGBC, and various other studies that attempt to compare building performance to some standard. Because of its wide-spread use, we have used CBECS as an index value.

5.3. CEUS Database

The California Commercial End-Use Survey (CEUS) was completed in 2006 and was designed to provide a comprehensive view of building characteristics and building energy use throughout the State of California. The study included over 2,500 buildings sampled from around the state using utility billing records. The major goals of this survey were associated with subdividing energy use in various building types into their component end uses (e.g., lighting, cooling, process equipment, etc.) and developing load shapes useful in assigning value to energy supplied or conserved in those end uses.

The development of EUIs for the CEUS database was a primary goal but the documentation of EUI development is minimal and leaves uncertainty as to the mechanisms used to account for parking garages, non-conditioned storage areas, outdoor sales areas, etc. In all the other comparisons we are confident that the EUIs are calculated using a common method (once the data was adjusted). In this case, we have reported the overall numbers derived from summary tables without direct knowledge of the level of comparability.

It should be pointed out, however, that this database subdivides the consumption among various end uses and none of the other summaries offer this level of detail. The CEUS data is compared on the overall EUI but also used to compare with end use data derived from the EZ Sim simulations (see Section 7).

5.4. Final EUI Comparison

Table 8 shows the consolidated comparison between the 2002-04 Baseline Study and the other databases reviewed. In the case of CBSA and the 2002-04 Baseline Study, the standard deviations are available in Table 4 and Table 6, but in the other comparison databases the underlying distributions are not presented and in some cases, not available so standard deviations cannot be calculated. In both the CBECS and the CEUS databases, the sample sizes are much larger than the regional datasets so means presented for those studies have been treated as point estimates to give a realistic scale to the regional values from CBSA and the 2002-04 Baseline Study.

Table 8: Comparison of EUIs All Databases

Building Type	CEUS, All	CBECS, All	CBECS, Post 1990	CBSA, ALL	Baseline 2002-2004
Assembly	—	68.7	81.5	61.6	83.1
College	76.1	83.1	80.6	67.8	62.2
Education (Schools)	41.6	83.1	80.6	58.9	61.4
Grocery	167.3	199.7	—	255.5	219.8
Health Services	142.3	94.6	84.4	84.9	111.8
Hospital		249.2		218.2	193.5
Institution	—	115.8	119.7	141.8	75.2
Office	72.8	92.9	88.0	80.8	71.7
Other	56.8	164.4	—	106.2	102.5
Residential/Lodging	83.7	100.0	88.1	141.4	64.1
Restaurant/Bar	346.7	258.3	361.2	435.6	451.0
Retail	52.7	91.3	94.4	96.5	95.5
Warehouse	56.8	45.2	33.3	60.5	70.5

6. Electric/Gas EUIs

Electric and gas EUIs differ among samples. As with most of the EUI summaries these differences are often traced to small differences in relatively small sample sizes. For purposes of this comparison the Baseline, CBSA, and CEUS databases all report electric and gas use separately. We have summarized these three sources, although the CEUS database is specific to California and differences between this data and the two Northwest samples are

more readily traced to that fact. In these summaries we have used the entire CBSA and Baseline samples. As we have seen in the previous summaries, the differences between the age cohorts in CBSA and the new and existing distinctions in the Baseline are not so significant that the sample reduction is justified. Furthermore, the CEUS data actually includes samples across essentially all California building cohorts.

Appendix B provides the summary statistics for the electric and gas usage in the 2002-04 Baseline Study.

As noted in Section 5.1 the screening of the CBSA database had difficulty discerning the true all-electric buildings from buildings where the gas bill was just missing. As a result all of these buildings were restricted from the summaries (thereby avoiding a downward bias on the total EUI). The consequences of this decision are that the buildings that are truly all electric are missing from this summary. As a result the CBSA electric EUI is probably biased low. We do not have the basis for correcting this situation at the time of this writing. It would be useful for this database to be reviewed to reliably establish the all electric buildings. Table 9 summarizes the electric EUI in the three samples.

Table 9: Comparison of Electric EUIs All Databases (kWh/sf)

Building Type	CEUS, All	CBSA, All	Baseline 2002-2004
Assembly	—	9.6	13.3
College	13.6	10.4	12.7
Education (Schools)	8.2	7.0	9.6
Grocery	41.7	53.5	46.6
Health Services	20.3	19.1	14.3
Hospital		46.9	25.3
Institution	—	19.9	15.4
Office	16.0	18.4	17.8
Other	9.9	16.7	18.3
Residential/Lodging	13.3	16.7	10.6
Restaurant/Bar	46.2	52.8	86.2
Retail	15.4	20.9	21.6
Warehouse	5.7	12.2	15.1

While the electric use levels in these three samples vary, the differences are not particularly troubling. Especially where large samples are present (such as Schools and Offices) the comparisons suggest reasonable compatibility between these groups. The one exception is the dramatic difference between the electric use in the CEUS and the Northwest samples in the Retail sector. This difference may be explained by the treatment of refrigeration loads (that are essentially grocery applications), but this difference is reflected in comparisons to the CEUS retail sector throughout this report.

The gas EUIs were assembled for the same building sample. Table 10 summarizes the samples. The problems with the CBSA screening are not likely to affect the gas EUI estimates. For this summary all available buildings were used without regard to building vintage.

Table 10: Comparison of Gas EUIs All Databases (th/sf)

Building Type	CEUS, All	CBSA, All	Baseline 2002-2004
Assembly	—	0.29	0.37
College	.24	0.32	0.18
Education (Schools)	.12	0.35	0.30
Grocery	.21	0.73	0.61
Health Services	.68	0.20	0.69
Hospital		0.58	1.07
Institution	—	0.74	0.22
Office	.11	0.18	0.11
Other	.24	0.49	0.22
Residential/Lodging	.41	0.84	0.23
Restaurant/Bar	2.49	2.55	1.57
Retail	.03	0.25	0.21
Warehouse	.03	0.19	0.18

As with the CEUS, gas use is consistently smaller than the levels observed in the CBSA and the 2002-04 Baseline Study samples. Given that the CEUS sample is from California we would expect gas use to be half of the Pacific Northwest samples. Except for the use types with large process loads (Hospitals and Restaurants), this pattern seems be reflected in the comparison table. In this summary as well, the retail sector has a much lower EUI than the Northwest samples. It is difficult to believe that this level of difference and this level of efficiency is actually consistent with the retail sector anywhere, including California.

7. End-Use Estimates

7.1. Baseline End-Use Review

The final review of the 2002-04 Baseline Study EUIs was conducted using the results of the EZ Sim simulation. EZ Sim is a spreadsheet-based program which uses correlations developed from DOE-2 prototypical runs and allows the user to construct a calibrated bill that matches individual building utility bills such as those collected for the 2002-2004 Baseline Study. The EZ Sim program also normalizes the bills based on long-term weather data at each particular site and constructs from the simulation an estimate of the energy-use components of the building such as space heat, space cooling, lighting, etc.

The summary of the EZ Sim runs is calculated in the same way as all the previous EUI calculations. When EZ Sim estimates a zero load for any one building end use, it is averaged with all other estimates for sample. For example, buildings with no electric space heat would have a zero load in that cell, and that would be averaged with all the other buildings, similarly with cooling loads.

163 of the EZ Sim runs were thought to be sufficiently well-related to both the audit information, the billing information, and the square footage information to include in this dataset. Since the EZ Sim runs are calibrated to the actual energy use, they are largely consistent with the overall energy use and billing patterns of the buildings as audited and constructed for this analysis.

7.1. CEUS Database End-Use Review

In 2004-06 the state of California undertook a major effort to characterize energy end uses in existing California commercial buildings. The methodology used was roughly similar to EZ Sim except the end use splits were developed by an automated DOE 2.2 simulation calibrated to the utility bills and using the characteristics developed from a detailed energy audit. The principal difference was that in the California study 17% of the buildings had sub-metered data collected on particular end uses. However, the calibration in the billing data was largely the result of an automated process supplemented by a careful hand review and adjustment.

The comparison between the CEUS summaries and the summaries developed from the EZ Sim runs show some correspondence. The principle differences seem traceable to the gas use. The disaggregation of the gas bills by EZ Sim could probably benefit from a more careful recalibration step during the simulation. A further difficulty with the EZ Sim runs is the definition of "Vent." This was meant to ascribe the electric energy used by the HVAC system when neither heating nor cooling was required (thus ventilation load). It is apparent that for CEUS the distribution energy was separated as an end use. Thus the comparability in the electric energy between EZ Sim and CEUS must be thought of as the total of the electric HVAC load.

7.2. End-Use Summary and Comparison

Table 11 and
Table 12 summarize non-electric EUIs for the EZ Sim runs and CEUS runs for each of the 2002-04 Baseline Study building types. In both databases, this summary includes all non-electric fuel, including oil, propane, and metered use from various district heating systems.

Appendix C provides some of the statistical details of the EZ Sim runs, including the means, standard deviations, medians, and applicable sample sizes.

A few differences between the datasets should be noted. The CEUS data consolidated all health services in a single building type. The 2002-04 Baseline Study separated out hospitals and summarized the health sector separately. Thus, in comparing these two datasets, the CEUS data should be between the two health sectors in the 2002-2004 Baseline Study. Another notable difference between the two datasets is that the "Other" category, which includes most assembly and institutional uses as well as various light industrial uses, was not included in the 2002-04 Baseline Study.

Also, for the most part EZ Sim does not allow for process or other loads. This meant that the heating and DHW end uses absorbed the energy use that might be associated with these other uses. This did not seem to damage the analysis with the exception of restaurants. In this sector the EZ Sim runs were abandoned because they failed to take into account the cooking loads.

Table 11: 2002-2004 Baseline Study Non-Electric End-Use Summary

Building Type	Gas KBtu/sf	Heat KBtu/sf	DHW KBtu/sf
Assembly	38.3	22.8	15.6
College	18.4	15.9	2.5
Education	29.8	23.6	6.2
Grocery	60.8	40.3	20.4
Health Services	69.9	33.5	36.4
Hospital	107.1	39.3	67.9
Institution	21.6	11.9	9.8
Office	9.5	8.8	0.7
Other	22.8	21.9	0.9
Residential/Lodging	24.3	6.3	18.1
Restaurant / Bar*	156.7		
Retail	23.3	17.5	5.8
Warehouse	12.4	10.4	2.0

Table 12: CEUS Non-Electric End-Use Summary

Building Type	Gas KBtu/sf	Heat KBtu/sf	DHW KBtu/sf	Other KBtu/sf
Assembly*	—	—	—	—
College	24	13.2	6.3	4.5
Education	12.1	6.1	4.9	1.1
Grocery	21.8	6.1	5.9	9.8
Health Services	68.3	34.8	24	9.5
Hospital				
Institution*	—	—	—	—
Office	11	8	2.2	0.8
Other	24.1	5.1	10.9	8.1
Residential/Lodging	40.9	10.8	25.5	4.6
Restaurant / Bar	249.1	8.4	60.5	180.2
Retail	2.5	1.1	0.7	0.7
Warehouse	2.9	2.1	0.2	0.6

* Included in the "other" building type category

Table 13 and Table 14 summarize electric end-use EUIs. The definition of end uses and the comparability between these two databases was similar to the gas comparison. The EZ Sim program uses a fairly simplified billing analysis based on temperature response. The result is that much of the base load in the analysis depends on the correlations. It is apparent that the EZ Sim analysis uses a correlation for this portion of the analysis that biases the end uses to the "other" category. This includes plug loads and other important process loads but the mechanism for separating these loads from the HVAC system seems to bias the results of both. The EZ Sim estimates of HVAC energy loads is about 60% of the CEUS estimates for the same end uses. The bias suggests that the EZ Sim process would have to be adjusted in order to provide more reliable end use splits. Other areas where the end use analysis provided by EZ Sim was suspect include restaurants and groceries. Both these cases seem to be damaged by the particular end use

split for the base load included in the current analysis.

On the other hand, there are end uses and building types in the CEUS data that appear anomalous and probably are more biased than comparable estimates in EZ Sim. For example, the EZ Sim decision to assign 37% of the electric EUI in Schools to "Other" seems to be fairly justified by virtue of computers and other activities that are part of the school end use. In the case of CEUS, this was less than a third of this value. Since the "Other" category is not directly simulated by either program, the size of this allocation is largely the discretion of the modeler. It seems likely that the assumptions used in the EZ Sim modeling were more consistent with this building type. This issue results from disaggregating billing analysis to individual end uses. The process requires considerable judgment on the part of the modelers and even with substantial attention, these assumptions are the sources of biases and mis-specification that can be very misleading.

Table 13: 2002-2004 Baseline Study Electric End-Use Loads

Building Type	EUI kWh/sf	Heat kWh/sf	Cool kWh/sf	Vent kWh/sf	Refrig. kWh/sf	DHW kWh/sf	Lights Int. kWh/sf	Lights Ext. kWh/sf	Other kWh/sf
Assembly	13.3	1.2	2.4	0.2	0.1	0	4.6	0.6	4.2
College	12.7	0.3	1.7	0.2	0	0.4	3.1	0.6	6.4
Education	9.6	0.7	0.9	0.3	0	0.2	3.3	0.6	3.6
Grocery	46.6	0.3	2.8	0.3	14.8	0	10.8	0.9	16.7
Health Services	14.3	1.3	1.6	0.8	0	0	4.3	0.4	5.9
Hospital	25.3	1	5.3	1	0	0	7.3	0.3	10.4
Institution	15.4	0.9	2.4	0.5	0	0.4	4.8	1.1	5.3
Office	17.8	1.2	2	0.5	0	0.7	3.4	1.9	8.1
Other	18.3	0.4	1.4	0.1	0	0.6	2.9	0.1	12.8
Residential/Lodging	10.6	2.1	1.7	0.2	0	0	4.4	0.4	1.8
Restaurant / Bar *	86.2	—	—	—	—	—	—	—	—
Retail	21.6	0.8	1.6	0.2	2.5	1.1	8.2	1.5	5.7
Warehouse	15.1	0.1	0.2	0.1	0.3	0.5	3.6	7.7	2.6

* EZ Sim mis-specification in the Restaurant sector

Table 14: CEUS Electric End-Use Loads

Building Type	EUI kWh/sf	Heat kWh/sf	Cool kWh/sf	Fans kWh/sf	Refrig. kWh/sf	DHW kWh/sf	Lights Int kWh/sf	Lights Ext kWh/sf	Other kWh/sf
Assembly	—	—	—	—	—	—	—	—	—
College	13.6	1.2	2.1	2.0	0.3	0.1	4.5	0.7	2.7
Education	8.2	0.1	1.6	1.0	0.5	0.1	3.1	0.7	1.1
Grocery	41.7	0.2	3.6	2.8	21.7	0.2	6.6	1.0	5.6
Health Services / **Hospital**	20.3	0.8	4.3	4.2	0.7	0.1	4.9	0.7	4.6
Institution	—	—	—	—	—	—	—	—	—
Office	16.0	0.2	3.5	2.3	0.4	0.2	4.4	0.9	4.1
Other	9.9	0.1	1.4	0.7	0.9	0.1	2.4	1.1	3.2
Residential/ Lodging	13.3	0.3	3.0	1.7	1.0	0.0	3.7	0.7	2.9
Restaurant / Bar	46.2	0.0	7.9	4.1	10.4	0.5	7.1	2.7	13.5
Retail	15.4	0.0	2.8	1.9	1.0	0.1	6.6	1.1	1.9
Warehouse	5.7	0.0	0.4	0.3	1.4	0.0	2.2	0.2	1.2

8. Conclusions

A review of the 2002-04 Baseline Study EUIs leads to the conclusion that there are no significant differences between the energy use per square foot in the buildings built in the 2002-2004 period and the other samples, especially the earlier buildings surveyed in the CBSA database (Figure 3). The differences we see are as easily explained by variations within the two samples as any underlying change in efficiency. For example, there is a 13% improvement in the "grocery" sector when the EUIs are observed. However, the addition of grocery stores inside "big box retail" buildings dilutes the impact of refrigeration since there is more retail space than in a typical grocery.

The size of the variance in any of these estimates would swamp even a 20% improvement in efficiency. That said there is very little evidence that an improvement of that size could be inferred from the billing records. In this review, the lack of efficiency-related changes in EUIs is relatively consistent with the results of the characteristics survey. In most cases differences could be traced to particular buildings. In cases such as "Institutions" and "Health Services," the categories include a diverse set of uses and the efficiency improvements are masked or enhanced by the particular mix of buildings that ended up in the sample used.

These factors point to the limitations of an EUI as a performance index. It is apparent from this study, and from the various other data sets that were reviewed, that the variance in energy use among buildings that are otherwise comparable in design and use type is a serious limitation. The practical limitation of the size of samples and the expense of gathering this information precludes developing samples that are large enough to verify differences and the impact of various code or performance provisions that attempt to develop incremental energy efficiency. Even fairly dramatic improvements can be difficult to discern when occupancy factors intervene.

For example, in this summary two office buildings were removed because they had a connected server and communication equipment load of 6 and 12 MW respectively. This resulted in EUIs that were three times the average of the remaining offices. When these two buildings were included the 2002-04 Baseline, offices had an average EUI more than 20% higher than when they were not included and 15% higher than any office sector in the comparison datasets (including CBSA).

In principle, these problems could be solved by larger samples drawn with random sample designs. Unfortunately, the evidence of this dataset suggests that the standard deviation in any one sector is more than half the mean and thus in any one building type samples approaching 250 buildings would be necessary to reliably deal with the underlying variance in most subsectors. For either the CBSA or the Baseline sample this would imply sample sizes approaching 3000 buildings. The CBSA sample design might eventually yield this level of sample, but the mechanics of assembling billing data probably would require a 30 to 40% larger sample.

The limitations of this approach are partially due to utility billing release requirements. Most (but not all) utilities require a direct permission and release from the building owner to release the bills. Obtaining billing histories in this way is very time consuming and unreliable. Many of the releases secured in this study did not result in a useable bill, and almost all the releases required substantial effort to develop a means for the utility to identify and supply the bills. The process was very interactive. If this sort of measure is to be useful, broader cooperation from the utilities is essential. Utilities could improve the region's ability to analyze energy use if they collect and assemble bills with less strict privacy requirements for dealing with individual customers. The energy use datasets are large statistical aggregates that can be protected in ways that do not choke the process and limit the usability of the data. Without such cooperation the result of these energy use reviews will be either inconclusive or misleading. Both outcomes hinder efforts to understand the impacts and directions of commercial sector energy efficiency programs. NEEA acknowledges that obtaining billing data has been a consistent problem in regional studies and is attempting to address this in a current study by contacting utilities directly and negotiating agreements for billing releases. NEEA believes this will be more effective than having its contractors contact the utilities. In any event, a permanent solution should be sought.

The results of the end-use disaggregation using the EZ Sim program are somewhat encouraging. This technique is much less time consuming than the traditional alternative using a DOE2 or other hourly simulation to do this same job. The comparison with one such study suggests that the analysis presented is partly consistent with the more elaborate analysis. The EZ Sim analysis provides the opportunity to develop and weather normalize directly as a result of the analysis. But the large differences in non-weather sensitive end use estimates between DOE2 and EZ Sim suggest that further analysis and verification is required. We believe that a more rigorous comparison might be helpful especially if it could be accomplished with a database large enough to assess the consistency of the results.

It is also apparent that certain uses and occupancies can only be resolved with a direct sub meter. The results of the CEUS study suggest that this might not be helpful in most cases. For EZ Sim, the need for generalized datasets that could be used to inform the program's algorithms would probably be essential in further developing this technique. Given the complications of

developing a calibrated hourly model it seems likely that such a step could provide benefits in assessing energy end uses among large building aggregates. At this point, however, the simple approach has limitations that require more interaction with the building description, the energy bills, and the building operation to develop a useful description of the energy end uses.

Finally, regional consensus is needed on the primary metric for these broad regional market studies. If the metric is building characteristics, then past studies have been sufficient. If EUIs become the primary metric, then sample sizes (and therefore budgets) will need to increase to generate acceptable levels of statistical confidence while allowing for attrition in billing data. Past sample sizes have been set to obtain acceptable statistical accuracy for all buildings in the sample, rather than the subset for which billing data is obtained. Alternative samples would be necessary if EUI "benchmarking" are to be a primary focus of this effort. NEEA will address this issue as part of convening a forum on regional data collection activities in 2009.

If the EUI is to be used as a benchmark for efficiency (as it is in several national programs such as the 2030 Challenge and EnergyStar), then a further consensus must be developed on the methods and interpretations used in the calculation. To create a sound platform for accelerating and gauging energy efficiency gains in the Pacific Northwest, NEEA or some other regional entity should facilitate an effort to develop this consensus among regional stakeholders. In the absence of a consistent approach to developing and interpreting EUIs, baseline and building comparisons will become unnecessarily complex, costly, and potentially irrelevant.

9. References

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Appendix A: Building EUI Summaries

This appendix summarizes the distribution of total EUIs (all sources) in the 2002-04 Baseline sample. A total of 194 buildings are included in this summary. Various subsets of this sample are included. In most cases sample sizes are inadequate to evaluate and compare these sub-samples. They are included here to illustrate the distribution of building performance throughout the sample. Often, when state sub-samples are shown, the samples and their comparisons are a function of the particular buildings for which EUIs could be drawn as much as any identifiable characteristics of the state or its building stock. The second part of this summary repeats the tables but includes only those buildings where a majority of the building area covered by the energy bill is new construction.

Full Baseline Sample (all available buildings):

Table A-1 EUI Characteristics (KBTU/sf)

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	83.1	37.1	74.1	165.9	22.9	7
College	62.2	9.1	62.4	71.2	51.0	3
Education	61.4	18.2	63.2	95.3	30.9	34
Grocery	219.8	102.2	220.4	447.7	119.6	7
Health Services	111.8	35.3	105.4	152.7	38.4	10
Hospital	193.5	46.6	190.8	342.8	123.1	10
Institution	75.2	29.7	68.8	186.3	23.0	20
Office	112.5	74.9	75.4	249.8	21.1	21
Other	102.5	76.0	80.4	267.4	34.8	5
Residential/Lodging	64.1	23.1	59.6	214.3	43.4	8
Restaurant / Bar	451.0	249.8	425.1	902.8	160.4	4
Retail	95.7	34.3	81.8	161.0	21.0	41
Warehouse	70.5	58.1	50.0	334.0	6.2	25

Summary for each state:

Table A-2 EUI Characteristics (KBTU/sf), Idaho

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	165.9		165.9	165.9	165.9	1
College	51.0		51.0	51.0	51.0	1
Education	47.0	19.9	39.8	81.9	34.9	4
Health Services	56.0	45.5	38.4	136.9	38.4	3
Hospital	223.2		223.2	223.2	223.2	1
Institution	53.3		53.3	53.3	53.3	1
Office	68.1	23.0	75.4	97.7	21.1	5
Other	83.4		83.4	83.4	83.4	1
Restaurant / Bar	160.4		160.4	160.4	160.4	1
Retail	102.4	42.1	81.8	159.9	31.2	5
Warehouse	11.9	23.2	6.2	75.3	6.2	3

Table A-3 EUI Characteristics (KBTU/sf), Montana

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	23.0		23.0	23.0	23.0	1
Office	48.3	16.2	53.6	53.6	23.6	2
Other	267.4		267.4	267.4	267.4	1
Residential/Lodging	107.3		107.3	107.3	107.3	1
Retail	73.0	12.8	71.7	96.6	59.9	4
Warehouse	103.9	114.7	46.9	334.0	28.4	5

Table A-4 EUI Characteristics (KBTU/sf), Oregon

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	74.6	1.4	74.1	76.3	74.1	2
College	65.9	6.1	62.4	71.2	62.4	2
Education	51.9	12.0	51.3	90.1	30.9	15
Grocery	206.3	137.6	119.6	447.7	119.6	4
Health Services	91.8		91.8	91.8	91.8	1
Hospital	241.9	82.9	293.1	293.1	123.1	3
Institution	102.8	40.0	86.1	186.3	37.4	7
Office	83.4	31.6	67.5	146.4	58.6	8
Other	48.2	35.9	34.8	96.3	34.8	2
Residential/Lodging	60.3	22.6	54.3	214.3	43.4	6
Restaurant / Bar	512.7	261.4	425.1	902.8	425.1	2
Retail	76.7	27.4	74.9	135.7	21.0	14
Warehouse	31.8	15.3	28.7	57.6	18.3	5

Table A-5 EUI Characteristics (KBTU/sf), Washington

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	64.1	15.0	67.4	69.0	22.9	4
Education	72.3	17.6	73.3	95.3	34.7	15
Grocery	237.4	48.6	220.4	290.5	197.4	3
Health Services	119.9	27.3	105.4	152.7	63.8	6
Hospital	184.5	34.9	190.8	342.8	163.1	6
Institution	71.6	20.7	68.0	158.1	41.7	11
Office	153.0	93.5	166.2	249.8	49.9	6
Other	80.4		80.4	80.4	80.4	1
Residential/Lodging	59.6		59.6	59.6	59.6	1
Restaurant / Bar	622.3		622.3	622.3	622.3	1
Retail	110.3	32.5	112.8	161.0	56.6	18
Warehouse	88.8	55.1	103.3	197.9	10.6	12

Summaries for Buildings with Two Outlying Offices removed:

Table A-6 EUI Characteristics (KBTU/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	83.1	37.1	74.1	22.9	165.9	7
College	62.2	9.1	62.4	51.0	71.2	3
Education	61.4	18.2	63.2	30.9	95.3	34
Grocery	219.8	102.2	220.4	119.6	447.7	7
Health Services	111.8	35.3	105.4	38.4	152.7	10
Hospital	193.5	46.6	190.8	123.1	342.8	10
Institution	75.2	29.7	68.8	23.0	186.3	20
Office	71.7	26.1	72.0	21.1	146.4	19
Other	102.5	76.0	80.4	34.8	267.4	5
Residential/Lodging	64.1	23.1	59.6	43.4	214.3	8
Restaurant / Bar	451.0	249.8	425.1	160.4	902.8	4
Retail	95.5	34.9	81.8	21.0	161.0	40
Warehouse	70.5	58.1	50.0	6.2	334.0	25

Table A-7 EUI Characteristics (KBTU/sf), Washington Sample, Outliers Removed*

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	56.6	22.5	67.3	22.9	68.9	4
Education	68.0	19.1	72.4	34.7	95.3	15
Grocery	236.1	48.5	220.4	197.4	290.5	3
Health Services	107.6	28.5	108.5	63.8	152.7	6
Hospital	231.1	64.8	219.3	163.1	342.8	6
Institution	91.4	35.2	85.8	41.7	158.1	11
Office	60.2	12.4	49.9	49.9	80.5	4
Other	80.3	80.3	80.3	80.3		1
Residential/Lodging	59.6	59.6	59.6	59.6		1
Restaurant / Bar	622.3	622.3	622.3	622.3		1
Retail	97.0	33.7	91.0	56.6	160.9	17
Warehouse	68.6	53.6	55.9	10.6	197.9	12

*Only the Washington state summary is affected by the Office outliers

Summaries for Buildings with Majority New Construction, Outliers Removed:

Table A-8 EUI Characteristics (KBTU/sf), All Buildings

Building Type	Mean	Std. Dev.	Median	Maximum	Minimum	N
Assembly	88.1	46.0	69.0	165.9	22.9	6
College	62.2	9.1	62.4	71.2	51.0	3
Education	61.8	19.9	63.2	95.3	34.7	26
Grocery	218.5	105.6	220.4	447.7	119.6	6
Health Services	111.9	35.3	105.4	152.7	38.4	10
Hospital	199.6	53.9	190.8	342.8	123.1	5
Institution	75.2	29.7	68.8	186.3	23.0	20
Office	72.7	30.9	71.8	146.4	21.1	18
Other	127.6	98.3	80.4	267.4	80.4	3
Residential/Lodging	62.9	18.3	59.6	107.3	43.4	7
Restaurant / Bar	451.0	249.8	425.1	902.8	160.4	4
Retail	94.7	34.6	81.8	161.0	21.0	39
Warehouse	59.1	46.0	42.1	334.0	6.2	23

Summary for each state:

Table A-9 EUI Characteristics (KBTU/sf), Idaho

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	165.9		165.9	165.9	165.9	1
College	51.0		51.0	51.0	51.0	1
Education	38.6	3.2	39.8	34.9	45.6	3
Health Services	56.0	45.5	38.4	38.4	136.9	3
Hospital	223.2		223.2	223.2	223.2	1
Institution	53.3		53.3	53.3	53.3	1
Office	68.1	23.0	75.4	21.1	97.7	5
Restaurant / Bar	160.4		160.4	160.4	160.4	1
Retail	102.4	42.1	81.8	31.2	159.9	5
Warehouse	11.9	23.2	6.2	6.2	75.3	3

Table A-10 EUI Characteristics (KBTU/sf), Montana

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	23.0		23.0	23.0	23.0	1
Office	48.3	16.2	53.6	23.6	53.6	2
Other	267.4		267.4	267.4	267.4	1
Residential/Lodging	107.3		107.3	107.3	107.3	1
Retail	73.0	12.8	71.7	59.9	96.6	4
Warehouse	103.9	114.7	46.9	28.4	334.0	5

Table A-11 EUI Characteristics (KBTU/sf), Oregon

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	76.3		76.3	76.3	76.3	1
College	65.9	6.1	62.4	62.4	71.2	2
Education	48.5	13.2	41.8	38.5	90.1	10
Grocery	202.8	150.7	119.6	119.6	447.7	3
Health Services	91.8		91.8	91.8	91.8	1
Hospital	123.1		123.1	123.1	123.1	1
Institution	102.8	40.0	86.1	37.4	186.3	7
Office	81.9	31.4	62.8	58.6	146.4	7
Other	96.3		96.3	96.3	96.3	1
Residential/Lodging	58.5	13.6	54.3	43.4	79.0	5
Restaurant / Bar	512.7	261.4	425.1	425.1	902.8	2
Retail	76.8	27.4	74.9	21.0	135.7	14
Warehouse	31.8	15.4	28.7	18.3	57.6	5

Table A-12 EUI Characteristics (KBTU/sf), Washington

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	64.1	15.0	67.4	22.9	69.0	4
Education	72.0	17.8	73.3	34.7	95.3	13
Grocery	237.4	48.6	220.4	197.4	290.5	3
Health Services	119.9	27.3	105.4	63.8	152.7	6
Hospital	210.1	51.6	190.8	190.8	342.8	3
Institution	71.6	20.7	68.0	41.7	158.1	11
Office	60.2	12.4	49.9	49.9	80.5	4
Other	80.4		80.4	80.4	80.4	1
Residential/Lodging	59.6		59.6	59.6	59.6	1
Restaurant / Bar	622.3		622.3	622.3	622.3	1
Retail	112.1	34.9	112.8	56.6	161.0	15
Warehouse	73.1	38.3	103.3	10.6	104.0	10

Appendix B: Electric and Gas EUI Summaries

This appendix summarizes the energy use by major fuel. The first section is the electric EUI and summarizes all the electric energy reported in the utility bills. The second section is for the gas EUI but includes other fuels such as propane and purchased steam. Both summaries are divided into two parts. The first part is the entire sample for which EUIs were collected. The second part is the portion of the sample where a majority of the space included in the energy bill was new construction, about 75% of the EUI sample.

Electric EUIs

Table B-1 Electric EUI (kWh/sf), Full Sample

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	13.3	6.8	13.1	2.6	24.2	7
College	12.7	5.2	13.2	6.1	17.5	3
Education	9.6	3.5	9.6	4.5	43.3	34
Grocery	46.6	25.1	45.5	27.5	111.6	7
Health Services	14.3	6.6	11.0	5.4	31.7	9
Hospital	25.3	8.4	24.8	20.7	66.7	10
Institution	15.4	3.7	15.6	1.8	23.3	20
Office	30.0	22.3	20.0	1.6	71.7	21
Other	18.3	8.1	17.0	9.4	35.4	5
Residential/Lodging	10.6	3.3	10.7	8.0	34.3	8
Restaurant / Bar	86.2	38.8	103.2	31.2	131.5	4
Retail	21.6	6.0	19.7	3.6	37.6	40
Warehouse	15.1	11.7	9.4	0.8	42.7	25

Table B-2 Electric EUI (kWh/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	13.3	6.8	13.1	2.6	24.2	7
College	12.7	5.2	13.2	6.1	17.5	3
Education	9.6	3.5	9.6	4.5	43.3	34
Grocery	46.6	25.1	45.5	27.5	111.6	7
Health Services	14.3	6.6	11.0	5.4	31.7	9
Hospital	25.3	8.4	24.8	20.7	66.7	10
Institution	15.4	3.7	15.6	1.8	23.3	20
Office	17.8	7.0	17.8	1.6	37.7	19
Other	18.3	8.1	17.0	9.4	35.4	5
Residential/Lodging	10.6	3.3	10.7	8.0	34.3	8
Restaurant / Bar	86.2	38.8	103.2	31.2	131.5	4
Retail	21.6	6.0	19.7	3.6	37.6	40
Warehouse	15.1	11.7	9.4	0.8	42.7	25

Table B-3 Idaho Electric EUI (kWh/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	24.2		24.2	24.2	24.2	1
College	6.1		6.1	6.1	6.1	1
Education	9.8	1.5	10.1	7.6	11.6	4
Health Services	9.7	7.1	7.1	5.4	22.4	3
Hospital	61.1		61.1	61.1	61.1	1
Institution	13.9		13.9	13.9	13.9	1
Office	16.4	6.6	20.0	3.3	20.0	5
Other	16.4		16.4	16.4	16.4	1
Restaurant / Bar	31.2		31.2	31.2	31.2	1
Retail	21.3	6.0	18.6	3.6	29.2	5
Warehouse	1.9	3.1	1.3	0.8	10.4	3

Table B-4 Montana Electric EUI (kWh/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	1.8		1.8	1.8	1.8	1
Office	6.2	3.0	7.2	1.6	7.2	2
Other	35.4		35.4	35.4	35.4	1
Residential/Lodging	12.3		12.3	12.3	12.3	1
Retail	17.1	2.9	17.9	13.7	22.3	4
Warehouse	11.6	12.8	9.4	3.7	42.7	5

Table B-5 Oregon Electric EUI (kWh/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	15.1	5.0	13.1	13.1	21.2	2
College	14.9	3.0	13.2	13.2	17.5	2
Education	8.3	2.4	8.2	4.5	14.3	15
Grocery	47.7	34.8	27.5	27.5	111.6	4
Health Services	24.6		24.6	24.6	24.6	1
Hospital	23.8	1.4	24.8	22.1	24.8	3
Institution	18.0	5.1	18.8	6.9	23.3	7
Office	21.0	8.0	17.8	12.1	37.7	8
Other	10.0	0.5	10.2	9.4	10.2	2
Residential/Lodging	10.4	3.9	8.1	8.0	34.3	6
Restaurant / Bar	108.4	15.5	103.2	103.2	131.5	2
Retail	18.8	5.1	19.1	5.0	27.4	14
Warehouse	7.1	3.2	7.0	3.1	13.2	5

Table B-6 Washington Electric EUI (kWh/sf), Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	7.2	1.7	7.5	2.6	8.3	4
Education	10.9	4.2	10.5	6.9	43.3	15
Grocery	45.1	9.2	47.4	34.4	52.5	3
Health Services	14.9	6.2	11.0	11.0	31.7	5
Hospital	25.1	8.2	25.4	20.7	66.7	6
Institution	14.9	3.0	15.6	5.9	19.2	11
Office	15.8	1.5	14.6	13.1	18.0	4
Other	17.0		17.0	17.0	17.0	1
Residential/Lodging	10.7		10.7	10.7	10.7	1
Restaurant / Bar	60.9		60.9	60.9	60.9	1
Retail	24.6	5.8	24.6	11.4	37.6	17
Warehouse	19.8	11.6	27.5	1.9	31.7	12

Table B-7 Electric EUI (kWh/sf), Majority New Construction, Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	13.4	8.6	7.5	2.6	24.2	6
College	12.7	5.2	13.2	6.1	17.5	3
Education	10.2	3.7	10.1	6.5	43.3	26
Grocery	46.6	26.0	47.4	27.5	111.6	6
Health Services	14.3	6.6	11.0	5.4	31.7	9
Hospital	31.4	14.7	25.4	22.1	66.7	5
Institution	15.4	3.7	15.6	1.8	23.3	20
Office	17.7	7.0	17.0	1.6	37.7	18
Other	21.1	10.3	17.0	9.4	35.4	3
Residential/Lodging	10.4	2.3	10.7	8.0	14.0	7
Restaurant / Bar	86.2	38.8	103.2	31.2	131.5	4
Retail	21.3	6.0	19.5	3.6	37.6	38
Warehouse	13.8	11.1	9.3	0.8	42.7	23

Table B-8 Idaho Electric EUI (kWh/sf), Majority New Construction, Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	24.2		24.2	24.2	24.2	1
College	6.1		6.1	6.1	6.1	1
Education	9.3	1.4	10.1	7.6	10.1	3
Health Services	9.7	7.1	7.1	5.4	22.4	3
Hospital	61.1		61.1	61.1	61.1	1
Institution	13.9		13.9	13.9	13.9	1
Office	16.4	6.6	20.0	3.3	20.0	5
Restaurant / Bar	31.2		31.2	31.2	31.2	1
Retail	21.3	6.0	18.6	3.6	29.2	5
Warehouse	1.9	3.1	1.3	0.8	10.4	3

Table B-9 Montana Electric EUI (kWh/sf), Majority New Construction, Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	1.8		1.8	1.8	1.8	1
Office	6.2	3.0	7.2	1.6	7.2	2
Other	35.4		35.4	35.4	35.4	1
Residential/Lodging	12.3		12.3	12.3	12.3	1
Retail	17.1	2.9	17.9	13.7	22.3	4
Warehouse	11.6	12.8	9.4	3.7	42.7	5

Table B-10 Oregon Electric EUI (kWh/sf), Majority New Construction, Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	21.2		21.2	21.2	21.2	1
College	14.9	3.0	13.2	13.2	17.5	2
Education	8.9	2.3	8.2	6.5	13.6	10
Grocery	47.9	38.3	27.5	27.5	111.6	3
Health Services	24.6		24.6	24.6	24.6	1
Hospital	22.1		22.1	22.1	22.1	1
Institution	18.0	5.1	18.8	6.9	23.3	7
Office	20.9	8.3	17.8	12.1	37.7	7
Other	9.4		9.4	9.4	9.4	1
Residential/Lodging	10.2	2.8	8.1	8.0	14.0	5
Restaurant / Bar	108.4	15.5	103.2	103.2	131.5	2
Retail	18.8	5.1	19.1	5.0	27.4	14
Warehouse	7.1	3.2	7.0	3.1	13.2	5

Table B-11 Washington Electric EUI (kWh/sf), Majority New Construction, Outliers Removed

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	7.2	1.7	7.5	2.6	8.3	4
Education	11.0	4.4	10.5	7.2	43.3	13
Grocery	45.1	9.2	47.4	34.4	52.5	3
Health Services	14.9	6.2	11.0	11.0	31.7	5
Hospital	31.1	14.6	25.4	25.4	66.7	3
Institution	14.9	3.0	15.6	5.9	19.2	11
Office	15.8	1.5	14.6	13.1	18.0	4
Other	17.0		17.0	17.0	17.0	1
Residential/Lodging	10.7		10.7	10.7	10.7	1
Restaurant / Bar	60.9		60.9	60.9	60.9	1
Retail	24.5	6.1	24.6	11.4	37.6	15
Warehouse	18.4	11.5	27.5	1.9	27.5	10

Gas & Other Fuels EUIs

Table B-12 Gas EUI (th/sf), Full Sample

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.37	0.24	0.29	0.00	0.83	7
College	0.18	0.09	0.17	0.11	0.30	3
Education	0.30	0.16	0.34	0.00	0.97	34
Grocery	0.61	0.32	0.58	0.26	1.11	7
Health Services	0.69	0.47	0.43	0.03	1.15	9
Hospital	1.07	0.38	0.98	0.15	2.09	10
Institution	0.22	0.24	0.06	0.00	1.17	20
Office	0.11	0.13	0.06	0.00	0.70	21
Other	0.22	0.13	0.22	0.00	0.64	5
Residential/Lodging	0.23	0.12	0.23	0.07	0.97	8
Restaurant / Bar	1.57	1.82	0.73	0.54	4.54	4
Retail	0.21	0.19	0.15	0.00	0.65	40
Warehouse	0.18	0.28	0.10	0.00	1.79	25

Table B-13 Gas EUI (th/sf), Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.37	0.24	0.29	0.00	0.83	7
College	0.18	0.09	0.17	0.11	0.30	3
Education	0.30	0.16	0.34	0.00	0.97	34
Grocery	0.61	0.32	0.58	0.26	1.11	7
Health Services	0.69	0.47	0.43	0.03	1.15	9
Hospital	1.07	0.38	0.98	0.15	2.09	10
Institution	0.22	0.24	0.06	0.00	1.17	20
Office	0.13	0.15	0.07	0.00	0.70	19
Other	0.22	0.13	0.22	0.00	0.64	5
Residential/Lodging	0.23	0.12	0.23	0.07	0.97	8
Restaurant / Bar	1.57	1.82	0.73	0.54	4.54	4
Retail	0.21	0.19	0.15	0.00	0.65	40
Warehouse	0.18	0.28	0.10	0.00	1.79	25

Table B-14 Idaho Gas EUI (th/sf), Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.83		0.83	0.83	0.83	1
College	0.30		0.30	0.30	0.30	1
Education	0.13	0.16	0.05	0.05	0.42	4
Health Services	0.23	0.21	0.14	0.14	0.60	3
Hospital	0.15		0.15	0.15	0.15	1
Institution	0.06		0.06	0.06	0.06	1
Office	0.12	0.12	0.07	0.07	0.48	5
Other	0.28		0.28	0.28	0.28	1
Restaurant / Bar	0.54		0.54	0.54	0.54	1
Retail	0.29	0.22	0.18	0.15	0.60	5
Warehouse	0.06	0.13	0.02	0.02	0.40	3

Table B-15 Montana Gas EUI (th/sf), Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	0.02		0.02	0.02	0.02	1
Office	0.03	0.01	0.03	0.02	0.03	2
Other	0.16		0.16	0.16	0.16	1
Residential/Lodging	0.07		0.07	0.07	0.07	1
Retail	0.02	0.01	0.02	0.01	0.02	4
Warehouse	0.33	0.72	0.02	0.02	1.79	5

Table B-16 Oregon Gas EUI (th/sf), Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.23	0.15	0.29	0.04	0.29	2
College	0.15	0.04	0.17	0.11	0.17	2
Education	0.23	0.13	0.28	0.00	0.44	15
Grocery	0.44	0.26	0.26	0.26	0.96	4
Health Services	0.08		0.08	0.08	0.08	1
Hospital	1.61	0.78	2.09	0.48	2.09	3
Institution	0.41	0.31	0.36	0.00	1.17	7
Office	0.12	0.13	0.06	0.02	0.70	8
Other	0.14	0.37	0.00	0.00	0.64	2
Residential/Lodging	0.25	0.13	0.18	0.16	0.97	6
Restaurant / Bar	1.43	2.08	0.73	0.73	4.54	2
Retail	0.13	0.14	0.07	0.00	0.50	14
Warehouse	0.08	0.08	0.02	0.01	0.18	5

Table B-17 Washington Gas EUI (th/sf), Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.38	0.14	0.42	0.00	0.43	4
Education	0.37	0.15	0.40	0.00	0.97	15
Grocery	0.83	0.27	0.80	0.58	1.11	3
Health Services	0.82	0.45	1.15	0.03	1.15	5
Hospital	0.99	0.11	0.98	0.93	1.40	6
Institution	0.20	0.20	0.30	0.02	1.17	11
Office	0.17	0.23	0.00	0.00	0.40	4
Other	0.22		0.22	0.22	0.22	1
Residential/Lodging	0.23		0.23	0.23	0.23	1
Restaurant / Bar	4.14		4.14	4.14	4.14	1
Retail	0.27	0.20	0.16	0.00	0.65	17
Warehouse	0.22	0.28	0.10	0.00	0.90	12

Table B-18 Gas EUI (th/sf), Majority New Construction, Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.41	0.29	0.42	0.00	0.83	6
College	0.18	0.09	0.17	0.11	0.30	3
Education	0.28	0.17	0.39	0.00	0.97	26
Grocery	0.59	0.32	0.58	0.26	1.11	6
Health Services	0.69	0.47	0.43	0.03	1.15	9
Hospital	0.92	0.29	1.04	0.15	1.15	5
Institution	0.22	0.24	0.06	0.00	1.17	20
Office	0.12	0.15	0.07	0.00	0.70	18
Other	0.23	0.13	0.22	0.16	0.64	3
Residential/Lodging	0.22	0.10	0.23	0.07	0.43	7
Restaurant / Bar	1.57	1.82	0.73	0.54	4.54	4
Retail	0.20	0.20	0.14	0.00	0.65	38
Warehouse	0.11	0.17	0.10	0.00	1.79	23

Table B-19 Idaho Gas EUI (th/sf), Majority New Construction, Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.83		0.83	0.83	0.83	1
College	0.30		0.30	0.30	0.30	1
Education	0.07	0.03	0.05	0.05	0.15	3
Health Services	0.23	0.21	0.14	0.14	0.60	3
Hospital	0.15		0.15	0.15	0.15	1
Institution	0.06		0.06	0.06	0.06	1
Office	0.12	0.12	0.07	0.07	0.48	5
Restaurant / Bar	0.54	0.00	0.54	0.54	0.54	1
Retail	0.29	0.22	0.18	0.15	0.60	5
Warehouse	0.06	0.13	0.02	0.02	0.40	3

Table B-20 Montana Gas EUI (th/sf), Majority New Construction, Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Institution	0.02		0.02	0.02	0.02	1
Office	0.03	0.01	0.03	0.02	0.03	2
Other	0.16		0.16	0.16	0.16	1
Residential/Lodging	0.07		0.07	0.07	0.07	1
Retail	0.02	0.01	0.02	0.01	0.02	4
Warehouse	0.33	0.72	0.02	0.02	1.79	5

Table B-21 Oregon Gas EUI (th/sf), Majority New Construction, Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.04		0.04	0.04	0.04	1
College	0.15	0.04	0.17	0.11	0.17	2
Education	0.18	0.14	0.18	0.00	0.44	10
Grocery	0.39	0.21	0.26	0.26	0.67	3
Health Services	0.08		0.08	0.08	0.08	1
Hospital	0.48		0.48	0.48	0.48	1
Institution	0.41	0.31	0.36	0.00	1.17	7
Office	0.10	0.12	0.06	0.02	0.70	7
Other	0.64		0.64	0.64	0.64	1
Residential/Lodging	0.24	0.10	0.18	0.16	0.43	5
Restaurant / Bar	1.43	2.08	0.73	0.73	4.54	2
Retail	0.13	0.14	0.07	0.00	0.50	14
Warehouse	0.08	0.08	0.02	0.01	0.18	5

Table B-22 Washington Gas EUI (th/sf), Majority New Construction, Minus Area Outliers

Building Type	Mean	Std. Dev.	Median	Minimum	Maximum	N
Assembly	0.38	0.14	0.42	0.00	0.43	4
Education	0.37	0.15	0.40	0.00	0.97	13
Grocery	0.83	0.27	0.80	0.58	1.11	3
Health Services	0.82	0.45	1.15	0.03	1.15	5
Hospital	1.04	0.05	1.04	0.98	1.15	3
Institution	0.20	0.20	0.30	0.02	1.17	11
Office	0.17	0.23	0.00	0.00	0.40	4
Other	0.22		0.22	0.22	0.22	1
Residential/Lodging	0.23		0.23	0.23	0.23	1
Restaurant / Bar	4.14		4.14	4.14	4.14	1
Retail	0.28	0.21	0.16	0.00	0.65	15
Warehouse	0.11	0.04	0.10	0.00	0.29	10

Appendix C: End Use EUI Summaries

This appendix summarizes the end use results from about 170 EZ Sim runs. These end uses are calculated from the building characteristics and billing information. In about 20% of the cases the EZ Sim runs were compromised and not used in these summaries. This includes all of the "Restaurant" sector and the "Office" outliers as well as several runs that failed and could not be re-run with the resources available. Like the other EUI summaries this section includes both all runs done and a subset of buildings where a majority of the building area was actually new construction (about 75% of the sample). The summary is divided into electric and gas (all fuels) end uses. These summaries include all runs with zero use assumed where that was appropriate. These zero values are included in the statistics reported here.

Table C-1 Electric Total EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	13.7	6.6	13.1	6
College	12.7	5.2	13.2	3
Education	9.4	2.3	9.5	31
Grocery	46.6	25.1	45.5	7
Health Services	14.3	6.6	11.0	8
Hospital	25.3	8.4	24.8	10
Institution	15.5	3.7	15.6	18
Office	18.6	7.1	17.8	16
Other	15.5	2.9	16.4	4
Residential/Lodging	10.5	3.4	10.6	7
Retail	22.4	6.0	20.7	34
Warehouse	13.6	11.1	9.3	19

Table C-2 Electric Heating EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	1.2	2.5	0.0	6
College	0.3	0.6	0.1	3
Education	0.8	0.9	0.9	31
Grocery	0.3	0.9	0.0	7
Health Services	1.3	1.2	0.9	8
Hospital	1.0	0.9	0.9	10
Institution	0.9	1.7	0.7	18
Office	1.2	1.4	0.8	16
Other	0.4	1.0	0.1	4
Residential/Lodging	2.1	0.9	1.9	7
Retail	0.8	1.0	0.4	34
Warehouse	0.2	0.5	0.0	19

Table C-3 Electric Cooling EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	2.5	1.7	2.5	6
College	1.7	0.6	1.6	3
Education	1.0	0.8	0.8	31
Grocery	2.8	2.4	1.6	7
Health Services	1.6	2.2	0.2	8
Hospital	5.3	4.7	4.0	10
Institution	2.4	1.8	2.0	18
Office	2.0	0.8	1.9	16
Other	1.4	1.4	0.6	4
Residential/Lodging	1.7	1.5	1.4	7
Retail	1.6	1.1	1.4	34
Warehouse	0.2	0.4	0.0	19

Table C-4 Ventilation EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.2	0.3	0.1	6
College	0.2	0.2	0.2	3
Education	0.3	0.2	0.4	31
Grocery	0.3	0.2	0.2	7
Health Services	0.8	0.9	0.4	8
Hospital	1.0	0.6	0.7	10
Institution	0.5	0.4	0.4	18
Office	0.5	0.6	0.4	16
Other	0.1	0.2	0.1	4
Residential/Lodging	0.2	0.3	0.1	7
Retail	0.2	0.2	0.1	34
Warehouse	0.1	0.1	0.1	19

Table C-5 Refrigeration EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.1	0.2	0.0	6
College	0.0	0.0	0.0	3
Education	0.0	0.0	0.0	31
Grocery	14.8	9.5	15.0	7
Health Services	0.0	0.0	0.0	8
Hospital	0.0	0.0	0.0	10
Institution	0.0	0.0	0.0	18
Office	0.0	0.1	0.0	16
Other	0.0	0.0	0.0	4
Residential/Lodging	0.0	0.0	0.0	7
Retail	2.5	3.4	0.0	34
Warehouse	0.3	0.7	0.0	19

Table C-6 Domestic Hot Water EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.0	0.0	0.0	6
College	0.4	0.5	0.0	3
Education	0.2	0.5	0.0	31
Grocery	0.0	0.0	0.0	7
Health Services	0.0	0.2	0.0	8
Hospital	0.0	0.0	0.0	10
Institution	0.4	0.7	0.0	18
Office	0.7	0.4	0.9	16
Other	0.6	0.7	0.9	4
Residential/Lodging	0.0	0.0	0.0	7
Retail	1.1	0.8	1.8	34
Warehouse	0.5	0.7	0.1	19

Table C-7 Interior Lighting EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	4.6	1.9	4.2	6
College	3.1	0.8	2.8	3
Education	3.3	1.0	3.1	31
Grocery	10.8	3.3	12.2	7
Health Services	4.3	1.4	5.2	8
Hospital	7.3	2.3	7.7	10
Institution	4.8	1.8	5.0	18
Office	3.4	2.1	3.3	16
Other	2.9	1.4	3.0	4
Residential/Lodging	4.4	3.4	3.0	7
Retail	8.2	2.6	8.5	34
Warehouse	3.6	2.3	2.5	19

Table C-8 Exterior Lighting EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.6	0.5	0.5	6
College	0.6	0.2	0.6	3
Education	0.6	0.7	0.2	31
Grocery	0.9	0.5	0.9	7
Health Services	0.4	0.3	0.2	8
Hospital	0.3	1.1	0.0	10
Institution	1.1	2.4	0.4	18
Office	1.9	3.1	1.0	16
Other	0.1	0.0	0.1	4
Residential/Lodging	0.4	0.4	0.3	7
Retail	1.5	0.8	1.4	34
Warehouse	7.7	10.1	0.4	19

Table C-9 Other EUI (kWh/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	4.6	4.2	3.7	6
College	6.4	3.3	6.8	3
Education	3.4	1.9	2.9	31
Grocery	16.6	19.1	14.9	7
Health Services	6.0	4.5	4.3	8
Hospital	10.5	4.8	8.3	10
Institution	5.4	3.0	6.7	18
Office	8.8	2.8	9.3	16
Other	10.0	4.6	8.9	4
Residential/Lodging	1.6	1.6	1.8	7
Retail	6.5	4.4	6.1	34
Warehouse	1.0	2.8	0.0	19

Table C-10 Gas Total EUI (th/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.4	0.2	0.4	6
College	0.2	0.1	0.2	3
Education	0.3	0.2	0.3	31
Grocery	0.6	0.3	0.6	7
Health Services	0.7	0.5	0.4	8
Hospital	1.1	0.4	1.0	10
Institution	0.2	0.2	0.1	18
Office	0.1	0.1	0.1	16
Other	0.2	0.1	0.2	4
Residential/Lodging	0.2	0.1	0.2	7
Retail	0.2	0.2	0.2	34
Warehouse	0.1	0.2	0.1	19

Table C-10 Gas Heat EUI (th/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.2	0.2	0.3	6
College	0.2	0.1	0.2	3
Education	0.2	0.1	0.3	31
Grocery	0.4	0.2	0.4	7
Health Services	0.3	0.2	0.4	8
Hospital	0.4	0.3	0.2	10
Institution	0.1	0.2	0.0	18
Office	0.1	0.1	0.1	16
Other	0.2	0.1	0.2	4
Residential/Lodging	0.1	0.1	0.1	7
Retail	0.2	0.1	0.2	34
Warehouse	0.1	0.1	0.1	19

Table C-10 Gas Hot Water EUI (th/sf), Valid Runs Only

Building Type	Mean	Std. Dev.	Median	N
Assembly	0.2	0.1	0.2	6
College	0.0	0.1	0.0	3
Education	0.1	0.0	0.1	31
Grocery	0.2	0.2	0.1	7
Health Services	0.4	0.3	0.3	8
Hospital	0.7	0.4	0.7	10
Institution	0.1	0.1	0.0	18
Office	0.0	0.0	0.0	16
Other	0.0	0.0	0.0	4
Residential/Lodging	0.2	0.1	0.2	7
Retail	0.1	0.1	0.0	34
Warehouse	0.0	0.2	0.0	19