2018 Building Performance Analysis Conference and
SimBuild co-organized by ASHRAE and IBPSA-USA
Chicago, IL
September 26-28, 2018

INFLUENCE OF PLUG AND PROCESS LOADS AND OCCUPANCY ON ULTIMATE ENERGY SAVINGS – A NEW APPROACH

Roger Chang[1], Drury B Crawley[2]
[1]DLR Group, Washington, DC
[2]Bentley Systems, Washington, DC

ABSTRACT

The energy utilization index (EUI) is commonly used to describe a building's energy performance. But this index has significant shortcomings because it does not address space utilization, occupant density, plug or process loads. This paper explores a bottom-up approach for energy benchmarking, both for design optimization and portfolio analysis, utilizing a concept known as energy usage effectiveness (EUE). EUE is the ratio of a building's total energy use divided by an adapted calculation of unregulated process energy use. We started by evaluating benchmark EUE values using all 16 DOE Commercial Prototype Buildings for ASHRAE Standard 90.1-2013 for the full range of ASHRAE climate zones. In this paper, we compare EUE to calculated EUI to highlight correlations and divergences. We explore normalized and non-normalized approaches to treatment of unregulated process loads and the impact of significant variation in these loads on EUE. This includes the impact of occupant density and corresponding ventilation rates. We also compare how these results relate to the Standard 90.1 building performance factor methodology. As outcome-based energy code compliance pathways are introduced, there is a need for target setting for code compliance and stretch energy codes that ultimately scale to building utilization, rather than fixed values most commonly tied to the 2003 and 2012 Commercial Buildings Energy Consumption Survey.

INTRODUCTION

With an ever increasing focus on low-energy buildings, energy benchmarking has become even more importantg. The predominant metric for benchmarking commercial office building energy use continues to be the energy utilization index (EUI). Use of EUI alone can mask poor performance, as the metric does not explicitly capture variation due to a partially occupied building or a building with a low net-to-gross floor area ratio.

Low-energy buildings require the participation of an engaged occupant group to realize process energy use savings. Yet, there is also a need to achieve energy efficiency without compromising user productivity.

Benchmarking often starts with an EUI target, either determined using the EPA's ENERGY STAR Target Finder (ENERGY STAR 2018) or based on the Architecture 2030 challenge framework (Architecture 2030 2018). What if we built targets starting with a building's process load? Although there is some movement within ASHRAE Standard 90.1 and California's state energy code (T24) to regulate these loads, they are typically d unregulated, leaving them to be a point of focus later in a design process than they should be.

Based on a recent high-performance building project, the design team found that ASHRAE standard utilization schedules had poor correlation to measured process load energy use profiles (Chang 2014). When tenants were questioned about their use, they became frustrated at being encouraged to reduce equipment energy use that would t compromising function. In interacting with tenants over an 18-month period we were brought to a new way of viewing energy use. What if design teams focused on a building level coefficient of performance, in addition to EUI?

This work builds on previous research utilizing pre-computed results from the DOE Commercial Prototype Buildings (pre-1980, post-1980, 90.1-2004). This past research focused on the impact of building vintage on EUE, across all 16 prototype buildings for all climate zones. Generally, lower EUEs were evident for newer buildings (Chang 2015). The past work did not study the impact of variation of process load.

EUE METRIC DEFINITION

The proposed metric is termed energy usage effectiveness (EUE), the ratio of building energy use divided by process energy use. This metric has similarities to the Power Usage Effectiveness (PUE) metric used for data centers (Avelar 2012), but with broader application to a wide range of commercial buildings. The intent is to focus on annualized energy use, rather than power demand.

Total Building Energy Use
Regulated by ASHRAE Standard 90.1 (Enclosure, Lighting, Service Hot Water, HVAC) + Process Energy

÷

Total Process Energy Use
Typical Items: Computers, Printing Equipment, Machine Tools, Medical Equipment, Specialty Lighting*

*Some debate exists over what should be counted as process energy use. For example, elevators, escalators, and lavatory service hot water could be interpreted as not directly contributing to the core function of a commercial entity.

The EUE can be used to start setting targets for a range of buildings, with an emphasis on office buildings. It is conjectured that this methodology is not as suitable for building types with a significant amount of ventilation driven process requirements, such as hospitals, restaurants, and laboratories. The EUE metric is intended to capture demand reduction measures; on-site renewable energy production would be excluded from the metric.

TEST CASES

We explored the EUE concept using parametric energy simulation using the ASHRAE 90.1-2013 DOE Commercial Reference Building Models and EnergyPlus v8.8. We intended to use the latest available ASHRAE 90.1 reference standard, the 90.1-2016 reference models were not available as expected during the period of this research work.

Our intent was to observe correlations between EUE and EUI and determine a reasonable range for EUE across 4 major building types: medium office, large office, secondary school, and high-rise residential. WE created eight permutations from the standard models:

- Process Load 1 (P1): 25% of reference model
- Process Load 2 (P2): 50% of reference model
- Process Load 3 (P3): 150% of reference model
- Occupancy Load (O1): 25% of reference model, no ventilation rate adjustment
- Occupancy Load 2 (O2): 50% of reference model, no ventilation rate adjustment
- Combination 1 (C1): Occupancy, Ventilation, and Process Load at 25% of reference model
- Combination 2 (C2): Occupancy, Ventilation, and Process Load at 50% of reference model.

Cases P1, P2, and P3 allow us to evaluate the impact of process load density on EUE and EUI. With a baseline process load density of 1 W/ft^2, permutations at 0.25, 0.50, and 1.5 W/ft^2 reflect the typical range of values for modern office environments developed through ASHRAE RP-1742 (Sarfraz 2018).

Cases O1 and O2 allow an independent study of the impact of differences of occupant density alone on EUE and EUI. This represents the increasing occupant densification of spaces in existing buildings, with no additional ventilation control management and process load as a neutral variable.

Cases C1 and C2 represent trends in high-performance building design and operation, where systems, including process loads scale in parallel with occupant load.

We started with the three hypotheses:

- EUE values would be lower for a given building type in less extreme climate zones. While climate normalized data is often referenced, it generally makes sense that it is more energy intensive to operate a building in certain climate zones. The PUE concept for data centers has shown the incredible benefits of building these centers in climates with a significant number of economizer cooling hours (High-Performance PUE = 1.0 to 1.2).
- There would be a correlation between EUE and EUI, with a fixed process load. EUE is better suited for office and education building types, where ventilation driven processes are non-dominant.
- Results plotted for a given building type and climate zone would show non-linear behavior for the two Occupancy Load cases and for the two Combination cases. The research would evaluate whether there are any clear trends for inflection points in the trend data, showing the potential for optimization.

RESULTS

We present the results in tabular and plotted formats below. Tables 1 and 2 present benchmark EUE and EUI values, respectively, for ASHRAE Standard 90.1-2013 reference cases. These are based on simulation results pre-computed and available at https://www.energycodes.gov/development/commercial/prototype_models.

EUE exhibits a wide range from a low of 1.5 for a large office in Climate Zone 3C to a high of 18.2 for a Strip Mall retail typology in Climate Zone 8. The results show that very different building types, with very different EUI ranges can have similar EUE ranges, as further seen in Figure 1.

Figure 2 presents what happens when EUE is multiplied by EUI (EUEI) for each climate zone and building type. A higher value indicates more opportunity for regulated energy savings optimization.

Figure 4 and 5 present EUI and EUE data utilizing averaged results across all climate zones for the medium office. At low normalized process load, the EUE increases, with a higher increase for case P1 versus C1. The EUE associated with case C1 begins to reflect how well a building and its subsystems reacts to reduced load demand.

Figure 6 presents EUE results for all climate zones and modeling cases for the medium office and show the significant influence of climate on the EUE metric.

Table 3 represents all EUE data points for the medium office. Table 4, 5, and 6 represent ranges, means, and normalized values of EUI and EUE for all modeling cases by building type and option. The large office building shows the least amount of sensitivity to change in process load density.

DISCUSSION

The analysis was intended to provide data which can be further built upon and considered for a wide variety of applications. The results show that there may be an inherent issue with optimizing energy codes around fixed process load assumptions, particularly for buildings dominated by lighting and process load heat gain. Between these two components alone, the total power density has generally decreased from 4 to 0.75 W/ft^2 over the past twenty years.

EUE may be utilized for preliminary design target setting. Assume that a building has an average process load of 0.5 W/ft^2 over a typical year. This would equate to a process load EUI of 15 kBtu/y-ft^2 (47.3 kWh/y-m^2). A building with an EUE of 3.0 would theoretically not be able to have an overall EUI any lower than 45 kBtu/y-ft^2 (142 kWh/y-m^2). This allows modelers to set realistic targets, before any energy modeling is performed, for a typical building type in a specific ASHRAE climate zone.

The National Renewable Energy Laboratory has developed useful guidance for evaluating process loads, based on daytime and nighttime demand for one of their high-performance office buildings (Lobato 2011). By using these in conjunction with EUE ranges, modelers can easily set targets for buildings both during design and operation phases. An EUE of one 1.0 ultimately represents a building with no unregulated energy use—a building that could be wholly passively conditioned and lit.

BUILDING PERFORMANCE FACTOR ALIGNMENT

The building performance factor methodology was introduced within addendum BM to ASHRAE Standard 90.1-2013, with the intent of allowing for a stable baseline for performance based compliance indexed to a ASHRAE 90.1-2004 level of stringency. This approach significantly reduces the challenge of energy simulation baseline workflows that change with each new standard cycle. The BPF methodology allows simple differential factors by building type and climate zone to be updated as stringency increases. A recent study (Chang 2017) shows the inherent difficulty in setting target EUIs using this methodology, because it uses a process load neutral approach. While normalized scales, like the zEPI (NBI 2018), seek a simpler presentation of relative stringency of different standard versions, there is not a mechanism to scale EUI targets to accommodate varying process loads. A high process load office building designed to 90.1-2013 would not have the same EUI target as a low process load building, but both have a zEPI of 54 and a BPF of 0.65. Future outcome-based codes must address this to be fair. It is better for a building to have a higher EUI, due to high occupant density, than one that as an artificially low EUI due to limited occupancy. The EUE factor may be a way to adapt EUIs for a range of process load intensity.

APPLICATION

EUE is applicable across the full building life-cycle, including planning, design, commissioning, and operation phases.

- Planning: a EUE target can be set using the pre-computed values presented in Table 1. The EUE target would be less than these values.
- Design: EUE may be easily calculated from whole building energy simulation results and viewed in conjunction with EUI, either alone or as a multiplier (EUE x EUI). An increasingly low EUE x EUI value represents

a design that has been optimized for both regulated and unregulated energy.

- Commissioning/operations: tracking real-time EUE may allow optimization of system operation for improved part-load performance.
- Outcome-based code frameworks: a building's target EUI may be viewed in conjunction with EUE, where measured process load energy x EUE can be used to set adjusted EUI targets.

CONCLUSION

This study presents pre-computed data that can be referenced by design and operations teams for benchmarking. The use of the EUEI metric shows potential for unregulated load optimization across climate zones and building types. We are considering additional sensitivity analyses for office buildings, to inform its implementation in outcome-based energy code compliance pathways.

ACKNOWLEDGMENT

Special thanks to the District of Columbia Department of Environment for its work on adoption of the International Green Construction Code and its introduction of an outcome-based code compliance pathway. That became the major inspiration for this research.

REFERENCES

Architecuture 2030, http://architecture2030.org/2030_challenges/2030-challenge/, 2018

Avelar, V., Azevedo, D., French, A., PUE: A Comprehensive Examination of the Metric, 2012. ASHRAE, High-Performance Building Magazine, Multiple Issues (Summer 2011, Winter 2011, Fall 2012, Winter 2013, Fall 2014, Spring 2014, Summer 2014, Spring 2015, Winter 2015).

Chang, R., Landmark Resurrection, ASHRAE High-Performance Building Magazine, Summer, 2014.

Chang, R., Energy Utilization Effectiveness (EUE): A New Metric for Commercial Building Energy Use Characterization, ASHRAE Winter Conference, 2016.

ENERGY STAR, https://www.energystar.gov/buildings/tools-and-resources/target-finder-0, 2018

Lobato, C., Pless S., Sheppy M., Torcellini. Reducing Plug and Process Loads for a Large Scale, Low Energy Office Building: NREL's Research Support Facility, ASHRAE Winter Conference, 2011.

New Buildings Institute, https://newbuildings.org/code_policy/zepi/, 2018

Rosenberg, M., Hart R., Developing Performance Cost Targets for ASHRAE Standard 90.1 Appendix G – Performance Rating Method, February 2016.

Sarfraz, O., Bach C., Wilkins C. Plug Load Design Factors, ASHRAE Journal, January 2018.

Zhao, J, Yun, R., Lasternas, B., Wang, H., Lam, K.P., Aziz, A., Loftness, V., Occupant Behavior and Schedule Prediction Based on Office Appliance Energy Consumption Data Mining, CISBAT, 2013.

Climate Zone	Hi-Rise Apt	Mid-Rise Apt	Hospital	Lg Hotel	Sm Hotel	Lg Off	Med Off	Sm Off	Outpt Clinic	Fast Food	Restaurant	Std Alone Retail	Strip Mall	Primary School	Secondary School	Warehse
1A	3.6	2.9	3.3	3.6	2.8	1.9	2.7	3.7	2.7	1.7	2.0	6.3	9.2	2.8	3.5	4.5
2A	3.4	2.8	3.2	3.5	2.7	1.8	2.6	3.6	2.6	1.8	2.1	6.1	9.5	2.8	3.3	5.1
2B	3.6	2.9	3.0	3.3	2.7	1.9	2.6	3.8	2.5	1.8	2.1	6.7	9.8	2.7	3.4	6.3
3A	3.7	3.0	3.3	3.4	2.7	1.8	2.6	3.6	2.6	2.0	2.2	6.0	9.9	2.9	3.2	6.2
3B	3.3	2.8	3.0	3.1	2.6	1.8	2.4	3.5	2.3	1.8	2.1	6.2	8.9	2.4	3.1	5.6
3C	2.8	2.5	2.9	2.9	2.5	1.5	2.0	3.1	2.1	1.9	2.0	5.0	7.6	2.3	2.7	6.0
4A	3.8	3.1	3.3	3.3	2.8	1.8	2.5	3.4	2.5	2.1	2.8	5.9	10.4	2.9	3.0	7.2
4B	3.5	2.9	3.0	3.1	2.7	1.8	2.3	3.5	2.3	1.9	2.2	6.2	10.1	2.6	3.2	6.4
4C	3.5	2.9	3.0	3.1	2.6	1.7	2.3	3.3	2.2	2.0	2.3	6.1	9.5	2.6	3.3	6.8
5A	4.3	3.5	3.4	3.4	2.9	2.0	2.8	3.4	2.5	2.3	2.6	6.2	12.0	3.0	3.1	9.2
5B	3.7	3.1	3.1	3.2	2.7	1.8	2.4	3.6	2.3	2.1	2.4	6.7	10.2	2.7	3.5	7.2
5C	3.6	3.0	3.1	3.1	2.7	1.7	2.3	3.2	2.2	2.1	2.4	6.2	10.1	2.6	2.9	7.4
6A	4.3	3.5	3.4	3.4	3.0	2.0	2.8	3.5	2.5	2.4	2.8	6.3	12.6	3.0	3.0	9.6
6B	3.9	3.3	3.2	3.3	2.9	1.9	2.6	3.5	2.4	2.3	2.6	6.1	11.4	2.8	2.9	8.4
7	4.8	3.9	3.5	3.5	3.2	2.1	2.5	3.9	2.6	2.7	3.1	6.8	14.1	3.2	3.2	13.0
8	5.6	4.6	3.8	4.3	3.6	1.8	3.1	4.8	3.0	3.2	3.8	8.4	18.2	4.1	4.3	13.1

Table 1 Benchmark EUE Values (ASHRAE 90.1-2013)

Climate Zone	Hi-Rise Apt	Mid-Rise Apt	Hospital	Lg Hotel	Sm Hotel	Lg Off	Med Off	Sm Off	Outpt Clinic	Fast Food	Restaurant	Std Alone Retail	Strip Mall	Primary School	Secondary School	Warehse
1A	45.7	41.6	124.9	96.2	59.1	73.5	35.9	31.0	125.9	485.6	316.8	46.6	49.8	53.7	46.7	11.3
2A	43.7	40.5	123.6	92.3	57.9	69.9	34.2	29.9	121.4	518.5	331.3	45.1	51.3	53.6	43.0	12.8
2B	45.3	42.2	116.0	89.1	57.5	71.2	35.0	31.2	116.2	507.5	332.9	49.5	52.9	51.3	44.9	15.7
3A	46.8	43.0	124.2	92.2	58.6	70.9	34.4	29.5	119.9	558.6	355.0	44.5	53.4	55.0	42.3	15.5
3B	42.2	40.1	115.1	83.5	56.1	69.0	31.2	29.3	108.1	514.8	331.2	45.6	48.0	47.0	41.4	13.9
3C	36.1	35.6	109.0	77.4	53.6	59.3	26.4	25.9	100.0	523.0	324.2	37.1	41.2	43.7	36.0	14.9
4A	48.1	44.7	124.7	87.9	59.7	71.0	33.5	28.2	114.5	584.8	441.2	43.7	56.0	55.4	39.9	18.0
4B	44.5	42.0	112.6	83.2	57.0	69.0	30.8	28.8	106.6	538.4	341.4	46.0	48.0	48.0	42.6	15.8
4C	44.5	41.9	115.2	82.8	56.8	63.8	30.2	27.3	103.8	568.7	368.3	44.8	51.3	49.8	43.3	16.9
5A	54.0	49.7	127.8	91.3	63.2	75.1	37.0	28.5	116.8	645.8	418.4	45.7	64.6	57.4	40.7	22.8
5B	47.2	44.3	118.9	85.1	58.6	69.3	32.0	29.8	107.2	591.9	378.8	49.3	54.9	51.4	46.7	17.9
5C	45.2	42.8	116.3	83.0	57.3	63.8	30.4	26.9	102.8	589.8	381.6	45.7	54.3	49.4	38.2	18.4
6A	54.9	50.9	128.9	91.6	64.4	76.0	37.3	29.5	117.3	678.2	441.2	46.3	67.9	58.5	40.0	23.9
6B	50.1	47.3	121.5	88.1	61.7	74.1	34.3	29.2	111.1	650.1	417.8	45.0	61.3	53.9	38.5	20.8
7	61.1	56.1	131.7	94.7	68.6	79.4	33.6	32.1	121.1	750.3	489.8	49.9	75.9	61.8	41.7	32.3
8	70.5	65.4	146.3	114.6	78.0	69.4	41.5	39.6	140.6	908.9	601.4	61.9	98.2	79.4	56.9	32.4

Table 2 Benchmark EUI Values (ASHRAE 90.1-2013, kBtu/y-ft^2)

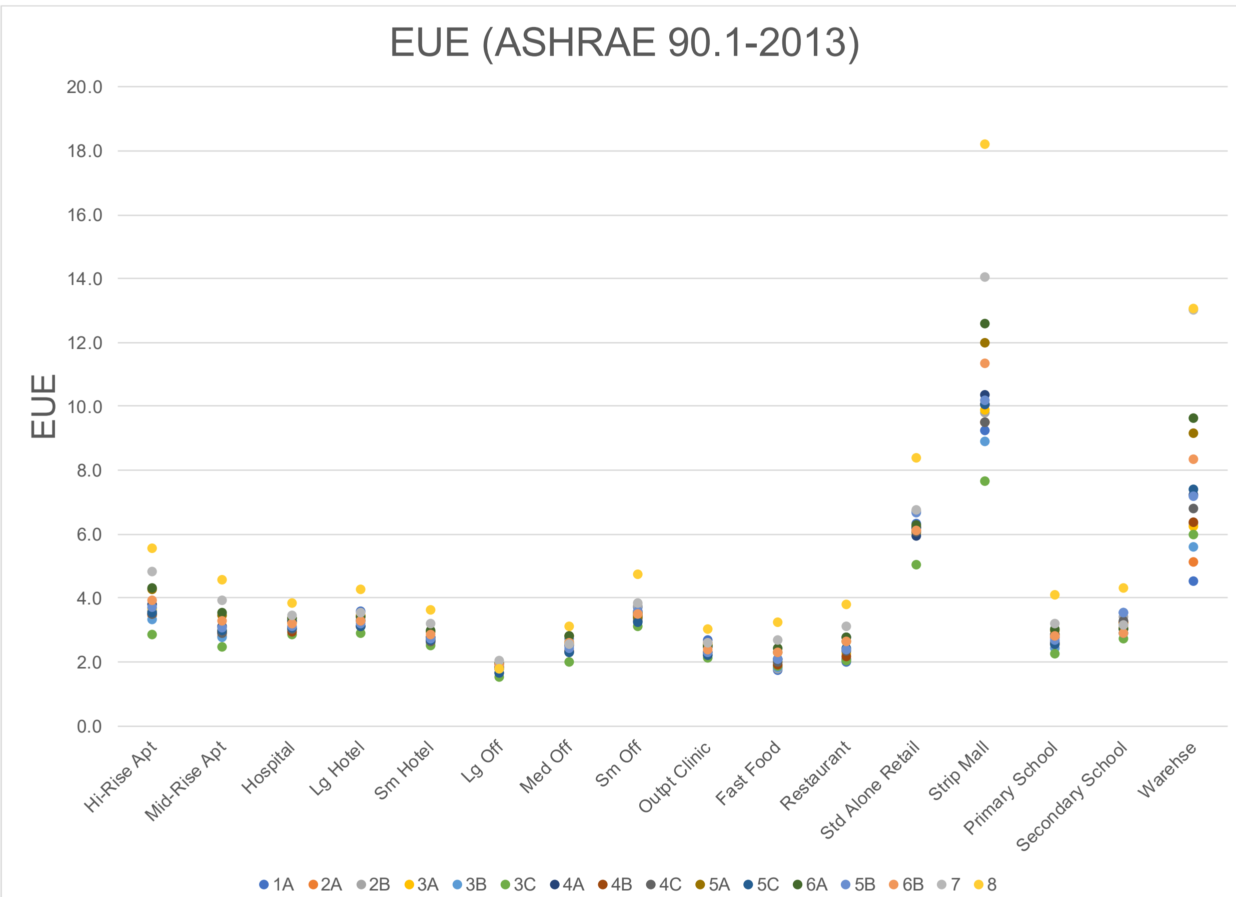


Figure 1 Benchmark EUE Values (ASHRAE 90.1-2013)

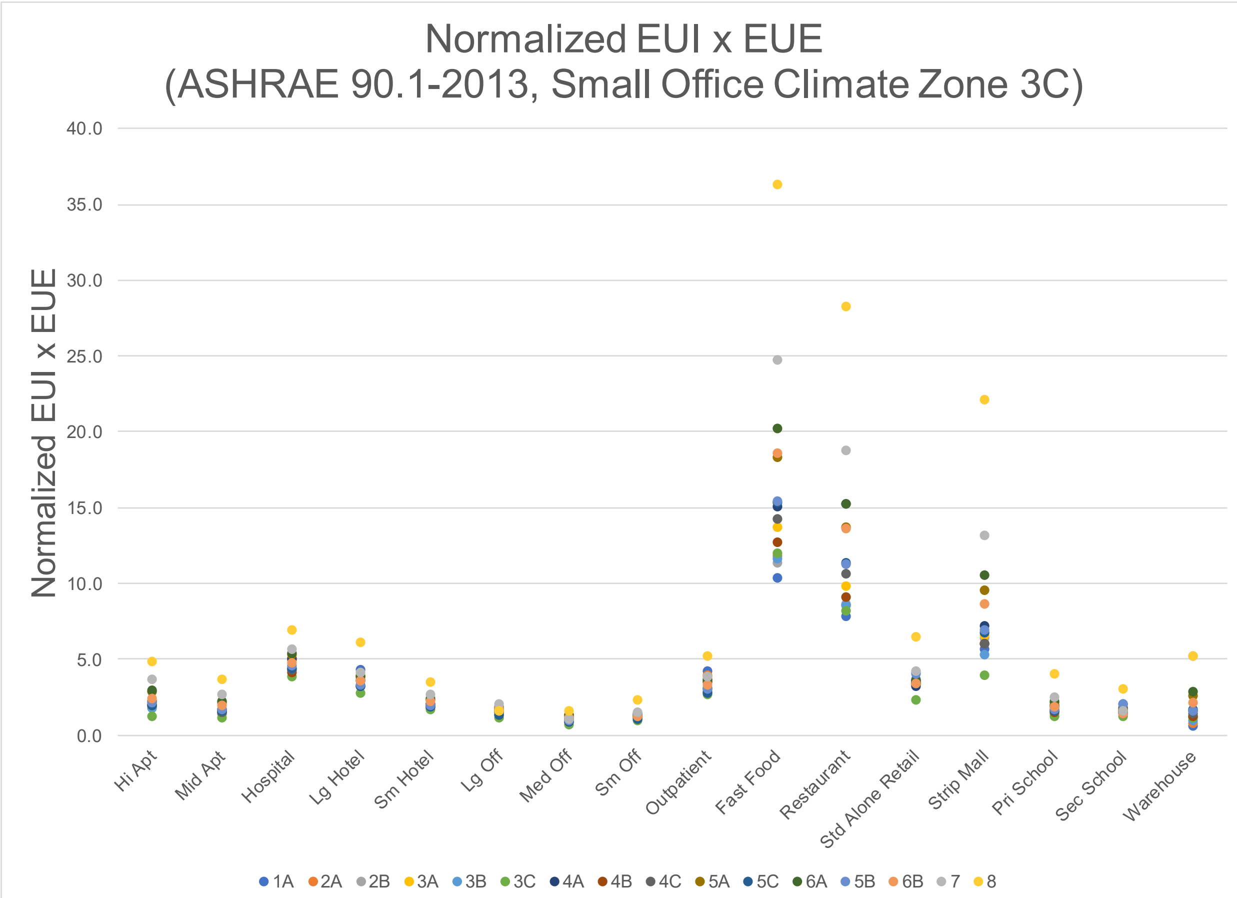
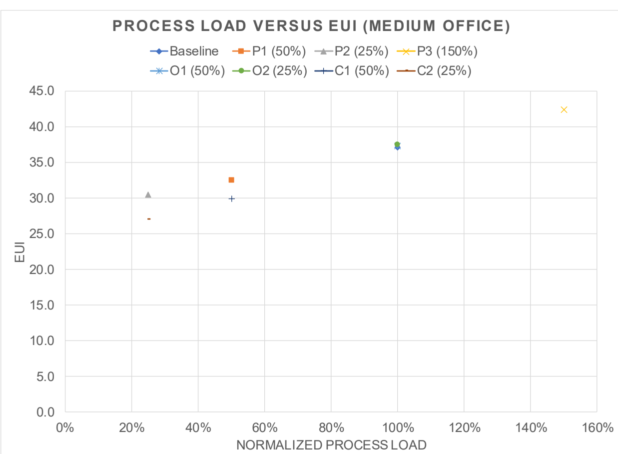


Figure 2 Benchmark EUI x EUE Values (ASHRAE 90.1-2013)



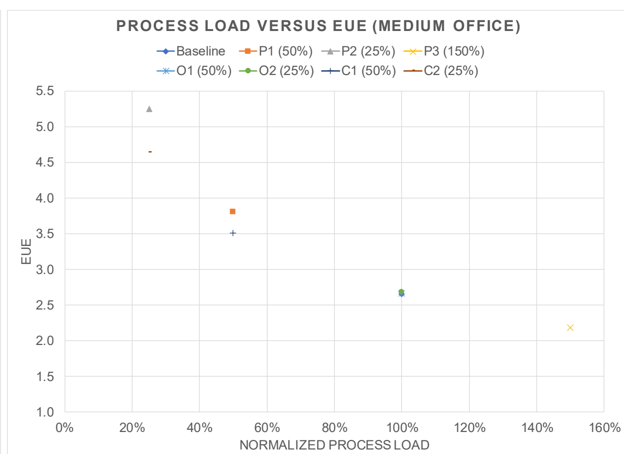


Figure 4 (LEFT) Process Load versus EUI for Medium Office Cases (Averaged Across Climate Cases)
Figure 5 (RIGHT) Process Load versus EUE for Medium Office Cases (Averaged Across Climate Cases)

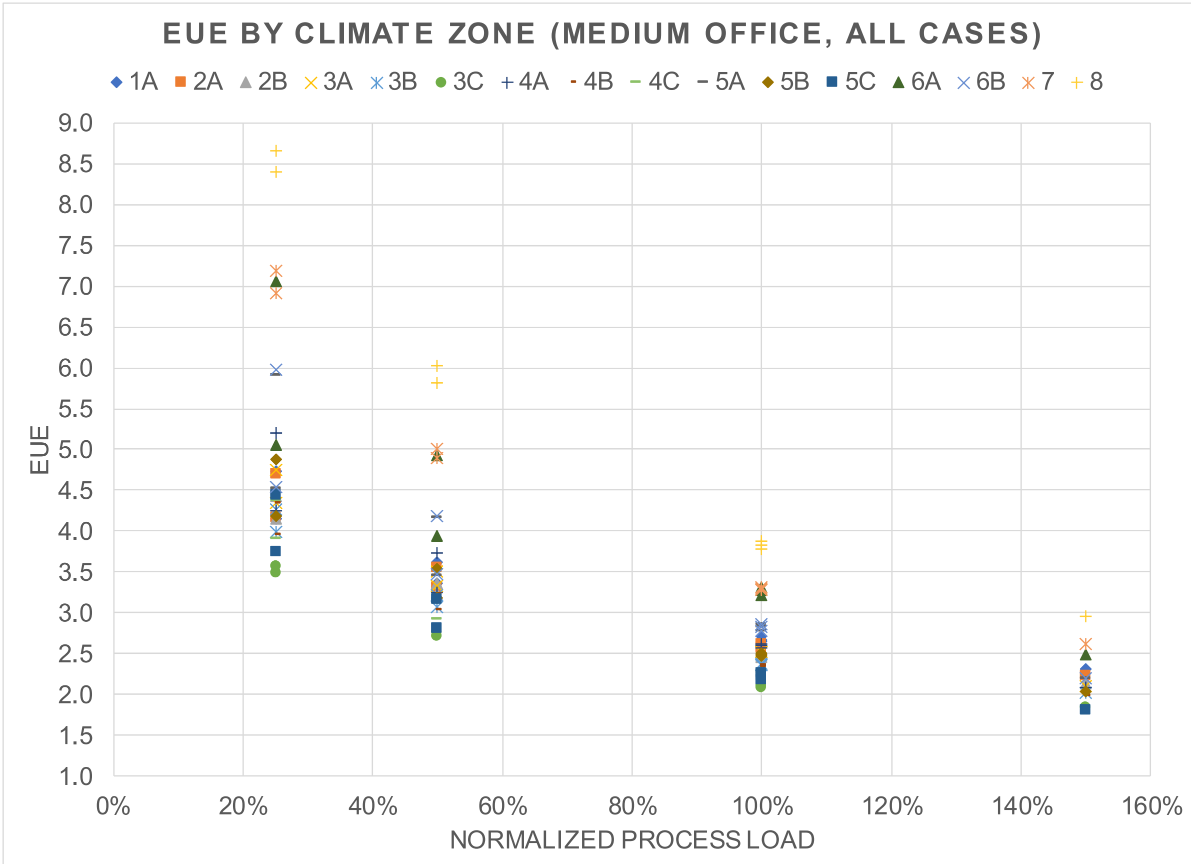


Figure 6 Process Load versus EUE for Medium Office Cases with All Cases and Climate Zones

EUE Results	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Baseline	2.7	2.6	2.5	2.5	2.4	2.1	2.6	2.3	2.2	2.8	2.5	2.2	3.2	2.8	3.3	3.8
P1 (50%)	3.6	3.5	3.4	3.5	3.2	2.8	3.7	3.2	3.2	4.2	3.5	3.2	4.9	4.2	4.9	5.8
P2 (25%)	4.7	4.7	4.4	4.7	4.3	3.6	5.2	4.3	4.4	5.9	4.9	4.4	7.1	6.0	6.9	8.4
P3 (150%)	2.3	2.2	2.1	2.1	2.0	1.8	2.1	2.0	1.8	2.2	2.0	1.8	2.5	2.2	2.6	2.9
O1 (50%)	2.7	2.6	2.5	2.5	2.4	2.1	2.6	2.3	2.3	2.8	2.5	2.2	3.3	2.8	3.3	3.8
O2 (25%)	2.6	2.6	2.5	2.5	2.4	2.1	2.6	2.4	2.3	2.9	2.5	2.3	3.3	2.9	3.3	3.9
C1 (50%)	3.4	3.3	3.2	3.3	3.1	2.7	3.2	3.0	2.9	3.5	3.2	2.8	3.9	3.5	5.0	6.0
C2 (25%)	4.2	4.2	4.2	4.3	4.0	3.5	4.3	3.9	3.9	4.5	4.2	3.8	5.1	4.5	7.2	8.7
25% Combined	20.3 to 50.3		55.7 to 88.3	29.1 to 56.4		26.0 to 47.0		25% Combined		3.5 to 8.7		1.7 to 2.7	6.1 to 11.9		6.5 to 11.8	

Table 3 EUE Values for Medium Office Cases for All Climate Zones

Range	**Building Type**					**Building Type**			
EUI (kbtu/yr-gsf)	Medium Office	Large Office	Multifamily	Secondary School	**EUE**	Medium Office	Large Office	Multifamily	Secondary School
Baseline	29.5 to 52.9	64.8 to 91.8	39.7 to 74.9	41.2 to 67.8	Baseline	2.1 to 3.8	1.6 to 2.3	3 to 5.6	2.9 to 4.8
50% Process	23.6 to 49.6	59.6 to 88.7	33 to 71.9	34.0 to 60.5	50% Process	2.8 to 5.8	1.7 to 2.5	4.3 to 9.4	4.6 to 8.2
25% Process	20.8 to 48.8	56.6 to 87.2	30.3 to 70.5	30.8 to 56.3	25% Process	3.6 to 8.4	1.7 to 2.7	6.4 to 14.8	7.7 to 14.2
150% Process	35.8 to 57.3	69.8 to 95	47.5 to 78.4	48.6 to 72.9	150% Process	1.8 to 2.9	1.5 to 2.1	2.5 to 4.1	2.3 to 3.5
50% Occupancy	29.3 to 53.5	65.1 to 92.5	39.5 to 76	38.7 to 63.3	50% Occupancy	2.1 to 3.8	1.6 to 2.3	2.9 to 5.7	2.7 to 4.5
25% Occupancy	29.2 to 54.2	65.3 to 92.9	39.5 to 76.5	37.8 to 62.5	25% Occupancy	2.1 to 3.9	1.6 to 2.3	2.9 to 5.7	2.7 to 4.4
50% Combined	23.2 to 51.4	58.1 to 89.3	32.5 to 62.6	31.0 to 53.5	50% Combined	2.7 to 6.0	1.6 to 2.5	4.2 to 8.2	4.2 to 7.3
25% Combined	20.3 to 50.3	55.7 to 88.3	29.1 to 56.4	26.0 to 47.0	25% Combined	3.5 to 8.7	1.7 to 2.7	6.1 to 11.9	6.5 to 11.8

Table 4 EUI and EUE Range for Medium Office, Large Office, Multifamily, and Secondary School Cases

Mean	Building Type					Building Type			
EUI (kbtu/yr-gsf)	Medium Office	Large Office	Multifamily	Secondary School	**EUE**	Medium Office	Large Office	Multifamily	Secondary School
Baseline	37.1	75.3	53.0	51.6	Baseline	2.7	1.9	4.0	3.7
50% Process	32.4	70.4	47.7	45.2	50% Process	3.8	2.0	6.2	6.2
25% Process	30.5	68.1	45.4	41.7	25% Process	5.2	2.0	9.5	10.5
150% Process	42.3	80.5	59.0	57.9	150% Process	2.2	1.7	3.1	2.8
50% Occupancy	37.3	75.4	53.3	47.9	50% Occupancy	2.7	1.8	4.0	3.4
25% Occupancy	37.4	75.4	54.4	46.5	25% Occupancy	2.7	1.8	4.0	3.3
50% Combined	29.9	69.7	44.4	38.4	50% Combined	3.5	1.9	5.8	5.2
25% Combined	27.0	67.1	40.2	33.1	25% Combined	4.6	2.0	8.4	8.3

Table 5 EUI and EUE Means for Medium Office, Large Office, Multifamily, and Secondary School Cases

Normalized	Building Type					Building Type			
EUI (kbtu/yr-gsf)	Medium Office	Large Office	Multifamily	Secondary School	**EUE**	Medium Office	Large Office	Multifamily	Secondary School
Baseline	100%	100%	100%	100%	Baseline	100%	100%	100%	100%
50% Process	87%	93%	90%	79%	50% Process	141%	105%	155%	165%
25% Process	82%	90%	86%	73%	25% Process	196%	105%	238%	281%
150% Process	114%	107%	111%	102%	150% Process	81%	89%	78%	76%
50% Occupancy	100%	100%	101%	84%	50% Occupancy	100%	95%	100%	92%
25% Occupancy	101%	100%	103%	81%	25% Occupancy	100%	95%	100%	89%
50% Combined	81%	93%	84%	68%	50% Combined	130%	100%	145%	143%
25% Combined	73%	89%	76%	58%	25% Combined	174%	105%	210%	227%

Table 6 EUI and EUE Normalized Values to Baseline for Medium Office, Large Office, Multifamily, and Secondary School Cases