MEMO: EUI Target Recommendations for the Washington Building Performance Standard

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GLOSSARY OF TERMS & ACRONYMS

BPA	Bonneville Power Administration
BPS	Building performance standard
CBECS	Commercial Buildings Energy Consumption Survey
CBSA	Commercial Building Stock Assessment
DOAS	Dedicated outside air system
ERV	Energy recovery ventilation
EUI	Energy use intensity
EUIt	Energy use intensity target
GHG	Greenhouse gas
HB	House bill
HVAC	Heating, Ventilation, and Air Conditioning
LED	Light emitting diode
LPD	Lighting power density
RTF	Regional Technical Forum
RTU	Roof top unit
SF	Square feet
TSPR	HVAC Total System Performance Ratio
WSEC	Washington State Energy Code
VAV	Variable air volume

INTRODUCTION

Washington's Clean Buildings Act (HB 1257) directs the Washington Department of Commerce (Commerce) to establish energy use intensity (EUI) targets for commercial buildings larger than 50,000 sf as part of a new mandatory building performance standard (BPS) scheduled to go into effect starting in 2026. The EUI target setting process for the BPS has been informed by:

- Washington State's recently passed statutory 2030 GHG reduction targets (HB 2311).
- Public input throughout the pre-rulemaking process during winter/spring 2020.
- Review of cost-effective measures and design strategies that are readily available, supported by utility programs, and in some cases already current practice and/or required by the Washington State Energy Code (WSEC) for both new and existing buildings.

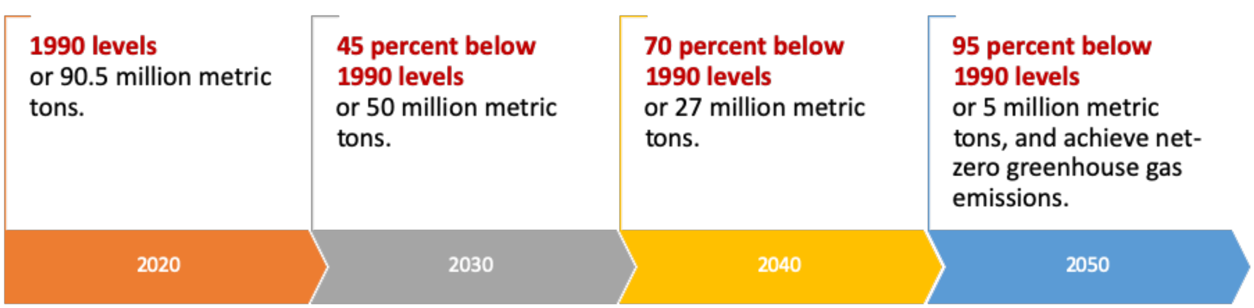
This memo discusses these target setting considerations and recommends EUI reduction ratios for existing building EUI targets and newer construction EUI targets.

ENERGY AND GHG REDUCTION GOALS

In developing the BPS, HB 1257 directs Commerce to maximize reductions of greenhouse gas (GHG) emissions from the building sector and to use ASHRAE Standard 100 as an initial model for the standard. In addition, the EUI targets cannot be greater than the average EUI for each covered commercial building type, thereby creating an upper limit to the EUI targets allowable under the law.

There are a number of ways to maximize reductions of GHG emissions as a key criterion for designing the EUI targets. Although, Washington has not identified sector specific GHG reduction targets, the economywide statutory targets included HB 2311 imply aggressive reductions in GHG emissions across the economy overall. The incremental economywide targets through 2050 are presented in the figure below.

Figure 1. Washington State Statutory GHG Reduction Goals (HB 2311)



According to HB 1257 “buildings represent the second largest source of greenhouse gas emissions in Washington and emissions from the buildings sector have grown by fifty percent since 1990, far outpacing all other emission sources.” Therefore, building sector policies must be designed to help ensure Washington is responsive to the economywide 2030 target to reduce emissions to 45% below 1990 levels. Since commercial buildings constitute a significant percentage of the overall building sector square footage, energy use, and GHG emissions, the BPS will be a central strategy for achieving the 2030 GHG targets. The first cycle of the BPS, with compliance deadlines in 2026, 2027, and 2028 (depending on size), is the first and last opportunity for the BPS to contribute to meeting the 2030 GHG targets. The EUI targets recommended in this memo attempt to balance this time sensitive policy context surrounding the BPS with market trends and the availability of cost-effective measures and utility program support for reducing energy use and emissions in commercial buildings.

SUMMARY OF PUBLIC INPUT ON TARGET SETTING

Over a period of approximately seven months and multiple public workshops, stakeholders across a spectrum of interests contributed input on the EUI target setting objectives and process. The following list includes a high-level summary of the input as of July 2, 2020:

- Establish long-term targets aligned with statutory 2030 and 2050 GHG reduction goals.
- Require steeper reductions early, then taper.
- Include more stringent scenarios as “stretch goal targets” for jurisdictions.
- Add GHG intensity requirements.
- Address on-site gas for heating in targets.
- Set the first compliance targets at a level that impacts approximately two-thirds of the existing building stock.
- Consider removing normalizations factors, and/or setting lower targets.
- Establish lower EUI targets for newer construction that recognize Washington’s national leadership in building energy codes
- Treat recently constructed and permitted buildings as existing and apply newer construction targets to buildings built to future codes.
- Align future codes with BPS newer construction targets.
- Develop a multifamily building EUI target that is more stringent, allowing greater access for voluntary utility incentives.
- Further refine and analyze local data to better inform target setting in order to maximize energy and GHG emissions reductions.
- Establish EUI targets at least 5% below the mean level with moderate step decreases in near-term compliance periods to accelerate carbon emission reductions.

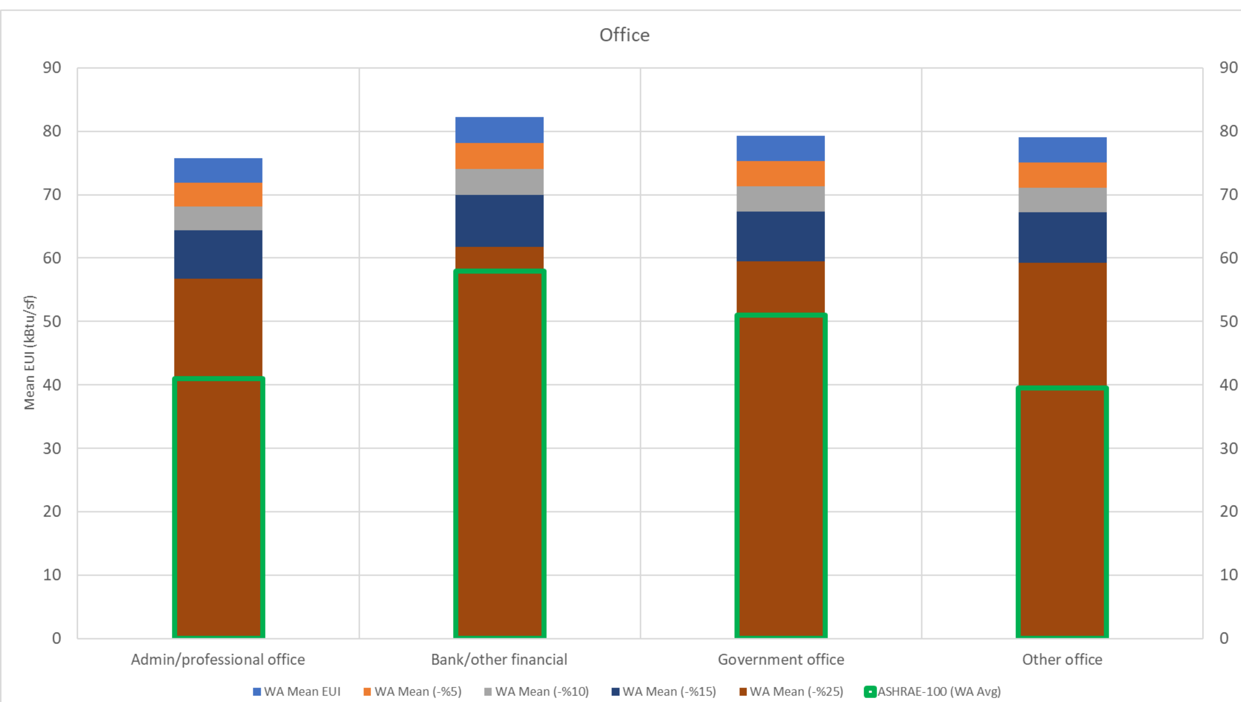
EUI TARGET SCENARIOS

To support the EUI target setting process the project team developed a continuum of possible targets by building type between the Washington average EUIs and the ASHRAE Standard 100 EUI targets. On this continuum of targets the average EUIs are the upper bound for the EUI targets (as per HB 1257) and the ASHRAE Standard 100 targets are assumed to be the lower bound since they constitute the "initial model" for the BPS. For most building types, the Standard 100 targets are significantly lower than the average EUIs generated for the Washington state building stock. Approximately three quarters of the Standard 100 EUI targets are more than 30% less than the average EUIs developed for the current state building stock, and nearly half are more than 50% below these average Washington EUIs. Between the upper and lower bounds of the average EUIs and the Standard 100 targets, the project team developed the following four additional target scenarios:

- 5% less than average EUIs
- 10% less than average EUIs
- 15% less than average EUIs
- 25% less than average EUIs

The figure below presents these scenarios as applied to the Office building types. The full bar for each building type represents the average EUI, the stacks within the bars represent each of the progressively greater EUI reductions for the scenarios, and the bright green outline for each bar represents the Standard 100 EUI targets. The following section describes some of the key opportunities and drivers for energy reductions that can help covered commercial buildings achieve the levels of savings implied by these target scenarios.

Figure 2. Continuum of EUI Target Scenarios for Offices



KEY DRIVERS FOR ENERGY & GHG SAVINGS

To align with the Clean Buildings Act directives and the state's 2030 GHG reduction goals, the EUI targets should account for:

- Downward trends in average EUIs.
- Readily available and cost-effective technologies, measures, and design strategies.
- O&M and retuning opportunities.
- Energy codes and standards effective for existing and new buildings in Washington state.

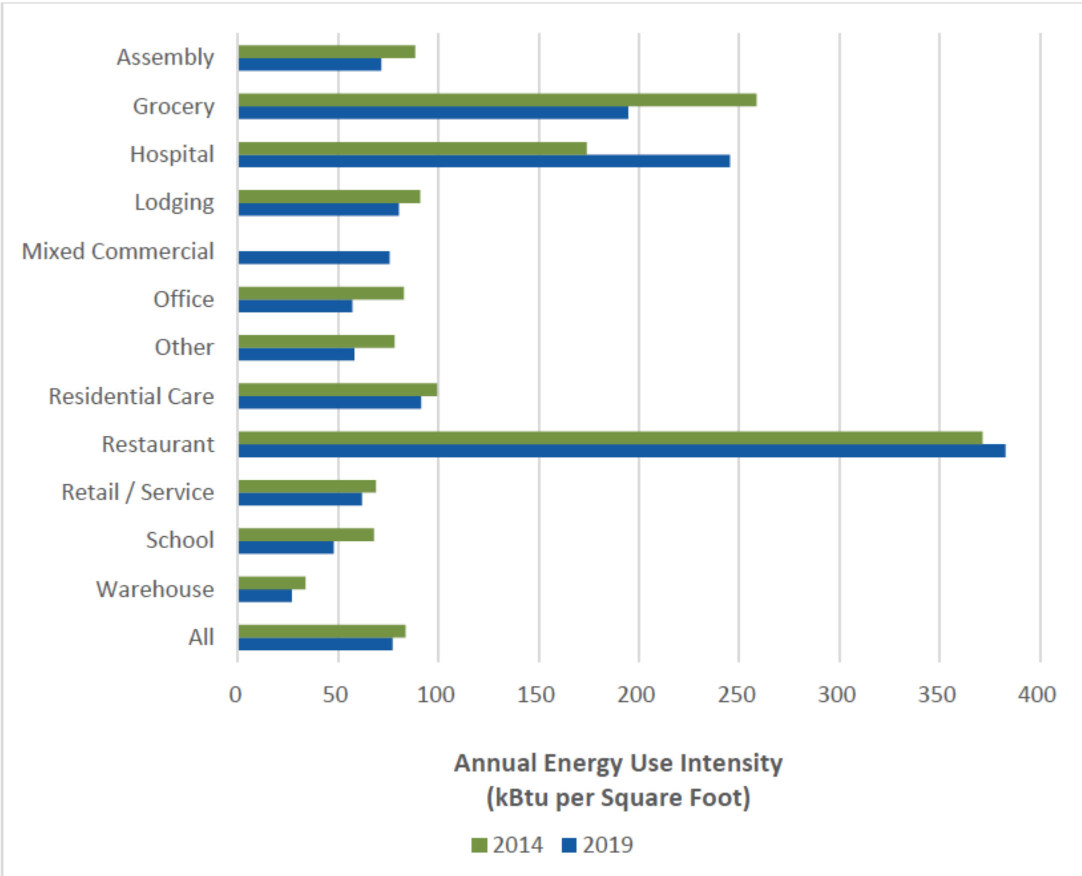
This section describes examples of key drivers for energy and GHG savings in Washington commercial buildings over the last five years and up through the first BPS compliance years in the late 2020s. The examples represent cost-effective, utility supported strategies that have been vetted by the Regional Technical Forum (RTF) and/or in energy codes and standards development processes. Therefore, they represent, a conservative estimate of potential savings and the corresponding EUI targets that can be met by leveraging relatively standard measures that simultaneously deliver high energy savings, low incremental first costs, and high lifecycle cost savings.

ACCOUNTING FOR CURRENT COMMERCIAL BUILDING STOCK DATA

The lag time in commercial building stock studies is an important consideration for establishing average EUIs and setting the EUI targets. The first BPS compliance year of 2026 is 10-20 years later than most of the building stock data available to develop average EUIs for targets at a detailed building type level. For example, the most recent national Commercial Buildings Energy Consumption Survey (CBECS) energy use data is from 2012 and most of the Northwest Commercial Building Stock Assessment (CBSA) data is from 2007 to 2014. Hence, in most cases the draft average EUIs established as a basis for the BPS EUI targets are higher than what the average EUIs likely are today or will be in 2026. Two newer datasets that were analyzed, including the 2019 CBSA and the City of Seattle 2018 benchmarking data, show generally lower EUIs than the data from the older CBSA studies.

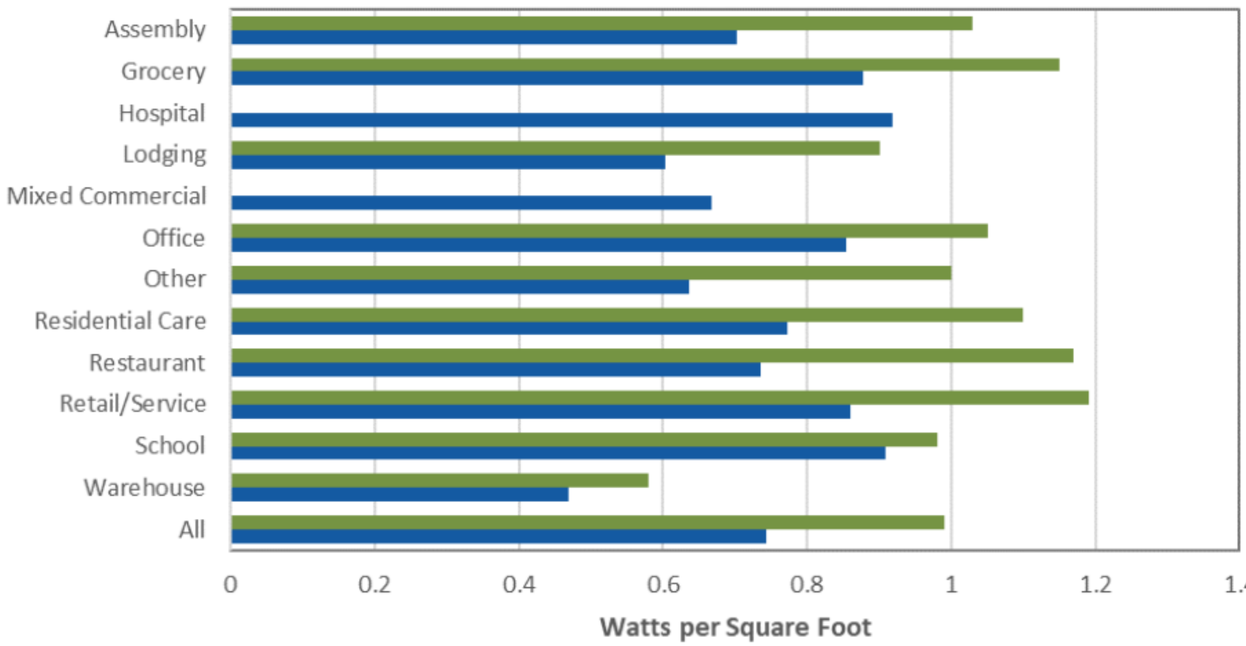
In the 2019 CBSA, the assembly, grocery, lodging, office, schools, and warehouse building categories all show a decline in EUIs between 2014 and 2019 (Figure 3). In some cases, such as offices, the decline is more than 25%. Similar EUI trends are also evident in the most recent Seattle benchmarking data, which includes energy use data from 2018. These changes indicate a nearly across-the-board shift in commercial building energy use that has not been fully accounted for in the draft average EUIs established for setting the EUI targets. The 2019 CBSA findings described below illustrate these EUI declines for specific building categories and detail some of the trends driving these changes. In order to best reflect current average EUIs in Washington State, and as a final step in the regional adjustment process, the draft average EUIs should be adjusted for key building types to better reflect trends in the 2019 CBSA and the 2018 Seattle benchmarking data.

Figure 3. EUI Reductions Between 2014 and 2019 (Cadmus, 2020)



According to the 2019 CBSA report, the declines in EUIs are mainly attributed to downward trends in electricity consumption. Nearly all building types showed significant declines in electric EUIs. The report indicates that lighting power density (LPD) decreased for all building types and that this change is largely due to a switch from lower efficiency lighting to LEDs, making lower LPDs a key driver for the downward trend in EUIs (Figure 4). According to the report, “the region’s commercial buildings have replaced existing equipment with LED lighting at an unprecedented rate,” going from 1% penetration in 2014 to 17% in 2019, a 20-fold increase in LEDs over a five-year period (Cadmus, 2020). The sections below discuss how LED lighting and other strategies are contributing to lower average EUIs in buildings today and can drive down EUIs in the future.

Figure 4. Lighting Power Density Reduction Between 2014 and 201 (Cadmus, 2020)[a]



[a]These data were not available for hospitals from the published 2014 CBSA data.

LIGHTING TRENDS

The development of draft average EUIs and targets for the BPS has mostly depended on data collected about five to thirteen years ago. For some building systems, this data reflects the existing building stock even today. The primary exception is the advent of LED lighting over the last five years. This technology has the potential to completely alter lighting practice in the commercial sector. In the 2019 CBSA published in 2020 (Cadmus, 2020) 16% of the lighting wattage was LEDs[1]. As described above, this shift was a primary determinant of the drop in lighting power between the 2019 CBSA and the previous two CBSAs.

This high saturation of LEDs has already led to a decline in EUIs below the draft average EUIs developed for this BPS study, and if this saturation rate continues at the pace observed in the 2019 CBSA we would expect to see a 50% reduction in the energy use associated with lighting systems by 2026. This trend represents a combination of utility programs and upgrades to lighting systems in the normal course of tenant and marketing cycles. RTF analysis suggests that the cost of an LED retrofit (including some fixture replacements) are about $0.20/sf for a typical commercial use.[2] Utility incentives are available from Bonneville Power Administration (BPA) and most Washington utilities and amount to about a third of these costs. Savings from such a retrofit when most lighting is changed to LEDs amounts to 5% to 15% of the entire

[1] https://neea.org/resources/cbsa-4-2019-final-report
[2] https://rtf.nwcouncil.org/measure/non-residential-lighting-midstream

energy budget. The payback period for such a retrofit is typically less than two years. From 2016 to 2018, regional utility programs supported the installation of almost 1.5 million TLED fixtures per year.[3] This volume would be enough to retrofit about 50 million square feet of commercial buildings throughout the region each year. At this pace of lighting retrofits observed in the existing building stock, about 30% of all commercial floor area would be converted by 2025.

Since the data used to develop EUI target scenarios was largely collected before 2014, the effect of these lighting retrofits and LED change outs are not represented in these data or in the final assessment of the average EUIs. Given this, the EUI targets should be adjusted to account for past and ongoing effects of adoption of LED technologies by at least 10%. This provides a significant incentive to employ LED to meet the target EUIs with a minimum of engineering support and a maximum of utility support.

TUNE-UPS TRENDS

The development of building tune-ups has shown considerable promise over the last few years. The City of Seattle, for example has required a building tune-up for all buildings over 50,000 sf. In general, the "building tune-up" is aimed at a review of the functioning of controls to optimize building performance. The ASHRAE Standard 100 (Annex L) requires all buildings to conduct a tune up review as part of the requirements of the standard.

PNNL, in 2016 evaluated a series of nationwide tune up programs (about 25% of the buildings evaluated were in Washington). This study showed the impact of building tune-ups on overall building energy use. In this study of actual buildings some exceeded 25% of the building's energy with an average savings of about 15%.[4] The actual measures in the recommendations included substantial changes in HVAC equipment and building envelope, however very few of those measures were used, with, most buildings implementing scheduling and controls upgrades. Overall, about half of the measures recommended in the re-tuning building audits were implemented. These measures were generally very low cost and require almost no added capital improvements apart from the need for skilled intervention in the existing control system. About 60% of the savings identified in the study could be attributed to these very low-cost options.

The Annex L requirements would result in a careful review of controls and settings for all buildings. It also requires an O&M review to identify worn and broken components which would be fixed in the first cycle. Based on this work, a conservative estimate of the impact of the requirements of Standard 100 for a tune-up and O&M review as part of the initial intake of the building into the program would be about 10% energy savings in the building EUI. Almost any building developing the Standard 100, Annex L review could expect this impact, and in some cases the savings could be significantly higher depending on the O&M status prior to the tuning.

[3] https://nwcouncil.app.box.com/v/20191106NEEALinearLampMemo
[4] https://buildingretuning.pnnl.gov/documents/pnnl_sa_110686.pdf.

HVAC TRENDS

OPERATION AND MAINTENANCE

New replacement equipment: In existing buildings there are significant opportunities that arise with more regular O&M actions. The Federal standards for most equipment in operation today has been enhanced in the last decade and minimum performance has been improved. Approximately 22 new standards aimed at HVAC equipment and motors have been implemented in the last decade. For example, in the last 10 years federal standards for cooling equipment has mandated an increase of almost 15% in DX cooling equipment and almost 10% in heat pump heating efficiency. The federal standard requires that all equipment manufactured after 2017 to meet these standards. In most cases these new equipment standards represent a 10% improvement over the previous requirements. While these standards do not affect the overall design of the HVAC system, they do add efficiency to older buildings when components are replaced before the systems as a whole need replacement. A change in the worn or broken equipment is often done without any other changes to the HVAC systems and controls, and are not impacted by the improved design standards in the WSEC. Even with this caveat the overall impact on building EUI would be about 5% particularly in buildings dominated by cooling requirements.

O&M upgrades: An exploration of smaller packaged "roof top units" (RTUs) showed substantial savings in adding smart controllers and adjusting or repairing worn parts such as damper motors and economizer controllers.[5] There are several systems available on the market. The RTF maintains savings and costs for upgrades to this technology.[6] For heating and cooling loads the controller and fan upgrades would save 15% of the HVAC energy with a payback of about five years. RTUs are the dominant HVAC systems in most retail buildings, regardless of size, and this equipment requires continuous maintenance to repair controls and dampers. However, they have a life expectancy of about 15 years and are easily replaced when they fail. With more advanced designs using modern fan and control technologies, the new systems can reduce their energy requirement by 30 to 50%. Moreover, the new systems can include heat pump technologies which would improve the heating efficiency and reduce the GHG of typical RTUs by replacing the gas-fired single stage heating equipment.

HVAC REPLACEMENTS

The Washington energy code was revised in 2015 to require a design strategy based on a dedicated outside air system (DOAS) for ventilation. Included in this change was a restriction on system sizing and a more rigorous definition of HVAC zones. These design changes were documented in the code development process along with savings and costs.[7] The documentation references a retrofit HVAC system in two medium buildings which resulted in a reduction in the overall HVAC energy of over 70%. The cost of this design was about $15/sf, which is roughly comparable to a low-cost variable air volume (VAV) or similar system in an

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[5] https://ecotope-publications-database.ecotope.com/2002_002_EnhancedOperationsMaintenance.pdf
[6] https://nwcouncil.app.box.com/v/ComRTUControllerv1-1
[7] https://ecotope-publications-database.ecotope.com/2014_006_DesignForOff.pdf

office occupancy. With this reduction in HVAC energy, a reduction in overall EUI could exceed 50% in most buildings.

The savings from this approach were mandated for a range of commercial occupancies including office, retail, and schools as well as most institutional and assembly occupancies. These occupancies include about 2/3 of commercial space (with some design exceptions) when the HVAC change outs require a permit under the WSEC for existing buildings requirements.

The average life of a major system like HVAC is about 20 years. In the past the replacement could be a similar design but with the energy code, a much more efficient system is required for major systems. Even for buildings where the DOAS is not required, a design based on the same principles can deliver substantial energy savings. HVAC systems in existing buildings today will be replaced as the equipment fails in most buildings by 2050. These design strategies provide opportunities to significantly improve energy performance in new and existing buildings across the commercial sector.

NEW CONSTRUCTION TRENDS

Newer construction energy use is influenced by the lighting and mechanical system trends and measures described above, with the addition of other energy code requirements such as higher insulation and air tightness levels. Efficiency required in the Washington energy code is largely driven by a state mandate that commercial and residential buildings built to the 2031 code must use 70% less energy than those built to the 2006 code.[8] Starting with the 2012 WSEC, the code stringency has stayed on a path to meeting the 2031 targets. As described above, the 2015 WSEC introduced a series of HVAC design strategies and requirements with very high savings potential for some of the most prevalent new construction and retrofit building types. These code provisions include DOAS as well as a series of complementary measures such as maximum ventilation rates, energy recovery ventilation (ERV), and thermostatic zone controls.

In the 2018 WSEC, the list of building types requiring DOAS and related measures was significantly expanded to include the majority of building types. The 2018 WSEC also introduces a more rigorous total building performance path to ensure that buildings using modeling-based compliance will better align savings with the 2031 trajectory, and a total system performance ratio (TSPR) to regulate HVAC energy use at the system level rather than just at the component level. Both of these requirements include carbon-based compliance metrics. The addition of these HVAC design strategies, whole building modeling, and HVAC system energy use limits represent a major step in reducing HVAC energy use and emissions in new construction. Along with increasingly efficient lighting and envelope requirements, new buildings in Washington State are well equipped to meet the 70% energy reduction requirements by 2031 and should be operating at significantly lower EUIs.

[8] RCW 19.27A.160 (https://app.leg.wa.gov/rcw/default.aspx?cite=19.27A.160)

RECOMMENDED EUI TARGETS

The trends and energy saving strategies described above illustrate the depth of savings that buildings can achieve in Washington State using cost-effective, readily available measures. High performance buildings throughout the state demonstrate that existing buildings and newly constructed buildings can achieve total EUI savings of more than 50%. In the case of an HVAC redesign, coupled with an LED lighting upgrade and minimum envelope compliance with the WSEC, reductions of 70% can be achieved. In the next three decades these are the reductions that will be required to reduce commercial sector energy use and achieve economywide, net-zero carbon emissions by 2050. The ability of the building sector to substantially reduce overall energy use will be essential if the needs for energy in the transportation and other sectors are to be met with hydro and renewable energy.

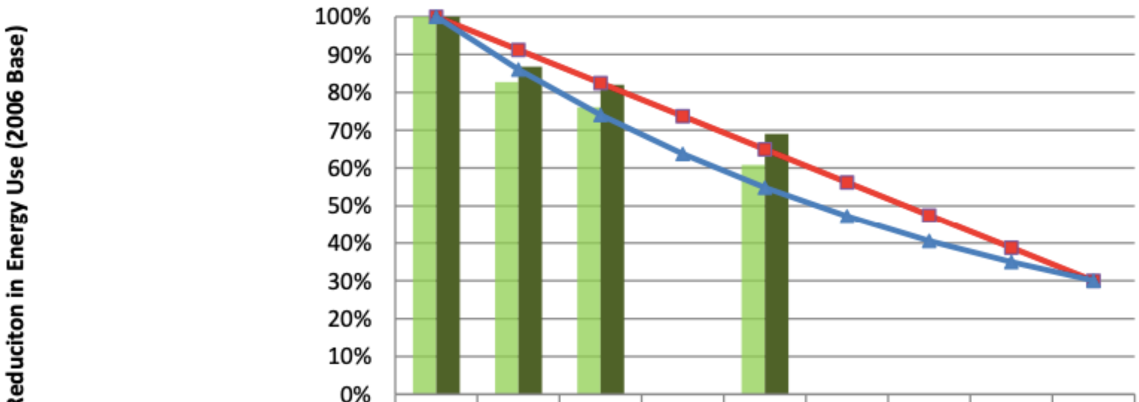
EXISTING BUILDING EUI TARGET RECOMMENDATIONS

The path laid out in the trends and strategies described in this memo shows that in combination with the Standard 100 requirements for an energy management plan and O&M reviews, tuning, and basic upgrades, existing buildings on average can achieve 25% -35% reduction in overall energy use without major changes to obsolete HVAC systems. Buildings that require HVAC replacements in the timeframe prior to the first BPS compliance years, have an opportunity to further deepen energy savings and GHG emissions, and are required to do so by energy code provisions applicable to systems upgrades in existing buildings. For the targets set for building owners and operators over the next decade, this range of expected savings is well within the technologies available today and meeting the state's GHG reduction goals will require savings at this scale by 2030. In addition, higher EUI targets could cost building owners significantly higher energy costs. As long as the measures used to meet the EUI targets remain within the cost-effectiveness bounds set forth in the law, increasingly lower EUI targets will correlate directly with life cycle cost savings for building owners. Conversely, higher EUI targets will increase operating costs for building owners.

NEWER CONSTRUCTION EUI TARGET RECOMMENDATIONS

The trajectory to meeting the 2031 WSEC mandate requires steady incremental improvements in efficiency at each code cycle between 2012 and 2031. These projected improvements provide useful context for setting BPS newer construction EUI targets. For example, Figure 5 below presents the targeted efficiency for each code cycle (shown in the bottom two rows) as well as the estimated progress achieved (top two rows) by each code cycle based on calibrated prototype modeling. As the figure shows, the commercial building targeted savings compared to the 2006 WSEC (see the redline) is 26% for the 2015 code and 45% for the 2018 code. Modeled savings estimates predict that the adopted code is undershooting the 2018 target slightly in the 2018 WSEC but are on track to deliver approximately 41% savings from the 2006 baseline. The WSEC progress to date in addition to the high savings potential for HVAC systems incorporated in the 2015 and 2018 code cycles and the availability of custom and whole building utility new construction programs indicates that the BPS EUI targets for newer construction should be set between 25% and 40% less than the average EUIs.[9]

Figure 5. WSEC Trajectory to Reduce Energy Use 70% by 2031[a]



	2006	2009	2012	2015	2018	2021	2024	2027	2030
Residential	100%	82.7%	76.1%		60.8%				
Commercial	100%	86.8%	82.0%		69.0%				
Target: 8.75 % savings compared to the 2006 WSEC	100%	91%	83%	74%	65%	56%	48%	39%	30%
Target: 14% savings compared to each previous code	100%	86%	74%	64%	55%	47%	41%	35%	30%

[a] The 2015 WSEC estimates were in progress and unavailable at the time of this memo.

[9] Considering, the age of energy use data used for developing the average EUIs, along with the lower stringency of the energy code in 2006, it is reasonable to use the same baseline as the existing buildings.

REFERENCES

1. Katipamula, S., 2016, “Improving Commercial Building Operation through Re-tuning, Meta-Analysis,” Pacific Northwest National Laboratory, Richland, WA. https://buildingretuning.pnnl.gov/documents/pnnl_sa_110686.pdf.
2. Regional Technical Forum, 2018, “Advanced Rooftop Controls,” RTF Worksheet, Northwest Power and Conservation Council, Portland, OR. https://nwcouncil.app.box.com/v/ComRTUControllerv1-1
3. David, R., Francisco, P., Kennedy, M, Baylon, D., Manclark, B., 2002, *Enhanced Operations & Maintenance Procedures for Small Packaged Rooftop HVAC Systems,* Prepared for Eugene Water and Electric Board, Eugene, OR. https://ecotope-publications-database.ecotope.com/2002_002_EnhancedOperationsMaintenance.pdf
4. Heller, J. Baylon, D., Oram, S., “Design For Off: Key Mechanical Engineering Design Features for Significant Energy Savings.” ACEEE 2014 Summer Study, Washington, D.C. https://ecotope-publications-database.ecotope.com/2014_006_DesignForOff.pdf
5. Cadmus Group, 2020, *Commercial Building Stock Assessment (4) Final report*. Northwest Energy Efficiency Alliance, Portland, OR. https://neea.org/resources/cbsa-4-2019-final-report
6. Regional Technical Forum, 2020, “Non-Residential Lighting Midstream,” RTF Worksheet, Northwest Power and Conservation Council, Portland, OR. https://rtf.nwcouncil.org/measure/non-residential-lighting-midstream
7. Northwest Energy Efficiency Alliance, 2019, “4’Llinear Lamp Sales” Memorandum to RTF staff, Portland, OT. https://nwcouncil.app.box.com/v/20191106NEEALinearLampMemo