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Review of Market Share Forecast and Key Assumptions for Efficient Rooftop Units

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Introduction

Northwest Energy Efficiency Alliance (NEEA) contracted with Cadmus to review its approach to developing a naturally occurring baseline market share forecast for efficient rooftop units (ERTUs) and other key assumptions. NEEA's target market for an ERTU includes any nonresidential building with three stories or less with an existing gas RTU. The measure has two tiers that can be met through performance or prescriptive approaches, as shown in Table 1.

Table 1. Efficient Rooftop Unit System Requirements

	Tier 1	Tier 2
Prescriptive Path	>=80% thermal efficiency AND Insulated cabinets with minimum of R-12 and sealed to ensure no insulation fibers enter airstream AND Damper leakage rate under ASHRAE specifications	All Tier 1 requirements AND Heat or energy recovery ventilator OR Condensing furnace
Performance Path[a]	$TCOP_{HS}$>0.70	$TCOP_{HS}$>0.80

[a] Total Heating Season Coefficient of Performance ($TCOP_{HS}$)

The key research questions for this review are the following.

Naturally Occurring Baseline Market Share Forecast Review

- Has NEEA captured the primary market drivers influencing market adoption to date? Are there other market drivers that NEEA should factor into its naturally occurring baseline market share?
- Is NEEA's forecast appropriate and credible?

Key Assumptions Review

- Is NEEA's approach to estimating Efficient RTU sales market share in the region under the naturally occurring baseline scenario reasonable?
  - Are there other data sources or proxies that could inform the starting point, terminus, or adoption rate for NEEA's naturally occurring baseline?
  - If so, in what ways would the recommended data sources or proxies change the naturally occurring baseline?
- Are the data and methods used to determine unit energy savings and market size reasonable and sufficient for credible accounting of energy savings?
- Are data sources and methods for determining measure life, the incremental first cost of the measure (both the prescriptive path and the performance path), and incremental operations and maintenance cost reasonable and sufficient for credible estimates of cost-effectiveness?
- Will NEEA's approach for tracking unit sales and market share provide realistic and credible estimates of market adoption?

NEEA provided Cadmus with a memo describing its market research and proposed naturally occurring baseline market forecast for ERTUs. NEEA provided Cadmus with four supplemental memos, Python code, and an Excel workbook that covered these specifics:

- Methodology for measuring market adoption: Efficient Rooftop Units
- Synthesis of ERTU market research and data to support of baseline and modeling key assumptions.
- ERTUs: Incremental cost methods and sources
- ERTU market size
- ERTU Unit Energy Savings (UES) data and methods (Excel)
- Efficient_RTU_assumptions (Python)

NEEA also provided additional data sources and references in support of these materials, including NEEA's previous market baseline review findings for condensing RTUs. Cadmus carefully reviewed these key data sources and calculations.

In secondary research to support this review, Cadmus found additional relevant documents from the U.S. Department of Energy (DOE) Energy Efficiency Program for consumer products and commercial and industrial equipment. The Technical Support Document (TSD), dated January 16, 2015, for commercial warm air furnaces includes data that can provide additional validation to the work NEEA has done. NEEA was not aware of this source of information, so it was not included in the ERTU market baseline.

This report summarizes Cadmus' review findings and recommendations.

Naturally Occurring Baseline Market Share Forecast Review

NEEA's key research questions are shown in blue text. Cadmus provides answers in black text. Recommendations are in **bold** text.

Has NEEA captured the primary market drivers influencing market adoption to date? Are there other market drivers that NEEA should factor into its naturally occurring baseline market share?

Cadmus finds NEEA's market research comprehensively captures the major decision points, barriers, and drivers of adoption. We do not recommend including additional market drivers.

Is NEEA's approach to estimating ERTU sales market share in the region under our naturally occurring baseline scenario reasonable?

Are there other data sources or proxies that could inform the starting point, terminus or adoption rate for NEEA's naturally occurring baseline?

If so, in what ways would the recommended data sources or proxies change the naturally occurring baseline?

Cadmus finds NEEA's method for forecasting the naturally occurring baseline market share of ERTU sales, along with the proposed naturally occurring baseline and the proposed starting point (2016) and terminus (2039), to be generally reasonable. Our rationale is described here. **Note that NEEA should indicate on Figure A1 in its ERTU Baseline Assumptions memo the date it began intervening in the market because it predates this study by a meaningful amount of time.**

Top-down validation. Cadmus compared NEEA's Tier 2 condensing gas furnace (CGF) market share against the CGF base case market share from the US DOE's TSD. Table 2 shows that the CGF market share from DOE's TSD exceeds NEEA's Tier 2 CGF market share but that the two estimates differ by less than 1%. This difference is expected as the CGF base case in the DOE's TSD does not include all of the Tier 1 ERTU features that characterize a Tier 2 CGF. These additional system requirements, as described in Table 1 above, for a Tier 2 CGF will push NEEA's market share lower than the typical CGF.

Table 2. Comparison of 2018 Baseline Market Share for Condensing Furnace Technology

	2022 NEEA Tier 2 Gas Furnace	2015 US DOE Condensing Furnace [a]
2018 Baseline Market Share	0.3%	1%

[a] Table 8.2.19 of the U.S. Department of Energy Technical Support Document (TSD).

Bottom-up validation. In this section, Cadmus examines the key inputs into the baseline calculation. NEEA states in the memo that the naturally occurring baseline estimation is calculated with the following formula:

$$Sales\ Market\ Share = Initial\ Condition_t + \frac{Saturation}{1 + Factor^{\left(\frac{Hypergrowth + \frac{Takeover}{2} - Year}{Takeover}\right)}}$$

NEEA uses a six-step process for estimating market adoption. Table 3 shows Cadmus' assessment of each step. Cadmus' recommendations are in **bold** text.

Table 3. Naturally Occurring Baseline Market Share Forecast Estimation Review

Step	Cadmus Assessment
1: Existing building square footage with owners who prioritize efficiency over simple payback	By focusing only on the building owner's decision-making, NEEA's forecast is conservative and simplified compared to trying to account for other market conditions, such as equipment availability or building constraints. NEEA uses ENERGY STAR® square footage in Oregon and Washington as a proxy for the share of existing building area managed by owners engaged in efficiency practices.[1] However, in the condensing RTU baseline review, NEEA used LEED-certified floor area as a proxy. NEEA did not use LEED floor area in this baseline forecast because of the impression that LEED focused primarily on new buildings. LEED's Existing Building Operations and Maintenance (LEED EB O&M) certification represents another indicator of existing square footage owned/managed by individuals or organizations who prioritize efficiency and sustainability. Cadmus found LEED EB O&M-certified floor area is twice that of the ENERGY STAR floor area (Oregon and Washington).

[1] The majority of NEEA's gas funders are located in Oregon and Washington, which results in these two states being the focus of this analysis.

Step	Cadmus Assessment
	NEEA should consider either supplementing its ENERGY STAR data with the LEED EB O&M floor area (avoiding double counting of the same building) or using just the LEED EB O&M floor area. Cadmus conducted additional analysis to show the effect of considering LEED EB O&M certified floor area. See the *Comparison of Proxy Measurements for Commercial Building Owners Who Prioritize Energy Efficiency* section for more information. **Furthermore, NEEA should apply a 50% discount to this value since not all buildings with ENERGY STAR or LEED labels would be managed or owned by persons willing to pay a premium for an ERTU.**
2: Forecast efficient square footage through 2039	NEEA forecasted the efficient square footage but not the total square footage, which is kept constant and is needed to create the "Percentage of Sqft in CBSA" in Step 3. **Cadmus recommends that NEEA either uses static values for both the efficient square footage (numerator) and total square footage (denominator) or forecasts both sets of values**. Either method would, in theory, result in a constant forecast because, barring any external influences, the relationship between total floor area and efficient floor area would remain constant. Thus, forecasting both would result in both terms growing at the same rate, which, when inputted into the "Percentage of Sqft in CBSA," functionally equates to a constant.
3a: Convert forecasted floor area into percentage of Commercial Building Stock Assessment (CBSA) building area	To calculate the forecasted floor area applicable to ERTUs (gas-fueled buildings with fewer than four stories), NEEA applied a 21% "incidence rate" developed from the CBSA (2019) dataset. This means that buildings standing under four stories with gas rooftop units comprise 21% of all floor area in the CBSA (2019) dataset. **Cadmus recommends that NEEA round its 21% incidence rate down to 20% to account for square footage within its subset of building floor area that could be unconditioned or heated with alternative types of equipment.** Cadmus used Google Earth's 3D mapping feature on a random sample of ENERGY STAR buildings in Oregon and Washington to identify the percentage of this sample that were fewer than four stories and had RTUs. This exercise found that 27% (3 of 11) of the buildings fit the criteria. Though the random sampling supports the incidence rate identified with CBSA data, the sample was too small to be generalizable and **NEEA could perform a similar exercise on a larger sample (from the population used in Step 1) for further validation.** Rather than performing this manually, validation could be supported by using machine learning image analysis, which can scan a series of images of a building and determine suitability for ERTUs.
3b: Develop market momentum	Market momentum was generated using three inputs (saturation, hypergrowth year, and takeover period) provided by NEEA. Given that building code is a primary driver of adoption and market momentum but includes multiple compliance options that do not require ERTUs, a 20% saturation is appropriate since some consumers will select other compliance options. NEEA predicts the market share for ERTUs will experience accelerated growth by 2036, which is reasonable as this timeframe is in accordance with the three-year building code cycles of Washington and Oregon. NEEA assumes a takeover period of 15 years. Cadmus finds this assumption valid as this takeover period is predicated upon the effective useful life of ETRUs, 20-years, during which there will only be one opportunity to choose an efficient option. This suggests early retirement of inefficient units. Cadmus discusses the validity of NEEA's assumed measure life in *Key Assumptions Review*, the next section below.
4: Estimate overall RTU baseline market share	The sum of the two components (Step 3a and Step 3b output) is valid as each represents a different population of decision-makers, early adopters and laggards, respectively. As a result, there is no concern over double-counting.

Step	Cadmus Assessment
5: Estimate Tier 2 RTU baseline market share	NEEA's Tier 2 allocation is the percentage of all ENERGY STAR area that had achieved an efficiency score of above 90 (20% of the overall market share). Given the higher costs to achieve Tier 2, Cadmus finds this a reasonable allocation approach. **NEEA should revisit the baseline if historical data on actual Tier 1 and Tier 2 adoptions within the region become available. If the data are very different, NEEA should true-up the baseline to align with actual known historic adoption.**
6: Estimate Tier 1 RTU baseline market share	NEEA assigned the remaining market share to Tier 1. Cadmus finds this to be a reasonable allocation, although it does raise the question of how to characterize buildings that adopt only an ERV (Energy Recovery Ventilator) or condensing furnace but not the other Tier 1 features necessary for reaching Tier 2 via the prescriptive pathway. NEEA expects future sales data to include information on whether units also meet each Tier's performance path requirements. **Cadmus recommends NEEA characterize which pathway is most prevalent for each Tier and use that pathway to inform future research and assumptions. For example, if most installations with only an ERV can meet Tier 2 performance path requirements, then the energy modeling to develop weighted average UES would only need to include the ERV component and not any insulation or reduced damper leakage.**

Key Assumptions Review

NEEA's questions for the key assumptions review are shown in blue text. Cadmus provides answers in black text. Recommendations are in **bold** text.

Are data sources and methods for determining measure life, the incremental first cost of the measure (both the prescriptive path and the performance path), and incremental operations and maintenance cost reasonable and sufficient for credible estimates of cost effectiveness?

Effective Useful Life (EUL)

NEEA's proposed measure life of 20 years for commercial gas fired RTUs provides a reasonable estimate based on a range of literature. Though the US DOE's TSD and Consumer Reports found an 18-year average useful life for gas-fired warm air furnaces, the U.S. Energy Information Administration (EIA) cites a measure life of 23 years.[2]

Incremental Cost for Tier 1

NEEA's cost estimates account for equipment only, without ancillary costs. NEEA based its incremental cost for Tier 1 ERTU on costs for efficient-components (insulation and multi-blade dampers) from a third-party source of equipment prices and typical six- and 10-ton dimensions from Trane and AAON. Cadmus found this method of estimating incremental cost valid only for the prescriptive pathway. In addition, Cadmus found that the two-inch insulation and multi-blade damper costs appear in line with

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[2] Consumer Reports. March 21, 2009. "By the numbers: How long will your appliances last? It depends." https://www.consumerreports.org/cro/news/2009/03/by-the-numbers-how-long-will-your-appliances-last-it-depends/index.htm

U.S. Energy Information Administration. June 2018. *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies.* https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf prices offered by manufacturers and retailers. **If Tier 1 is mostly achieved via the performance pathway, and that pathway uses different technologies, then NEEA will need to revisit Tier 1 incremental costs.**

Cadmus noted that ancillary costs not accounted for include the lamination or coating required to seal and secure the insulation to the walls, manufacturing labor, or the additional metal materials and design work needed to expand the unit housing to accommodate the insulation**. If Tier 1 is mostly achieved via the prescriptive pathway, Cadmus believes it is reasonable to assume that certain costs would come down—in particular, setup costs and design work—once manufacturers retool to produce ERTUs. The level at which costs come down will depend on the volume, level of automation, and other factors, we would also expect that some of the retooling costs (the larger initial capital cost) to be passed to the customer. NEEA should conduct additional research on incremental costs for Tier 1.**

Incremental Cost for Tier 2

NEEA considered cost estimates from a third-party source of equipment prices, prior NEEA field studies, and a Bonneville Power Administration (BPA) HVAC guide to determine the incremental cost of Tier 2 ERTUs.

NEEA derived an average incremental cost of $3,095.30 (2021$) for a 10-ton Tier 2 CGF RTU. Due to the Tier 1 system requirements included in Tier 2 CGF RTU, NEEA's Tier 2 CGF estimate cannot be compared to incremental cost evidence for CGFs from the US DOE's TSD or US EIA. Therefore, for purposes of direct comparison (as shown in Table 4), Cadmus determined the incremental cost of CGF from NEEA's Tier 2 CGF RTU estimate—that is, subtracting ERTU Tier 1 incremental cost from ERTU Tier 2 CGF removes insulation and damper costs from consideration. The result, $2,224.30 for a 10-ton CGF, exceeded both the US DOE's and US EIA's estimates of $1,380.11 and $1,669.45, respectively, for an otherwise similar 20-ton CGF (all costs in 2021$).

Table 4. Comparison of Incremental Costs Across Sources for Condensing Furnace (2021$)

	NEEA CGF (10-ton)	US DOE TSD CGF (20-ton)	US EIA CGF (20-ton)
Equipment	$2,224.30	$1,380.11	$1,669.45
Installation	N/A	$464.70	$442.18
O&M (annual)	N/A	$14.11	$11.05
Total	$2,224.3	$1,858.92	$2,122.68

Given the lack of data on installation and operation and maintenance costs, NEEA should consider using values from the US DOE or US EIA as a proxy.

Based on evidence provided by the US DOE TSD and US EIA, Cadmus concludes that incremental operations and maintenance costs are fairly negligible for Tier 2 CGF ERTUs. Both estimates fall below $15 annually for condensate system inspection and cleaning, with the DOE's incremental O&M cost at $14.11 per year and the EIA's at $11.05 per year (all costs in 2021$).

For incremental costs along the other Tier 2 prescriptive option, Cadmus relied on information from an ERV ROI calculator.[3] This calculator estimates the ERV installed cost at $4 per CFM. Using Portland, OR as an example, with its humid winters,[4] a conversion rate[5] of 325 CFM/ton means a 6-ton RTU requires 1,950CFM and the ERV would cost $7,800. This is comparable to the value NEEA obtained for a 2,000 CFM ERV costing $8,875 from a third-party source of equipment prices. NEEA's ERV cost on a per CFM basis decreases as the maximum CFM increases, which Cadmus believes is reasonable pricing behavior.

Will NEEA's approach for tracking unit sales and market share provide realistic and credible estimates of market adoption and savings estimates?

In its ERTU Methodology for Measure Market Adoption memo, NEEA laid out a plan to track sales and the market share of ERTUs, which included relevant data sources and data collection limitations, and which should provide a comprehensive and realistic assessment of adoption. NEEA is collecting data that represent multiple perspectives, including suppliers, contractors, program administrators, and third-party evaluators.

HVAC supplier data offer the greatest potential as a source of sales and market share monitoring data. As such, Cadmus agrees with NEEA's strategic focus on cultivating manufacturer relations to produce a more robust supplier dataset.

NEEA's decision to report energy savings estimates based on observed adoption alone (and not extrapolated data) will establish a conservative estimate for at least the first few program years.

Table 5 shows NEEA's analytical approach to tracking market share process review.

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[3] AIRXCHANGE ROI Calculator, Accessed July 26. 2022. AIRX DXSystem News | Blog | Energy Recovery | Airxchange

[4] Weather and Climate.com, Accessed July 26, 2022. https://weather-and-climate.com/average-monthly-Humidity-perc,portland,United-States-of-America

[5] Learn Metrics HVAC Systems, Accessed July 26, 2022. https://learnmetrics.com/how-many-cfm-per-ton/

Table 5. NEEA's Analytical Approach to Tracking Market Share Process Review

Step	Cadmus Assessment
Step 1: Calculate market share of ERTUs based on observable adoption	NEEA's method for calculating market share based on observed RTUs and ETRUs appears valid and considers the need to account for potential double counting. Number of units by tier and **capacity should be tracked** to support application of appropriate Unit Energy Savings (UES, see related section below).
Step 2: Determine missing data	NEEA's plan for describing and documenting missing data has sound basis. **NEEA should determine and state the data conditions or coverage threshold that would trigger the inclusion of extrapolated values in the estimation of savings. Cadmus recommends examining whether the market share is relatively stable as the data's market coverage increases. If the measurement is stable with respect to incremental changes in market coverage, then NEEA should consider extrapolation the next year. Also, if NEEA's market coverage increases beyond 50%, then it should consider extrapolation.**
Step 3: Fill in data gaps with market progress evaluation reports (MPERs)	Cadmus agrees with the approach of using MPERs to verify the magnitude of adoption witnessed in observable data sources.
Step 4: Weigh and scale market share as necessary	Cadmus agrees with NEEA's described approach for infilling and calibrating sales. NEEA's proposed approach for using two data sources (manufacturer and contractor reported sales) and making sure they align is a good approach for filling in missing data.

Are the data and methods used to determine unit energy savings and market size reasonable and sufficient for credible accounting of energy savings?

Unit Energy Savings (UES)

NEEA started with energy modeling simulation results developed by another consulting firm and then created weighted unit energy savings (UES), across multiple building types and heating zones, based on measure tier and ERTU capacity. The weights are included in the Python code. Since market data are challenging to obtain and not yet available, Cadmus believes that a weighted average UES is appropriate until more data on actual installations are available. When using the weighted UES, only the quantity, tier, and ERTU capacity are required to specify savings. Furthermore, if the ERTU size is not available, the smallest 5.3-ton unit can be used for a conservative estimate of savings. The savings appear most sensitive to the tier, so collecting this attribute from the market tracking activities would be the most important.

When program data (specifications and other documents, evaluation studies, calculations) are available, NEEA should compare energy modeling results against project-specific calculations from partner programs and adjust the energy modeling results if there is a large difference. For example, if Tier 2 is achieved via the performance pathway with only an ERV and no insulation, then NEEA may want to revise the energy modeling to exclude extra insulation measures. NEEA expects to request "data annually to ascertain the number of incented units, the savings they generated and the amount of dollars provided in incentives (either per unit or total). If available, NEEA will request the location the incented units were installed." **Cadmus recommends asking for more detailed data (such as unit capacity, ERV CFM, and tier) on the number of units that are incented annually so an appropriate UES can be assigned.**

Market Size

NEEA supplied Cadmus with a second analytical memo that detailed its proposed market size forecast for ERTUs.

Top-down validation. Table 6 compares NEEA's Pacific Northwest market size forecast to the US DOE's projections (made in 2015 and scaled to the population of Oregon and Washington). In 2020, the number of shipments are on the same order of magnitude, suggesting NEEA's estimate is reasonable. The diverging forecast in 2040 is expected since NEEA works only in the Pacific Northwest and using national numbers would not reflect the increased electrification in this region nor would it account for other electrification trends that began accelerating since 2015.

Table 6. Furnace Shipment Forecast

Year	NEEA Estimates for Shipments to Oregon and Washington (and 1% for Idaho)	US DOE Data for Shipments (4% of national, representing Oregon and Washington)
2020	10,839	9,648
2030	9,782	8,868
2040	7,829	11,883

Bottom-Up Validation

The proposed market size forecast for ERTUs is based on the summation of existing unit replacement and new construction units. NEEA relied on the S-curve equation to show declines in the market size due to electrification.

$$1)\ SampleDecline = Sample/1 + factor^{\frac{hypergrowthyear + takeoverperiod/2 - Year}{takeoverperiod}}$$

To convert floor area into units, NEEA used this formula.

$$3)\ MedianCapacity = \frac{Heated\ sqft\ represented}{numunitsrepresented \times hvacsystemsampleweighte \times facilitysampleweight \times sitesampleweight}/400$$

NEEA's market size forecasting involved a two-part methodology, a four-step process for estimating the replacement market, and a five-step process for projecting the new construction market. Table 7 lists these steps and Cadmus' assessment. Recommendations are in **bold** text.

Table 7. Market Size Forecast Process Review

Step	Cadmus Assessment
Existing Unit Replacement Calculation	
Step 1: Subset sample using CSBA 21%	Previously discussed and found reasonable in Step 3a of Table 3 above.
Step 2: Calculate annual base replacements	The process for identifying quantity of units in the region using CBSA sample weights is reasonable. **NEEA should note in its methods memo that one in 20 of the stock is the base number of annual replacements**. NEEA performed this in Python script but did not document it in the memo.
Step 3: Estimate electrification loss	Method for estimating sample decline, or electrification loss, has sound basis in the S-curve equation and assumptions as examined below. **The S-curve equation in the market size memo should specify "Sample/(1+…)" rather than "Sample/1 +" to clarify the denominator**. NEEA's parameter assumptions for forecasting electrification loss, the hyper-growth year and takeover period, were found to be reasonable. NEEA proposed that accelerated growth in the market share for ERTUs will begin in 2030, which aligns with the three-year building code cycles of Washington and Oregon and with Oregon's 2030 climate goal. The length of the replacement market's takeover period was based on the timeline for full electrification of the RTUs and HVAC systems and the time horizons for Oregon's and Washington's climate goals, 2030 and 2050, respectively. Per this discussion, NEEA's assumptions appear realistic and the approach to estimating sample decline appears appropriate.
Step 4: Apply sample weights	The weights are based on gas funders and their represented regions, which do not cover all of NEEA's region.
New Construction Units Calculation	
Step 1: Subset sample to OR and ID	The decision to limit the sample to Oregon and Idaho and remove the Washington population was acceptable for the new construction market. The rationale is that Washington building codes governing new construction prevent new developments from installing HVAC systems that operate on fossil fuels.
Step 2: Subset sample using CSBA 21%	Previously discussed and found reasonable in Step 3a of Table 3 above.
Step 3: Run ARIMA model on Dodge data	The Seasonal ARIMA fit to Dodge data follows a default setup for ARIMA modeling, with the order of 1,0,0. NEEA selected the model's parameters based on AIC values, a commonly accepted practice. The model's use of a constant trend or intercept would be appropriate for forecasting baseline adoption or consumption. Overall, NEEA's application of this forecasting model is in accordance with ARIMA's documentation.
Step 4: Estimate sample decline	NEEA's method for estimating sample decline appears reasonable. NEEA's input assumptions for forecasting sample decline, the hyper-growth year and takeover period, were found realistic. A hyper-growth year of 2021 for new construction market aligns with the restrictive gas building policies being implemented in Washington and anticipated code adoption in Oregon. Following the same rationale, a brief takeover period of 12 years appears reasonable. **The S-curve equation in the market size memo should specify "Sample/(1+…)" rather than "Sample/1 +" to clarify the denominator**.
Final Conversion Step for Both Segments	
Step 5: Convert floor area to units	The equation used to estimate RTU capacity, Equation 3, calculates the mean capacity rather than the median capacity (as currently written). **NEEA should correct the formula to reflect the average calculation and specify that the area-to-units conversion relied on the median value of the average capacities.** Cadmus' examination of the CBSA data validated the right-skewed nature of the distribution and, thus, the use of the median. Cadmus also finds that NEEA's conversion rate of 400 square feet per 1-ton capacity is standard industry practice for sizing HVAC systems at the schematic design phase. **We recommend NEEA continue to use 400 square feet until actual data on installed units per square foot become available.**

Comparison of Proxy Measurements for Commercial Building Owners Who Prioritize Energy Efficiency

NEEA's approach to estimating the naturally occurring baseline market share of efficient rooftop units (ERTUs) depends on the use of a suitable proxy for the share of building area managed by individuals who "prioritize efficiency over simple payback period." NEEA uses ENERGY STAR square footage within Oregon and Washington from 2008 to 2021 as the proxy for this analysis, but in prior forecasting of the commercial rooftop unit (CRTU) market share, NEEA instead used LEED certified square footage. According to the NEEA, this decision was based on the understanding that LEED certification targeted new properties and that new construction was not considered in NEEA's analysis following the introduction of building codes in Washington (and in Oregon in the near future) that restrict new developments from being fueled by gas.

A specific category of LEED certification, Existing Buildings Operations and Maintenance (LEED EB O&M) is awarded to existing, non-residential buildings and may be a preferrable indicator for NEEA's forecasting exercise. This is because LEED certification considers energy efficiency in addition to a slew of other factors that relate to efficiency and sustainability, such as the quality of the indoor environment and clean innovation, while ENERGY STAR certification is based only on how buildings compare to one another in terms of energy performance and efficiency.[6] In considering these additional practices, LEED EB O&M captures a large segment of the population that is engaged in efficient decision-making and practices, and therefore will consider adopting ERTUs, but is not considered by ENERGY STAR.

Cadmus mapped the ENERGY STAR data against LEED EB O&M to ensure both certifications measure similar attributes of building floor area. Cadmus found that 54% of ENERGY STAR buildings in Washington (comprising 74% of the overall ENERGY STAR square footage in Washington) also have LEED EB O&M certification, while in Oregon, 55% of ENERGY STAR properties (67% of the total ENERGY STAR floor area in Oregon) also appear in LEED EB O&M data. The high degree of overlap with ENERGY STAR further validates the use of LEED EB O&M data in this analysis.

Figure 1 compares the quantity of ENERGY STAR floor area (2021) in Washington and Oregon to the LEED certified floor area (2021) in both states.[7] ENERGY STAR covers less than half the square footage of LEED EB O&M and, thus, offers a more conservative proxy of the share of building area managed by owners involved in energy efficient and sustainable practices.

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6 Due to the additional efficiency- and sustainability-related considerations captured by LEED, the efficiencies of ENERGY STAR and LEED buildings under various certification levels cannot directly compare.

7 'LEED EB OM Blank' represent LEED certified buildings which, due to user input, do not list a LEED certification level.

Figure 1. Comparison of LEED EB O&M and ENERGY STAR Total Building Area (Oregon and Washington)

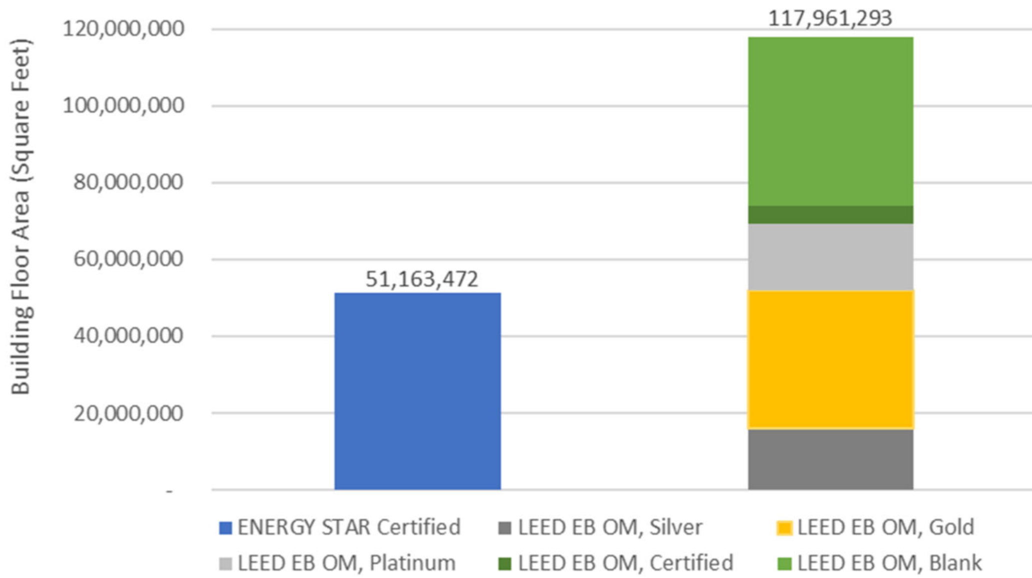


Figure 2 and Figure 3 break down the composite comparison of ENERGY STAR and LEED-certified building area in Figure 1 according to their state. As illustrated in Figure 2, Washington contains the majority of the total square footage, regardless of the certification type (78% and 71% of total ENERGY STAR and LEED-certified square footage, respectively). This leaves Oregon covering only roughly a quarter of the total square footage in either ENERGY STAR or LEED EB O&M data. In Washington, LEED EB O&M certifies roughly double the amount of floor area that ENERGY STAR covers in the state, while in Oregon, LEED EB O&M encompasses more than three times the square footage found in ENERGY STAR data.

Figure 2. Comparison of LEED EB O&M and ENERGY STAR Washington Building Area

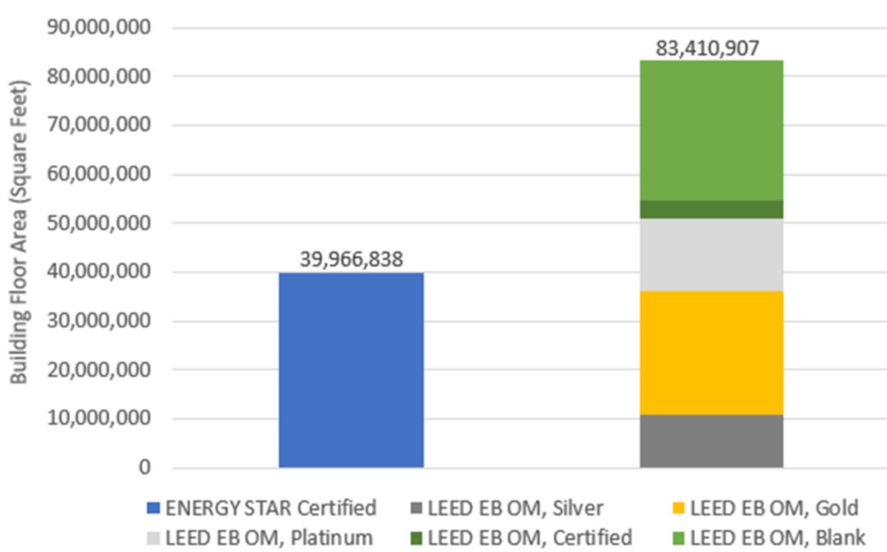
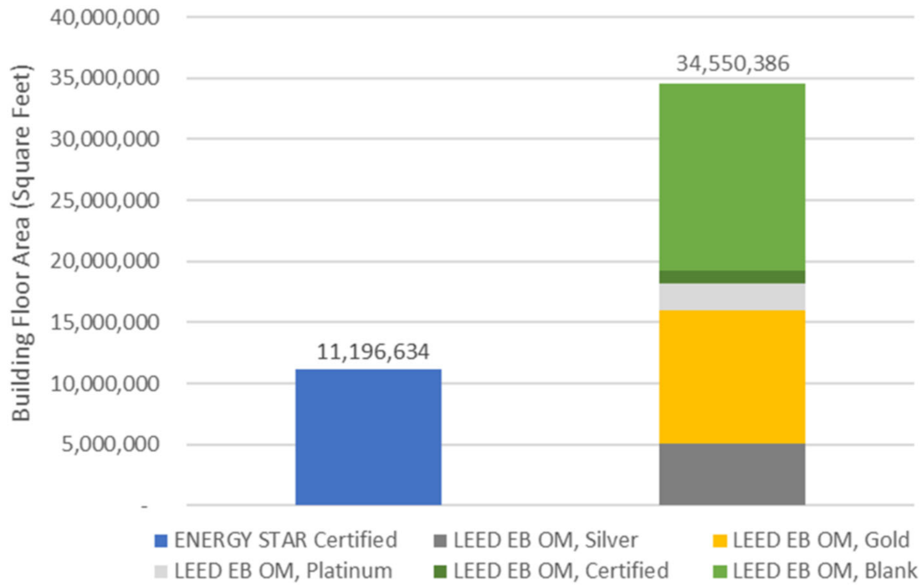


Figure 3. Comparison of LEED EB O&M and ENERGY STAR Oregon Building Area



Based on this comparison and these results, Cadmus recommends that NEEA consider either using a robust dataset that appends the additional LEED EB O&M building floor area (66,797,821 square feet) to the existing ENERGY STAR data (without double counting the overlapping area) or using the LEED EB O&M data in place of ENERGY STAR data for this analysis.

Additionally, NEEA should assign a 50% discount rate to the total building floor area given not all ENERGY STAR or LEED certified buildings would be managed or owned by individuals willing to pay a premium for an ERTU.