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Air Cleaner Unit Savings Review

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This memo presents findings from Apex Analytics' review of NEEA's unit energy savings, market size, and baseline assumptions for room air cleaners (air cleaners).

Background

NEEA included air cleaners in its Retail Products Portfolio (RPP) initiative beginning in 2014. Recognizing that the market share of ENERGY STAR® air cleaners in the Northwest was high and that there were opportunities to improve energy consumption measurement and product tracking, NEEA pursued measurement and compliance and specification revision strategies for air cleaners through the RPP initiative. In October 2018, the U.S. Environmental Protection Agency (EPA) began the process for an ENERGY STAR specification update for air cleaners. The final Version 2.0 (V2.0) specification was released in October 2019 and will take effect in October 2020. Apex prepared an Air Cleaner Specification and Baseline Assessment review memo assessing NEEA's influence on the ENERGY STAR specification update.

In order to assess the energy savings resulting from its intervention in the air cleaner market, NEEA estimates the underlying unit energy savings, baseline energy usage, and applicable market size. RPP sales data, along with energy consumption information included on the ENERGY STAR Qualified Products List (QPL) are key data sources informing these assumptions. For some product types, NEEA also draws on the DOE Compliance Certification Database and the California Energy Commission appliance database for energy consumption information, including information on non-ENERGY STAR products. However, these databases do not include information on air cleaners, which are not subject to Federal or California appliance efficiency standards. In addition, NEEA discontinued midstream incentives for air cleaners in 2019. As RPP program sponsors only receive current sales data for products they are actively incentivizing, NEEA no longer has access to current RPP sales data for air cleaners.

Given these changes in data availability and the recent adoption of a new ENERGY STAR specification (Version 2.0), NEEA sought Apex's review and feedback to ensure NEEA has properly documented its assumptions, validated these assumptions, and validated the calculations underlying its energy savings estimates.

Research Objectives

This memo addresses the following research objectives:

- Review NEEA's approach to estimating unit energy savings (UES), naturally occurring baseline, and tracked units (market size) for air cleaners, recognizing that RPP sales data are not available after March 2019.

Apex analyzed data from several sources (noted below) to identify areas where the data confirm NEEA's assumptions and areas where the data suggested alternatives to NEEA's assumptions. We also note any of NEEA's assumptions that we are unable to assess using existing market data.

Approach

The Apex team reviewed NEEA's assumptions around air cleaner unit UES, efficient market share, and tracked units. Apex reviewed the worksheets NEEA uses to track these assumptions (*Air Cleaners AMMO Inputs V2.xlsx*) and met with NEEA staff to ensure we have a complete understanding of NEEA's approach. We also conducted outreach and email correspondence with Energy Solutions and the Association of Home Appliance Manufacturers (AHAM) to help provide additional insight into NEEA's assumptions and the market in general. We then reviewed available market data to gather further insight related to NEEA's assumptions. As NEEA does not have access to current sales data, this review was primarily drawn on publicly available, secondary data sources, including:

- ENERGY STAR QPL
- The AHAM Verifide database
- Historical RPP sales data
- Retailer websites
- Public market research data

Unit Savings Review Findings

Apex assessed three aspects of NEEA's savings and baseline assumptions: unit energy savings (UES) calculations, market size estimates, and the naturally occurring baseline.

Unit Energy Savings Calculation

NEEA divides air cleaners into four capacity bins, defined by clean air delivery rate (CADR), in its unit energy consumption (UEC) and UES calculations.[1] NEEA further subdivides each of these bins into four efficiency tiers. Table 1 summarizes these capacity bins and efficiency tiers.

[1] CADR is a measure of the amount of air that passes through an air cleaner in a given period of time. It is measured in cubic feet per minute (CFM).

Table 1: Capacity Bins and Efficiency Tiers Used in Air Cleaner Savings Calculations

Characteristic	Values
Capacity Bins	• <100 CFM • 100-149 CFM • 150-250 CFM • >250 CFM
Efficiency Tiers	• Non-Qualifying • ENERGY STAR Version 2.0 (V2) • 30% more efficient than ENERGY STAR V2 (ENERGY STAR V2 + 30%) • ENERGY STAR V2 + 50%

NEEA's method for calculating air cleaner UES was well documented[2] and is as follows:

1. **Gather capacity and efficiency data across all RPP sales**: NEEA matches the air cleaner models listed in the RPP sales data to the ENERGY STAR QPL, which provides capacity, on-mode power and standby power data. NEEA then calculates sales-weighted averages of each of these values within capacity bins and efficiency tiers.[3]
2. **Calculate sales-weighted UEC:** NEEA calculates on-mode energy consumption within each capacity bin and efficiency tier by dividing the sales-weighted average efficiency values identified in step 1 (expressed in CADR/W) by the sales-weighted average CADR values. NEEA then multiplies this value by assumed on-mode operating hours and adds the result to the product of the sales-weighted standby energy consumption and the assumed standby operating hours to obtain an annual UEC value.
3. **Normalize for Capacity**: NEEA calculates a sales-weighted average CADR across efficiency tiers within each CADR group to obtain a group-wide average capacity value. NEEA then calculates an energy consumption per CFM value for each efficiency tier by dividing the UEC calculated in step 2 by the efficiency tier's sales weighted average CADR. NEEA multiplies this energy consumption per CFM value by the group-wide average capacity to obtain a normalized, sales weighted UEC. This calculation reduces differences in UEC between efficiency tiers due to variation in average air cleaner capacity across tiers. For example, ENERGY STAR V2 +50% air cleaners might skew toward the higher end of a particular capacity bin while non-qualified air cleaners skew toward the lower end of the capacity bin. The UEC values

[2] Mytelka, A, Energy Solutions, December 2019, Northwest Energy Efficiency Alliance (NEEA) Retail Products Portfolio (RPP) Methodology Documentation for Residential Room Air Cleaners; Mytelka, A. Energy Solutions, August 2020, Air Cleaners AMMO Inputs V2.xlsx

[3] NEEA defines four capacity bins for these calculations, defined by air cleaner CADR: <100 CFM, 100-149 CFM, 150-250 CFM, and >250 CFM. NEEA subdivides each capacity bin into four efficiency tiers: Non-qualifying, ENERGY STAR V2, 30% more efficient than ENERGY STAR V2 (ENERGY STAR V2 + 30%), and ENERGY STAR V2 + 50%.

calculated in step 2 would reflect those capacity differences, while the calculation in this step would control for them. This calculation is appropriate for a product like air cleaners in which NEEA's intervention is designed to raise the efficiency of products across the market, as a specification revision seeks to do. In this case, the efficiency level of products at all capacities is expected to increase, and minimizing differences in energy consumption due to differences in average capacity between efficiency tiers allows for a more apt comparison between efficient and inefficient products.[4]

4. **Aggregate UEC estimates across efficiency tiers**: NEEA calculates a sales-weighted average of the normalized UEC values obtained in step 3 that combines the three ENERGY STAR efficiency tiers (ENERGY STAR V2, ENERGY STAR V2+30%, and ENERGY STAR V2+50%). This provides an overall UEC estimate for ENERGY STAR air cleaners within each capacity group.
5. **Estimate UES**: NEEA calculates the UES for each capacity group by subtracting the ENERGY STAR V2 qualified UEC calculated in step 4 from the normalized UEC estimate for non-qualifying air cleaners calculated in step 3. In doing so, NEEA uses air cleaners that qualify for the V1.2 specification but not the V2 specification, which are categorized as "non-qualifying," as its energy consumption baseline.
6. **Sales-weight the UES**: Finally, NEEA calculates the sales-weighted average UES across CADR groups.

There are some capacity bins for which no models met the ENERGY STAR V2.0 specification in certain years. As a result, NEEA's UES calculation worksheet does not have an ENERGY STAR UEC estimate, and thus a UES calculation for these capacity bins. Apex notes that NEEA could develop a UES savings estimate for these capacity bins based on the minimum efficiency requirements for models matching the average capacity of non-qualifying models in the bin.

Table 2 summarizes the primary input variables to NEEA's UES calculations, their source, and our review of these values. We found no alternative sources of air cleaner capacity and energy consumption data, other than the ENERGY STAR QPL. We note that NEEA's on-mode hours assumption is considerably more conservative than the assumption used in the ENERGY STAR air cleaner energy consumption calculator, which some jurisdictions around the country have adopted for their Technical Reference Manuals (TRMs).[5] The ENERGY STAR calculator does not clearly document the sources on which its usage estimates are based.[6]

[4] Apex notes that this step would not be appropriate if the short term outcome of an intervention were to influence the purchase decisions of individual consumers; in that case, it would be important to capture energy consumption differences resulting from differences in average capacity between efficient and inefficient products.

[5] The Illinois TRM and Mid-Atlantic TRM both rely on the ENERGY STAR calculator for estimating air cleaner energy savings.

[6] Current Illinois and Mid-Atlantic TRMs note that the link to the ENERGY STAR calculator is no longer available; Apex was unable to identify a new URL which houses the calculator to verify.

NEEA's assumptions are consistent with findings from two studies conducted in California, both of which were published in 2004.[7]

Table 2. Air Cleaner Unit Energy Consumption Assumptions

Variable	Value	Source	Suggested Alternative	Notes / Identified Issues
On-mode hours	8	Not Listed	N/A	Conservative, is ½ the assumed ES hours.
Standby hours	16	Not Listed	N/A	Conservative, is twice the assumed ES hours.
Smoke CADR and CADR/Watt	Varies based on model	RPP Sales Data and ENERGY STAR QPL	N/A	No superior alternative data source identified
On-mode and standby power	Varies based on model	ENERGY STAR QPL	N/A	No superior alternative data source identified

To further assess NEEA's UEC estimates, we compared NEEA's calculated UEC values for each smoke CADR bin relative to the average of UEC values listed in the ENERGY STAR QPL for the equivalent smoke CADR bin. Because ENERGY STAR's UEC calculation assumes air cleaners operate in active mode for 16 hours per day, twice the active mode usage NEEA assumes, we halved the ENERGY STAR UEC averages for comparison to NEEA's estimates.

As Table 3 demonstrates, the average ENERGY STAR UEC values are within 15% of NEEA's values across the CADR bins, with the exception of the largest bin, in which NEEA's estimate is 28% larger than the ENERGY STAR average. It is important to note that the ENERGY STAR averages are straight averages by CADR bin and do not account for sales volumes. As a result, we would not expect them to be perfectly aligned with the estimates based on NEEA RPP sales data. Given these findings, we do not recommend changes to the UEC assumptions apart from adding citations for the operating hours to current documentation and providing clarity on the uncategorized sales data (as noted above).

Table 3. NEEA versus ENERGY STAR V2.0 Qualified Air Cleaner Metrics

CADR Bin	NEEA RPP Sales Data	ENERGY STAR QPL
	UEC (kWh)	
< 100	97	97
100-149	151	135
150-250	155	172
> 250	356	255

*2018 RPP sales data did not have ENERGY STAR qualified sales for the largest CADR bin.

[7] The Association of Home Appliance Manufacturers (AHAM), "Report to California Energy Commission: Analysis of Energy Efficiency of Room Air Cleaners" (Sacramento: California Energy Commission, August 9, 2004), http://www.energy.ca.gov/appliances/2003rulemaking/documents/public_comments/2004-8-13_AHAM.PDF; Davis Energy Group, "Draft Analysis of Standards Options for Portable Room Air Cleaners," Codes and Standards Enhancement Initiative For PY2004: Title 20 Standards Development (San Francisco: Pacific Gas and Electric Company, May 6, 2004), http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Port_Room_Air_Cleaner.pdf.

Conclusions:

- **Conclusion 1: The value of normalizing for capacity in calculating UES estimates was challenging to ascertain.** As noted above, NEEA's UES calculation normalizes UEC estimates across efficiency tiers within each efficiency bin. This calculation reduces the impact of differences in average capacity by efficiency tier on UEC estimates. Initially, it was unclear how this step improves the UEC estimates, and only after receiving the rationale from Energy Solutions was it finally clarified.
  - **Recommendation 1: NEEA should request Energy Solutions clearly describe the underlying rationale for UEC and UES logic along with its description of methodology in future product documentation.**
- **Conclusion 2: The inputs to NEEA's UEC and UES estimates are reasonable**. Given the limited availability of alternate data sources, it is reasonable for NEEA to draw on the ENERGY STAR QPL for air cleaner capacity and energy consumption data. While NEEA's air cleaner usage estimates differ from those used in jurisdictions that rely on the ENERGY STAR calculator, they are consistent with two well-documented studies. The sources of the ENERGY STAR calculator's assumptions are not clear, and the calculator itself is no longer available.
  - **Recommendation 2: NEEA should continue to use its current sources for UES calculation inputs.**

Market Size Estimate

This section reviews NEEA's approach to estimating air cleaner market size. NEEA's market size estimate is based on an approach commonly called a top-down model. To assess the accuracy of the market size estimate this model generates, Apex conducted a second market size analysis, using an approach commonly called a bottom-up model. As both models draw on ENERGY STAR Unit Shipment Data (USD) reports as a key input, we further sought to assess the accuracy of ENERGY STAR USD reporting.

Top-Down Model

NEEA's current method for estimating air cleaner market size relies on applying the ratio of the number of households in the NEEA region relative to the total US households to total US air cleaner sales, as indicated in the annual ENERGY STAR USD reports (see Table 5 below). Table 4 lists the key assumptions underlying a top-down model, the areas of uncertainty of those assumptions, and Apex's assessment of those assumptions.

Table 4: Top-Down Model Key Inputs and Assumptions

Key Assumptions	Data Sources Used	Areas of Uncertainty	Apex Assessment
Share of US households in NEEA region	US Census Bureau, American Community Survey 1-year estimate	None.	This is a reliable data source; continue using.
Total US air cleaner shipments	ENERGY STAR Unit Shipment Data (USD) Report	USD reporting may be incomplete. • RPP sales data have historically suggested a higher ENERGY STAR market share than USD reporting indicates. • One online market research source suggested a notably larger market size than USD reporting indicates. This source reported 6.3mm units sold in 2018.[8] Additionally, emails with AHAM suggested sales volumes are considerably higher than reported by USD.	Despite the potential that data are incomplete, ENERGY STAR USD reports are the best option for NEEA to use going forward: • NEEA no longer has access to current RPP sales data. • Differences in the products included can be a source of inconsistencies in air cleaner estimates. The publicly available market data source did not include sufficient data on included products to assess its consistency with RPP products. • The updated V2.0 ENERGY STAR specification includes changes to reporting requirements designed to increase the accuracy of USD estimates.
Relative air cleaner sales in NEEA region vs. US as a whole	None – Sales assumed to be equivalent	Air cleaner sales are likely responsive to local conditions (allergies, wildfires, air quality) and thus may vary by region.	With no known data sources available to assess air cleaner sales differences between regions, it is reasonable to continue assuming that NEEA region sales are proportional to national sales. NEEA may consider collecting air cleaner data in the upcoming Residential Building Stock Assessment (RBSA).

[8] https://www.statista.com/statistics/515011/us-retail-unit-sales-of-air-cleaners/

The top-down model results in an estimated 76,107 total ENERGY STAR qualified units sold in 2018 within the NEEA region (Table 5).[9]

Table 5. 2018 NEEA Air Cleaner Market Size Assumptions, Top-down

Variable	Assumed Value	Source
Top-down estimate		
US Housing Stock	138,539,906	U.S. Census, ACS[1]
NEEA Housing Stock	6,187,691	U.S. Census, ACS[1]
NEEA % of Housing stock	4.5%	Ratio
Total 2018 US ENERGY STAR qualified shipments	1,704,000	EPA shipments report[2]
2018 ENERGY STAR Market Share	35%	EPA shipments report[2]
Total US shipments (ENERGY STAR qualified and not qualified)	4,868,571	Calculation
Total 2018 NEEA sales	**219,086**	Calculation
ENERGY STAR Qualified NEEA sales	**76,107**	Calculation

1 United States Census Bureau. American Community Survey. 2018: ACS 1-Year Estimates Data Profiles.
2 US EPA, ENERGY STAR® Unit Shipment and Market Penetration Report Calendar Year 2018 Summary

Bottom-Up Model

An alternative method for estimating air cleaner market size relies on calculating the annual demand of units from NEEA housing stock and an annual air cleaner turnover rate. This approach is commonly referred to as a bottom-up model. Table 6 lists the key assumptions, data sources, areas of uncertainty, and Apex's assessment of the uncertainty included in a bottom-up model.

[9] For this analysis, we are being consistent with NEEAs approach of converting the USD shipments into NEEA region sales on a one-to-one basis. Without any data to specify the relationship between shipments and sales, we assume sales are equivalent to shipments.

Table 6: Bottom-Up Model Inputs and Key Assumptions

Key Assumptions	Data Sources Used	Areas of Uncertainty	Apex Assessment
Total households in NEEA region	US Census Bureau American Community Survey 1-year estimates	None.	This is a reliable data source.
Share of NEEA households with an air cleaner	Consumer Reports, "Air Purifiers and the Cost of Clean Air"	Because the article does not provide a source for its household penetration estimate, we cannot assess the timing or likely accuracy of this value. In addition, the listed estimate is at the national level. Household penetration in the Northwest may vary from the national average. The penetration rate also ignores the possibility that some households own multiple air cleaners.	There is no other known data source for household penetration, and, as noted above, no known Northwest-specific sources. Including air cleaner data in the RBSA could address this gap.
Expected useful life	Illinois Technical Reference Manual	Actual measure life may be shorter than this estimate suggests given technological change and likelihood that some consumers do not change filters as frequently as recommended, placing additional stress on fan motors.	No alternate data sources are available, although, as discussed below, a measure life assumption of 7 years is consistent with top-down market size estimates.
Market growth	ENERGY STAR Unit Shipment Data Report, average year-over-year shipment growth 2015-2019	As noted in Table 4, above, USD reporting may be incomplete.	It is important to consider market growth, as market analysts have predicted and continue to anticipate, growth in the air cleaner market. ENERGY STAR USD reports are consistent with this assessment, showing steady growth in shipments since 2015. ENERGY STAR USD reports are the most readily available data source to assess market growth.

The bottom-up model estimates a total of between 147,661 and 232,038 air cleaners sold in the NEEA region in 2018, depending on the air cleaner measure life (Table 7).

Table 7. 2018 NEEA Air Cleaner Market Size Assumptions, Bottom-up

Variable	Assumed Value			Source
Bottom-up estimate				
NEEA Housing Stock	6,187,691			U.S. Census, ACS1
% of Housing with air cleaner	25%			Consumer Reports[2]
Assumed Life	7	9	11	Mid-point 9-year basis from IL TRM[3]
Turnover Rate (1/Life)	14%	11%	9%	Calculation
2018 NEEA region Replacement Units	220,989	171,880	140,629	Calculation
Market Growth	5%			ENERGY STAR USD[4]
Total 2018 NEEA Region Units	**232,038**	**180,474**	**147,661**	Calculation

1 United States Census Bureau. American Community Survey. 2018: ACS 1-Year Estimates Data Profiles.
2 Consumers Reports, Air Purifiers and the Cost of Clean Air, https://www.consumerreports.org/air-purifiers/air-purifiers-and-the-cost-of-clean-air/
3 ILSAG, 2020 Illinois Statewide Technical Reference Manual, https://s3.amazonaws.com/ilsag/IL-TRM_Effective_01-01-20_v8.0_Vol_3_Res_10-17-19_Final.pdf
4 Average year-over-year shipment growth 2015-2019

The bottom-up estimate assuming a 7-year measure life (232,038 units) provides a market size estimate very similar to the result of the top-down estimate (219,086). This consistency between the two estimates derived using different methods increases our confidence in their accuracy. As noted above, however, the data underlying each estimate include areas of uncertainty.

ENERGY STAR Market Share

As noted in Table 4, there are some indications that the ENERGY STAR USD reporting may be incomplete. Given the importance of the USD reporting in NEEA's market size estimates and limited availability of alternate sources for estimates of market size and ENERGY STAR market share, Apex sought to determine whether USD market share estimates are likely to be reliable.

Soon after it included air cleaners in RPP, NEEA identified a discrepancy between the ENERGY STAR market share listed in EPA's annual USD reports and the ENERGY STAR market share reflected in RPP sales data. While the USD reports showed relatively low market share, RPP sales data indicated that the vast majority of air cleaners sold were ENERGY STAR. For example, in 2017 the USD report listed an ENERGY STAR market share of 39%, while 93% of air cleaner sales in RPP sales data were ENERGY STAR.

NEEA began to engage with EPA staff on air cleaners and took steps to investigate the extent to which RPP sales data were representative of the market as a whole. These efforts

included a study that Energy Solutions conducted in 2018 using web scraping to gather product data from retailer websites. The study included both RPP and non-RPP retailers, including online-only retailers.

Energy Solutions used three different methods to estimate ENERGY STAR market share based on the information available on retailer websites, including the model ranking when sorted by "most popular" items and the number of customer reviews. These approaches yielded market share estimates that ranged from 47% to 78% (Table 8), notably higher than the USD report's estimate of 35% in 2018, but lower than the 87% market share indicated by RPP sales data for that year.

Table 8: 2018 ENERGY STAR Air Cleaner Market Share Estimates

Retailer Type	ENERGY STAR USD Report	ESRPP Sales Data	Energy Solutions Web Scraping Approaches		
			ENERGY STAR Models as Share of 40 Top Selling	Top Selling Models Weighted by Sales Distribution*	Share of All Customer Reviews on ENERGY STAR Products
ESRPP Retailers	Not Covered	87%	63%	71%	78%
Online-Only Retailers		Not Covered	51%	53%	58%
Other Retailers			52%	47%	55%
Total	35%		Not Covered		

* Energy Solutions used RPP data to determine a relationship between a product's sales rank on a retailer's website and its market share. Energy Solutions then used this relationship to estimate market share based on product sales ranks in the web scraped data.

Apex conducted a more limited review of the websites of major retailers to further assess the accuracy of the ENERGY STAR USD reporting.[10] We calculated the share of all models and the share of the ten best-selling models on each retailer website that were ENERGY STAR. If the share of ENERGY STAR models among top sellers is notably larger than the overall share of ENERGY STAR models, it is likely that the share of ENERGY STAR models underestimates ENERGY STAR market share. Likewise, if ENERGY STAR models are underrepresented among top sellers, market share is likely lower than the overall model share.

The share of ENERGY STAR qualified units on each website ranged from 25% to 53% (Table 9**Error! Reference source not found.**). The share of top-selling models that were ENERGY STAR also varied widely, ranging from 20% to 70%, and the relationship between the share of top sellers that were ENERGY STAR and the overall model share was not consistent across retailers. Nonetheless, both the overall model shares and the share of ENERGY STAR

[10] We also reviewed Amazon online marketplace but could not produce equivalent findings as noted above because Amazon does not offer sorting by product popularity nor does it offer a filter for ENERGY STAR qualified models.

models among top sellers are broadly consistent with the 43% market share reported in the 2019 ENERGY STAR USD report.

Table 9. Unique Model and ENERGY STAR counts on retailer websites

Retailer	Total Model Count	ENERGY STAR model count	Percent ENERGY STAR	Top seller ENERGY STAR?	Percent of top ten sellers ENERGY STAR
Home Depot	230	58	25%	No	20%
Lowe's	74	33	45%	Yes	60%
Costco	15	8	53%	No	40%
Best Buy	88	34	39%	No	60%
Sears	111	36	32%	No	70%

*Walmart and Target online stores did not include a filter to identify ENERGY STAR models.

Conclusions:

- **Conclusion 3: NEEA's market size estimation approach, and its market size estimate, are reasonable but could be enhanced with additional market data.** The top-down approach that NEEA uses provides a market size estimate very similar to the result of a bottom-up approach that assumes a seven-year measure life. This similarity in results across different approaches increases our confidence in NEEA's estimate. Nonetheless, the uncertainty in both estimates could be reduced with more granular data on household penetration of air cleaners in the Northwest. This could allow for adjustments to the top down model to address differences in air cleaner sales in the Northwest relative to the rest of the country, while household penetration is a direct input in the bottom-up model.
  - **Recommendation 3: NEEA should include air cleaners in the upcoming RBSA.**
- **Conclusion 4: While it is important to recognize there is uncertainty in ENERGY STAR USD reporting, it is reasonable for NEEA to draw on USD values in its market size estimates.** Both the Energy Solutions web scraping analysis and the market research source cited in Table 4 indicate that there may be gaps in ENERGY STAR USD coverage. Nonetheless, the most recent ENERGY STAR USD market share estimates are in line with Apex's limited website review. In addition, EPA adopted changes in the recently updated, Version 2, ENERGY STAR specification for air cleaners designed to increase the accuracy of USD reporting.[11] In consideration of these changes and the lack of alternative sources for market share and market size data the ENERGY STAR USD reports are a reasonable input to NEEA's calculations.

[11] These changes included clarifying the definition of air cleaners and listing that definition on the Unit Shipment data collection form, with the intention that doing so would reduce the potential for manufacturers to report sales of products like filter replacements or air fresheners as air cleaners.

- **Recommendation 4: NEEA should continue to use USD reports as an input to its market size analysis.**

Naturally Occurring Baseline

There are two key components to the naturally occurring baseline: market share and energy usage. The **Specification Assessment Memo** addresses the baseline market share of air cleaner products. As noted above, NEEA's baseline energy usage estimates are based on the reported energy consumption of air cleaners that qualify for the ENERGY STAR V1.2 specification but do not qualify for the V2 specification. This is a conservative assumption, as the baseline also includes products that do not qualify for any ENERGY STAR specification.[12] However, as no federal or state efficiency standards apply to air cleaners and the AHAM Verifide program does not publish air cleaner efficiency or energy consumption data, there is no publicly available source of energy data for non-ENERGY STAR air cleaners.

In 2016, PG&E conducted a metering study to assess the energy consumption of non-ENERGY STAR air cleaners. Among the nine models the study tested that were included in RPP sales data, the sales weighted average CADR/W was 1.96, slightly below the ENERGY STAR V1.2 threshold of 2.0.[13] The limited difference between the average efficiency of non-qualified models and the ENERGY STAR V1.2 threshold this study found further supports NEEA's decision to use models that meet the V1.2 specification but do not qualify for the V2 specification to calculate an energy consumption baseline.

Finally, Apex sought to identify any trends in air cleaner energy consumption that might suggest changes to baseline consumption over time. From April 2017 until NEEA discontinued midstream incentives for air cleaners, the RPP basic tier qualification for air cleaners was a CADR/W at least 30% greater than the ENERGY STAR V1.2 minimum specification (ENERGY STAR V1.2 + 30%). Defining ENERGY STAR models with efficiency levels below the RPP basic tier as baseline models, we analyzed average efficiency levels by CADR bin based on the year each baseline model became available on the market. However, the number of models meeting these criteria were limited and the available data do not indicate clear trends in efficiency of baseline models (Table 10). As a result, we do not recommend any adjustments to baseline energy consumption to account for trends in efficiency of baseline models.

[12] NEEA's UES calculation workbook does not document the volume of sales of these models, or their distribution across capacity bins.

[13] Note that the study based its conclusions on an unweighted average CADR/W value of 2.2. Apex calculated the sales weighted average based on model-level sales and efficiency information included in the report. The sample included one model that tested as highly efficient but had limited sales.

Table 10: Efficiency of ENERGY STAR V1.2 Air Cleaners Not Qualifying for RPP Basic Tier (ENERGY STAR + 30%) by Year Available on Market

CADR Bin	2017		2018		2019	
	# of Models	Avg. CADR/W	# of Models	Avg. CADR/W	# of Models	Avg. CADR/W
30≤ CADR <100	1	2.5	5	2.1	3	2.3
100≤ CADR <150	0	N/A	8	2.3	2	2.5
CADR ≥150	2	2.3	5	2.2	0	N/A

Conclusions:

- **Conclusion 5: Air cleaners that meet the ENERGY STAR V1.2 specification but not the V2 specification provide a reasonable energy consumption baseline.** While this baseline does not include products that do not qualify for ENERGY STAR, the results of the PG&E metering study indicate that the energy consumption of these air cleaners may be relatively close to the ENERGY STAR V1.2 requirement. In addition, no alternate data source exists for non-qualified air cleaner energy use.
  - **Recommendation 5: Continue using ENERGY STAR V1.2 models that do not qualify for the V2 specification as an energy consumption baseline.**