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Refrigerator and Freezer Influence Assessment and Baseline Review

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Introduction

This report presents updated findings from Apex Analytics' review of NEEA's efforts to influence the residential refrigerator and freezer markets, particularly through support of the 2020/2021 ENERGY STAR[®] Emerging Technology Award (ETA) for refrigerators and the accompanying alternative test procedure. Apex also reviewed the assumptions underlying NEEA's naturally occurring baseline (NOB) for refrigerators and freezers meeting the ETA, as well as the ENERGY STAR Most Efficient (ESME) specification, which NEEA primarily supported through midstream incentives.

Apex gathered data from multiple sources to inform this review, listed in Table 1. Apex completed the bulk of this review in the spring of 2022. That initial analysis drew on an ETA Qualified Products List (QPL) that was current as of the end of 2021 and included 49 refrigerator and freezer models. Over the course of 2022, manufacturers added a total of 35 models to the ETA QPL, increasing the total number of qualified models to 84. The majority of the added models (27 of 35) were refrigerators with bottom-mounted freezers (bottom-mount models). RPP retailers reported sales for 12 of those added bottom-mount models prior to the launch of the ETA in 2020. Those additional sales altered the pre-award market share estimates on which the recommended NOB approach had been based, and, at NEEA's request, Apex revisited their review of baseline assumptions for bottommount models in the spring of 2023.¹

Data Source	Quantity	Objectives
Interviews with NEEA Staff	1 interview with 2 staff	Understand NEEA's activities in the refrigerator market and involvement in ETA.
Interviews with EPA Staff	1 interview with 2 staff	Understand process of establishing the ETA and assess NEEA's influence.
Interviews with refrigerator manufacturers	3 interviews	Understand role of ETA in increasing adoption of refrigerators with advanced adaptive compressors. Identify broader refrigerator market trends. Understand reasons for delayed certification of some models.
Sales data analysis	N/A	Identify trends in uptake of refrigerators meeting ETA and ESME specifications.
Secondary research	N/A	Gather data on adoption and promotion of refrigerators with advanced adaptive compressors, identify broader refrigerator market trends.

Table	1:	Data	Sources
10010		Data	0001000

¹ In addition to bottom-mount models, the models added to the ETA QPL in 2022 included one refrigerator with a side-mounted freezer, four refrigerators with top-mounted freezers, and three stand-alone freezer models. ESRPP retailers did not report sales of any of these models prior to the award's launch in 2020. As a result, their addition does not impact our initial baseline assessment. This report begins with an assessment of NEEA's influence on the ETA and baseline assumptions around models meeting ETA requirements, followed by an assessment of NEEA's baseline assumptions for ESME models.

ETA Assessment

Background

Through conversations with the U.S. Environmental Protection Agency (EPA) and manufacturers, NEEA identified advanced adaptive compressors as an emerging technology with potential to significantly increase refrigerator and freezer efficiency. A standard compressor in a refrigerator or freezer turns on when the temperature inside the cooling compartment reaches a certain threshold. The compressor runs at a constant speed until the temperature returns to a target level. An advanced adaptive compressor combines more sophisticated controls to monitor conditions in the cooling compartment with a variable speed compressor, which can continuously adapt its power. Advanced adaptive compressors can achieve significant energy savings over a standard compressor by running at lower speeds to maintain a more constant temperature.

EPA, with support of partners including NEEA, selected advanced adaptive compressors as the focus of the Emerging Technology Award (ETA) in 2020 to encourage increased availability and reduced costs for refrigerators and freezers incorporating the technology and other efficiency improvements.² EPA extended the ETA for refrigerators and freezers through 2021, and, beginning in 2022, the ESME specifications for refrigerators and freezers incorporated some elements from the ETA.

EPA also determined that refrigerators and freezers using advanced adaptive compressors were more efficient under real-world conditions than the current test procedure indicates. As a result, EPA developed an alternate test procedure, based on the International Electrotechnical Commission's (IEC) requirements, that would better demonstrate these efficiency differences. Refrigerator and freezer models can qualify for the ETA using either the current test procedure (by achieving an efficiency level 30% greater than the federal minimum standard) or the alternate test procedure (by achieving an efficiency level with the compressor in adaptive mode that is 25% greater than the model's efficiency level with the compressor in fixed-speed mode).

A key difference in the test procedures is that the alternate test procedure tests at multiple ambient temperatures, while the standard test procedure tests at a single ambient temperature of 90 degrees Fahrenheit. One motivation for testing at an ambient temperature that is higher than a typical kitchen is to account for the increased energy use that would result from the refrigerator or freezer door being opened and closed in real world conditions. A steady-state test at a relatively

² EPA has offered the ETA since 2011 to raise awareness of leading energy efficient technologies. EPA typically features technologies through the award for one-to-two years.

extreme temperature does not effectively capture advanced adaptive compressors' ability to modulate the compressor's power in response to more subtle temperature changes.

NEEA's approach to estimating naturally occurring baseline adoption for refrigerators and freezers meeting the ETA requirements is based on an estimate of NEEA's influence on the adoption of the ETA and incorporation of the alternate test procedure to support it. The proposed baseline that NEEA asked Apex to review assumes that, without the ENERGY STAR Retail Products Platform (ESRPP) program, there would, effectively, be no sales of models qualifying for the ETA, on the basis that the program was highly influential in establishment of the award and incorporation of the alternate test procedure. As a result, NEEA proposes a baseline market share of zero for products qualifying for the ETA.

If either DOE or ENERGY STAR adopt the alternate test procedure, NEEA will report all of the savings from models qualifying under that test procedure as Net Market Effects until a new federal standard update takes effect, which NEEA's proposed baseline assumes will take place in 2026. This assumption anticipates that a new test procedure would be adopted with an updated federal standard.

Approach

Apex assessed NEEA's influence on the adoption of the ETA and baseline assumptions around adoption of ETA models in two parts: first Apex considered the extent to which NEEA influenced EPA's decision to use the ETA to support advanced adaptive compressors in refrigerators and freezers and their inclusion of the alternative test procedure in the ETA.

Second, Apex considered the role of the ETA in increasing adoption of qualified models. In estimating a baseline market share of 0% for products meeting the ETA requirements, NEEA assumes that none of these products would be available, or that sales of available products would be close to zero, absent the ETA and the alternate test procedure. Strong adoption of refrigerators meeting ETA requirements prior to the establishment of the award would contradict these assumptions, so we assessed trends in adoption of qualified models prior to the establishment of the ETA. We also sought to understand any non-energy benefits that might have driven adoption of advanced adaptive compressors independent of the ETA in our assessment of the role the ETA played in adoption of qualified products. Finally, we investigated the importance of the recognition the ETA provided on manufacturers' decisions to develop qualified products. Table 2 lists these objectives and the more specific questions we investigated to address each.

Objective	Research Questions
Understand the extent to which NEEA influenced	Which elements of the ETA and decision to incorporate the alternate test procedure originated with NEEA and other ESRPP sponsors?

Table 2: ETA Assessment	Objectives
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adoption of ETA for refrigeration products using advanced adaptive compressors	What role did NEEA's support play in motivating EPA to implement the ETA.	What barriers did EPA face in implementing the ETA? How, if at all, did NEEA help overcome those barriers?	
	including the alternative test procedure, when and how it did?	What other actors sought to influence the development of the ETA, and how did they hope to influence it?	
	To what extent were products meeting the ETA requirements, and particularly those using the alternate test procedure, available prior to the establishment of the ETA?		
Understand the influence of the ETA in increasing adoption of qualified products	How important was the ETA in the growth in	What role did the recognition the ETA provided play in motivating manufacturers to offer products with advanced adaptive compressors?	
produces	availability of products meeting the requirements?	What non-energy benefits do products with advanced adaptive compressors offer to consumers and/or manufacturers? How do those benefits compare to efficiency in motivating product development?	

Finding: NEEA's Influence on the ETA

Interview findings suggest NEEA influenced adoption of the ETA for refrigerators and freezers.

NEEA and EPA staff reported that NEEA began engaging with EPA on advanced adaptive compressors following a 2017 presentation EPA staff delivered to ESRPP program sponsors on emerging efficiency opportunities in refrigeration. Discussions between NEEA and EPA initially focused on a proposed initiative to increase production and drive uptake of efficient technologies through bulk purchases. In their discussions, NEEA and EPA narrowed down the specific technologies and efficiency requirements refrigerators would need to meet to be included in the proposed bulk purchasing effort. These discussions also helped to identify the challenges the current test procedure poses for products with advanced adaptive compressors, and NEEA conducted testing to further document these issues.

While the proposed bulk purchasing initiative did not come to fruition, EPA leveraged the technology and efficiency requirements and test procedure findings refined through their discussions with NEEA in developing the ETA. Interview findings suggest that the clarity around efficiency opportunities and test procedure challenges resulting from NEEA's discussions with EPA staff provided important support for the establishment of the ETA. According to one EPA staff member, "I can see a scenario where, if there wasn't that interest in [the proposed bulk purchase initiative], we would not have had those conversations with manufacturers [to identify the most promising opportunities in refrigeration] and we may never have had that conversation about creating an ETA award."

EPA staff further suggested that feedback from ESRPP retailers factored into their consideration of establishing the ETA. Specifically, retailer sustainability staff APEX ANALYTICS

reported that it can be difficult to communicate efficiency specification levels that go beyond basic ENERGY STAR certification to stakeholders within their organizations. EPA staff saw the ETA as a way to provide a qualified products list documenting the specific models using technologies EPA and ESRPP program sponsors sought to promote. As one staff member explained, "because some of the things NEEA told us, if we are really trying to push the refrigeration market and get [products with advanced adaptive compressors] highlighted...having it be part of an established program like ETA is the better way to go. Information like that was very helpful in encouraging us to do the ETA."

ESRPP incentives may have driven manufacturers to develop ETA models.

Interviewed EPA staff indicated that ESRPP incentives for models meeting the ETA specification may have motivated manufacturers to produce a larger number of models meeting the criteria. EPA staff noted that the ETA for refrigeration products had been successful, in that manufacturers had certified a relatively large number of products and seemed to feel some competitive pressure to certify products.

EPA staff attributed this uptake to the availability of ESRPP incentives. EPA staff explained that, without incentives, the primary benefit qualifying for an ETA offers to manufacturers comes from marketing and public relations. The promotional benefits of using the award to position a manufacturer as an industry leader and promote the efficiency of their product line are greatest for the first models that manufacturers certify. There is limited incremental benefit in certifying additional models from a promotional perspective. According to one EPA staff member, "having some incentive behind [the ETA] gives [manufacturers] some other reason to increase [the number of certified models] beyond having 'recipient of the ETA' on your web page; there is more to gain than just that."

Finding: ETA Influence on Adoption of Advanced Adaptive

Compressors

Refrigerators using variable speed compressors were available independent of the ETA but may not have met ETA efficiency requirements.

Refrigerators and freezers with advanced adaptive compressors have variable speed compressors that are controlled by sensors to optimize the cooling capacity to match the thermal load in the cooling compartment.³ While refrigerators using variable speed compressors were available prior to the establishment of the ETA, some of these models may not have met the ETA's efficiency requirements for advanced adaptive compressors. Tracking historical adoption of variable speed compressors is challenging since available product databases, like the ENERGY STAR Qualified Products List and ESRPP sales data, do not specify the type of compressor a model uses. Available data suggest that refrigerators with variable

³ Variable speed compressors are also called inverter compressors.

speed compressors entered the market as early as 2014, and likely accounted for more than 5% of refrigerator sales by 2015. Press releases on LG and Samsung's websites indicate that both companies offered refrigerators using variable speed compressors in 2014 or 2015.

In 2020, LG settled a class action lawsuit related to the reliability of the variable speed compressors installed in refrigerators it sold between 2014 and 2017. In the settlement, LG denied wrongdoing and argued that the compressors were not defective.⁴ Nonetheless, the list of refrigerators covered by the lawsuit provides some insight into the market share of refrigerators using variable speed compressors during that time period.⁵ Covered LG models accounted for 4.8% of refrigerator sales through ESRPP retailers in the Northwest in 2015, with market share declining in subsequent years, likely as covered models left the market (Figure 1).



Figure 1: Market Share of LG Refrigerators with Variable Speed Compressors Included in 2020 Settlement, 2015-2020

Manufacturers marketed their variable speed compressors as providing greater energy efficiency, as well as a variety of non-energy benefits, including:

⁴ Daniel Wroclawski, "LG Settles Class-Action Lawsuit Over Refrigerator Compressors," Consumer Reports, September 17, 2020, https://www.consumerreports.org/lawsuitssettlements/lg-settles-class-action-lawsuit-over-refrigerator-compressors/.

⁵ "Covered Models," LG Refrigerator Class Action Settlement Bentley, Et Al. v. LG Electronics U.S.A., Inc., accessed March 30, 2022, https://www.lgfridgesettlement.com/covered-models.php.

- **Reliability**: some manufacturers offer linear variable speed compressors, which they market as more reliable due to having fewer moving parts than a conventional compressor.⁶
- Noise reduction: the ability to operate at lower speeds enables variable speed compressors to operate more quietly than conventional compressors. Fewer moving parts can also contribute to noise reduction in products using linear compressors.
- **Food preservation:** variable speed compressors can maintain more consistent temperatures within the refrigerator, preserving foods more effectively.

While refrigerators with variable speed compressors were available prior to the establishment of the ETA, interviews and data analysis findings suggest that few of these models met the requirements for advanced adaptive compressors included in the ETA. NEEA staff described the ability to adapt to conditions within the refrigerator or freezer compartment as a key feature of the advanced adaptive compressors the ETA sought to promote, and EPA staff described ETA models as a "second generation" of products using variable speed compressors.

Analysis of RPP sales data supports these assertions. In 2020 and 2021, ESRPP retailers sold 81 unique refrigerator and freezer models that gualified for the ETA.⁷ Only 14 of those models (17%) were available prior to the ETA's launch in 2020, with seven introduced in 2018 and seven introduced in 2019. ETA-gualified models accounted for a small share of total refrigerator sales prior to the launch of the award, with a market share of 0.5% in 2018 and 1.0% in 2019 before growing notably in 2020 when the award became available (Figure 2). The lower share of gualified models in 2018 and 2019 may, to some extent, reflect natural market turnover. Qualified models may have been available in 2018 and 2019 that left the market prior to the establishment of the ETA in 2020 and thus were not certified. The pace of refrigerator model turnover suggests this likely has a limited effect, however. Sixty percent of all refrigerator models sold in 2020, accounting for 85% of total refrigerator sales, were available in 2018. It is also possible that NEEA's initial discussions with EPA and manufacturers may have contributed to the availability of qualified models prior to the launch of the ETA. No ETA-qualified freezer models were available prior to 2020.

⁶ A linear compressor uses an electromagnet to move the compressor shaft back and forth, rather than a rotary arm used in conventional compressors. Manufacturers using linear compressors argue that this approach reduces the number of moving parts and friction points and should therefore increase reliability. Both linear compressors and conventional compressors can be combined with variable speed drives and advanced controls to meet ETA requirements as advanced adaptive compressors.

⁷ Model counts reflect model numbers listed in ESRPP sales data. In some cases, multiple model numbers listed in sales data correspond to a single record in the ETA Qualified Products List.



Figure 2: Annual Market Share of ETA Refrigerators 2018-2022 (All Configurations)

The ETA increased availability of qualified products.

As Figure 2 demonstrates, market share of qualified products increased notably with the establishment of the ETA. NEEA, EPA, and manufacturer interview respondents credited the recognition the ETA brought to the efficiency of products with advanced adaptive compressors for this increase.

Interview respondents noted that the current test procedure, which tests products at a single, relatively high ambient temperature, does not effectively demonstrate the efficiency benefits of advanced adaptive compressors. Analysis of models on the ETA qualified products list confirmed this finding. Among models for which performance data using both the standard and alternate test procedures were available, there was no relationship between the efficiency levels measured using each approach (Figure 3). As a result, the energy consumption values listed on the Energy Guide label and other metrics using the standard test procedure would indicate no efficiency benefit for models with advanced adaptive compressors.





The ETA provided third party recognition of the efficiency benefits of advanced adaptive compressors, which would not otherwise be available. Taking advantage of this recognition, all three manufacturers that offered qualified products featured the products' ETA qualification on their websites (Figure 4).





EPA staff reported that recognition could motivate manufacturers to increase their product offerings with advanced adaptive compressors. According to one respondent, "I think we had some influence on products that had the technology in there, it gave [manufacturers] a reason to offer the product in a way that might not get the lowest energy consumption from the DOE test but will have a better result when testing it using the ETA test approach, which we believe is more reflective of instances in the real world."

One manufacturer confirmed the assertion that the award had helped justify development of additional qualified products, saying "We needed something that would motivate why we would commit so much investment, so much research and development. The ETA award category has really helped justify that from an internal decision to bring it to the market." This manufacturer further stated that they had increased the number of qualified models available as a result of the award, saying that, without the ETA, "we would [offer models with advanced adaptive compressors] but far less. I can be sure of that because, if you look at the award timeline, it was first introduced in 2020 with only a few models...there were additional models we were able to bring to market in 2021. The award has played a part to expand the product availability and product market for this technology."

ETA Baseline Assessment

Apex's review confirmed that NEEA played an important role in the establishment of the ETA to promote advanced adaptive compressors and that the ETA led to an increase in the availability and market share of products with advanced adaptive compressors. However, findings also suggest that some products with advanced adaptive compressors would be available absent the ETA. Some qualified models were available before the award was established, and variable speed compressors (of which advanced adaptive compressors are a subset) offer a variety of nonenergy benefits manufacturers can use to differentiate their products.

Given these findings, a baseline market share of zero is likely not appropriate for all refrigerator and freezer configurations. Almost all of the qualified models available prior to the establishment of the ETA were refrigerators with a bottom-mounted freezer. All 28 of the bottom-mount models added to the ETA QPL in 2022 came from a single brand. A contact from that manufacturer confirmed that the newly certified models had met ETA requirements prior to their certification. This manufacturer reported that they had prioritized certifying some models in 2020, while testing for others had been delayed to correspond to the manufacturer's new model development schedule. EPA staff noted that the alternate test procedure included in the ETA specification requires more extensive product testing than the standard test procedure and speculated this may also have contributed to the delay in testing.

The availability of the alternate test procedure distinguishes the ETA from other ESRPP product specifications. For most ESRPP product specifications, it is possible to use reported product and energy consumption data to identify models meeting a particular efficiency specification, even if that specification is not current. However, as noted above, the standard test procedure for refrigerators does not reflect efficiency gains from the use of advanced adaptive compressors, and there is no clear relationship between a model's reported efficiency using the standard test procedure and its efficiency using the alternate test procedure. As a result, Apex

was unable to identify models meeting ETA requirements prior to the establishment of the award by their reported energy consumption.⁸

Because of this inability to track qualified models over time based on reported product and energy consumption data, the ETA QPL provides a short-term snapshot of the qualified models available during the limited period when the award was current. Due to the short-term nature of the ETA QPL, it is important to consider the impact of product turnover when assessing trends in market share based on historical sales of the models listed.

Manufacturers add new models to the market each year and remove old ones. As a result, among any set of models available in a given year, many were likely available the prior year, a smaller number available two years prior, and still fewer available three years prior. As the number of models available in a given year decreases with each prior year, the market share of models available in the reference year relative to total sales in each prior year will also likely decrease, as fewer models typically account for fewer sales.

Consistent with this pattern, ESRPP retailers reported sales of 69 bottom-mount ETA refrigerators in 2022.⁹ All but one of those models were also available in 2021, but only 43 of the 69 models were available in 2020 and the number available fell notably with each prior year. As Figure 5 shows, the change in ETA market share largely paralleled the number of available models.

 $^{^{\}rm 8}$ Product databases do not track the type of compressor used in a particular refrigerator model.

⁹ Some models listed on the ETA QPL correspond to multiple models in the ESRPP sales data. Model numbers listed in sales data may reflect non-energy related characteristics like a device's color or finish, while those listed on the QPL are more general, for example using wildcard characters to indicate potential variation.





To some extent, the growth in both model availability and market share of ETA models likely reflects growing adoption of advanced adaptive compressors and, after 2020, the effects of the ETA and ESRPP incentives. However, it also reflects model turnover, as discussed above. To assess the extent to which the growth in market share of ETA models is likely to reflect model turnover, Apex randomly selected sets of 69 bottom-mount models available in 2022, equivalent to the number of unique bottom-mount ETA models ESRPP retailers sold that year. The purpose of these random model sets was to serve as a kind of control group; each set's market share was unlikely to be impacted by the adoption of new technologies that affected ETA model uptake.¹⁰ Instead, change in market share of the random model sets over time would primarily reflect model turnover along with, potentially, trends impacting the market as a whole.

Apex calculated the market share of each random model set for each year from 2016 to 2022 as a ratio of that year's total sales of models within the random model set to total sales for all models that year. We repeated the randomization 100 times and calculated an average market share for each year from the 100 random comparison model sets. The result, shown in Figure 6, illustrates the growth in market share we believe is attributable to model turnover.

¹⁰ The random nature of these groupings should minimize the extent to which trends in uptake of particular product features impact changes in market share over time since the likelihood that a product included in the grouping would have a trending feature is equivalent to the prevalence of that feature in the market as a whole. Our approach of averaging across multiple random selections should further mitigate the potential that any random grouping would reflect a non-representative trend by chance.



Figure 6: Average Market Share of Randomly Selected Bottom-Mount Model Sets

Any increase in the share of ETA models beyond the growth due to model turnover reflects other market forces, which Apex anticipates would likely continue to drive uptake of ETA models in a baseline case. From 2017 to 2019, the market share of ETA models grew from 0.6% to 8.8%, an average annual increase of 4.1%.¹¹ Over the same period, the average market share of our random model groupings grew from 2.0% to 6.7%, an average annual increase of 2.4%. Thus, it is assumed that, of the 4.1% observed annual growth in bottom-mount ETA market share prior to the establishment of the award, 2.4% reflects model turnover and the remaining 1.7% reflects other market forces.

Market share in 2019, the year prior to the establishment of the ETA, remains a reasonable starting point for the bottom-mount ETA NOB forecast. Bottom-mount ETA market share was 8.8% in 2019. We assume that, in a baseline case, ETA market share will continue to grow at the average growth rate of the random model groupings in the years between 2019 and 2022, plus the 1.7% of additional annual growth resulting from other market forces. After 2022, we assume bottom-mount ETA market share will continue to grow steadily at an annual rate of 1.7%. Figure 7 shows this recommended NOB market share forecast.

¹¹ Apex begins this analysis with 2017 (rather than 2016) because 2017 is the first year for which reported refrigerator sales are available for all current ESRPP retailers.



Figure 7: Recommended Bottom-Mount NOB Forecast

Table 3 lists the forecasted NOB market share for each year until 2030.

Year	Actual Market Share	Recommended NOB Market Share Estimate
2019	9%	N/A
2020	21%	13%
2021	32%	16%
2022	29%	18%
2023		19%
2024		21%
2025		23%
2026		24%
2027		26%
2028		28%
2029		29%

Table 3: Recommended Bottom-Mount NOB Market Share

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Apex's recommended market share forecast predicts that, in a baseline scenario, ETA market share will continue to grow at a rate of 1.7% per year into the future. This assumes that the incremental growth above model turnover observed in the 2017-2019 period was due to factors independent of the establishment of the ETA and ESRPP incentives and that those factors will continue to impact the market. For example, as noted above, manufacturers market a variety of non-energy benefits of refrigerators with advanced adaptive compressors, including quiet operation and the potential to keep food fresh longer by better regulating temperature. However, market forces like competing technologies or supply chain disruptions could affect uptake of ETA models. Stagnant or declining ETA market shares would indicate the assumption of continuing 1.7% growth is no longer applicable. As a result, NEEA should continue to monitor the market and review and adjust its NOB forecast if market conditions change.

Product configurations other than bottom-mount refrigerators, including side-byside refrigerator/freezers and upright freezers, had no models that qualified for the ETA prior to the launch of the award, even considering the models added to the QPL in 2022. As a result, we find that a market share of zero is a reasonable baseline estimate for these configurations.

It is reasonable for NEEA to maintain these baseline estimates until the Department of Energy (DOE) adopts a test procedure for refrigeration products that reflects the efficiency benefits of advanced adaptive compressors. DOE is in the process of reviewing its test procedure and federal efficiency standards for refrigerators, but NEEA and EPA staff reported it appears unlikely the current update will incorporate the alternative test procedure. As a result, there will remain limited opportunities outside of the ETA to promote the efficiency of refrigerators and freezers with advanced adaptive compressors until the subsequent test procedure review. DOE is required to review appliance standards every six years and test procedures every seven years.¹² Thus, the next federal standard review will not be required until at least 2028. NEEA's estimate of an update occurring in 2026 is reasonable, as it assumes DOE will review the standard and accompanying test procedure before it is legally required to do so. If DOE waits until 2028 or later to update the federal standard and test procedure, NEEA may be justified in reporting additional years of savings over the current baseline estimates.

Table 4 summarizes Apex's assessment of NEEA's assumptions around baseline uptake of ETA refrigerators and freezers.

Product Configuration	NEEA Assumption	Apex Assessment
Bottom- freezer	All sales of models qualifying for the ETA are net market effects	Qualified models likely would have been available absent the ETA. NEEA should adopt the recommended baseline forecast in Figure 3, which is based on uptake in 2017-

Table 4: Apex Assessment of Assumptions Related to ETA Baseline Estimates

https://www.aceee.org/blog/2020/01/trouble-ahead-us-appliance-efficiency

¹² Andrew deLaski, "Trouble Ahead for US Appliance Efficiency Standards," American Council for an Energy Efficient Economy, January 24, 2020,

	of the program (NOB market share = 0%)	2019, when qualified market share increased by 1.7% per year beyond the growth that would be expected due to model turnover.
All others		No qualified models were available prior to the launch of the ETA, and manufacturer motivation to develop them would be limited. A NOB market share of 0% is appropriate.
All	Current baseline trends will continue until DOE adopts an updated test procedure	NEEA's estimate of a test procedure update occurring in 2026 is reasonable, if conservative. A test procedure update would likely accompany the next federal standard review, which will likely not be required until at least 2028 (although DOE could choose to act sooner).

Midstream Incentives Assessment

Background

NEEA uses midstream incentives as a primary strategy to influence uptake of ESME refrigerators and ENERGY STAR freezers. RPP program logic anticipates that these incentives will motivate retailers to take actions like favoring qualified products in assortment and marketing decisions that will increase sales of qualified products. NEEA uses historical data to estimate baseline sales absent incentives, assuming each year's baseline market share would be equivalent to a rolling average of the market share from the two prior years.

Approach

In using a rolling average market share as a baseline, NEEA assumes that market share trends from prior years would continue absent program intervention. To assess this assumption, Apex investigated trends impacting the refrigerator and freezer markets. A variety of factors, including changes in technologies or product availability, might lead to shifts in efficient market share trends. Specifically, Apex investigated the following questions:

- What shifts in refrigerator or freezer technology, availability, and demand have occurred in the past few years? What shifts are expected in coming years?
- How, if at all, might those shifts impact refrigerator or freezer efficiency and efficient product market share?

We included questions about the refrigerator and freezer markets in interviews with EPA and manufacturers and supplemented their responses with online secondary research and refrigerator sales data analysis.

Finding: Refrigerator and Freezer Market Trends

Interviews with EPA staff and manufacturers identified a variety of trends in the refrigerator market, including:

- Continued growth in in-door displays that provide a variety of functions, including keeping notes, displaying photos, and other applications.
- Growth in technologies that enable users to monitor refrigerator contents without opening, or fully opening, the door, like door-in-door designs or cameras inside the refrigerator.
- Growth in bottom-mount freezer configurations with French doors.
- Continued decline in side-by-side refrigerator/freezer configurations.

It is not yet clear how in-door displays and door-in-door designs or other, similar features might impact a refrigerator's ability to meet ENERGY STAR specifications, and thus the potential impact of these trends on ENERGY STAR market share. Bottom-mount freezer configurations have historically had relatively high ENERGY STAR market shares, while side-by-side configurations have had lower market shares. Thus, a shift toward bottom-mount models could increase ENERGY STAR market shares in the refrigerator market overall. Nonetheless, all of these trends are ongoing, and neither interview findings nor Apex's secondary data review provide indications they are likely to accelerate significantly in the coming years.

Freezer sales have been more volatile in recent years than refrigerator sales. There was a large jump in freezer sales in 2020, likely as a result of the COVID-19 pandemic. Compact freezer sales, which are primarily smaller, chest freezer models, more than doubled in 2020 relative to 2019 levels, while standard size chest freezer sales increased by more than 85%. Upright freezer sales increased by more than 30% (Figure 8). Chest freezer sales decreased somewhat in 2021 but remained above their 2019 level. Upright freezer sales continued to grow in 2021, but at a slower pace than in 2020.



Figure 8: Reported Freezer Sales in the Northwest 2017-2021

Source: ESRPP Sales Data

There were large shifts in ENERGY STAR market share of freezers in 2020 along with the shifts in overall sales (Figure 9). Market share of upright freezers, in particular, dropped notably from 2019 to 2020.



Source: ESRPP Sales Data

One freezer manufacturer anticipated that demand for stand-alone freezers would remain strong as Americans with large homes seek increased space for food storage. Nonetheless, much of the growth in freezer sales likely reflected households seeking to store more food at home and thus reduce the frequency of shopping trips during the pandemic. As a result, freezer sales will likely fall as people return to more normal purchasing patterns, eat in restaurants more frequently, and feel less pressure to minimize shopping trips.

Midstream Incentives Baseline Assessment

Apex's review finds that extrapolating from historical trends is appropriate for estimating a baseline for refrigerators and freezers. All of the refrigeration market trends our review identified are ongoing, and thus would be captured in a baseline estimate drawing on historical data, and Apex found no evidence to suggest any trends would rapidly accelerate.

We recommend, however, that NEEA modify its approach to estimating a baseline from historical trends. NEEA's current approach of using a two-year rolling average market share does not allow for declining efficient market share trends to continue in baseline forecasts.¹³ As a result, we recommend that NEEA calculate a two-year rolling average of the year-over-year change in market share and apply that change to each year's estimated baseline value to establish the subsequent year's baseline market share. This approach allows for trends of either increasing or decreasing efficient market share to continue.

As Figure 10 shows, this approach provides a baseline estimate relatively similar to NEEA's existing approach for products like ESME top-mount refrigerators, with baseline trends of increasing efficient market shares.



Figure 10: Top-Mount Refrigerator ESME Baseline Approach

Applying a two-year rolling average of the year-over-year difference in efficient market share could provide an opportunity for baseline market share estimates to either grow to 100% or shrink to 0%, depending on the trend in the baseline data. Either scenario is unlikely. As a result, NEEA should consider conditions that might lead market share to deviate from the observed trend. Some of these conditions are market events that NEEA already considers in baseline estimates.¹⁴ Potential conditions include:

¹³ If market shares are declining, the efficient market share two years prior to the first forecast year will be higher than the efficient market share the year prior to the first forecast year, as will the average of the two numbers. As a result, a baseline forecast based on a rolling average of market share from prior years will predict a rebound in market share in the first forecast year.

¹⁴ In addition to market events with potential to influence market share baselines for products receiving midstream incentives, NEEA seeks to influence federal efficiency standards and ENERGY STAR specifications. When estimating baselines, it is important to consider how standards and specifications might change absent NEEA and its partners' intervention.

- **Changes to standards:** An update of federal efficiency standards for a product category can have a dramatic impact on efficient market shares, particularly if the standards adopt an efficiency specification that the program had formerly supported.
- Changes to ENERGY STAR specifications: Eventually, increasing efficient market shares are likely to trigger an ENERGY STAR specification update. Previous research has found that EPA typically launches a specification revision before efficient market share reaches 60%.¹⁵ A specification update would likely accelerate uptake of qualified products.
- **Price barriers:** Manufacturers may be less inclined to design to efficiency standards in lower-cost models, where they face greater price competition. In some product categories, there may be a price threshold below which few efficient models are available. The market share of models below this price threshold represents a potential cap on efficient market share: if, for example, 30% of sales are at price points with little availability of efficient products, then NEEA could assume that market share growth would likely plateau at 70% or less.
- Market shifts: Shifts in a variety of market factors could impact the share of efficient products. For example, shifts in availability of qualified products among models selling in high volume, changes in manufacturer or retailer market share, and shifts in consumer demand for certain features, configurations, or capacities could all impact sales of qualified products. If NEEA can identify the shifts driving an observed change in efficient market share, it may be able to determine whether those shifts are likely to persist, or if the shifts are transitory and efficient market share is likely to stabilize.

Ideally, NEEA would research each market to assess these conditions and adjust baseline estimates accordingly. However, this type of research can be resource intensive, and it may not, ultimately, be possible to isolate the cause of all observed changes in efficient market share. If NEEA does not have data on the market conditions described above or other cause to anticipate otherwise, it is reasonable to assume that baseline efficient market share would stabilize three years after the last observed market share data are available.¹⁶

Figure 11 illustrates this approach for upright freezers. The difference between Apex's recommended baseline approach and NEEA's existing approach is more pronounced for upright freezers than ESME top-mounted refrigerators since upright freezers showed a trend of declining efficient market share. In response to a declining market share trend, NEEA's baseline approach will always predict a

¹⁵ Apex Analytics. 2020. "Air Cleaner Specification and Baseline Assessment Review." Prepared for NEEA. Available at: <u>https://neea.org/img/documents/Air-Cleaner-Specification-and-Baseline-Assessment-Review.pdf</u>

¹⁶ Under the approach recommended here, any market share forecast beyond three years after the latest observed data would draw purely on previous years' forecasts.

rebound in market share.¹⁷ We further adjusted our recommended baseline estimate for upright freezers to account for anomalies in the freezer market related to the COVID-19 pandemic in 2020. Rather than basing our baseline forecast on actual market data from 2020, we assumed a continuous market share trend from 2019 to 2021. In doing so, we sought to avoid basing future estimates on market conditions that are unlikely to impact the period under consideration.



Figure 11: Upright Freezer ENERGY STAR Baseline Approach

Table 5 summarizes our assessment of NEEA's assumptions related to ENERGY STAR and ESME products.

Product Configuration	NEEA Assumption	Apex Assessment
Refrigerators (All configurations)	Projecting historical sales trends is an appropriate approach to estimating a NOB.	Findings identified no market trends likely to drive shifts in efficient market share not already represented in ESRPP sales data. As a result, historical market share is an appropriate basis for baseline estimates.
Freezers (All configurations)		There was significant disruption in the freezer market in 2020. As this was likely driven by the unique circumstances of the COVID-19 pandemic, NEEA should avoid drawing too strongly on 2020 data in establishing baseline estimates. One approach could be to forecast

¹⁷ NEEA's approach predicts the current year's baseline market share based on the average market share of the previous two years. In a declining market share trend, the market share two years prior to the estimate will be higher than the market share in the year prior. As a result, the average of the two numbers will also be higher than the market share in the year prior to the estimate. Thus, an estimate based on a two-year rolling average will predict a rebound in efficient market share.

		assuming a continuous trend in market share from 2019 to 2021.
All NOE rollin mar prev	3 calculated as ng average of rket share from vious two years.	Rather than using a rolling average of absolute market share, NEEA should calculate a two-year rolling average of the year-over-year change in market share and apply that change to the previous year's estimate. This approach better allows NOB estimates to reflect declining market share trends. NEEA should seek to understand the causes of any increases or decreases in market share observed in baseline data to assess whether those trends are likely to continue. If NEEA is unable to identify a cause, it is reasonable to assume market share will stabilize in the third year after observed data are available.