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Televisions: ENERGY STAR Version 9 Specification Influence Assessment and Baseline Assumptions Review

Prepared For NEEA:
Meghan Bean, Sr. MRE Scientist

Prepared by:
Rupam Singla, Technical Project Manager
Avani Goyal, Associate Project Manager
Marian Goebes, Technical Director

TRC Engineers, Inc.
21 Griffin Road North
Windsor, CT 06095

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
EMAIL
info@neea.org

436 14th Street
Oakland, CA 94612

510.469.0810 PHONE

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EXECUTIVE SUMMARY

On behalf of the Northwest Energy Efficiency Alliance (NEEA), TRC conducted the *Televisions: ENERGY STAR® Version 9 Specification Influence Assessment and Baseline Assumptions Review*. As part of its work to advance the efficiency of consumer goods, NEEA and its partners engage with the U.S. Environmental Protection Agency (EPA) on the development and revision of ENERGY STAR® product specifications. At the completion of specification development or revision processes, NEEA conducts third-party evaluations to assess the effectiveness of its efforts and support its work to incorporate specification development/revisions into its naturally occurring baseline market share (NOBMS) forecasts, where the baseline refers to the hypothetical market adoption of the product in the absence of NEEA's involvement.

The objectives of this study were to:

1. Review NEEA and its partners' (Pacific Crest Labs, Energy Solutions, Natural Resources Defense Council, American Council for an Energy-Efficient Economy, Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric; "NEEA") influence on the ENERGY STAR Version 9 specification revision
2. Review NEEA's NOBMS assumptions
3. Conduct a technical review of NEEA's Unit Energy Savings (UES) calculation and baseline adoption breakdown.

TRC collected data to inform the evaluation primarily through literature review and interviewing stakeholders involved in the ENERGY STAR specification revision process. TRC developed a qualitative assessment of NEEA's influence on the specification revision and the impact of the proposed test procedure referenced in the specification on manufacturers. TRC reviewed UES and baseline calculation spreadsheets shared by NEEA, including a critical review of the calculations to investigate the calculation and inputs for improvements to the overall energy savings estimate.

TRC's evaluation of NEEA's influence indicated that:

- NEEA had a significant impact on the ENERGY STAR Version 9 specification revision.
- NEEA played a lead role in developing the testing approach and efficiency metrics for the revised television efficiency specification.
- NEEA, in collaboration with EPA and other stakeholders, played a key role in setting efficiency limits in the televisions specification.
- NEEA had a supporting role in the Consumer Technology Association (CTA) adoption of a test method and of the pre-voluntary agreement between manufacturers and efficiency organizations.

TRC's evaluation suggests that in the absence of NEEA, the Version 9 specification would have been very different, particularly the testing approach, the testing conditions, and efficiency metrics. The evaluation also suggests that the Version 9 revision encouraged manufacturers to pursue ENERGY STAR certification, mainly because:

- Version 9 contains a more representative, repeatable test method,
- CTA adopted the test standard, and
- Manufacturers and efficiency organizations signed the pre-voluntary agreement.

TRC determined that NEEA's general approach for calculating UES is reasonable. TRC has specific recommendations to improve the accuracy, including revising the assumption for daily hours in On Mode, weighting each picture preset setting (PPS) based on consumer behavior, breaking down Standby power calculations by operating system, and weighting test volume by sales volume. TRC also determined that NEEA's approach to determining its NOBMS is reasonable. Specifically, TRC found that it is reasonable for NEEA to:

- Estimate the baseline starting point using lab test results and market data,
- Use the manufacturer plans to project the natural baseline growth through current knowledge of the manufacturers' plans and their current technology, and
- Break down the baseline adoption by resolution and technology.

BACKGROUND AND OBJECTIVES

On behalf of the Northwest Energy Efficiency Alliance (NEEA), TRC conducted the *Televisions: ENERGY STAR® Version 9 Specification Influence Assessment and Baseline Assumptions Review*. As part of its work to advance the efficiency of consumer goods, NEEA and its partners engage with the U.S. Environmental Protection Agency (EPA) on the development and revision of ENERGY STAR® product specifications. At the completion of specification development or revision processes, NEEA conducts third-party evaluations to assess the effectiveness of its efforts and support its work to develop naturally occurring baseline market share (NOBMS) forecasts, where the baseline refers to the hypothetical market adoption of the product in the absence of NEEA's involvement.

The objectives of the this evaluation were to:

1. Review NEEA and its partners' (Pacific Crest Labs, Energy Solutions, Natural Resources Defense Council, American Council for an Energy-Efficient Economy, Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric; "NEEA") influence on the ENERGY STAR Version 9 specification revision.[1] Specifically, the evaluation investigated the following questions:
   - Did NEEA influence the Version 9 ENERGY STAR specification for televisions through activities including development of a new test procedure and comments to the U.S. EPA?
   - If so, in what ways did NEEA influence the revision of the specification? For example, did NEEA's influence speed up the specification, influence the content of the specification, or influence the stringency of the specification?
   - What is the potential impact of the specification revision on manufacturers' decision-making regarding television efficiency?
2. Review the following questions regarding NEEA's NOBMS assumptions:
   - Is it reasonable for the NOBMS starting point to be estimated using lab test results and market data?
   - The longer-term NOBMS growth in adoption is being estimated through current knowledge of the manufacturers' plans and their current technology. Is this reasonable?

[1] At the time of this report, since the specification was not yet final, TRC based the evaluation on the current draft, which was Draft 2. https://www.ENERGY STAR.gov/products/spec/televisions_specification_version_9_0_pd

3. Conduct a technical review of NEEA's Unit Energy Savings (UES) calculation and baseline adoption breakdown, to address the following research questions:
    - Should revisions be made to NEEA's approach for calculating the UES? If so, what are the recommended updates?
    - Should the baseline be broken down by any other factors besides resolution and technology?

Based on investigations of the research questions above, TRC provides the following outcomes through this study:

- A qualitative assessment of NEEA influence on the U.S. EPA's revision of the ENERGY STAR specification for televisions
- Quantitative recommendations for NEEA's televisions NOBMS
- Quantitative recommendations for how NEEA calculates the televisions UES

METHODOLOGY

This section provides an overview of the data collection activities and analysis methodology for this evaluation.

Data Collection

To collect data for this evaluation, TRC reviewed literature and gathered feedback from stakeholders, primarily through phone interviews.

For the first objective (reviewing NEEA's influence on the Version 9 specification revision), TRC reviewed:

- Documents from NEEA and its contractors.
- Written public comments submitted by NEEA to EPA in response to the specification drafts.
- Comments from other entities involved in the process, such as manufacturers, to understand how NEEA fits into the broader specification revision process.
- Publicly available ENERGY STAR slides and notes from public meetings on the specification revision.
- The draft test procedure and comments on that procedure.
- The manufacturer pre-voluntary agreement for adopting and promoting the test method (Milestone Agreement on Television Energy Efficiency) that NEEA supported, along with other relevant information publicly available through the Consumer Technology Association (CTA).[2]

For the second objective (reviewing NOBMS assumptions), TRC's literature review included:

- Documents from NEEA.
- Research studies on television market trends.

[2] https://www.cta.tech/Resources/Newsroom/Media-Releases/2020/October/Tech-Industry,-Leading-NGOs-Reach-Milestone-Agreem

For the third objective (technical review), TRC's literature review included:

- Documents from NEEA on their UES approach.
- Research studies on television market trends.
- Televisions Test Report on EPA website.[3]

TRC conducted phone interviews with staff at various organizations that were active in the ENERGY STAR specification revision process. The primary focus of the interviews was to understand NEEA's influence on the specification revision, but TRC also asked questions to inform TRC's review of NEEA's assumptions for UES and NOBMS where appropriate.

TRC identified key stakeholders involved in the ENERGY STAR Version 9 Specification revision based on literature review and input from NEEA. Figure 1 summarizes the interviews completed.

Figure 1. Number of Completed Interviews by Stakeholder Category

Stakeholder Category	Number of Interviews Completed
NEEA and staff from its contractor organizations	2[4]
Other energy efficiency organizations	2
Manufacturers	3
U.S. EPA staff	1
Total	**8**

ENERGY STAR V9 Specification Influence

With data from a literature review and interviews, TRC developed a qualitative assessment of NEEA's influence on the specification revision and the impact of the proposed test procedure on manufacturers. The interviews were designed to address the gaps of literature review and confirm the data collected through a diverse set of stakeholders. TRC noted NEEA's activities in each step of the specification revision process, along with the role of other stakeholders relative to NEEA to accurately assess NEEA's influence. The interviews also requested that stakeholders hypothesize a scenario where NEEA did not participate at all (the counterfactual), as another way of assessing the influence NEEA had on the ENERGY STAR Version 9 Specification.

[3] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20TVs%20Test%20Report%20-%20April%202021.pdf
[4] In addition to these stakeholder interviews, TRC had multiple meetings with NEEA and staff from its contractor organizations to understand NEEA's involvement in the ENERGY STAR specification revision and to understand their UES and baseline calculations.

Unit Energy Savings and NOBMS Review Results

TRC reviewed UES and NOBMS calculation spreadsheets shared by NEEA, including a critical review of the calculations to investigate the calculation and inputs for potential improvements to the overall energy savings estimate. TRC also conducted a sensitivity analysis on key inputs to assess the potential impact of our recommendations.

ENERGY STAR V9 SPECIFICATION INFLUENCE RESULTS

This section summarizes the influence that NEEA had on the televisions ENERGY STAR specification revision process. Note that NEEA, independently of its partners, funded Pacific Crest Labs (PCL) to contribute heavily to the specification revision. TRC does not differentiate between the roles that NEEA and PCL had and considers their influence as one. At the time of writing this report, the ENERGY STAR Version 9 specification was not yet finalized, and the current draft was Draft 2. For this evaluation, TRC assumes that the final version of the specification is the same as Draft 2.

Overview of Influence

ENERGY STAR Specification Revision Process

The U.S. EPA and the U.S. Department of Energy (DOE) work together to develop ENERGY STAR specifications, which identify the highest energy conserving products, and test methods. The final step in the specification development cycle is to revise the specification when needed.[5,6] The test method is core to performing repeatable and accurate tests to qualify for ENERGY STAR certification. As detailed in the sections below, NEEA was involved in and supported various steps of the specification revision cycle summarized in Figure 2, including "identification and validation of test procedures," "assemble data," and "release draft specifications."

[5] ENERGY STAR Specification Development Process Description
[6] ENERGY STAR Test Procedures and Verification | Department of Energy

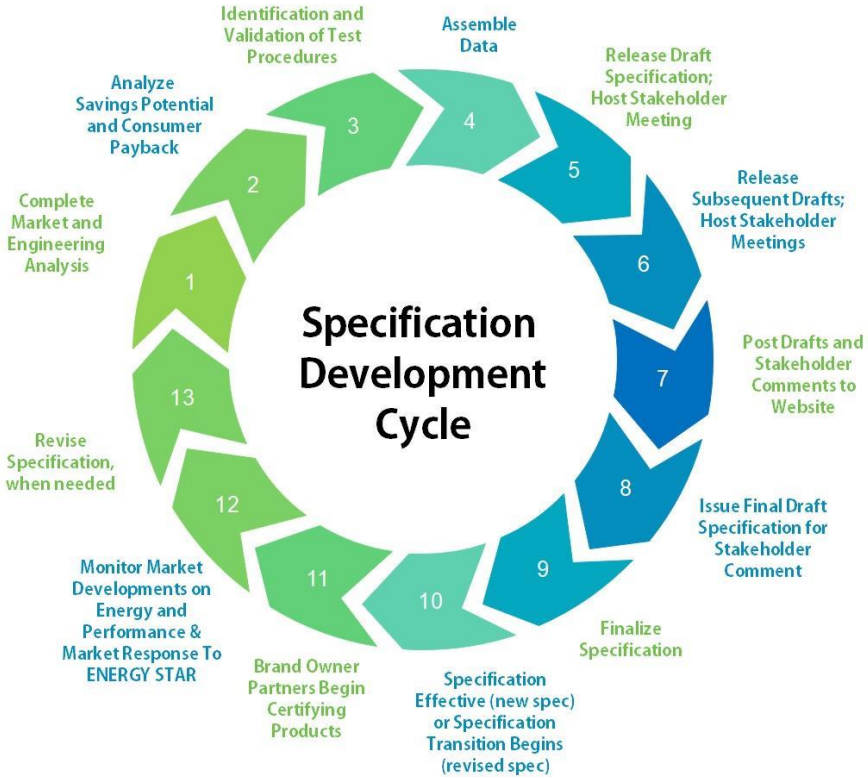

Figure 2. ENERGY STAR Specification Development Cycle *(Source: **ENERGY STAR Website**)*

ENERGY STAR specifications typically reference the U.S. DOE test procedures used to test products to meet federal appliance efficiency standards. ENERGY STAR Version 8 references the IEC 62087 Edition 3.0 test method,[7] which is also the test method that the current DOE test procedure references.[8,9] At the initiation of the specification Version 9 revision, in its cover letter to the Draft 1 specification, ENERGY STAR highlighted challenges with the referenced test method and highlighted the need for a new test method that encourages manufacturers to develop televisions that produce light efficiently and tests at conditions representative of television use.[10] In general, for test methods not already adopted by DOE, the greater the industry consensus for an alternate test method, the easier it will be for ENERGY STAR to move forward with it.

ENERGY STAR certified televisions are, on average, in the top 25% bracket of energy efficiency in all the usage modes such as On and Standby.[11] The ENERGY STAR program saw very low participation in Version 8 from the television manufacturers compared to previous versions. According to PCL staff, there were 1,900 products qualified under Version 7 of the ENERGY STAR specification, while the ENERGY STAR Product Finder shows 117

[7] International Electrotechnical Commission (IEC) Standard 62087:2011, ("IEC 62087 Ed. 3.0"), Methods of Measurement for the Power Consumption of Audio, Video, and Related Equipment, Edition 3.0, 2011-04
[8] https://www.ENERGY STAR.gov/sites/default/files/Final%20V8.0%20TVs%20Program%20Requirements.pdf
[9] 10 CFR 430, Subpart B, Appendix H, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B/appendix-Appendix%20H%20to%20Subpart%20B%20of%20Part%20430
[10] https://www.ENERGY STAR.gov/sites/default/files/ENERGY%20STAR%20V9.0%20TVs%20Draft%201%20Cover%20Memo_Launch%20Letter.pdf
[11] https://www.ENERGY STAR.gov/products/televisions

models certified to Version 8.[12] According to manufacturers and efficiency organizations, the low participation in Version 8 was primarily because of a lack of consensus on test methods recognized by DOE.

The Version 9 Specification revision started in September 2020. Based on stakeholder interviews, EPA was very interested in involving industry in this specification revision to ensure increased participation in ENERGY STAR program compared to Version 8. NEEA was involved in the entire specification revision process, including research and development of the test method, collaboration with industry through CTA, and direct collaboration with EPA and other efficiency organizations to help make adjustments and overcome any roadblocks. Figure 3 summarizes the role of NEEA and their associated outcomes related to technical specification revision. Rows marked with an asterisk represent elements where stakeholders other than NEEA also played a critical role.

Figure 3. Outcome of NEEA's Activities in Technical Specification Revision

	Increase energy savings resulting from revision	Increase expected market penetration of ENERGY STAR V9	Implement more representative, repeatable test method	Address industry-understood shortcomings with prior specification
Proposed Testing Approach				
Camera photometer equipment, test approach and defining dynamic luminance for On Mode test setup		✓	✓	✓
Video test clip for On Mode test setup		✓	✓	
Standby Mode test setup, including having the Smart Wake feature enabled*		✓	✓	
Testing conditions (defining test points and when Automatic Brightness Control should be enabled)*		✓	✓	
Proposed Efficiency Metrics				
On Mode power limit curve based on screen area and dynamic luminance			✓	
Lower luminance thresholds			✓	
Standby Low Mode power limit			✓	
Proposed Efficiency Limits*	✓			

There were two key areas in which NEEA had less of a role in technical development and more of a role in stakeholder coordination. Figure 4 summarizes the outcomes of NEEA's role in these areas. Rows marked with an asterisk represent elements where stakeholders other than NEEA also played a critical role.

[12] https://www.energystar.gov/productfinder/product/certified-televisions/results. Accessed November 9, 2021

Figure 4. Outcome of NEEA's Activities in Stakeholder Coordination

	Influence on Specification Revision Process		
	Increase likelihood of EPA adopting revision	**Increase expected market penetration of ENERGY STAR V9**	**Address industry-understood shortcomings with prior specification**
CTA adoption of test standard*	✓	✓	✓
Pre-voluntary agreement*		✓	

Detailed Findings of Influence

NEEA's Role in Technical Specification Revision

Testing Approach

NEEA began heavily researching and testing televisions around 2016 in preparation for Version 8 Specification revision in 2019. Through this research, NEEA identified that there were many challenges with how televisions were tested under the Version 8 specification, and generally the test outputs did not correlate with real world performance. Based on their extensive testing, NEEA developed a new testing approach for televisions that has three key components:

- The On Mode test setup,
- The Standby Mode test setup, and
- The test conditions.

NEEA's primary activities as part of the specification revision were to conduct testing, propose ideas, engage industry, solicit and address stakeholder input, and garner support for their recommendations. The primary outcomes of the specification revision process are increased energy savings, increased likelihood of adoption by EPA, increased ENERGY STAR market penetration, development of a more representative and repeatable test method, and addressed shortcomings.

In the prior test method for the On Mode, luminance was measured at only one point (in the center of the screen). The test setup and the test metric inadvertently incentivized dimming televisions beyond how consumers would typically use them in order to meet the On Mode power specification. As part of the proposed Version 9 On Mode test setup, NEEA developed testing equipment, including a camera photometer that measures "dynamic luminance" across a screen area (as opposed to a single point) and a video test clip which is played on a television under test. [13] This was a completely different test method than what had been used previously. Energy efficiency organizations interviewed as part of this research commented that NEEA developed the On Mode test process. Manufacturers commented that NEEA played a pivotal role in developing the proposed On Mode test process and made it possible to revise the old test method. Additionally, one manufacturer commented that the main issue of On Mode test setup was particularly critical for new technology of organic light emitting diode (OLED) televisions.

While NEEA played a lead role in the development of the test procedure, other organizations also played a role. For example:

[13] Camera Photometer Method for Measuring TV Screen-Average Dynamic Luminance (PDF, 1.8 MB)

- As part of the Standby Mode test setup, NEEA collaborated with the efficiency organization Natural Resource Defense Council (NRDC) to define testing requirements when smart wake features are enabled.[14] While the testing for Standby Mode specification was largely funded by NEEA, NRDC added considerable value from the technical expertise standpoint. Based on an stakeholder interviews, NRDC tested the smart speaker power draw during a Standby test and made the final proposal on Standby test requirements when the smart wake feature is enabled, using research done by NEEA. NEEA did supplemental testing under NRDC's direction, and the combined data then supported the Standby test proposal. As part of the testing conditions specification, NEEA primarily developed the test points when automatic brightness control (ABC) is enabled. NEEA's 2019 television usage survey informed the picture preset settings (PPS) at which the televisions should be tested to represent common usage patterns of consumers. For testing conditions such as defining test points when ABC is enabled, NEEA funded the research to perform the testing, and the final proposal was led by NEEA in conjunction with industry partners.
- During interviews, energy efficiency organizations and one manufacturer commented that NEEA led the development for test points, with another manufacturer reporting that EPA decided the test points in conjunction with NEEA. Two other manufacturers reported that NEEA proposed the starting point and industry made modifications to it.

When asked if the revised test method in Version 9 would change their interest in obtaining ENERGY STAR certification, manufacturers shared their support for the Version 9 test method but did not provide direct answers on plans for certifying their television products. One manufacturer noted that even though they may be interested in ENERGY STAR certification, products may not be able to qualify in the required time frame and may have to wait for the next round of specification. A second manufacturer noted that it was too early to make any decision, as Version 9 has not yet been finalized.

Stakeholders held different opinions regarding what the specification would have looked like if NEEA did not participate, but all views indicated that NEEA had a strong influence. Efficiency organizations reported that the specification would not have happened or that it would have resulted in an inadequate test method, which may not have corrected the fundamental flaws and would not have driven the long term energy savings. Several stakeholders, including manufacturers, reported that there still would have been a more accurate test method developed in future, but it would have taken a long time without NEEA's research and innovation.

In summary, **NEEA played a lead role in developing the testing approach for the ENERGY STAR specification, which included the On Mode test setup, Standby Mode test setup, and defining testing conditions.**

Efficiency Metrics

The Version 9 specification draft has multiple efficiency requirements, including:

- An On Mode power limit curve based on screen area and dynamic luminance—that is, the maximum amount of power (in Watts) a qualifying television can consume;
- An On Mode lower luminance threshold—that is, the dynamic luminance value used in calculations if the actual dynamic luminance is below this value (this is to ensure that there is no incentive to overly dim televisions in order to meet ENERGY STAR criteria levels); and

[14] Smart wake features refer to those that switch a television from Standby to On Mode upon a signal from a wireless speaker (for example, Amazon Echo) or other wireless device (for example, a smart phone).

- A Standby Active Low Mode power limit—that is, the maximum amount of power (in Watts) the television can consume when connected to power while not producing any sound or picture but while being receptive to switching into another mode with remote, internal, or external signal.

While Version 8 also had efficiency limits for On Mode and Standby Mode, the test method used to determine these values, the use of a limit curve, and the creation of the dynamic luminance metric are new to Version 9.

NEEA led the process of defining these new metrics. Energy efficiency organizations involved in the rulemaking process noted that the On Mode efficiency metric was completely developed by NEEA, whereas NEEA and NRDC worked together on the Standby Low Mode efficiency metric. The interviewees reported that NEEA played the lead role in coming up with metrics, which were further tweaked by EPA or CTA for manufacturer specifications.

In summary, **NEEA played a lead role in developing efficiency metrics for television efficiency specification.**

Efficiency Limits

NEEA proposed the On Mode power limit, lower luminance thresholds, and Standby Active-Low Mode power limit, which were later refined by EPA for the current draft of Version 9.

In interviews, an efficiency organization noted that EPA and NEEA, along with other industry stakeholders, were involved in proposing the actual efficiency limits. The manufacturers noted that NEEA played a pivotal role in developing efficiency thresholds using the revised test methods, especially as a starting point for setting the specification.

In summary, **NEEA, in collaboration with EPA and other stakeholders, played a key role in setting efficiency limits in the televisions specification.**

NEEA's Role in Stakeholder Coordination

NEEA coordinated with CTA, a major industry group, in an effort to increase industry adoption of the ENERGY STAR specification.

NEEA shared the proposed test method with CTA to engage industry and incorporate their feedback. Many television manufacturers and energy efficiency organizations are involved in the CTA working group, which is in the process of adopting a televisions test method: CTA-2037-C. Based on stakeholder interviews, the proceedings of developing CTA-2037-C test method were primarily driven by NRDC and the American Council for an Energy Efficient Economy (ACEEE), while NEEA led the technical aspects. NEEA introduced the revised test method to CTA, and together they presented the details to industry to align everyone and gain consensus. Some stakeholders, including manufacturers, reported in interviews that CTA-led industry engagement would encourage television manufacturers' participation in ENERGY STAR certification. Another stakeholder active in the process reported that adoption of the CTA test method has minimal effect on the ENERGY STAR certification process, since EPA wanted to adopt a new test method as soon as possible. Another stakeholder concurred, reporting that if CTA would not have adopted this test method, ENERGY STAR would have adopted it once it became a DOE test method. In other words, while NEEA was successful in achieving CTA support for the standard, it is possible that EPA would have adopted the test method regardless.

CTA developed a pre-voluntary agreement between television manufacturers, CTA, NRDC, and ACEEE to evaluate and finalize the new test method. CTA wrote a letter to EPA requesting that DOE reference the CTA-2037-C test method in the federal appliance standard, which would make it easier for manufacturers to comply with the requirements.[15] In October 2020, members of CTA 2037 working group signed a voluntary agreement to promote a

[15] CTA Letter to EPA re Version 9.0 ENERGY STAR TV Specification, 1-5-21

wider acceptance of the new test method to ensure consistency and more effective deployment. While the pre-voluntary agreement was primarily executed by NRDC and ACEEE, NEEA played a technical lead role and supported the testing and evaluation of television products using the new test method developed by NEEA by providing test kits and answering technical questions.

While the support of CTA (influenced by NEEA) may not have impacted the test method that EPA adopted, CTA support appears to have increased the likelihood that manufacturers signed the pre-voluntary agreement.

During stakeholder interviews, when asked if NEEA influenced their decision to participate in the pre-voluntary agreement, manufacturers had mixed comments, with one manufacturer indicating yes and the other manufacturer indicating no. The manufacturer that confirmed NEEA's influence added that NEEA's new test approach and commitment to promote energy efficient televisions helped their participation.

In summary, **CTA adopted the method that NEEA developed, and NEEA had a supporting role of the pre-voluntary agreement between manufacturers and efficiency organizations.**

UES Review Results

NEEA calculates energy savings associated with the ENERGY STAR specification revision. For the ENERGY STAR specification, the main pieces of this energy savings calculation are:

- UES, which is the annual energy savings of an ENERGY STAR qualifying television compared to a non-ENERGY STAR qualifying television;
- Estimated sales of the ENERGY STAR-qualifying televisions and sales of the non-ENERGY STAR qualifying televisions; and
- NOBMS, which represents the projected sales of ENERGY STAR qualifying televisions that would have been sold even in the absence of the new ENERGY STAR specification or test method. NEEA does not include these televisions in the energy savings estimate.

Overview of NEEA's Calculation of UES

The following is a description of NEEA's calculation of UES.

In Draft 2 of ENERGY STAR Version 9 test method, power is measured in On Mode at three different PPS, which refers to pre-determined combinations of brightness, contrast, color and sharpness settings programmed in televisions.

NEEA determines the UES separately for different technologies (4K LED, 4K OLED, 8K) and different sizes (Medium, Large, Extra Large). NEEA calculates UES separately for On Mode and Standby Mode, and adds these together. Below are the equations that NEEA uses:

$$UES_{On} = \left((Nonqual_{On} - NonqualLimit_{On}) + \ (QualLimit_{On} - Qual_{On})\right) * Hours_{On} * 365/1000 \ [kWh]$$

Where:

$Nonqual_{On}$ = Measured On Mode power of non- ENERGY STAR-qualifying televisions [W]

$NonqualLimit_{On}$ = Maximum On Mode power allowed to qualify for ENERGY STAR, determined specifically for non-ENERGY STAR-qualifying televisions [W]

$Qual_{On}$ = Measured On Mode power of ENERGY STAR-qualifying televisions [W]

$QualLimit_{On}$ = Maximum On Mode power allowed to qualify for ENERGY STAR, determined specifically for ENERGY STAR-qualifying televisions [W]

$Hours_{On}$ = Hours per day that television is in On Mode [hours]

$$UES_{Standby} = \left(Nonqual_{Standby} - Qual_{Standby}\right) * Hours_{Standby} * 365/1000\ [kWh]$$

Where:

$Nonqual_{Standby}$ = Measured Standby Mode power of non-ENERGY STAR-qualifying televisions [W]

$Qual_{Standby}$ = Measured Standby Mode power of ENERGY STAR-qualifying televisions [W]

$Hours_{Standby}$ = Hour per day that television is in Standby Mode [hours]

$$UES_{Total} = UES_{On} + UES_{Standby}\ [kWh]$$

The ENERGY STAR Version 9 specification set limits for power that depend on the product size, with larger limits allowed for larger televisions. To determine UES for a certain class of television products (for example all televisions of a certain size that use LED technology), the most straightforward way would be to take the average energy use for non-ENERGY STAR qualifying televisions in that product class and subtract the energy use of qualifying televisions in the same product class (NonQualOn minus QualOn). However, while television products can be grouped into general product classes, their characteristics (particularly size) vary within that class and do not fall into discrete conditions. For example, the 4K LED Medium category includes products with screen size diagonals of 39 to 49 inches. Consequently, the non-qualifying televisions may be (on average) a slightly different size than qualifying televisions to which they are compared, so they would have different ENERGY STAR limits for power. To account for this, NEEA takes the difference in the actual energy use of non-qualifying televisions in the product class (NonqualOn) with the ENERGY STAR limit for the nonqualifying products (NonqualLimitOn), and adds this to the difference in the actual energy use of qualifying televisions (QualOn) with the ENERGY STAR limit for the qualifying products.

TRC finds NEEA's general approach for determining UES to be adequate for NEEA's purposes. While TRC agrees with the general approach, we have recommendations related to specific inputs into the calculation. Figure 5 summarizes the key inputs in NEEA's UES calculations and TRC's recommendations to NEEA.

Figure 5. UES Assumptions and Recommendations

Input	NEEA Assumption	Recommendation
$Hours_{On}$ and $Hours_{Standby}$	On: 5.2 hours Standby: 18.8 hours This is based on Roth & McKenney (2007)[16]. EPA and DOE assume 5 hours of On Mode. NRDC 2005[17] also found On Mode of 5 hours	**Reduce On Mode usage to 4 hours**. Rationale: NEEA cites a 2007 study. Two studies have been conducted since that showed the average daily hours of On Mode has decreased: • Donovan et. Al. (2014): 4.4 hours[18] • Fraunhofer Study (2017 CE Usage Survey)[19]: 3.9 hours. Based on data from 1,009 survey participants, and they estimate the error for this value as +/- 0.2 hours. Given changes in the market, such as the number of televisions in homes, which may affect the hours of use (HOU) for any single television; the increased prevalence of Standby Mode functions in television, which could decrease On Mode hours; and increased use of tablets/handheld devices, which could reduce television HOU, TRC believe is it important to use more recent sources for HOU. NEEA's assumption is based on data from 2007. EPA reported that they continue to use 5 hours to align with DOE assumptions. While TRC recognizes the value in aligning with EPA and DOE, we recommend changing to 4 hours because it is based on much more recent data. Section *Supplemental Information on On Mode Hours of Use* below gives a comparison of HOU studies and additional detail on these findings.

[16] Operating hours based on Roth and McKenney (2007; Table 5.55). https://envirostats.files.wordpress.com/2007/09/ceenergyconsumption.pdf
[17] http://www.nrdc.org/air/energy/energyeff/tv.pdf
18 Donovan, S.M., L.-B Desroaches, M.F. Pirie, and J.B. Greenblatt. (2014). Determination of accurate television usage profiles: a U.S. case study. Energy Efficiency. 2014 (7) 257-270.
[19] https://cdn.cta.tech/cta/media/media/advocacy/pdfs/energy-consumption-of-consumer-electronics-in-u-s-homes-in-2017-(fraunhofer-usa,-commissioned-by-cta,-december-2017).pdf

Input	NEEA Assumption	Recommendation
$Qual_{On}$ and $Nonqual_{On}$	Calculate On Mode Power as average power of three different PPS: Default, Brightest, and High Dynamic Range content (HDR10). Default is the average of four different test points if ABC is enabled.	**No immediate change recommended. We recommend that NEEA update the calculation in the future with more specific and accurate data on usage distribution of Default, Brightest, and HDR10 PPS.** TRC proposes a weighted average across the three PPS based on expected consumer behavior. The weightings may vary by year. Rationale: A 2019 NEEA field survey of 500 consumers shows about one-third of consumers use Default and about a quarter of consumers use Brightest settings. The Fraunhofer 2017 study suggests consumers use a "brighter" PPS half of the time. NEEA's current assumption is that HDR10 will increase in the future due to the rise of over-the-top content streaming platforms such as Netflix and HDR content. Hence, while the weighted PPS may vary by year over the next 10 years, the average across the 10 years could be a weighted PPS with an even split between the three PPS. Due to lack of more specific data, TRC proposes keeping the equal weighting across each PPS approach as is. However, we recommend that NEEA collect more data on this and update it in the future. Figure 7 below shows the results of a sensitivity analysis that TRC conducted, which shows that the weighting of the three PPS has a significant impact on the UES.
$Qual_{Standby}$ and $Nonqual_{Standby}$	$Qual_{Standby}$ is 0.5 W and $Nonqual_{Standby}$ is 12.5 W, based roughly on test data across all televisions tested.	**TRC recommends using the actual $Qual_{Standby}$ and $Nonqual_{Standby}$ from test data. TRC recommends weighting the measured powers based on sales data. NEEA should investigate operating system categories and size variations within each and apply test data separately for each operating system category.** Rationale: Sales weighting would better represent market purchases compared to availability data. Standby power depends on operating system. Test data show that standby power varies by size, but that may be due to the operating system variation within each size category.

Input	NEEA Assumption	Recommendation
$Qual_{On}$ and $Nonqual_{On}$	NEEA assumes the qualified power and the non-qualified power to be the average of all televisions tested.	**TRC recommends weighting the measured powers based on sales data instead of doing a straight average**. While NEEA may not be able to obtain market data that would allow weighting by individual models, NEEA does have market data to be able to weight by manufacturer market share. Rationale: Sales weighting would better represent market purchases compared to availability data.
HCR adjustment for 4K OLED Televisions	The testing data only includes two OLED televisions. Therefore, rather than extrapolate consumption from these two televisions, the 4K LED wattages have been adjusted using the HCR adjustment factor in the Draft 2 specification for each television size. The average diagonal for each size bin was determined using NPD sales data.	**No change recommended.** Rationale: TRC compared the calculated On Mode power from the adjustment with the actual test output for the two OLED televisions and found the results to be similar. While this is only a small sample, it indicates the method may be sound.
Pixel factor adjustment for 8K Televisions	The testing data only includes one 8K television. Therefore, rather than extrapolate consumption from this television, the 4K LED wattages have been adjusted using the pixel adjustment factor in the Draft 2 specification. The adjustment factor is not dependent on size.	**No immediate change recommended. TRC recommends that in the future, once PG&E's test data is available, that NEEA validate their approach with test data from 8K televisions.** Rationale: PG&E is performing tests on more televisions including 8K televisions. Current test data includes only one product. TRC compared its power wattage to the adjusted power using pixel factor in UES calculations, and they did not align closely. During stakeholder interviews, one efficiency organization interviewee noted that the proposed test approach should be further checked and validated by industry especially for 8K televisions.

Supplemental Information on On Mode Hours of Use

Figure 6 gives a summary of three different studies that looked at On Mode hours of use. All studies were done with U.S. households. In general, all studies compared in the table above are robust in size (include over 1,000 households). Since the Fraunhofer (2017) study was the most recent, TRC recommends that NEEA use its finding: 3.9 hours/day.

Figure 6. Summary of Studies on Televisions Daily Hours of Use

	Fraunhofer et al 2017	Donovan et. al 2014	Roth & McKenney 2007 (referenced by NEEA)	Comment on accuracy or validity
HOU estimated (hours per day)	3.9 for all televisions	4.4	5.2*	Not applicable.
Estimated precision for estimate	+/-0.2 hr/day at the 90% confidence level	Not reported	Not reported	The Fraunhofer estimates a small level of uncertainty at the 90% confidence interval, which implies greater validity. Error was not estimated in the other two studies.
Year Data Collected	2017	2007-2011	2006	More recent results are more applicable, because factors such as number of televisions per home and consumer behavior (such as using tablets or mobile devices for entertainment instead of television) continues to change, which might affect average television HOU.
Number of consumers included in HOU/day	1,009	12,000	2,000	Higher number of households included in data collection implies more accuracy.
Data collection method for HOU: measured or surveyed	Survey	Metered Usage	CEA Phone Survey	Metered data is more accurate than consumer survey (self-reported).

* Includes analog televisions only

436 14th Street
Oakland, CA 94612

510.469.0810 PHONE

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Supplemental Information on PPS Weights

There is a lack of data showing which picture preset settings (PPS) – default, brightest, and HDR10 – are most frequently used by consumers. Given the lack of data, NEEA currently calculates On Mode power as the average of the three. To investigate the impact of this assumption, TRC conducted a sensitivity analysis by changing assumptions in the UES workbook from NEEA. Figure 7 shows the sensitivity analysis of weighted distribution of PPS settings on UES. It shows percent change as compared to the equal weighted baseline. The results show that heavily weighting any one PPS has a large impact on the UES. This supports our recommendation in Figure 5 to update this weighting in the future if more accurate data on the usage distribution of the three PPS options becomes available.

Figure 7. Percent Change in UES due to weighted PPS settings

	PPS Weighting			Impact on UES by television Size Category		
Scenario	**Default**	**HDR**	**Brightest**	**Medium**	**Large**	**Extra Large**
NEEA	0.33	0.33	0.33	-	-	-
Default PPS is most used	0.80	0.10	0.10	39%	-9%	0%
Brightest PPS is most used	0.30	0.10	0.60	-23%	-15%	3%
HDR10 increasing in future	0.30	0.30	0.40	-7%	-2%	1%
HDR10 highest, others lower	0.20	0.50	0.30	-3%	9%	-1%
HDR10 highest, others lower	0.10	0.80	0.10	9%	26%	-4%

MARKET BASELINE REVIEW RESULTS

Overview of NEEA's NOBMS Assumptions for Televisions

In its current NOBMS calculation, NEEA estimates a percentage of television sales that would have been qualified for ENERGY STAR Version 9 in the absence of NEEA's influence on the ENERGY STAR Version 9 specification and test method. NEEA uses the NOBMS to track savings resulting from its efforts, with energy savings due to NEEA's efforts equal to 100% minus the NOBMS. NEEA determines its televisions NOBMS separately for different technologies (4K LED, 4K OLED, 8K) and different screen sizes (Medium, Large, Extra Large).

Based on stakeholder interviews with NEEA, EPA, efficiency advocates, and manufacturers, TRC found that television efficiency ratings prior to ENERGY STAR Version 9 were not meaningful and did not correlate to actual energy usage. In general, TRC found that while consumer preferences and other market forces (like utility rebate programs) could drive the market towards more energy-efficient products, in the absence of ENERGY STAR Version 9, driving the market towards more energy-efficient products would not have been feasible, as there was no way for consumers or utilities to identify more efficient televisions. In addition, based on a review of a sample of 30 televisions available on Amazon.com and at BestBuy.com, TRC found no discussion in the product description of energy use or energy efficiency, indicating that energy use and energy efficiency is not a product feature driving the market. TRC notes that televisions on Amazon.com typically have a reference to the Energy Guide label and that televisions on BestBuy.com typically indicate whether they have ENERGY STAR certification, but that these are not advertised in the main product description, and are only listed under the television specification details. Because it

does not appear that energy efficiency is a product feature driving the market, TRC largely expects that the NOBMS is the same as today.

TRC asked interviewees to hypothesize what the average television efficiency would look like in the future in the absence of the Version 9 specification and what the external factors are that would drive it. The results were mixed, and many interviewees noted the uncertainty in their response.

Multiple interviewees noted that consumer demands for bigger and brighter televisions could drive up energy consumption in the future. One manufacturer commented that energy consumption will increase over the next ten years as consumers buy bigger, brighter televisions with added smart functions and artificial intelligence features[20].

Multiple efficiency organizations and one manufacturer commented that there would be continued minor improvements in energy efficiency if there was no ENERGY STAR program, but that these products may not have a big market share. Interviewees cited climate change concerns among consumers and corporations' environmental and social goals as potential drivers cited for the improvements in efficiency in the absence of ENERGY STAR.

Efficiency organizations and one manufacturer noted that it is essential to have a proper test procedure to assess and drive energy savings. Another manufacturer supported that ENERGY STAR "really motivates manufacturers" to innovate and incentivize efficient products and reported energy consumption would "sky rocket" without it. A third manufacturer suggested that they continually research improvements and rely on technological innovations instead of ENERGY STAR for efficient product design.

TRC finds NEEA's general approach for determining the NOBMS to be reasonable. TRC finds NEEA's approach to estimating the baseline starting point using lab test results and market data to be reasonable. NEEA's baseline adoption breakdown by resolution and technology is reasonable, and TRC does not recommend breaking down the baseline by any other factors. While TRC agrees with the general approach, we have recommendations related to specific inputs into the calculation. Figure 8 summarizes the key inputs in NEEA's UES calculations and TRC's recommendations to NEEA. This assessment does not consider the relative market share of different product categories or sizes except as it impacts the NOBMS, since NEEA makes these adjustments to report savings based on actual market data.

Figure 8. NOBMS Assumptions and Recommendations

Input					NEEA Assumption	Recommendation
Variable	Mode	PC	Size	Year		
NOBMS	On	All	All	2020	NOBMS in 2020 is equal to the pass rate for On power. The pass rate is the percent out of the 33 televisions tested that meet the ENERGY STAR Draft 2.0 Version 9 specification.	**No change recommended.**

[20] TRC notes that efficiency – the energy use of a product compared to a baseline product, is different from consumption – total energy use.

Input					NEEA Assumption	Recommendation
Variable	Mode	PC	Size	Year		
NOBMS	Standby	All	All	2020	Standby Mode pass rate is based on Samsung + LG market share from NPD data	**No change recommended.**
NOBMS	On	4K LED	All	2021-2030	NOBMS is a fixed percentage 2020-2030. Medium: 86%; Large: 31%; Extra Large: 36%	**No change recommended.**
NOBMS	Standby	4K LED	All	2021-2030	NOBMS is a fixed percentage 2020-2030. Medium: 50%; Large: 46%; Extra Large: 68%	**No change recommended.**
NOBMS	On	4K OLED	Med	2021-2030	NOBMS is a fixed percentage (86%) 2020-2030, which is the same as the 4K LED product class.	**No change recommended.**
NOBMS	On	4K OLED	Large	2021-2030	Driven by Samsung's investment in QD-OLED televisions, the NOBMS grows at a fast rate from 2022-2024. The NOBMS goes from 31% to 54% from 2022 to 2024, after which it stays around 54% until 2030.	**TRC recommends that NEEA update the NOBMS when actual Samsung QD-OLED televisions sales data is available.** **TRC recommends that NEEA revise the growth rate if needed to not over-represent Samsung in the NOBMS.** Rationale: TRC conducted a sensitivity analysis, which shows that with NEEA's current assumptions, including assumptions for sales projections, the total market energy savings increases by 1% when the growth rate goes from 15% to 30%. The analysis shows that this input has little impact. However, given the uncertainty in sales projections and the relatively low level of effort, TRC recommends that NEEA make this revision. Section *Supplemental Information on 4K OLED Televisions* below gives details on these findings.

Input					NEEA Assumption	Recommendation
Variable	Mode	PC	Size	Year		
NOBMS	On	4K OLED	Extra Large	2021-2030	Driven by Samsung's investment in QD-OLED televisions, the NOBMS grows from 36 to 60% from 2020 to 2030.	**Same recommendation as Large size category.**
NOBMS	Standby	4K OLED	All	2021-2030	NOBMS is a fixed percentage 2020-2030. Medium: 99%; Large 85%; Extra Large 82%	**No change recommended.**
NOBMS	On	8K	All	2021-2030	NOBMS is a fixed percentage 2020-2030. Medium: 86%; Large: 31%; Extra Large: 36%	**No change recommended.**
NOBMS	Standby	8K	All	2021-2030	NOBMS is a fixed percentage 2020-2030. Medium: 0%; Large 100%; Extra Large 97%	**No change recommended.**

Supplemental Information on 4K OLED Televisions

For 4K OLED televisions, NEEA used 2017 OLED sales as proxy for Samsung's OLED sales starting in 2023. 2017 OLED sales represents the first year when OLED televisions became a viable option for consumers, and it is primarily comprised of LG's OLED television market share.[21] Samsung currently does not produce any OLED televisions but has invested $11 billion in a facility to start doing so, in the form of Quantum Dot-OLED televisions[22]. The assumption that Samsung's OLED television sales in 2023 will be the same as LG OLED television's 2017 sales likely overestimates Samsung's production ramp up, and there is no data to support this. NEEA noted that they expect Samsung sales to be on the higher side of market share because their televisions will qualify under the Version 9 specification. Hence, NEEA assumed a similar number of 4K OLED product sales in 2024 by Samsung as there was in 2017 by LG. TRC recommends that in 2023, once there is actual data collected through the program and industry sources, that NEEA update the NOBMS values for 4K OLED televisions.

LIMITATIONS

TRC noted several limitations with this evaluation.

The first limitation is that most of the television market today is 4K LED televisions, with 4K OLED and 8K televisions comprising only a fraction of the market. Because of this, most of the television testing done by NEEA and other stakeholders to date has been of the 4K televisions, with few 4K OLED and 8K televisions tested. With limited test results from 4K OLED and 8K televisions, impacts on the UES are difficult to gauge. Additionally, the market characteristics of 4K OLED and 8K televisions are difficult to gauge because their markets are still relatively new.

[21] https://www.lg.com/uk/lg-magazine/brand-story/the-history-of-the-oled-tv.
[22] https://www.cnet.com/news/samsung-oled-tv-with-quantum-dots-could-challenge-lg-as-soon-as-next-year/

Additionally, TRC notes that given our small sample sizes, our interview results are anecdotal. For example, TRC spoke with two manufacturers that were signatories in the pre-voluntary agreement and one manufacturer that was not. Also, while manufacturers did provide input to most of TRC's questions, we noted that manufacturers did not respond fully to some questions, likely not wanting to reveal proprietary information.

Lastly, we note that the ENERGY STAR Version 9 specification is not yet final, and that it could change between the current draft (Draft 2) and the final version, which may make some of NEEA's stated influence inaccurate.

Despite these limitations, TRC notes that we had a good understanding of NEEA's influence on the ENERGY STAR specification revision and were able to gather sufficient information to provide a technical review and provide recommendations on NEEA's UES and NOBMS calculations.

CONCLUSIONS

TRC's evaluation of NEEA's influence indicates that NEEA had a significant impact on the ENERGY STAR Version 9 specification revision, particularly on the On Mode test setup, Standby Mode test setup, testing conditions, efficiency metrics, and efficiency limits. TRC's evaluation suggests that in the absence of NEEA, the Version 9 specification would have been very different and that the Version 9 revision encourage manufacturers to pursue ENERGY STAR certification. TRC's technical review of the UES and NOBMS showed that NEEA's general approach for both calculations is reasonable. TRC had several recommendations related to specific inputs which would have an impact on NEEA's savings attribution, including revising the assumption for daily hours in On Mode, weighting each PPS based on consumer behavior, breaking down Standby power calculations by operating system, and weighting test volume by sales volume.

Figure 9 summarizes TRC's findings for each evaluation objective and question from NEEA.

Figure 9. Summary of TRC's Findings on each Evaluation Objective and Question

Area	Evaluation Objectives and Questions	TRC Findings
NEEA's Influence on the ENERGY STAR Version 9 Specification Revision	Did NEEA influence the Version 9 ENERGY STAR specification for televisions through activities including development of a new test procedure and comments to EPA?	Yes, NEEA had a significant influence on the ENERGY Version 9 specification.
	In what ways did NEEA influence the revision of the specification?	NEEA played a lead role in developing the testing approach and developing efficiency metrics.
	What is the potential impact of the specification revision on manufacturers' decision-making regarding television efficiency?	Manufacturers generally support the specification revision but have not committed to meeting it. CTA's adoption of the test method is likely to encourage manufacturer participation in ENERGY STAR.

Area	Evaluation Objectives and Questions	TRC Findings
NEEA's UES Calculation	Review NEEA's approach for calculating the UES and make recommendations for updating the approach if warranted.	NEEA's general approach for calculating UES is reasonable. TRC has specific recommendations to improve the accuracy, including revising the assumption for daily hours in On Mode, weighting each PPS based on consumer behavior, breaking down Standby power calculations by operating system, and weighting test volume by sales volume.
NEEA's NOBMS Assumptions	Is it reasonable for the baseline starting point to be estimated using lab test results and market data?	Yes, it is reasonable to estimate the baseline starting point using lab test results and market data.
	The longer-term natural baseline growth in adoption is being estimated through current knowledge of the manufacturers' plans and their current technology. Is this reasonable?	Yes, it is reasonable to use manufacturer plans to project the natural baseline growth.
	Baseline adoption is broken down by resolution and technology. Should the baseline be broken down by any other factors?	No, baseline adoption need not be broken down by any factors other than resolution and technology.

Memorandum

Dec. 13, 2021

TO: Amy Webb, Senior Manager Market Research & Evaluation, NEEA

CC: Susan Hermenet, Director of Analytics, Research & Evaluation, NEEA
Meghan Bean, Senior Market Research & Evaluation Scientist, NEEA

FROM: Christina Steinhoff, Principal Planning Analyst, NEEA

SUBJECT: Response to TRC Recommendation regarding Televisions Hours of Use Assumption

NEEA intends to implement all recommendations made by TRC in their review of the technical assumptions we use calculate energy consumption for ultra-high-definition televisions, with the exception of their recommendation that NEEA reduce On Mode usage from 5.2 hours per day to 4 hours per day. This memo provides NEEA's rationale for using an On Mode assumption of 5 hours.

TRC's Recommendations: Reduce On Mode Usage Assumption

NEEA breaks the television energy consumption estimates into On Mode and Standby Mode based on an hours-on-per-day assumption. NEEA assumes the average On Mode usage is approximately 210 kWh/year and the Standby Mode usage is approximately 6 kWh/year. The assumption about usage is key to measuring total consumption due to the large difference in energy usage between the two modes.

For its previous Televisions Program (2009-2014), NEEA assumed televisions were on 5.2 hours on per day based on a 2007 study.[23] TRC cited newer studies estimating 3.9 to 4.4 hours of use per day.[24,25] Meanwhile, the EPA uses 5 hours, citing Nielsen data. Results across the cited reports suggest that usage per television is lower than 5.2 hours per day, but the range in findings is large.

NEEA's Response

NEEA will update its assumption to 5 hours per day to align with the EPA. Aligning with the EPA is consistent with the program's goal of leveraging the ENERGY STAR® label to increase adoption of the most energy efficient products. Meanwhile, NEEA is collecting survey data through the Residential Building Stock Assessment (RBSA) that will help estimate the hours of use. The RBSA asks respondents how many hours

[23] TIAX LLC. January 2007. Energy Consumption by Consumer Electronics in U.S. Residences.
[24] http://www.nrdc.org/air/energy/energyeff/tv.pdf
[25] https://cdn.cta.tech/cta/media/media/advocacy/pdfs/energy-consumption-of-consumer-electronics-in-u-s-homes-in-2017-(fraunhofer-usa,-commissioned-by-cta,-december-2017).pdf

Northwest Energy Efficiency Alliance
700 NE Multnomah Street, Suite 1300, Portland, OR 97232
503.688.5400 | Fax 503.688.5447
neea.org | info@neea.org

per day their primary and secondary televisions are on. The results should be available in 2023. NEEA will combine the RBSA information with the studies cited by TRC and potentially other research to refine the usage assumption. In the meantime, NEEA's assumption for 2022 will be 5 hours on per day.

NEEA plans to have this assumption reviewed by its Cost Effectiveness Advisory Committee (CEAC) in March 2022. Please contact Christina Steinhoff (csteinhoff@neea.org) with any questions.