Advancing ENERGY STAR Specifications Through Improved Retail Sales Data Analytics

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ABSTRACT

As the energy efficiency of HVAC and lighting continues to increase, plug-in equipment plays an increasingly large role and currently accounts for roughly two thirds of residential energy consumption in California (NRDC 2015). Despite widespread recognition that addressing plug load energy use is critical to meeting energy reduction goals, developing cost-effective incentive program strategies is extremely challenging due to the distributed nature of the savings opportunities which necessitates low per-unit consumer purchase incentives and the frequent lack of data available to accurately calculate energy savings. The ENERGY STAR Retail Product Platform (ESRPP) program attempts to overcome these barriers and improve the efficiency of consumer electronics and appliances sold through retail channels. A key aspect of this effort is utilizing program sales data to generate market insights and support increasing the energy efficiency requirements of ENERGY STAR product specifications. While EPA uses the best available model level data to inform the ENERGY STAR product specification development process, NEEA's Retail Product Portfolio (RPP) program product sales data can augment and complement existing sources to provide a more nuanced understanding of emerging product sales trends and both track and forecast product efficiency over time. The result is a data-driven approach to forecasting product market penetration so that specifications more accurately reflect market conditions. This paper provides a detailed example of the process at work for Ultra High Definition (UHD) televisions (TVs), which offer a prime example of an emerging technology that threatens prior TV efficiency gains as its market share increases and challenges the current EPA process.

RPP and the ENERGY STAR Program within the Broader Context of Market Transformation

As the energy efficiency of heating, ventilation and air conditioning (HVAC) and lighting continues to increase, plug-in equipment plays an increasingly large role in residential energy consumption. Plug-in equipment currently accounts for roughly two thirds of residential energy consumption in California (NRDC 2015). Unlike other major end uses such as HVAC, lighting, and water heating which are concentrated among a small set of products, plug-in equipment is so varied that no single end use makes up a majority of total plug load energy consumption, as shown in Figure 1. Moreover, energy consumption from plug-in equipment is expected to increase in the next decade. Natural Resources Defense Council (NRDC) estimates that 77% of electricity demand growth from 2015-2024 will be due to plug-in and miscellaneous electric loads (NRDC 2015). This is due to improvements in HVAC and lighting efficiency, as well as increases in the number of electronic devices used within the home. Despite widespread recognition that addressing plug load energy use is critical to meeting energy reduction goals,

developing cost-effective incentive program strategies is extremely challenging due to the distributed nature of savings opportunities which necessitates low per-unit consumer purchase incentives, and the frequent lack of data available to accurately calculate energy savings.
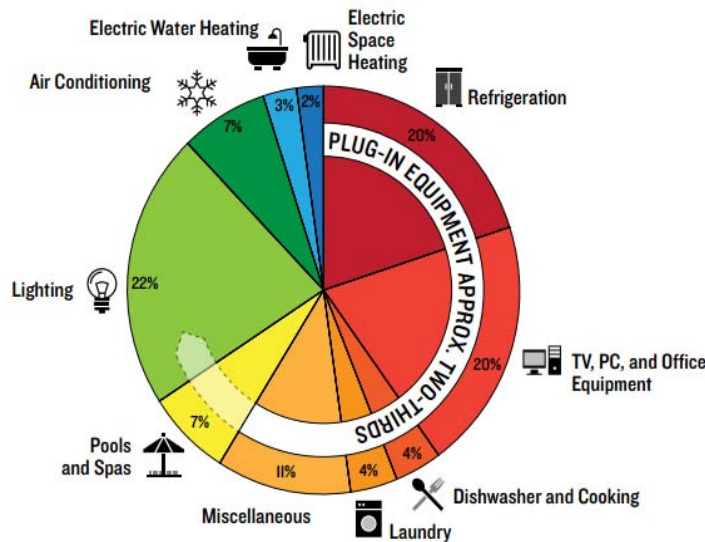
Figure 1: Plug-in equipment accounts for Approximately Two Thirds of Residential Energy Consumption (NRDC 2015)[1]

Effectively addressing this challenge requires scale and a network of tools that can be leveraged across a wide range of product categories. NEEA's Retail Product Portfolio (RPP) and the national ENERGY STAR Retail Products Platform (ESRPP) are complementary efforts intended to stem this tide of increasing energy consumption from plug-in equipment by improving the efficiency of products sold through retail channels. This paper examines how analysis of RPP's retail sales data provides actionable insights in both the ENERGY STAR specification revision process and RPP program design.

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[1] NRDC Note: This chart is focused on electricity and includes only a small share of water and space heating energy, which comes primarily from natural gas in California. Equipment in the Pools and Spas, Lighting, Air Conditioning, and Electric Space Heating categories are mostly hard-wired to the building, but some is plug-in, such as portable electric spaces, plug-in lamps, and portable heaters and air conditioners (NRDC 2015).
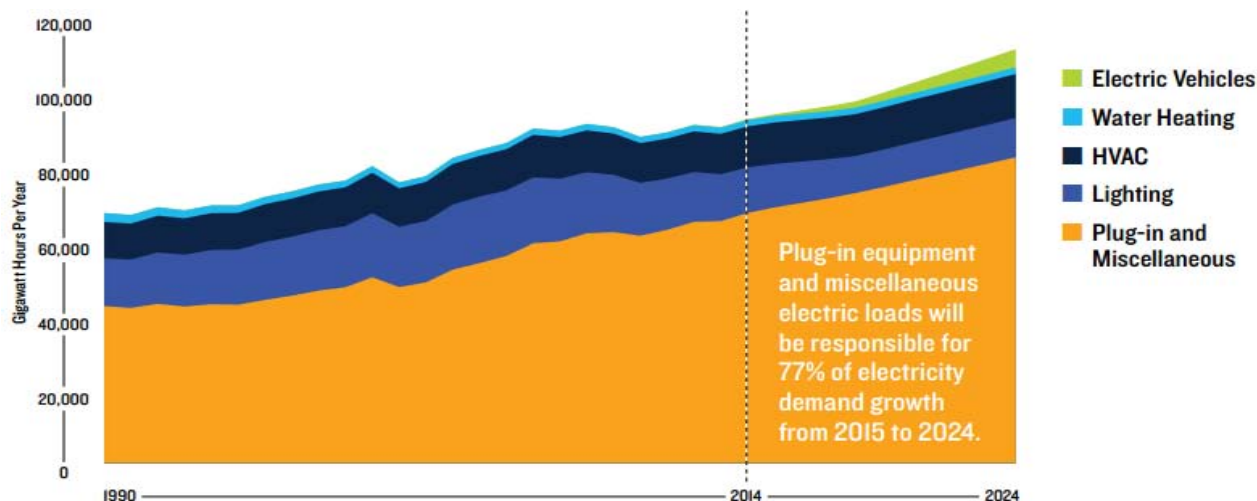
Figure 2: California Residential Electricity Growth Forecast (NRDC 2015)

Retail Product Portfolio (RPP) Overview

Several market forces have created the need for a new approach to utility programs that work in the retail sector: the general success of both federal standards and ENERGY STAR specifications that have increased the energy efficiency of dozens of retail products and increasing competition in the retail sector. When combined these two forces result in low energy efficiency participation rates by retailers since small consumer-facing or downstream incentives are not effective at influencing sales, and the administrative burden of managing rebates is not a profitable use of time for the retailer. The RPP is designed as a market transformation program,[2] and as such, its focus is on creating systemic changes within the market, rather than a simple resource acquisition program for utilities (Keating 2014). RPP creates sustained market effects by paying a per-unit mid-stream incentive to retailers for every program-qualified model sold during the program period. Program-qualified models are typically ENERGY STAR models in each product category, which are more efficient than comparable non-qualifying models within a retailer's existing product category assortment. Through this sustained retailer engagement the RPP influences retailer buying assortment practices, ultimately driving increased production of efficient products and increasing stringency of voluntary and mandatory product efficiency requirements.

The RPP relies on building scale through collaboration of utilities and retailers to adopt uniform processes while giving utilities local flexibility on customer facing activities intended to impact results. Operating at a larger scale allows the program to operate cost effectively and gives it the influence necessary to achieve market transformation goals. As part of the RPP program, retailers submit sales data – for both qualified and non-qualified product sales– in each of RPP's product categories to an online portal, which automatically determines program qualification status and matches each model with its ENERGY STAR listing if any exist. This gives RPP highly actionable data concerning the current state of the market in these product categories.

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[2] Market Transformation can be defined as "sustained increases in the adoption and penetration of energy efficient technologies and practices through structural changes in the market and in behaviors of market actors" (Keating 2014).

The RPP evolved out of the Television Initiative which NEEA launched in 2009 in conjunction with California utilities Pacific Gas & Electric and Sacramento Municipal Utility District. The Television Initiative set the stage for the RPP program design and worked with many of the same retailers. By 2013, major strides were made in TV efficiency and NEEA ended the market intervention. Based on the success of the TV Initiative and its successful engagement with market actors, NEEA's RPP launched in 2014 to address increasing energy consumption of plug-in equipment, starting with a small portfolio of plug-in equipment consumer products. Around the same time ENERGY STAR, retailers and NEEA opened conversations regarding taking RPP to scale at the national level. Today, NEEA's RPP operates in close collaboration with the national ENERGY STAR Retail Products Platform (ESRPP).

The Power of the ENERGY STAR Brand in Influencing Consumer Purchasing Behavior

The ENERGY STAR program is an important driver of product efficiency in the market due to its widespread consumer awareness. In a 2014 brand awareness survey, 89% of households recognized the ENERGY STAR brand with a visual aid. Over 320 million ENERGY STAR certified products were sold in 2014 across more than 70 different product categories, many of those sold through retail channels. ENERGY STAR has strong consumer recognition in large plug load and appliances such as refrigerators, water heaters and electronics. Of households surveyed, 45 percent knowingly purchased an ENERGY STAR certified product in the past year. Of those purchases, about 77 percent reported that label as influential in their purchasing decision; and 75% also reported they are likely to recommend products that have earned the ENERGY STAR to friends (EPA 2015). In addition, EPA continues to expand specifications to new product categories, and its widespread consumer recognition makes the ENERGY STAR label a key product differentiation factor that manufacturers consider in their product design process.

The ENERGY STAR Specification Revision Process

As products evolve, the ENERGY STAR Specification revision process plays a critical role in advancing product efficiency over time. Since the first ENERGY STAR specification went into effect in 1992 for desktop computers and monitors, more than 150 revisions have been effective across more than 70 product categories. From 2012-14, thirty new or revised specifications took effect and nine revisions or developments were completed in 2014. The primary goal of the revision process is to update the ENERGY STAR product specification so that it remains the mark of efficiency as products evolve. As outlined in EPA's 2012 Strategic Vision and Guiding Principles document, reasons for initiating a specification revision include:
- Significant increase in market penetration of ENERGY STAR qualified models
- Change in the Federal minimum efficiency standards
- Technological advancements with a product category
- Product availability limitations
- Issues with consumers realizing expected energy savings
- Performance or quality issues
- Issues with test procedures

As part of its ENERGY STAR program requirements, EPA requires Partner manufacturers to submit aggregate unit shipment data which provides high-level insights into the market such as total shipments and the fraction of ENERGY STAR qualified products in the market.

ENERGY STAR products specifications are typically reviewed for a possible revision every three years or when market share of qualified products reaches 35% and for rapidly evolving products, such as displays and televisions, product specifications are revised every two years. As part of the specification revision process, EPA sets product qualifying levels to ensure that products avoid proprietary technologies and capture a good selection across product sizes and sub-categories. For example, freezers come in a number of product configurations, such as chest or upright, with auto or manual defrost, standardized test procedures form the basis of how product energy consumption is measured within a specification. For supplemental product features, ENERGY STAR specifications may include 'adders' to account for additional energy consumption that is specific to that feature that consumers seek and may not be uniform over an entire product category. Product categories with rapidly evolving feature sets may require adjustments to the test method over time to ensure that the test procedures incorporate new features that may impact energy consumption.

When setting the levels of the revised specification, EPA utilizes four main tools to determine if a product specification is ready for revision and identify opportunities for improving energy efficiency: its existing Qualified Products List (EPA can focus on the most recently certified models in this dataset), additional data from datasets such as those housed by regulatory bodies such as the California Energy Commission or Department of Energy, additional product performance data from manufacturers or other stakeholders, and communication with manufacturers.

After EPA determines a specification revision is warranted, EPA releases and seeks comment on a draft revised specification. Based on that feedback, EPA will revise the draft and again put it out for comment, prior to finalizing the specification. The revision process typically takes one year for most products, although time varies by specification and can be longer for more complex specifications such as data centers and shorter for less complicated products such as commercial food service or heating and cooling equipment. Updated product specifications go into effect nine months after the revision to the specification has been finalized though products can be certified to the new specification as soon as it is completed.

How Data Analytics and Forecasting Can Support the ENERGY STAR Specification Process

The ENERGY STAR specification revision process can be enhanced by incorporating RPP program sales data to track emerging product sales trends and use time series forecasting to more accurately predict product efficiency over time. The result can be a data-driven approach to forecasting product market penetration so future specifications more accurately reflect market conditions. RPP data can inform the ENERGY STAR specification process in four key ways:
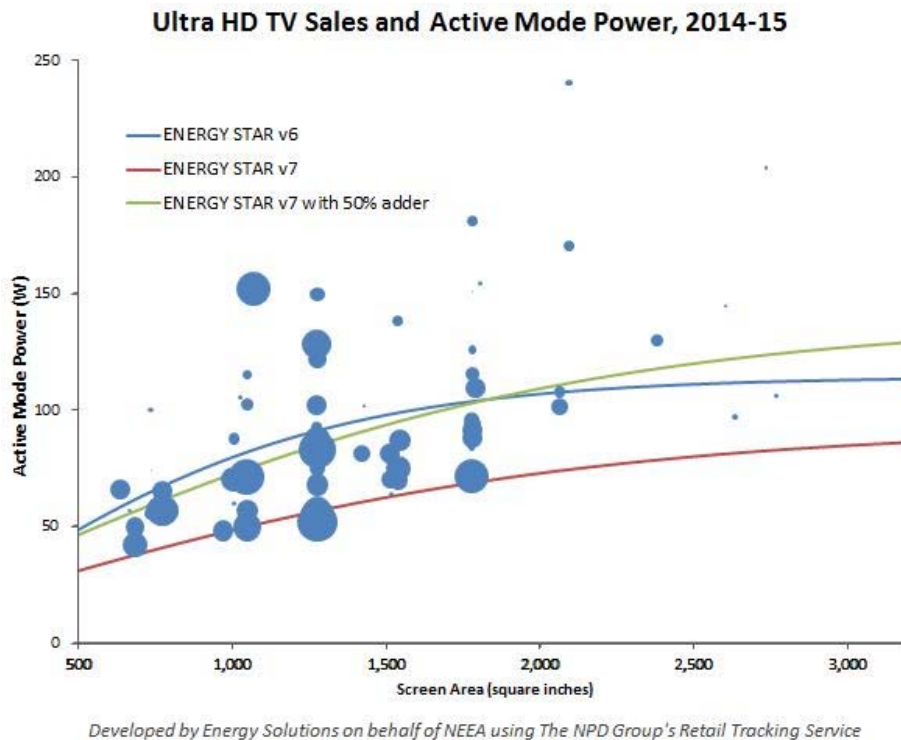
Utilizing monthly sales data to identify when a specification can be triggered. RPP's highly granular retail sales data can complement EPA's manufacturer approach by providing more detailed information on product trends and ENERGY STAR market share.[3] RPP can support EPA by providing market share trends, notifying EPA when products meet EPA's requirements

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[3] To protect retailer privacy, data trends are aggregated across all participating retailers so that the outcome reflects the broader trends within the industry as opposed as a specific retailer)

to trigger a specification revision. In addition, RPP sales data can provide detailed information on the types of products being sold in the market and the number of manufacturers and models which meet existing or proposed specifications.

Identifying discrepancies between sales-weighted and model-weighted patterns. As part of the specification revision process, EPA collects manufacturer-submitted model data to develop a test dataset that is thought to reflect the makeup of the current market. This dataset is then utilized to set specification requirements (e.g. the specification should be designed so that 25% of available models can meet the performance criteria). Comparing model-weighted and sales-weighted datasets can help EPA better understand market trends and the implications for setting new specification requirements: are models with lower sales driving the market forward with new innovative features, or are models with low volumes less efficient than the rest of the market? For example, over 1000 TV models were sold in the US in 2015. However, the Top 100 best-selling televisions in 2015 represented over 80% of sales, and the top 200 represented 90% of sales and on average were significantly more efficient than low volume models. Thus, a model-weighted approach with 1000 models may lead to significantly different conclusions than a sales weighted one, particularly if there are differences between products that are available and products that drive sales. For example, Figure 3, which is based on RPP data, shows that a significantly higher fraction of UHD TV sales met the ENERGY STAR Version 7 requirements than on a model-weighted basis, suggesting that the using a sales-weighted approach would lead to a more stringent specification to meet EPA's goal of 25% market share.

Developed by Energy Solutions on behalf of NEEA using The NPD Group's Retail Tracking Service

Figure 3: Average UHD TV Sales by Active Mode Power. Bubble size represents sales for 2014-2015; lines represent maximum allowable active mode power to meet the ENERGY STAR specifications.

Incorporating Emerging Product Features into the ENERGY STAR Specification or Updating Test Procedures. In many product categories, new product features emerge which provide greater functionality but may impact energy consumption. Sales data can identify whether specific product features are gaining sufficient traction to warrant specific consideration in the ENERGY STAR specification. For example, 3D TV was heavily publicized in 2011, but ultimately did not gain traction in the market. On the other hand, UHD has gained substantial traction in the TV market and is already standard in larger screen sizes. Tracking market adoption of new product features early on can help EPA identify and prioritize which product features they should seriously consider integrating into their specification. All ENERGY STAR energy consumption data is measured and based on a standard test procedure, which typically is standardized with the Department of Energy's TV test procedure. If product features that significantly impact product energy consumption are not properly incorporated into the standard test procedure, this can result in reported values than are lower than are actually occurring during standard use. Retail sales data can actively track market share of emerging features and proactively identify those that should be incorporated into updated test procedures.

Improved Forecasting of ENERGY STAR Market Penetration over Time. An inherent challenge of the specification development process, particularly for rapidly evolving product categories, is setting specifications that align with changing markets. Currently, EPA must utilize historic data to set a specification that will go into effect often 1-2 years into the future. For example, Version 7 of the Television specification began with the release of Draft 1 in June 2014, Draft 2 in September 2014, was finalized in December 2014, and went into effect in October 2015. Although the dataset used to determine the Version 7 qualification levels was based primarily on relatively recent model data from 2014, in fast moving product categories there is often a shift in product efficiency from the models in the last updated dataset until the time when the specification goes into effect. For example, EPA's goal is to have a 25% market share when the specification goes into effect, and in some rapidly moving product categories it is necessary to set a lower pass rate to account for expected changes in the market between the time in which the specification revision is finalized and when it takes effect. Recognizing this, EPA has taken this tact with TVs, for example. Analyzing monthly retail sales data can help stakeholders better understand product efficiency trends and forecast market penetration over the next 9-12 months, assisting EPA in setting its specification requirements.

**Using Retail Sales Data to Support Energy Policy Decisions of UHD TVs**

UHD TVs offer a prime example of how highly granular sales data can inform policy and program design decisions for both RPP and the ENERGY STAR specification-setting process. UHD televisions have double the horizontal and vertical resolution of standard high-definition televisions, containing four times as many pixels per square inch. This results in a crisper image for consumers, but the increased pixel count is energy-intensive. Initial UHD models consumed more power than an HD model, causing significant concern that these products would lead to significantly higher energy consumption and higher energy costs to customers. While energy consumption of High Definition (HD) TVs has decreased greatly since 2008, increased adoption of UHD threatens to reverse prior TV efficiency gains.

Early Identification of Increasing UHD Market Share. As part of its TV Market Transformation Initiative, NEEA has intensively tracked the television market since 2009,

collecting a wealth of highly granular monthly retail sales data on product trends and energy consumption over time. When EPA revised the ENERGY STAR Version 7 TV specification, an important aspect was assessing the how much additional power is needed to enable UHD, a highly popular consumer feature.[4]

Analysis performed on retail point of sale (POS) data shows that in 2014, UHD TVs had less than 2% market penetration across the entire television market, and thus its growth could only be tracked with monthly model-level sales data. TVs released in Q2 2014 showed a sharp uptick in UHD market penetration for those with screen sizes above 60", rising from 2% to roughly 40% from July 2014 to July 2015. More importantly, the data also showed that UHD adoption was propagating to smaller, more mainstream screen sizes as UHD costs came down through economies of scale. This was a bellwether of strong future growth, because successful new product features must expand to the mainstream market as costs come down rather than remaining in luxury products.

This key finding was made possible by the granularity of the sales data available to NEEA, which broke out sales by month and screen size. Using model-level data, the pattern would only have been shown as a slight increase in number of models, missing the large increase in sales volume. Using annual, non-model-specific sales quantities, the pattern would only have been seen as a small increase in market share rather than a large increase in market share at the high end of the market which predicted strong future growth. Combining these two elements yielded entirely new insights.
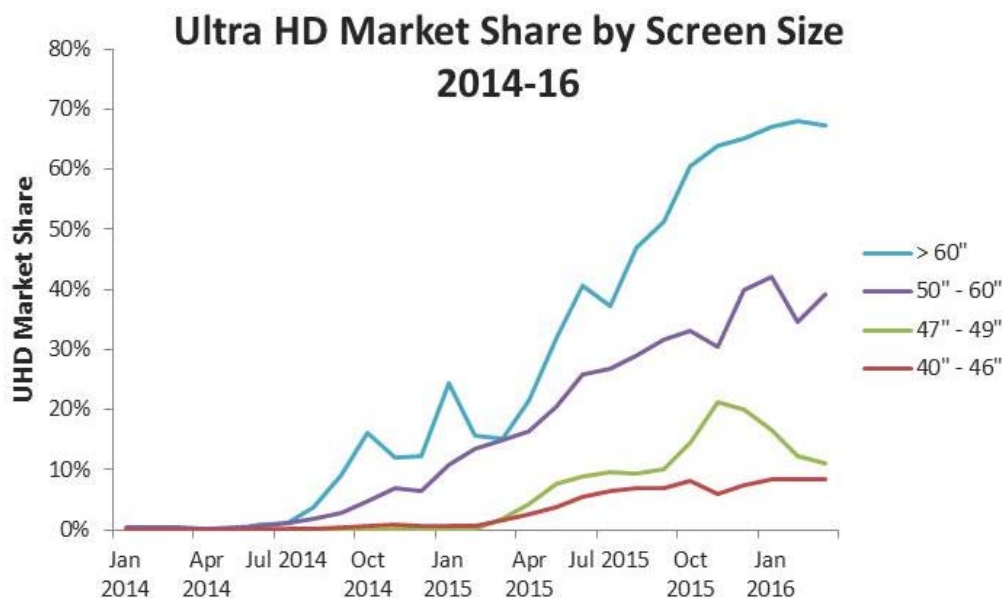
Developed by Energy Solutions on behalf of NEEA using The NPD Group/Retail Tracking Service

Figure 4: Ultra HD has become standard for TVs over 60" and will soon be standard for TVs over 50"

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[4] To avoid asking customers to sacrifice performance for efficiency, EPA may give adders when doing so is required for critical product features to work.

While UHD adoption was dramatically increasing for TVs with larger screen sizes in 2014, the energy consumption of UHD TVs was still substantially higher than ENERGY STAR. At that time, no UHD TV models qualified for the proposed ENERGY STAR 7 specification.

Based on this data, NEEA submitted a comment letter for Draft 1 of the ENERGY STAR specification in July 2014 identifying UHD as an important product feature that needed to receive distinct treatment and recommending that UHD TVs be given an adder to allow some of the most efficient UHD TVs to qualify for ENERGY STAR. This would enable efficiency programs such as RPP to gain traction with retailers by offering incentives for producing relatively energy-efficient UHD products.

By November 2014, when the Draft 2 of the Version 7 specification was released, UHD TVs accounted for over 10% for all TV sales above 60". More critically, the data showed that the technology was continuing to propagate into smaller size bins and becoming standard across a growing section of the TV market, ultimately resulting in an increase in TV energy consumption. NEEA submitted another comment letter recommending that although an adder was appropriate at the time to account for the energy consumption differences between HD and UHD, it should be reviewed annually and reduced or sunset over time to account for expected improvements to UHD energy consumption over time.

Using Sales Data to Set RPP Program Levels. By July 2015, market share of UHD TVs rose to 40% for TVs larger than 60" and 25% for TVs between 50-60". Due to the increased energy consumption of UHD TVs, NEEA identified separate trends in UHD and non-UHD products using model-level sales data. The trends show that while the energy consumption of non-UHD products continued to decrease at roughly 3% per year, the uptick of increased UHD sales over the entire market offset the efficiency gains achieved by HD TVs for the entire year, resulting in a nationwide savings loss of roughly 90 GWh in first-year savings.

With this key insight, NEEA identified that the most effective way to continue transforming the changing television market was not to revive an incentive program for all televisions, but to create incentives *specifically* for UHD televisions. Energy consumption of UHD TVs had dramatically changed since the ENERGY STAR Version 7 revision in 2014 due to technological improvements that occurred in late 2014 and early 2015, just as the Version 7 specification was being finalized, and thus could not fully be accounted for in this revision. NEEA analyzed program sales data to determine the most appropriate incentive level for a fast-moving target market, with the goal of capturing 10-25% of the UHD TV market by Q2 2016. Utilizing existing sales data and forecasting market adoption out to Q2 2016, NEEA decided to eliminate the need for UHD adder entirely because the top 10% of models no longer needed an adder to meet the ENERGY STAR specification (

Figure 5).

**UHD Market Penetration with ENERGY STAR v7 UHD Adders, 2014-16**
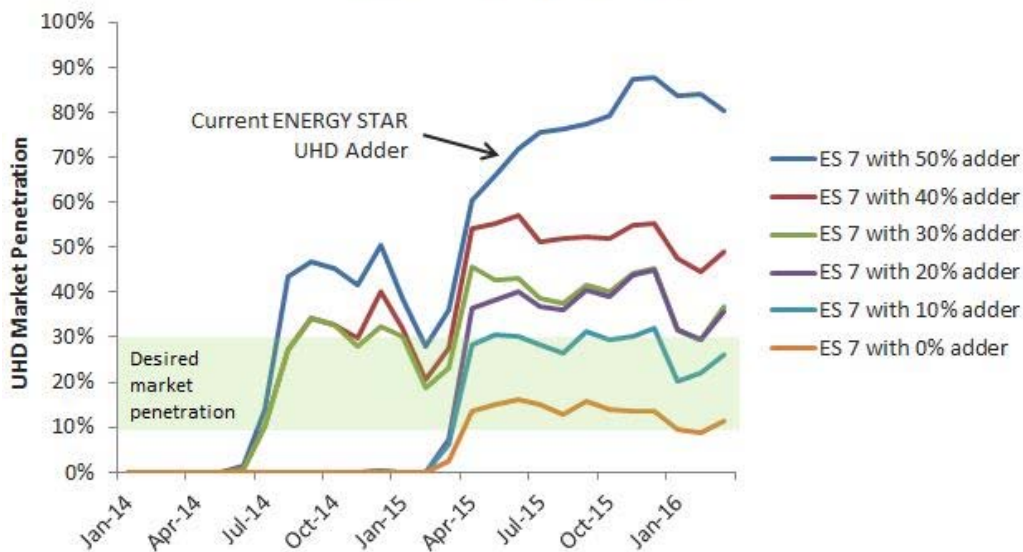
Developed by Energy Solutions on behalf of NEEA using The NPD Group's Retail Tracking Service

Figure 5. UHD market penetration with various possible adders

Forecasting UHD Energy Consumption to Support Future ENERGY STAR Specification Revisions

As UHD becomes standard in most screen sizes above 40", it will play an increasingly large role in driving TV energy consumption. Subsequent ENERGY STAR specifications must therefore reduce the UHD adder to encourage manufacturers to improve efficiency of UHD TVs and close the gap in energy consumption between HD and UHD TVs. ENERGY STAR Version 8 will face a similar challenge in setting levels for a rapidly changing UHD market, with significantly higher stakes because the UHD adders will be impacting a large fraction of the market. By the time ENERGY STAR Version 8 is effective (likely in late 2017 or 2018), UHD annual sales will be at 14 million (40% market share) and becoming standard for all screen sizes above 40". Based on our data of UHD energy consumption over time, by July 2015 5% of total sales already met ENERGY STAR without any adder, and 25% of sales met ENERGY STAR requirements with only a 25% adder, as shown in Figure 6. Based on this data, we forecast that by Q2 2017, 25% of UHD TVs will meet the ENERGY STAR Version 7 specification without an adder, suggesting that the need for an adder has been significantly diminshed. EPA's practice of discontinuing adders when a feature is broadly available across models, arguing that they can be powered with base energy, could be applied in this scenario.

UHD Adder Required for ENERGY STAR Desired Market Penetration, 2014-16

Developed by Energy Solutions on behalf of NEEA using The NPD Group's Retail Tracking Service
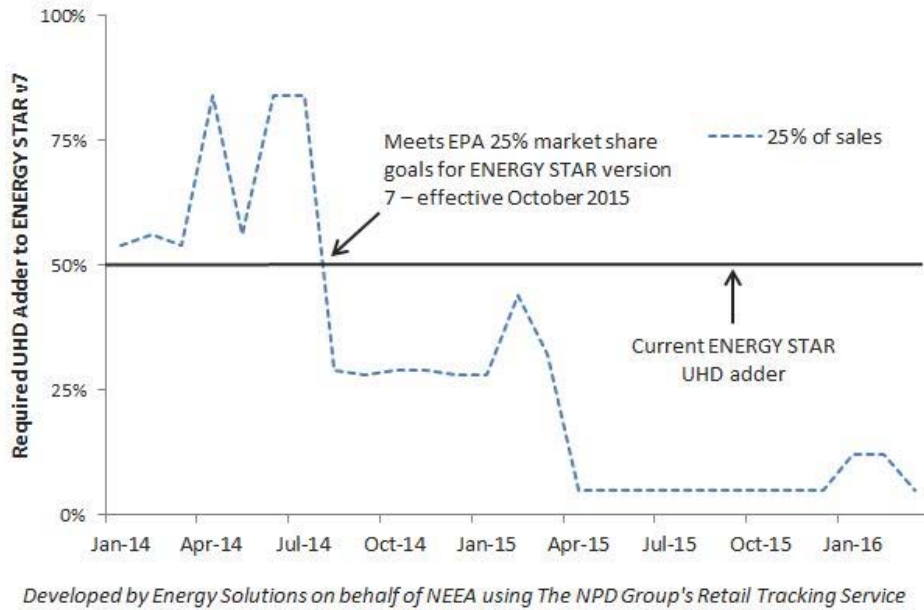
Figure 6. Required UHD adder for different resulting ENERGY STAR market penetration

More generally, highly granular sales data can help EPA and stakeholders identify shifts in the market at key points in time and help to identify their underlying drivers, such as a marketing push confined to specific models and manufacturers or broader changes occuring across the entire market. This data assists in anticipating market trends and growing market share before EPA receives its annual unit shipment data from manufacturers, allowing them to proactively consider triggering a specification revision. It also augments model level and unit shipment data, allowing for granular examination of upcoming trends like UHD and more actionable tracking and projection.

Expanding Analytics Approaches to Additional Product Categories

NEEA's TV Initiative began in 2008 and since that time has compiled a rich dataset and nuanced understanding of the TV market, utilizing this data to inform program strategy and support the ENERGY STAR specification revision process. NEEA has expanded these analytics efforts to additional product categories during the initial rollout of the RPP program, using the data-driven TV method approach as a model to inform decision making. While these capabilities may be limited in the first years of RPP, as the program gains scale it is expected that this data will evolve into a robust tool to inform program design and ENERGY STAR specifications. To date and in the short-term future, retail sales data analysis for non-TV RPP product categories will primarily focus on informing RPP program design, such as setting incentive levels and forecasting market adoption for participating retailers. However, as the RPP program expands to new product categories and increases the number of participating retailers, the scale and scope of its analytics capabilities will continue to grow. For example, the existing POS data covers roughly 80% of the brick and mortar TV market, providing nearly comprehensive insight into

product feature trends and energy consumption of the entire market.[5] The result is that insight from the TV data can not only inform NEEA's RPP program decision, but also inform EPA on specification setting across the entire market.

In more fragmented product markets, particularly those with online sales, RPP sales data may initially be less representative of the entire market. For example, in the air cleaner product category, participating RPP retailers had significantly higher sales of ENERGY STAR air cleaners than the broader market compared with EPA's market-wide manufacturer shipment data (60% of total sales compared to national sales of 20%).[6] While this discrepancy suggests that RPP program data may not be entirely representative of the broader market and therefore less useful in providing insight into specification setting, it clearly identifies an opportunity to expand program focus to improve product efficiency for retailers not currently participating in the program. This unique level of insight and program strategy vision is achieved through the combination of RPP's model-level data and EPA's aggregated manufacturer shipment data.

As the program expands to include more retail channels for longer time periods, the completeness and the value of the resulting market data will grow. The roadmap and lessons learned from televisions and specifically UHD TVs will inform both program design and data analysis methods for other product categories. In time, NEEA aims to provide similar value across several product types, creating actionable forecasts and specification recommendations to improve ENERGY STAR's specifications process and contribute to significant energy reductions across a wide range of plug-in equipment products.

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[5] The vast majority of TV sales are sold through brick and mortar locations. Although RPP sales data does not currently include online sales, it may be included in the future.
[6] http://www.energystar.gov/index.cfm?c=partners.unit_shipment_data