

Retail Products Platform Market Barriers Research

Final Report

December 21, 2016



Prepared by

research > into > action^{inc}

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Funded By:

Pacific Gas & Electric Company

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Executive Summary

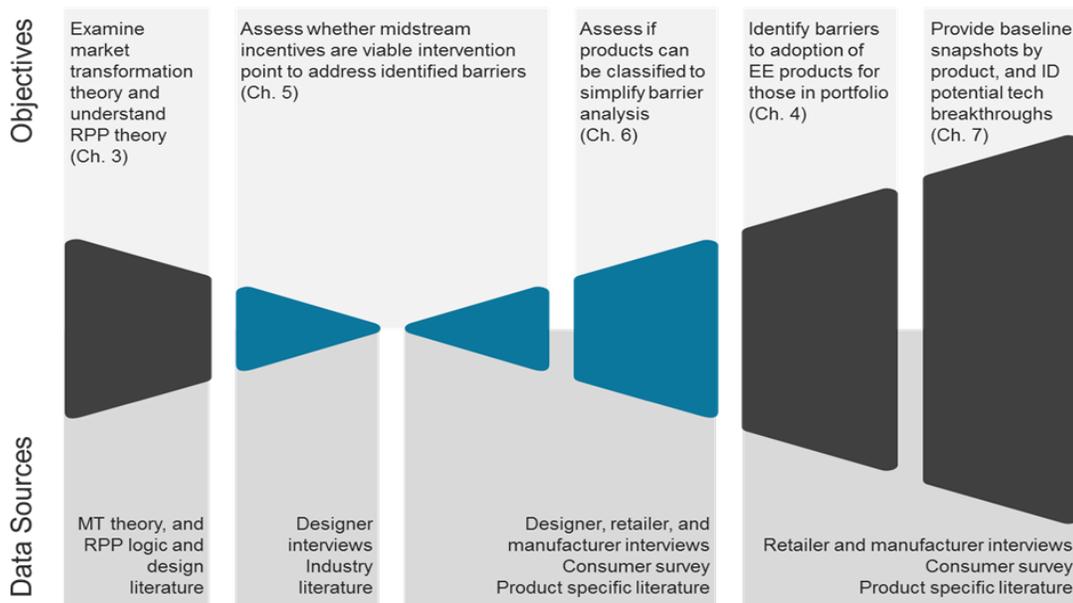
Pacific Gas & Electric Company’s (PG&E’s) Retail Products Portfolio (RPP) program offers participating retailers – which collectively control a large share of the targeted product markets – an incentive for each unit sold that meets its efficiency criteria. PG&E’s RPP program is part of a nationally-coordinated effort that seeks to maximize the program’s ability to influence retailers by bringing together program administrators from across the country. RPP currently targets sound bars, room air cleaners, clothes dryers, room air conditioners, and freezers; however, administrators may add and/or drop product categories as markets change and new savings opportunities arise.

PG&E commissioned this research under mandate from the California Public Utilities Commission (CPUC). It updates and extends prior market characterization research and seeks to better understand the supply chain and market barriers for PG&E’s 2016 and 2017 product categories.¹ This study addresses the five following research objectives:

1. Reconcile current market transformation theory with RPP program theory
2. Identify overarching and product-specific barriers to adoption of energy efficient products
3. Assess if midstream incentives effectively help overcome the identified barriers
4. Assess if broader product classifications can simplify barrier analysis
5. Provide baseline snapshots and potential technical breakthroughs for RPP products.

Figure ES-1 shows how we matched the research objectives to research activities.

Figure ES-1: Research Objectives and Data Sources



¹ The Office of Ratepayer Advocates, in its comments to the Draft RPP EMV Plan dated November 9, 2015, and the CPUC’s Ex Ante Review Team, in its disposition to the RPP workpaper dated December 15, 2015, communicated the requirement to conduct new primary research for RPP as described in this report.

Key Insights for Each Research Objective

Reconcile Current Market Transformation Theory with RPP Program Theory

Market barriers are central to the CPUC's definition of market transformation, which states that market transformation occurs when an intervention "[reduces] barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate."² In a widely-cited paper, Eto, Prah, and Schlegel identified 14 market barriers that could limit the adoption of an energy-efficient product or service.³

To facilitate the application of these barriers to RPP products, we categorize them within a consumer decision framework in which certain conditions are required for consumer uptake of an efficient product to occur. First, consumers must value and demand the efficient option, which requires that consumers perceive the benefits of the efficient option to outweigh its costs. Second, the market must supply the efficient option, making it both available and affordable to the consumer.⁴ Market barriers are factors that inhibit one or more of these conditions, increasing consumers' perceived cost of the efficient option, decreasing the perceived benefit, or inhibiting supply.

Our review of RPP program theory, based on both PG&E's RPP Program Theory and Logic Model and interviews with program designers, identified one additional condition necessary for consumer uptake of an efficient product and an associated barrier. In addition to recognizing that the benefits of energy efficiency exceed the costs, and thus valuing efficient options, consumers must prioritize energy efficiency over other, competing features to demand efficient models. While a consumer may value energy efficiency, they may opt to purchase an inefficient option that offers some other feature they value more.

Identify Barriers to Adoption

Our research shows six market barriers inhibit uptake of efficient models of one or more RPP products:

- **Competing priorities** (overarching): Consumers may be aware of efficient models and value energy efficiency as a product feature, but fail to purchase an efficient model because one is not available with other features that they value more.
- **Information and search costs**: The effort involved in learning about and identifying energy-efficient products may effectively increase consumers' perception of the cost of an efficient model to the point that the cost exceeds the perceived benefit from efficiency.
- **Performance uncertainty**: Consumers may be unsure whether an efficient model will deliver the promised energy savings while functioning as well as an inefficient option, and thus may be

² California Public Utilities Commission, *Decision Approving 2010 to 2012 Energy Efficiency Portfolios and Budgets*, D.09-09-047, 2009, <http://docs.cpuc.ca.gov/PUBLISHED/GRAPHICS/107829.PDF>.

³ Joseph Eto, Ralph Prah, and Jeff Schlegel, "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs" (Berkeley, CA: Earnest Orlando Lawrence Berkeley National Laboratory, July 1996).

⁴ In this context, affordability refers to the ability of the consumer to pay the upfront cost of the efficient option, including their access to financing. This is distinct from the product's incremental cost, which Eto, Prah, and Schlegel and others argue is not a barrier as, assuming the measure is cost effective, the energy saving benefits will, by definition, exceed the incremental costs, unless other barriers exist that either increase the perceived benefit or decrease the perceived cost.

reluctant to choose the efficient model. Similarly, retailers and manufacturers may be uncertain whether demand for efficient models will be sufficient to justify their investment in increasing the availability of those models.

- **Product unavailability:** Consumers may be unable to purchase an efficient model because it is impractical or impossible to find efficient models available for purchase. As noted, this may result from retailers' and manufacturers' uncertainty over the demand for efficient products.
- **Inseparability of product features:** For some products, all the energy efficient options may be models with other premium features not related to energy efficiency. This creates a barrier by increasing the cost of the efficient option for consumers not seeking the additional features, causing the cost of the efficient model to exceed the perceived benefit.

The operation and influence of these barriers vary by product and market.

Overarching Barrier: Energy Efficiency is a Lower Priority Feature for Many Product Purchases

Survey data show that consumers, when buying RPP products, consistently prioritize other product features over energy efficiency and the presence of an ENERGY STAR® label. In indicating which features were important in their purchase decision from a list customized for each product, between 78% and 89% of the surveyed consumers selected the most frequently-cited feature for each product. These proportions far exceed the 22% to 45% of respondents purchasing each product that reported selecting the model they chose because it had an ENERGY STAR label. The proportions of consumers reporting they specifically looked for ENERGY STAR models and gave energy efficiency a high priority in their purchase decision were similar to those selecting the model they purchased because of its ENERGY STAR qualification.

The discussion of product-specific barriers below provides additional detail on how competing priorities limit the uptake of efficient models of each product. It is important to note that, while consumers may prioritize features other than efficiency, our findings do not suggest consumers actively avoid energy-efficient models of the products examined due to performance uncertainties (except for heat pump dryers) or other factors.

Product-Specific Barriers

› **Clothes Dryers:**

- *Competing priorities:* The fact that three-quarters of dryer purchases are part of a matched washer/dryer set suggests dryer energy efficiency is not a high priority.
- *Information and search costs:* Unlike other white goods, clothes dryers are a relatively recent arrival to the ENERGY STAR program. Thus, consumers may not be aware that energy use differs notably among dryer models. Consumers may also believe that a dryer purchased as part of a set with an energy-efficient washer will also be efficient.
- *Performance uncertainty (heat pump dryers only):* Dryers using heat pump technology are considerably more efficient than standard, electric dryers, but can take more than 30%

longer to dry a load of clothes.⁵ Manufacturers reported they are uncertain how well U.S. consumers will accept these longer drying times.

- *Product availability (heat pump dryers only):* Because market acceptance and sales of heat pump dryers is uncertain, manufacturers have not made these products widely available in the U.S. As one manufacturer said, “...we don’t think the infrastructure of the market is there yet.”

› **Clothes Washers:**

- *Competing priorities:* While most survey respondents reported they sought out and purchased ENERGY STAR clothes washers, those who did not said energy efficiency did not interest them (69%), suggesting these consumers see low energy cost-savings and other benefits for efficient washers. As one program designer put it, “people don’t care about saving \$20 or \$200 over the [15 year] life of a product.”
- *Information and search costs:* Of those respondents who did not prioritize energy efficiency, those who did not purchase an ENERGY STAR clothes washer were significantly more likely than those who did to report they did not know how to find or what to look for in energy efficient models.⁶

› **Refrigerators:**

- *Competing priorities:* Because kitchens in modern homes have become key living areas, other priorities have limited the uptake of efficient refrigerators. Notably, some less efficient refrigerator configurations, including side-by-side and bottom freezer configurations, have gained market share.⁷ Reduced energy cost savings due to increased efficiency levels across the board, may further reduce consumers’ willingness to prioritize efficiency. As one manufacturer noted “Consumers have to weigh how much extra [they pay] for an ENERGY STAR appliance with how much they save.”
- *Inseparability of product features:* Per a leading manufacturer, efficient models are available among the refrigerators with the fewest features, and thus lowest-cost, but most of these low-featured efficient models have a top freezer configuration. In other configurations, like side- and bottom-freezer models, this manufacturer reported that there are fewer efficient options among the low-featured products.

› **Stand-Alone Freezers**

- *Competing priorities:* Among survey respondents who did not prioritize energy efficiency in their purchase decision, most said they lacked interest in energy efficiency (68%) and that other features took priority (61%).

⁵ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

⁶ Fifty-two percent of those who did not prioritize efficiency *and* did not purchase ENERGY STAR models reported they did not know how to find or what to look for in efficient models, relative to 37% of those who did not prioritize efficiency, but did purchase efficient models ($p < 0.05$)

⁷ Based on a comparison of subsequent RASS and CLASS studies.

- **Product availability:** Between May and October 2016, participating retailers in PG&E territory assorted a lower proportion of ENERGY STAR freezer models than any of the other products tracked in the RPP data portal. ENERGY STAR models made up only 23% of the freezers that sold at least 10 units. Consistent with this finding, 53% of survey respondents who did not prioritize efficiency in their purchase decision, cited product availability as a barrier.

› Room Air Purifiers

- **Competing priorities:** Market research shows that consumers are likely to cite ease of use, cost, rated room cleaning size, and clean air delivery rate as more important than energy efficiency in their purchases of air purifiers.⁸ The emphasis on product performance reflects that consumers buy room air purifiers to reduce allergens.⁹ According to one RPP program designer, “when we [consumers] have health and safety issues, we jump to what is most effective; energy efficiency is not a driving factor there.”

› Room Air Conditioners

- **Competing priorities:** Room air conditioner sales vary, with warmer weather driving higher sales.¹⁰ This suggests consumers buy room air conditioners to meet an immediate comfort need. As one program designer reported, air conditioners are “something bought in a hurry, something broke,” and that “efficiency gets lost in the noise of needing something that does the job.” Survey findings support this opinion; room air conditioners had the second lowest proportion of consumers who selected the ENERGY STAR label as a buying criterion.
- **Information and search costs:** Among survey respondents who did not prioritize efficiency,¹¹ those who did not purchase ENERGY STAR room air conditioners were significantly more likely than those who purchased ENERGY STAR models to report they did not notice efficiency as a product feature.¹² This same group was significantly more likely to report they did not know how to find or what to look for in efficient models.¹³ A study in New Jersey

⁸ AHAM, “Air Cleaners: Big Savings Opportunities in Small Market Appliances.” <https://www.energystar.gov/ia/partners/downloads/AHAM-Messner.pdf?38cf-3ac1>

⁹ Cheri Wright, “Big Savings Opportunities in Small Market Appliances: The Air Purification Market” (ENERGY STAR Products Partner Meeting, St. Paul, MN, October 24, 2012), <https://www.energystar.gov/ia/partners/downloads/Kaz-Wright.pdf?5442-a1e8>.

¹⁰ “Room Air Conditioners: 2007 Partner Resource Guide” (U.S. Department of Energy, 2007), https://www.energystar.gov/ia/partners/manuf_res/downloads/2007RoomAC_prg.pdf.

¹¹ The consumer survey asked respondents who reported they did not prioritize efficiency in their purchase decision, some of whom nonetheless purchased ENERGY STAR products, why they had not sought an efficient product.

¹² Fifty-two percent of survey respondents who did not prioritize efficiency but purchased an ENERGY STAR model reported they did not notice efficiency as a product feature, relative to 70% of respondents who did not prioritize efficiency and did not purchase an ENERGY STAR model ($p < 0.05$).

¹³ Fifty percent of survey respondents who did not prioritize efficiency but purchased an ENERGY STAR model reported they did not know how to find or what to look for in efficient models, compared to 71% of respondents who did not prioritize efficiency and did not purchase an ENERGY STAR model ($p < 0.05$).

also found retailers had lower awareness of ENERGY STAR room air conditioners than other ENERGY STAR products.¹⁴

› Soundbars

- *Competing priorities:* One leading manufacturer stated that, in choosing a soundbar, consumers look for the “best quality, and I will tell you, energy is definitely. . . not in there.” Consumer survey findings also show energy efficiency does not tend to influence purchases. Among other findings, respondents reported they did not prioritize efficiency because they were not interested in efficiency (72%), and other features were more important (70%).
- *Information and search costs:* Few manufacturers offer ENERGY STAR soundbars, and manufacturers and retailers have done little to reveal or promote energy efficiency in soundbars. Analysis of the limited data available on energy usage of non-ENERGY STAR soundbars further suggests the ENERGY STAR specification may not differentiate between efficient and inefficient models.

Assess if Midstream Incentives Are an Effective Intervention Point

According to RPP program designers and program logic, midstream incentives will help mitigate all of the product barriers discussed above with the exception of performance uncertainty as retailers respond to the incentives’ potential to increase their profit margins. Program designers anticipate that the lure of increased profits will prompt retailers to favor efficient over inefficient products, resulting in changes to their product assortment, merchandising, and promotion practices. When efficient models are more prominent, the barrier of competing priorities that afflicts all RPP products will be reduced. As one program designer explained, “RPP eliminates inefficient options for consumers. . . thereby increasing the adoption of efficient ones.”

As retailers carry a larger proportion of more energy-efficient models, program logic anticipates that manufacturers will see increased demand for efficient products and start to offer efficient options more broadly across their product lines. This would further mitigate the barrier of competing priorities because consumers would not have to choose between an efficient product and one that has the features they want. A wider range of efficient products would also address the product availability barrier, as more efficient products would enter the market, and the inseparability of product features barrier, as more efficient options would be available in products without premium features.

By motivating retailers to make changes in their product assortments, RPP can also circumvent information and search cost barriers. Program designers believe that if a larger proportion of the models in retail stores are energy efficient, even uninformed consumers are more likely to select efficient products. RPP retailers and administrators may also choose to reduce information and search cost barriers through in-store marketing efforts and training of sales associates, making it easier for consumers to identify efficient products.

¹⁴ Summit Blue Consulting, Quantec, LLC, and Gabel Associates, “Energy Efficiency Market Assessment of New Jersey Clean Energy Programs: Book II - Residential Programs” (Newark, NJ: New Jersey Board of Public Utilities, July 20, 2006), <http://www.njcleanenergy.com/files/file/NJ%20Mkt%20Assess%20Book%20II%20072006%20FINAL.pdf>.

Finally, program designers anticipate that, as RPP accelerates adoption of efficient products and the program generates data on market demand, PG&E and other RPP administrators will advocate for more stringent ENERGY STAR specifications and appliance efficiency standards. This advocacy will help reduce information and search costs by ensuring efficient products are differentiated from less efficient ones.

Assess If Broader Product Classifications Can Simplify Barrier Analysis

RPP is designed to easily allow new products to be added to the portfolio. Before investing in incentives on a new product, however, PG&E and other program sponsors must determine whether the type of midstream incentives RPP offers would be an effective intervention in that product's market. Identifying barriers that are common to a larger group of products could facilitate this understanding by reducing the need for detailed, product-specific research like that presented in this report. From an analysis of the product-specific market barriers described above, we find that products within broad classifications like white goods face some common market barriers. However, a combination of key product characteristics predict what barriers a product will face more precisely than broad classifications.

Most of the white good products included in this research share some characteristics due to the size of the purchase and sales process, as well as their long history with efficiency specifications and program activity.¹⁵ However, we find that a comparison of product characteristics provides a more accurate way to determine which barriers a product will face, for both white goods and the other products examined, than broader classifications. Specifically, our research revealed five factors affect the barriers a product is likely to face:

- › **The extent to which the product provides primary functionality or enhances an environment:**¹⁶ Consumers are likely to assume that products providing primary functionality, like a refrigerator, will perform adequately and thus focus their attention on other features. In contrast, maximizing performance is a top priority in the purchase decision for products that are designed to enhance an environment, like soundbars. Because consumers can achieve the basic tasks of accessing TV audio without soundbars, its performance in enhancing sound is of primary importance in the purchase decision. Thus, competing priorities, and potential performance uncertainty, may be particularly important barriers for products that enhance an environment.
- › **Availability of added features to differentiate the product:** Products with fewer features beyond their basic functionality, like stand-alone freezers and room air conditioners, are likely to face greater price pressure. Thus, manufacturers may be less likely to invest in their design and retailers may be less willing to stock them, leading to low availability of efficient products on the market.

¹⁵ Four of the products examined in this research fall within the classification of white goods: clothes washers, clothes dryers, refrigerators, and stand-alone freezers. One product, soundbars, falls within the broad classification of consumer electronics. The remaining products, room air conditioners and air purifiers, are not easily categorized into this type of broader classification. As a result, white goods are the only product classification with sufficient products included in this study to allow for a cross-product comparison to identify barriers common to products in that classification.

¹⁶ A product that provides primary functionality is one without which a consumer would be unable to perform some basic task. For example, without a refrigerator, a consumer would be unable to keep food cold. Products that enhance an environment improve on a basic task that the consumer could accomplish even without that product. For example, without a soundbar, a consumer could access audio content through their TV's speakers.

- › **History of efficiency specification and program activity:** Products that have a long history of efficiency specifications and program activity, such as washing machines, may be less likely to face information and search cost barriers.
- › **Prominence in the home:** As the findings on refrigerator market barriers suggest, consumers may be particularly prone to prioritizing other features, particularly aesthetics, over energy efficiency when purchasing products for key living areas of the home.
- › **Familiarity of efficient technology:** Products like heat pump dryers, which achieve efficiency gains by incorporating fundamentally different technologies than baseline products, are more likely to face information search cost and performance uncertainty barriers than products that become more efficient through incremental improvements to existing technologies.

Provide Baseline Snapshots by Product Category and Identify Energy Efficiency Technical Breakthroughs

The length of time products have had an ENERGY STAR specification overall and the amount of time the current specification has been in effect influence the market share of efficient products.¹⁷ Given the wide range of products included in this research, market penetration varies greatly, ranging from 15% to 56% based on 2015 ENERGY STAR shipment data (Table ES-1).

Table ES-1: ENERGY STAR Market Share and Proportion of Models Exceeding Specification

Product	ENERGY STAR Market Share ^a	ENERGY STAR Models Exceeding Specification by ≥3%
Clothes washers	56%	58%
Room air conditioners	54%	0%
Refrigerators	46%	37%
Soundbars	33%	99% ^b
Freezers	30%	20%
Air purifiers	29%	96%
Clothes dryers	15%	9% ^c

^a From 2015 ENERGY STAR Unit Shipment Data report.

^b Based on sleep mode energy usage requirement.

^c Electric clothes dryers only. No gas clothes dryers exceeded the ENERGY STAR specification by 3% or more.

The percent of models that exceed the minimum ENERGY STAR specification also provides insight into the way manufacturers approach energy efficiency. In cases where there is a large proportion of

¹⁷ Research Into Action, Inc., “Consumer Electronics Television Initiative Market Progress Evaluation Report #2” (Portland, OR: Northwest Energy Efficiency Alliance, April 29, 2013), <http://neea.org/docs/default-source/reports/consumer-electronics-television-initiative-market-progress-evaluation-report-2.pdf?sfvrsn=10>.

qualified models that exceed the minimum ENERGY STAR specification, such as with soundbars and room air purifiers, manufacturers are likely to incorporate efficiency into their designs to achieve non-energy or other benefits beyond consumer recognition of the ENERGY STAR label. Coupled with a high market share of ENERGY STAR products, a large proportion of models exceeding the ENERGY STAR specification also indicates an opportunity for RPP to advocate for more stringent specifications.

Market actors and program designers most often cited connectivity as the technical breakthrough that could affect RPP products. Although connectivity already exists in some white goods such as clothes washers and refrigerators, this functionality is still evolving, and it is unclear how it will effect products' energy use.

Conclusions and Recommendations

Based on the findings from this research, we offer two conclusions and associated recommendations.

Conclusion: The types of midstream incentives RPP offers are an appropriate intervention strategy for the products in the 2016 portfolio and planned for 2017.

RPP is well positioned to address product unavailability barriers as its incentives motivate retailers to replace inefficient models in their product assortments with efficient options. An increase in the availability of efficient models would also address other barriers, like consumers' competing priorities and information and search costs. With more efficient models available, and fewer inefficient models, consumers would be more likely to find an efficient option with the features they prioritize most highly. In addition, consumers unaware of or indifferent to energy efficiency would be more likely to select an efficient option based on other criteria. RPP has the potential to further reduce information and search costs as retailers increase promotion of efficient models, and as PG&E conducts in-store marketing activities. These barriers – product availability, information and search costs, and competing priorities – were the ones that most prominently applied to the examined products.

RPP's design is less suited to address barriers that might motivate participants to actively choose not to purchase an efficient model, like performance uncertainty. Retailers will be reluctant to favor efficient models of these products, as doing so could reduce their overall sales. In addition, increasing the proportion of efficient models in product assortments is likely to have less impact on sales of efficient models if consumers actively seek the inefficient option. Heat pump dryers were the only product included in this research that face a performance uncertainty barrier.

Recommendation: In selecting products for inclusion in RPP, avoid those for which performance uncertainty or other barriers might lead consumers to actively avoid efficient models. RPP's midstream intervention is unlikely to be effective for these products. Instead, for these products, a combination of upstream efforts and standards to address product performance, coupled with downstream efforts to address consumers' concerns are likely to be more effective than a midstream approach.

Conclusion: Rather than relying on broad classifications, like white goods, an examination of key product characteristics more accurately predicts the barriers a given product is likely to face.

The analysis of product specific barriers in this report identified six characteristics that together determine the barriers that prevent greater sales of efficient models of a particular product and the way

those barriers might influence consumer purchase decisions. Most products within broad classifications, like white goods, are likely to share many of these characteristics, but they are unlikely to be universal across all products in that classification. These variations can have important implications for which market barriers apply. As a result, it is important for program designers to look beyond the distinction between appliances and consumer electronics in determining which barriers are likely to be relevant to a particular product.

Recommendation: Consider the specific characteristics of a product to determine which barriers are likely to apply and how they might impact consumer decisions. There may be important differences between products within the broader groupings of consumer electronics and appliances. Nonetheless, products that are similar in certain key ways, like those listed in this report, are likely to share market barriers.

1. Introduction

Plug load energy use is forecasted to be one of the fastest growing energy end uses over the next 20 years. For many of these products, however, the per-unit energy savings of efficient models versus non-efficient models are too small to justify incentives sufficient to influence an end-user's purchase decision. Thus, it is more difficult for programs to offer the types of downstream rebates on these products that have traditionally been a part of energy efficiency programs. In response to these challenges, program administrators have sought new approaches to promote the uptake of energy-efficient products, particularly those that can transform markets.

To transform markets, programs must create “long-lasting, sustainable changes in the structure or functioning of a market achieved.”¹⁸ The Retail Products Platform (RPP) represents one approach to achieve this goal. RPP offers participating retailers an incentive for each eligible unit sold that meets the program-defined efficiency criteria. These retailers primarily consist of national, “big box” chains that control a large share of the market for the targeted products. RPP currently targets sound bars, room air cleaners, clothes dryers, room air conditioners, and freezers; however, administrators may add and drop products as markets change and new savings opportunities arise.

To effectively transform the market in response to plug load proliferation, RPP must overcome market barriers for each product incented. Eto, Prah, and Schlegel¹⁹, in their foundational research, defined 14 market barriers that could keep consumers from adopting energy-efficient products. Examples include information or search costs, performance uncertainties, or inseparability of product features.

While prior research²⁰ identified barriers for many plug load products, it did not assess these barriers from a market transformation perspective or assess whether a single intervention point – namely retailer incentives – could overcome the barriers. This study updates and augments prior market characterization research to address these two key gaps.

¹⁸ D.09-09-047 at 89

¹⁹ Joseph Eto, Ralph Prah, and Jeff Schlegel, “A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs” (Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, July 1996).

²⁰ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

Research Into Action (2015). Product Trends and Manufacturer Insights for Residential Laundry, Cooking, and Refrigeration Appliances Final Report. Pacific Gas & Electric, Southern California Edison and Sempra utilities.

1.1. Research Objectives

Commissioned by Pacific Gas & Electric Company (PG&E) under mandate from the California Public Utilities Commission (CPUC),²¹ this research addresses five key objectives:

1. Reconcile current market transformation theory with RPP program theory,
2. Identify overarching and product-specific barriers to the adoption of energy-efficient models,
3. Assess if midstream incentives are an effective intervention point to overcome the identified barriers,
4. Determine whether barriers can be categorized by product classification, and
5. Provide baseline snapshots and potential technical breakthroughs for products in the portfolio.

The study focuses on seven products: 1) air purifiers, 2) clothes dryers (both gas and electric), 3) clothes washers, 4) freezers, 5) refrigerators, 6) room air conditioners, and 7) soundbars. Clothes washers and refrigerators are under consideration for inclusion in RPP for 2017; RPP currently provides incentives for the remaining products.

1.2. Research Activities

To address the research objectives, we conducted three activities:

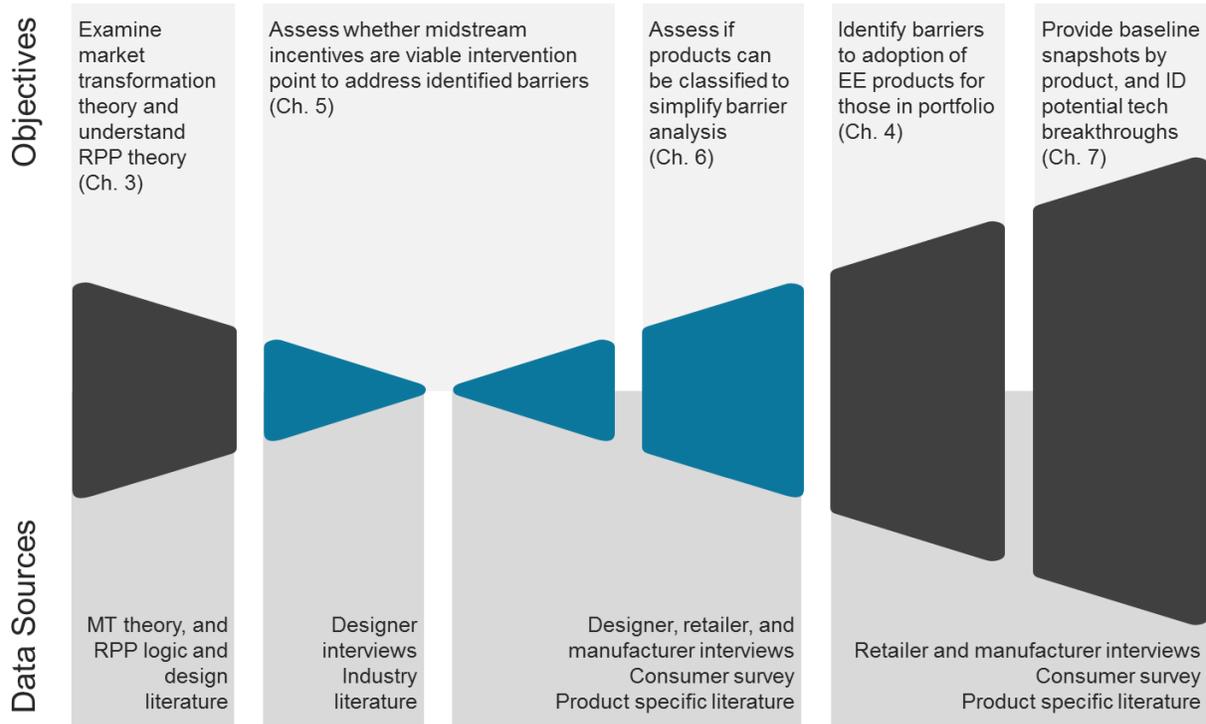
1. Reviewed documentation:
 - a. Market transformation literature, including Eto, Prael, and Schlegel's seminal work.
 - b. RPP logic, planning, and design documentation (including both PG&E and the national ENERGY STAR® RPP documentation)
 - c. Program-provided sales data
 - d. Product-specific market reports, articles, press releases, and published data
 - e. Product-specific data scrapes from Enervee and participating retailer websites
 - f. Interview transcripts from ENERGY STAR RPP interviews with participating retailer merchandizing and marketing staff
2. Interviewed design staff and market actors
 - a. RPP design staff (including PG&E, Northwest Energy Efficiency Alliance [NEEA], United States Environmental Protection Agency [EPA], and implementation staff)
 - b. RPP participating retailer sustainability staff
 - c. Manufacturer and component manufacturer staff
3. Surveyed California consumers

Figure 1-1 shows the data sources that informed each research objective. We first addressed the objectives in gray in Figure 1-1, which in turn allowed us to address the two objectives in blue –

²¹ The requirement to conduct new primary research as described in this document to identify and understand in greater detail the product-specific market barriers to the adoption of energy efficient models of products targeted by RPP was communicated by the Office of Ratepayer Advocates in its comments to the Draft RPP EMV Plan dated November 9, 2015 and by the CPUC's Ex Ante Review Team in its disposition to the RPP workpaper dated December 15, 2015.

assessing the efficacy of midstream incentives to mitigate market barriers, and to determine if products can be categorized in such a way that barriers can be generalized across those categories.

Figure 1-1: Research Objectives and Data Sources



1.3. Structure of this Report

The main body of the report describes the research methodology, summarizes key findings by research objective, and ends with conclusions and recommendations for PG&E’s RPP program.

The appendices offer the following additional information:

- › Detailed market characterizations for the seven researched products (Appendix A).
- › A Strengths, Weaknesses, Opportunities, and Threat (SWOT) assessment for the RPP program (Appendix B).
- › Detailed consumer survey findings (Appendix C).
- › In-depth interview guides (Appendix D).
- › Consumer survey guide (Appendix E).

2. Methods

This chapter provides a detailed description of each of the data collection activities that inform this report.

2.1. Secondary Research

For each of the seven selected products (the five selected for RPP's 2016 portfolio, plus clothes washers and refrigerator/freezers) we conducted an in-depth literature review to identify market trends, market barriers, key players, and the role energy efficiency plays in the product's market. In addition to this literature review, we used model specific data from the Enervee website to calculate correlations between price and efficiency, as well as data on the participating retailers' sales of qualified products within PG&E territory, which the retailers reported to the program, to investigate sales trends and top manufacturers. This research informed the product-level characterizations (Appendix A).

2.1.1. Literature Review

We conducted an in-depth literature review to identify market trends, market barriers, key players, and the product market's attitude towards energy efficiency. The following are examples of documents we reviewed for each product.

- › Published energy use studies
- › Documentation from energy-related meetings (for example, ENERGY STAR specification development meetings), including PowerPoint presentations and meeting notes
- › Articles, press releases, research reports and published data from print and online-only sources including consumer-facing publications, industry-specific publications/organizations, manufacturer websites, and market research firms. These included:
 - **Business data source:** Hoovers.com, IBIS World reports
 - **Industry-specific publications/organizations:** *Electronics Weekly*, eWeek, National Cable and Telecommunications Association (NCTA), TWICE
 - **Market research firms:** ABI Research, Dell'Oro Group, Gartner, IDC, iSupply, NPD Group, VDC Research Group
 - **Popular media:** Business Week, The New York Times, The Wall Street Journal

2.1.2. Enervee Data Analysis

For the product-level market characterizations, we used data from the Enervee.com website to assess linkages between cost and efficiency.²² Enervee maintains a website that provides model specific data for consumer products. We used web scraping techniques to translate this data into a useable form for analysis. This data most notably includes price for each model and an Enervee score, which rates each product's energy efficiency from 1 – 100. Enervee describes this score as “a universal way of comparing a product's energy use against all similar sized models.”²³ The data also contains information regarding models' capacity or size, configuration, ENERGY STAR qualification, reviews, energy savings, features, and other relevant information.

We analyzed Enervee data to determine if and to what extent and direction price and efficiency were correlated, whether this correlation remained when we controlled for capacity or size, features, etc. and if there was any indication of inseparability of product features.²⁴ This analysis drew only on data that was available on the search results page for a given product. As a result, for some products, little data on features beyond the price and Enervee Score were available. For products for which additional data (such as capacity, size, features, or configuration) was obtained, we controlled for those variables in our calculations of correlation.

To obtain results that more accurately reflect the models sold by the retailers participating in PG&E's RPP program, for all our analyses on the relationship between price and efficiency, we removed models that had a price more than two standard deviations from the mean. Frequently, these were very expensive, premium models for specialty applications. Due to the significant difference between heat pump clothes dryers and standard clothes dryers, we also removed heat pump clothes dryers from our analysis of dyers. Analysis of these relationships were added to the market characterization an assessment of product specific barriers where relevant.

2.1.3. Sales Data

For all seven products except refrigerators, we analyzed data on RPP participating retailers' sales in PG&E territory for sales that occurred between March and September 2016. This seven-month period contained complete sales data for all the products analyzed. Sales data for refrigerators was not tracked in the RPP data for this time. Instead, we used sales data from March through September 2015 for refrigerators.

We analyzed the sales data to identify top manufacturers and retailers by product, characterize sales trends, and determine ENERGY STAR penetration.

²² We are not using these data to assess incremental cost, but rather to investigate the relationship between efficiency, features, and price.

²³ Enervee.com

²⁴ Inseparability of product features is a market barrier that applies when the efficient models of a given product include additional features not related to energy efficiency that increase the cost of the model, preventing consumers not willing to pay for those additional features from purchasing an efficient model. An inseparability of product features barrier applies only if the added cost of efficient models comes from features other than the efficient technology itself. Thus, identifying this type of barriers requires an analysis of product features in addition to price.

For most targeted products, RPP offers an incentive for sales of models that meet the ENERGY STAR specification. For these products, we determined ENERGY STAR qualification based on the “tier” assigned by the RPP data management contractor to identify the program specification a given model meets.²⁵ RPP data for refrigerators did not contain information on ENERGY STAR qualification. For products that we could not determine ENERGY STAR qualification based on the provided sales data, we matched models listed in the sales data to the ENERGY STAR qualified products list.

2.2. In-Depth Interviews

We conducted in depth interviews with RPP program designers and market actors. For all in-depth interviews, interviewers took notes and, with respondents’ permission, recorded the interviews. We used qualitative analysis software to aggregate and categorize interview responses.

2.2.1. Program designers

The RPP Program Theory and Logic Model (PTLM) discusses the market barriers the program faces and the strategic interventions intended to address them. The discussion of these barriers largely reflects the perspectives of program designers and administrators, which in turn must be reconciled with perceptions regarding the key market barriers as seen by market actors such as retailers and manufacturers. We conducted interviews with six individuals working directly with RPP on program design. These individuals included program managers at EPA, PG&E, NEEA, and program implementation staff at Navitas.

We conducted the interviews as free flowing, open-ended interviews, lasting between 45 and 60 minutes each, covering the following topics:

- › Cataloging market barriers,
- › Identification of supply chain intervention points, and
- › Identification of key players in supply chain.

2.2.2. Market Actors

To obtain key information on market barriers and product trends not available via secondary data, we interviewed retailer sustainability staff, leading manufacturers in each targeted category, staff from trade associations, and a component supplier. As summarized in Table 2-1, we completed 11 interviews with market actors across the supply chains for the targeted products.

²⁵ Soundbars were the only product for which the assigned tier did not indicate ENERGY STAR qualification. As with many products, RPP offers two incentive tiers for soundbars. However, while the lower incentive tier is the ENERGY STAR specification for most products, RPP has defined an efficiency level 15% more stringent than the base ENERGY STAR specification for soundbars. Thus, some products not assigned a program tier nonetheless qualify for ENERGY STAR. We manually matched soundbar sales data to the ENERGY STAR Qualified Products List to identify these models.

Table 2-1: In-Depth Interviews

Respondent Type	Completed Number of Interviews
Retailers	3
Manufacturers	6
Trade Associations	1
Component Suppliers	1

Interviews with each program designer and market actor group helped inform question design and identify key players in the supply chain to contact. For example, to help identify key component suppliers and appropriate questions to ask them, we first needed to complete manufacturer interviews.

2.2.2.1. Retailers

We interviewed corporate sustainability staff members from the three national retailers participating in RPP in 2016: Best Buy, Home Depot, and Sears. These interviews probed retailers' perspectives on consumers' attitudes toward energy efficiency in the targeted product categories, the role of efficiency in the retailers' interactions with manufacturers, the availability of efficient products in the targeted categories, and anticipated trends in consumer demand and product technologies. From these interviews, we assessed the factors that, in the retailers' view, prevent greater uptake of efficient products.

We also included findings from interviews with retailer sustainability staff, merchants responsible for assortment and other merchandising decisions, and marketing staff focused on the targeted products in our analysis. The Cadmus Group conducted these interviews under contract to EPA, as part of the national RPP coordination efforts. While these interviews primarily focused on identifying any potential influence RPP had on retailer decisions, they contained some findings relevant to this study's analysis of market barriers.

2.2.2.2. Manufacturers

We interviewed staff members of leading manufacturers in each product category. We identified manufacturers with the largest market share across RPP's three participating retailers (Sears Holdings, The Home Depot, and Best Buy), as well as manufacturers who manufacture multiple products incented through RPP. These manufacturers are likely to have the largest touch with RPP through their work with participating retailers and their focus on multiple covered products. As a result, these manufacturers may be the most likely to eventually be influenced by RPP. Some manufacturers are leaders in multiple categories (see Table 2-2). For these manufacturers, we sought to obtain data about all of the relevant categories.

Table 2-2: Manufacturers Interviewed and the Products Covered

Company	Products Covered				
	Air Cleaners	Clothes Washers & Dryers	Refrigerators & Freezers	Room AC	Soundbars
Sears Brand Management Corp.		Yes	Yes		
Samsung		Yes			Yes
Whirlpool/Maytag	Yes		Yes		
General Electric (GE)		Yes	Yes		
Electrolux/Frigidaire			Yes	Yes	
Kaz	Yes				

Manufacturer interviews focused on technology trends, manufacturers' perspectives on consumer preferences related to energy efficiency, and manufacturers' perceptions of retailers' views on efficiency. Through these interviews, we sought to assess the primary barriers preventing manufacturers from increasing the efficiency of their product designs.

We also reviewed raw manufacturer interview transcripts from research conducted for the California utilities in 2015.²⁶ These five manufacturer interviews provided information on refrigerators, clothes washers, and clothes dryers. Interviews focused on future product and market trends, price points for ENERGY STAR products, the level of washer and dryer pairing, and the potential for integrating connected technologies in designs.

2.2.2.3. Component Suppliers

During our interviews with manufacturers, we asked them to provide relevant supplier contacts. These interviews and the secondary research identified few component suppliers had particularly large market share within a particular product category. We also worked with PG&E and implementation staff to identify viable component supplier contacts. Through this effort, we interviewed one component supplier. Our interview focused on how their products impact energy use of devices, supplier motivations and barriers to make products more efficient, and important technologies entering the market.

2.2.2.4. Key Trade Associations

In order to gain a broader perspective on the supply chains for the targeted products than individual retailers and manufacturers can provide, we interviewed staff at a key industry organization, the Association of Home Appliance Manufacturers (AHAM), which represents appliance manufacturers. The interview with AHAM addressed trends in technologies and consumer preferences with implications for

²⁶ Research Into Action (2015). Product Trends and Manufacturer Insights for Residential Laundry, Cooking, and Refrigeration Appliances Final Report. Pacific Gas & Electric, Southern California Edison and Sempra utilities.

energy use, as well as the most important factors preventing greater uptake of efficient products in the targeted categories.

2.3. End-User Survey

We conducted a web survey of consumers to identify end-user barriers and characterize the general awareness, knowledge, and attitudes toward various energy efficiency behaviors for consumers in PG&E territory. Respondents completed 1,570 online panel surveys during the period of November 3-11, 2016.

2.3.1. Sampling, Weighting, and Data Cleaning

The survey sought to gauge the opinions of residents in all occupied households in the state of California. To control costs and ensure we accurately reflected California's diverse population, we used Survey Sampling International's (SSI) Dynamix™ online panel.²⁷

We used two strategies to reduce the biases associated with an opt-in panel: 1) We carefully controlled the panel members invited to complete the survey by using quotas to best resemble the make-up of the California's general household population on age, household income, homeownership, and education level; 2) we weighted respondents in the completed sample so it matches the general household population on the same set of demographic variables used to define the quotas to compensate for the effects of survey nonresponse. For these strategies, we referenced the most recent (2014 data release) U.S. Census Bureau's American Community Survey (ACS) data. To accommodate the California's diverse population, we also offered English and Spanish language options during the survey invitation.

Additionally, we thoroughly cleaned the data by removing cases of respondents that entered invalid survey responses and/or completed the survey in less than the minimum threshold deemed reasonable for thoughtfully completing the survey. As a result, we dropped about 15% of the originally completed respondents. After removing questionable survey responses, the average length of interview was 12.20 minutes and the total incidence rate was 82%.

After applying weights, the overall sample size of this study was 1,570, which we derived from a 95%+/-10% confidence and precision target within each of the California IOUs. The confidence and precision of the overall sample is 95%+/-3%. Table 2-3 shows the distribution of demographics based on the 2014 Census compared the survey sample with weights applied. By using quotas during fielding, we were able to minimize weights applied, with the maximum weight equaling 1.65.

²⁷ With its proprietary Dynamix™ methodology, SSI enhances sample representativeness by drawing from a broad range of online sources and then controlling for variations in respondent characteristics that are associated with those sources. SSI has invested significantly in developing its sample blending approach and has been using it successfully for several years.

Table 2-3: Sampling Strategy

	2014 Census Total Percent	Total with Applied Weights (n=1,570)
Home Ownership		
Owner occupied	55%	57%
Renter occupied	45%	43%
Age		
Less than 44 years old	37%	37%
45 - 64 years old	40%	41%
65 years or older	23%	22%
Annual Income		
Less than \$50,000	42%	45%
\$50,000 to less than \$100,000	29%	28%
\$100,000 or more	30%	27%
Education Level Attained		
High school or less	33%	32%
Some college or associate	32%	32%
Bachelor's degree or more	35%	36%

3. Review of Market Transformation Theory

This chapter presents a review of industry literature and regulatory guidance documents related to market barriers and their role in market transformation programs. This review provides context for Chapter 4's discussion of the specific market barriers RPP products face, and the review of how RPP's program logic addresses those barriers in Chapter 5.

This section reviews the role of market barriers in market transformation programs, the relationship between market failures and market barriers, and specific market barriers industry literature has identified. We also suggest an additional market barrier, competing priorities, that the research presented in the remainder of this report suggests plays an important role in the markets for the examined products. Finally, we review additional factors that, based on current literature, contribute to the success of a market transformation program.

3.1. Role of Market Barriers in Market Transformation

Market barriers are central to the CPUC's definition of market transformation. Per this definition, market transformation occurs when an intervention "[reduces] barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate."²⁸ Thus, it is important for market transformation programs to clearly define which market barriers they will address and how the intervention will address those barriers.

Addressing a single market barrier may not lead to an increase in uptake of the efficient product or service because other barriers, which may or may not have been apparent previously, may remain in place.²⁹ As a result, market transformation programs may need to combine multiple interventions at different points in the market to increase adoption.³⁰ Efforts to create change in a market that will be sustained without further program support are a defining characteristic of market transformation programs. However, program interventions cannot permanently overcome some market barriers. As a result, ongoing intervention in a market may be justified, even after a market transformation program has successfully addressed barriers in that market.³¹ Changes in a market that are unrelated to market transformation interventions may also affect the barriers that prevent uptake of an efficient product, potentially removing some barriers while creating other, new barriers.³²

²⁸ California Public Utilities Commission, *Decision Approving 2010 to 2012 Energy Efficiency Portfolios and Budgets*, D.09–09–047, 2009, <http://docs.cpuc.ca.gov/PUBLISHED/GRAPHICS/107829.PDF>.

²⁹ Joseph Eto, Ralph Pahl, and Jeff Schlegel, "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs" (Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, July 1996).

³⁰ "Market Transformation: A Practical Guide to Designing and Evaluating Energy Efficiency Programs" (Palo Alto, CA: EPRI, 2001).

³¹ Ralph Pahl and Ken Keating, "Building a Policy Framework to Support Energy Efficiency Market Transformation in California" (California Public Utilities Commission, Energy Division, October 13, 2014).

³² Eto, Pahl, and Schlegel, "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs."

3.2. Specific Market Failures and Market Barriers

3.2.1. Market Failures

The presence of market failures is necessary to justify the use of public or ratepayer funds to intervene in a market. Market failures are relatively high-level concepts, based on economic theory. Sebold et al. identify four types of market failures relevant to efficiency programs:

- › **Externalities:** Cases in which a product's price does not reflect all of the costs of that product, from a societal perspective. The cost of environmental damage associated with electricity production that is not captured in electric rates is one example. Individuals holding private discount rates that are higher than the societal discount rate are another example, as the societal value of the investment is greater than the value of the investment to the individual consumer.
- › **Imperfect information:** Cases in which one or more market actors do not have all of the information they need to fully assess a product's value. This is common in the case of new technologies.
- › **Public goods:** Goods for which it is highly impractical, or impossible to limit the benefits to those paying the cost, and for which the incremental cost of providing the good to an additional person is very small or zero. Support for research and development of efficient products and services can be considered a public good, since the knowledge these activities gain can have wide benefits.
- › **Imperfect competition:** Too few firms in a market, difficulty entering or exiting the market, and goods and services that cannot be easily compared can limit the amount of competition in a market.³³

3.2.2. Market Barriers and a Consumer Decision Framework

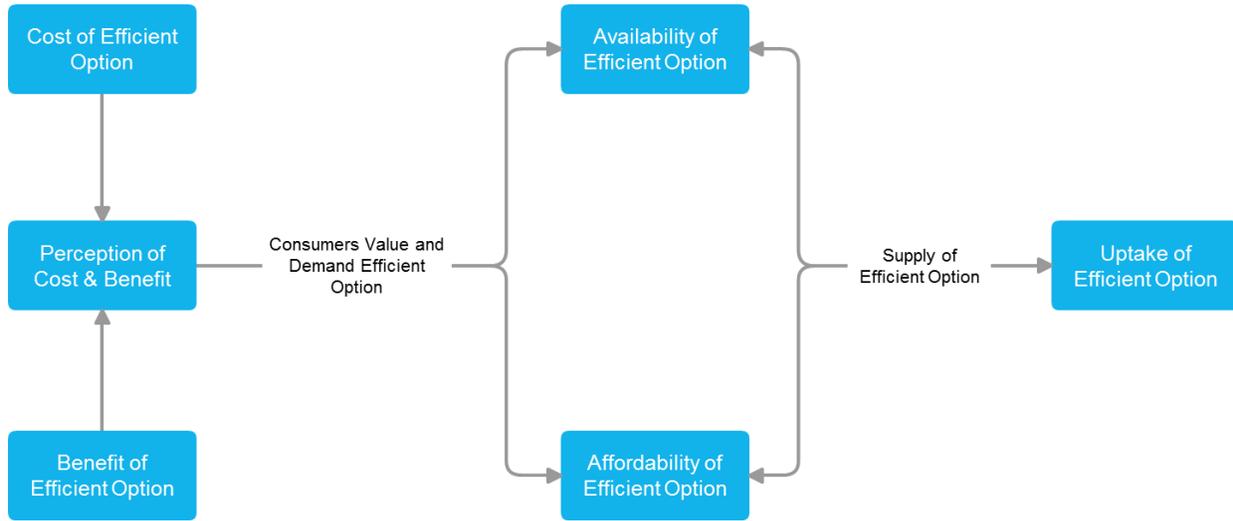
Market barriers are more specific characteristics of a market that prevent adoption of energy-efficient products or services in situations in which adoption would be cost effective. Eto, Prah, and Schlegel identify 14 market barriers that could limit the adoption of an efficient product or service.³⁴

One way to classify these market barriers is to place them within a high-level framework of consumer decision-making. This framework is based on the premise that, for uptake of an efficient product or technology to occur, there must be both demand for and supply of the efficient option. For demand to be present, consumers' perceptions of the benefits of the efficient option must exceed their perceptions of the cost of the efficient option. For supply to be present, the efficient option must be available and affordable to consumers. Figure 3-1 illustrates this framework.

³³ Frederick Sebold et al., "A Framework for Planning and Assessing Publicly Funded Energy Efficiency" (San Francisco: Pacific Gas and Electric Company, March 1, 2001).

³⁴ Eto, Prah, and Schlegel, "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs."

Figure 3-1: Framework for Consumer Decision to Purchase an Efficient Product or Service



Within this framework, market barriers are factors that inhibit one or more of the conditions necessary for either supply or demand of the efficient product to exist. Barriers can increase the cost of the efficient option, decrease the benefit of the efficient option, influence consumers’ perceptions of those costs and benefits, limit the availability of the efficient option, and/or reduce the affordability of the efficient option. Table 3-1 classifies the barriers Eto, Prahl, and Schlegel defined according to the conditions of this decision-making framework.

Table 3-1: Market Barriers Mapped to Consumer Decision Framework

Element of Consumer Decision	Related Market Barriers
Cost of Efficient Option	<ul style="list-style-type: none"> Information or search costs Asymmetric information and opportunism Hassle or transaction cost Organizational practice or custom Non-externality mispricing
Benefits of Efficient Option	<ul style="list-style-type: none"> Performance uncertainties Hidden costs Misplaced or split incentives Irreversibility Externalities
Perception of Costs and Benefits	<ul style="list-style-type: none"> Bounded rationality
Availability of Efficient Option	<ul style="list-style-type: none"> Product or service unavailability Inseparability of product features
Affordability of Efficient Option	<ul style="list-style-type: none"> Lack of access to financing

3.2.3. Competing Priorities: An Additional Barrier

Our review of RPP program theory and the barriers faced by the examined products (detailed in subsequent chapters) identified one additional condition necessary for consumer uptake of an efficient product, as well as an associated barrier. In addition to recognizing that the benefits of energy efficiency exceed the costs – thus valuing efficient options – consumers must prioritize energy efficiency over other, competing features to demand efficient models. A consumer may value energy efficiency, but opt to purchase an inefficient option that offers some other feature they value more.

An unwillingness to prioritize energy efficiency over other product features is closely related to the barrier of product unavailability. If the product is defined very narrowly, then a product unavailability barrier exists if there is not an efficient option with those features. For example, while energy-efficient refrigerators may be readily available, it may be much harder to find efficient 22-cubic-foot refrigerators with side freezers, through-the-door ice makers, and stainless steel doors.

There are important differences between this type of product unavailability barrier, which is driven by a consumer's feature preferences, and a broader product unavailability barrier that might exist for an emerging technology, which could be difficult to obtain in any configuration. While broader product unavailability applies to all consumers equally, product unavailability barriers that depend on consumer feature preferences vary based on each consumer's willingness to prioritize energy efficiency in their purchase decision. Thus, there is a demand-side element to this barrier that is not captured in the "availability of efficient option" condition of the consumer decision framework illustrated in Figure 3-1.

The extent consumers are willing to prioritize energy efficiency over other product features reflects the economic concept of opportunity cost. If selecting an energy-efficient model requires consumers to give up some other product feature, then the opportunity cost of the efficient model increases to reflect the benefit the consumer would gain from that feature if they chose an inefficient option. However, none of the barriers that we have categorized as increasing the cost of the efficient product precisely capture this dynamic. In addition, it is important for program designers to understand whether consumers perceive that the benefit of energy efficiency outweigh the costs, independent of consumers' willingness to prioritize energy efficiency over other product features. As a result, we add a consideration to the decision framework in Figure 3-1 to capture consumers' willingness to prioritize energy efficiency over other product features (Figure 3-2).

focus on an individual market actor’s decision-making, these considerations take a broader, programmatic view and include:

- › **Cost effectiveness:** The benefits of market transformation programs should exceed their costs. However, it may take time for market transformation efforts to bring about sustainable change.³⁷ Market transformation efforts may also bring about reductions in incremental costs of efficient measures over time.³⁸ As a result, it may be most appropriate to assess the cost effectiveness of market transformation programs over the long term.
- › **Market size:** In order to achieve long term cost effectiveness, the market a program hopes to transform must be large enough to provide sufficient energy savings to justify the resources and long-term commitment necessary for market transformation.³⁹
- › **Potential to leverage existing industry practices:** As one guidance document stated, “Well-designed market transformation programs are not about incentives, but rather are about strategic partnerships with market actors seeking similar goals for their own purpose.”⁴⁰ Through these partnerships, programs can leverage upstream market actors to influence end-user adoption of efficient products.⁴¹
- › **Non-energy benefits:** The presence of non-energy benefits can facilitate program efforts to increase adoption of an efficient product by increasing the value of the efficient option to consumers, and thus making them more willing to accept higher costs for the efficient product.⁴²
- › **Stage of Innovation Diffusion:** The uptake of new products follows relatively consistent patterns of adoption and market penetration over time, which can be plotted on a curve.⁴³ Accelerating the adoption of energy efficiency products and services at different stages on these curves will require different types of interventions.⁴⁴ For example, programs may need different strategies

³⁷ NMR Group, Inc., “A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts” (San Francisco: Pacific Gas and Electric Company, November 25, 2013).

³⁸ Keating, “Guidance on Designing and Implementing Energy Efficiency Market Transformation Initiatives.”

³⁹ NMR Group, Inc., “A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts”; Prah and Keating, “Building a Policy Framework to Support Energy Efficiency Market Transformation in California.”

⁴⁰ Keating, “Guidance on Designing and Implementing Energy Efficiency Market Transformation Initiatives.”

⁴¹ NMR Group, Inc., “A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts.”

⁴² Keating, “Guidance on Designing and Implementing Energy Efficiency Market Transformation Initiatives”; NMR Group, Inc., “A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts”; Prah and Keating, “Building a Policy Framework to Support Energy Efficiency Market Transformation in California.”

⁴³ Everett Rogers, *Diffusion of Innovations*, Fourth Edition (New York: The Free Press, 1995).

⁴⁴ “Market Transformation: A Practical Guide to Designing and Evaluating Energy Efficiency Programs”; Keating, “Guidance on Designing and Implementing Energy Efficiency Market Transformation Initiatives.”

to reach innovators, the very first group of adopters, and early adopters, the next group, who are more influential in encouraging wider uptake.⁴⁵

Related to cost effectiveness, some sources cite the savings per transaction as a consideration in determining whether a product is a good candidate for market transformation.⁴⁶ Market transformation may be the best approach for markets in which each transaction yields a small amount of savings, but the aggregate savings potential is large. However, this reflects the potential for resource acquisition programs to succeed in these markets more than an indicator of the markets' susceptibility to market transformation. Although products with relatively low savings per transaction are often considered to be candidates for market transformation programs, there is no reason that high savings per transaction would necessarily hinder the potential to transform a market. For example, NMR cites ENERGY STAR new homes, which offer high savings, as a successful market transformation effort.⁴⁷

⁴⁵ NMR Group, Inc., "A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts."

⁴⁶ Ibid.; PrahI and Keating, "Building a Policy Framework to Support Energy Efficiency Market Transformation in California."

⁴⁷ NMR Group, Inc., "A Review of Effective Practices for the Planning, Design, Implementation, and Evaluation of Market Transformation Efforts."

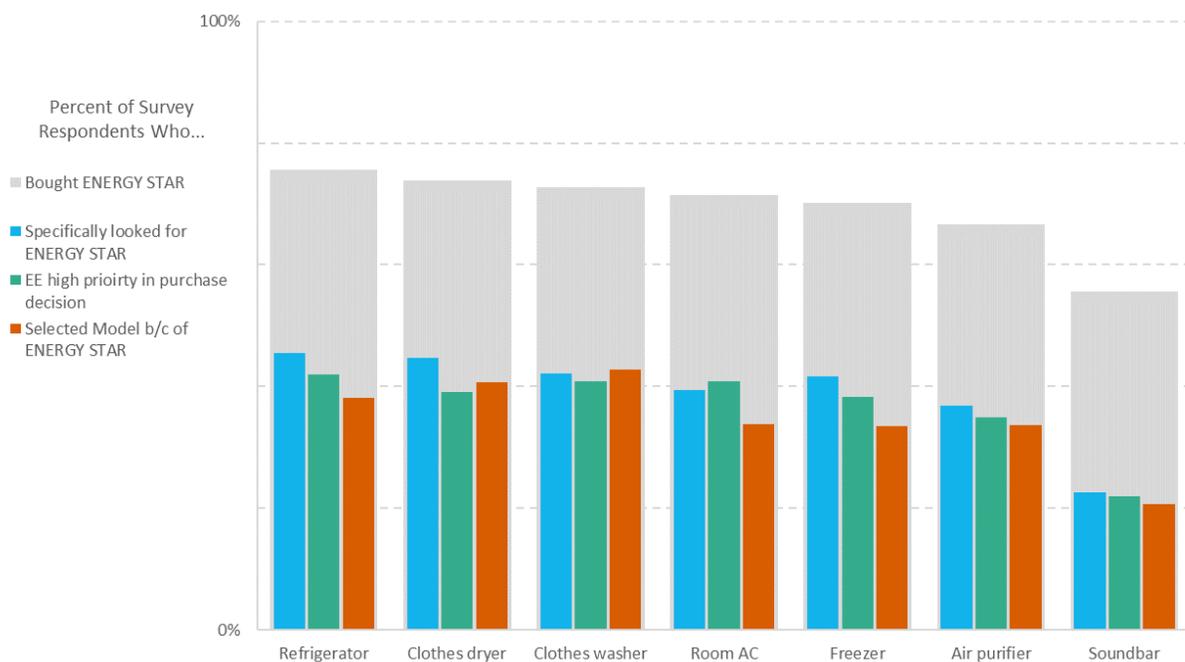
4. Barriers to Adoption: Overarching and Product-Specific

This chapter presents findings on the market barriers that prevent greater uptake of efficient models of the products for which RPP offered incentives in 2016 (i.e., clothes dryers, stand-alone freezers, room air purifiers, room air conditioners [AC], and soundbars), as well as two products under consideration for inclusion in 2017 (clothes washers and refrigerators). These findings draw on secondary research, a statewide survey of consumers, and interviews with market actors and program designers. The chapter begins with a discussion of barriers that apply across the examined products, followed by a more detailed summary of barriers that apply to each product individually.

4.1. Energy Efficiency in the Consumer Purchase Decision

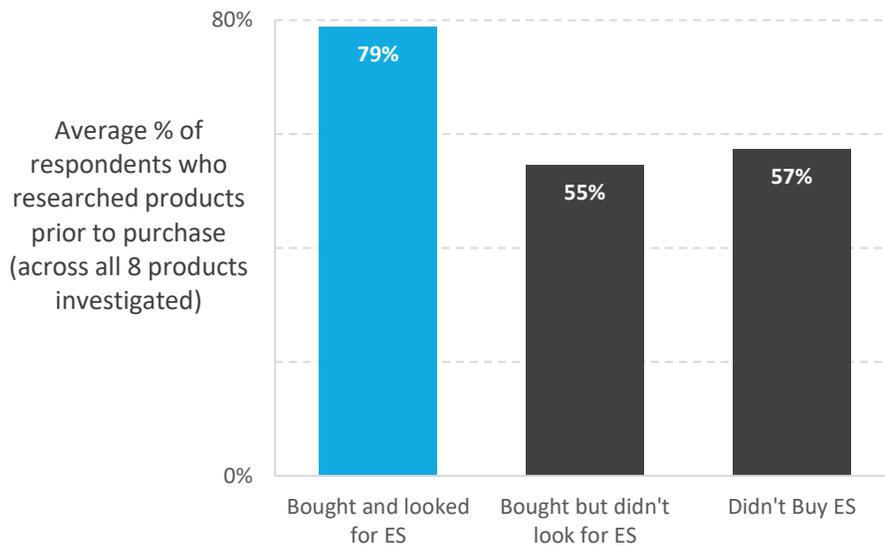
For most of the products examined, energy efficiency was an important part of most consumers' purchase decisions. With the exception of soundbars, large majorities of consumers who bought each product type reported purchasing ENERGY STAR products. Further, majorities of those who made ENERGY STAR purchases reported that they specifically sought ENERGY STAR models, prioritized efficiency in their purchase decision, and selected the model they did because it was ENERGY STAR (Figure 4-1).

Figure 4-1: Proportion of Survey Respondents Buying ENERGY STAR Products and Role of Efficiency in Purchase Decision



While many survey respondents sought out and purchased ENERGY STAR models, survey findings across products suggest that these consumers approached their purchases differently from those who did not seek an ENERGY STAR model. For all products, respondents who both sought and purchased an ENERGY STAR model were more likely to research the available types, features, and prices prior to their purchase than those who did not (see Figure 4-2). These differences were statistically significant for all products, except clothes washers and room air conditioners.

Figure 4-2: Average Percent of Respondents Who Researched Products Prior to Purchase



In addition, for all products except air purifiers and soundbars, consumers who both sought and purchased ENERGY STAR models were significantly more likely to report they selected the models they did because they received good reviews. Except for clothes washers and soundbars, this group was also significantly more likely to report they selected the model they did based on the brand. This preference for a particular brand likely reflects research or experience with the product or brand before or during the purchase process.

4.2. Overarching Barrier: Competing Priorities

These differences in the way consumers seeking ENERGY STAR products approach their purchase decisions relative to consumers not seeking ENERGY STAR products reflect a market barrier that applies across the products examined in this research: unwillingness to prioritize energy efficiency in the purchase decision. For some products, this takes the form of consumers valuing energy efficiency as a product feature, but selecting an inefficient model that offers other features they value more highly. For other products, this barrier reflects a complete failure to consider energy efficiency in the purchase decision.

As noted above, many surveyed consumers reported valuing energy efficiency. For all products except soundbars, having an ENERGY STAR label was among the three most frequently-selected reasons

participants chose a specific model, with between 36% and 45% of respondents selecting it.⁴⁸ Similar proportions reported specifically looking for ENERGY STAR models and prioritizing energy efficiency in their purchase decision. Nonetheless, for all products, a notably larger proportion of respondents reported that other, product-specific features were more important than energy efficiency in their purchase decision, suggesting that these types of features may take priority over energy efficiency in consumer decisions (Table 4-1).

Table 4-1: Importance of Product Features and ENERGY STAR Label

Product	Feature Most Frequently Selected as Important in Purchase Decision	% Reporting Feature Was Important	% Reporting ENERGY STAR Label Was Important in Selection of Model
Air purifiers	Filter included	89%	37%
Clothes dryers	Damp dry	88%	42%
Clothes washers	Large capacity	87%	45%
Soundbars	Remote control	84%	22%
Freezers	Interior lights	82%	37%
Refrigerators	Frost free*	81%	40%
Room AC	Auto shut off	78%	36%

* The most frequently selected feature in the purchase decision for refrigerators was “Energy Efficient” with 86% of respondents selecting it. We omit this response here because it is inconsistent with prior responses about the importance of energy efficiency in the purchase decision (48% give it a high priority) and the importance of ENERGY STAR in product selection (40% selected). In addition, the survey did not include energy efficiency among the product-specific features for the other examined products, and thus does not provide comparable data.

The following discussion of product-specific barriers provides additional detail on how competing priorities limit the uptake of efficient models. It is important to note that survey data, interviews, and secondary sources do not suggest that consumers actively avoid energy-efficient models. Instead, these findings suggest consumers who do not purchase efficient models do not consider energy efficiency or prioritize other features over efficiency.

4.3. Product-Specific Barriers

4.3.1. Clothes Dryers

Clothes dryers differ from other types of white goods in two key ways that have implications for the purchase of energy-efficient products. First, while ENERGY STAR specifications have applied to other white goods for nearly 20 years, the first specification for dryers took effect on January 1, 2015.⁴⁹

⁴⁸ For soundbar purchasers, ENERGY STAR qualification ranked seventh among the eight reasons listed for selecting the model a respondent purchased, with 22% of respondents selecting that reason.

⁴⁹ The first ENERGY STAR specifications for dishwashers, refrigerators and room air conditioners were announced in 1996, and the first specifications for clothes washers were announced in 1997.

Second, while most other white goods offer incremental efficiency gains from improvements to the efficiency of existing technologies, heat pump dryers offer much larger efficiency improvements by incorporating a technology that is fundamentally different from that of most existing models. Reflecting these conditions, dryers face four key market barriers, two of which apply primarily to heat pump dryers.

4.3.1.1. Competing Priorities

Market actor interviews and secondary data suggest that a variety of factors unrelated to energy affect consumers' decisions about which dryer to purchase. One retailer reported that brand, color, and capacity were all important features to consumers, along with energy efficiency. Consumers' tendency to purchase dryers as a pair with a clothes washer may also limit their consideration of and willingness to prioritize energy efficiency. According to several research studies, the majority (79%) of clothes washers and dryers are purchased as a set.⁵⁰

A real or perceived incremental cost of efficient clothes dryers may exacerbate consumers' unwillingness to prioritize energy efficiency. One retailer stated that the higher prices of efficient models is a key reason sales of efficient products are not higher. A second retailer stated that consumers may perceive efficient dryers to be more expensive, whether or not that is the case. Consumers may be less willing to prioritize energy efficiency over other features if doing so requires them to purchase a more expensive model. Information barriers that limit consumers' awareness that efficient options provide meaningful benefits over less expensive alternatives may further exacerbate this problem.

4.3.1.2. Information and Search Costs

Unlike other white goods, clothes dryers were included in the ENERGY STAR program relatively recently. As a result, consumers may not be aware that energy use differs notably among dryer models. As one interviewed program designer noted, "there is a misconception in the market that [all] dryers are efficient."

4.3.1.3. Performance Uncertainty (Heat Pump Dryers Only)

Dryers that use heat pump technologies face barriers common to emerging technologies, but distinct from other white goods, for which efficiency gains are more incremental. These barriers include performance uncertainty on the part of consumers, as well as retailers and manufacturers. In particular, one program designer noted that consumers may be uncertain about heat pump dryers because of "potential issues with how long it will take to dry [clothes] using this new technology." Drying times for dryers that rely fully on heat pump technology can be more than 30% longer than dryers using electric

⁵⁰ JD Power. 2014. Customer Satisfaction Drives Brand Loyalty That Can Translate to More Same-Brand Packages Sold. Retrieved from <http://www.jdpower.com/es/node/5246>

Research Into Action (2015). Product Trends and Manufacturer Insights for Residential Laundry, Cooking, and Refrigeration Appliances Final Report. Pacific Gas & Electric, Southern California Edison and Sempra utilities.

resistance heat.⁵¹ Due to U.S. consumers' expectations for drying times, product experts do not expect heat pump clothes dryer's penetration in the U.S. to increase substantially without market interventions.⁵²

4.3.1.4. Lack of Product Availability (Heat Pump Dryers Only)

Retailers and manufacturers are uncertain of the business performance of heat pump dryers, resulting in product unavailability. Given the potential for consumer concerns about longer drying times, retailers are hesitant to assort heat pump clothes dryers because they are uncertain whether consumer demand will justify their investment. As one program designer noted, "No big box retailers were stocking them because of low demand." A manufacturer expressed similar concerns about offering heat pump dryers in the U.S. market, saying, "We have the technology, whenever we see the market, we know we can bring it out...we don't think the infrastructure of the market is there yet."

Two program designers noted that heat pump clothes dryers continue to be mostly unavailable in the United States. In contrast to the European market, in which there were roughly 90 residential heat pump dryer models from 18 different manufacturers available in 2012, the U.S. market currently has two hybrid heat pump models.⁵³ Both models include an electric resistance heater to speed the drying process, which makes them less efficient than models that rely purely on heat pumps. These hybrid heat pump dryer models are high-end models that cost about \$1,600. This is considerably higher than the average cost of the top 25 recommended electric dryers (\$1,089) and gas dryers (\$1,185).⁵⁴ As with other efficient dryers, this incremental cost may exacerbate the information and search costs and performance uncertainty barriers that consumers face when purchasing an efficient dryer.

4.3.2. Clothes Washers

Unlike dryers, clothes washers have a long history of ENERGY STAR specifications and downstream energy efficiency rebates. As a result, there are few data to suggest that consumers are uncertain of the performance of efficient products, and surveys have found that consumers value efficiency as a product feature. Instead, findings suggest consumers' tendency to prioritize other features over energy efficiency and information and search costs as the primary end-user barriers to increased uptake of efficient products.

While performance uncertainty is not a notable barrier from a consumer perspective, retailers and manufacturers expressed uncertainty that they could continue to design increasingly efficient clothes washers without sacrificing performance. According to one, "There has been a weakening of the performance of the product" as efficiency has increased. Similarly, another manufacturer said,

⁵¹ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

⁵² Ibid.

⁵³ Topten Focus (2012). Heat pump driers: 50% energy saving potential. Retrieved on October 6, 2016 from <http://www.topten.eu/uploads/File/Topten%20Focus%20HP%20driers%20Apr%2012.pdf>

⁵⁴ Evergreen Economics. 2016. Characterization of the Super-Efficient Dryer Market. Northwest Energy Efficiency Alliance.

“Grandma’s washing machine could clean anything, but used 50 gallons of water, current machines use four gallons of water, but don’t clean clothes as well.”

4.3.2.1. Competing Priorities

The surveyed consumers who did not prioritize efficiency and did not purchase an ENERGY STAR clothes washers most often (69%) reported that they were not interested in energy efficiency. As clothes washers have become more efficient overall, the energy savings an efficient model offers over a baseline model has been reduced. This lower potential for energy cost savings may contribute to consumers’ unwillingness to prioritize efficiency over other features. After a lack of interest in energy efficiency, the next most frequently-cited reason among consumers who did not purchase an ENERGY STAR clothes washer and did not prioritize efficiency was that most models are more efficient than what they had before (64%). This is consistent with one program designer’s assessment that “people don’t care about saving \$20 or \$200 over the life of a product that is 15 years long.”

Secondary data suggest that convenience and ease of use may be among the features that consumers prioritize over energy efficiency in their clothes washer purchases. Consumer Reports found that while front-loading washing machines use less water and achieve cleaner clothes, they have longer cycle times than top-loading washers. On average, high-efficiency top-loaders took 60-90 minutes to clean an eight-pound load on normal wash, while the front-load washers took 75-100 minutes to do the same.⁵⁵ The Laundry Appliance Satisfaction Study also found that ease of use was an important factor for clothes washer and dryer purchases.⁵⁶

4.3.2.2. Information and Search Costs

While most surveyed consumers reported seeking out and purchasing ENERGY STAR clothes washers, those who did not prioritize efficiency and did not purchase an ENERGY STAR clothes washer were significantly more likely than those who purchased an ENERGY STAR model to report they did not know how to find or what to look for in energy efficient models.⁵⁷

4.3.3. Freezers

Relative to other appliances, there are few feature or configuration options to differentiate one stand-alone freezer model from another. With fewer features other than price on which to compete, retailers and manufacturers likely face greater pressure to offer models at low prices for stand-alone freezers than for other appliances. The relatively high level of concentration among stand-alone freezer manufacturers is consistent with price competition as low margins may discourage new entrants to the market and existing manufacturers depend on high volume to profit from their freezer business. As a

⁵⁵ Consumer Reports. 2014. Pros and Cons of High-Efficiency Washers. Retrieved on August 28, 2016 from <http://www.consumerreports.org/cro/news/2014/09/the-pros-and-cons-of-high-efficiency-washers/index.htm>

⁵⁶ JD Power. 2014. Customer Satisfaction Drives Brand Loyalty That Can Translate to More Same-Brand Packages Sold. Retrieved from <http://www.jdpower.com/es/node/5246>

⁵⁷ CA Consumer Survey: Percent reporting not knowing what to look for in EE models - 52% of those who did not purchase ENERGY STAR versus 37% of those who did purchase ENERGY STAR. Chi-square significant $p < 0.05$.

result of these conditions, freezers face barriers related to product availability, as well as competing consumer priorities.

4.3.3.1. Competing Priorities

The reasons surveyed consumers cited most frequently for not purchasing an efficient model included a lack of interest in energy efficiency (68% of respondents who did not prioritize efficiency in their purchase decision) and that other features took priority (61%).

4.3.3.2. Product Availability

Because of the price pressure they face, manufacturers and retailers may be reluctant to invest in efficient freezers due to uncertainty regarding consumers' willingness to pay a premium for a more efficient product, leading to a product availability barrier. Between May and October, 2016, participating retailers in PG&E territory assorted a lower proportion of ENERGY STAR freezers than any of the other products tracked in the RPP data portal. Only 23% of the freezer models that sold at least 10 units during the five-month period were ENERGY STAR-qualified (Table 4-2).

Table 4-2: Assortment of Qualified Freezers at RPP Participating Retailers, May-October 2016

Product	Unique Models Selling ≥10 Units		
	Total	ENERGY STAR	Proportion Qualified
Clothes Washers	151	109	72%
Air Cleaners	35	19	54%
Clothes Dryers	291	122	42%
Soundbars	74	25	34%
Air Conditioners	59	18	31%
Freezers	60	14	23%

Consistent with this relatively low assortment of qualified products, freezers were second only to air purifiers in the proportion of survey respondents (53% of freezer purchasers) who reported they did not purchase an efficient product because there was not a sufficient range of choices.

4.3.4. Refrigerators

Like clothes washers, refrigerators have long been a focus of energy efficiency efforts. As a result, program designers reported that there are few information or search cost barriers and little performance uncertainty for consumers in purchasing efficient models. Instead, refrigerators face market barriers related to competing priorities and inseparability of product features.

4.3.4.1. Competing Priorities

Because of their location in the kitchen, a key living area within the home, competing priorities, especially aesthetics, are a significant barrier to the uptake of efficient refrigerators than they are for other white goods. As one program designer stated, “The look and feel of the kitchen is important to customers, and it cannot be separate from the living area. Now there is more of a desire to appeal to aesthetics in addition to functionality.” A manufacturer further noted that there is no aesthetic advantage to an energy efficient refrigerator, saying, “Once the product is in the home, there is no difference between an ENERGY STAR unit and a non-ENERGY STAR unit. Everything that makes it ENERGY STAR is invisible to the consumer.”

Reflecting the importance consumers place on aesthetics over energy efficiency, some less efficient refrigerator configurations have become more popular. Side-by-side and bottom freezer configurations have been gaining market share, both of which typically consume more energy than top freezer configurations.⁵⁸ Additionally, built-in units, though a niche variety, are gaining market share.⁵⁹ These units seldom reach the highest efficiency classes due to their limited use of insulation and lack of airflow.⁶⁰

As with clothes washers, reduced savings potential as baseline refrigerator energy usage has fallen may further reduce consumers’ willingness to prioritize efficiency. One manufacturer said, “Consumers have to weigh how much extra are they paying for an ENERGY STAR appliance with how much are they saving with that. If they keep this 10 years, are they getting their money back?”

4.3.4.2. Inseparability of Product Features

One manufacturer reported that efficient options are available in top freezer configurations, which are typically the least expensive. However, for side- and bottom-freezer configurations there are fewer ENERGY STAR models available among the lower-featured, and thus lower-cost, products than there are with similarly configured higher end models. Two program designers also noted a perception among consumers that energy efficiency was only available on higher-end refrigerators. According to one, “Customers still think energy-efficient means expensive, and that is not necessarily true for refrigerators and doesn’t have to be.”

⁵⁸ DNV-GL. 2012 California Lighting and Appliance Saturation Study;
DNV-GL. 2009 Residential Appliance Saturation Study (RASS);
DOE. ENERGY STAR Certified Residential Refrigerators Qualified Products Lists, September 2016.;
DOE. 2009. “Refrigerator Market Profile” http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

⁵⁹ “Global Chest and Upright Freezer Market 2016-2020 | Technavio - Discover Market Opportunities,” accessed August 16, 2016, <http://www.technavio.com/report/global-home-kitchen-and-large-appliances-chest-and-upright-freezer-market>.

⁶⁰ Geppert, J. and Stamminger, R. 2012. “Potential for Improving Energy Efficiency of Built-in Refrigerators”. University of Bonn, Institute of Agricultural Engineering, Household, and Appliance Technology Section.

4.3.5. Room Air Conditioners

Room air conditioner sales vary from year-to-year and region-to-region, with warmer weather driving higher sales.⁶¹ This seasonality contributes to barriers related to both competing priorities and information and search costs.

4.3.5.1. Competing Priorities

As one program designer suggested, the responsiveness of room air conditioner sales to weather indicates consumers buy room air conditioners to meet an immediate need. According to this program designer, air conditioners are “seasonal, something bought in a hurry, something broke. Trying to draw attention to efficiency gets lost in the noise of needing something that does the job.” Consistent with this assessment, consumer survey respondents were less likely to select having an ENERGY STAR label as a reason they selected the room air conditioner model they purchased than purchasers of any of the other products examined, except soundbars. Respondents who purchased ENERGY STAR room air conditioners were also less likely to report they were specifically looking for an ENERGY STAR product than respondents who purchased any of the other appliances.

Consistent with the nature of room air conditioners as a product purchased to meet an immediate need, studies in New York and New Jersey found that consumers are less likely to consult information sources that provide detailed product information in their air conditioner purchases. These studies found that consumers were less likely to use sources like the internet and Consumer Reports to research room air conditioners and more likely to consult newspaper circulars, friends or family, or report that they did not do research prior to their purchase than buyers of other appliances.⁶² This limited research prior to purchase is consistent with consumers prioritizing simply obtaining a working room air conditioner over identifying an efficient model or closely considering other available features.

4.3.5.2. Information and Search Costs

Among consumer survey respondents who did not prioritize efficiency in their purchase decisions,⁶³ those who did not purchase ENERGY STAR room air conditioners were significantly more likely than those who purchased ENERGY STAR products to report that they did not notice efficiency as a product feature. Likewise, those who did not purchase ENERGY STAR room air conditioners were significantly more likely to report they did not know how to find or what to look for in efficient models.⁶⁴ Consistent

⁶¹ “Room Air Conditioners: 2007 Partner Resource Guide” (U.S. Department of Energy, 2007), https://www.energystar.gov/ia/partners/manuf_res/downloads/2007RoomAC_prg.pdf.

⁶² Apex Analytics LLC and Research Into Action, Inc., “New York Products Program: Market Characterization, Assessment, Process, and Market-Based Impact Evaluation.”; Summit Blue Consulting, Quantec, LLC, and Gabel Associates, “Energy Efficiency Market Assessment of New Jersey Clean Energy Programs: Book II - Residential Programs” (Newark, NJ: New Jersey Board of Public Utilities, July 20, 2006), <http://www.njcleanenergy.com/files/file/NJ%20Mkt%20Assess%20Book%20II%20072006%20FINAL.pdf>.

⁶³ The consumer survey asked respondents who reported they did not prioritize efficiency in their purchase decision, some of whom nonetheless purchased ENERGY STAR products, why they had not sought an efficient product.

⁶⁴ With 70% of non-ENERGY STAR purchasers noting they did not know how to find or what to look for in EE models compared to 52% of ENERGY STAR purchasers. Chi-square comparison significant at $p < .05$.

with these findings, a study in New Jersey found that retailers had lower awareness of ENERGY STAR room air conditioners than other ENERGY STAR products, although most nonetheless reported they were “very familiar” (52%) or “somewhat familiar” (33%) with ENERGY STAR air conditioners.⁶⁵ The study suggests that this lower familiarity may be a result of air conditioners’ status as a seasonal product, with fewer retail sales staff dedicated to the category than is the case for other types of appliances.

4.3.6. Room Air Purifiers

Room air purifiers are unique among the products examined in this research in that health concerns are an important motivating factor for consumers. Market researchers have found that consumers most often purchase room air cleaners to reduce allergens.⁶⁶ This focus on the health benefits of air cleaners makes competing priorities an important barrier preventing wider adoption of efficient models. As one program designer said, “When we have health and safety issues, we jump to what is most effective; energy efficiency is not a driving factor there.” Consistent with this assessment, consumer research conducted by an industry organization found that consumers cited ease of use, cost, rated room cleaning size, and clean air delivery rate (CADR) as important considerations in their air purifier purchase more frequently than energy efficiency.⁶⁷ This study’s consumer survey further supports these findings. Price and good product reviews were the most common reasons respondents reported for selecting the air purifier model they chose, with both cited more frequently than ENERGY STAR qualification.

4.3.7. Soundbars

Based on survey findings, consumers’ decisions around soundbar purchases differ from their decisions around the other products examined, with priorities other than energy efficiency playing a particularly important role.

4.3.7.1. Competing Priorities

One leading manufacturer stated that, in choosing a soundbar, “[Consumers are looking for the] best quality. And I will tell you, energy is definitely not an answer. It’s not in there.” Consumer survey findings are consistent with this assessment. ENERGY STAR qualification was the second or third most frequently selected reason why survey respondents chose the specific model they purchased for all the products discussed above (price was the most frequently selected reason for all products). In contrast, ENERGY STAR qualification was the seventh most frequently selected reason, of eight reasons given, for soundbars. Respondents were also least likely to rate that energy efficiency was a high priority in their soundbar purchase decision and to state that they specifically looked for an ENERGY STAR soundbar.

⁶⁵ Summit Blue Consulting, Quantec, LLC, and Gabel Associates, “Energy Efficiency Market Assessment of New Jersey Clean Energy Programs: Book II - Residential Programs” (Newark, NJ: New Jersey Board of Public Utilities, July 20, 2006), <http://www.njcleanenergy.com/files/file/NJ%20Mkt%20Assess%20Book%20II%20072006%20FINAL.pdf>.

⁶⁶ Cheri Wright, “Big Savings Opportunities in Small Market Appliances: The Air Purification Market” (ENERGY STAR Products Partner Meeting, St. Paul, MN, October 24, 2012), <https://www.energystar.gov/ia/partners/downloads/Kaz-Wright.pdf?5442-a1e8>.

⁶⁷ AHAM, “Air Cleaners: Big Savings Opportunities in Small Market Appliances.” <https://www.energystar.gov/ia/partners/downloads/AHAM-Messner.pdf?38cf-3ac1>

Respondents who did not prioritize energy efficiency most often reported that they were not interested in efficiency (72%), that other features took priority (70%), and that retail staff did not promote efficiency (67%).

4.3.7.2. Information and Search Costs

Manufacturers and retailers have done little to promote energy efficiency in soundbars. One manufacturer noted that the materials they used on soundbars made it difficult to display an ENERGY STAR logo on the product. One of the two leading soundbar manufacturers displays the ENERGY STAR logo approximately half way down the product detail page on their website, five screen lengths from the top of the page. The other does not indicate the ENERGY STAR status of qualified soundbars on the product detail page. In addition, relatively few manufacturers offer ENERGY STAR soundbars. In early October 2016, ESRPP retailers together offered soundbar models from 37 brands on their websites. Only six of those brands offer ENERGY STAR soundbars. Survey findings suggest retailers also do not focus on soundbar efficiency in their promotional efforts. That retail staff did not recommend efficiency was the third most frequently cited reason consumer survey respondents reported they did not prioritize efficiency in their soundbar purchases, after a general lack of interest in efficiency and prioritizing other features.

In addition to this general lack of promotion, it is not clear whether the ENERGY STAR label effectively differentiates efficient soundbars from inefficient models. Soundbars are not subject to federal minimum efficiency standards; thus, relatively little data are available about the energy consumption of non-qualified models. In addition, as a relatively new product, few energy usage studies have included soundbars as a distinct device type. For example, one widely-cited report uses the energy consumption of mini shelf stereo systems as a proxy for soundbars.⁶⁸

Given this lack of more comprehensive assessment of soundbar energy use, analysis of the ENERGY STAR qualified products list and the California Energy Commission (CEC) Appliance Efficiency Database raises questions about the effectiveness of ENERGY STAR as a differentiator. While the ENERGY STAR specification defines three metrics that could apply to soundbar energy use, for 90% of the soundbars on the qualified products list, only the sleep mode requirement applies.⁶⁹ Further, a large majority of ENERGY STAR soundbar models (85%) exceed the sleep mode energy usage requirements by at least 50%.

With so many ENERGY STAR models exceeding the specification by such a large margin, one might expect market penetration of ENERGY STAR soundbars to be higher than the 44% of soundbar sales that RPP participating retailers reported in PG&E territory between March and September 2016. An analysis of CEC Appliance Efficiency data suggests that manufacturers may not submit some models that meet the specification for ENERGY STAR qualification. Matching to both the ENERGY STAR Qualified Products List and the CEC database, we obtained sleep mode energy consumption estimates for 62 of the 146 soundbar models RPP retailers sold in PG&E territory between March and August 2016, accounting for

⁶⁸ Fraunhofer USA Center for Sustainable Energy Systems, “Energy Consumption of Consumer Electronics in U.S. Homes in 2013” (Consumer Electronics Association, June 2014).

⁶⁹ Idle mode energy usage requirements apply only to soundbars with default auto-power down (APD) settings of more than 30 minutes or soundbars on which the APD settings can be disabled or increased beyond 30 minutes. Amplifier efficiency requirements apply only to soundbars for which the amplifier input power at 1/8 of the amplifier’s maximum undistorted power output is 20 W or more.

57% of all soundbar sales during that period. There was no meaningful difference between the sales-weighted average sleep mode energy usage of the ENERGY STAR soundbars and the non-ENERGY STAR models (Table 4-3).

Table 4-3: Sleep Mode Energy Usage of ENERGY STAR and Matched Non-ENERGY STAR Soundbars

ENERGY STAR Status	Count of Matched Models	Total Sales of Matched Models (Mar.-Aug. 2016)	Sales-Weighted Avg. Sleep Mode Usage (W)
ENERGY STAR	34	8,429	0.40
Non-ENERGY STAR	28	2,412	0.37

It is possible that the models we matched to the CEC database are not representative of non-ENERGY STAR soundbars overall. In addition, the CEC database does not provide data on soundbar energy consumption in states other than sleep mode and whether the products meet the conditions that trigger ENERGY STAR specifications in those usage modes. As noted above, other sources of data on the energy consumption of non-qualified soundbars, against which we could assess the validity of the estimates in Table 4-3 are not available. Nonetheless, these findings suggest that some manufacturers are likely not submitting models that meet the specification for ENERGY STAR qualification.

5. Assess if Midstream Incentives Effectively Help Overcome Identified Barriers

This chapter reviews the extent to which RPP’s program logic addresses the barriers that prevent greater uptake of efficient product models in this study. The RPP program logic described in this chapter reflects PG&E’s RPP Program Theory and Logic Model (PTLM), as well as findings from in-depth interviews with six individuals involved in the design of the RPP program (program designers). In addition to RPP staff, the interviewed program designers represented Navitas, the U.S. EPA, NEEA, and contractors advising PG&E on RPP. According to RPP program designers and program logic, midstream incentives will help mitigate all of the barriers discussed in the previous chapter with the exception of performance uncertainty.⁷⁰

This chapter begins with a discussion of how RPP influences the market, followed by a more detailed review of how that influence addresses the specific barriers the products included in the portfolio face. We also note one market barrier that RPP does not appear to fully address.

5.1. Mechanisms of RPP’s Influence on the Market

The RPP midstream incentives aim to motivate participating retailers to take action, and it is the retailers’ actions that directly address barriers to consumer uptake of efficient products. According to PG&E’s RPP PTLM, “Good faith implementation of the marketing plan [detailing the actions retailers will take to increase sales of efficient products] reflects *retailer* willingness to overcome key market barriers” [emphasis added].

RPP’s incentives effectively increase the profit margin retailers can earn from sales of efficient products. As retailers seek to maximize their profits, program designers anticipate they will take steps to increase sales of products that qualify for RPP incentives. The steps program designers anticipate retailers will take include altering their assortment, merchandising, and promotion practices to favor efficient products over inefficient alternatives. According to one program designer, “Retailers have a limited set of strategies – stocking, assortment, pricing product placement – those are the levers they have available to them to move product, and they know how to do that.”

RPP program logic further anticipates that, as RPP incentives motivate retailers to assort and sell more energy-efficient models, manufacturers will recognize an increased demand for efficient products and offer efficient options more broadly across their product lines. As one program designer said, “This is providing a signal much closer to where it needs to go in the market in terms of making more energy-efficient products available. Manufacturers get their signals from what retailers are selling and ordering.”

⁷⁰ It is important to note that this assessment is based on RPP’s program logic, as expressed in the PTLM and interviews. This research does not include an evaluation of the extent to which RPP is achieving the outcomes its PTLM anticipates.

Finally, program designers anticipate that, as RPP accelerates adoption of efficient products and the program generates data on the market for those products, PG&E and other administrators with RPP programs will advocate for more stringent ENERGY STAR specifications and appliance efficiency standards. These accelerated and more stringent standards will further drive energy efficiency in the targeted product categories.

5.2. RPP’s Role in Overcoming Specific Market Barriers

PG&E’s PTLM for RPP and interviews with program designers described ways for RPP to address each of the market barriers identified in the previous chapters, with the exception of performance uncertainty, discussed further below. Table 5-1 summarizes the actions program designers anticipate RPP incentives will motivate retailers to take to address each barrier and how those actions will mitigate the barrier. A more detailed discussion of how RPP addresses each barrier follows the table.

Table 5-1: RPP Mechanisms and Outcomes for Addressing Identified Market Barriers

Barrier:	Products Affected	RPP Outcome:	Mechanism for Addressing Barrier:
Competing Priorities	All	<ul style="list-style-type: none"> • Retailers increase assortment of EE models • Manufacturers design more models to be EE 	<ul style="list-style-type: none"> • With efficient models making up a larger proportion of the available models, even consumers not prioritizing efficiency are more likely to select an efficient model. • As the range of efficient models increases, fewer consumers will need to choose between an efficient model and one with other desirable features.
Information and Search Costs	<ul style="list-style-type: none"> • Clothes dryers • Clothes washers • Room Air Conditioners • Soundbars 	<ul style="list-style-type: none"> • Retailers increase assortment of EE models • Retailers increase promotion of EE models • Program sponsors conduct in-store marketing activities 	<ul style="list-style-type: none"> • Efficient models become easier to find and identify for consumers seeking them. • Given more efficient choices and fewer inefficient ones, consumers not aware of efficiency are more likely to select an efficient model. • Promotional efforts increase awareness of energy efficiency.
Product Availability	<ul style="list-style-type: none"> • Clothes dryers (heat pump only) • Freezers 	<ul style="list-style-type: none"> • Retailers increase assortment of EE models • Manufacturers design more models to be EE 	<ul style="list-style-type: none"> • Availability increases as retailers replace inefficient models in their product assortments with efficient options. • Manufacturers respond to retailer demand by further increasing availability of efficient products
Inseparability of Product Features	<ul style="list-style-type: none"> • Refrigerators 	<ul style="list-style-type: none"> • Manufacturers design more models to be EE 	<ul style="list-style-type: none"> • With a wider range of efficient models available, efficient options will be less concentrated among high-featured products

5.2.1. Competing Priorities

Program designers expect RPP's midstream incentives to address the barrier of competing priorities by motivating retailers to assort a larger proportion of efficient models. With a greater proportion of efficient products in a retailer's assortment, program designers anticipate that consumers not interested in energy efficiency are more likely to nonetheless select an efficient model based on the features they prioritize. As one program designer stated, "RPP is basically designed to take the load off of consumers in making choices when it comes to energy efficiency."

As RPP incentives motivate retailers to assort and sell more energy-efficient models, program logic anticipates that manufacturers will recognize an increased demand for efficient products and offer efficient options more broadly across their product lines. This would further address the barrier of consumers' competing priorities as availability of efficient products with a wider range of feature sets would make it less likely that consumers would be required to choose between an efficient product and one that has the features they want. According to one program designer, "The goal of the program is to give the consumer more choice, more options across more price points, to give them the opportunity to purchase more energy-efficient products."

5.2.2. Information and Search Costs

In addition to addressing competing priorities, RPP's program logic anticipates that by motivating retailers to change their assortments, the program's midstream incentives can address information and search cost barriers. Multiple program designers reported that increasing the proportion of products in a retailer's assortment that are energy-efficient would reduce consumers' need to search for efficient models, essentially making efficiency the default choice. With a greater number of efficient models available, there would be a greater likelihood that even a consumer who is unaware of energy efficiency would select an efficient product. One program designer explained, "It is really [consumers not] being aware that there is a difference in efficiency and performance of products...RPP addresses that by eliminating inefficient options for consumers to purchase, thereby increasing the adoption of the efficient ones."

In addition to altering their assortment decisions, RPP's PTLM anticipates that retailers will increase their promotion of efficient products in order to increase sales of those products and thus earn more incentives. As part of this effort, retailers may also inform store-level sales associates about the benefits of energy-efficient products, allowing them to better inform consumers. PG&E's agreements with the retailers participating in RPP also allow it to conduct in-store marketing activities directly, like placing point-of-purchase materials and informing sales associates about energy efficiency. These activities make it easier for consumers to identify efficient products, further reducing information and search costs.

Finally, program designers anticipate that, as RPP accelerates adoption of efficient products and the program generates data on market demand, PG&E and other RPP administrators will advocate for more stringent ENERGY STAR specifications and appliance efficiency standards. This advocacy will help reduce information and search costs by ensuring efficient products are differentiated from less efficient ones.

5.2.3. Product Availability

As described above, increasing the availability of efficient products is a key outcome program designers anticipate will follow from RPP's midstream incentives, and program designers expect this increased availability to alleviate multiple barriers. As one program designer stated, RPP seeks to "crowd out the inefficient stuff on the shelf." According to RPP's program theory, midstream incentives will increase the availability of efficient models as retailers select efficient models, rather than inefficient options, to include in their product assortments. Program theory further anticipates that availability will increase as manufacturers respond to increased retailer demand for efficient models by incorporating energy efficiency into models across their product lines.

5.2.4. Inseparability of Product Features

In a sense, the barrier of inseparability of product features is the converse of the competing priorities: rather than being unable to find an efficient model with the features they seek, with inseparability of product features consumers are unable to find an efficient model *without* features they *do not* seek. Reflecting this relationship, program designers expect RPP to address inseparability of product features through the same mechanism that it uses to address competing priorities. Program designers reported that RPP incentives are designed to motivate retailers to assort and, in turn, motivate manufacturers to design efficient products across a wider range of feature sets.

5.3. Performance Uncertainty: A Barrier RPP Does Not Address

PG&E's RPP PTLM and the interviewed program designers did not address one end-user barrier identified as relevant to the products examined in this research: performance uncertainty, which applied only to heat pump dryers. Our assessment of program logic suggests that RPP's ability to address performance uncertainty as a market barrier is limited. Influencing efficiency standards and specifications to incorporate performance standards provides RPP with one mechanism to improve product performance and thus address barriers. In addition, motivating retailers to increase promotion of efficient products and PG&E-led, in-store activities may well address performance uncertainties to the extent that the message of those promotional activities reassures end-users as to the performance of efficient products.

RPP's potential to motivate retailers to increase assortment of efficient products, RPP's most significant lever, would likely do little to address a performance uncertainty barrier, however. Consumers that actively avoid purchasing efficient models due to concerns over their performance would seek out inefficient options, even if these made up only a small proportion of a retailer's assortment. Consumers actively seeking inefficient models would also reduce RPP's ability to influence retailers more generally, by reducing the potential for midstream incentives to increase their profits. If efficient models sell in lower volume than inefficient alternatives, favoring those models in their assortment, merchandising, and promotion could reduce a retailer's overall profit despite program incentives.

6. Assess If Broader Product Classifications Can Simplify Barrier Analysis

RPP is designed to easily allow new products to be added to the portfolio. Before investing in incentives on a new product, however, it is important for PG&E and other program sponsors to determine whether the type of midstream incentives RPP offers would be an effective intervention in that product's market. If broader product classifications with a common set of barriers can be identified, it would reduce the need for product-specific research.

In this chapter, we analyze whether such schemes can accurately predict product barriers and simplify barrier analysis. We find that products within existing classifications, like white goods, share some important characteristics that influence the barriers they do and do not face. However, collapsing products under these broad categories, reduces our understanding of product-specific market barriers significantly. Instead, we found that classifying products under key characteristics is likely to be a better predictor of product barriers.

6.1. Product Characteristics Influencing Market Barriers

While products within existing classifications like “white goods” share certain market barriers, the array is not universal, and may not apply in the same way for all products. These differences in barriers reflect certain key product characteristics, each of which impacts the likelihood that specific barriers will apply to a given product. Our research into the barriers influencing the examined products identified five characteristics that determine the barriers each product faces:

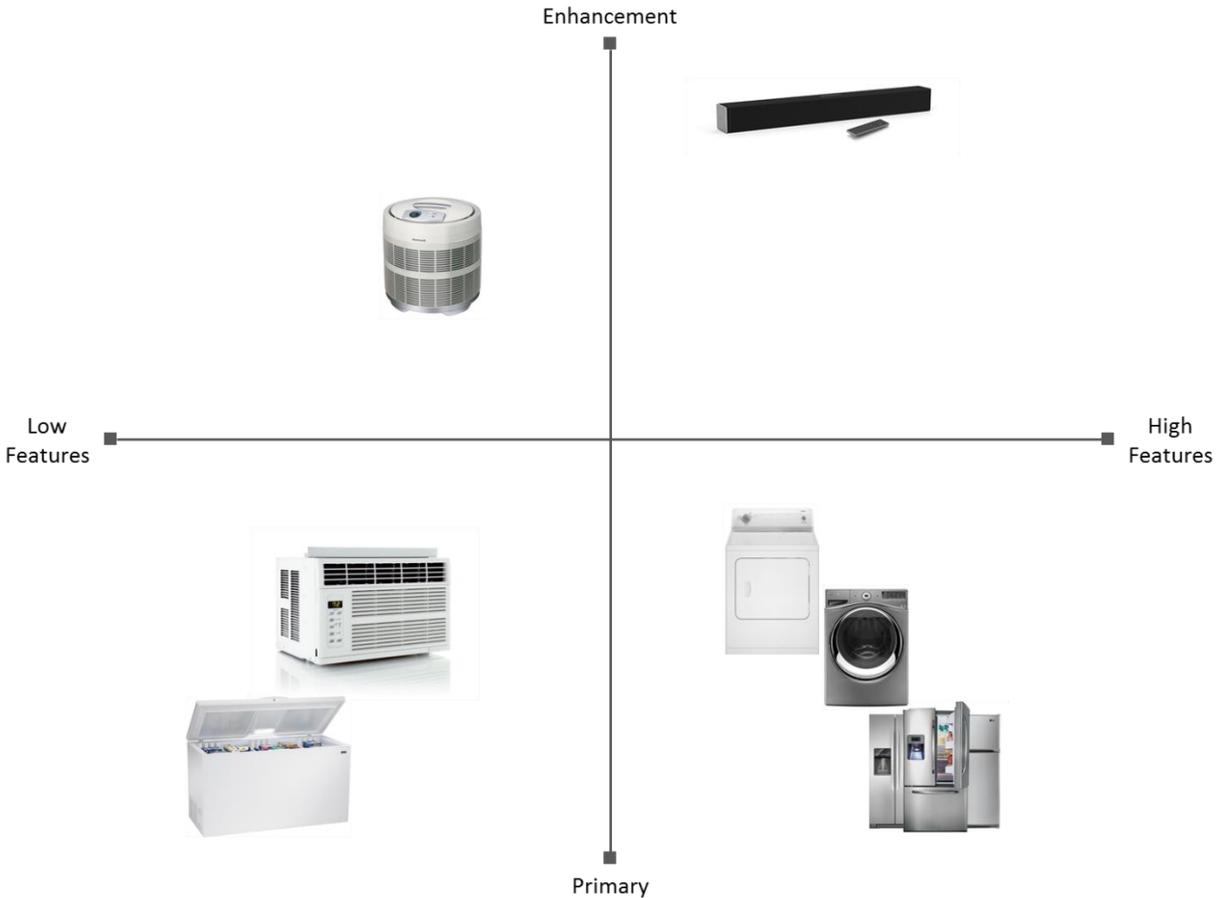
- › **The extent to which the product serves a primary function or enhances an environment:** A product that provides a primary household function is one without which a consumer would be unable to perform some basic task. For example, without a refrigerator, a consumer would not be able to keep food cold. In purchasing these products, most consumers likely assume they will provide adequate performance. In contrast, maximizing performance is a top priority in the purchase decision for products that are designed to enhance an environment, like soundbars. Because consumers can achieve the basic tasks of accessing TV audio without these devices, the devices' performance in enhancing those tasks is of primary importance in the purchase decision. As a result, competing priorities, and potentially performance uncertainty, are likely to be particularly important barriers for products that enhance an environment.
- › **Availability of added features to differentiate the product:** A wider range of product features gives manufacturers greater opportunity to differentiate their products and compete on features rather than just price. With less to distinguish them from their competitors, products with few features beyond their basic functionality are likely to face greater price pressure. As a result, risk averse manufacturers and retailers may be reluctant to invest in designing and assorting more efficient models due to uncertainty that those models would generate sufficient

sales to justify the investment. This can lead to product availability barriers from the end-user's perspective.

- › **History of efficiency specification and program activity:** As the discussion of white goods in the previous section suggests, a history of efficiency specifications and program activity is likely to build consumer awareness of a product's energy use and consideration of efficiency as a product feature. Products without this history are more likely to face information and search cost barriers.
- › **Prominence in the home:** As the findings on refrigerator market barriers suggest, aesthetics are likely to be a particularly important consideration in the purchase of products that will be prominent features of key living areas within the home. As a result, competing priorities may be a more significant barrier for these products.
- › **Familiarity of efficient technology:** Some products, achieve efficiency gains through incremental improvements to existing technologies. Other products, like heat pump dryers, achieve efficiency gains by incorporating a technology that is fundamentally different from that of the baseline product. These products are more likely to face information barriers and performance uncertainty barriers as both retailers and consumers are unfamiliar with, and uncertain of, the new technology.
- › **Level of engagement with purchase:** Consumers are more engaged in some purchase decisions than others, conducting research into the available products prior to the purchase and interacting with retail sales staff when shopping. This research and interaction provides an opportunity for consumers to learn about the benefits of energy efficiency, and products with a higher level of consumer engagement in the purchase may be less likely to face information and search cost barriers.

The combination of these characteristics determines which barriers are relevant for a given product. Because none of the products examined share all five characteristics, the set of barriers each product faces is unique. To illustrate this concept, we mapped the products against two of the characteristics we deemed particularly important: the number of distinct product features and whether it serves a primary or enhanced function (Figure 6-1). While this type of two-characteristic analysis helps to identify some relationships between products, a consideration of all five characteristics is important to fully understand the barriers likely to influence a particular product category.

Figure 6-1: Positioning of Products Based on Availability of Features and Type of Functionality



6.2. Existing Product Classifications: White Goods

White goods are the only product classification for which this research allows an analysis of common market barriers, with four products falling within the classification of white goods: clothes washers, clothes dryers, refrigerators, and stand-alone freezers.⁷¹ In Figure 6-1 above, all of the white goods, with the exception of stand-alone freezers, are grouped together, indicating that these products share some important characteristics. However, as described in the previous chapter and summarized in Table 6-1, there are important differences in the barriers that apply to each product.

⁷¹ Soundbars, falls within the classification of consumer electronics but with only one product in this category, we cannot analyze the efficacy of using this broader umbrella. The remaining products, room air purifiers and air conditioners, do not easily fit into either the white goods or consumer electronics classifications. Program designers suggested that they are sufficiently distinct from each other that grouping them into a classification would not be meaningful.

Table 6-1: Comparison of White Good Product Barriers

White Good Products	Competing Priorities	Information/Search Costs	Performance Uncertainty	Product Unavailability	Inseparability of Product Features
Clothes Dryers	X	X	Heat Pump Only	Heat Pump Only	
Clothes Washers	X	X			
Refrigerators	X				X
Stand Alone Freezer	X			X	

We classify all the white goods as providing primary functionality and all but freezers providing a relatively wide range of features. This difference is important in determining the barriers freezers face, however. The narrower range of features offered in freezers relative to refrigerators and laundry appliances likely increases the downward price pressure they face, leading to a product unavailability barrier as manufacturers and retailers are reluctant to invest in greater efficiency.

As products that serve a primary function, consumers’ tendency to prioritize functionality over other features, including efficiency, is likely to be less pronounced for white goods than for air purifiers or soundbars, which both enhance an environment. Nonetheless, the white good products all face competing priority barriers due to other product characteristics. For example, refrigerators are a prominent appliance in the home, and thus aesthetics are likely to take precedence in the purchase decision.

With dryers as a notable exception, white goods have also been a focus of energy efficiency programs for decades. As a result, consumer awareness of these products’ energy usage is higher than for other types of products, and consumers are more likely to consider energy efficiency in their product selection.⁷² One program designer said that utility sponsored efficiency programs have “increased demand of efficient products by increasing knowledge and providing incentives to end users.” Program designers and market actors, including retailers and manufacturers, suggested that the history of these programs results in consumers becoming more accustomed to thinking about energy efficiency in their white good purchases.

As relatively large purchases, program designers reported that consumers likely conduct more research and have more interaction with retail sales staff when purchasing white goods than is typical for other types of products. This greater engagement in the purchase increases the opportunity for efficiency programs and others to reach consumers with messages about energy efficiency. In addition, a freezer merchant at one retailer noted that energy efficiency can be a greater consideration for white goods

⁷² EPA Office of Air and Radiation, Climate Protection Partnerships Division, “National Awareness of ENERGY STAR for 2015: Analysis of CEE Household Survey” (Washington DC: U.S. Environmental Protection Agency, 2016), https://www.energystar.gov/index.cfm?fuseaction=home.downloadfile&file=F84267790DF5B5F22EB9D715BC7BEC4F2E6F21C078AD0D8DB716916D20CB04C3778CC40ABE8B9DBF508BE77DAD9A753D5EAA2CFC510D5530702AC176F23ACA67F51939211384A8256F097182F6234B80CC51C3BB639D51552DAB56D4A545B4EC28CA75636445B36DBC1EBCFB00613B4901FD9F2DFC20B85E0A8A1CF8C266ED6C552155DB4A2FA9F326381FE0D89F4D1F&app_code=publications&env_name=other.

because they offer larger overall energy savings, saying “Energy efficiency plays an important role, especially in appliances, as the savings are higher in these products.”

Together, this history of energy efficiency program activity and consumer engagement in the purchase lead to most white goods being less susceptible to information and search cost and performance uncertainty barriers relative to other products. However, as the findings presented in Chapter 4 suggest, this does not apply universally across the product classification, and prioritization of factors other than energy efficiency may motivate consumers to nonetheless purchase inefficient white goods products.

7. Baseline Product Snapshots and Technological Breakthroughs

This chapter presents findings drawn from our market characterization research regarding the current status of energy efficiency within the markets for the examined products and any technological breakthroughs expected to influence energy use in the near future. These findings provide a sense for the current conditions RPP faces as it begins to intervene in these markets and the opportunity to increase efficiency in each market.

7.1. Energy Efficiency

ENERGY STAR specifications apply to all of the products RPP targets, and most are also subject to mandatory, U.S. Department of Energy efficiency standards (Table 7-1).

Table 7-1: DOE Standards Applicable to Examined Products

Product	Subject to DOE Standard	Effective Date of Most Recent Standard
Clothes Washers	Yes	3/7/2015
Clothes Dryers	Yes	1/1/2015
Freezers	Yes	9/15/2014
Refrigerators	Yes	9/15/2014
Room Air Conditioners	Yes	6/1/2014
Air Cleaners	No	
Soundbars	No	

For most of the examined products, PG&E defines the efficient models that qualify for RPP incentives as those that meet or exceed the ENERGY STAR specification.⁷³ Thus, a key goal of RPP is to increase the market share of ENERGY STAR products in the targeted product categories. Based on 2015 ENERGY STAR Unit Shipment Data (Table 7-2), baseline ENERGY STAR market penetration varies notably between the examined product categories, ranging from 15% for clothes dryers to 56% for clothes washers.

⁷³ As a result of the high market share of ENERGY STAR soundbars, models must be 15% more efficient than the ENERGY STAR specification to qualify for the basic RPP incentive. PG&E offers a higher, advanced RPP incentive for air cleaners and freezers that exceed the ENERGY STAR specification by set amounts, soundbars that further exceed the ENERGY STAR specification, and heat pump dryers.

Table 7-2: ENERGY STAR Market Share*

Product	Market Penetration
Clothes washers	56%
Room air conditioners	54%
Refrigerators	46%
Soundbars	33%
Freezers	30%
Room air purifiers	29%
Clothes dryers	15%

* Market share is based on 2015 ENERGY STAR Unit Shipment Data

Two factors influence the market share of ENERGY STAR models for each product: one, how recently the current specification took effect, and two, how long the product has been subject to ENERGY STAR specifications. The market share of ENERGY STAR models typically drops immediately after a new specification takes effect and then gradually increases as manufacturers adapt to the new specification before dropping again after the next revision.⁷⁴ The RPP program designers interviewed for this report also suggested that ENERGY STAR penetration is likely to be higher for products that have been subject to ENERGY STAR specifications longer. Table 7-3 lists the year each of the examined products first received an ENERGY STAR specification and the effective date of the current specification.

Table 7-3: ENERGY STAR Specification History of Examined Products

Product	Year of First Specification	Effective Quarter and Year of Current Specification	Years with Specification
Room air conditioners	1997	Q4 2015	20
Refrigerators	1996	Q3 2014	20
Freezers	1996	Q3 2014	20
Clothes washers	1999	Q1 2015	19
Soundbars	1996	Q2 2013	17
Room air purifiers	2004	Q3 2004	12
Clothes dryers	2015	Q1 2015	1

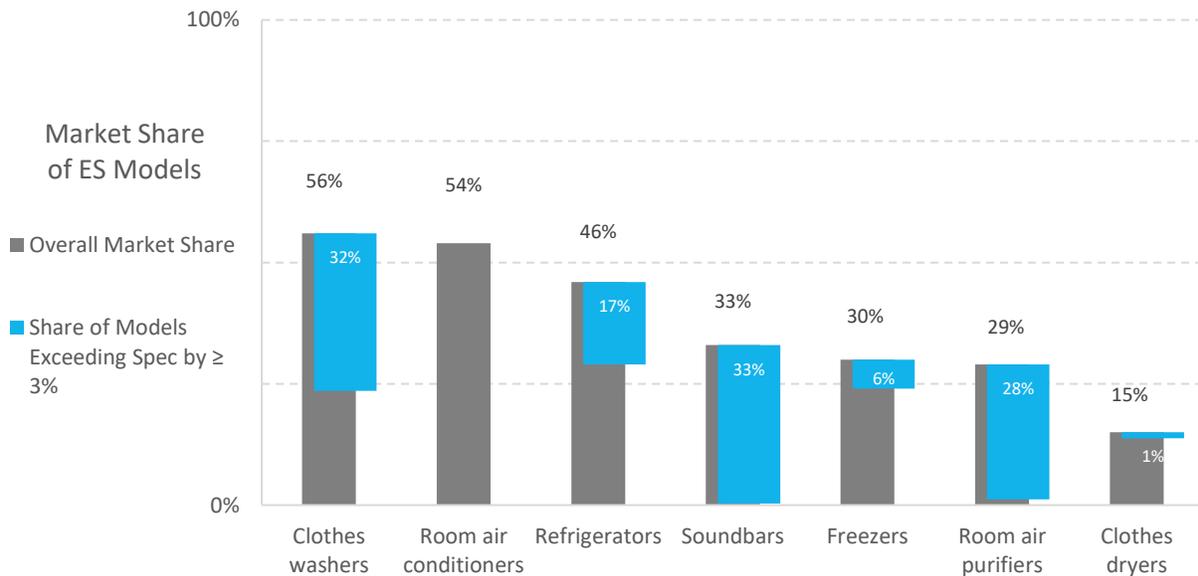
The proportion of qualified models that exceed the ENERGY STAR specification provides another relevant data point for understanding the role of energy efficiency in the market for each of the

⁷⁴ Research Into Action, Inc., "Consumer Electronics Television Initiative Market Progress Evaluation Report #2" (Portland, OR: Northwest Energy Efficiency Alliance, April 29, 2013), <http://neea.org/docs/default-source/reports/consumer-electronics-television-initiative-market-progress-evaluation-report-2.pdf?sfvrsn=10>.

examined products. For some products, very few models exceed the baseline ENERGY STAR requirement. In these cases, manufacturers are likely designing products to meet the ENERGY STAR specification specifically. In contrast, for other products, a large proportion of qualified models exceed the ENERGY STAR specification. For these products, it is likely that some benefit other than the ENERGY STAR label alone motivates manufacturers to design efficient products. For example, non-energy benefits like quieter operation or reduced stress on components due to heat loss might motivate manufacturers to design more efficient models. The combination of a high ENERGY STAR market penetration and a large proportion of qualified products exceeding the specification also indicates an opportunity to adopt a more stringent specification.

Figure 7-1 illustrates the market share of ENERGY STAR models for each of the examined products, as well as the proportion of those models that exceed the ENERGY STAR specification by at least 3%. The following sections provide additional detail on each of the examined products.

Figure 7-1: Market Share of ENERGY STAR Models and Models Exceeding Specification by 3% or More*



* We use 3% more efficient than ENERGY STAR as a cutoff to distinguish between models that marginally exceed the specification, but were nonetheless likely designed with the specification as a target, and those for which efficiency levels were likely less directly driven by the specification.

7.1.1. Clothes Dryers

Clothes dryers have the lowest ENERGY STAR market share of all the examined products because of their recent inclusion in the ENERGY STAR program. The clothes dryer specification took effect at the beginning of 2015, concurrent with a revised federal minimum efficiency standard. This was the first update to federal standards for dryers in 20 years. Consistent with the new specification and low market share, few ENERGY STAR dryers exceed the minimum specification. RPP sales data suggests that clothes dryer market share has likely increased in 2016, because 27% of the models participating retailers reported selling in PG&E territory between March and October were ENERGY STAR.

Electric dryers are more likely to qualify for ENERGY STAR and to exceed the minimum specification. A larger proportion of the electric dryers available in the market are ENERGY STAR, and all the ENERGY STAR models that exceed the specification by at least 3% are electric.⁷⁵ Heat pump dryers offer an opportunity to achieve large efficiency improvements over electric resistance dryers.⁷⁶ However, as noted above, these models face a variety of market barriers, and manufacturers do not expect them to gain significant market share without the intervention of efficiency programs.

7.1.2. Clothes Washers

Clothes washers have a long history of ENERGY STAR specifications, and have the highest market share of ENERGY STAR models among the examined products. The market share of ENERGY STAR clothes washers held relatively steady between 2010 and 2014 at approximately 65%, with 2015 market share reflecting a decrease as a new specification took effect. Most ENERGY STAR clothes washers (58%) exceed the minimum specification by at least 3%, with front-loading clothes washers more likely to do so than top-loading models. Clothes washer technology trends indicate incremental improvement to overall efficiency. Front-loading models have been increasing their market share over the past five years and industry sources expect this trend to continue.⁷⁷

7.1.3. Refrigerators

The market share of ENERGY STAR refrigerators shown in Figure 7-1 reflects a decline following a new specification taking effect late in 2014. Between 2012 and 2014, the market share of ENERGY STAR refrigerators was steady at approximately 75%. While market share fell in 2015, a market share of 46% in the first year after a specification takes effect is relatively high. To ensure the ENERGY STAR label effectively differentiates the most efficient products, EPA typically seeks to ensure the market share of qualified products does not greatly exceed 35%.⁷⁸ This high market share may reflect manufacturers' and retailers' promotion of energy efficiency as a product feature of higher-end refrigerator models.⁷⁹

Historically, federal and state efficiency standards have driven declines in refrigerator energy use, even as the average size of refrigerators has increased.⁸⁰ Looking forward, manufacturers do not expect major changes or technological innovations that will affect refrigerator efficiency before 2018. While manufacturers noted that incremental efficiency gains are possible through improvements to certain

⁷⁵ DOE Compliance Certification Database. Retrieved on October 13, 2016 from https://www.regulations.doe.gov/certification-data/CCMS-4-Clothes_Dryers_-_Residential_Appendices_D1_and_D2.html#q=Product_Group_s%3A%22Clothes%20Dryers%20-%20Residential%20Appendices%20D1%20and%20D2%22

⁷⁶ NRDC. 2014. A Call to Action for More Efficient Clothes Dryers. NRDC Issue Brief.

⁷⁷ IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

⁷⁸ U.S. Environmental Protection Agency, "ENERGY STAR Products Program Strategic Vision and Guiding Principles," accessed December 20, 2016, https://www.energystar.gov/ia/partners/prod_development/downloads/ENERGY_STAR_Strategic_Vision_and_Guiding_Principles.pdf?188d-4b0b.

⁷⁹ DOE. 2009. "Refrigerator Market Profile" http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

⁸⁰ DOE. 2009. "Refrigerator Market Profile" http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

components, they questioned whether these changes would generate sufficient energy savings to justify the increased cost.

7.1.4. Freezers

The market share of ENERGY STAR freezers was relatively stable between 2013 and 2015, even as a revised specification took effect in late 2014. The new ENERGY STAR specification coincided with the effective date of a new DOE efficiency standard for freezers, which had been finalized in 2011. The lack of a drop in ENERGY STAR market share suggests that manufacturers could adapt their product designs to meet the more stringent standards, and corresponding ENERGY STAR specification, in the three years since the revised specification was finalized. Relatively few freezer models exceed the ENERGY STAR specification by more than 3%, and most of those that do are compact models. This suggests that in designing freezers, manufacturers specifically seek the ENERGY STAR label, rather than incorporating efficient features for other reasons.

7.1.5. Room Air Purifiers

The current ENERGY STAR specification for room air purifiers has been in effect for more than ten years, considerably longer than any of the other products examined. Likely reflecting manufacturers' long experience with the specification, most of the qualified air purifiers exceed the ENERGY STAR specification. Nonetheless, the market share of ENERGY STAR room air purifiers remains relatively low. This combination of low market share and a high proportion of models exceeding the specification may reflect the diversity of technologies used in room air purifiers. For example, one interviewed manufacturer stated that it may be more difficult for air purifiers using UV light or generating large amounts of ozone to qualify for ENERGY STAR than for air purifiers using other technologies.

7.1.6. Room Air Conditioners

While the ENERGY STAR market share of room air conditioners is relatively high, very few qualified models exceed the specification by 3% or more. As with freezers, this likely indicates that manufacturers design efficient room air conditioners to achieve the benefits of the ENERGY STAR label, rather than to achieve some other, non-energy benefit. Analysis of the database of AHAM Verifide room air conditioners, which includes both ENERGY STAR and non-ENERGY STAR models, suggests that manufacturers can meet the ENERGY STAR specification across air conditioner sizes. At approximately 40%, the proportion of qualified models is relatively constant across air conditioner capacity bins. As air conditioner technologies improve and incorporate less toxic refrigerants with lower climate impacts, industry analysts anticipate that energy and environmental benefits, supported by government and non-profit awareness-raising efforts, will increase demand for new air conditioners.⁸¹

⁸¹ "North America Air Conditioning Systems Market Analysis," *Grand View Research*, May 2014, <http://www.grandviewresearch.com/industry-analysis/north-america-air-conditioning-systems-market>.

7.1.7. Soundbars

Like air purifiers, ENERGY STAR soundbars have relatively low market penetration, but almost all qualified models exceed the ENERGY STAR specification. More than 90% of soundbar models that qualify for ENERGY STAR do so based only on their energy use in sleep mode.⁸² Because soundbars are a relatively new product category and are not subject to DOE efficiency standards, little data exists on the energy usage of non-ENERGY STAR models. Nonetheless, our analysis found no meaningful difference in sleep mode energy usage between ENERGY STAR models and the limited number of non-qualified models that could be matched between RPP sales data and the California Energy Commission's (CEC) Appliance Efficiency Database.⁸³ While the matched models may not represent all non-qualified soundbars, this finding suggests that manufacturers likely opt not to submit some soundbar models that would nonetheless meet the specification for ENERGY STAR qualification. Manufacturers' limited of promotion of ENERGY STAR models is consistent with this finding.

7.2. Energy Efficiency Technology Innovations

Most of the examined products rely on relatively mature technologies, with only incremental efficiency gains expected in the near future. As noted above, heat pump dryers are an exception to this trend, although manufacturers do not expect them to gain significant market share without program intervention. In fact, two manufacturers expressed concern that existing technologies had limited capacity for additional efficiency gains without sacrificing product performance. Both manufacturers noted that the cleaning performance of clothes washers specifically had decreased as the products had become more efficient. According to one, "Looking at [maintaining a trend of a] 10% decrease [in energy usage] every year, eventually will require a loss of functionality."

One technological change that the interviewed retailers and manufacturers, as well as program designers, expected to gain market share across all the products examined was connectivity. One program designer noted, "In general, talking about all categories, there has been an interest in making everything connected. Adding that feature to a washer or dryer or room AC unit, that is changing the market a lot." While product connectivity is expected to become more prevalent, it is unclear how that will affect the energy use of the examined products. Consumer awareness and uptake of connected devices remain relatively low, and product manufacturers are still identifying which connected functions are most appealing to consumers.⁸⁴

⁸² Based on the configuration of the device, idle mode energy usage and amplifier efficiency requirements may also apply. Idle mode energy usage requirements apply only to soundbars with default auto-power down (APD) settings of 30 minutes or more, or those that can be disabled or increased beyond 30 minutes. Amplifier efficiency requirements apply only to soundbars for which the amplifier input power at 1/8 of the amplifier's maximum undistorted power output is 20 W or more.

⁸³ For a more detailed summary of this analysis, see Appendix A.

⁸⁴ Findings sourced from manufacturer interviews and PG&E presentations from the ESPPM session on connected devices.

8. Conclusions and Recommendations

Based on the findings from this research, we offer two conclusions and associated recommendations.

Conclusion: The types of midstream incentives RPP offers are an appropriate intervention strategy for the products in the 2016 portfolio and planned for 2017.

RPP is well positioned to address product unavailability barriers as its incentives motivate retailers to replace inefficient models in their product assortments with efficient options. An increase in the availability of efficient models would also address other barriers, like consumers' competing priorities and information and search costs. With more efficient models available, and fewer inefficient models, consumers would be more likely to find an efficient option with the features they prioritize most highly. In addition, consumers unaware of or indifferent to energy efficiency would be more likely to select an efficient option based on other criteria. RPP has the potential to further reduce information and search costs as retailers increase promotion of efficient models, and as PG&E conducts in-store marketing activities. These barriers – product availability, information and search costs, and competing priorities – were the ones that most prominently applied to the examined products.

RPP's design is less suited to address barriers that might motivate participants to actively choose not to purchase an efficient model, like performance uncertainty. Retailers will be reluctant to favor efficient models of these products, as doing so could reduce their overall sales. In addition, increasing the proportion of efficient models in product assortments is likely to have less impact on sales of efficient models if consumers actively seek the inefficient option. Heat pump dryers were the only product included in this research that face a performance uncertainty barrier.

Recommendation: In selecting products for inclusion in RPP, avoid those for which performance uncertainty or other barriers might lead consumers to actively avoid efficient models. RPP's midstream intervention is unlikely to be effective for these products. Instead, for these products, a combination of upstream efforts and standards to address product performance, coupled with downstream efforts to address consumers' concerns are likely to be more effective than a midstream approach.

Conclusion: Rather than relying on broad classifications, like white goods, an examination of key product characteristics more accurately predicts the barriers a given product is likely to face.

The analysis of product specific barriers in this report identified six characteristics that together determine the barriers that prevent greater sales of efficient models of a particular product and the way those barriers might influence consumer purchase decisions. Most products within broad classifications, like white goods, are likely to share many of these characteristics, but they are unlikely to be universal across all products in that classification. These variations can have important implications for which market barriers apply. As a result, it is important for program designers to look beyond the distinction between appliances and consumer electronics in determining which barriers are likely to be relevant to a particular product.

Recommendation: Consider the specific characteristics of a product to determine which barriers are likely to apply and how they might impact consumer decisions. There may be important

differences between products within the broader groupings of consumer electronics and appliances. Nonetheless, products that are similar in certain key ways, like those listed in this report, are likely to share market barriers.

Appendix A. Detailed Product Characterizations

A.1. Clothes Dryers

Clothes dryers are a major household appliance that are part of a home laundry system, which also includes clothes washers and water heaters.

A.1.1. Product Description

The different types of clothes dryers are defined by their primary fuel source, drying method, and size. There are three primary types of clothes dryers that use slightly different drying methods:



- › **Vented clothes dryers** used forced air circulation to heat air from outside the dryer and blow it into the drum. Vented models exhaust the evaporated moisture through a flexible vent and it is blown outside. Both gas and electric clothes dryers may be vented.
- › **Ventless clothes dryers** use a closed-loop system with an internal condenser to remove the evaporated moisture from the air. These dryers do not require a vent to the outside, and thus can be used in places where vent is not practical or possible. Only electric clothes dryers may be ventless.
- › **Heat pump clothes dryers** use the condenser side of the heat pump to heat the air, which is then blown through the drum to evaporate water from clothes. As humidity increases the air passes through the evaporator side of the heat pump, and moisture condenses out. The air is then recycled and heated again. Only electric clothes dryers use heat pump technology; however, heat pump technology can be applied to both vented and ventless clothes dryers.⁸⁵

Clothes dryer size is defined by the capacity, in cubic feet, of the drum. Clothes dryer capacities range from 3.4 cubic feet to 9 cubic feet.⁸⁶ Compact units are defined as those with capacities less than 4.4 cubic feet.⁸⁷ There are no compact gas clothes dryers.

Clothes dryers have two key energy-using components: a motor(s) to turn the drum and operate the fan, and a heat source (electric resistance heater, heat pump, or gas burner) to heat the air entering the drum. The motor(s) turning the drum and fan of a typical, standard-sized dryer (>4.4 cubic feet) draws

⁸⁵ Meyers, S., Franco, V., Lekov, A., Thompson, L., and A. Sturgen. 2010. Do Heat Pump Clothes Dryers Make Sense for the U.S. Market? ACEEE.

⁸⁶ CNET. 2013. Dryer Buying Guide. Retrieved on August 18, 2016 from <https://www.cnet.com/topics/dryers/buying-guide/>

⁸⁷ Energy Star. 2016. Clothes Dryer Key Product Criteria. Retrieved on August 15, 2016 from https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

200 to 300 watts. The heater draws about 5 kW of electrical power or 20,000 to 25,000 BTU/hr of gas. The components and construction of clothes dryers have changed little in the past 30 years.⁸⁸

A.1.2. Supply Chain

A.1.2.1. Manufacturing

Manufacturing of clothes dryers is consolidated, with two companies holding 84% or more market share. Whirlpool and General Electric (GE), which both have a substantial manufacturing presence in the US, make up the majority market share of clothes dryers sold in the U.S. (see Table A-1). Additional clothes dryer manufacturers include Electrolux, LG Electronics and Samsung, all of which have considerable brand recognition in the appliances market.⁸⁹ There may be eight or more other manufacturers selling in the U.S. market, although they represent a small portion of the market and may have less brand recognition.

Table A-1: U.S. Clothes Dryer Manufacturer Market Share, 2008

Manufacturer	Fuel Type	
	Electric	Gas
Whirlpool/Maytag	70%	74%
GE	16%	10%
Electrolux	8%	5%
Other	6%	11%

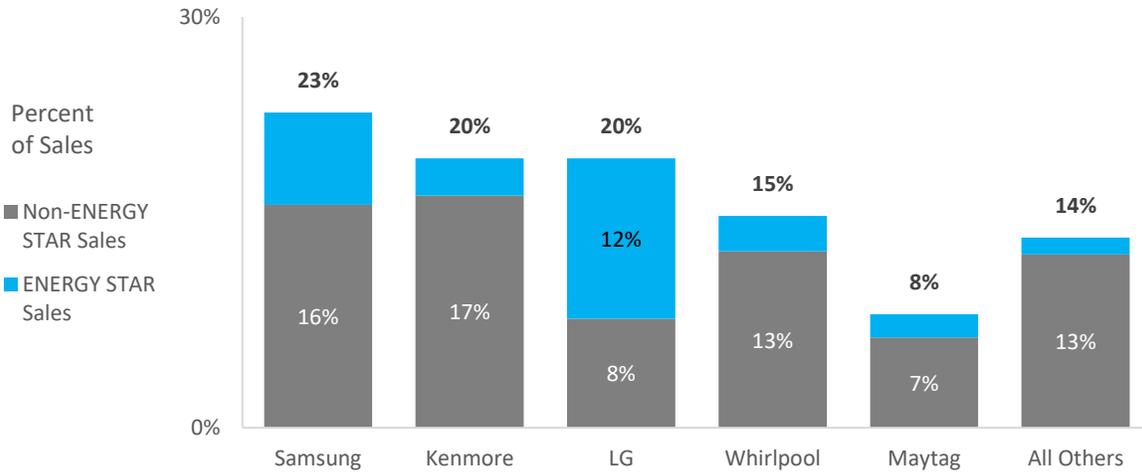
Source: DOE

In PG&E territory, five manufactures account for nearly all clothes dryer sales at participating retailers. Between March and September of 2016, over 50 thousand dryers were sold through participating retailers in PG&E service territory, consisting of 567 unique models produced by 14 manufactures. Together, Samsung, Kenmore, LG, Whirlpool, and Maytag made up about 86% of total dryer sales (Figure A-). Samsung accounted for the largest share of clothes dryer sales (23%) followed by Kenmore and LG (20% each). Additionally, LG had the largest proportion of sales of ENERGY STAR qualified models (12% of total dryer sales or 60% of sales for the brand).

⁸⁸ Ecos. 2010. Are We Missing Energy Savings in Clothes Dryers? ACEEE.

⁸⁹ IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

Figure A-1: Clothes Dryer Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 52,078)



Source: PG&E RPP Sales Data, March through September 2016.

A.1.2.2. Retailers

Retailers represent the majority of the market and all major appliance retailers in the U.S. sell clothes dryers. In 2015, more than half (56%) of US-manufactured washers and dryers were sold directly to retailers, with the rest sold to wholesalers (23%), exports (10%) and direct sales (10%). Retail stores that purchase washers and dryers include Lowe's, Sears, The Home Depot and Best Buy.⁹⁰ Retailers have grown as a proportion of revenue over the past five years as export markets have declined and the industry has relied more heavily on its domestic market. Furthermore, retailers are increasingly purchasing directly from manufacturers and bypassing wholesalers to increase profit margins.⁹¹ Most respondents to the 2016 California Consumer Survey purchased their clothes dryer at a big box retail store (53%) or local retail store (20%) (see Table A-2).

⁹⁰ Ibid.

⁹¹ Ibid.

Table A-2: Location

	Total (n = 395)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	53%
At a local retail store	20%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	18%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	5%
Other	3%
Don't know	1%
Total	100%

Home improvement stores may be overtaking appliance stores in clothes dryer sales. In the early and mid-2000’s, the clothes dryer industry changed as market share shifted from appliance stores to home improvement retailers. In 2007, Sears and appliance stores still sold most laundry equipment. However, in between 2000 and 2007, these retailers lost market share to home improvement centers such as Lowe’s and Home Depot.⁹² RPP sales data provides further evidence that home improvement stores have over taken traditional appliance stores in clothes dryer sales. Between March and September 2016, about half (53%) of program qualified clothes dryers were sold by Home Depot, compared to 26% sold by Best Buy and 20% sold by Sears.

A.1.2.3. End Users

Consumers often use the internet, salespeople, and word of mouth to make their decisions about clothes dryer purchases. Results from the 2016 California Consumer Survey found that dryer purchasers most often reported the internet (27%) salesperson (20%) and friends or family (14%) as the most influential information sources (see Table A-3).

⁹² D&R International, Ltd. 2008. Clothes Washer Product Snapshot May 2008. DOE and Energy Star.

Table A-3: Most Influential Information Source (Among Respondents that Purchased a Clothes Dryer in the Last Two Years)

	Total (n = 521)
Internet	27%
Salesperson at the store	20%
Friend or family member	14%
Consumer Report or other product-oriented magazines	10%
Advertisement	8%
Electric or gas utility	7%
Contractor	2%
Other	2%
Didn't seek information	10%
Don't know	2%
Total	100%

Many consumers think about energy efficiency when selecting a clothes dryer model. About two fifths (42%) of respondents to the 2016 California Consumer Survey that had recently purchased a clothes dryer reported that the ENERGY STAR label was one of the reasons they purchased a selected model (see Table A-4). Slightly more (44%) rated energy consumption as a “high priority” in their decision making.

Table A-4: Reasons for Purchasing Selected Model (Among Respondents that Purchased Clothes Dryer in the Last Two Years)

Reasons	Total (n = 521)
It was in my price range	50%
It had an ENERGY STAR label	42%
It had the features I wanted	41%
It had good reviews	38%
I wanted the brand	29%
It was available	28%
It costs less to operate	25%
It was recommended to me	21%
Other	2%

Steam cleaning, moisture sensing and other smart technologies are becoming more prevalent. One of the most popular recent developments in dryer technology has been the addition of steam cleaning cycles.⁹³ The benefits of steam are anti-wrinkling as well as “freshening.” Currently, the energy implications of this technology is unclear. Manufacturers also noted that consumers are interested in features that lessen the impact drying has on clothing, such as lower temperature and shorter drying time.⁹⁴ Moisture sensing is one popular energy saving feature. “These sensors detect when your clothes are dry, then tell the dryer to go ahead and shut down, preventing over-drying and also saving energy.”⁹⁵ There are many features included in ‘smart’ dryers, but there currently is not a lot of selection for those models. Smart features include usage tracking, remote controls and touch screen displays.

Longer drying times and high incremental cost may further delay heat-pump dryers in the US. There are currently two hybrid heat pump dryer models available in the U.S. market, both of which are high-end models that cost about \$1600. This is considerably higher than the average cost of the top twenty-five recommended electric dryers (\$1,089) and gas dryers (\$1,185)⁹⁶. Full heat pump technology typically has longer drying times, which may not appeal to consumers. Drying times can be more than 30% longer.⁹⁷ As a result, these hybrid heat pump models also include an electric resistance heater to speed the drying process, which makes them less efficient than true heat pump models

A.1.3. Energy Efficiency

Dryers represent substantial opportunity for energy savings. Of the three appliances that are a part of the residential laundry system, clothes dryers use the most energy (see Figure A-). Almost 80% of U.S. households have a clothes dryer⁹⁸. In PG&E and SCE service territories dryer saturation is slightly lower at 72%⁹⁹. The high penetration of the appliance and high energy use creates a great opportunity for energy savings. Additionally, with heat pump technology, the technical potential exists to reduce energy use. According to recent tests, heat pump technology has the potential to reduce energy use of residential dryers by 50-60%.¹⁰⁰

⁹³ CNET. 2013. Dryer Buying Guide. Retrieved on August 18, 2016 from <https://www.cnet.com/topics/dryers/buying-guide/>

⁹⁴ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

⁹⁵ CNET. 2013. Dryer Buying Guide. Retrieved on August 18, 2016 from <https://www.cnet.com/topics/dryers/buying-guide/>

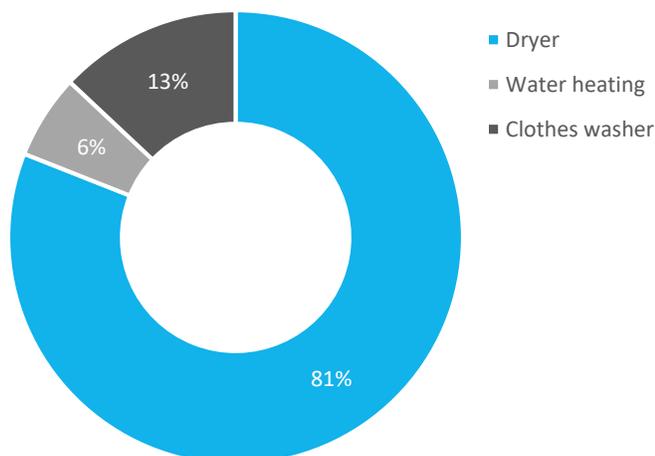
⁹⁶ Evergreen Economics. 2016. Characterization of the Super-Efficient Dryer Market. Northwest Energy Efficiency Alliance.

⁹⁷ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

⁹⁸ Ibid.

⁹⁹ DNV-GL. 2012 California Lighting and Appliance Saturation Study.

¹⁰⁰ NRDC. 2014. A Call to Action for More Efficient Clothes Dryers. NRDC Issue Brief.

Figure A-2: Energy Used for Residential Clothes Washing

Source: The Cadmus Group, Inc. 2010. *Do the Savings Come out in the Wash?* ACEEE.

A revised Federal minimum standard for clothes dryers took effect on January 1, 2015. This was the first update to Federal standards in over 20 years. For standard vented models, the new minimum standard increased efficiency requirements by about 24%. The new standard measures efficiency by the combined energy factor (CEF), which is calculated as the number of pounds of clothes dried per kWh.¹⁰¹ The higher the CEF, the more efficient the clothes dryer. While the previous metric (energy factor [EF]) only considered energy use in active mode, the CEF also incorporates energy use in standby and off mode.¹⁰²

ENERGY STAR clothes dryer market penetration is still in its early stages. ENERGY STAR began certifying clothes dryers in January of 2015, and estimate a 15% market penetration for 2015.¹⁰³ The 2016 California Consumer Survey reported that among those that have recently purchased, three-quarters (74%) were reportedly ENERGY STAR models. This large discrepancy may be due to consumer assumptions regarding the efficiency of their clothes washer being like that of their clothes dryer.

Most ENERGY STAR qualified clothes dryers do not substantially exceed the specification. Eight percent of all qualified model types exceed the minimum ENERGY STAR specification by more than 3%. None of the gas dryers exceeded the ENERGY STAR specification by more than 3%. When looking at non-qualified and qualified clothes dryer models, while the split between gas and electric standard size dryer models is relatively equally, there are more ENERGY STAR qualified electric models. According to DOE's Compliance Certification database, 20% of all models meet the current ENERGY STAR specification, with

¹⁰¹ Energy Star. 2016. Clothes Dryer Key Product Criteria. Retrieved on August 15, 2016 from https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

¹⁰² Office of Energy Efficiency and Renewable Energy, Department of Energy. 2015. Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers. DOE.

¹⁰³ Energy Star. 2015. Unit Shipment and Market Penetration Report Calendar Year 2015 Summary.

standard electric clothes dryers (25%) having a larger proportion than standard gas clothes dryers (13%).¹⁰⁴

Most ENERGY STAR clothes dryers sold in PG&E service territory are from two manufactures. Between March and September 2016, sales of ENERGY STAR qualified clothes dryers made up about one-quarter (27%) of total dryer sales at participating retailers in PG&E service territory. Five manufactures accounted for 95% of ENERGY STAR sales, with two (LG and Samsung) accounting for over two-thirds (69%) of all ENERGY STAR sales in the territory (Table A-5). Additionally, over two-fifths of LG and Samsung models sold in PG&E service territory (42% and 43%, respectively) were ENERGY STAR qualified – twice the average proportion of ENERGY STAR models across all 14 manufacturers (19% on average).

Table A-5: ENERGY STAR Qualified Clothes Dryer Sales in PG&E Service Territory, by Manufacturer

Manufacturer	Total ENERGY STAR Sales	Proportion ENERGY STAR Sales
LG	6,101	44%
Samsung	3,510	25%
Kenmore	1,413	10%
Whirlpool	1,342	10%
Maytag	891	6%
All Others	638	5%
Total	13,895	100%

Source: PG&E RPP Sales Data, March through September 2016.

A.1.4. Sales Trends

Most California households own a clothes dryer. The results from the 2016 California Consumer Survey showed a market penetration of 83% in the state of California. This is slightly higher than the 2012 California Lighting and Appliance Saturation Survey, which showed a market penetration of 77%.¹⁰⁵ According to the 2016 California Consumer Survey, about one third (33%) of clothes dryer purchases were recent (within the last two years) and 15% of respondents plan to purchase within the next two years.

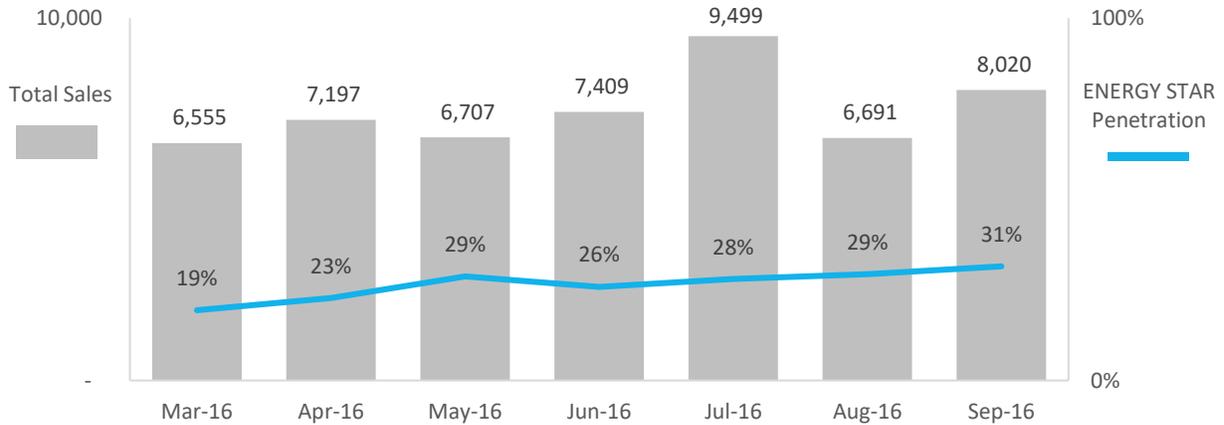
Clothes dryer sales are expected to continue to increase slightly year over year. Clothes dryer shipments have seen a gradual increase yearly since 2012 with an estimated 7 million shipments in 2015 (see Figure A-4). Industry experts suggest that continued strength in the U.S. housing market will

¹⁰⁴ DOE Compliance Certification Database. Retrieved on October 13, 2016 from https://www.regulations.doe.gov/certification-data/CCMS-4-Clothes_Dryers_-_Residential_Appendices_D1_and_D2.html#q=Product_Group_s%3A%22Clothes%20Dryers%20-%20Residential%20Appendices%20D1%20and%20D2%22

¹⁰⁵ California Lighting and Appliance Saturation Study (CLASS) 2012. https://webtools.dnvgi.com/susc/CPUC_CLASS_2012/SUSc_CPUC_CLASS_2012.aspx

continue fuel demand for household appliances, including washers and dryers.¹⁰⁶ Additionally, RPP program data suggest sales in PG&E service territory have increased slightly between March and September of 2016 (Figure A-3). Apart from March and April of 2016 (when the RPP program began), penetration of ENERGY STAR models was remained stable.

Figure A-3: Clothes Dryer Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR penetration, March through September 2016 (n = 52,078)



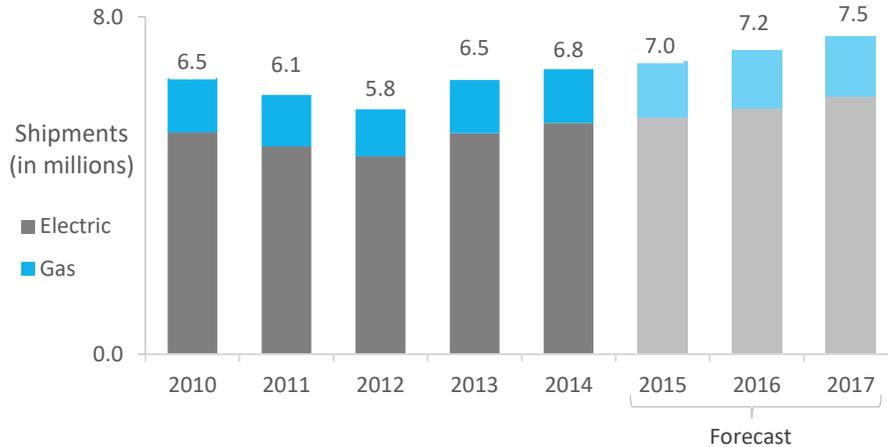
Source: PG&E RPP Sales Data, March through September 2016.

The mix of electric and gas dryers has remained relatively stable. From 2010 to 2017, most units shipped (80-81%) were electric (see Figure A-4). Electric dryers have experienced just over a 2% increase in household penetration from 2000 to 2010.¹⁰⁷ Among qualified dryer models, the majority (78%) are standard vented electric. California’s electric to gas dryer ratio is slightly more skewed towards gas dryers with 48% of all residents owning a gas dryer and 27% owning an electric dryer in 2012.¹⁰⁸

¹⁰⁶ IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

¹⁰⁷ DOE– EIA. Residential Energy Consumption Survey 2001, 2005, 2009 Public Use Data Files.

¹⁰⁸ DNV-GL. 2012 California Lighting and Appliance Saturation Study.

Figure A-4: Total Unit Shipments of Gas and Electric Dryers in the United States from 2010 to 2015

Source: AHAM; ApplianceDesign.com

Heat Pump clothes dryers, while more efficient, are slow to enter the U.S. market. While heat-pump technology has been frequently used in dryers across Europe, it is not widespread in the United States. Europe has a much higher penetration of heat pump dryers with Switzerland leading the market share of heat pump dryers (at 100% in 2012), and high penetration in Germany, Austria, and Italy (around 40%). In the European market in 2012, there were roughly 90 residential heat pump dryer models from 18 different manufacturers available.¹⁰⁹ Testing suggests that heat pump models can use 50-60% less energy than standard electric dryers.¹¹⁰ However, due to differences between Europe and the U.S. in consumer expectations for drying times, product experts do not expect heat pump clothes dryer's penetration in the U.S. to increase substantially without market interventions.¹¹¹

Two key organizations are working to make heat pump dryers more available in major U.S. markets. The Super-Efficient Dryer Initiative (SEDI) and the Collaborative Labeling & Appliance Standards Program (CLASP) are working, together with ENERGY STAR, encourage manufacturers to design heat pump dryers in for U.S. consumers.¹¹² In 2013 and 2014, the EPA recognized heat pump hybrid clothes dryers with the ENERGY STAR Emerging Technology Award.¹¹³

¹⁰⁹ Topten Focus (2012). Heat pump driers: 50% energy saving potential. Retrieved on October 6, 2016 from <http://www.topten.eu/uploads/File/Topten%20Focus%20HP%20driers%20Apr%2012.pdf>

¹¹⁰ NRDC. 2014. A Call to Action for More Efficient Clothes Dryers. NRDC Issue Brief.

¹¹¹ Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

¹¹² Ibid.

¹¹³ Energy Star. 2014 Emerging Technology Award: Advanced Clothes Dryers. Retrieved on October 6, 2016 from <https://www.energystar.gov/about/awards/energy-star-emerging-technology-award/2014-emerging-technology-award-advanced-clothes-dryers>.

A.2. Clothes Washers

Clothes washers are a major household appliance that are part of a home laundry system, which also includes clothes dryers and water heaters.

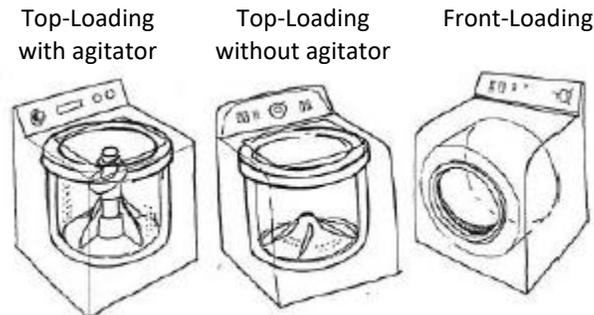
A.2.1. Product Description

The different types of clothes washers are mostly defined by configuration, size, and the presence or absence of an agitator (Figure A-5).

- › **Front-loading clothes washers** have a horizontal axis and typically use less water since clothes do not need to be completely submerged.
- › **Top-loading clothes washers with agitator** have a vertical axis and an agitator that is used to swirl the water and clothes around.
- › **Top-loading clothes washers without agitators** have a vertical axis and instead of an agitator they may use a moving plate in the bottom of the tub to bounce clothes through the water.
- › **Compact clothes washers** are defined by the clothes capacity, as measured in cubic feet. DOE defines compact clothes washers as those with less than 1.6 cubic feet of capacity, while ENERGY STAR defines compact as less than or equal to 2.5 cubic feet.



Figure A-5: Clothes Washer Configurations



Source: ACEEE

The performance of clothes washers is measured by the Integrated Modified Energy Factor (IMEF), which incorporates both energy and water consumption.¹¹⁴ IMEF is the proportion of the capacity of the clothes container, divided by the total clothes washer energy consumption per cycle. Higher values indicate more efficient the clothes washers.¹¹⁵ Integrated Water Factor (IWF) is the water performance

¹¹⁴ IMEF became the energy consumption metric for ENERGY STAR certified residential clothes washers as of March 7, 2015.

¹¹⁵ ENERGY STAR Clothes Washers Key Product Criteria retrieved on August 29, 2016 from https://www.energystar.gov/products/appliances/clothes_washers/key_product_criteria

metric for residential clothes washers. This metric allows the comparison of clothes washer water consumption independent of clothes washer capacity. Manufacturers must submit water consumption factors with their ENERGY STAR certified residential clothes washers. IWF is the proportion of the total weighted per-cycle water consumption for all wash cycles, divided by the capacity of the clothes washer. Lower values indicate more water efficient the clothes washers.

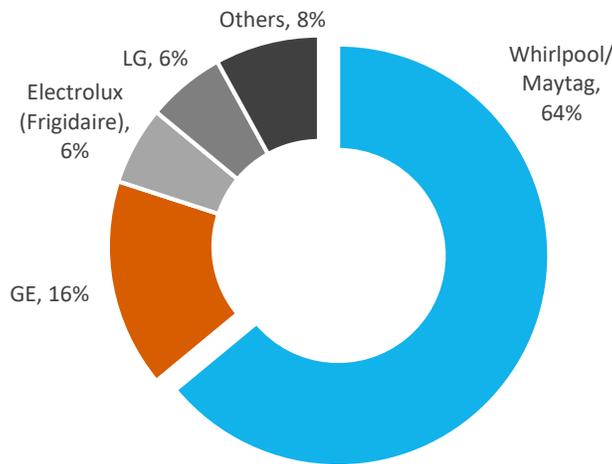
A.2.2. Supply Chain

DOE maintains a database of clothes washer models submitted to them and certified by manufacturers and their third-party representatives. As of October 10, 2016, this database listed 526 clothes washer models from 39 brands.

A.2.2.1. Manufacturers

Production of clothes washers is concentrated among a relatively small group of manufacturers. Based on 2008 DOE data, there were 17 residential clothes washer manufacturers, four of which (Whirlpool/Maytag, GE, Electrolux- Frigidaire, and LG) comprised 92% of the market (see Figure A-6).¹¹⁶ Production of ENERGY STAR models is also concentrated, with six brands, at least two of which are also produced by another top manufacturer,¹¹⁷ comprising the majority (73%) of ENERGY STAR models.¹¹⁸

Figure A-6: Residential Market Share by Manufacturer, 2008



Source: DOE Technical Support Document 2012

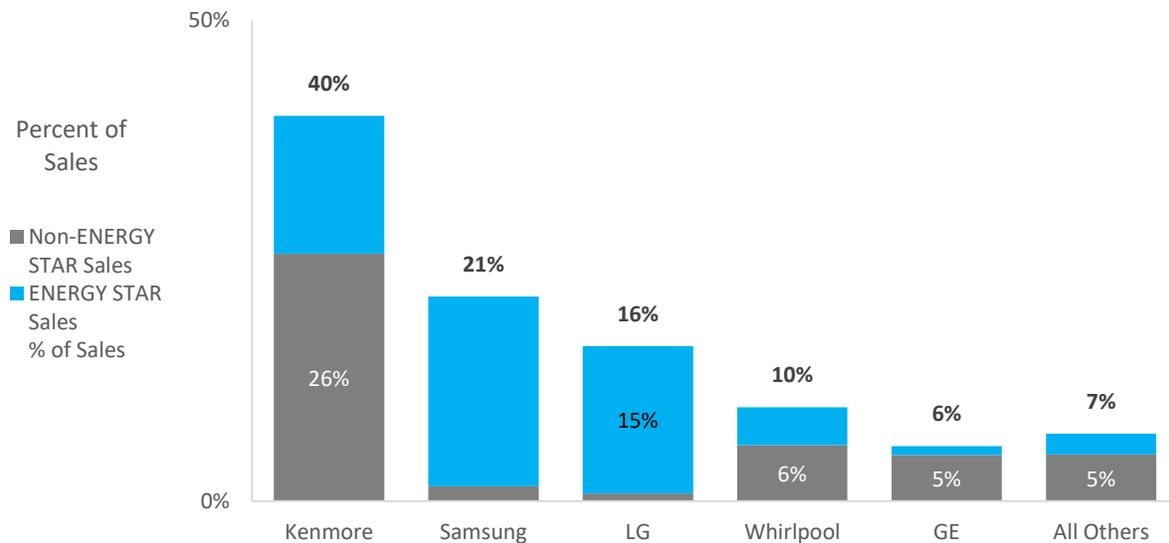
¹¹⁶ DOE. 2012. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers

¹¹⁷ Whirlpool and Maytag merged in 2006 but have continued both product lines. Kenmore brand comprises 34% of the ENERGY STAR qualified models. The brand is sold and controlled by Sears but produced by various manufacturers including Whirlpool.

¹¹⁸ Energy Star Qualified Product List retrieved on August 29, 2016 from <https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Clothes-Washers/bghd-e2wd>

Five manufactures account for nearly all clothes washer sales at participating retailers in PG&E territory. Between March and September of 2016, over 30 thousand washers were sold through participating retailers in PG&E service territory, consisting of 220 unique models produced by 12 manufactures. Together, Kenmore, Samsung, LG, Whirlpool, and GE made up about 93% of total washer sales (Figure A-7). Kenmore accounted for the largest share of clothes washer sales (40%) followed by Samsung and LG (21% and 16%, respectively). Additionally, Samsung and LG had the largest proportion of sales of ENERGY STAR qualified models (20% and 15% of total dryer sales or 93% and 95% of sales for the brand, respectively).

Figure A-7: Clothes Washer Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 33,054)



Source: PG&E RPP Sales Data, March through September 2016. For clothes washers, we inferred which models were ENERGY STAR qualified by whether they were classified under the “basic” RPP program tier.

A.2.2.2. Retailers

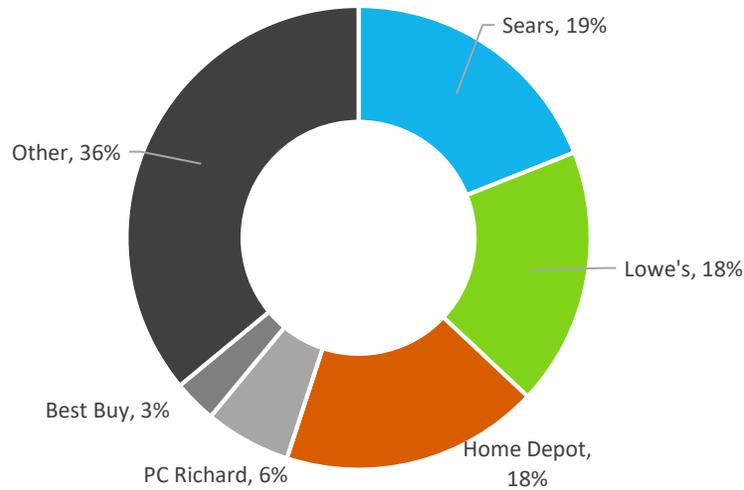
Clothes Washers are most often sold through home improvement stores and appliance or electronic stores. According to a New York study, the majority of clothes washers are sold through home improvement stores (40%) and appliance/electronic stores (39%), while mass merchandisers comprise 9% of sales.¹¹⁹ According to this study, this represents a shift from previous years’ data where mass merchandisers accounted for almost a quarter of all sales. According to an ACEEE white paper, the top retailers of clothes washers include department stores and big-box home goods stores such as Sears, Home Depot, Lowe’s, and Best Buy, along with local and regional independent stores.¹²⁰ This is

¹¹⁹ Apex Analytics LLC and Research Into Action, Inc. (2014) New York Products Program Market Characterization, Assessment, Process, and Market-Based Impact Evaluation. NYSERDA.

¹²⁰ Cluett, Rachel, et al. 2013. Saving Energy and Water through State Programs for Clothes Washer Replacement in the Great Lakes Region. ACEEE.

consistent with the findings from the New York study mentioned previously, which found that the majority (69%) of all clothes washer purchases occurred in the four national department and big-box home good stores mentioned previously as well as one regional store (see Figure A-8).¹²¹ The 2016 California Consumer Survey also found that consumers most often purchase clothes washers at big box retail stores (48%), followed by online big box stores (22%) and local retail stores (20%).

Figure A-8: Market Share of Retailers, 2013



Source: MCAP 2013 Residential End-Use Customer Telephone Survey

A.2.2.3. End-Users

Consumers often reported energy efficiency and ENERGY STAR qualification as important features in selecting a clothes washer model. According to a New York Study, when asked what features were most important when selecting a clothes washer model, consumers most often reported energy efficiency (40%), price (24%) and size (21%) as most important.¹²² Clothes washer purchasers noted energy efficiency more frequently than other appliance purchasers. This is somewhat consistent with results from the 2016 California Consumer Survey, which found that respondents most often reported price (50%), ENERGY STAR qualification (45%), and features (44%) as reasons why they purchased a selected clothes washer model (see Table A-6). The 2016 California Consumer Survey also found that nearly half (47%) of clothes washer purchasers reported that energy consumption was a “high priority” in their selection of the purchased model.

¹²¹ Apex Analytics LLC and Research Into Action, Inc. (2014) New York Products Program Market Characterization, Assessment, Process, and Market-Based Impact Evaluation. NYSERDA.

¹²² Ibid.

Table A-6: Reasons for Purchasing Selected Model (Among Respondents that Purchased a Clothes Washer in the Last Two Years)

Reason	Total (n = 575)
It was in my price range	50%
It had an ENERGY STAR label	45%
It had the features I wanted	44%
It had good reviews	34%
It was available	29%
I wanted the brand	28%
It costs less to operate	24%
It was recommended to me	20%
Other)	2%

Source: 2016 California Consumer Survey

Consumers most often get their information regarding clothes washers online or in the store.

Respondents to the 2016 California Consumer Survey most often reported the internet (27%), salesperson (25%), and friend or family members (15%) as the most influential information source (see Table A-7).

Table A-7: Most Influential Information Source (Among Respondents that Purchased a Clothes Washer in the Last Two Years)

Information Source	Total (n = 575)
Internet	24%
Salesperson at the store	22%
Friend or family member	13%
Consumer Report or other product-oriented magazines	11%
Advertisement	7%
Electric or gas utility	7%
Contractor	2%
Other	1%
Didn't seek information	11%
Don't know	1%
Total	100%

Source: 2016 California Consumer Survey

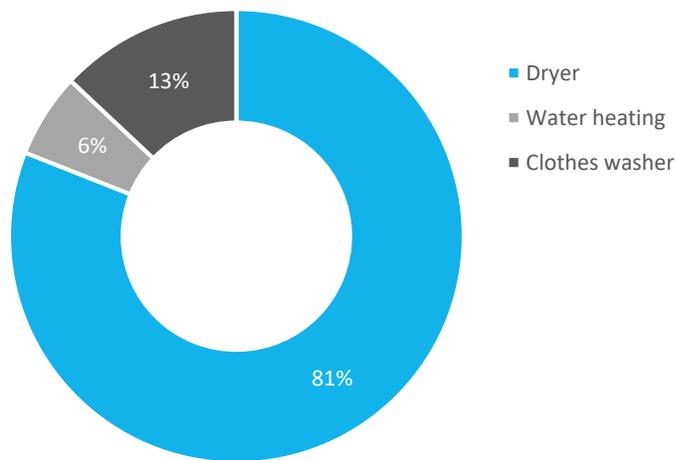
The average household uses their clothes washers 260-365 times per year. Sources varied on their yearly use estimates with one study finding residents ran about five loads of laundry per week¹²³, and another suggesting the average was approximately seven times a week.¹²⁴

Longer cycle time may be a barrier to more efficient clothes washer models. Consumer Reports found that while front-loading washing machines use less water and achieve cleaner clothes, they have longer cycle times than front-loading washers. On average, high-efficiency top-loaders took 60-90 minutes to clean an eight-pound load on normal wash while the front-load washers took 75-100 minutes to do the same.¹²⁵

A.2.3. Energy Efficiency

Compared to other laundry appliances, clothes washers use relatively little energy. Of the three appliances in the laundry group (clothes washers, dryers, and water heaters), clothes washers use the least energy (see Figure A-9). Efficient clothes washers have the unique attribute of achieving nearly all their energy savings by reducing the energy needs of other devices.¹²⁶

Figure A-9: Energy Used for Residential Clothes Washing¹²⁷



¹²³ The Cadmus Group, Inc. 2010. Do the Savings Come Out in the Wash? A Large Scale Study of In-Situ Residential Laundry Systems. ACEEE

¹²⁴ Statista. 2014. Washer per Week of Washing Machines in 2014, by Region. Retrieved on August 29, 2016 from <https://www.statista.com/statistics/306825/washes-per-week-of-washing-machines-by-region/>

¹²⁵ Consumer Reports. 2014. Pros and Cons of High-Efficiency Washers. Retrieved on August 28, 2016 from <http://www.consumerreports.org/cro/news/2014/09/the-pros-and-cons-of-high-efficiency-washers/index.htm>

¹²⁶ The Cadmus Group, Inc. 2010. Do the Savings Come Out in the Wash? A Large Scale Study of In-Situ Residential Laundry Systems. ACEEE

¹²⁷ Ibid.

Most clothes washer models on the ENERGY STAR qualified product list exceed the energy and water efficiency required for the current specification. Of the 315 models on the ENERGY STAR qualified product list¹²⁸, the majority (58%) have an IMEF that exceeds the current ENERGY STAR specification by at least 3%. This proportion is much lower for top-loading clothes washers (35%) compared to front-loading and compact clothes washers (68% each). Qualified clothes washers exceed the base specification by a maximum of 34% and an average of about 10% better.¹²⁹ Many ENERGY STAR qualified clothes washers (65%) exceed the current specification's minimum water efficiency requirement by at least 3%. The proportion also varied by configuration, with compact clothes washers (86%) having a larger portion of models that exceeded the specification more than 3% compared to front-loading clothes washers (72%) and top-loading clothes washers (48%) Qualified clothes washers exceed the base specification for water efficiency by a maximum of 30% and an average of about 10% better.¹³⁰

Front-loading clothes washers use less energy and water, and while they may be the minority, their market share has been increasing. Front loading models are more efficient largely due to lower water consumption and faster spin cycles that extract more water from clothing.¹³¹ According to DOE's Compliance Certification database, on average front-loading standard clothes washers are over 50% more efficient than top-loading models. As a result, a majority (68%) of ENERGY STAR clothes washers are front-loading. According to a 2014 article, front-loading washers increased in sales, but appeared to peak in 2009. According to a sales tracking firm, in 2009 about 45% of clothes washers sold in the U.S. were front-loading. In 2014, that number had dropped to about 30%. However, industry sources suggest that top-loading washers have lost market share over the past five years to front-loading washers and predict they will continue to do so due to their higher efficiency.¹³²

While front loaders are more efficient and perform better, they are also more expensive. 2014 data from a sales tracking firm shows front-loading machines typically cost about \$200 more than comparable top-loaders.¹³³ Front-loading washers continue to be seen as 'high end' indeed continue to have a higher price tag than top-loading washers. However, because front-loading washers require less energy and water, this upfront cost difference may be offset over the life of the product.

ENERGY STAR market penetration has held steady over the past 15 years, but saw a slight drop in 2015, perhaps due to changes in the calculation of specification requirements. From 2010 to 2014 market penetration of ENERGY STAR clothes washers held around 65%. There was a slight drop in penetration in 2015 (see Figure A-10). This could be a result of the changes made to the ENERGY STAR specification. For the current specification, which took effect in 2015, the EPA calculated the ENERGY STAR qualification criteria by product type (compact, front-loading, and top-loading), a change from

¹²⁸ Energy Star Qualified Product List retrieved on August 29, 2016 from <https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Clothes-Washers/bghd-e2wd>

¹²⁹ Including those that just met the specification.

¹³⁰ Including those that just met the specification.

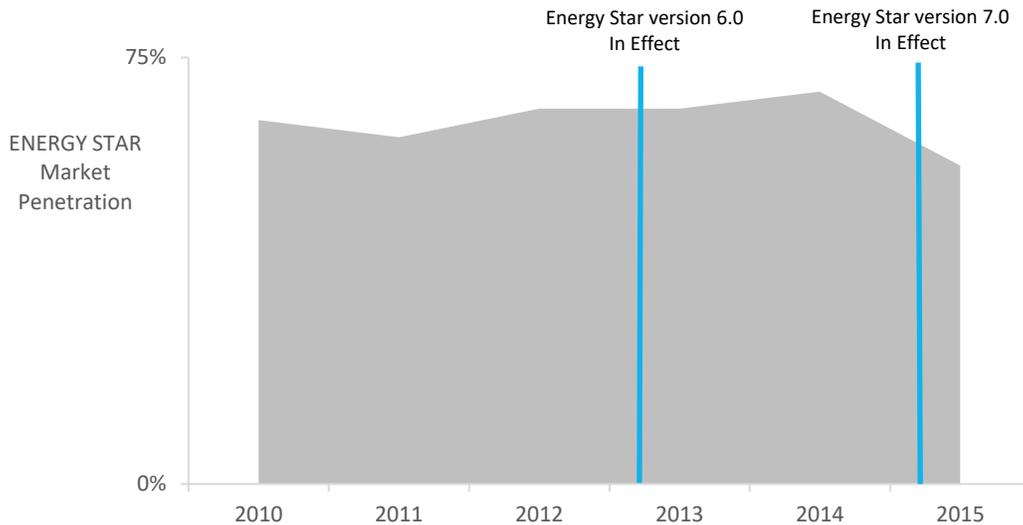
¹³¹ Cluett, Rachel, et al. 2013. Saving Energy and Water through State Programs for Clothes Washer Replacement in the Great Lakes Region. ACEEE.

¹³² IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

¹³³ Wroclawski, Daniel. 2014. *The Great Washer Debate: Are front loaders really better?* USA Today. Retrieved from <http://www.usatoday.com/story/tech/2014/10/13/the-great-washer-debate-are-front-loaders-really-better/17204535/>

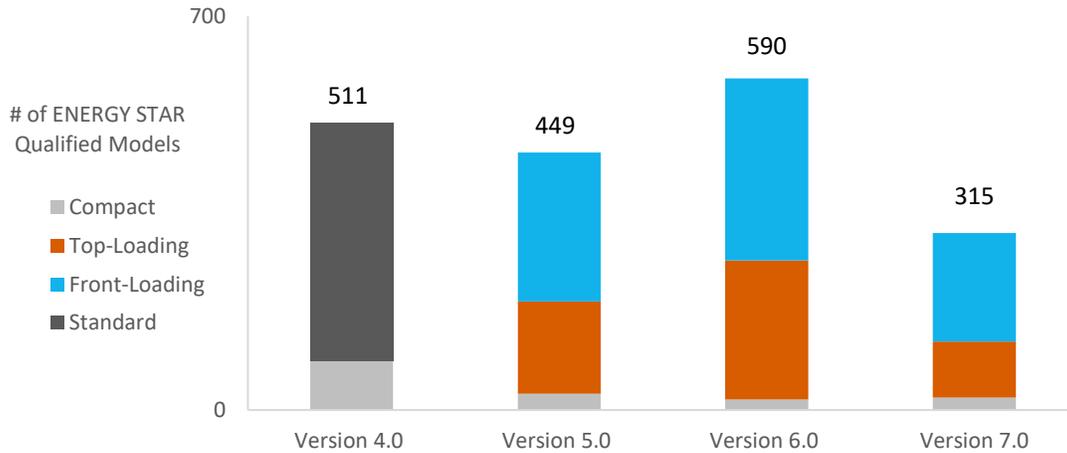
previous years. They also changed the qualification criteria from the modified energy factor (MEF) to the integrated modified energy factor (IMEF), which takes into account the combined low-power mode energy consumption.

Figure A-10: Energy Star Market Penetration



Prior to the specification version 6.0 that took effect in February 2013, 449 models qualified for ENERGY STAR certification. After the version 6.0 specification took effect, the number of qualified models increased to 590 (see Figure A-11). This fluctuation could be a result of an overall increase in clothes washer sales from low sales in 2012. Under the current ENERGY STAR specification (version 7.0) which took effect in March 2015, 315 models qualify.¹³⁴

¹³⁴ Energy Star Qualified Product List retrieved on August 29, 2016 from <https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Clothes-Washers/bghd-e2wd>

Figure A-11: Number of ENERGY STAR Qualified Models Under each Specification Change

Prior to version 5, ENERGY STAR did not record the configuration in their qualified product list therefore clothes washers are only distinguished by their size (compact or standard)

Most ENERGY STAR qualified clothes washers sold in PG&E service territory are from three manufacturers. Between March and September 2016, sales of ENERGY STAR qualified clothes washers made up over half (56%) of total washer sales at participating retailers in PG&E service territory. Five manufacturers accounted for 97% of ENERGY STAR sales, with three (LG, Samsung, and Electrolux) accounting for over four-fifths (87%) of all ENERGY STAR sales in the territory (Table A-8). Additionally, a large majority of LG and Samsung models sold in PG&E service territory (74% and 85%, respectively) were ENERGY STAR qualified – twice the average proportion of ENERGY STAR models across all 12 manufacturers (43% on average).

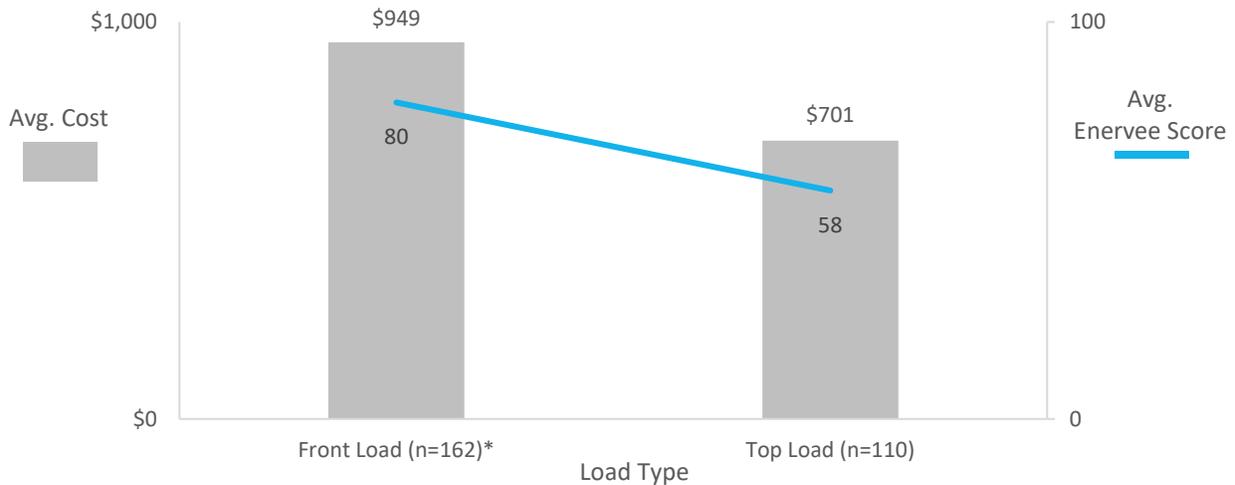
Table A-8: ENERGY STAR Qualified Clothes Washer Sales in PG&E Service Territory, by Manufacturer

Manufacturer	Total ENERGY STAR Sales	Proportion ENERGY STAR Sales
LG	5,065	35%
Samsung	6,520	27%
Electrolux	108	25%
Whirlpool	1,304	7%
Kenmore	4,729	3%
All Others	913	3%
Total	18,639	100%

Source: PG&E RPP Sales Data, March through September 2016; excludes manufacturers who sold 100 or fewer clothes washers. For clothes washers, we inferred which models were ENERGY STAR qualified by whether they were classified under the “basic” RPP program tier.

Technology trends may incrementally improve overall efficiency. Newer clothes washers use load sensing technology to automatically determine the size of the laundry load and adjust water levels accordingly.¹³⁵ Front-loading models have been increasing their market share over the past five years and industry sources expect this trend to continue.¹³⁶ Front-loading models are more efficient largely due to lower water consumption and faster spin cycles that extract more water from clothing.¹³⁷ Analysis of Enervee data also showed front-loading models were on average more expensive and more efficient than top-loading models (see Figure A-12).¹³⁸

Figure A-12: Average Cost and Efficiency Rating of Clothes Washers by Configuration



* Differences are significant, $\alpha < .05$

A.2.4. Sales Trends

The U.S. clothes washer market is highly saturated and clothes washer sales are expected to continue to increase slightly year over year. As of 2009, the clothes washer market was near saturation with 82% of U.S. households having a clothes washer.¹³⁹ This is slightly less in California, with an estimated 79% of homes with clothes washers in 2012.¹⁴⁰ Although per the 2016 California Consumer Survey, there was a market penetration of 85%. Clothes washer shipments have seen a gradual increase yearly since 2012 with an estimated ten million shipments in 2015 (see Figure A-13).

¹³⁵ Pilkington, Katie. 2013. Rules for Buying a Washer. CNET

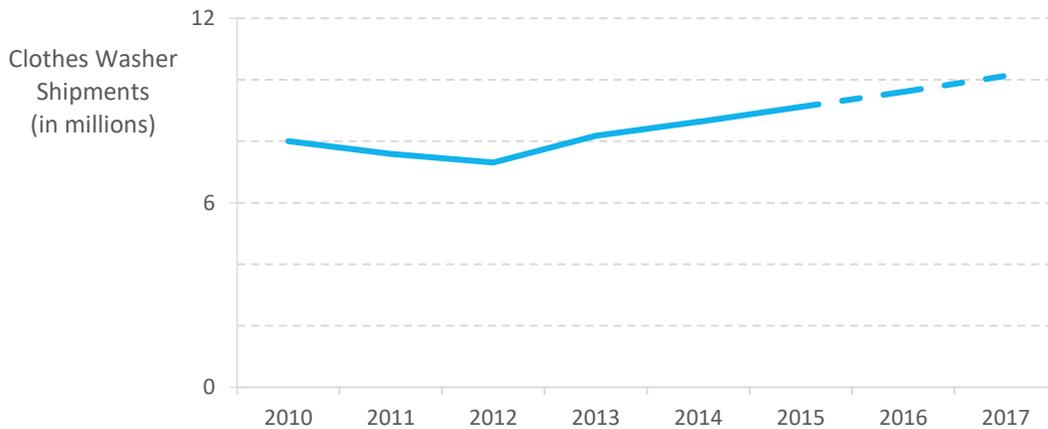
¹³⁶ IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

¹³⁷ Cluett, Rachel, et al. 2013. Saving Energy and Water through State Programs for Clothes Washer Replacement in the Great Lakes Region. ACEEE.

¹³⁸ Enervee Clothes Washers (2016). Retrieved from <https://enervee.com/washers/>

¹³⁹ U.S. Energy Information Administration. 2011. Residential Energy Consumption Survey 2009.

¹⁴⁰ DNV-GL. 2012 California Lighting and Appliance Saturation Study.

Figure A-13: Annual Clothes Washer Shipments to the U.S.

Source: EIA

Industry experts suggest that continued strength in the U.S. housing market will continue fuel demand for household appliances, including washers and dryers.¹⁴¹ About one-third (36%) of respondents to the 2016 California Consumer Survey reported purchasing a clothes washer in the past two years and over one tenth (14%) plan to purchase in the next two years (see Table A-9).

Table A-9: 2016 California Consumer Survey Clothes Washer Purchase and Intention Rates

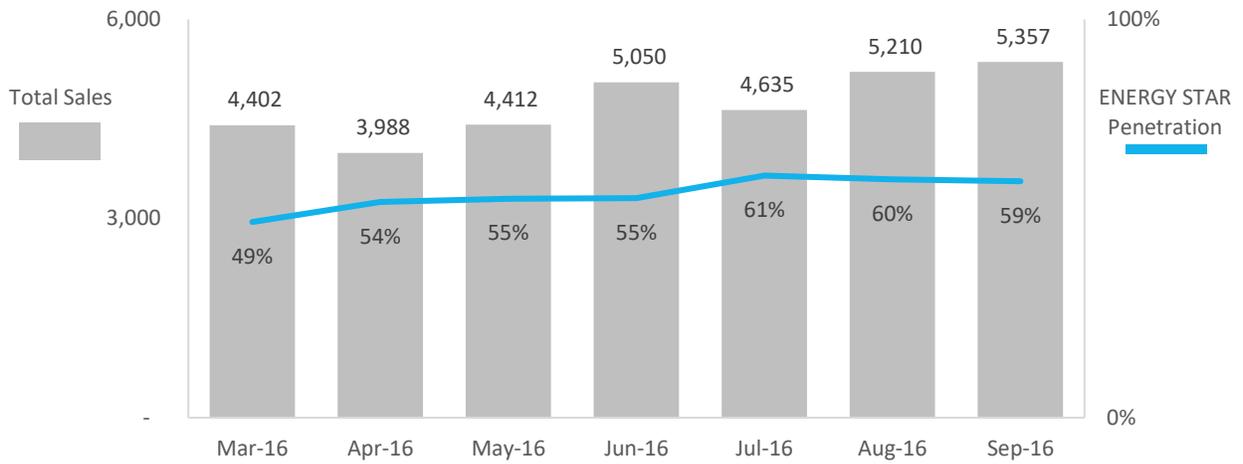
Rates	Total n=1,570
Recent purchase rate	36%
(Purchased used)	(7%)
ENERGY STAR rate	72%
Market penetration rate	85%
Purchase intention rate	14%

Note: Recent purchase rates include both new and used equipment purchases in the last 24 months, (%) indicates used equipment portion. Purchase intention measures intention of future purchase in the next 24 months.

About half of clothes washers sold in in PG&E's service territory are ENERGY STAR qualified and has remained relatively stable since the RPP program rolled out in March of 2016. Between March and September 2016 33,054 clothes washers were sold at participating retailers in PG&E service territory (Figure A-14). Overall, about three-quarters (56%) of clothes washers sold were ENERGY STAR qualified, which has increased slightly from March to September 2016.

¹⁴¹ IBISWorld. 2015. Washer and Dryer Manufacturing in the US. IBISWorld Industry Report OD4261.

Figure A-14: Clothes Washer Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR penetration, March through September 2016 (n = 33,054)



Source: PG&E RPP Sales Data, March through September 2016. For clothes washers, we inferred which models were ENERGY STAR qualified by whether they were classified under the “basic” RPP program tier.

A.3. Freezers

A.3.1. Product Description

Standalone freezers are cabinets designed as a unit for the freezing and storage of food at ambient temperatures down to -18°C . Standalone freezers come in two configurations;

- › **Chest freezers** open from the top and are generally the most economical type because nearly every interior inch of the appliance provides usable storage. Heavy insulation allows chest freezers to hold low temperatures well and translates into relatively low energy use. However, this configuration has a large horizontal footprint and requires adequate space above the device to open the lid.¹⁴² Chest freezers consume, on average, 46% less energy than similarly-sized upright models.¹⁴³
- › **Upright freezers** open from the front and look much like a refrigerator. They have a smaller footprint than similarly-sized chest freezers and make organizing the contents easier, since they typically have adjustable shelves and other options to make food easy to reach. Nonetheless, upright freezers generally cost more, provide about 15% less storage capacity, and are less efficient than chest models.¹⁴⁴



Standalone freezers range in size from compact models with capacities of less than eight cubic feet to full size models as large as 45 cubic feet. Upright freezers generally have larger capacities than chest freezers. Most both the chest freezer models available in the U.S. (59%) and the chest freezers installed in California homes (90%) have capacities of less than 15 cubic feet. In contrast, most both the upright freezer models available in the U.S. (64%) and the upright freezers installed in California homes (58%) have capacities of 15 cubic feet or more.^{145, 146}

Several factors influence freezer energy use, including configuration, compressor design, quantity and quality of insulation, quality of the door seal, and size. The configuration – positioning of the door and storage compartments and the compressor efficiency, has the greatest influence on annual energy

¹⁴² “Consumer Energy Center - Refrigerators and Freezers,” accessed August 5, 2016, <http://www.consumerenergycenter.org/residential/appliances/refrigerators.html>.

¹⁴³ “Association of Home Appliance Manufacturers,” Dataset, *Refrigerator and Freezer Verification Program*, accessed October 7, 2016, <http://rfdirectory.aham.org/AdvancedSearch.aspx>.

¹⁴⁴ “Residential Refrigerators and Freezers,” *California Energy Commission - Consumer Energy Center*, accessed October 7, 2016, <http://www.consumerenergycenter.org/residential/appliances/refrigerators.html>.

¹⁴⁵ “California Lighting and Appliances Study > Home,” accessed September 6, 2016, <https://webtools.dnvgl.com/projects62/Default.aspx?tabid=190>.

¹⁴⁶ “DOE Refrigerator Market Profile, 2009” (U.S. Department of Energy, December 2009), http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf.

consumption. Analyses conducted by the DOE prior to the adoption of the current standard found that adoption of efficient technologies could lead to cost-effective energy savings in the range of 20-30% for residential refrigeration equipment depending on the product class.¹⁴⁷ Manufacturers see more limited potential for efficiency gains, reporting that, while small efficiency gains (5-10%) are still possible through a number of component improvements, they do not anticipate major “step changes” or technological innovations before 2018.¹⁴⁸ The energy efficiency opportunities for standalone freezers focus on six key aspects of the device:

- › **Increased compressor efficiency:** Almost all residential freezers utilize an electrically driven compressor, which compresses a gaseous refrigerant to drive heat exchange and cool the air in the freezer compartment.¹⁴⁹ Efficient freezers have high-efficiency compressors that create less heat when they are running and are often quieter than standard compressors. Freezers may gain additional energy savings by using variable speed compressors (VSC), which operate at multiple speeds typically using brushless DC fan motors to avoid losing savings because of increased fan energy. Additionally, VSCs increase operating effectiveness of heat exchangers and reduce cycling losses by reducing the number of cycles. Linear compressors are another potential way to increase freezer efficiency, relative to single or variable compressors. These compressors use linear rather than rotary motors to minimize friction and side-forces.
- › **High-efficiency evaporators:** Within a freezer’s evaporator, the refrigerant absorbs heat from the air inside the cabinet. Technologies that increase the surface area of the evaporator can increase its energy efficiency. Using brushless fans to move air over both the evaporator and condenser can also increase freezer efficiency levels. In addition, the addition of valves that prevent refrigerant migration can achieve substantial energy savings.
- › **Improved defrost mechanisms:** Self-defrosting freezers automatically melt frost that accumulates in the cabinet. The typical automatic defrost system has three functional components: a defrost timer, a defrost heater, and a defrost thermostat.¹⁵⁰ Adding these capabilities can have a notable impact on freezer energy use, with freezers with automatic defrost using, on average, 50% more energy than those requiring manual defrosting. Adaptive defrost systems can reduce this energy usage by adjusting the time interval between defrost cycles based on some indication of the need for defrost – a common indicator is the length of time require to complete the previous defrost – resulting in fewer defrost cycles.
- › **Improved insulation and design to minimize heat loss:** Improved insulation in the form of vacuum insulated panels (VIPs), gas filled panels (GFPs) or thicker panels located in doors and exterior walls reduces the need to run the compressor to maintain the desired temperature within the freezer. Improved insulation has additional, non-energy benefits in that it helps food

¹⁴⁷ “Technical Support Document - Refrigerator, Refrigerator-Freezer and Freezers Rulemaking.” (U.S. Department of Energy – Energy Efficiency and Renewable Energy, September 2, 2011)

¹⁴⁸ “Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE)” (Research Into Action, Energy Market Innovations, August 30, 2012).

¹⁴⁹ Claus Barthel, “What Users Can Save with Energy-Efficient Refrigerators and Freezers” (bigEE, December 2012).

¹⁵⁰ “Technical Support Document. Refrigerator, Refrigerator-Freezer and Freezers Rulemaking. Washington, D.C. U.S. Department of Energy Efficiency and Renewable Energy.pdf,” n.d.

stay cold in the event of a blackout and muffles noise. Better design of gaskets and doors further reduces heat leakage into freezers.

- › **More precise temperature control:** All freezers have a thermostat or electronic temperature control to maintain the proper temperature. Electronic control systems generally use thermistors as temperature sensors, using relays mounted on the circuit boards to activate the compressor and other components such as the evaporator and condenser fans.¹⁵¹ More precise temperature and defrost mechanisms help the freezer operate more efficiently, while ensuring food is kept at the optimum temperature.
- › **Smart/Connected functionality:** By connecting to wireless networks, there is potential for freezers to optimize functions like defrosting to take advantage of periods of low energy demand, thus contributing to peak demand reductions.

Table A-10: Design options used to improve efficiency of standalone freezers

Design Options	Upright Freezer	Chest Freezer	Compact Chest Freezer
Brushless DC Fan Motors	x		
Improved Insulation	x	x	x
Adaptive Defrost	x		
Efficient Compressor	x	x	x
Variable Speed Compressor		x	x
Larger Evaporator	x	x	
Larger Condenser		x	
Forced Convection Condenser	x		
Vacuum Insulated Panel (in <u>cabinet</u>)	x		
Vacuum Insulated Panel (in <u>bottom wall</u>)		x	x
Vacuum Insulated Panel (in <u>door</u>)	x	x	

Source: DOE. 2011. *Technical Support Document. Refrigerator, Refrigerator-Freezer and Freezers Rulemaking*. Washington, D.C.: U.S. Department of Energy: Energy Efficiency and Renewable Energy.

A.3.2. Supply Chain

A.3.2.1. Component Suppliers

Six major manufacturers supply manufacturers with compressors, the key energy-using component of freezers. Embraco has the largest global market share, although several other manufacturers have

¹⁵¹ Ibid.

significant global market share as well.¹⁵² The other five major compressor manufacturers supplying the world refrigerator and freezer market are: Appliances Components Companies (ACC), Tecumseh Compressor Company (Tecumseh), Danfoss Compressors GmbH, Matsushita Electric Industrial Co., Ltd. (Matsushita), and LG Electronics.¹⁵³

A.3.2.2. Manufacturers

Compared to the larger household appliance industry, the standalone freezer market has a relatively high level of concentration amongst three manufacturers. Three manufacturers, Electrolux, W.C. Wood and Haier, made up 99% of the U.S. freezer market in 2008 (Table A-). Electrolux, the leading manufacturer, held nearly two-thirds of the market.¹⁵⁴ In contrast, the four largest players in the global household appliance industry are expected to account for just 30% of industry revenue in 2016 (see Figure 4).¹⁵⁵ This concentration has continued to grow through recent mergers. Whirlpool, which had been the fifth-largest dryer manufacturer, acquired W.C. Wood after the company declared bankruptcy in 2009. More recently, Haier acquired General Electric Appliances in January 2016. Per RPP program sales data, between March and September of 2016, one manufacturer, Magic Chef, accounted for most freezer sales in PG&E territory, followed by Kenmore and Frigidaire (Figure A-).

Table A-11: U.S. Freezer Manufacturer Market Share (1995-2008)

Company	1995	2005	2008
Electrolux	67%	67%	64%
W.C. Wood (Declared bankruptcy in May, 2009 – Acquired by Whirlpool)	30%	21%	19%
Haier	0%	11%	16%
Sanyo	1%	1%	1%
Whirlpool	1%	0%	1%
Other	1%	0%	0%
Total	100%	100%	100%

Source: DOE. 2011. *Technical Support Document*. Refrigerator, Refrigerator-Freezer and Freezers Rulemaking. Washington, D.C.: U.S. Department of Energy: Energy Efficiency and Renewable Energy.

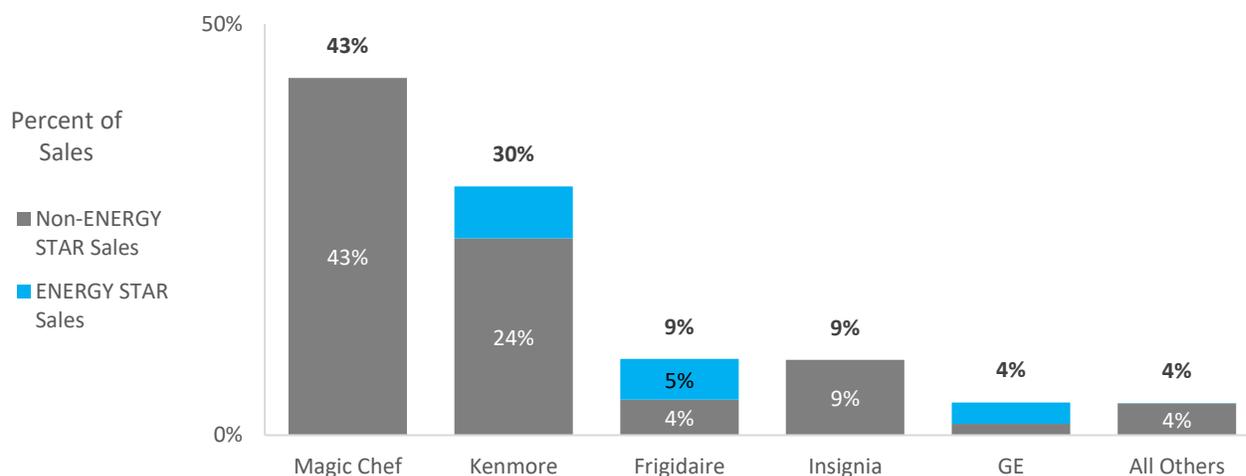
¹⁵² “Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE).”

¹⁵³ “Technical Support Document - Refrigerator, Refrigerator-Freezer and Freezers Rulemaking.”

¹⁵⁴ Erik Jacobson, “Request for Authority for Retail Products Platform (RPP) Pilot within PG&E’s Residential Energy Efficiency Plug-Load and Appliances Sub-Program,” February 12, 2016.

¹⁵⁵ “Global Household Cooking & Appliance Manufacturing” (IBISWorld Industry Reports, April 2016).

Figure A-15: Freezer Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 10,684)



Source: PG&E RPP Sales Data, March through September 2016.

Volatility and increases in prices of raw materials have increased costs to manufacturers, cutting into their profit margins. The prices of plastic and steel have exhibited significant volatility, with a general trend of rising prices.¹⁵⁶ Increases in the costs of these key production inputs increase the cost of freezer manufacturing. Since there are few long-term buying contracts in the industry, major mass merchandisers such as Walmart, Costco and Sears can easily switch suppliers and negotiate lower prices. As a result, manufacturers' ability to pass on increased production costs to retailers, and ultimately consumers, is limited, and higher raw materials costs cut into manufacturers' profits.¹⁵⁷

New freezer models come to market every 18 months. Older models are closed out, either because demand lags or the manufacturer updated the model's design to include new features. Extremely popular models can stay on the market for four to five years. Design can take longer than 18 months if there are technical challenges.¹⁵⁸

Price pressure is likely to limit freezer manufacturers' willingness to invest in efficiency improvements and retailers' willingness to carry more expensive, efficient freezer models. While high-end and built-in standalone freezer models have grown in popularity, they remain a relatively small part of the market. Most products are utilitarian, with few features to differentiate them from their competition. This, along with fluctuations in prices of raw materials, is likely to result in price pressure, reducing the profit margins standalone freezers offer to manufacturers and retailers. The relatively high level of concentration among standalone freezer manufacturers is consistent with this hypothesis: low margins may discourage new entrants to the market while existing manufacturers depend on high volume to justify their freezer business.

¹⁵⁶ Dmitry Diment, "Major Household Appliance Manufacturing in the US" (IBISWorld Industry Reports, November 2015).

¹⁵⁷ Ibid.

¹⁵⁸ "Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE)."

A.3.2.3. Retailers

Most consumers purchase freezers through big box retailers. Respondents to the 2016 California Consumer Survey most often purchased freezers in store at big box retailers (48%) (see Table A-12).

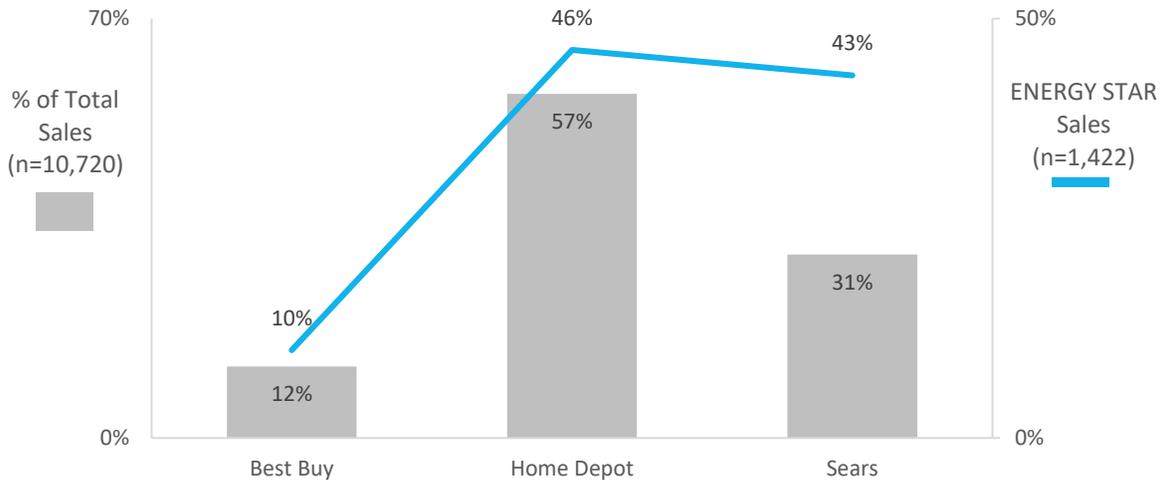
Table A-12: Purchase location

	Total (n = 259)
At a big box retail store	48%
An online big box	22%
At a local retail store	20%
An online-only retail store	8%
Other	0%
Don't know	1%
Total	100%

Source: 2016 California Consumer Survey 2016

Among RPP participating retailers, Home Depot has the most overall and qualified freezer sales. All participating retailers in PG&E’s service territory fall into the ‘Big Box’ retail store category, with more than half of total sales and nearly half of ENERGY STAR sales coming from Home Depot locations (Figure A-16).

Figure A-16: Freezer Sales in PG&E Service Territory by Retailer, March through September 2016



Source: PG&E RPP Sales Data, March through September 2016.

A.3.2.4. End-Users

End-users most often use the internet and recommendations from retail staff to inform their freezer purchase decision. Based on the 2016 California Consumer Survey, Freezer purchasers most often reported the internet (30%) and sales person at store (22%) as the most influential information source when purchasing their freezer (see Table A-13).

Table A-13: Most Influential Information Source (Among Those that Purchased Freezer in the Past Two Years)

Information Source	Total (n = 341)
Internet	30%
Salesperson at the store	22%
Friend or family member	13%
Electric or gas utility	9%
Consumer Report or other product-oriented magazines	8%
Advertisement	7%
Contractor	3%
Other	1%
Didn't seek information	7%
Don't know	1%
Total	100%

Some consumers consider energy efficiency when purchasing their freezer. Nearly two-fifths (37%) of freezer purchasers reported that they selected the freezer model because it had an ENERGY STAR label (see Table A-14). Among those that did not prioritize efficiency, the majority were not interested in efficiency (68%), felt most models were more efficient than their previous model (63%) or other features took priority (61%).

Table A-14: Reasons for Selecting the Purchased Model (Among Those that Purchased a Freezer in the Past Two Years)

Reason	Total (n = 341)
It was in my price range	45%
It had an ENERGY STAR label	37%
It had good reviews	34%
It had the features I wanted	33%
It was available	29%
I wanted the brand	28%
It was recommended to me	23%
It costs less to operate	20%
Other	3%

Source: 2016 California Consumer Survey

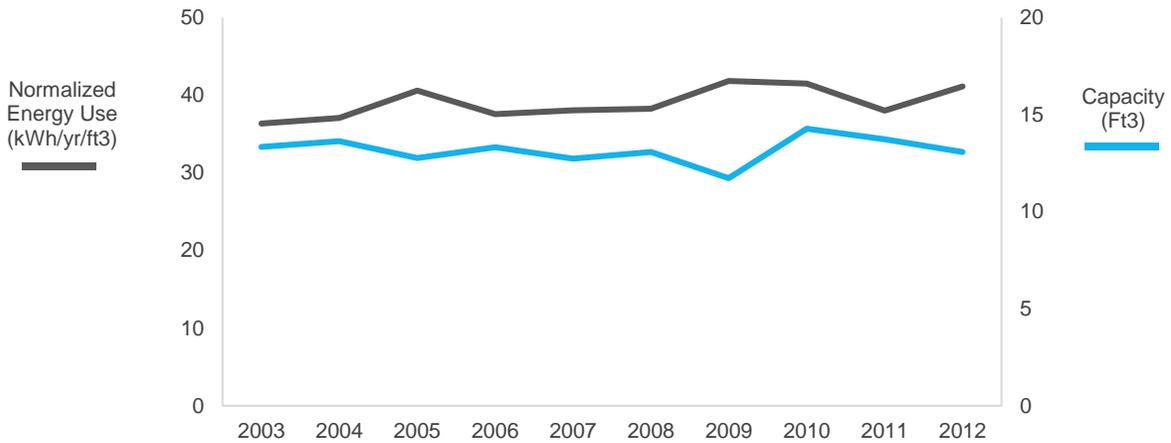
A.3.3. Energy Efficiency

Stand-alone freezers have been subject to the U.S. Department of Energy’s mandatory energy efficiency standards since 1990. The most recent revision of the standards took effect in September 2014. The most recent revision of the ENERGY STAR specification for freezers (Version 5.0) took effect at the same time as the revised federal standard.

Freezer energy usage was relatively steady in the decade leading up to 2012. One report found a year-over-year decrease of 1.3% in unit energy consumption for freezers in the U.S. Historical FTC data shows a trend of slightly increasing energy consumption among new freezer models, normalized for freezer size, over the same period (Figure A-17).¹⁵⁹ Note that normalized energy use is inversely related to the average capacity of freezers entering the market in a given year, suggesting that larger freezers use less energy on a per-cubic-foot basis than smaller freezers.

¹⁵⁹ “Refrigerators and Freezers by Year — U.S. Dept. of Energy Regulations & Compliance,” accessed October 7, 2016, https://www.regulations.doe.gov/FTC_archives/refrigerators_freezers_year.

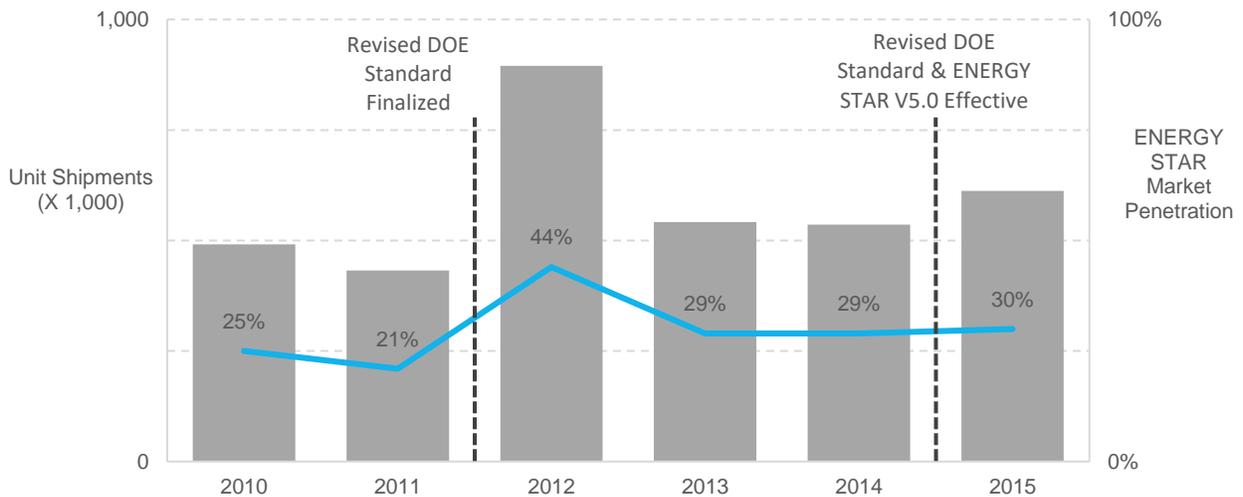
Figure A-17: Freezer Energy Usage Normalized by Capacity, 2003-2012



Source: "Refrigerators and Freezers by Year — U.S. Dept. of Energy Regulations & Compliance," accessed October 7, 2016, https://www.regulations.doe.gov/FTC_archives/refrigerators_freezers_year.

Market penetration of ENERGY STAR freezers remained relatively stable between 2013 and 2015. ENERGY STAR penetration under the previous specification (V4.0) peaked in 2012, after the release of the revised DOE specification (Figure A-18). The lack of a notable dip in ENERGY STAR penetration after the specification took effect late in 2014 suggests that, between 2011 and 2014, manufacturers were able to adapt their product designs to meet the more stringent standards.

Figure A-18: Freezer Unit Shipment and ENERGY STAR Market Penetration, 2010-2015

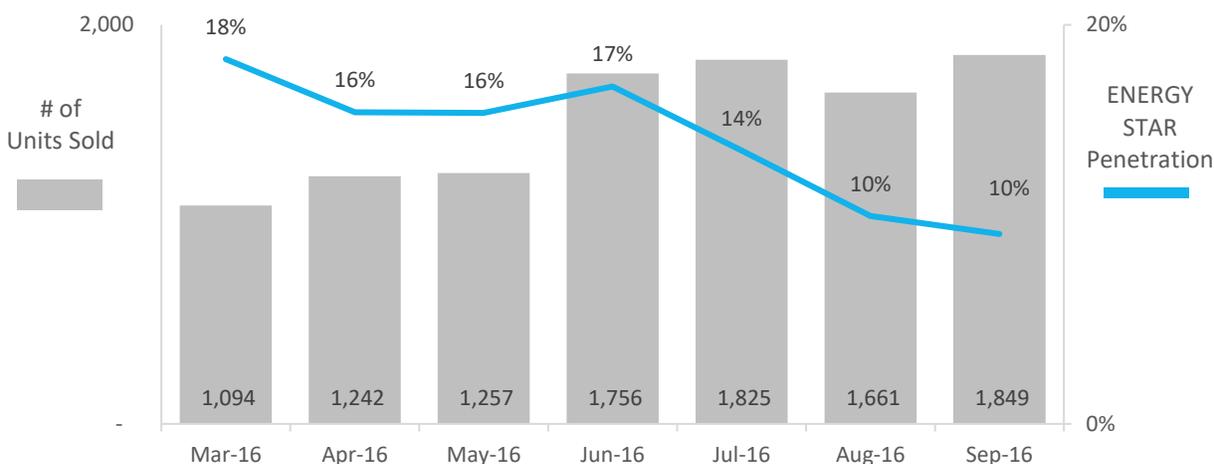


Source: "Unit Shipment and Sales Data Archives | ENERGY STAR," accessed October 7, 2016, https://www.energystar.gov/index.cfm?c=partners.unit_shipment_data_archives.

Penetration of ENERGY STAR freezer models in PG&E’s service territory is relatively low. Penetration has decreased by 8 percentage points while total sales increased since the RPP program rolled out in

March of 2016. Between March and September 2016 10,684 freezers were sold at participating retailers in PG&E service territory – only 1,486 of which were ENERGY STAR certified (Figure A-19).

Figure A-19: Freezer Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR Penetration, March through September 2016 (n = 10,684)



Source: PG&E RPP Sales Data, March through September 2016.

Average efficiency levels of ENERGY STAR freezers exceed the minimum ENERGY STAR specification, although this average reflects considerable variation across sizes and configurations. For most products, the ENERGY STAR specification is designed to be 10% more efficient than the DOE standard.¹⁶⁰ On average, the ENERGY STAR freezers in the DOE’s compliance certification database are 15% more efficient than non-qualified models with similar sizes and configurations, saving approximately 59 kWh/year. The efficiency of ENERGY STAR freezers over standard models varies by capacity and configuration, ranging from 8% (49 kWh/yr) for 27 cubic foot, built-in upright freezers with automatic defrost and automatic icemakers to 26% (150 kWh/yr) for 29 cubic foot, upright freezers with automatic defrost and no icemaker.

Both federal standards and voluntary specifications appear to drive design of full-sized freezers.

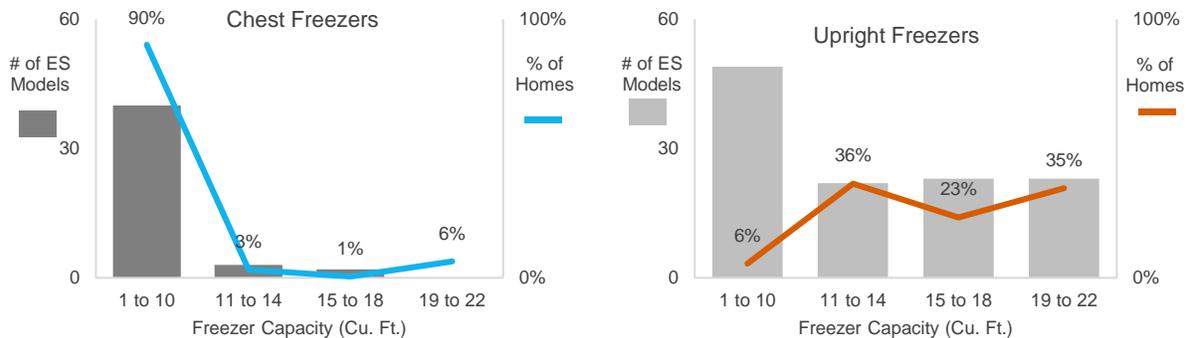
Among full-sized freezers that qualify for ENERGY STAR, only 3% of models exceed ENERGY STAR specifications by more than 3%. Almost all the full-sized freezers that do not qualify for ENERGY STAR have energy usage levels very close to the maximums allowed under the DOE’s 2014 standard, with only 2% of models exceeding the standard by more than 3%.

Energy usage of compact freezers is less reflective of standards and specifications. More than a third of ENERGY STAR compact freezers exceed the specification by more than 3%. Non-ENERGY STAR compact freezers are also more likely to exceed the DOE’s minimum standard than full-sized freezers, although a large majority (92%) are still within 3% of the DOE standard.

¹⁶⁰ “ENERGY STAR Program Requirements for Residential Refrigerators and Freezers” (U.S. Environmental Protection Agency, September 15, 2014), https://www.energystar.gov/ia/partners/product_specs/program_reqs/Refrigerators_and_Freezers_Program_Requirements_V5.0.pdf.

ENERGY STAR availability may lag in the most commonly-installed upright freezer sizes. Most ENERGY STAR freezers (55%) have capacities of less than 10 cubic feet. While this distribution is consistent with the installed base of chest freezers, it suggests that ENERGY STAR penetration may lag in the most popular upright freezer sizes (Figure A-20).

Figure A-20: Distribution of ENERGY STAR Freezer Models by Size Group and Household Penetration in California



While most brands produce both freezer types, there is relatively little overlap between brands of ENERGY STAR upright freezers and brands of ENERGY STAR chest freezers. For both freezer types, most brands offer either only ENERGY STAR chest freezers (7 of 12) or only ENERGY STAR upright freezers (27 of 32). This contrasts with the DOE product certification database, which indicates that most brands (23 of 35 chest freezer brands and 23 of 44 upright freezer brands) offer both chest and upright freezers.

Production of ENERGY STAR chest freezers is concentrated among a relatively small number of brands. More than half of all ENERGY STAR chest freezer models (60%) are sold under one of three brand names (Igloo, Avanti, and Haier). This is somewhat more concentrated than the market overall. Among the products certified with DOE in the past year, the eight manufacturers with the most models accounted for half (53%) of all chest freezers.¹⁶¹ There is somewhat less concentration in ENERGY STAR upright freezers, with the seven brands with the most models accounting for half (53%) of all qualified models. This is consistent with DOE data, which indicate that the eight brands with the most models account for half (52%) of the models certified in the past year.

Nearly all ENERGY STAR qualified freezers sold in PG&E service territory are from three manufacturers; Kenmore, Frigidaire and GE (Table A-15). These three manufacturers accounted for nearly 100% of ENERGY STAR sales in the territory.

¹⁶¹ "ENERGY STAR Certified Residential Freezers | ENERGY STAR Certified Products | U.S. Environmental Protection Agency," *Data.energystar.gov*, accessed October 7, 2016, <https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Freezers/8t9c-g3tn>.

Table A-15: ENERGY STAR Qualified Freezer Sales in PG&E Service Territory, by Manufacturer

Manufacturers	Total ENERGY STAR Sales	% ENERGY STAR Sales
Kenmore	672	45%
Frigidaire	531	36%
GE	279	19%
All Others	4	0%
Total	1,486	100%

A.3.4. Sales Trends

Californians may be less likely to have stand-alone freezers than people in other parts of the country.¹⁶² The CLASS 2012 survey found that approximately 15% of California homes have a standalone freezer.¹⁶³ This figure is lower than national estimates of stand-alone freezer use, with RECS and U.S. Census data indicating that, in 2009, 26% of U.S. households (approximately 34.6 million homes) owned a standalone freezer.¹⁶⁴ A 2011 report from the DOE estimated that closer to one-third of U.S. households owned a standalone freezer. However, the 2016 California Consumer Survey indicate a market penetration of 59% and a purchase intention of 11% (see Table A-16).

Table A-16: Purchase and Intention Rates

	Total (n=1,570)
Recent purchase rate	21%
(Purchased used)	(5%)
<i>ENERGY STAR rate</i>	73%
Market penetration rate	59%
Purchase intention rate	11%

Note: Recent purchase rates include both new and used equipment purchases in the last 24 months, (%) indicates used equipment portion. Purchase intention measures intention of future purchase in the next 24 months.

Additional studies suggest that penetration of stand-alone freezers may vary in different parts of the country. A study by the Energy Center of Wisconsin in 2010 found the proportion of households with a stand-alone freezer to be greater than these national estimates, with more than half (57%) of the

¹⁶² "Technical Support Document - Refrigerator, Refrigerator-Freezer and Freezers Rulemaking." (U.S. Department of Energy – Energy Efficiency and Renewable Energy, September 2, 2011)

¹⁶³ "WO21: Residential On-Site Study: California Lighting and Appliance Saturation Study (CLASS 2012)" (California Public Utilities Commission / KEMA, Inc., May 21, 2014).

¹⁶⁴ "Residential Energy Consumption Survey (RECS) - Data - U.S. Energy Information Administration (EIA)," accessed October 7, 2016, <http://www.eia.gov/consumption/residential/data/2009/#appliances>.

Minnesota households surveyed having at least one in their home.¹⁶⁵ California households with stand-alone freezers, like those in the rest of the country, typically have only one unit, with 99% of California homes with a stand-alone freezer having only one, while 92% of U.S. households with a freezer have only one.¹⁶⁶

While chest units have made up the majority of freezer shipments since at least 2005, upright units make up a majority of the installed base. The 2012 CLASS survey found that about half of stand-alone freezers installed in California homes were upright units (54%), with chest freezers comprising the remainder. Consistent with shipment data, chest units tend to be purchased more recently, with nearly half (49.7%) of the chest units in California homes purchased since 2006, compared to less than 30% of the upright freezers.

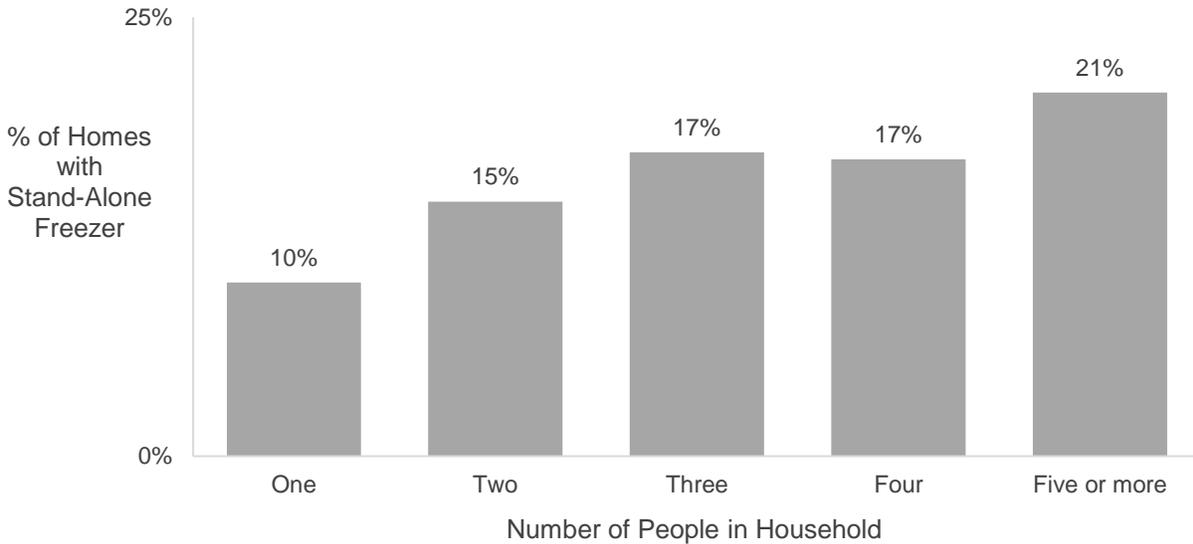
The average age of freezers in California homes has declined since 2000, due to more frequent replacement. The average age of standalone freezers installed in California homes declined from 13.6 years in the 2000 CLASS survey to 10.4 years in the 2012 survey.¹⁶⁷ This decline appears to result from Californians replacing their existing freezers, rather than an influx of new freezers to the installed base. The proportion of California homes with standalone freezers remained relatively constant between 2000 (16%) and 2012 (15%). As a result, the installed base of freezers likely grew by approximately 2% (400,000 units) over that period, reflecting the state's population growth.

Households with a greater number of residents are more likely to own a standalone freezer. California households with the more than five residents were somewhat more likely than smaller households to have a standalone freezer (see Figure A-21). Households with only one resident were considerably less likely than larger households to have a freezer. Household income does not influence the prevalence of standalone freezers.

¹⁶⁵ Bensch et al., "Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes: A Technical and Behavioral Field Assessment" (Energy Center of Wisconsin, May 2010).

¹⁶⁶ Ibid.

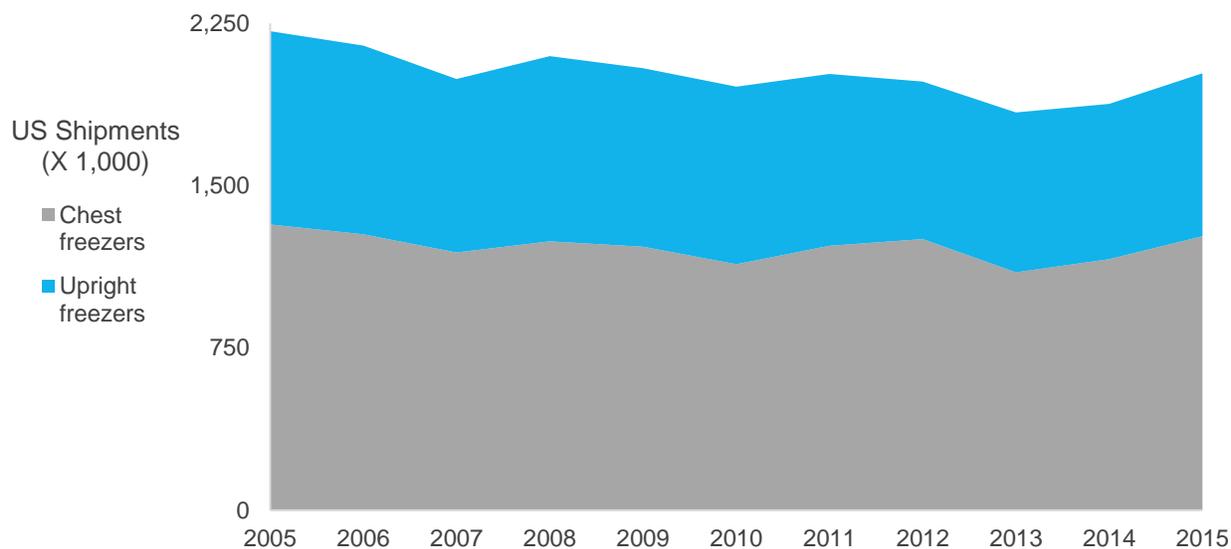
¹⁶⁷ "WO21: Residential On-Site Study: California Lighting and Appliance Saturation Study (CLASS 2012)."

Figure A-21: Percentage of California Households with a Standalone Freezer by Household Size

Source: "California Lighting and Appliances Study > Home," accessed September 6, 2016, <https://webtools.dnvgl.com/projects62/Default.aspx?tabid=190>.

After generally falling for most of the past decade, stand-alone freezer shipments rose in 2014 and 2015. Stand-alone freezer shipments declined from 2.2 million units in 2005 to 1.8 million units in 2013, an average decline of 2% per year (Figure A-22). Shipments increased in 2014 and 2015, the first-time shipments had increased over two consecutive years since at least 2005, reaching 2 million units in 2015. The division of freezer shipments by chest and upright units remained relatively constant around its average of 60% from 2005 to 2015.¹⁶⁸

¹⁶⁸ "Forecasts/Shipments Archives | Appliance DESIGN," accessed October 7, 2016, <http://www.appliancesdesign.com/ForecastShipmentArchives>.

Figure A-22: Stand-Alone Freezer Shipments to the United States, 2005-2015

While chest freezers sell in greater volume, a larger number of upright freezer models are available in the market. The DOE’s Compliance Certification Database lists more upright freezer models (258) than chest freezer models (217) certified in the past year.¹⁶⁹ This discrepancy may reflect greater variation in the configurations of upright models available than chest models. Among the eight stand-alone freezer configurations that DOE defines, six apply to upright freezers. In addition, upright freezers are sold under more brand names (44) than chest freezers (32).

Analysts anticipate that built-in models will be a growing part of the standalone freezer market.¹⁷⁰ In 2011 comments to ENERGY STAR, one leading manufacturer of built-in freezers described them as “a small...but steady and attractive market.”¹⁷¹ Market analysts note that demand for built-in freezers comes from the strength of the residential construction and kitchen remodeling markets, which demand built-in appliances to achieve popular minimalist designs.¹⁷²

¹⁶⁹ “CCMS - Public Database,” *U.S. Department of Energy Compliance Certification Database*, accessed October 7, 2016, https://www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*.

¹⁷⁰ “Global Chest and Upright Freezer Market 2016-2020 | Technavio - Discover Market Opportunities,” accessed August 16, 2016, <http://www.technavio.com/report/global-home-kitchen-and-large-appliances-chest-and-upright-freezer-market>.

¹⁷¹ Sub Zero - Wolf Incorporated, “Comments to EPA on Draft 1 Version 5.0 of Refrigerator Energy Star Specification” (U.S. Environmental Protection Agency, December 15, 2011), https://www.energystar.gov/sites/default/files/specs//Comments_to_EPA_on_V5_of_Refrigerator_Energy_Star_Specifications_Sub-Zero_Inc.pdf.

¹⁷² Technavio, “Global Chest and Upright Freezer Market 2016-2020,” accessed October 6, 2016, <http://www.technavio.com/report/global-home-kitchen-and-large-appliances-chest-and-upright-freezer-market>.

Analysts predict that, as consumers become more quality conscious, sales of high-end chest and upright freezers are likely to increase over the next five years.¹⁷³ Vendors are incorporating features like automatic defrost and slated steel finish, which were once only part of commercial and professional appliances, in models for residential use.

¹⁷³ “Growing Use of Built-in Freezers Will Drive the Global Chest and Upright Freezer Market Through 2020, Says Technavio | Business Wire,” accessed August 15, 2016, <http://www.businesswire.com/news/home/20160126005036/en/Growing-Built-in-Freezers-Drive-Global-Chest-Upright>.

A.4. Refrigerators

A.4.1. Product Description

Refrigerators are cabinets designed as a unit for the storage of food at temperatures from 32°F to 50°F. Refrigerators consist of a thermal insulated compartment and a heat pump that transfers heat from the inside of the fridge to its external environment. Most configurations include a separate compartment for freezing and storage of food below 32°F. Refrigerators typically come in three configurations:¹⁷⁴



- › **Top Freezer:** Positions the freezer compartment at eye level, above the refrigerator compartment, offering wide shelves and easy access to items stored in the back of the unit. This is the most popular configuration purchased by consumers.¹⁷⁵ These tend to offer the most space for their size (typically 30 to 33 inches wide) and have an average capacity of 18 cubic feet.¹⁷⁶
- › **Bottom Freezer:** Positions the freezer compartment below the refrigerator compartment, allowing for maximum accessibility to the refrigerator compartment. They range from 30 to 36 inches wide and have an average capacity of 22 cubic feet.¹⁷⁷
- › **Side-by-Side:** Positions the refrigerator and freezer compartments side-by-side, allowing for proportionally more freezer space than top and bottom freezer configurations. These units generally are equipped with through-the-door ice and water dispensers and temperature-controlled bins. Side-by-side models range from 32 to 36 inches wide and have an average capacity of 23 cubic feet.¹⁷⁸

Through-the-door ice and water dispenser is the most popular refrigerator feature for consumers. However, models with this feature also require the most repairs and typically consume more energy than models without it. In 2009, about one-third of refrigerators in California had through-the-door ice and water dispensers.¹⁷⁹ Additional common refrigerator features include:

- › **Door-in-door storage access:** allows for access to frequently-used items without opening the entire door, which helps retain temperature levels.

¹⁷⁴ Consumer Reports. 2016. "Refrigerator Buying Guide." <http://www.consumerreports.org/cro/refrigerators/buying-guide.htm>

¹⁷⁵ DOE– EIA. 2009 Residential Energy Consumption Survey (RECS) Public Use Data Files.

¹⁷⁶ DNV-GL. 2012 California Lighting and Appliance Saturation Study (CLASS).

¹⁷⁷ Ibid.

¹⁷⁸ Ibid.

¹⁷⁹ DNV-GL. 2009 Residential Appliance Saturation Study (RASS).

- › **Segmented temperature control:** allows a user to control the temperature in certain areas of the refrigerator for specific items.
- › **Freshness features:** dual evaporators help maintain higher humidity levels in the refrigerated areas and prevent freezer odors from migrating there. Air purifiers eliminate bacteria and mold spores, while vacuum-sealed crisper drawers claim to keep food fresher longer.
- › **Smart-grid compatibility:** “smart” refrigerators shift demand caused by high-energy functions like defrost and ice production to off-peak hours. Manufacturers say penetration will depend on the establishment of communication protocols/standards and expect the number of models with this feature to increase after 2015.

Although the average lifetime of a refrigerator is 12 years, many units are considerably older. Nationally, one-quarter (25%) of refrigerators in operation in 2009 were between 10 and 19 years old, with about one in ten (8%) being over 20 years old.¹⁸⁰ In the same year, about one-fifth (17%) of refrigerators in California were over 10 years old.¹⁸¹

Refrigerator design and manufacturing follows a model also found in consumer electronics. Low-end and commodity products (for example, compact refrigerators or some top-mount products) are more likely to be designed and manufactured by an original equipment manufacturer (OEM). High-end products are more likely to be fully specified and manufactured by the brand. Design of new models can take 18 months or longer depending on technical challenges. Additionally, new refrigerator models come to market approximately every 18 months. Popular refrigerator models can stay on the market for up to five years.¹⁸²

A.4.2. Supply Chain

DOE maintains a database of refrigerator models submitted to them and certified by manufacturers and their third-party representatives. As of November 16, 2016, this database listed 2,469 standard sized refrigerator models from 85 brands.

A.4.2.1. Manufacturers

The U.S. refrigerator market is dominated by three manufacturers who together hold over 80% of the market. As of 2008, Whirlpool, GE, and Electrolux each had between a one-third and one-quarter share of the U.S. refrigerator market (Table A-17). The three have shuffled positions during the last 15 years with Whirlpool taking over from GE as the dominant brand, and Electrolux and Haier gaining market share. Samsung, although not on the chart of top U.S. refrigerator manufacturers, reports rapidly growing sales worldwide and in the U.S.¹⁸³

¹⁸⁰ DOE– EIA. 2009 Residential Energy Consumption Survey (RECS) Public Use Data Files.

¹⁸¹ DNV-GL. 2009 Residential Appliance Saturation Study (RASS).

¹⁸² Research Into Action and EMI. (2012). Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE) Final Report. Pacific Gas & Electric and Southern California Edison.

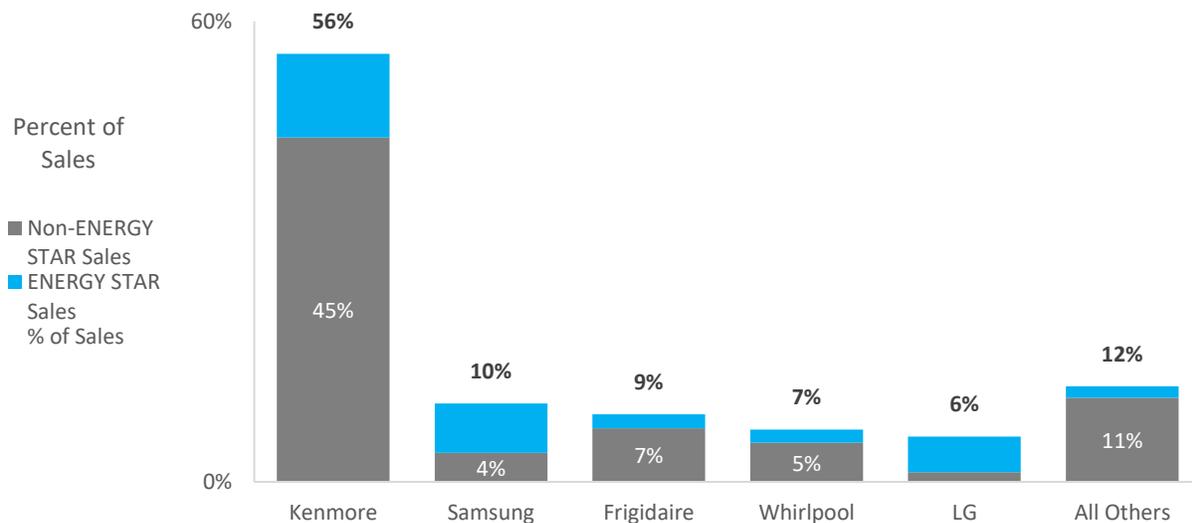
¹⁸³ PG&E. 2016. “Program Theory and Logic Model for the PG&E 2016 Retail Product Platform (RPP) Program”

Table A-17: U.S. Refrigerator Manufacturer Market Share (1995-2008)

Manufacturer	1995	2005	2008
Whirlpool	27%	25%	33%
GE	35%	29%	27%
Electrolux	17%	25%	23%
Haier	0%	2%	6%
Other	21%	19%	11%
Total	100%	100%	100%

Source: DOE. 2011. *Technical Support Document*. Refrigerator, Refrigerator-Freezer and Freezers Rulemaking. Washington, D.C.: U.S. Department of Energy: Energy Efficiency and Renewable Energy.

Over half of refrigerator sales in PG&E service territory are from one brand. RPP sales data show that five brand names account for over four-fifths (88%) of refrigerator sales, with Kenmore accounting for about half of sales (Figure A-23). It is important to note that refrigerator manufacturers often make products that are marketed under another company's brand. This is particularly the case with the Kenmore brand, which may be made by any of the top manufacturers including Whirlpool, LG, and Frigidaire.

Figure A-23: Refrigerator Sales in PG&E Service Territory by Brand, March through September 2016 (n =33,808)

Source: PG&E RPP Sales Data, March through September 2015. For this analysis, we manually matched models sold in PG&E service territory with the ENERGY STAR Qualified Products List. We excluded 14,759 sales of compact refrigerators from this analysis.

Most ENERGY STAR qualified refrigerators sold in PG&E service territory are sold under three brands. Between March and September 2015, sales of ENERGY STAR qualified refrigerators made up about one-quarter (27%) of total refrigerator sales at participating retailers in PG&E service territory. Three

manufacturers accounted for about four-fifths (81%) of ENERGY STAR sales in the territory (Table A-18). Additionally, a large proportion of LG and Samsung models sold in PG&E service territory (68% and 51%, respectively) were ENERGY STAR qualified – considerably higher than the average proportion of ENERGY STAR models across all 28 manufacturers (15% on average).

Table A-18: ENERGY STAR Qualified Refrigerator Sales in PG&E Service Territory, by Brand

Manufacturer	Total ENERGY STAR Sales	Proportion ENERGY STAR Sales
Kenmore	3,695	40%
GE	2,174	24%
Kenmore	1,570	17%
Frigidaire	625	7%
Whirlpool	569	6%
All others	512	6%
Total	9,145	100%

Source: PG&E RPP Sales Data, March through September 2015. For this analysis, we manually matched models sold in PG&E service territory with the ENERGY STAR Qualified Products List. We excluded 14,759 sales of compact refrigerators from this analysis.

A.4.2.2. Retailers

Retailer market share has been shifting from traditional appliance retailers to home improvement retailers. Accounting to a 2014 study in New York State the largest proportion of refrigerators sales were through home improvements retailers (31%), followed by Sears (20%), and local appliance retailers (17%).¹⁸⁴ The share of sales has shifted over the last five years, with Sears and independent appliance dealers losing market share to home improvement retailers, big box stores, and online outlets. Additionally, data from the 2016 California Consumer Survey show that half of consumers (50%) purchase refrigerators at a big box retail store, followed by online big box stores (22%), local retail stores (19%), and online-only retail stores (5%). Online sales of large kitchen appliances, such as refrigerators, are expected to grow to an annual rate of 7% by 2020.¹⁸⁵

A.4.2.3. End-Users

Refrigerators with side by side configurations appear to be gaining in popularity in California. The 2009 Residential Appliance Saturation Study (RASS) reported about two-fifths (38%) of households in California had refrigerators with a side-by-side configuration. Data from the 2012 California Lighting and Appliance Saturation Study (CLASS) shows that this the penetration of refrigerators with side-by-side

¹⁸⁴ Apex Analytics LLC and Research Into Action, Inc. (2014) New York Products Program Market Characterization, Assessment, Process, and Market-Based Impact Evaluation. NYSERDA.

¹⁸⁵ IBISWorld. 2016. "OD5083 Online Large Kitchen Appliance Sales Industry Report.pdf." <http://www.ibisworld.com/industry/online-large-kitchen-appliance-sales.html>

configurations have increased to about half (47%). Additionally, analysis of Google Trends data suggests that the side-by-side configuration is likely gaining in popularity over other configurations.

The use of second refrigerators has grown steadily over the past two decades in California. Every year, approximately 10% of households purchasing a new refrigerator keep their old unit, increasing the base of second units by 800,000 to one million units annually.¹⁸⁶ In 2009, about one-quarter (23%) of U.S. households (approximately 26 million homes) had a second refrigerator in their home.¹⁸⁷

Consumers most often get information regarding refrigerators online or in the store. Respondents to the 2016 California Consumer Survey most often reported the internet (30%) and store sales staff (25%) as the most influential information source (Table A-19). Additionally, A 2014 study conducted in New York State found that over half of refrigerator purchasers (55%) visited stores for information, followed by the internet (25%).¹⁸⁸

Table A-19: Most Influential Information Source (Among Respondents that Purchased a Refrigerator in the Last Two Years; n=543)

Information Source	Percent
Internet	30%
Salesperson	23%
Friend or family member	12%
Consumer Report or other product-oriented magazines	12%
Advertisement	9%
Electric or gas utility	7%
Contractor	3%
Other	1%
Didn't seek information	2%
Total	100%

Price and features are more important to consumers when selecting a refrigerator model, followed by ENERGY STAR qualification. According to a New York Study, when asked what features were most important when selecting a refrigerator model, consumers most often reported size (47%), features (28%), and energy efficiency (28%) as most important in their selection.¹⁸⁹ This is consistent with results from the 2016 California Consumer Survey, which found that respondents most often reported price (49%), features (42%), and ENERGY STAR qualification (45%) as the top reasons why they purchased a

¹⁸⁶ DOE. 2009. "Refrigerator Market Profile" http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

¹⁸⁷ DOE– EIA. 2009 Residential Energy Consumption Survey (RECS) Public Use Data Files.

¹⁸⁸ Apex Analytics LLC and Research Into Action, Inc. (2014) New York Products Program Market Characterization, Assessment, Process, and Market-Based Impact Evaluation. NYSERDA.

¹⁸⁹ Ibid.

refrigerator model (multiple responses allowed; Table A-20). The survey also found that nearly half (48%) of refrigerator purchasers reported that energy consumption was a “high priority” in their selection of the purchased model.

Table A-20: Reasons for Purchasing Selected Model (Among Respondents that Purchased a Clothes Washer in the Last Two Years; n=593; Multiple Responses Allowed)

Reason	Percent
It was in my price range	49%
It had the features I wanted	42%
It had an ENERGY STAR label	40%
It was available	34%
It had good reviews	34%
I wanted the brand	29%
It was recommended to me	20%
It costs less to operate	19%
Another reason	4%

A.4.3. Energy Efficiency

Refrigerator energy consumption continues to decrease with the implementation of more stringent federal and state efficiency standards. Refrigerators manufactured today consume about one-third as much electricity as those manufactured 30 years ago, and about half as much as the typical unit manufactured before 1993. While there has been a decline in energy consumption, the average size of refrigerators has increased by 10% during the same time.¹⁹⁰ A revised federal minimum standard took effect in 2014 which is expected to reduce energy consumption 25% below the 2014 baseline. The current ENERGY STAR Version 5.0 specification went into effect September 2014, and is designed to be 10% more stringent than the 2014 Federal Standard.

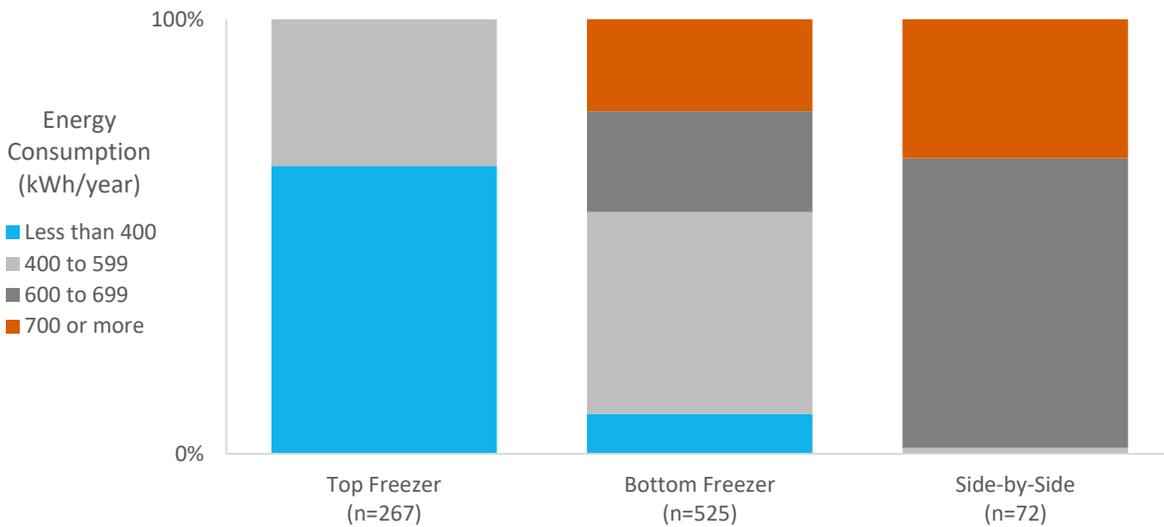
Refrigerators are a mature technology which manufacturers do not expect major changes or technical innovations before 2018. Refrigerator efficiency increased dramatically since the first Federal standards in 1978. Manufacturers note small efficiency gains (5-10%) are still possible through several component substitutions, including more efficient variable speed compressors and improved insulation. However, they think these improvements follow the law of diminishing returns and energy savings will decrease in subsequent models.

Refrigerator models with a side-by-side configuration use more energy than other configurations. On average, almost all (99%) of ENERGY STAR qualified models with a side-by-side configuration use over 600 kWh/year to operate, and almost a third (32%) use more than 700 kWh/year (Figure A-24). ENERGY

¹⁹⁰ DOE. 2009. “Refrigerator Market Profile” http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

STAR qualified refrigerators with a top freezer configuration use considerably less energy, on average, than those with either side-by-side or bottom mounted freezer configuration. A primary reason higher energy consumption for refrigerators with side-by-side configurations is ice and water dispensers that are often included in these models.¹⁹¹ About four-fifths (82%) of ENERGY STAR qualified refrigerators with side-by-side, top, or bottom freezer configurations exceed the DOE minimum specifications by 10% or less.¹⁹²

Figure A-24: Energy Consumption of ENERGY STAR Certified Residential Refrigerators, by Configuration



Source: ENERGY STAR Certified Residential Refrigerators Qualified Products Lists, September 2016.

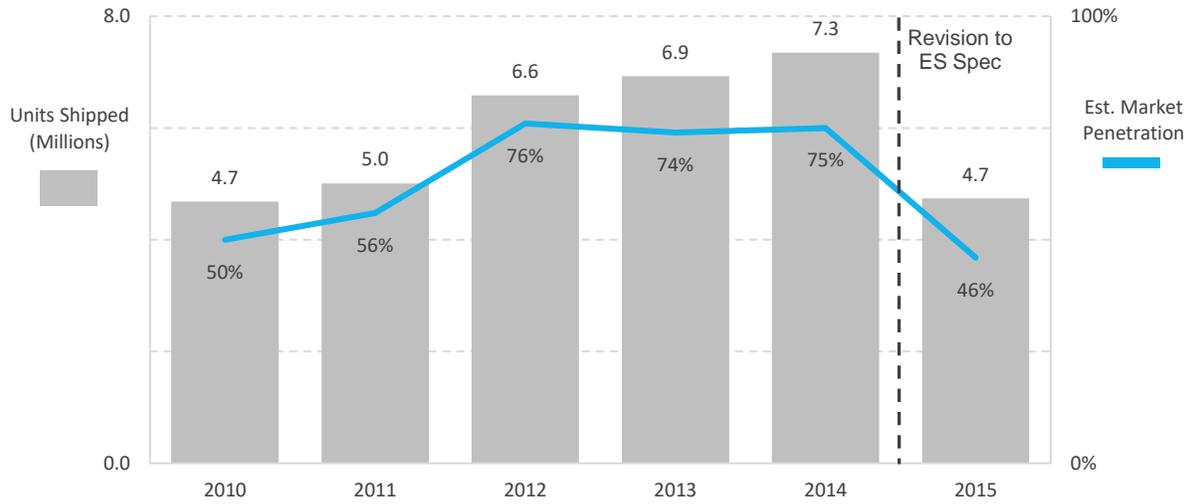
About half of refrigerators shipped are ENERGY STAR certified. Between 2012 and 2014, about three-quarters of refrigerators shipped to the United States were ENERGY STAR qualified (Figure A-25). ENERGY STAR penetration decreased considerably in 2015 after the revised ENERGY STAR specification (Version 5) went into effect - falling to about half (46%) of units shipped in 2015. The general stability of ENERGY STAR market penetration may be due in part to the fact that manufacturers and retailers have promoted energy efficiency as a product feature to increase sales of more expensive products with higher profit margins.¹⁹³

¹⁹¹ DOE. 2009. "Refrigerator Market Profile" http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

¹⁹² DOE. ENERGY STAR Certified Residential Refrigerators Qualified Products Lists, September 2016.

¹⁹³ DOE. 2009. "Refrigerator Market Profile" http://apps1.eere.energy.gov/states/pdfs/ref_market_profile.pdf

Figure A-25: Unit Shipments and Market Penetration of ENERGY STAR Refrigerators, 2010-2015



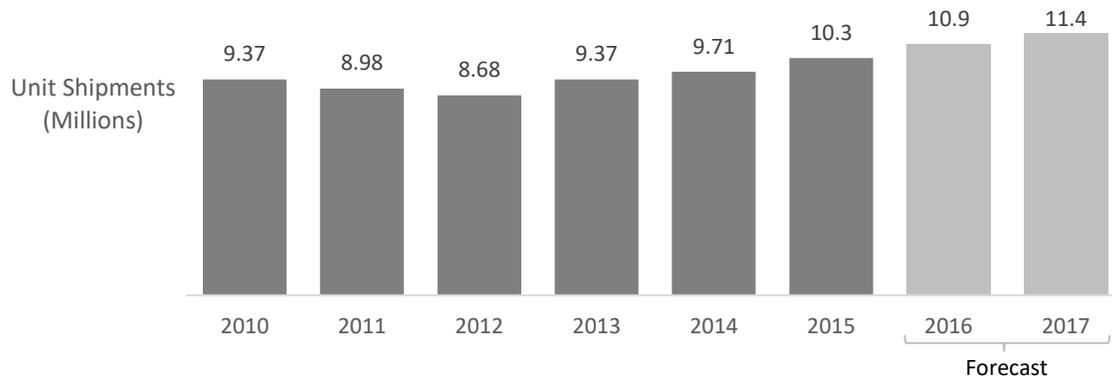
Note: Includes compact products. The decrease in market penetration between 2014 and 2015 is likely due to a revision to the ENERGY STAR specification in 2014.

Source: ENERGY STAR Unit Shipment Data Reports, 2010-2015.

A.4.4. Sales Trends

The market for refrigerators in the U.S. is mature and relatively stable and shipments of refrigerators to the increased slightly since 2012. Residential refrigeration equipment manufacturing is the third-largest (21%) product segment of the major household appliance manufacturing market in the U.S.¹⁹⁴ Between 2012 and 2015, there has been a general increase in refrigerator shipments to the U.S. by about 20% (Figure A-26). Shipments of refrigerators to the U.S. are expected to continue to increase in 2016 and 2017.

Figure A-26: Total Unit Shipments Refrigerators in the United States from 2010 to 2017



¹⁹⁴ "33522 Major Household Appliance Manufacturing in the U.S. Industry Report.pdf," n.d.

A.5. Room Air Conditioners

A.5.1. Product Description

Like other air conditioners, room air conditioners cool an indoor space by cycling a refrigerant through a compressor that increases its pressure, a condenser that releases the heat from the high-pressure refrigerant, and an evaporator in which the refrigerant's pressure drops and it absorbs heat from the surrounding air.¹⁹⁵ A fan moves air from the room over the evaporator coil, cooling the air before circulating it through the room. Another fan moves outside air over the condenser, helping to transfer the refrigerant's heat into the air.¹⁹⁶ A room air conditioner combines these components within a single cabinet, designed to fit within a window frame. Some room air conditioner models also have settings allowing them to provide heat.¹⁹⁷



Room air conditioners vary in their cooling capacity, which is expressed in British Thermal Units per hour (BTU/hr). The smallest units have capacities less than 5,000 BTU/hr, while the largest have capacities up to 36,000 BTU/hr. Room air conditioners most often have capacities between 8,000 and 13,000 BTU/hour.¹⁹⁸ According to ENERGY STAR, air conditioners in that capacity range are appropriate for cooling spaces between 300 and 550 square feet.

Technological opportunities to increase the energy efficiency of room air conditioners include:

- › Increasing the energy efficiency of fan motors
- › Incorporating advanced compressors
- › Including timers to allow units to run only when needed.¹⁹⁹

Room air conditioner energy efficiency is expressed in a Combined Energy Efficiency Ratio (CEER), which is the ratio of the unit's cooling output to its energy consumption in both active and standby modes. CEER replaced an earlier metric, the Energy Efficiency Ratio (EER), which did not account for standby power use, in the most recent ENERGY STAR specification.

¹⁹⁵ Air-Conditioning, Heating, & Refrigeration Institute, "How Things Work: Air Conditioning Systems," *AHRI*, 2016, <http://www.ahrinet.org/Homeowners/How-Things-Work.aspx?S=109>.

¹⁹⁶ *Ibid.*

¹⁹⁷ "ENERGY STAR Program Requirements for Room Air Conditioners: Eligibility Criteria Version 4.0" (U.S. Environmental Protection Agency, February 20, 2015), <https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%204.0%20Room%20Air%20Conditioners%20Program%20Requirements.pdf>.

¹⁹⁸ 58% of room air conditioner models in the AHAM Verifide database (discussed further below) fall into this range. Consistent with this finding, the 2012 CLASS survey found that 63% of window and wall air conditioners installed in California homes have capacities less than 12,000 BTU/hour.

¹⁹⁹ "Room Air Conditioners: 2007 Partner Resource Guide" (U.S. Department of Energy, 2007), https://www.energystar.gov/ia/partners/manuf_res/downloads/2007RoomAC_prg.pdf.

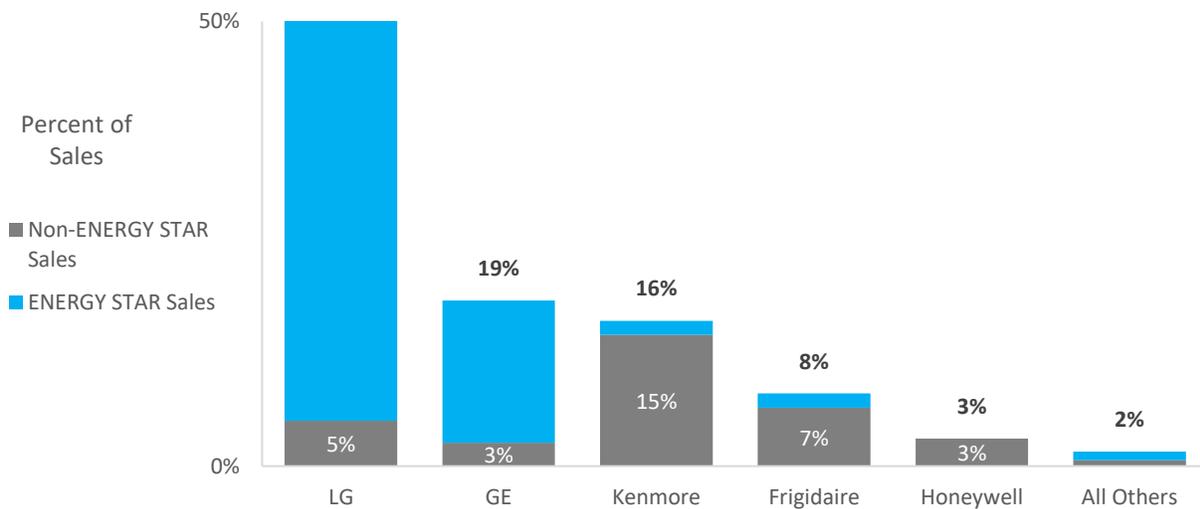
A.5.2. Supply Chain

The Association of Home Appliance Manufacturers (AHAM) maintains a database of room air conditioner models produced by manufacturers participating in the organization’s AHAM Verifide verification program. As of August 31, 2016, this database listed 706 room air conditioner models from 32 brands.²⁰⁰

A.5.2.1. Manufacturers

Production of room air conditioners, and particularly ENERGY STAR models, is concentrated among a relatively small group of manufacturers. The eight manufacturers with the most models produce more than three-fourths (76%) of the room air conditioner models in the AHAM database. Production of ENERGY STAR models is even more concentrated, with these eight manufacturers, all of whom produce ENERGY STAR models, responsible for 88% of all ENERGY STAR room air conditioner models. Only 10 of the remaining 24 manufacturers offer ENERGY STAR models. Further, RPP sales data show that five manufactures account for nearly all room air conditioner sales, with LG accounting for about half of sales (Figure A-27). Two manufactures (LG and GE) make up 94% of all ENERGY STAR sales at participating RPP retailers in PG&E territory.

Figure A-27: Room Air Conditioner Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 15,667)



Source: PG&E RPP Sales Data, March through September 2016.

²⁰⁰ This list appears to include almost all of the models on the ENERGY STAR qualified product list, with 281 of the models in the AHAM database listed as ENERGY STAR, and 284 models listed on the current ENERGY STAR qualified products list.

New manufacturers' entry to the market in the mid-2000's increased price pressure in the room air conditioner market. These new manufacturers largely came from Asia, and entered the market with low-cost models. At the same time, domestic manufactures shifted production overseas.²⁰¹ These low-cost models were less likely to qualify for ENERGY STAR.²⁰² The need to compete with these new, low-cost models reduced profit margins across the industry. To balance these lower profit margins, manufacturers reduced their marketing budgets for room air conditioners.²⁰³

All ENERGY STAR qualified room air conditioners sold in PG&E service territory are from four manufactures. Between March and September 2016, sales of ENERGY STAR qualified room air conditioners made up about over two-thirds (67%) of total air conditioner sales at participating retailers in PG&E service territory. Four manufactures accounted for all ENERGY STAR sales, with two (LG and GE) accounting for 94% of all ENERGY STAR sales in the territory (Table A-21). Two room air conditioner models accounted for 33% of all sales (and 49% of ENERGY STAR Sales), one from LG and one from GE.

Table A-21: ENERGY STAR Qualified Room Air Conditioner Sales in PG&E Service Territory, by Manufacturer

Manufacturer	Total ENERGY STAR Sales	Proportion ENERGY STAR Sales
LG	7,372	70%
GE	2,504	24%
Kenmore	397	4%
Frigidaire	249	2%
All Others	0	0%
Total	10,522	100%

Source: PG&E RPP Sales Data, March through September 2016.

A.5.2.2. Retailers

Room air conditioners are sold through a more diverse range of retail outlets than other types of appliances. A study in New York found that, while refrigerators, clothes washers, and dish washers were most often sold through home improvement and appliance/electronics stores, room air conditioners were most often sold through mass merchandisers. This study also found that, of all the appliance categories examined, the top five retailers had the lowest market share of room air conditioners (49%).²⁰⁴ Another study noted that many mass merchandisers, warehouse stores, grocery stores, and

²⁰¹ "Room Air Conditioners: 2007 Partner Resource Guide."

²⁰² Nexus Market Research, Inc., "Market Assessment for ENERGY STAR Room Air Conditioners in Connecticut" (Berlin, CT: Northeast Utilities - Connecticut Light and Power, The United Illuminating Company, August 17, 2009), <https://library.cee1.org/sites/default/files/library/2055/1240.pdf>.

²⁰³ "Room Air Conditioners: 2007 Partner Resource Guide."

²⁰⁴ Apex Analytics LLC and Research Into Action, Inc., "New York Products Program: Market Characterization, Assessment, Process, and Market-Based Impact Evaluation" (Albany, NY: New York State Energy Research and Development Authority, April 2014),

drug stores carry room air conditioners as a seasonal item. These retailers typically carry a relatively small number of largely low-end models, and see them as a way to increase customer convenience rather than a significant source of profit.²⁰⁵ However, based on the 2016 California Consumer Survey, respondents most often purchased their room air conditioner at a big box store (see Table A-22).

Table A-22: Purchase Location

	Total (n = 348)
At a big box retail store	43%
An online big box store	23%
At a local retail store	19%
An online-only retail store	10%
Other	2%
Don't know	3%
Total	100%

Source: 2016 2016 California Consumer Survey

Retailers stock room air conditioners as a seasonal product; they do not place orders on an ongoing basis. Retailers place orders for room air conditioners prior to the cooling season, potentially as early as the previous fall.²⁰⁶ Room air conditioner shipment data shows the cyclical nature of these purchases (Figure A-28), although shipments are likely delayed from retailers’ ordering. Each year, room air conditioner shipments peak in March, prior to the summer heating season, with a secondary peak occurring in May or June in some years. There are typically very few room air conditioner shipments in the late summer and fall.

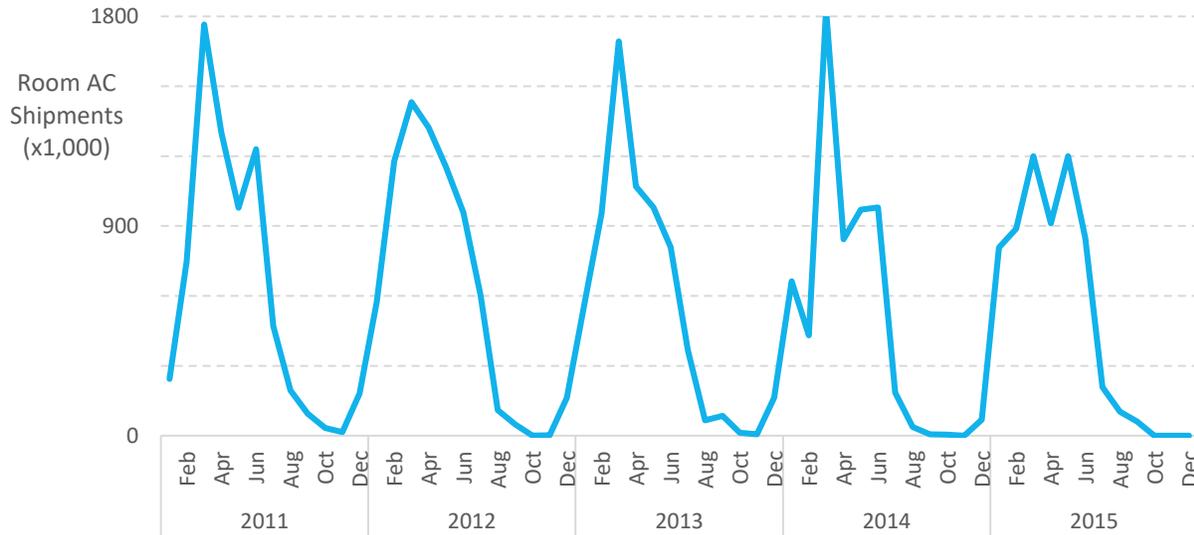
Retailers may not be closely engaged with room air conditioners as a product. This limited engagement has potential consequences at the store level, in that, as a seasonal product, sales associates may not be as familiar with room air conditioner efficiency as they are with other products. At the corporate level, if retailers do not view room air conditioners as a key source of profit, program incentives, which increase profits, may be less influential.

<https://www.nyscrda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2014ContractorReports/2014-New-York-Products-Program-Evaluation.pdf>

²⁰⁵ Nexus Market Research, Inc., “Market Assessment for ENERGY STAR Room Air Conditioners in Connecticut.”

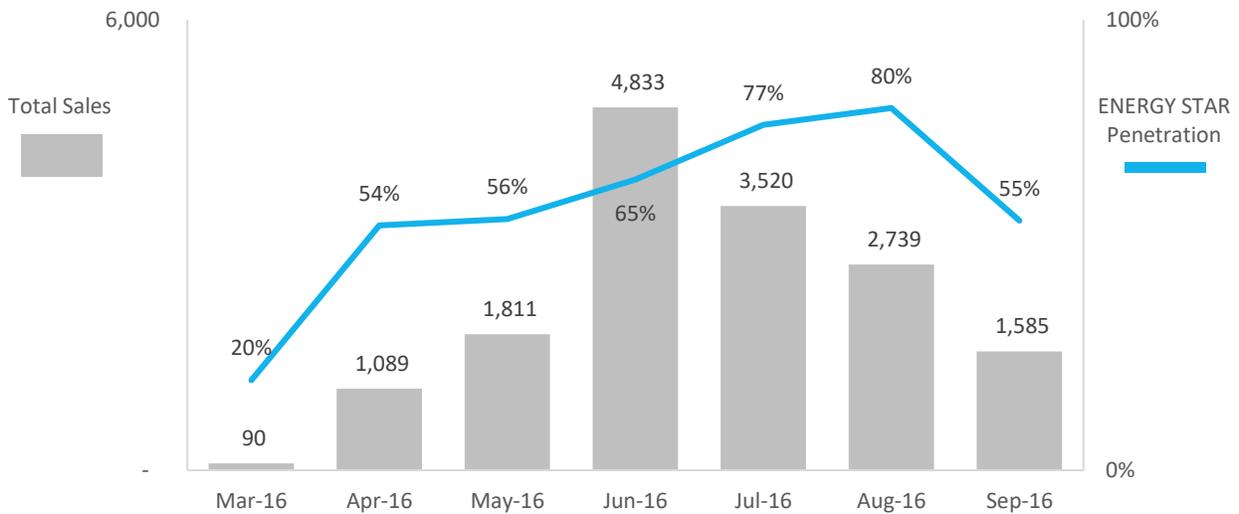
²⁰⁶ “Room Air Conditioners: 2007 Partner Resource Guide.”

Figure A-28: New Figure: Monthly U.S. Room Air Conditioner Shipments 2011-2015



The seasonal availability of room air conditioners may result in fewer ENERGY STAR qualified units being available outside of the summer cooling season. RPP program data show that room air conditioner sales at participating retailers peaked in June of 2016 with 4,833 units sold, of which over two-thirds (65%) were ENERGY STAR qualified (Figure A-29). Apart from July and August, the proportion of ENERGY STAR sales decreased slightly in September, and accounted for just one-fifth of sales in March of 2016.

Figure A-29: Room Air Conditioner Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR penetration, March through September 2016 (n = 15,667)



Source: PG&E RPP Sales Data, March through September 2016.

As a seasonal product, retail sales staff may be less familiar with room air conditioners, including efficient options, than they are with other appliance types. A survey of retailers in New Jersey found that, while awareness of ENERGY STAR room air conditioners was relatively high, with 52% reporting they were “very familiar” and an additional 33% reporting they were somewhat familiar with ENERGY STAR models, retailers had lower awareness of ENERGY STAR room air conditioners than of other appliances.²⁰⁷

A.5.2.3. End-Users

End-users often buy room air conditioners as an impulse purchase in response to hot weather. As a result, room air conditioner sales vary from year-to-year and region-to-region as weather patterns change.²⁰⁸ A study in New York found that, as with other appliance types, end-users most often learned about room air conditioners from visiting stores. However, consistent with room air conditioners’ status as an impulse purchase, end-users were less likely to use sources like the internet and Consumer Reports to research room air conditioner purchases than purchases of other types of appliances. Instead, room air conditioner purchasers were more likely than other appliance purchasers to consult newspaper circulars, friends or family, or to report they did not do research prior to their purchase.²⁰⁹

Table A-23: Most influential information source (Among Respondents that Purchased a Room Air Conditioner in the Last Two Years)

	Total (n = 424)
Internet	31%
Friend or family member	14%
Salesperson at the store	13%
Advertisement	9%
Consumer Report or other product-oriented magazines	8%
Electric or gas utility	8%
Contractor	5%
Other	1%
Didn't seek information	10%
Don't know	1%
Total	100%

Source: 2016 California Consumer Survey

²⁰⁷ Summit Blue Consulting, Quantec, LLC, and Gabel Associates, “Energy Efficiency Market Assessment of New Jersey Clean Energy Programs: Book II - Residential Programs” (Newark, NJ: New Jersey Board of Public Utilities, July 20, 2006), <http://www.njcleanenergy.com/files/file/NJ%20Mkt%20Assess%20Book%2011%20072006%20FINAL.pdf>.

²⁰⁸ “Room Air Conditioners: 2007 Partner Resource Guide.”

²⁰⁹ Apex Analytics LLC and Research Into Action, Inc., “New York Products Program: Market Characterization, Assessment, Process, and Market-Based Impact Evaluation.”

Energy efficiency may not be a consideration, or may be a low priority, in the room air conditioner purchase for many consumers. A survey of consumers in New Jersey found that the most common reason they did not purchase an ENERGY STAR room air conditioner (42%) was that energy efficiency was not a consideration in their purchase decision. The next most common response was that consumers (19%) were unable to find an efficient model with the features they wanted. Both of these barriers were more frequently mentioned than the cost of efficient models (15%).²¹⁰ However, about one-third (36%) of respondents to the 2016 California Consumer Survey reported that the ENERGY STAR label influenced their decision to purchase a specific model (see Table A-24), and half of respondents (50%) reported that the level of energy consumption was a “high priority” in their decision making.

Table A-24: Reasons for Selecting Purchased Model (Among Respondents that Purchased a Room Air Conditioner in the Last Two Years)

	Total (n = 424)
It was in my price range	47%
It had an ENERGY STAR label	36%
It had good reviews	35%
It had the features I wanted	34%
It was available	31%
It was recommended to me	26%
It costs less to operate	22%
I wanted the brand	21%
Other	2%

Source: 2016 California Consumer Survey

As an impulse purchase, end-users may not prioritize energy efficiency in room air conditioners. End-users conduct relatively little research prior to purchasing a room air conditioner, and often purchase room air conditioners when the weather is hot and there is an immediate need.

A.5.3. Energy Efficiency

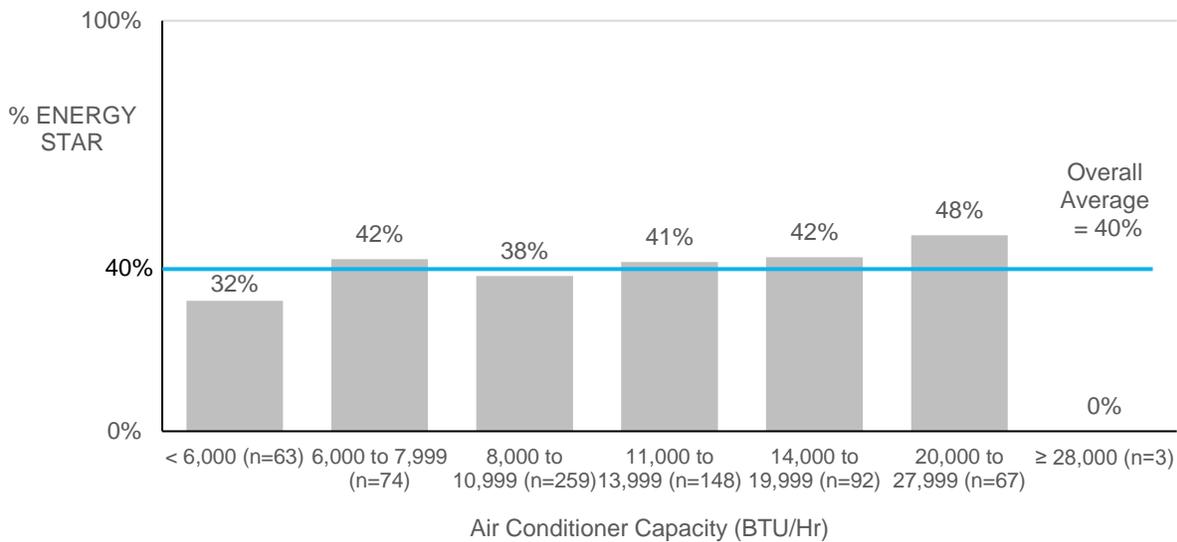
ENERGY STAR data suggests manufacturers design room air conditioners to meet the ENERGY STAR specification. There are currently 283 room air conditioner models that qualify for ENERGY STAR. Of those, only nine exceed the minimum specified efficiency levels and none do so by more than two percent. At the time of the most recent specification change, which increased efficiency levels between 1% and 10% based on the size and configuration of the unit, there were 631 qualified models, of which 31 exceeded the specification. The most efficient model exceeded the specification by 10%, although most (22 of 31) did so by 3% or less. The small proportions of models exceeding the ENERGY STAR

²¹⁰ Summit Blue Consulting, Quantec, LLC, and Gabel Associates, “Energy Efficiency Market Assessment of New Jersey Clean Energy Programs: Book II - Residential Programs.”

specification are consistent with manufacturers deliberately setting the ENERGY STAR efficiency levels as a design target, rather than seeking more generally to design an efficient product or incorporating efficient technologies for other reasons.

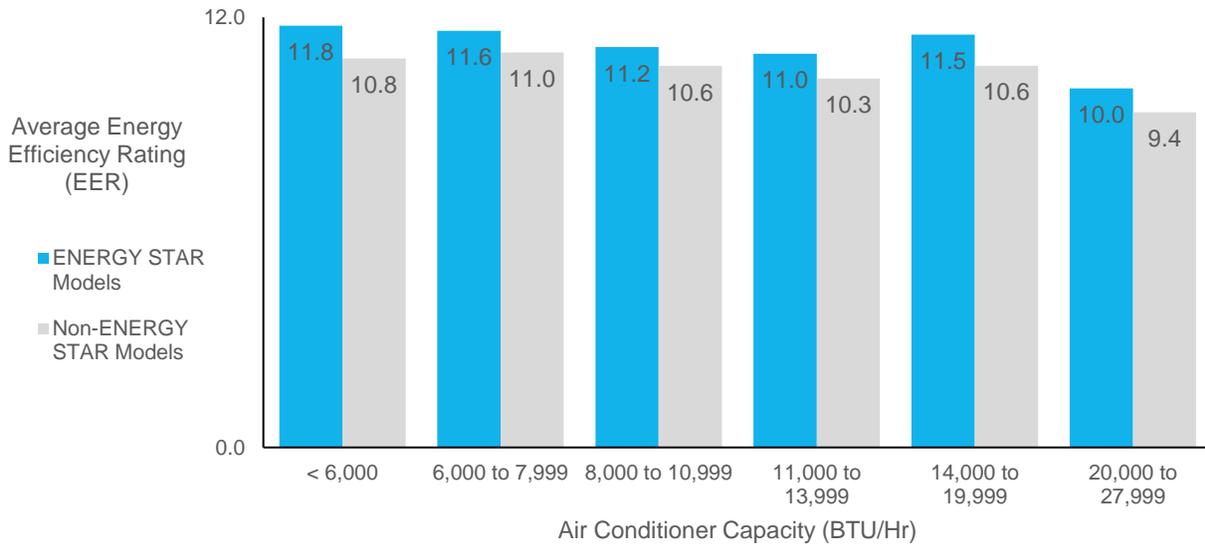
Manufacturers can meet ENERGY STAR requirements across air conditioner sizes. Overall, 40% of the room air conditioner models listed in the AHAM database qualify for ENERGY STAR (Figure A-30). While there is slightly more variation between very small and very large models, this proportion remains relatively constant across air conditioner capacity bins. While none of the models in the group with the greatest capacity qualify for ENERGY STAR, the database contains only three models in this group.

Figure A-30: Proportion of ENERGY STAR Rated Models by Capacity



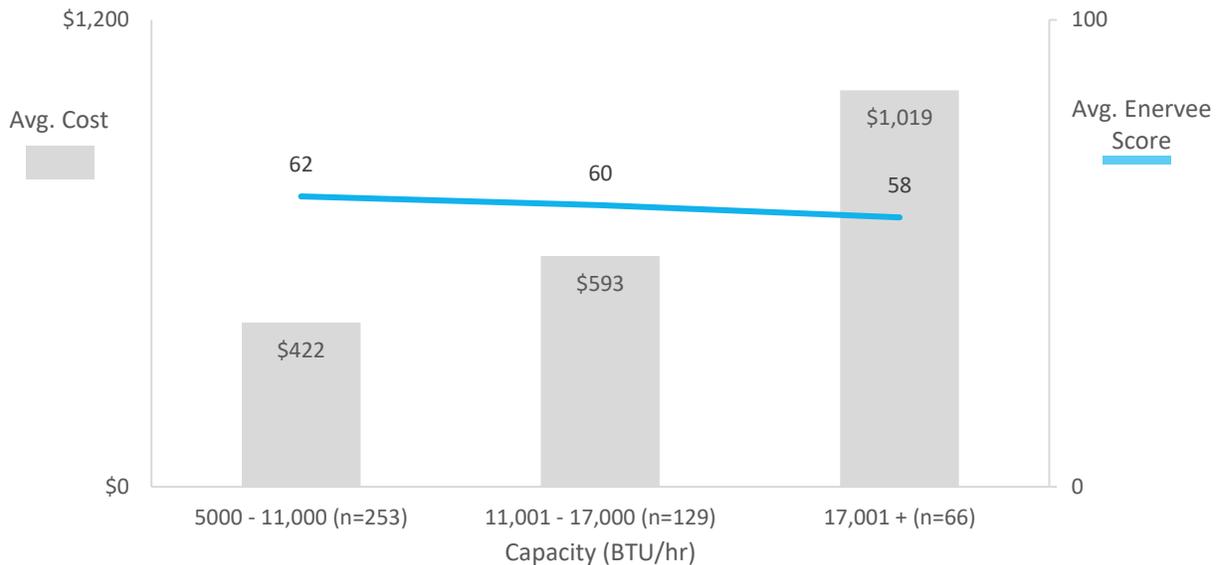
Across size categories, ENERGY STAR air conditioners are, on average, 6% more efficient than non-ENERGY STAR models. Differences in efficiency between ENERGY STAR models and others are somewhat greater in both larger and smaller capacity models. Both ENERGY STAR models with capacities less than 6,000 BTU/hour and those with capacities between 14,000 and 19,999 BTU/hour average 8% more efficient than similarly-sized non-ENERGY STAR models (Figure A-31). In contrast, ENERGY STAR models between 6,000 and 7,999 BTU/hour and 8,000 to 10,999 BTU/hour average 5% more efficient than other, similarly-sized models.

Figure A-31: Room Air Conditioner Efficiency Rating by Capacity



Higher efficiency room air conditioners are less expensive, but also have smaller capacity. Analysis of Enervue data found a negative relationship between cost and efficiency, but this was due to an increase in capacity (see Figure A-32).²¹¹ In other words, as air conditioners increase in size, they become more expensive and less efficient.

Figure A-32: Average Cost and Efficiency of Room Air Conditioners at Capacity Levels



- * (Cost) Differences are significant for the highest two capacity brackets, $\alpha < .05$
- * (Enervue Score) Differences are significant for the lowest capacity bracket, $\alpha < .05$

²¹¹ Enervue Room Air Conditioners (2016). Retrieved from <https://enervue.com/air-conditioners/>

A.5.4. Sales Trends

Market penetration of room air conditioners is about 50%. According to the 2016 California Consumer Survey, about half of households (50%) own a room air conditioner, and 9% intend to purchase in the next two years (see Table A-25). Survey respondents reported a higher ENERGY STAR penetration (71%) compared to 2015 ENERGY STAR shipment data (54%), and PG&E RPP participating retailer sales data (67%).

Table A-25: 2016 California Consumer Survey Room Air Conditioner Purchase and Intention Rates

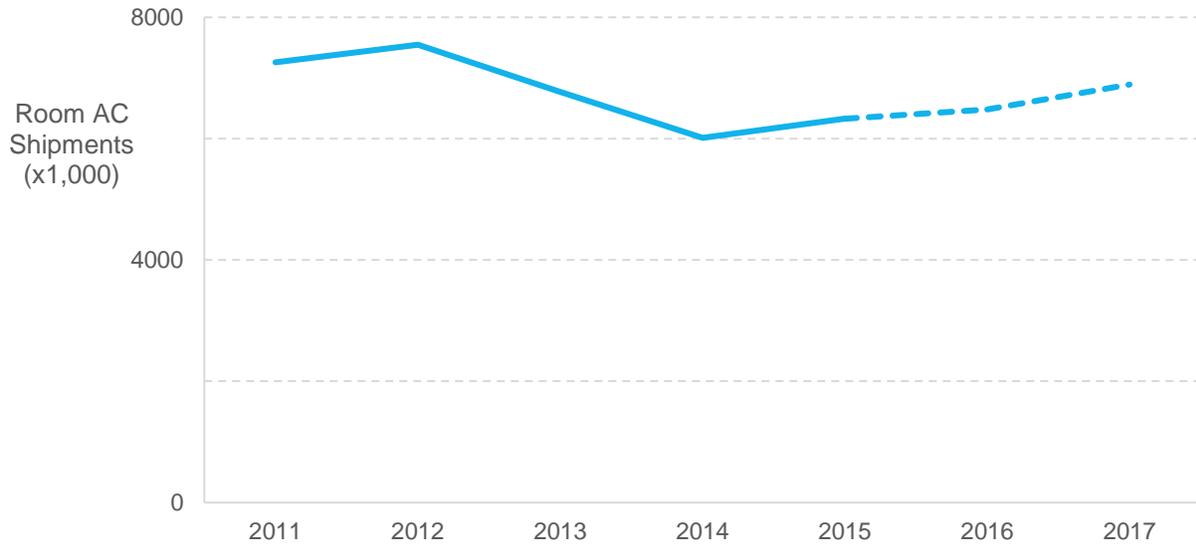
Rates	Total n=1,570
Recent purchase rate	27%
(Purchased used)	(5%)
<i>ENERGY STAR rate</i>	71%
Market penetration rate	50%
Purchase intention rate	9%

Note: Recent purchase rates include both new and used equipment purchases in the last 24 months, (%) indicates used equipment portion. Purchase intention measures intention of future purchase in the next 24 months.

Room air conditioner shipments to the U.S. declined between 2012 and 2014, but increased in 2015. Previous market characterizations have found that room air conditioner sales are sensitive to weather.²¹² Weather may play a role in the decline in sales in 2013 and 2014. In the continental U.S., the summers of those years were, on average, the coolest of the five-year period.²¹³ Nonetheless, as Figure A-33 suggests, most room air conditioners are shipped to retailers in the spring. As a result, shipment data are likely less responsive to temperature than sales data would be.

²¹² "Room Air Conditioners: 2007 Partner Resource Guide."

²¹³ "Climatological Rankings," NOAA National Centers for Environmental Information, accessed September 12, 2016, <https://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/index.php>.

Figure A-33: Annual Room Air Conditioner Shipments to the U.S.

Room air conditioner sales are projected to continue to increase steadily through 2020. As Figure A-33 shows, room air conditioner shipments are projected to continue to increase steadily through 2016 and 2017. Analysts predict that North American air conditioner shipments overall, including window units as well as other types, will grow at an annual rate of 5.3% between 2014 and 2020.

Analysts predict that energy efficiency and environmental benefits will drive industry growth. As air conditioner technologies improve and become more energy efficient and as refrigerants that are less toxic and have lower global warming potential come on the market, analysts anticipate that these benefits will increase demand for new air conditioners. Analysts expect that government and non-profit awareness-raising efforts will help build this demand.²¹⁴

²¹⁴ "North America Air Conditioning Systems Market Analysis," *Grand View Research*, May 2014, <http://www.grandviewresearch.com/industry-analysis/north-america-air-conditioning-systems-market>.

A.6. Room Air Purifiers

A.6.1. Product Description

Room air purifiers, sometimes referred to as room air cleaners, are appliances that primarily function to remove pollutants from the air. Unlike whole-house air purifiers, room air purifiers are portable and can be easily moved from room to room. One key performance metric associated with room air purifiers is the clean air delivery rate (CADR). The CADR provides a measure of an air purifier's capability for filtering out three airborne pollutants: dust, pollen, and smoke. Air purifiers receive a separate CADR for each type of pollutant. The CADR is directly related to the type and size of the filter used by the air purifier. Portable air purifiers generally use one or a combination of the following types of filtration systems:²¹⁵



- › **Mechanical filtration on fibrous medium:** Most widely used filtration method. The filter medium is made of fibers that remove particles from air that passes through the medium.
- › **Electrostatic precipitation:** A two-part system where particles passing through the purifier are electrified before passing between metal plates which attract the electrified particles.
- › **Adsorption:** An absorbent medium is used to absorb gaseous substances onto its surface through chemical reactions.
- › **Photocatalysis:** An ultraviolet (UV) source is used to eliminate gaseous molecules and microorganisms, such as organic compounds (VOCs).
- › **Plasma:** Used to remove molecules and gasses from the air. Uses high voltage to ionize the air which destroys pollutants.

The performance of a room air purifier is based on the air flow rate, the number of air changes per hour (ACH), and the amount of pollutants removed from the air. The air flow rate indicates the volume of air passing through the air purifier over a period of time. The air flow rate and CADR of a room air purifier is measured in cubic feet per minute (CFM) and is dependent on the power of the fan in the unit and the efficiency of the air filter. The ACH indicates how many times the entire volume of air inside a room is replaced during one hour. The number of changes usually varies anywhere between one and seven. The CADR value indicates the air filter's ability to remove all pollutant particles and is expressed in CFM. Air purifiers that have higher ACH and CADR values are generally more desirable, but are often more expensive.²¹⁶

²¹⁵ International Energy Agency, "Development and Evaluation of a New Test Method for Portable Air Cleaners." http://www.aivc.org/sites/default/files/members_area/medias/pdf/CR/CR15_New%20test%20method%20for%20portable%20air%20cleaners.pdf

²¹⁶ Plenty Air, "Air Flow, Performance and Air Changes per Hour." <http://www.plentyair.com/performance/>

The Association of Home Appliance Manufacturers (AHAM) ensures product design specifications and verifies energy usage of room air purifiers. AHAM is principally responsible for testing air purifiers to ensure they perform according to the manufacturer's product claims for suggested room size and the CADR for tobacco smoke, dust, and pollen.²¹⁷ AHAM's tests determine the recommended room size and the CADR values that are listed on product packaging. AHAM maintains a publicly accessible database of room air purifier models produced by manufacturers participating in the AHAM Verifide verification program. As of September of 2016, this database listed 379 room air conditioner models from 48 brands.

In addition to testing the CADR and recommended room size, AHAM also verifies energy consumption of air purifiers for ENERGY STAR designation.²¹⁸ The current ENERGY STAR specification (Version 1.2) for room air purifiers requires an efficiency level for dust particles of 2.0 CADR per watt (CADR/W) or less and a standby power rating of less than 2.0 watts. In addition to power consumption, the current ENERGY STAR specification also requires that air purifiers meet the Underwriters Laboratory Safety Standard 867 for ozone emissions which establishes 50 parts per billion as the maximum safe limit for air purifier ozone emissions.

A.6.2. Supply Chain

The Association of Home Appliance Manufacturers (AHAM) maintains a database of room air conditioner models produced by manufacturers participating in the organization's AHAM Verifide verification program. As of August 29, 2016, this database listed 379 air purifier models from 48 brands.

A.6.2.1. Manufacturers

Production of air purifiers appears to be spread out across several manufacturers, except for one manufacturer which appears to have the highest market share. According to PG&E's RPP Program Theory and Logic Model, there are 11 manufactures, 21 brands, and 8 ENERGY STAR partners for air purifiers on the market in PG&E territory.²¹⁹ Nationally, AHAM Certified data shows that there are about 48 air purifier brands with the majority (75%) having at least one ENERGY STAR qualified model. According to RPP program sales data, between March and September of 2016, one manufacturer, Honeywell, accounted for over half of room air purifier sales in PG&E territory (Figure A-34). Honeywell also produces the most air purifier models nationally, consisting of 30% of the air purifier models in the AHAM database.²²⁰ The remaining brands in the AHAM database consisting of less than 10% of models each with a range from <1% - 7% and an average of 1% of air purifier models. Honeywell also has the greatest number of room air conditioner models in the ENERGY STAR qualified product list (10%), followed closely by Blueair (10%) and Winix (8%).²²¹ In addition, RPP sales data shows that a large

²¹⁷ AHAM, "Room Air Cleaners." <http://ahamverifide.org/search-for-products/room-air-cleaners/>

²¹⁸ <https://www.energystar.gov/ia/partners/downloads/AHAM-Messner.pdf?38cf-3ac1>

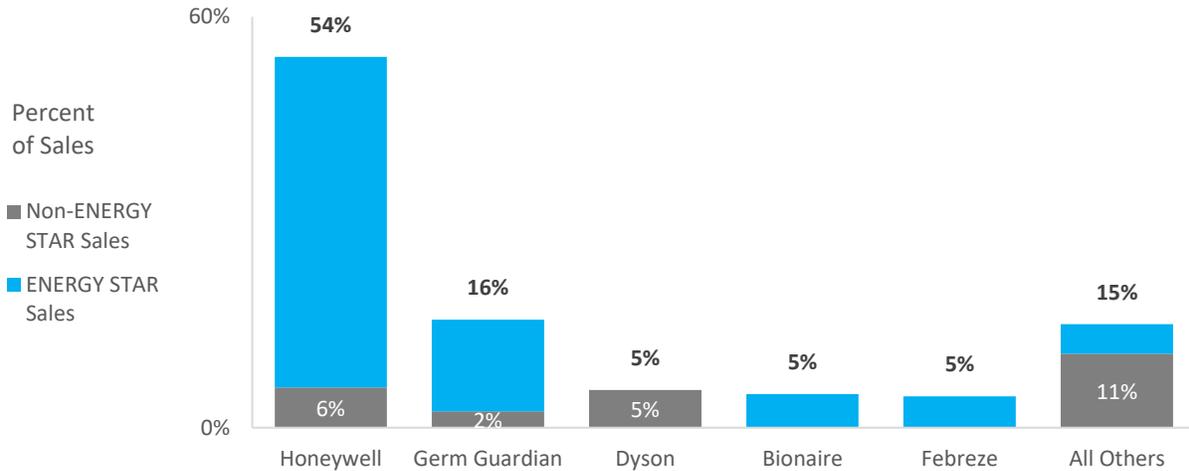
²¹⁹ Program Theory and Logic Model for the PG&E 2016 Retail Product Platform (RPP) Program

²²⁰ AHAM, "Room Air Cleaners." <http://ahamverifide.org/search-for-products/room-air-cleaners/>

²²¹ ENERGY STAR Qualified Product List, 2016

majority of Honeywell models sold in PG&E service territory were ENERGY STAR qualified models (48% of total air purifier sales of 89% of sales for the brand).

Figure A-34: Room Air Purifier Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 15,667)



Source: PG&E RPP Sales Data, March through September 2016.

A.6.2.2. Retailers

Accessible information of the market share for retailers is limited. According to the 2016 California Consumer Survey, consumers most often purchase air purifiers at a big box retail store (41%), followed by online big box stores (19%), and online-only retail stores (18%), and local retail stores (17%). Based on PG&E’s Program Theory and Logic Model, all the ESRPP participating retailers carry air purifiers and these stores make up about 24% of overall market shares (see Table A-26). According to RPP program sales data, between March and September 2016, about half (58%) of program qualified room air purifiers were sold by Home Depot, compared to 39% sold by Best Buy and 3% sold by Sears.

Table A-26: Market Shares of All Air Purifier Sales, by Participating and Nonparticipating Retailers

Products	Sears Holdings (Kmart & Sears)	Best Buy	Home Depot	Total Market Share of 4 Participating Retailers	Remaining Market Share of Non-Participating Retailers
Air Purifiers	10.5%	3.0%	10.0%	23.5%	76.5%

Source: Program Theory and Logic Model for the PG&E 2016 Retail Product Platform (RPP) Program

A.6.2.3. End-Users

Consumer decision making regarding air purifier purchasing is complex process and energy efficiency plays a marginal role. The type of air purifier purchased is often dependent on the type of air pollutants the consumer is interested in removing and the size of the room. To account for each specification, manufacturers offer a large array of models to consumers. According to a 2012 study conducted by AHAM, about two-thirds of consumers seek information via websites prior to purchasing a room air purifier.²²² Manufacturer websites, followed by websites providing consumer opinions are the two types of websites most frequently visited by potential room air purifier purchasers. Results from the 2016 California Consumer Survey found that air purifier purchasers most often reported the internet as the most influential information source (see Table A-27).

Table A-27: Most Influential Information Source (Among Respondents that Purchased an Air Purifier in the Last Two Years)

Information Source	Total (n = 346)
Internet	34%
Friend or family member	14%
Salesperson at the store	14%
Consumer Report or other product-oriented magazines	9%
Electric or gas utility	8%
Advertisement	5%
Contractor	3%
Other	1%
Didn't seek information	10%
Don't know	1%
Total	100%

Source: 2016 California Consumer Survey

Further, about two-fifths of air purifier purchasers report that energy efficiency as being “very important” in their purchasing decision.²²³ Similarly, the 2016 California Consumer Survey found two-fifths (42%) of air purifier purchasers reported that energy consumption was a “high priority” in their selection of the purchased model. Efficiency, however, ranks behind the ease of use, cost, rated room cleaning size, and the CADR.²²⁴ This was also consistent with results from the 2016 California Consumer Survey, which found that respondents most often reported cost (44%), performance (42%), as indicated

²²² AHAM, “Air Cleaners: Big Savings Opportunities in Small Market Appliances.” <https://www.energystar.gov/ia/partners/downloads/AHAM-Messner.pdf?38cf-3ac1>

²²³ Ibid.

²²⁴ Ibid.

by reviews, and existence of ENERGY STAR label (37%) as their reasons for selecting the purchased model (see Table A-28).

Table A-28: Reasons for Purchasing Selected Model (Among Respondents that Purchased an Air Purifier in the Last Two Years)

Reason	Total (n = 346)
It was in my price range	44%
It had good reviews	42%
It had an ENERGY STAR label	37%
It had the features I wanted	36%
It was available	28%
It was recommended to me	23%
I wanted the brand	22%
It costs less to operate	21%
Other	1%

Source: 2016 California Consumer Survey

The largest segments of air purifier buyers are households with two or more adults and no children, and they commonly purchase their air purifiers to alleviate allergies. According to a study conducted by the Stevenson Company in 2012, about half of consumers who purchase room air purifiers come from households of two or more adults living in the home with no children (Table A-29).²²⁵ Additionally, the study found that reducing allergens in the air was the most common reason for purchasing air purifiers, closely followed by reducing dust in the home (61% and 59%, respectively; multiple responses allowed).

Table A-29: Consumer Household Makeup Among Those Who Purchase Air Purifiers

Household Makeup	Percent
Two or more adults, no children	46%
Single adult	26%
Two or more adults with children	25%
Single Adult with children	3%
Total	100%

²²⁵ Wright, "Big Savings Opportunities in Small Market Appliances: The Air Purification Market."

A.6.3. Energy Efficiency

A large proportion of room air purifiers sold by RPP participating retailers are ENERGY STAR qualified. RPP program sales data shows that between March and September 2016 three-quarters (75%) of air purifiers sold at participating retailers in PG&E territory were ENERGY STAR qualified models. Of those sales, about one-quarter (26%) exceeded the current ENERGY STAR specification by 30%. Additionally, of the ten manufacturers who sold 50 or more room air purifiers in PG&E’s service territory, half had 80% or more of their sales consisting of ENERGY STAR qualified models.

Nearly all air purifier models on the ENERGY STAR qualified product list exceed the current specification. Of the 191 models on the ENERGY STAR list nearly all (96%) have a dust CADR/W rating that exceeds the current ENERGY STAR specification. Among those models that exceed the current ENERGY STAR specification, about half (45%) exceed the current specification by 50% (Table A-30). Another component of the current ENERGY STAR specification is having a standby power rating of less than two watts. On average, current ENERGY STAR qualified models use 0.6 watts of standby power with over two-thirds (69%) of models using less than one watt.

Table A-30: Proportion of ENERGY STAR Qualified Models Exceeding Specification (n= 191)

Proportion Exceeding Specification (Dust CADR/W)	Count	Percent
<15%	32	17%
15%	159	83%
30%	122	64%
50%	85	45%
75%	58	30%
90%	51	27%

Source: ENERGY STAR Qualified Product List, 2016.

Data on room air purifier energy use is limited, but does suggest an overall decrease in energy usage. A 2010 metering study of plug load appliances in Minnesota homes measured energy consumption of room air purifiers.²²⁶ However, only four air purifiers were included in this study’s sample, and the data reported did not provide sufficient detail to determine CADR/W values. The Minnesota study estimated the average annual energy usage of the room air purifiers it tested to be 54.7 kWh/year, considerably lower than 2002 baseline estimates conducted for the EPA, which ranged from 250 to 1641 kWh/year based on air purifier capacity (Table A-31).²²⁷

²²⁶ Energy Center of Wisconsin, “Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes.”

²²⁷ Fanara, Andrew (2003), “ENERGY STAR & Air Cleaners.”
https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/air_cleaners/AirCleanersatIHS-Presentation-Final.ppt

Table A-31: EPA 2002 Air Purifier Energy Usage Assumptions

CADR	Baseline UEC (kWh/yr)	ENERGY STAR UEC (kWh/yr)
0-50	250	73
51-100	596	322
101-150	1072	519
151-200	1480	756
201-250	1887	993
Over 250	1641	1251

Source: Fanara 2003

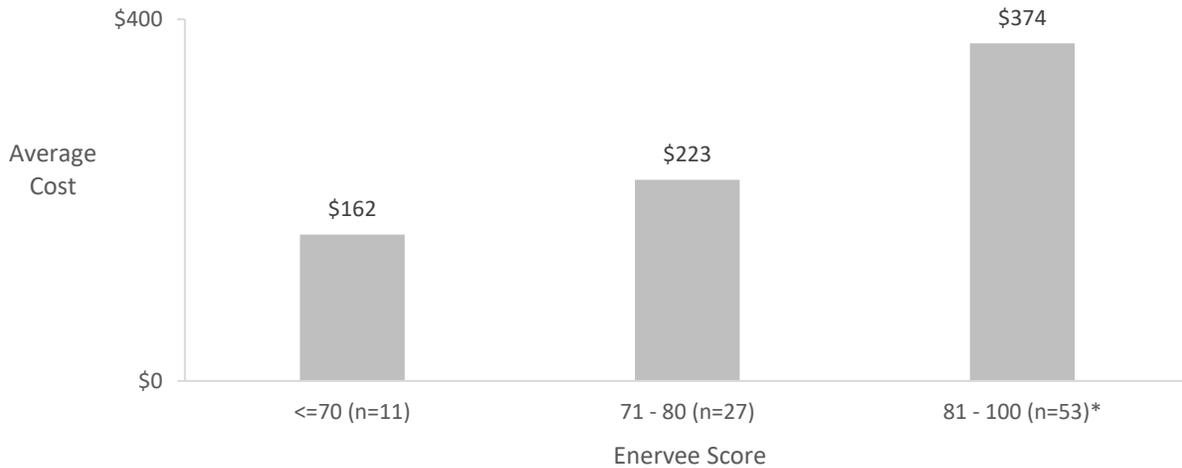
Research suggests that room air purifiers are operational for approximately eight hours per day. Two studies suggest that, on average, air purifiers are in use between 12.5 and 13.6 hours per day during the times when they are used.²²⁸ However, while most consumers operate their air purifier year-round (71%-75%), some use air purifiers only during allergy season. In addition, while most users operate their air purifiers every day, some use them less frequently. Overall, the findings from the two studies suggest that air purifiers are in use an average of between 56% and 65% of the year. Applying these proportions to the daily usage estimates yields a year-round average daily usage of between 7.6 and 8.1 hours.

Higher efficiency ratings are correlated with higher cost of air purifiers. Analysis of Enervee data showed a significant increase in average cost among air purifiers in with higher (81-100)²²⁹ efficiency ratings (see Figure A-35).²³⁰ Model data showed that cost and efficiency rating were positively correlated (Pearson Correlation .476, $p < .01$.) However, it should be noted that this is across all air purifiers with varying features and capacities.

²²⁸ AHAM, "Report to California Energy Commission: Analysis of Energy Efficiency of Room Air Cleaners"; Davis Energy Group, "Draft Analysis of Standards Options for Portable Room Air Cleaners."

²²⁹ The Energy Cost for Air Purifiers is calculated based on hours of daily usage and your local electricity rate.

²³⁰ Enervee Air Purifiers (2016). Retrieved from <https://enervee.com/air-purifiers/>

Figure A-35: Average Cost of Air Purifiers at Various Efficiency Levels

* Differences are significant, $\alpha < .05$

There is a lack of energy use differentiation in product marketing. Consumers are faced with substantial variety in room air purifiers which have numerous features and specifications to consider when making a purchasing decision. Additionally, the efficiency metric (CADR/W) is not generally used in marketing the products and the ENERGY STAR designation is not regularly used in marketing materials.²³¹

A.6.4. Sales Trends

Market penetration of room air purifiers in households is relatively low. In 2012, about one in ten U.S. households had a room air purifier.²³² According to the 2009 Residential Appliance Saturation Study (RASS), fewer than one in ten households (7%) in California had a room air purifier.²³³ Room air purifier penetration was fairly consistent across IOUs, with PG&E having 8% penetration and SCE and SDG&E having 6% and 7% penetration, respectively. According to the 2016 California Consumer Survey, about one-fifth (22%) of respondents had purchased an air purifier in the past two years and about one-tenth (11%) plan to purchase (Table A-32).

²³¹ Research Into Action (2015), Residential Solutions Workbook (Phase II). http://www.calmac.org/startDownload.asp?Name=Air_Cleaners_RSW_II_6-15-15_FINAL.xlsx&Size=131KB

²³² AHAM, "Air Cleaners: Big Savings Opportunities in Small Market Appliances." <https://www.energystar.gov/ia/partners/downloads/AHAM-Messner.pdf?38cf-3ac1>

²³³ RASS 2009, "2009 California Statewide Residential Appliance Saturation Study." <https://webtools.dnvgl.com/rass2009/Default.aspx>

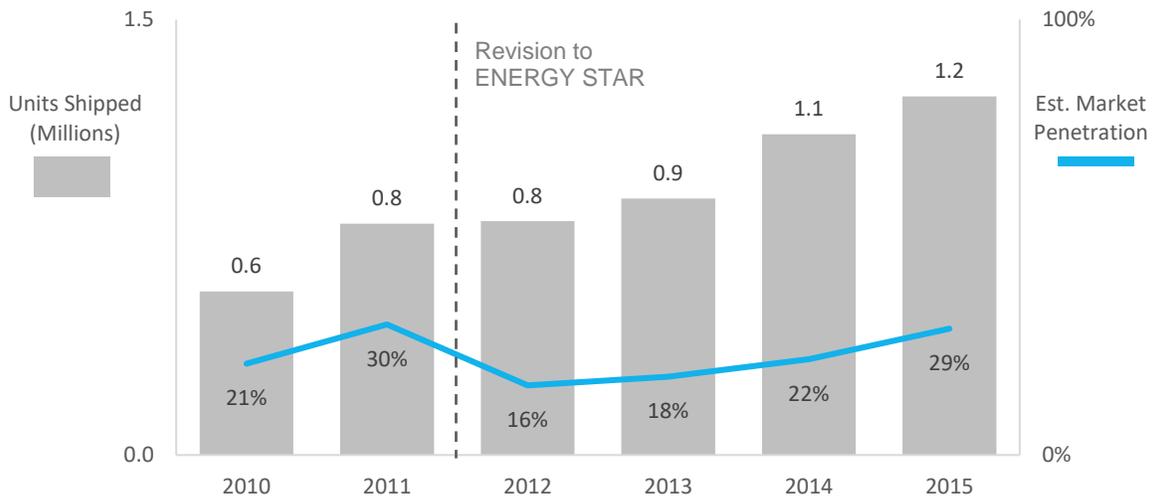
Table A-32: 2016 California Consumer Survey Air Purifier Purchase and Intention Rates

Rates	Total n=1,570
Recent purchase rate	22%
(Purchased used)	(4%)
ENERGY STAR rate	66%
Market penetration rate	34%
Purchase intention rate	11%

Note: Recent purchase rates include both new and used equipment purchases in the last 24 months, (%) indicates used equipment portion. Purchase intention measures intention of future purchase in the next 24 months.

Penetration of ENERGY STAR certified air purifiers remains low, but there are discrepancies between ENERGY STAR and AHAM data. In 2015, about one-third (29%) of air purifiers shipped to the United States were ENERGY STAR qualified (Figure A-36). The market penetration of ENERGY STAR qualified models has increased steadily since the revised ENERGY STAR specification (Version 1.2) went into effect in July of 2011. The proportion of models in the AHAM database listed as ENERGY STAR qualified (62%) is nearly twice ENERGY STAR’s estimate of market penetration in 2015. The AHAM database does not include sales data. Thus, this discrepancy likely reflects either disproportionate sales of non-qualified air purifier models, which could occur if these are designed to be high volume, low cost products, or a notable number of air purifier models not being submitted to the voluntary, AHAM Verifide program.

Figure A-36: Unit Shipments and Market Penetration of ENERGY STAR Air Purifiers, 2010-2015

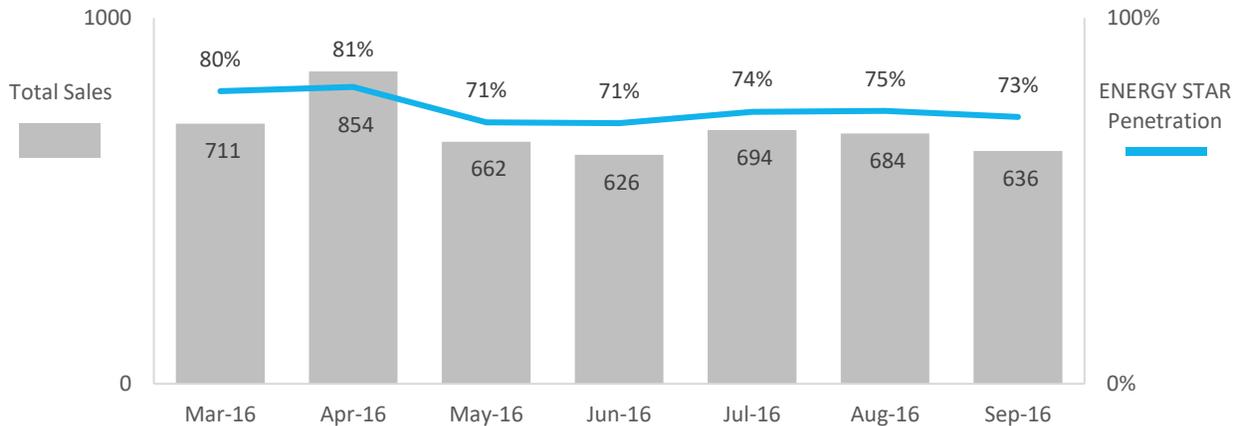


Note: The drop-in market penetration between 2011 and 2012 is likely due to a revision to the ENERGY STAR specification in 2011.

Source: ENERGY STAR Unit Shipment Data Reports, 2010-2015.

Penetration of ENERGY STAR models in PG&E’s service territory is high and has remained relatively stable since the RPP program rolled out in March of 2016. Between March and September 2016 4,867 room air purifiers were sold at participating retailers in PG&E service territory, or about 700 per month (Figure A-37). Overall, about three-quarters (75%) of models sold were ENERGY STAR qualified, which remained relatively consistent from month to month.

Figure A-37: Air Purifier Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR penetration, March through September 2016 (n = 4,867)

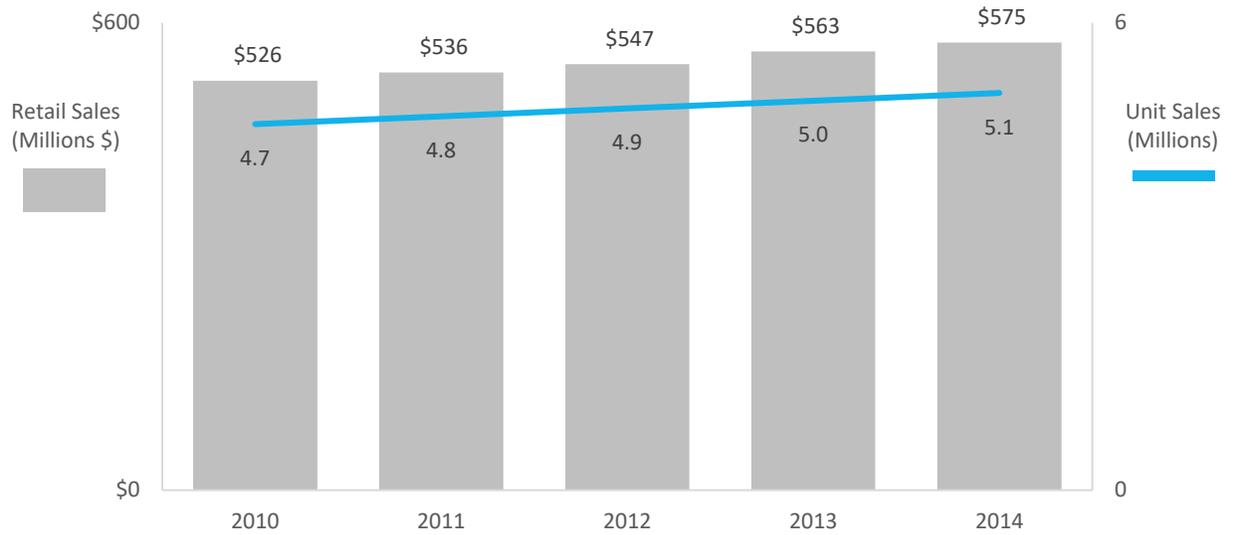


Source: PG&E RPP Sales Data, March through September 2016.

Continued growth in the air purifier market in the coming years is expected due to increasing consumer concern for indoor air quality. Retail sales of air purifiers have grown from approximately 4.7 million units sold in 2010 to 5.1 million units sold in 2014 (Figure A-38). In 2014, air purifier sales in the United States totaled \$575 million. Analysts anticipate the market for room air purifiers will continue to grow between 2015 and 2020.²³⁴ The growth in the air purifier market is largely due to concerns from consumers regarding air contamination.

²³⁴ TechSci Research, “United States Air Purifiers Market Poised to Grow at 10% CAGR by 2020.”

Figure A-38: Retail Sales and Unit Sales of Air Purifiers in the United States, 2010-2014



Source: Statista, 2014.

A.7. Soundbars

A.7.1. Product Description

A soundbar is a compact active-loudspeaker unit with a built-in amplifier, multiple drivers and integrated audio decoding and processing.²³⁵ It is comprised of a special loudspeaker enclosure that generates sound from a single cabinet and array of drivers. Soundbars were originally designed to take advantage of the growing popularity of flat-panel TVs,²³⁶ which typically have low-quality audio playback. As a result, soundbars must give consumers a perceived measure of performance improvement compared to the TV audio quality. To achieve this, a soundbar must have a power output of at least 15 watts per channel for stereo (2.1 channel) configurations to compete with HDTVs, which typically offer 10 watts per channel.²³⁷ Mid-range models typically offer a 3.1 channel or higher configuration with at least 45-90 watts total power output. Typically, mid-range models also offer a separate, wireless, powered subwoofer, which can have output ranging from 50 up to 250 watts.²³⁸ In addition to improving TV sound, most soundbars seek to add further value by incorporating other audio features that require post-processing capability (DSP). Examples of these technologies include; virtual surround-sound decoding, multiband parametric equalization as well as automated audio-leveling.²³⁹



To blend seamlessly with current HDTV designs, soundbars must have, at minimum, a stereo analog interface and optical audio or HDMI inputs and outputs. A soundbar's compact structure eliminates the need for a multitude of external cables, which makes for an easy set-up. Most consumers match the width of their flat panel TV to the soundbar. Like other consumer audio products, soundbars typically have a slim form factor, straight lines, symmetrical shapes, and neutral colors, which allows for affordable production and ease of reproduction.

While soundbars were developed to improve TV sound quality, one study found that 55% of soundbar owners use their soundbar for music or other audio content, in addition to using it while they watch TV.²⁴⁰ Supporting this expanded soundbar usage, wireless streaming capability is a key soundbar feature

²³⁵ David Grant, "Soundbars: A Market Overview and Design Considerations" (Cirrus Logic, Inc., 2009).

²³⁶ Jeff Berman, "Is the Popularity of Soundbars Good or Bad for the Audio Industry?," *HomeTheaterReview.com*, January 25, 2016, <http://hometheaterreview.com/is-the-popularity-of-soundbars-good-or-bad-for-the-audio-industry/>.

²³⁷ Grant, "Soundbars: A Market Overview and Design Considerations."

²³⁸ Ibid.

²³⁹ Ibid.

²⁴⁰ David Riley, "More than Half of Consumers Use Soundbars to Listen to Radio, Music or Podcasts According to NPD," *Millennials Pave the Way for Future Growth and Use*, 2015, <https://www.npd.com/wps/portal/npd/us/news/press-releases/2015/more-than-half-of-consumers-use-soundbars-to-listen-to-radio-music-or-podcasts-according-to-npd/>.

that has been driving recent market growth;²⁴¹ Bluetooth and other wireless technologies are typically integrated with soundbar units, allowing users to connect with their mobile devices, tablets and laptops. The following describes soundbar features in greater detail:

- › **Amplifier:** The type of amplifier within soundbars can play a significant role in determining the device's energy consumption. Because of their slim form factor, soundbars most frequently use Class-D amplifiers.²⁴² Class-D amplifiers, can achieve close to 90% efficiency, losing considerably less energy as heat than the Class A and B amplifiers that component home-audio products have traditionally used, which are up to 50% efficient. This allows manufacturers to eliminate the aluminum heat sinks that other types of amplifiers require. As a result, Class-D amplifiers take up less space than other types, which has led to their use in devices like soundbars, as well as car and portable audio devices, that must incorporate a great deal of functionality in a single unit.²⁴³ Some audio enthusiasts criticize Class-D amplifiers for providing lower sound quality.
- › **Bluetooth** The majority (80%) of soundbar units have Bluetooth capability.²⁴⁴ Bluetooth capability allows the soundbar system to be controlled by a proprietary mobile app and/or play content wirelessly using streaming applications such as Spotify and SoundCloud.²⁴⁵
- › **Wi-Fi:** Wi-Fi capability is similar to Bluetooth; however, it enables the soundbar to access streaming services directly without the use of a mobile device.²⁴⁶
- › **High-definition multimedia interface (HDMI):** HDMI inputs enable the soundbar to communicate with the TV, allowing the user to switch between source components. Audio Return Channel (ARC) or HDMI output enables a TV to send audio back to the soundbar, allowing for a single connection.²⁴⁷
- › **Dolby Digital/Digital Theater Systems (DTS):** Dolby Digital is a system of stereophonic sound involving three or more speakers. Many systems today utilize 'virtual surround sound' technology, enabling manufacturers to create an immersive sound effect from a single array of speakers in one location. Dolby Digital formats are the industry standard, discrete multichannel surround sound formats.²⁴⁸

²⁴¹ TechNavio, "Research and Markets: Global Soundbar Market 2015-2019" (Research & Markets, 2015), http://www.researchandmarkets.com/research/2x222l/global_soundbar.

²⁴² Grant, "Soundbars: A Market Overview and Design Considerations."

²⁴³ Research Into Action and EMI, "Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE)" (Research Into Action, 2012).

²⁴⁴ Berman, "Is the Popularity of Soundbars Good or Bad for the Audio Industry?"

²⁴⁵ Mathew Moskovciak, "Soundbar Buying Guide: What You Need to Know," *CNET*, 2013, <https://www.cnet.com/news/sound-bar-buying-guide-what-you-need-to-know/>.

²⁴⁶ Ibid.

²⁴⁷ Ibid.

²⁴⁸ Tracy Wilson, "How Virtual Surround Sound Works" (HOW STUFF WORKS, 2015), <http://electronics.howstuffworks.com/virtual-surround-sound.htm>.

- › **Subwoofer:** The majority (71%) of soundbar units have subwoofers.²⁴⁹ Many soundbar systems include a wireless subwoofer to capture low-end frequencies (<200 Hz).
- › **Digital Signal Processing (DSP):** DSP capabilities allow the user to adjust the output spectrum of a stereo system to most closely match the spectrum of the audio content's source.²⁵⁰ DSP capabilities are becoming less pervasive in soundbars as streaming services like Spotify expand their signal processing capabilities, thus reducing the need to adjust stereo systems to their content.²⁵¹
- › **Power output:** Power output is the electrical power transferred from an audio amplifier to a loudspeaker, measured in watts. The electrical power delivered to the loudspeaker, together with its sensitivity rating, determines the sound power level generated.²⁵² The RMS power metric is the standard for consumer audio, although multiple metrics for measuring amplifier power output exist, and product descriptions listing 'output wattage' or 'power output' may not specify the metric used.²⁵³ Although it is often featured in manufacturer marketing materials, higher power output does not necessarily translate to a better product or high-quality playback.²⁵⁴ A soundbar's power output also does not determine the unit's energy use; amplifiers vary in the amount of input power lost as heat, and variables like the listening volume and signal dynamics impact speaker energy use.^{255, 256} Most mid-range soundbars have an RMS power outputs in the range of 50-250 watts (including external subwoofer).

A.7.2. Supply Chain

A.7.2.1. Manufacturers

The leading soundbar manufacturers include companies best known for producing TVs, rather than audio products. Samsung was the U.S. soundbar market-share leader in revenue from November 2014 to October 2015, while VIZIO led in unit shipments (Table A-33).²⁵⁷ While they have been leading TV manufacturers, Samsung, VIZIO, and LG (ranked fifth for soundbar revenue share and fourth for

²⁴⁹ Joseph Palenchar, "Soundbar Sales Get Clubbed In Q1," *TWICE*, 2015, <http://www.twice.com/news/statistics/soundbar-sales-get-clubbed-q1/57420>.

²⁵⁰ Moskovciak, "Soundbar Buying Guide: What You Need to Know."

²⁵¹ Ibid.

²⁵² Roy Lewallen, "RMS Power" (W7EL, 2009), http://www.eznec.com/Amateur/RMS_Power.pdf.

²⁵³ Paul Quillen, "What's RMS Power or RMS Watts?" (N4LCD, 1993), <http://www.n4lcd.com/RMS.pdf>.

²⁵⁴ Apse, Will. 2015. *Speaker Watts, Sound Quality, and Loudness Explained*. November. <https://spinditty.com/instruments-gear/Speaker-Watt>.

²⁵⁵ Bryan Urban and Victoria Shmakova, "Energy Consumption of Consumer Electronics in U.S. Homes in 2013" (Fraunhofer USA, 2014), <https://www.cta.tech/CTA/media/policyImages/Energy-Consumption-of-Consumer-Electronics.pdf>.

²⁵⁶ TJ Cornish, "Understanding Power Consumption," *Thomas Cornish Consulting*, 2014, <http://tjcornish.com/articles/understanding-power-consump.html>.

²⁵⁷ Berman, "Is the Popularity of Soundbars Good or Bad for the Audio Industry?"

shipments) have not traditionally been known for producing audio products. In part, this may reflect deep discounts or even free soundbars that these manufacturers offer to consumers who purchase their TVs.²⁵⁸ Nonetheless, analysts suggest that soundbars may provide these companies with an opportunity to expand into the home audio market. Traditional home audio manufacturers have been less successful in the soundbar market.²⁵⁹

Table A-33: Leading Soundbar Manufacturers

Manufacturer	Rank (Nov. 2014 – Oct. 2015)		Produce ENERGY STAR Soundbars
	Revenue	Units	
Samsung	1	2	Yes
VIZIO	2	1	Yes
Bose	3	Not Ranked	No
Sony	4	3	No
LG	5	4	No
iLive	Not Ranked	5	No

The development timeline for home audio products is 6 to 12 months, depending on the complexity of the product. As a result of the high level of technological change in the A/V industry, home audio products generally have relatively short life cycles as manufacturers engage in continuous design and development efforts.²⁶⁰ Analysts anticipate that this cycle may lengthen somewhat as wireless technology improves, and greater acceptance of wireless technologies leads to growth in demand. As a result, soundbar manufacturers may shift their focus from development to scaling.²⁶¹

The soundbar market is made up of many different manufacturers. RPP program sales data show that there are 20 manufacturers who sold soundbars in PG&E territory between March and September 2016. Samsung accounted for the largest share of soundbar sales, followed by Sony, Bose, LG, and Vizio (Figure A-39). Samsung had the largest share of ENERGY STAR sales, with 29% of total soundbar sales of 88% of sales for the brand. Additionally, all soundbar models manufactured by Vizio were ENERGY STAR qualified. No soundbar models manufactured by Sony, Bose, or LG were ENERGY STAR qualified.

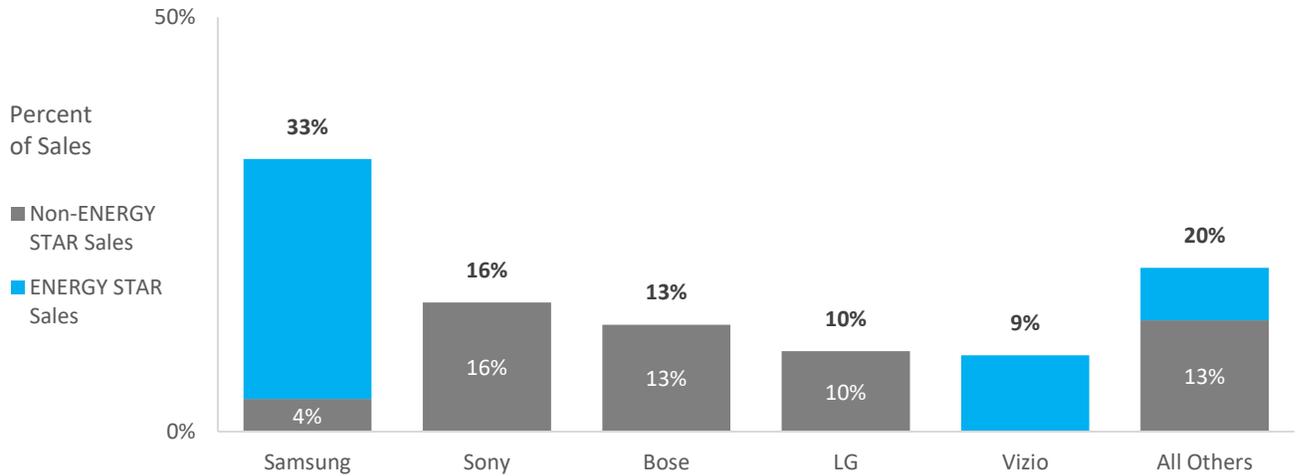
²⁵⁸ Ibid.

²⁵⁹ Ibid.

²⁶⁰ Edward Rivera, "IBISWorld Industry Report: Audio & Video Equipment Manufacturing in the US" (IBISWorld, 2016).

²⁶¹ Fredi Fernandez, "SONOS Strategic Analysis" (Alpha Origins, 2015), http://www.alphaorigins.com/AO/reports/20140801_SONOS_strategic_report.pdf.

Figure A-39: Soundbar Sales in PG&E Service Territory by Manufacturer, March through September 2016 (n = 18,974)



Source: PG&E RPP Sales Data, March through September 2016.

A.7.2.2. Retailers

Best Buy and Amazon are the largest home audio equipment retailers. Together, the two companies accounted for nearly one-fourth (23%; 16% Amazon, 7% Best Buy) of industry market share in 2015. RPP sales data show that about three-quarters (73%) of program qualified soundbars were sold through Best Buy between March and September of 2016. According to the statewide consumer survey, consumers most often (42%) reported purchasing soundbars from big box retailers (see Table A-34).

Table A-34: Purchase location

	Total (n = 312)
At a big box retail store	42%
An online-only retail	19%
An online big box store	17%
A local retail store	17%
Other	2%
Don't know	3%
Total	100%

Source: 2016 California Consumer Survey

A.7.2.3. End-Users

Table A-35: Most Influential Data Source

	Total (n = 380)
Internet	33%
Salesperson at the store	18%
Friend or family member	14%
Consumer Report or other product-oriented magazines	8%
Advertisement	7%
Electric or gas utility	6%
Contractor	3%
Other	1%
Didn't seek information	7%
Don't know	2%
Total	100%

End users of audio and video equipment choose products based on performance, technical differences and brand identification. High-income customers who are typically knowledgeable about the latest technological trends tend to purchase products newly introduced to the market. Throughout the market, many consumers associate quality with certain brand names.²⁶²

Smart features, styling, immersive sound and wireless connectivity have supplanted power output as a focus of audio equipment advertising. Power output as a marketing tactic has been steadily declining. Many audio enthusiasts consider claims about power output to be a marketing ploy by audio equipment manufacturers. In 1974 the FTC implemented stricter rules on advertising power of audio systems due to the “wild abuse of output ratings” which had been based on a variety of rating standards that did not reflect the actual power output.²⁶³ According to the statewide consumer survey, the minority of soundbar purchasers (22%) consider the ENERGY STAR label when selecting a soundbar model (see Table A-36). One quarter (25%) of soundbar purchasers rated energy use as a “high priority” when making their purchase decision.

²⁶² Rivera, “IBISWorld Industry Report: Audio & Video Equipment Manufacturing in the US.”

²⁶³ Federal Trade Commission, “Trade Regulation Rule Relating to Power Output Claims for Amplifiers Utilized in Home Entertainment Products; Final Rule,” n.d.

Table A-36: Reasons for Selecting the Purchased Model (Multiple Choice)

	Total (n = 380)
It was in my price range	46%
It had good reviews	39%
It had the features I wanted	39%
I wanted the brand	30%
It was available	27%
It was recommended to me	23%
It had an ENERGY STAR label	22%
It costs less to operate	14%
Other	1%

Soundbar users are generally wealthier and relatively technologically proficient. Consumer research by one soundbar manufacturer found that soundbar buyers most often have household incomes in the range of \$100,000, own smartphones, and are familiar with streaming music platforms. Soundbar buyers are also more likely to be male than female, and are most often between 22 and 55 years old.²⁶⁴

There is little promotion of energy efficiency in the soundbar market. Manufacturers do little to promote the energy efficiency of soundbars, even when they offer models that qualify for ENERGY STAR. This likely reflects a perceived lack of interest in soundbar efficiency on the part of consumers. However, it can also lead to other barriers to the purchase of efficient products, like increased information and search costs for customers interested in purchasing an efficient soundbar.

A.7.3. Energy Efficiency

Soundbars are not subject to minimum efficiency standards, and thus, less data is available about their energy use, particularly the energy use of models not qualified for ENERGY STAR, than is available for other RPP products. In addition, as a relatively new product (achieving widespread adoption in 2013), relatively few energy usage and market saturation studies include soundbars as a distinct device type.

Components other than the amplifier are likely to drive most soundbar energy use. Amplifiers consume relatively little power at low listening volumes, with the greatest gains from efficient amplifiers coming at volumes above 80 dB, which is above the level EPA has identified as the maximum volume to protect against hearing loss (70 dB).²⁶⁵ Other components typically play a larger role than the amplifier

²⁶⁴ Fernandez, "SONOS Strategic Analysis."

²⁶⁵ Benjamin Ealey, Jeff Dols, and Brian Fortenbery, "Efficiency Assessment of Modern Home Audio Equipment," *ACEEE Summer Study on Energy Efficient Buildings*, n.d., <http://aceee.org/files/proceedings/2014/data/papers/9-979.pdf>.

in determining an audio device's energy use at the volume levels at which consumers are likely to use them.²⁶⁶

Inclusion of networking and other advanced features can notably increase the standby power consumption of soundbars. Reflecting this potential, the current ENERGY STAR specification allows an adder of one watt for each active, in-use networking or control protocol and two watts for each active, in-use Wi-Fi or gigabit Ethernet protocol. These adders represent a significant increase over the base allowance of one watt for products without these protocols.

Home audio energy consumption is expected to grow at a slow, but steady rate. According to a 2013 report by the U.S. Energy Information Administration, home audio as a whole (component audio, compact audio, HTIB and soundbars) consumed 17.3 TWh in 2015 and was expected to grow to 18.2 TWh by 2040.²⁶⁷

Almost all soundbars that qualify for ENERGY STAR do so based only on their energy use in sleep mode. Based on the configuration of the device, ENERGY STAR specifies maximum energy consumption levels for soundbars in sleep mode and idle mode as well as a minimum amplifier efficiency level. However, the amplifier efficiency and idle mode requirements apply only to devices that meet certain conditions, which most soundbars do not meet.²⁶⁸ For more than 90% of the soundbar models on the ENERGY STAR qualified products list as of October 13, 2016, (79 of 86 models), the sleep mode energy usage allowance was the only requirement that applied.

Most ENERGY STAR soundbars exceed the sleep mode energy usage requirements by at least 50%. ENERGY STAR provides a base allowance of 1W for sleep mode energy use with adders of 1W for an in-use networking/control protocol with wake capability and 2W for an in-use Wi-Fi or gigabit Ethernet protocol with wake capability. Most qualified soundbars exceed these requirements, with 85% (73 of 86) exceeding the requirement by at least 50%. Further, as Table A-37 suggests, while adding Wi-Fi or gigabit Ethernet protocols increases sleep mode energy use, adding networking/control protocols appears to have little impact on sleep mode energy use.

²⁶⁶ Benjamin Ealy et al., "Efficiency Assessment of Modern Home Audio Equipment" (ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy, 2014).

²⁶⁷ US Energy Information Administration, "Updated Buildings Sector Appliance and Equipment Costs and Efficiencies" (Department of Energy, 2016), <https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf>.

²⁶⁸ Idle mode energy usage requirements do not apply to soundbars with default auto-power down (APD) settings of 30 minutes or less that cannot be disabled or increased beyond 30 minutes. Amplifier efficiency requirements apply only to soundbars for which the amplifier input power at 1/8 of the amplifier's maximum undistorted power output is 20 W or more.

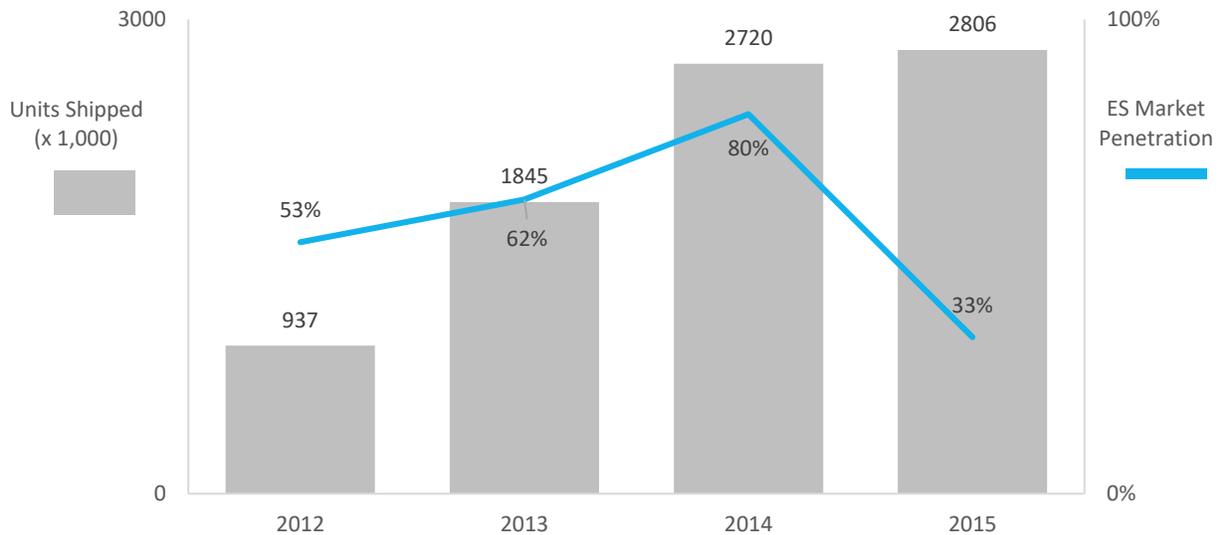
Table A-37: Average Sleep Mode Energy Use of ENERGY STAR Soundbars

Applicable Adders	Count of Models	Total Sleep Mode Allowance (W)	Average Sleep Mode Use (W)
None	40	1	0.47
In-use networking/control protocol with wake capability only	21	2	0.45
In-use Wi-Fi or gigabit Ethernet protocol with wake capability only	18	3	0.64
Both networking/control and Wi-Fi or gigabit Ethernet protocols	7	4	0.63

There is little difference in sleep mode energy consumption between ENERGY STAR soundbars and non-certified models. By matching to the ENERGY STAR qualified products list and the California Energy Commission’s (CEC) Appliance Efficiency Database, we obtained sleep mode energy consumption estimates for 62 of the 146 soundbar models RPP retailers sold in PG&E territory between March and September 2016. These models accounted for 57% of all soundbar sales at participating retailers in PG&E territory during that period. Among these models, there was no meaningful difference in the sales-weighted average sleep mode energy consumption between ENERGY STAR soundbars (0.40 W) and soundbars that were not ENERGY STAR (0.37 W). The CEC database does not provide sufficient detail for these analyses to account for differences in the functionality of soundbar units. It is possible that the ENERGY STAR soundbars are more fully-featured than the non-qualified units. However, it is notable that none of the matched soundbars exceeded even the base ENERGY STAR sleep mode allowance, regardless of any applicable adders.

From 2014 to 2015, the penetration of ENERGY STAR certified soundbars fell by more than half, from 80% to 33%.²⁶⁹ It is not clear what is driving this decrease in ENERGY STAR penetration. Similar drops in penetration are typical following the effective date of a new ENERGY STAR specification, but the current specification has been in place since May 1, 2013. RPP program data are consistent with ENERGY STAR unit shipment data estimates, although RPP data suggest that ENERGY STAR soundbar penetration has increased somewhat through 2016. RPP sales data for March through August 2016 show ENERGY STAR market penetration of soundbars sold by participating retailers in PG&E territory reaching a low of 28% in April before increasing steadily to 48% in August. Approximately 9% of the soundbars ESRPP retailers sold between March and August 2016 met the programs’ qualification levels, with most of those models exceeding the ENERGY STAR specification by more than 50%.

²⁶⁹ US Department of Energy, “ENERGY STAR Unit Shipment and Market Penetration Report, 2015 Summary,” n.d., https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2015_USD_Summary_Report.pdf.

Figure A-40: Unit Shipments and Market Penetration of ENERGY STAR Soundbars, 2012-2015

Few manufacturers offer ENERGY STAR soundbars, and those that offer ENERGY STAR models do little to promote their ENERGY STAR qualification. In early October 2016, ESRPP retailers together offered 158 unique soundbar models from 37 unique brands on their websites. Only six of those manufacturers make a total of 86 soundbar models that qualify for ENERGY STAR. The two leading soundbar manufacturers (Vizio and Samsung) both offer ENERGY STAR units. One of these leading manufacturers includes the ENERGY STAR logo among the product specifications on its product pages for qualified soundbars. The other does not indicate that a given soundbar model is ENERGY STAR qualified on the product page. None of the other manufacturers ranked in the top five for either unit shipments or revenues offer ENERGY STAR models. Consistent with manufacturers' lack of promotion, audio products were among the categories on which respondents in a national survey were least likely to recall having seen an ENERGY STAR label.²⁷⁰

Soundbars may offer greater energy savings opportunities than other audiovisual (A/V) products. The EPA's ENERGY STAR promotional materials claim that ENERGY STAR soundbars are 78% more efficient than standard models, while promotional materials for A/V equipment more generally claim ENERGY STAR products can be up to 50% more efficient than standard models.

Nearly all ENERGY STAR qualified soundbars sold in PG&E service territory are from three manufactures. Between March and September 2016, sales of ENERGY STAR qualified soundbars made up about two-fifths (44%) of total soundbar sales at participating retailers in PG&E service territory. Together, Samsung, Vizio, and Nakamichi accounted for 98% of ENERGY STAR soundbar sales (Table A-38). Additionally, all Vizio models and about half of Nakamichi and Samsung models sold in PG&E

²⁷⁰ EPA Office of Air and Radiation, Climate Protection Partnerships Division, "National Awareness of ENERGY STAR for 2015: Analysis of CEE Household Survey" (Washington DC: U.S. Environmental Protection Agency, 2016), https://www.energystar.gov/index.cfm?fuseaction=home.downloadfile&file=F84267790DF5B5F22EB9D715BC7BEC4F2E6F21C078AD0D8DB716916D20CB04C3778CC40ABE8B9DBF508BE77DAD9A753D5EAA2CFC510D5530702AC176F23ACA67F51939211384A8256F097182F6234B80CC51C3BB639D51552DAB56D4A545B4EC28CA75636445B36DBC1EBCFB00613B4901FD9F2DFC20B85E0A8A1CF8C266ED6C552155DB4A2FA9F326381FE0D89F4D1F&app_code=publications&env_name=other.

service territory (50% and 48%, respectively) were ENERGY STAR qualified – a considerably higher proportion than the average proportion of ENERGY STAR models across all 20 manufacturers (11% on average).

Table A-38: ENERGY STAR Qualified Soundbar Sales in PG&E Service Territory, by Manufacturer

Manufacturer	Total ENERGY STAR Sales	Proportion ENERGY STAR Sales
Samsung	5,491	65%
Vizio	1,744	21%
Nakamichi	999	12%
Polk Audio	200	2%
All Others	0	0%
Total	8,434	100%

Source: PG&E RPP Sales Data, March through September 2016.

The ENERGY STAR specification does not effectively differentiate efficient soundbars. For most soundbar models, the ENERGY STAR specification applies only to the devices' energy consumption in standby mode, and most qualified products easily exceed those requirements. Due to the lack of energy usage studies and other sources of data on the energy usage of non-qualified soundbar models, the efficiency of ENERGY STAR models relative to non-qualified products is not clear. Given the limited promotion of efficiency as a soundbar feature, it is possible that some manufacturers may opt not to go through the process of ENERGY STAR qualification, even if products meet the specifications.

Efficiency and cost of soundbars is not correlated. Based on Enervee data, we found no difference in more efficient soundbars in average cost compared to less efficient soundbars.

A.7.4. Sales Trends

Relatively few California households have external audio devices connected to their TVs. The 2012 CLASS survey found that approximately 5% of California homes with TVs had an external audio device connected to their TV.²⁷¹ This proportion was notably larger for households with flat panel TVs (6%) than for households with cathode ray tube TVs (2%). As noted above, soundbars did not achieve widespread adoption until 2013, and the CLASS survey did not include them as a distinct category. Nonetheless, based on the level of shipments listed in ENERGY STAR unit shipment data for 2012 to 2015, the proportion of California homes with external audio devices connected to their TVs remains unlikely to exceed approximately 12%, and may be considerably lower.²⁷² According to the statewide consumer

²⁷¹ The CLASS survey tracked households with amplifiers (3.6%), sound systems (2.3%), and stereo components (1.6%) connected to their TVs.

²⁷² ENERGY STAR unit shipment data suggest that approximately 8.3M soundbars were shipped to the U.S. between 2012 and 2015. California accounts for 11% of all U.S. households. Thus, assuming soundbar shipments are proportional to population, California likely received approximately 900,000 soundbars in the four-year period. As an upper bound, we assume that none of these shipments replaced the existing external audio devices catalogued in the CLASS survey. Adding 900,000 soundbars to the approximately 650,000 homes with

survey, about one-third (34%) of Californians own a soundbar and 11% plan to purchase one in the next two years. About one quarter (24%) purchased a soundbar in the past two years, and about half (54%) were reportedly ENERGY STAR models (see Table A-39).

Table A-39: Purchase Rates

	Total n = 1,570
Recent purchase rate (used)	24% (4%)
<i>ENERGY STAR rate</i>	54%
Market penetration rate	34%
Purchase intention rate	11%

Note: Recent purchase rates include both new and used equipment purchases in the last 24 months, (%) indicates used equipment portion. Purchase intention measures intention of future purchase in the next 24 months.

Soundbar sales have been growing steadily since the devices were introduced, achieving widespread adoption in 2013, and are expected to continue to grow. Global soundbar sales increased ten-fold in five years, from 1.3 million units sold worldwide in 2010 to 12.9 million units sold worldwide in 2015.²⁷³ Of the total \$16.2bn in revenue for the retail audio market, soundbars are projected to generate around \$2.5bn in revenues by 2017.²⁷⁴ Analysts expect that this growth will continue, with the speaker and soundbar product to hold the largest market share and dominate the Hi-Fi system market between 2016 and 2022.²⁷⁵

Nearly half of soundbars sold in in PG&E's service territory are ENERGY STAR qualified, increasing slightly since the RPP program rolled out in March of 2016. Between March and September 2016 18,974 soundbars were sold at participating retailers in PG&E service territory (Figure A-41). Overall, nearly half (44%) of soundbars sold were ENERGY STAR qualified, which has increased slightly from March to September 2016.

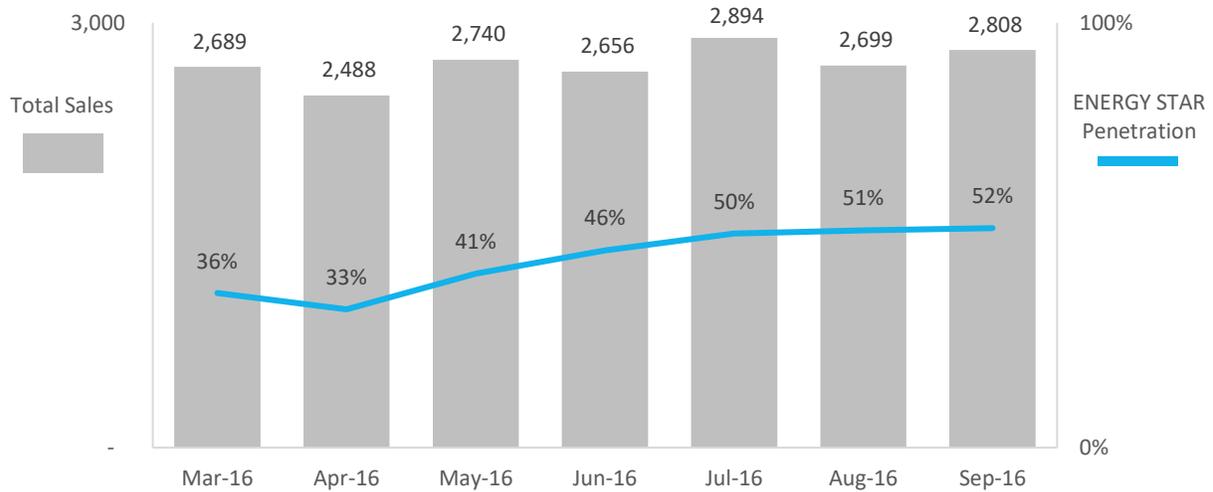
external audio devices indicated by CLASS data yields a total of 1.55M homes with external audio devices, which is 12% of the 12.9M households in California. The actual penetration may be considerably lower as some households with existing external audio devices likely replaced those devices with soundbars.

²⁷³ Statista, "Global Unit Sales of Soundbar Speakers from 2010 to 2015 (in Millions)," 2016.

²⁷⁴ Rivera, "IBISWorld Industry Report: Audio & Video Equipment Manufacturing in the US."

²⁷⁵ Markets and Markets, "Hi-Fi System Market Worth 16.49 Billion USD by 2022," 2016.

Figure A-41: Soundbar Sales at Participating Retailers in PG&E Service Territory and ENERGY STAR penetration, March through September 2016 (n = 18,974)



Source: PG&E RPP Sales Data, March through September 2016.

The increasing popularity of soundbars has both grown the home audio market and taken share from other home audio products. Analysts and retailers report that some end-users purchasing soundbars likely would not have purchased other types of home audio products, due to their cost, complexity, or both. According to an industry journalist, soundbars are “a fairly easy upsell for a good home theater salesperson” that one analyst reported are “bringing in a consumer that was not thinking about home theater before.”²⁷⁶ At the same time, sales of HTiB systems have declined substantially as soundbar popularity has grown, with HTiB revenues falling 41% between November 2014 and October 2015, following a 32% decline the previous year. Audio receiver sales have also declined as soundbar sales have grown, falling 3% in 2015 following a 12% decline in 2014.²⁷⁷

Global soundbar revenue is estimated to grow at a slower rate than volume. The soundbar market is forecast to have a compound annual growth rate of 10.6% in revenue compared to 18.4% in volume over the period from 2014 to 2019 – implying an expected reduction in price over the next three years.²⁷⁸

Manufacturers are redesigning almost all speaker categories to incorporate wireless connectivity in response to rapidly growing consumer demand.²⁷⁹ Reflecting this, soundbar units with streaming capabilities (Bluetooth and/or Wi-Fi) accounted for 83% of 2014 unit shipments.²⁸⁰

²⁷⁶ Berman, “Is the Popularity of Soundbars Good or Bad for the Audio Industry?”

²⁷⁷ Ibid.

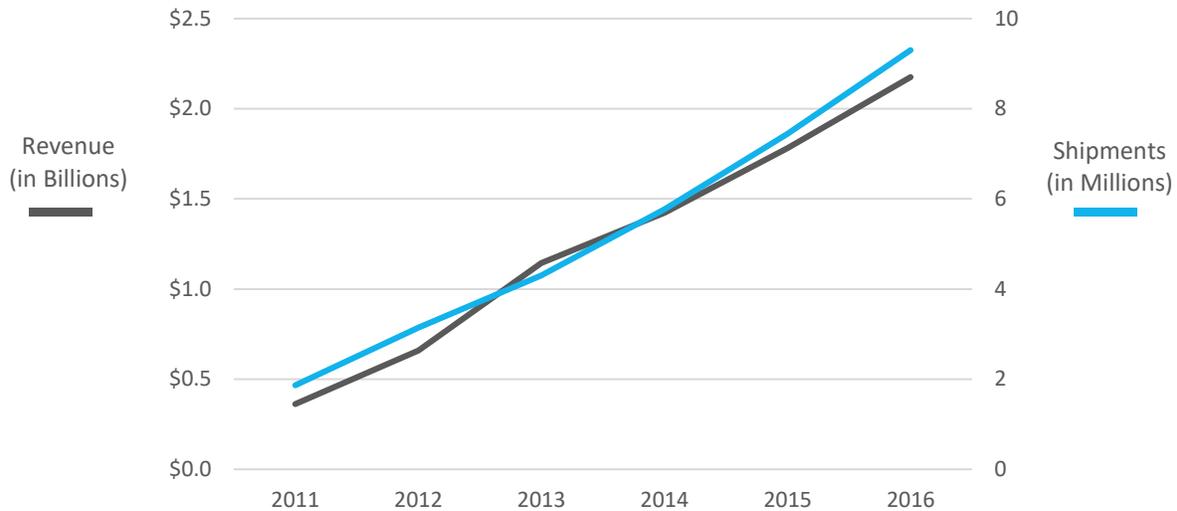
²⁷⁸ TechNavio, “Research and Markets: Global Soundbar Market 2015-2019.”

²⁷⁹ Markets and Markets, “Hi-Fi System Market Worth 16.49 Billion USD by 2022.”

²⁸⁰ Joseph Palenchar, “Retail Soundbar Sales Jump 31% to \$1.5 Billion in 2014,” *TWICE*, 2015, <http://www.twice.com/news/speakers/retail-soundbar-sales-jump-31-15-billion-14/56130>.

Mid-range soundbars experienced the greatest growth in 2014, with the majority models featuring HDMI inputs and wireless subwoofers. The \$300-\$399 price band had the biggest year-over-year growth at 3% in 2014.²⁸¹ Prices of soundbars at RPP retailers range from less than \$100 to \$2,000, with a median price of \$349.99. Additionally, the share of soundbars with HDMI inputs grew throughout 2014 to account for a 32% share of fourth-quarter unit shipments, and models with external subwoofer units continued to make up the bulk of the market in 2014 with a 55% unit share.²⁸²

Figure A-42: Soundbar Revenue, 2011 – 2016



Source: TWICE, “NPD’s Market Share Report,” n.d., http://www.nxtbook.com/nxtbooks/newbay/twice_20140107/index.php?startid=44#/0.

²⁸¹ CEPro, “Soundbar Revenues Grow to \$1.5B in 2014,” 2015, http://www.cepro.com/article/rreport_sound_bar_revenue_15b_2014.

²⁸² Palenchar, “Retail Soundbar Sales Jump 31% to \$1.5 Billion in 2014.”

Appendix B. SWOT Analysis

This section presents an analysis of RPP's strengths, weaknesses, opportunities, and threats from the perspective of the market barriers it addresses and the products in its portfolio.

B.1. Strengths

As discussed above, RPP is well suited to address certain barriers that are common to all the products in its portfolio. The consumer survey and research into each individual product indicates that, while the context in which the barriers act differs for each product, all of the products in RPP's portfolio share barriers related to availability, competing priorities, and information and search costs to greater or lesser degrees.

By motivating retailers to select efficient products for a larger proportion of the models in their product assortments, RPP has the potential to increase the availability of efficient products. A wider assortment of efficient models would also reduce barriers related to consumers prioritizing other features over efficiency by reducing the need to choose between desired features and efficiency. Finally, increasing the proportion of efficient products in a retailer's assortment could circumvent some information barriers by increasing the likelihood that an uninformed consumer will select an efficient product even if they are not seeking one. RPP could further address information-related barriers by motivating retailers to feature efficient products in their promotions and through program sponsors' in-store activities.

B.2. Weaknesses

While they are largely not relevant to the products included in this research, RPP is not well suited to address certain barriers. Altering a retailer's assortment and promotional decisions will likely have limited benefit if consumers actively avoid efficient products. This could occur for products that face barriers like performance uncertainty on the part of the consumer and the expectation of hidden costs that reduce a consumer's perception of the value of the efficient option over an inefficient alternative. These barriers are most likely to apply to emerging technologies and products that achieve efficiency gains by incorporating a technology that is radically different from the less efficient incumbent technology. Thus, RPP may not be the best program approach for these types of products.

Other considerations, not related to market barriers, may also limit RPP's ability to transform the market for certain products. For example, if the large retailers with which RPP works are not a primary distribution channel for the product, RPP's influence will be limited. Thus, RPP may be less effective for products that have significant distribution through contractors, even if they are also sold in the participating retail stores.

B.3. Opportunities

The barriers RPP addresses are likely common to many consumer electronics and appliance products, providing the program the opportunity to expand and adapt as markets change. In addition, while this analysis has focused on RPP's potential to motivate retailers to address consumer barriers to energy efficiency, RPP also has the potential to motivate retailers to influence actors further up the supply chain, like manufacturers and component suppliers. In doing so, RPP has the potential to drive greater efficiency in product design. Finally, the market data that RPP generates will provide program sponsors with information to drive more frequent and more stringent updates to both mandatory and voluntary efficiency standards. The potential to influence product design and standards and specifications gives RPP the opportunity to bring about more lasting market transformation than is likely to result from influencing retailer decisions alone.

B.4. Threats

The discussion of barriers RPP addresses in this report is based on RPP's program theory, both as expressed in the PTLM and as articulated by program designers. Factors that prevent the program from operating as its theory intended are the greatest threat to RPP's ability to address the market barriers relevant to the product categories the program targets. Information about RPP incentives and specification levels must reach the appropriate decision-makers within the participating retail organizations in time for them to incorporate that information into assortment and promotion decisions about the targeted products. Further, the incentives must motivate those decision-makers to favor efficient products in their business decisions. For this to occur, the program must achieve sufficient scale for the aggregate incentive levels to play a meaningful role in decisions that retailers make on a national scale and that may involve merchandise worth hundreds of millions of dollars. Any breakdown in this chain of influence poses a threat to the program's ability to address market barriers.

Challenges related to setting program specifications pose another threat to RPP's ability to address market barriers. Program specification levels, and ideally ENERGY STAR specifications, must differentiate between efficient and inefficient products in a meaningful way. RPP cannot overcome information barriers that prevent consumers from identifying efficient products if specifications do not effectively differentiate efficient products from inefficient ones. This can be particularly difficult to achieve for product categories in which technologies change quickly. In these categories, an efficiency level that captures only the most efficient models may quickly become the norm.

Appendix C. Consumer Survey Findings

C.1. California Consumer Survey Results

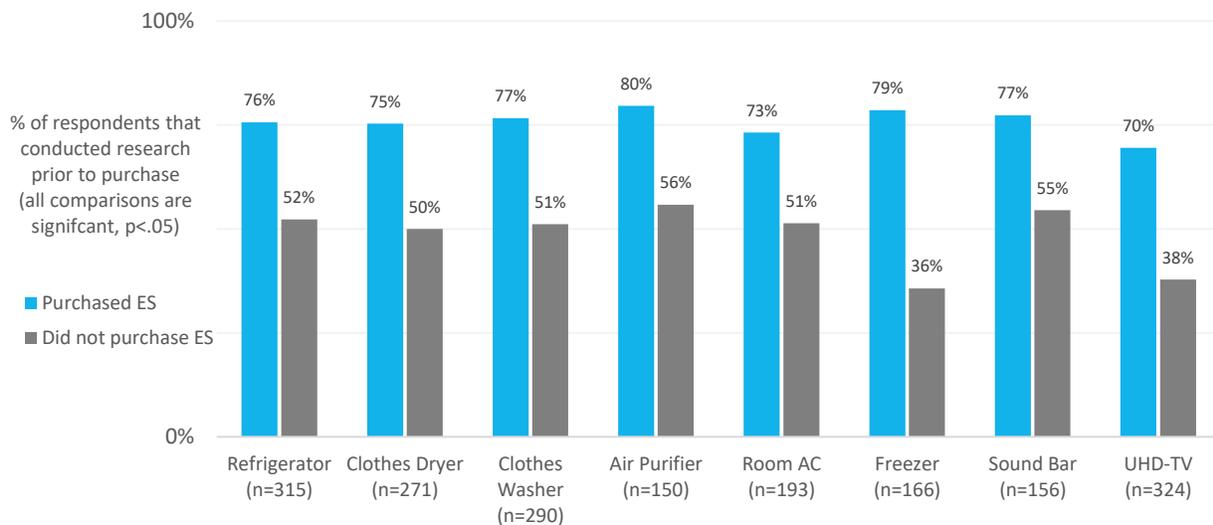
C.1.1. Consumer Survey Findings

The following section provides finding from the 2016 California Consumer Survey. Throughout this section, we compare responses between those survey respondents who reported purchasing an ENERGY STAR qualified product and those who did not, and note any significant differences between the two groups where they exist.

C.1.1.1. Sources of Product Information

Survey respondents who reported selecting an ENERGY STAR qualified version of products they purchased in the past two years were significantly more likely to report conducting research prior to selecting the product (Figure C-1). For example, Figure C-1 shows that 76% of ENERGY STAR refrigerator purchasers conducted research prior to purchasing, while 50% of non-ENERGY STAR purchasers conducted research. We found this to be consistent across all product categories. This trend is more notable for freezers and UHD-TVs, with considerably fewer respondents who reported purchasing non-ENERGY STAR qualified models reported conducting research prior to purchasing the product (36% and 38% reporting conducting prior research, respectively).

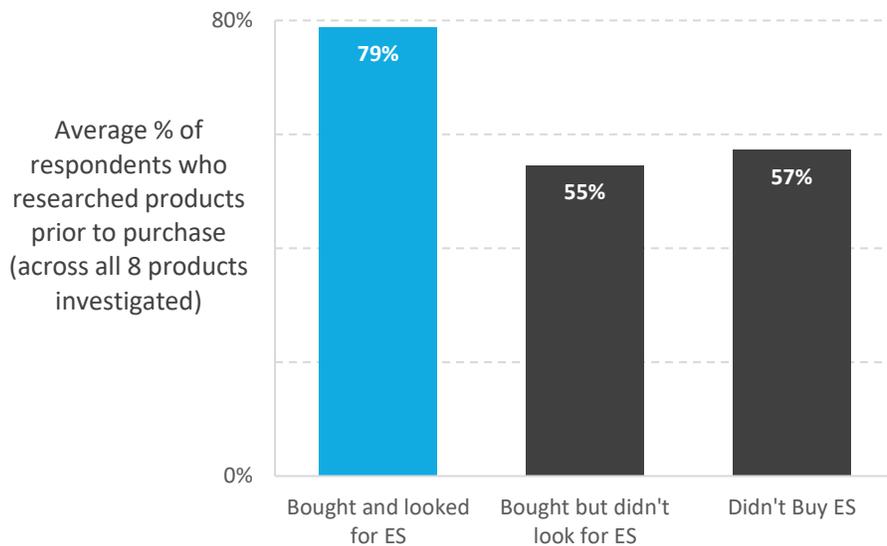
Figure C-1: Conducted Research Prior to Selection, by Product Type and ENERGY STAR Qualification*



* All comparisons for ENERGY STAR qualification are significant, $p < .05$.

This distinction, that customers who purchased ENERGY STAR models are more likely to conduct research prior to purchase, is made clearer when we separate out intentional ENERGY STAR purchasers from accidental ENERGY STAR purchasers (Figure C-2). On average, across all 8 products we asked about in the survey, almost 80% of customers who looked for the ENERGY STAR label researched their product prior to purchase. In contrast, about half (55%) of customers who purchased ENERGY STAR but did not look for the ENERGY STAR label did research. And this is similar to the proportion of customers who did research that did not buy an ENERGY STAR model (57% on average).

Figure C-2: Average Percent of Customers Who Conducted Research Prior to Purchase by Purchase Group



Across product categories, the most common sources of information respondents reported consulting prior selecting products was the internet followed by a salesperson at the store and friends or family (Figure C-3). There are two notable differences in the source of information consulted and whether the products respondents reported selecting were ENERGY STAR qualified. Significantly more respondents who reported purchasing an ENERGY STAR qualified refrigerator, dryer, clothes washer, freezer, or soundbar reported consulting information from their electric or gas utility compared to those who purchased a non-ENERGY STAR qualified version of these products. Additionally, significantly more respondents who reported not seeking information on the product they purchased selected a non-ENERGY STAR version of the product, bolstering the findings described in Figure C-2 above.

Figure C-3: Information Sources Used When Selecting Products, by Product Category and ENERGY STAR Qualification (Multiple Responses Allowed)

Information source		Refrigerator (n=560)	Dryer (n=487)*	Washer (n=536)*	Air Purifier (n=313)	Room AC (n=385)	Freezer (n=316)	Sound Bar (n=325)*	Ultra-HD TV (n=539)*
Internet	ES	29%	28%	24%	37%	34%	32%	36%	38%
	Not ES	24%	24%	26%	30%	21%	21%	35%	30%
Salesperson at the store	ES	20%	20%	24%	16%	12%	20%	19%	15%
	Not ES	20%	20%	18%	11%	19%	30%	15%	18%
Friends or family	ES	10%	14%	13%	14%	15%	12%	12%	11%
	Not ES	13%	14%	17%	12%	12%	18%	16%	15%
Consumer Report or other magazines	ES	11%	12%	13%	8%	9%	9%	7%	12%
	Not ES	12%	5%	4%	10%	10%	6%	8%	4%
Advertisement	ES	8%	8%	8%	6%	8%	8%	7%	9%
	Not ES	11%	4%	7%	6%	7%	6%	6%	10%
Electric or gas utility	ES	8%	8%	8%	8%	8%	10%	8%	5%
	Not ES	2%	4%	3%	13%	9%	4%	4%	3%
Contractor	ES	3%	2%	3%	4%	4%	3%	6%	1%
	Not ES	2%	2%	1%	1%	6%	3%	1%	0%
Other	ES	1%	1%	0%	0%	1%	0%	1%	1%
	Not ES	2%	3%	4%	1%	0%	1%	0%	1%
Didn't seek information	ES	7%	6%	8%	6%	8%	5%	2%	7%
	Not ES	13%	19%	18%	13%	15%	10%	11%	12%
Don't know	ES	2%	1%	1%	0%	1%	1%	0%	0%
	Not ES	3%	4%	1%	1%	1%	0%	4%	5%

* Comparisons between ENERGY STAR and non-ENERGY STAR qualified within product category are significant, p<.05.

C.1.1.2. Product Purchase Location

Survey findings suggest that place of purchase varies by product type and can influence whether a consumer selects an ENERGY STAR version of the product. Big box retailers were the most commonly mentioned location where survey respondents purchased products (Table C-1). Significantly more respondents who purchased clothes dryers or soundbars at big box retailers reported selecting an ENERGY STAR qualified version of these products, when compared to the proportion of ENERGY STAR products sold at other purchase locations. Conversely, significantly fewer respondents who reported purchasing air purifiers or ultra-HD TVs at big box retailers selected an ENERGY STAR qualified version. Significantly fewer respondents who purchased room ACs or soundbars at a local retail store reported purchasing an ENERGY STAR version. For those respondents who reported making purchases at online big box stores, significantly more reported selected an ENERGY STAR qualified clothes washer, air purifier, or room AC and significantly fewer select an ENERGY STAR qualified clothes dryer or freezer. Finally, significantly fewer respondents who reported purchasing products through an online-only retail store selected an ENERGY STAR qualified refrigerator, clothes washer, or soundbar.

Table C-1: Purchase Location by Product Type and ENERGY STAR Qualification*

Product	At a big box retailer			At a local retail store			An online big box store			An online-only retail store		
	ES	Not ES	Diff	ES	Not ES	Diff	ES	Not ES	Diff	ES	Not ES	Diff
Refrigerator	52%	51%		20%	19%		23%	21%		5%	10%	▼
Clothes Dryer	57%	47%	▲	20%	21%		18%	28%	▼	6%	4%	
Clothes Washer	50%	46%		20%	22%		25%	17%	▲	5%	15%	▼
Air Purifier	39%	50%	▼	17%	19%		24%	11%	▲	20%	20%	
Room AC	43%	44%		20%	27%	▼	26%	19%	▲	11%	10%	
Freezer	49%	44%		21%	20%		20%	31%	▼	9%	4%	
Soundbar	47%	37%	▲	15%	23%	▼	21%	20%		17%	20%	▼
UHDTV	52%	61%	▼	15%	16%		21%	19%		12%	4%	▲

* Differences between ENERGY STAR and non-ENERGY STAR qualified products noted by green and red are significant, p<.05.

C.1.1.3. Reasons for Product Selection

Respondents reported primarily selecting the product model they purchased based on the price of the model followed by the features associated with the model (Figure C-4). The reason for selection did not vary greatly by whether the purchased model was ENERGY STAR qualified, except for operational costs. Those who reported selecting a model based on operational costs were significantly more likely to have purchased an ENERGY STAR qualified version of the product.

Figure C-4: Reasons for Selecting the Purchased Model, by Product Category and ENERGY STAR Qualification (Multiple Responses Allowed) +

Reason for selection		Refrigerator (n=560)	Dryer (n=487)	Washer (n=536)	Air Purifier (n=313)	Room AC (n=385)	Freezer (n=316)	Sound Bar (n=325)	Ultra-HD TV (n=539)
It was in my price range	ES	50%	50%	50%	38%	43%	44%	42%	55%
	Not ES	44%	49%	47%	56%	51%	48%	48%	55%
It had the features I wanted	ES	44%	45%	49%	38%	37%	38%	40%	50%
	Not ES	36%	27%	31%	35%	28%	18%	35%	48%
It had good reviews	ES	36%	44%	39%	45%	39%	38%	40%	44%
	Not ES	28%	24%	17%	40%	27%	24%	42%	31%
It was available	ES	34%	27%	28%	27%	29%	27%	31%	29%
	Not ES	37%	31%	35%	30%	34%	31%	22%	28%
I wanted the brand	ES	32%	32%	30%	26%	24%	29%	32%	31%
	Not ES	23%	22%	21%	20%	18%	25%	30%	26%
It was recommended to me	ES	20%	23%	21%	26%	28%	21%	26%	24%
	Not ES	21%	14%	18%	18%	18%	32%	18%	20%
It costs less to operate*	ES	23%	28%	28%	24%	25%	22%	20%	18%
	Not ES	9%	17%	17%	18%	13%	13%	11%	6%

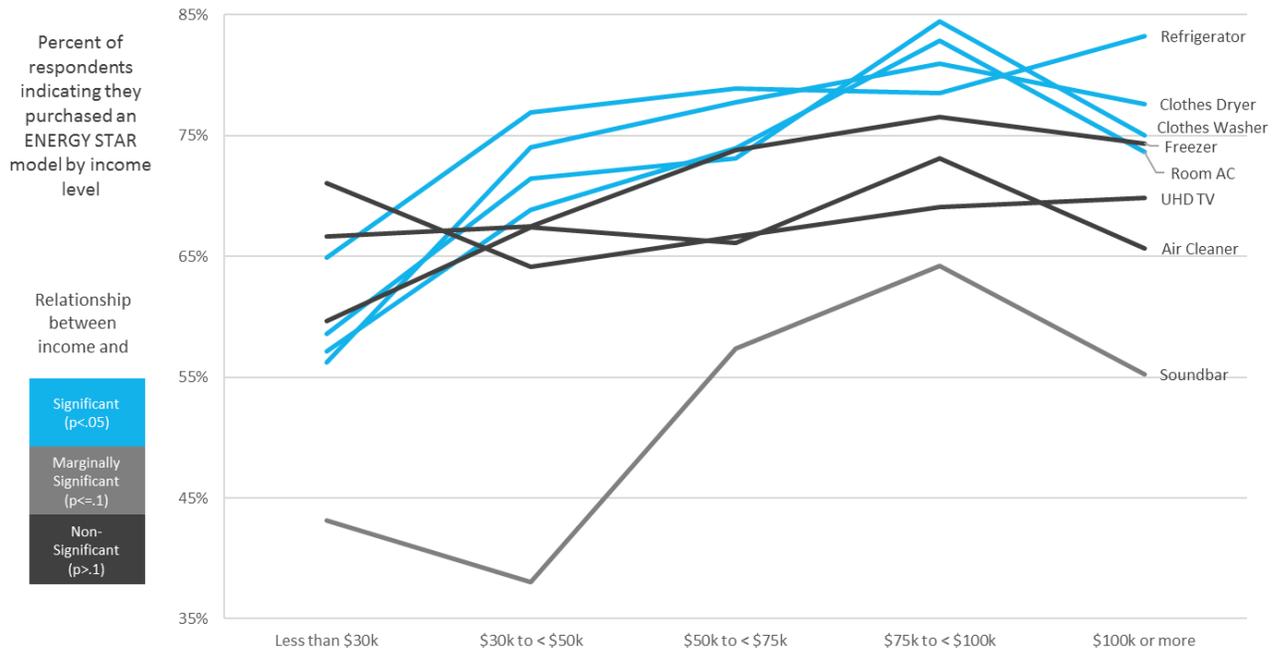
+ Data are from customers who did *not* prioritize energy efficiency in their purchase decision.

* Differences between ENERGY STAR and non-ENERGY STAR qualified products are significant, p<.05.

C.1.1.4. Demographic Differences by Product Selection

Overall, customers who purchased ENERGY STAR versions of the products they purchased tended to have a higher income than those who do not purchase.²⁸³ However, when viewed by product, the association is less clear. Refrigerators, clothes washers and dryers, and room air conditioners all show an association between income and those that purchased ENERGY STAR models (Figure C-5). In contrast, freezers, UHD TVs, air cleaners and soundbars do not show significant associations.

Figure C-5: Percent of Respondents Indicating They Purchased an ENERGY STAR Model by Income for All Products



C.1.2. Consumer Segmentation

In 2009, ODC conducted a household segmentation study on behalf of the California investor-owned utilities about marketing and outreach opportunities in the residential sector. ODC developed a segmentation algorithm that predicts the type of segment a resident falls into based on the resident’s responses to a set of nine questions:

- › Whether residents own or rent their home;
- › Whether residents have installed an attic vent, ceiling fan, programmable thermostat, or motion detector for lights (four questions);
- › Whether residents are aware of the term “carbon footprint;”

²⁸³ Chi-square = 73.65, df=4, N=1560, p<.001

- › Whether residents are likely to compare a product price with another;
- › Whether residents feel responsible for conserving energy; and,
- › Whether saving money, protecting the environment, or other reasons would motivate residents to save energy.

To develop this algorithm, the ODC team used cluster and CART analyses. A more detailed explanation of ODC's segmentation methodology can be found in their final report.²⁸⁴ The segmentation analysis yielded five segments:

- › Striving Believers
- › Leading Achievers
- › Thrifty Conservatives
- › Practical Spenders, and
- › Disconnected.

We conducted a comparison analysis using data from the 2016 California Consumer Survey to determine whether survey responses varied across eight products by these segments. Overall, more Leading Achievers and Practical Spenders from the 2016 consumer survey reported having purchased any of the eight products in the past two years when compared to other segments. Also, Leading Achievers and Practical Spenders were more likely to have looked for and purchased an ENERGY STAR version of those products, and had at least one those products in their home at the time of the survey than other segments.

Survey respondents in the Leading Achiever and Practical Spender consumer segments were significantly more likely to report purchasing any of the eight products during the past two years (Figure C-6). Overall, those respondents in the Striving Believer segment were least likely to report purchasing a product in the past two-years. Our analysis of survey data suggests there is little consistency within the five consumer segments and reported reasons for selecting the product respondents purchased. Across all products and segments respondents primarily reported selecting each product based on price.

²⁸⁴ Opinion Dynamics (2009). Market Segmentation Study of California Residents. Final Report retrieved Calmac.

Figure C-6: Proportion of Respondents Who Purchased a Product in Past Two Years, by Consumer Segment

Product	Striving Believers	Leading Achievers	Thirfty Conservers	Practical Spenders	Disconnected
Refrigerator	31%	60%	37%	60%	36%
Clothes Dryer	27%	53%	31%	62%	31%
Clothes Washer	31%	59%	35%	58%	35%
Air Purifier	16%	47%	21%	51%	19%
Room AC	19%	46%	29%	62%	26%
Freezer	15%	45%	22%	49%	19%
Sound bar	17%	47%	26%	52%	22%
Ultra-HD TV	33%	64%	36%	65%	38%

* Differences between segments are significant, $p < .05$.

Similarly, survey respondents in the Leading Achiever and Practical Spender consumer segments were significantly more likely to report purchasing an ENERGY STAR qualified product during the past two years (Figure C-7). Overall, those respondents in the Disconnected consumer segment were least likely to report purchasing an ENERGY STAR qualified product in the past two-years.

Figure C-7: Proportion of Respondents Who Purchased ENERGY STAR Version of Product in Past Two Years, by Consumer Segment

Product	Striving Believers	Leading Achievers	Thirfty Conservers	Practical Spenders	Disconnected
Refrigerator	83%	89%	73%	79%	65%
Clothes Dryer	79%	91%	72%	81%	56%
Clothes Washer	78%	92%	68%	79%	56%
Air Purifier	70%	76%	67%	78%	47%
Room AC	75%	86%	66%	79%	60%
Freezer	74%	79%	73%	81%	61%
Sound bar	51%	69%	51%	69%	45%
Ultra-HD TV	74%	74%	65%	80%	57%

* Differences between segments are significant, $p < .05$.

Survey respondents in the Leading Achiever and Practical Spender consumer segments were also significantly more likely to report looking for an ENERGY STAR version across all products (Figure C-8). Again, those respondents in the Disconnected consumer segment were least likely to report looking for an ENERGY STAR version of a product.

Figure C-8: Proportion of Respondents Who Looked for an ENERGY STAR Version of Product in Past Two Years, by Consumer Segment

Product	Striving Believers	Leading Achievers	Thrifty Conservers	Practical Spenders	Disconnected
Refrigerator	68%	78%	57%	70%	40%
Clothes Dryer	67%	79%	59%	70%	39%
Clothes Washer	63%	72%	54%	69%	43%
Air Purifier	56%	71%	52%	68%	39%
Room AC	59%	76%	54%	65%	38%
Freezer	61%	66%	62%	75%	40%
Sound bar	34%	59%	45%	53%	27%
Ultra-HD TV	46%	58%	39%	60%	33%

* Differences between segments are significant, $p < .05$.

Nearly all survey respondents, across segments, reported having a refrigerator, clothes dryer, and clothes washer in their home (Figure C-9). Significantly more respondents in the Leading Achievers and Practical Spender consumer segments reported having an air purifier, room AC, freezer, soundbar, or ultra-HD TVs in their home.

Figure C-9: Saturation of Products, by Consumer Segment

Product	Striving Believers	Leading Achievers	Thrifty Conservers	Practical Spenders	Disconnected
Refrigerator	97%	100%	97%	100%	95%
Clothes Dryer	82%	96%	86%	93%	78%
Clothes Washer	84%	96%	88%	95%	81%
Air Purifier	30%	58%	36%	60%	29%
Room AC	44%	63%	49%	78%	52%
Freezer	55%	74%	57%	83%	59%
Sound bar	30%	56%	34%	65%	31%
Ultra-HD TV	49%	74%	55%	75%	58%

* Differences between segments are significant, $p < .05$.

C.2. California Consumer Survey Results by IOU

This section provides results from the 2016 California Consumer Survey broken out by IOU. Overall, we found that survey responses did not differ significantly between IOUs.

C.2.1. Survey Results

C.2.1.1. Purchase Rates, Market Penetration, and Purchase Intention

Table C-2: Purchase Rate in the Last Two Years and Percent of Those Selecting and Energy Efficient Model, by IOU (Energy Efficient Percent is Among Those Who Purchased an ENERGY STAR Model; Multiple Responses Allowed)

Products	PG&E (n=663)		SCE (n=606)		SDG&E (n=153)		Other (n=148)		Total (n=1,570)	
	Purchase	EE	Purchase	EE	Purchase	EE	Purchase	EE	Purchase*	EE
Refrigerator	37%	78%	41%	78%	33%	72%	26%	70%	37% (7%)	77%
Dryer	35%	73%	35%	77%	27%	69%	20%	62%	33% (8%)	74%
Washer	37%	71%	40%	75%	31%	75%	21%	62%	36% (7%)	72%
Air purifier	22%	68%	23%	64%	20%	71%	14%	62%	22% (4%)	66%
Room AC	26%	72%	31%	73%	30%	65%	10%	49%	27% (5%)	71%
Freezer	23%	77%	23%	68%	21%	80%	7%	46%	21% (5%)	73%
Soundbar	27%	50%	22%	60%	25%	68%	17%	27%	24% (4%)	54%
Ultra-HD TV	39%	67%	42%	68%	34%	77%	28%	73%	39% (4%)	69%

* Purchase rates include both bought as new and used. () in total shows % of bought as old.

Table C-3: Market Penetration Rate of Each Technology, by IOU (Multiple Responses Allowed)

Product	PG&E (n=663)	SCE (n=606)	SDG&E (n=153)	Other (n=148)	Total (n=1,570)
Refrigerator	97%	97%	96%	96%	97%
Clothes Dryer	87%	82%	80%	74%	83%
Clothes Washer	88%	85%	84%	75%	85%
Air Purifier/Cleaner	35%	36%	33%	25%	34%
Room AC	50%	54%	50%	31%	50%
Freezer	62%	59%	60%	41%	59%
Soundbar	37%	34%	32%	26%	34%
Ultra-HD TV	54%	58%	53%	43%	55%

Table C-4: Purchase Intention in The Next 24 Months, by IOU (Multiple Responses Allowed)

Product	PG&E (n=663)	SCE (n=606)	SDG&E (n=153)	Other (n=148)	Total (n=1,570)
Refrigerator	15%	17%	12%	14%	15%
Clothes Dryer	17%	14%	17%	11%	15%
Clothes Washer	15%	13%	13%	13%	14%
Air Purifier/Cleaner	12%	12%	9%	6%	11%
Room AC	8%	11%	8%	5%	9%
Freezer	13%	11%	11%	7%	11%
Soundbar	11%	14%	8%	6%	11%
Ultra-HD TV	17%	15%	20%	12%	16%

C.2.1.2. Sources of Product Information

Table C-5: Most Influential Information Source (Refrigerator), by IOU

Source	PG&E (n=249)	SCE (n=254)	SDG&E (n=51)	Non-IOUs (n=39)	Total (n=593)
Internet	25%	32%	23%	19%	27%
Salesperson at the store	24%	16%	20%	22%	20%
Friend or family member	12%	11%	9%	5%	11%
Consumer Report or other product-oriented magazines	9%	10%	17%	22%	11%
Advertisement	9%	8%	8%	5%	8%
Electric or gas utility	6%	7%	8%	5%	7%
Contractor	3%	2%	10%	0%	3%
Other	1%	1%	0%	3%	1%
Didn't seek information	8%	10%	3%	11%	9%
Don't know	3%	2%	2%	8%	3%
Total	100%	100%	100%	100%	100%

Table C-6: Most Influential Information Source (Clothes Dryer), by IOU

Source	PG&E (n=236)	SCE (n=212)	SDG&E (n=42)	Non-IOUs (n=31)	Total (n=521)
Internet	22%	33%	24%	27%	27%
Salesperson at the store	23%	17%	16%	20%	20%
Friend or family member	13%	14%	13%	20%	14%
Consumer Report or other product-oriented magazines	10%	10%	7%	4%	10%
Advertisement	12%	3%	11%	0%	8%
Electric or gas utility	6%	6%	12%	3%	7%
Contractor	1%	2%	10%	0%	2%
Other	1%	1%	0%	11%	2%
Didn't seek information	9%	11%	5%	9%	10%
Don't know	2%	1%	3%	6%	2%
Total	100%	100%	100%	100%	100%

Table C-7: Most Influential Information Source (Clothes Washer), by IOU

Source	PG&E (n=251)	SCE (n=242)	SDG&E (n=50)	Non-IOUs (n=32)	Total (n=575)
Internet	20%	29%	25%	24%	24%
Salesperson at the store	23%	22%	15%	25%	22%
Friend or family member	14%	14%	13%	11%	13%
Consumer Report or other product-oriented magazines	10%	12%	11%	11%	11%
Advertisement	9%	6%	9%	0%	7%
Electric or gas utility	9%	4%	12%	3%	7%
Contractor	3%	1%	5%	0%	2%
Other	1%	0%	0%	14%	1%
Didn't seek information	10%	12%	11%	6%	11%
Don't know	1%	1%	0%	7%	1%
Total	100%	100%	100%	100%	100%

Table C-8: Most Influential Information Source (Air Purifier), by IOU

Source	PG&E (n=152)	SCE (n=141)	SDG&E (n=32)	Non-IOUs (n=21)	Total (n=346)
Internet	33%	36%	28%	38%	34%
Friend or family member	13%	16%	19%	5%	14%
Salesperson at the store	14%	12%	15%	31%	14%
Consumer Report or other product-oriented magazines	10%	8%	7%	12%	9%
Electric or gas utility	9%	9%	7%	0%	8%
Advertisement	8%	2%	6%	5%	5%
Contractor	2%	4%	7%	0%	3%
Other	1%	0%	0%	5%	1%
Didn't seek information	9%	12%	7%	4%	10%
Don't know	2%	1%	4%	0%	1%
Total	100%	100%	100%	100%	100%

Table C-9: Most Influential Information Source (Room AC), by IOU

Source	PG&E (n=176)	SCE (n=188)	SDG&E (n=46)	Non-IOUs (n=14)	Total (n=424)
Internet	28%	35%	34%	18%	31%
Friend or family member	15%	12%	15%	31%	14%
Salesperson at the store	13%	13%	10%	21%	13%
Advertisement	13%	6%	4%	16%	9%
Consumer Report or other product-oriented magazines	7%	11%	5%	0%	8%
Electric or gas utility	9%	7%	9%	0%	8%
Contractor	3%	4%	14%	6%	5%
Other	1%	0%	3%	0%	1%
Didn't seek information	11%	11%	6%	8%	10%
Don't know	1%	2%	0%	0%	1%
Total	100%	100%	100%	100%	100%

Table C-10: Most Influential Information Source (Freezer), by IOU

Source	PG&E (n=155)	SCE (n=141)	SDG&E (n=34)	Non-IOUs (n=11)	Total (n=341)
Internet	29%	31%	38%	20%	30%
Salesperson at the store	25%	23%	8%	15%	22%
Friend or family member	13%	10%	20%	18%	13%
Electric or gas utility	11%	7%	9%	9%	9%
Consumer Report or other product-oriented magazines	6%	9%	9%	10%	8%
Advertisement	8%	7%	5%	0%	7%
Contractor	2%	3%	7%	0%	3%
Other	1%	1%	0%	0%	1%
Didn't seek information	4%	8%	3%	28%	7%
Don't know	2%	1%	0%	0%	1%
Total	100%	100%	100%	100%	100%

Table C-11: Most Influential Information Source (Soundbar), by IOU

Source	PG&E (n=184)	SCE (n=135)	SDG&E (n=38)	Non-IOUs (n=23)	Total (n=380)
Internet	33%	38%	37%	8%	33%
Salesperson at the store	15%	21%	12%	33%	18%
Friend or family member	16%	12%	9%	22%	14%
Consumer Report or other product-oriented magazines	7%	5%	19%	14%	8%
Advertisement	11%	4%	2%	0%	7%
Electric or gas utility	5%	8%	3%	0%	6%
Contractor	4%	1%	12%	0%	3%
Other	0%	1%	0%	5%	1%
Didn't seek information	7%	8%	3%	8%	7%
Don't know	1%	2%	3%	10%	2%
Total	100%	100%	100%	100%	100%

Table C-12: Most Influential Information Source (Ultra-HD TV), by IOU

Source	PG&E (n=265)	SCE (n=254)	SDG&E (n=52)	Non-IOUs (n=41)	Total (n=612)
Internet	35%	38%	25%	28%	35%
Salesperson at the store	15%	15%	15%	31%	16%
Friend or family member	15%	11%	10%	10%	12%
Consumer Report or other product-oriented magazines	9%	10%	16%	11%	10%
Advertisement	10%	9%	9%	5%	9%
Electric or gas utility	4%	4%	7%	0%	4%
Contractor	1%	1%	6%	0%	1%
Other	1%	1%	2%	3%	1%
Didn't seek information	9%	9%	11%	12%	9%
Don't know	2%	2%	0%	0%	2%
Total	100%	100%	100%	100%	100%

C.2.1.3. Product Purchase Location

Table C-13: Purchase Location (Among Those Bought a New Refrigerator), by IOU

Location	PG&E (n=195)	SCE (n=206)	SDG&E (n=47)	Non-IOUs (n=32)	Total (n=480)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	47%	53%	38%	59%	50%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	22%	20%	33%	17%	22%
At a local retail store	19%	19%	21%	13%	19%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	8%	3%	7%	0%	5%
Other	2%	2%	2%	10%	2%
Don't know	2%	3%	0%	0%	2%
Total	100%	100%	100%	100%	100%

Table C-14: Purchase Location (Among Those Bought a New Clothes Dryer), by IOU

Location	PG&E (n=167)	SCE (n=169)	SDG&E (n=34)	Non-IOUs (n=25)	Total (n=395)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	56%	51%	55%	37%	53%
At a local retail store	17%	23%	15%	25%	20%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	21%	14%	15%	29%	18%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	4%	7%	5%	0%	5%
Other	1%	3%	6%	9%	3%
Don't know	1%	2%	3%	0%	1%
Total	100%	100%	100%	100%	100%

Table C-15: Purchase Location (Among Those Bought a New Clothes Washer), by IOU

Location	PG&E (n=190)	SCE (n=198)	SDG&E (n=44)	Non-IOUs (n=26)	Total (n=458)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	49%	49%	38%	40%	48%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	22%	20%	26%	35%	22%
At a local retail store	20%	18%	25%	20%	20%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	5%	8%	7%	0%	6%
Other	3%	4%	4%	5%	3%
Don't know	1%	1%	0%	0%	1%
Total	100%	100%	100%	100%	100%

Table C-16: Purchase Location (Among Those Bought a New Air Purifier), by IOU

Location	PG&E (n=121)	SCE (n=123)	SDG&E (n=26)	Non-IOUs (n=17)	Total (n=287)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	41%	42%	31%	43%	41%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	21%	18%	24%	6%	19%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	16%	18%	23%	28%	18%
At a local retail store	18%	16%	18%	11%	17%
Other	1%	3%	0%	12%	2%
Don't know	3%	2%	4%	0%	3%
Total	100%	100%	100%	100%	100%

Table C-17: Purchase Location (Among Those Bought a New Room AC), by IOU

Location	PG&E (n=141)	SCE (n=154)	SDG&E (n=40)	Non-IOUs (n=13)	Total (n=348)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	45%	41%	39%	49%	43%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	25%	24%	21%	5%	23%
At a local retail store	18%	20%	16%	38%	19%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	10%	8%	15%	7%	10%
Other	1%	4%	5%	0%	2%
Don't know	2%	3%	3%	0%	3%
Total	100%	100%	100%	100%	100%

Table C-18: Purchase Location (Among Those Bought a New Freezer), by IOU

Location	PG&E (n=115)	SCE (n=110)	SDG&E (n=25)	Non-IOUs (n=9)	Total (n=259)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	50%	46%	51%	54%	48%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	21%	25%	18%	23%	22%
At a local retail store	19%	22%	20%	12%	20%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	9%	6%	11%	0%	8%
Other	0%	1%	0%	0%	0%
Don't know	1%	1%	0%	12%	1%
Total	100%	100%	100%	100%	100%

Table C-19: Purchase Location (Among Those Bought a New Soundbar), by IOU

Location	PG&E (n=143)	SCE (n=116)	SDG&E (n=31)	Non-IOUs (n=22)	Total (n=312)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	38%	51%	33%	31%	42%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	18%	20%	19%	21%	19%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	22%	12%	18%	15%	17%
At a local retail store	17%	15%	26%	10%	17%
Other	2%	1%	0%	14%	2%
Don't know	2%	2%	4%	9%	3%
Total	100%	100%	100%	100%	100%

Table C-20: Purchase Location (Among Those Bought a New Ultra-HD TV), by IOU

Location	PG&E (n=231)	SCE (n=235)	SDG&E (n=46)	Non-IOUs (n=39)	Total (n=551)
At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	57%	52%	50%	56%	54%
An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.	21%	19%	20%	11%	19%
At a local retail store	12%	14%	13%	20%	14%
An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.	9%	11%	17%	8%	11%
Other	1%	3%	0%	2%	2%
Don't know	0%	1%	0%	3%	1%
Total	100%	100%	100%	100%	100%

C.2.1.4. Reasons for Product Selection

Table C-21: Reasons for Selecting the Purchased Model (Refrigerator), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=249)	SCE (n=254)	SDG&E (n=51)	Non-IOUs (n=39)	Total (n=593)
It was in my price range	47%	51%	45%	61%	49%
It had the features I wanted	40%	43%	34%	59%	42%
It had an ENERGY STAR label	37%	42%	40%	51%	40%
It was available	34%	30%	38%	53%	34%
It had good reviews	36%	33%	29%	30%	34%
I wanted the brand	28%	31%	29%	23%	29%
It was recommended to me	21%	20%	25%	8%	20%
It costs less to operate	17%	20%	20%	34%	19%
Other	3%	4%	4%	10%	4%

Table C-22: Reasons for Selecting the Purchased Model (Clothes Dryer), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=236)	SCE (n=212)	SDG&E (n=42)	Non-IOUs (n=31)	Total (n=521)
It was in my price range	47%	50%	58%	63%	50%
It had an ENERGY STAR label	45%	39%	31%	53%	42%
It had the features I wanted	35%	45%	52%	54%	41%
It had good reviews	36%	40%	37%	37%	38%
I wanted the brand	24%	30%	37%	43%	29%
It was available	27%	27%	34%	39%	28%
It costs less to operate	25%	27%	14%	20%	25%
It was recommended to me	23%	19%	19%	26%	21%
Other	1%	4%	0%	6%	2%

Table C-23: Reasons for Selecting the Purchased Model (Clothes Washer), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=251)	SCE (n=242)	SDG&E (n=50)	Non-IOUs (n=32)	Total (n=575)
It was in my price range	48%	53%	49%	64%	50%
It had an ENERGY STAR label	42%	40%	47%	51%	45%
It had the features I wanted	41%	55%	43%	61%	44%
It had good reviews	30%	31%	37%	48%	34%
It was available	31%	27%	27%	29%	29%
I wanted the brand	23%	32%	31%	34%	28%
It costs less to operate	24%	26%	24%	29%	24%
It was recommended to me	22%	23%	18%	19%	20%
Other	2%	2%	2%	9%	2%

Table C-24: Reasons for Selecting the Purchased Model (Air Purifier), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=152)	SCE (n=141)	SDG&E (n=32)	Non-IOUs (n=21)	Total (n=346)
It was in my price range	33%	49%	60%	66%	44%
It had good reviews	41%	40%	38%	61%	42%
It had an ENERGY STAR label	30%	43%	26%	53%	37%
It had the features I wanted	32%	38%	36%	61%	36%
It was available	30%	27%	23%	33%	28%
It was recommended to me	21%	27%	28%	4%	23%
I wanted the brand	19%	25%	23%	24%	22%
It costs less to operate	17%	27%	5%	29%	21%
Other	2%	1%	0%	4%	1%

Table C-25: Reasons for Selecting the Purchased Model (Room AC), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=176)	SCE (n=188)	SDG&E (n=46)	Non-IOUs (n=14)	Total (n=424)
It was in my price range	43%	50%	46%	56%	47%
It had an ENERGY STAR label	37%	36%	27%	43%	36%
It had good reviews	31%	38%	38%	35%	35%
It had the features I wanted	29%	37%	41%	48%	34%
It was available	36%	24%	34%	40%	31%
It was recommended to me	25%	26%	27%	26%	26%
It costs less to operate	16%	24%	33%	36%	22%
I wanted the brand	21%	24%	13%	22%	21%
Other	2%	1%	5%	6%	2%

Table C-26: Reasons for Selecting the Purchased Model (Freezer), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=155)	SCE (n=141)	SDG&E (n=34)	Non-IOUs (n=11)	Total (n=341)
It was in my price range	38%	50%	56%	55%	45%
It had an ENERGY STAR label	42%	33%	41%	10%	37%
It had good reviews	35%	31%	40%	29%	34%
It had the features I wanted	32%	31%	43%	50%	33%
It was available	27%	26%	38%	65%	29%
I wanted the brand	31%	26%	24%	10%	28%
It was recommended to me	21%	25%	21%	10%	23%
It costs less to operate	22%	18%	18%	10%	20%
Other	3%	2%	0%	8%	3%

Table C-27: Reasons for Selecting the Purchased Model (Soundbar), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=184)	SCE (n=135)	SDG&E (n=38)	Non-IOUs (n=23)	Total (n=380)
It was in my price range	44%	49%	43%	41%	46%
It had good reviews	39%	38%	47%	31%	39%
It had the features I wanted	36%	39%	52%	38%	39%
I wanted the brand	28%	29%	44%	24%	30%
It was available	29%	26%	24%	30%	27%
It was recommended to me	22%	20%	29%	37%	23%
It had an ENERGY STAR label	20%	27%	26%	9%	22%
It costs less to operate	15%	15%	17%	0%	14%
Other	1%	1%	0%	8%	1%

Table C-28: Reasons for Selecting the Purchased Model (Ultra-HD TV), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=265)	SCE (n=254)	SDG&E (n=52)	Non-IOUs (n=41)	Total (n=612)
It was in my price range	56%	57%	54%	72%	57%
It had the features I wanted	51%	48%	56%	49%	50%
It had good reviews	41%	42%	39%	44%	41%
It had an ENERGY STAR label	31%	33%	33%	40%	33%
I wanted the brand	28%	29%	38%	29%	30%
It was available	28%	28%	35%	35%	29%
It was recommended to me	21%	23%	36%	13%	23%
It costs less to operate	10%	16%	12%	23%	14%
Other	1%	2%	2%	2%	2%

C.2.1.5. Reasons Selecting Non-Efficient Product Model

Table C-29: Reasons for Not Selecting Non-Efficient Refrigerator Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=127)	SCE (n=122)	SDG&E (n=25)	Non-IOUs (n=23)	Total (n=297)
Other features took priorities	62%	65%	50%	50%	61%
Most models have better efficiency than what I had before	60%	57%	58%	64%	59%
Wasn't interested in EE, simply wanted the model	55%	56%	76%	44%	56%
More expensive than I wanted to pay for	50%	57%	56%	40%	53%
Had less discount	51%	46%	61%	36%	49%
Retail staff didn't recommend it	53%	48%	50%	15%	47%
Didn't notice EE as a feature	47%	49%	51%	26%	47%
Didn't know how/what to look for EE models	50%	39%	56%	36%	45%
Didn't have sufficient range of choices	42%	44%	38%	24%	41%

Table C-30: Reasons for Not Selecting Non-Efficient Clothes Dryer Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=119)	SCE (n=112)	SDG&E (n=24)	Non-IOUs (n=16)	Total (n=271)
Most models have better efficiency than what I had before	63%	56%	65%	63%	60%
More expensive than I wanted to pay for	56%	54%	60%	48%	55%
Other features took priorities	54%	53%	59%	44%	54%
Wasn't interested in EE, simply wanted the model	54%	50%	60%	39%	52%
Had less discount	53%	52%	63%	19%	52%
Didn't notice EE as a feature	49%	39%	66%	41%	46%
Didn't know how/what to look for EE models	44%	47%	52%	37%	46%
Retail staff didn't recommend it	44%	48%	39%	14%	44%
Didn't have sufficient range of choices	41%	44%	51%	30%	43%

Table C-31: Reasons for Not Selecting Non-Efficient Clothes Washer Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=125)	SCE (n=119)	SDG&E (n=26)	Non-IOUs (n=21)	Total (n=291)
Most models have better efficiency than what I had before	66%	57%	61%	61%	61%
Wasn't interested in EE, simply wanted the model	65%	53%	54%	29%	57%
More expensive than I wanted to pay for	60%	55%	54%	28%	55%
Other features took priorities	56%	53%	49%	48%	54%
Had less discount	54%	45%	54%	24%	48%
Didn't notice EE as a feature	52%	40%	39%	22%	44%
Retail staff didn't recommend it	46%	39%	72%	13%	44%
Didn't know how/what to look for EE models	43%	46%	44%	20%	43%
Didn't have sufficient range of choices	44%	42%	53%	15%	42%

Table C-32: Reasons for Not Selecting Non-Efficient Air Purifier Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=85)	SCE (n=71)	SDG&E (n=21)	Non-IOUs (n=14)	Total (n=191)
Wasn't interested in EE, simply wanted the model	70%	65%	90%	50%	69%
Most models have better efficiency than what I had before	73%	63%	58%	51%	66%
Other features took priorities	70%	63%	47%	44%	63%
Didn't notice EE as a feature	65%	60%	55%	31%	59%
More expensive than I wanted to pay for	57%	64%	67%	40%	59%
Had less discount	63%	57%	48%	64%	59%
Didn't have sufficient range of choices	63%	50%	46%	40%	55%
Didn't know how/what to look for EE models	54%	56%	49%	49%	54%
Retail staff didn't recommend it	52%	53%	51%	39%	51%

Table C-33: Reasons for Not Selecting Non-Efficient Room AC Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=93)	SCE (n=81)	SDG&E (n=23)	Non-IOUs (n=5)	Total (n=202)
Other features took priorities	63%	68%	58%	45%	64%
Wasn't interested in EE, simply wanted the model	59%	66%	71%	62%	63%
Most models have better efficiency than what I had before	66%	59%	43%	79%	61%
Had less discount	59%	57%	49%	62%	57%
Didn't notice EE as a feature	57%	55%	62%	20%	56%
Didn't know how/what to look for EE models	56%	56%	65%	20%	56%
More expensive than I wanted to pay for	58%	56%	39%	62%	55%
Retail staff didn't recommend it	59%	50%	60%	43%	55%
Didn't have sufficient range of choices	54%	43%	39%	37%	47%

Table C-34: Reasons for Not Selecting Non-Efficient Freezer Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=85)	SCE (n=67)	SDG&E (n=16)	Non-IOUs (n=7)	Total (n=175)
Wasn't interested in EE, simply wanted the model	69%	66%	74%	56%	68%
Most models have better efficiency than what I had before	65%	58%	62%	87%	63%
Other features took priorities	70%	56%	34%	45%	61%
More expensive than I wanted to pay for	58%	68%	37%	43%	59%
Didn't notice EE as a feature	61%	60%	43%	15%	58%
Retail staff didn't recommend it	60%	56%	55%	28%	57%
Didn't know how/what to look for EE models	52%	67%	49%	15%	56%
Had less discount	56%	57%	42%	43%	55%
Didn't have sufficient range of choices	51%	59%	40%	43%	53%

Table C-35: Reasons for Not Selecting Non-Efficient Soundbar Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=128)	SCE (n=95)	SDG&E (n=25)	Non-IOUs (n=17)	Total (n=265)
Wasn't interested in EE, simply wanted the model	75%	70%	70%	68%	72%
Other features took priorities	68%	71%	74%	67%	70%
Retail staff didn't recommend it	63%	65%	89%	76%	67%
Didn't notice EE as a feature	59%	62%	66%	76%	62%
Most models have better efficiency than what I had before	64%	55%	71%	60%	61%
Didn't know how/what to look for EE models	53%	61%	40%	48%	54%
Had less discount	58%	50%	48%	15%	51%
Didn't have sufficient range of choices	51%	52%	51%	22%	49%
More expensive than I wanted to pay for	51%	51%	43%	15%	48%

Table C-36: Reasons for Not Selecting Non-Efficient Ultra-HD TV Model (Among Those Low-Medium Priority), by IOU (Multiple Responses Allowed)

Reason	PG&E (n=174)	SCE (n=148)	SDG&E (n=34)	Non-IOUs (n=27)	Total (n=383)
Other features took priorities	70%	63%	78%	70%	68%
Wasn't interested in EE, simply wanted the model	68%	61%	54%	63%	63%
Most models have better efficiency than what I had before	66%	61%	53%	57%	62%
Didn't notice EE as a feature	60%	55%	65%	49%	58%
Retail staff didn't recommend it	60%	54%	54%	55%	57%
Didn't know how/what to look for EE models	56%	47%	50%	45%	51%
Had less discount	46%	45%	42%	29%	44%
More expensive than I wanted to pay for	44%	45%	39%	29%	43%
Didn't have sufficient range of choices	47%	41%	35%	31%	42%

C.2.1.6. Priority of Energy Consumption in Product Selection and Looking for ENERGY STAR Models

Table C-37: Priority Level of Energy Consumption in Selecting The Model (All), by IOU

Product	Priority	PG&E		SCE		SDG&E		Non-IOUs		Total	
		Count	%	Count	%	Count	%	Count	%	Count	%
Refrigerator	Low	21	8%	24	9%	4	8%	3	8%	52	9%
	Medium	106	43%	98	39%	21	42%	20	52%	245	41%
	High	117	47%	130	51%	26	50%	13	32%	286	48%
	DK	5	2%	2	1%	0	0%	3	8%	10	2%
	Total	249	100%	254	100%	51	100%	39	100%	593	100%
Clothes Dryer	Low	28	12%	22	10%	4	11%	4	13%	58	11%
	Medium	91	38%	90	43%	20	47%	12	40%	213	41%
	High	108	46%	92	44%	18	42%	13	41%	231	44%
	DK	9	4%	8	4%	0	0%	2	6%	19	4%
	Total	236	100%	212	100%	42	100%	31	100%	521	100%

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Product	Priority	PG&E		SCE		SDG&E		Non-IOUs		Total	
		Count	%	Count	%	Count	%	Count	%	Count	%
Clothes Washer	Low	28	11%	21	8%	5	11%	1	3%	55	10%
	Medium	97	38%	98	41%	21	41%	20	64%	236	41%
	High	118	47%	116	48%	24	48%	10	31%	268	47%
	DK	8	3%	7	3%	0	0%	1	2%	16	3%
	Total	251	100%	242	100%	50	100%	32	100%	575	100%
Air Purifier	Low	21	14%	20	14%	7	22%	2	10%	50	14%
	Medium	64	43%	51	36%	14	43%	12	56%	141	41%
	High	63	41%	67	48%	10	31%	6	28%	146	42%
	DK	4	3%	3	2%	1	4%	1	5%	9	3%
	Total	152	100%	141	100%	32	100%	21	100%	346	100%
Room AC	Low	18	10%	21	11%	3	7%	1	6%	43	10%
	Medium	75	43%	60	32%	20	43%	4	28%	159	38%
	High	80	45%	101	54%	23	49%	8	58%	212	50%
	DK	3	2%	6	3%	0	0%	1	8%	10	3%
	Total	176	100%	188	100%	46	100%	14	100%	424	100%
Freezer	Low	20	13%	20	14%	0	0%	2	17%	42	12%
	Medium	65	42%	47	33%	16	47%	5	46%	133	39%
	High	65	42%	74	53%	18	53%	2	20%	159	47%
	DK	5	4%	0	0%	0	0%	2	17%	7	2%
	Total	155	100%	141	100%	34	100%	11	100%	341	100%
Soundbar	Low	48	26%	36	27%	8	23%	6	24%	98	26%
	Medium	80	43%	59	43%	17	44%	11	49%	167	44%
	High	48	26%	34	25%	12	31%	3	14%	97	25%
	DK	8	4%	6	5%	1	2%	3	13%	18	5%
	Total	184	100%	135	100%	38	100%	23	100%	380	100%
Ultra-HD TV	Low	56	21%	41	16%	7	14%	5	14%	109	18%
	Medium	118	44%	107	42%	27	53%	22	54%	274	45%
	High	83	31%	99	39%	17	31%	14	33%	213	35%
	DK	8	3%	7	3%	1	2%	0	0%	16	3%
	Total	265	100%	254	100%	52	100%	41	100%	612	100%

Table C-38: Looked for ENERGY STAR Model When Buying (Among Those Who Bought ENERGY STAR Models), by IOU

Product		PG&E		SCE		SDG&E		Non-IOUs		Total	
		Count	%	Count	%	Count	%	Count	%	Count	%
Refrigerator	Yes	148	58%	156	62%	34	67%	20	51%	358	60%
	No	97	40%	97	38%	16	31%	19	49%	229	39%
	DK	4	2%	1	0%	1	2%	0	0%	6	1%
	Total	249	100%	254	100%	51	100%	39	100%	593	100%
Clothes Dryer	Yes	146	62%	130	60%	26	60%	17	56%	319	60%
	No	87	37%	78	38%	16	40%	14	44%	195	38%
	DK	3	1%	4	2%	0	0%	0	0%	7	1%
	Total	236	100%	212	100%	42	100%	31	100%	521	100%
Clothes Washer	Yes	139	54%	148	61%	32	62%	19	60%	338	58%
	No	109	44%	93	39%	18	38%	13	40%	233	41%
	DK	3	1%	1	1%	0	0%	0	0%	4	1%
	Total	251	100%	242	100%	50	100%	32	100%	575	100%
Air Purifier	Yes	89	58%	80	57%	13	40%	11	53%	193	55%
	No	59	40%	60	43%	18	56%	10	47%	147	43%
	DK	4	3%	1	1%	1	4%	0	0%	6	2%
	Total	152	100%	141	100%	32	100%	21	100%	346	100%
Room AC	Yes	105	58%	109	57%	19	40%	5	35%	238	55%
	No	66	38%	79	43%	27	60%	9	65%	181	43%
	DK	5	3%	0	0%	0	0%	0	0%	5	1%
	Total	176	100%	188	100%	46	100%	14	100%	424	100%
Freezer	Yes	99	63%	79	55%	23	68%	3	28%	204	59%
	No	55	36%	61	44%	11	32%	8	72%	135	40%
	DK	1	1%	1	1%	0	0%	0	0%	2	1%
	Total	155	100%	141	100%	34	100%	11	100%	341	100%
Soundbar	Yes	74	39%	61	45%	20	52%	3	13%	158	41%
	No	108	60%	73	54%	18	48%	20	87%	219	59%
	DK	2	1%	1	1%	0	0%	0	0%	3	1%
	Total	184	100%	135	100%	38	100%	23	100%	380	100%

Product		PG&E		SCE		SDG&E		Non-IOUs		Total	
		Count	%	Count	%	Count	%	Count	%	Count	%
Ultra-HD TV	Yes	117	43%	113	44%	28	54%	16	39%	274	44%
	No	146	56%	135	53%	23	44%	24	58%	328	54%
	DK	2	1%	6	3%	1	2%	1	3%	10	2%
	Total	265	100%	254	100%	52	100%	41	100%	612	100%

C.2.1.7. Important Features in Product Selection

Table C-39: Refrigerator Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=249)	SCE (n=254)	SDG&E (n=51)	Non-IOUs (n=39)	Total (n=593)
Ice maker	71%	74%	68%	61%	71%
Spill-safe shelves	64%	64%	65%	52%	63%
Water filter	73%	66%	66%	56%	68%
Door open alarm	47%	47%	47%	14%	45%
Frost free	77%	84%	78%	85%	81%
Child lock	40%	36%	44%	16%	37%
Cantilever shelves	52%	54%	56%	29%	51%
Energy efficient	85%	85%	88%	88%	86%
Other	59%	74%	48%	66%	65%

Table C-40: Clothes Dryer Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=236)	SCE (n=212)	SDG&E (n=42)	Non-IOUs (n=31)	Total (n=521)
Reversible door hinge	44%	49%	61%	26%	46%
Time remaining display	71%	70%	68%	53%	69%
Delay start	44%	41%	59%	15%	42%
Damp start	59%	58%	65%	46%	58%
Damp dry	84%	92%	89%	90%	88%
End of cycle signal	75%	78%	77%	73%	76%
Noise reduction	71%	74%	62%	74%	72%
Automatic temperature control	72%	73%	73%	69%	72%
Steam function	48%	53%	61%	16%	49%
Moisture sensor	62%	60%	75%	44%	61%
Interior light	57%	58%	65%	51%	58%
Large capacity	37%	31%	44%	0%	33%
Smart phone enabled	58%	69%	46%	0%	60%

Table C-41: Clothes Washer Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=251)	SCE (n=242)	SDG&E (n=50)	Non-IOUs (n=32)	Total (n=575)
Bleach dispenser	66%	69%	64%	49%	66%
Large capacity	86%	89%	83%	91%	87%
Delay start	44%	41%	52%	18%	42%
Vibration reduction	70%	72%	72%	56%	70%
Automatic temperature control	68%	66%	63%	47%	66%
Extra rinse cycle	68%	69%	78%	59%	69%
End of cycle signal	67%	73%	79%	54%	70%
Stackable	41%	40%	44%	21%	40%
Internal water heater	53%	52%	59%	18%	51%
Time remaining display	70%	67%	61%	41%	67%
Front loading	54%	57%	59%	44%	55%
Smart phone enabled	36%	32%	35%	4%	32%
Other	57%	70%	63%	74%	64%

Table C-42: Air Purifier Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=152)	SCE (n=141)	SDG&E (n=32)	Non-IOUs (n=21)	Total (n=346)
Filter included	87%	89%	91%	95%	89%
Filter indicator lights	81%	80%	77%	79%	80%
AHAM certified	58%	58%	34%	34%	54%
Ionizing	74%	70%	76%	80%	73%
App controlled	54%	53%	40%	15%	50%
Remote control	63%	63%	72%	36%	62%
Size or capacity	84%	88%	90%	85%	87%
Other	53%	67%	87%	68%	62%

Table C-43: Room AC Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=176)	SCE (n=188)	SDG&E (n=46)	Non-IOUs (n=14)	Total (n=424)
Remote control	73%	67%	78%	37%	70%
Timer	64%	69%	68%	52%	66%
Integrated fan	80%	77%	64%	72%	77%
Integrated heater	59%	49%	55%	22%	53%
Filter indicator light	73%	73%	66%	47%	72%
Integrated dehumidifier	63%	55%	57%	38%	58%
Overload protection	72%	79%	75%	63%	75%
Sleep mode	67%	62%	56%	49%	63%
Auto shut off	75%	79%	80%	71%	78%
Smart phone enabled	45%	40%	37%	15%	41%
Other	49%	59%	46%	24%	51%

Table C-44: Freezer Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=155)	SCE (n=141)	SDG&E (n=34)	Non-IOUs (n=11)	Total (n=341)
Power on indicator light	76%	77%	68%	48%	75%
Interior lights	83%	81%	83%	64%	82%
Compact	71%	65%	78%	65%	69%
Full size	76%	78%	69%	91%	76%
Adjustable leveling legs	65%	66%	64%	37%	65%
Child lock	57%	57%	46%	28%	55%
Magnetic doors	71%	71%	67%	38%	70%
In door storage	70%	72%	57%	29%	68%
Adjustable shelving	71%	70%	76%	64%	71%
Other	66%	70%	24%	65%	63%

Table C-45: Soundbar Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=184)	SCE (n=135)	SDG&E (n=38)	Non-IOUs (n=23)	Total (n=380)
Remote control	81%	85%	85%	97%	84%
Bluetooth enabled	75%	76%	84%	72%	76%
Wireless	79%	81%	85%	90%	81%
Separate subwoofer	65%	65%	79%	68%	67%
HDMI outputs	81%	77%	86%	78%	80%
Wireless woofer connectivity	78%	73%	73%	82%	76%
Virtual surround sound	79%	82%	74%	87%	80%
Wi-Fi built in	74%	77%	69%	65%	74%
Smart phone enabled	62%	67%	56%	34%	62%
Other	68%	62%	66%	46%	65%

Table C-46: Ultra HD-TV Features Perceived as "Important", by IOU (Multiple Responses Allowed)

Feature	PG&E (n=265)	SCE (n=254)	SDG&E (n=52)	Non-IOUs (n=41)	Total (n=612)
Wall mountable	59%	70%	68%	40%	63%
Digital tuner	66%	70%	61%	75%	68%
High dynamic range	66%	79%	72%	63%	72%
V-chip	44%	41%	45%	26%	42%
Headphone jack	41%	45%	50%	27%	43%
Sleep timer	51%	46%	48%	26%	47%
Simulated surround sound	67%	70%	59%	71%	68%
Smart phone enabled	52%	53%	47%	36%	51%
Other	65%	72%	41%	59%	66%

Appendix D. In-Depth Interview Guides

D.1. Design Staff

D.1.1. Introduction

Thank you for taking the time to speak with me today. As I mentioned in my [phone call/email], we're working with PG&E to assess the market barriers for each product incented in RPP. Your knowledge about the program and products in the portfolio will inform our product-specific market barrier assessment.

I anticipate we will need about 45 minutes. Is this a good time, or should we schedule time in the next week or so?

Would you mind if I record our conversation? The recording is just to help with my note taking. We won't report anything in a way that would identify any individual respondent.

RPP is designed to influence upstream, midstream, and downstream barriers, and the barriers preventing more efficient design differ from those preventing more efficient adoption. We would like to know more about upstream, midstream, and downstream barriers for the products incented in RPP.

D.1.2. Product-Specific Barriers to Market Adoption

Q1. As an intervention strategy, which market barriers does RPP address?

1. Are there any products currently in RPP that require different intervention strategies?

Q2. For the barriers you just described, how does RPP address those barriers?

[PROBE for differences between products]

1. What other changes in market structure or incentives do you think are necessary to increase the share of efficient products? [PROBE for differences between products]

First I'd like to talk about barriers for each of the following products.

We've grouped products into three groups.

1. White goods
 - a. Freezers
 - b. Electric and gas dryers
 - c. Refrigerators or clothes washers
2. Heating, venting and cooling
 - a. Air purifiers/cleaners

- b. Room air conditioners
- 3. Consumer electronics
 - a. Soundbars
 - b. UHD TVs

For [PRODUCT GROUP]

- Q3. What do you see as the key barriers preventing more energy efficient models from reaching consumers?
- 1. What role do you think consumer demand plays in driving efficiency improvements in [PRODUCT GROUP]? [PROBE for differences between products]
 - 2. [If not addressed] What barriers bar end-use customers from adopting EE models of [PRODUCT]? [PROBE for differences between products]

Q4. What are the key features for this product?

[PROBE for differences between products]

- 1. Where does energy efficiency fit into the feature set for [PRODUCT GROUP]? [PROBE for differences between products]
 - 2. What is the product-refresh cycle for [PRODUCT GROUP]? [PROBE for differences between products]
- Q5. What are the most important technologies or features coming down the road that program designers need to be aware of? These can be things that are going to increase or decrease the energy used by [PRODUCT GROUP].

[PROBE for differences between products]

Q6. When you think about [PRODUCT GROUP] is there any one change you think retailers or manufacturers could make to increase sales of energy efficient models? Is there any one change that would make it harder to increase sales of energy efficient models?

[PROBE for differences between products]

Q7. What (if any) changes do you expect to see regarding the market share of efficient models produced in the next 1, 3 and 5 years?

[PROBE for differences between products]

D.1.2.1. How RPP addresses barriers - General Qs

Q8. Thinking about the barriers you just mentioned across products, do you see similar barriers for these products? What are they? Why do you think RPP is the best method to address these?

- 1. Do you know of other intervention strategies currently being used with midstream and upstream actors? [PROBE: strengths and weaknesses]

- Q9. What makes a product promising in terms of potential savings? Potential engagement with retailers? Market transformation? Why?
- Q10. What other products, not discussed here, do you think should be considered for inclusion in RPP? Why?
- Q11. Thinking about the products in the RPP portfolio now (soundbars, room air cleaners, freezers, dryers, and room air conditioners), which markets are changing the fastest in terms of technologies or the structure of the market?
1. How are those markets changing?
 2. How will those changes impact the energy use of those products?
 3. How do you expect those changes will impact RPP's ability to influence the market?

D.1.3. Communication of EE

We're also interested in how the consumer electronics and white good market learns about energy efficiency.

- Q12. What kinds of communications have you seen organizations like CTA and AHAM produce to inform their members about energy efficiency? What were those organizations hoping to accomplish with those messages? How effective do you think those messages are?
- Q13. What other private organizations or government agencies do you think have the most influence on improving the efficiency of products, and why do you think they've been successful?
1. Are there any others success stories you think are important, or other lessons learned?

D.1.4. Generating Contacts

- Q14. [NAVITAS and EPA] Finally, can you help me with identifying some manufacturer and component supplier contacts?

D.2. Retailer Sustainability Staff

D.2.1. Introduction

Thank you for taking the time to speak with me today. As I mentioned in my [phone call/email], we're working with PG&E to identify market barriers for each product in RPP. Your knowledge about the program and its products is integral to our research.

I anticipate we will need about 30 minutes. Is this a good time, or should we schedule time in the next week or so?

Would you mind if I record our conversation? The recording is just to help with my note taking. We won't report anything in a way that would identify any individual respondent.

D.2.2. Identify Key Trends

First I'd like to talk about the key features and market trends for each of the following products. We'd like to understand what, if anything, is driving change in the market for each product.

We've grouped products into three groups.

1. White goods
 - a. Freezers
 - b. Electric and gas dryers
 - c. Refrigerators or clothes washers
 2. Heating, venting and cooling
 - a. Air purifiers/cleaners
 - b. Room air conditioners
 3. Consumer electronics
 - a. Soundbars
 - b. UHD TVs
- Q1. Please correct me if I'm mistaken, but we've heard in our past conversations with you and in conversations with other retailers that the most important thing you consider when deciding which products to assort and promote is consumer demand – you want to choose products that people will want to buy. What features do consumers look for when purchasing [PRODUCT GROUP]? [PROBE for differences between products]
1. Where does energy efficiency fit into the feature set for [PRODUCT GROUP]? [PROBE for differences between products]

- Q2. Other than consumer demand, what features or characteristics of a [PRODUCT GROUP] do you consider when you are making decisions about that category?
1. [If not addressed:] How, if at all, might those considerations lead you to choose more or less energy efficient products?
- Q3. When working with manufacturers, what features do you discuss most often for [PRODUCT GROUP]? [PROBE for differences between products]
- Q4. Do you make buying decisions for [PRODUCT GROUP] on a regular cycle, or is it an ongoing process? [PROBE for differences between products]
1. [If not addressed:] When in the year do you make buying decisions for [PRODUCT GROUP]?
 2. How long after you make your buying decisions do new models of [PRODUCT GROUP] become available in stores?
 3. And how long do they typically remain available before you replace them with a newer model?
 4. At what point in the year, if at all, do you discuss the product features you would like to see in upcoming models with manufacturers?
 5. When do you think is the best time for RPP to provide you with information about specification changes for the upcoming program year? Does this differ by product?
- Q5. What are the most important technologies or features coming down the road that we need to be aware of? These can be things that are going to increase or decrease the energy used by [PRODUCT GROUP].

[PROBE for differences between products]

- Q6. When you think about [PRODUCT GROUP] is there any one change you think [RETAILER NAME] or manufacturers could make to increase sales of energy efficient models? Is there any one change that would make it harder to increase sales of energy efficient models?

[PROBE for differences between products]

- Q7. How, if at all, do you expect overall energy use of [PRODUCT GROUP] to change in the next 1, 3 and 5 years?

[PROBE for differences between products]

D.2.3. Catalog Market Barriers

RPP offers incentives for sales of energy efficient products in certain categories. We'd like to understand what, if anything, keeps energy efficient models from penetrating the market.

For the next set of questions, we'll keep the same groups as before.

1. White goods
 - a. Freezers
 - b. Electric and gas dryers
 - c. Refrigerators or clothes washers
2. Heating, venting and cooling
 - a. Air purifiers/cleaners
 - b. Room air conditioners
3. Consumer electronics
 - a. Soundbars
 - b. UHD TVs

For [PRODUCT GROUP]

- Q8. What prevents manufacturers from designing [PRODUCT GROUP] to be more energy efficient?
1. What prevents them from including energy efficient technologies in a wider range of [PRODUCT GROUP] models?
- Q9. What are the most important reasons consumers do not purchase more energy efficient models?
- Q10. And finally, what prevents you from assorting and promoting a larger number of energy efficient models?
1. Are there enough efficient models available from manufacturers that you could increase the number you assort?
- Q11. Thinking about all the reasons you just told me that manufacturers don't produce more efficient models, consumers don't buy more of them, and you don't assort and promote them, what are the most important reasons there are not more efficient models of [PRODUCT GROUP] sold?
- Q12. Is RPP an effective way to overcome those challenges? Why or why not?

[PROBE for differences between products]

1. What other changes in the market do you think are necessary to increase the share of efficient products? [PROBE for differences between products]

D.2.4. Generating Contacts

- Q13. Finally, we hope to talk to key manufacturer and component suppliers for this research. Can you help me with identifying some manufacturer and component supplier contacts?

D.3. Manufacturer

D.3.1. Introduction

Thank you for taking the time to speak with me today. As I mentioned in my [phone call/email], we're working with PG&E to understand what prevents greater adoption of certain energy efficient appliances and consumer electronics products. Your knowledge about these products is integral to our research.

I anticipate we will need about 30 minutes. Is this a good time, or should we schedule time in the next week or so?

Would you mind if I record our conversation? The recording is just to help with my note taking. We won't report anything in a way that would identify any individual respondent.

D.3.2. Identify Key Trends

- Q1. I understand you make [PRODUCT 1], [PRODUCT 2], and [PRODUCT 3]. Is that correct?
- Q2. First, I'd like to talk about [PRODUCT 1] What are the key features consumers are interested in for [PRODUCT 1]?
1. Where does energy efficiency fit into the feature set for [PRODUCT]?
 2. Is energy efficiency typically bundled with premium features?
- Q3. What features or characteristics of [PRODUCT] do you consider when you are making design decisions about that category?
1. [If not addressed:] How, if at all, might those considerations lead you to design more or less energy efficient products?
- Q4. When working with retailers, what features do you discuss most often for [PRODUCT]?
- Q5. How long does it take for a new model of [PRODUCT] to go from the start of the design process to being available in stores?
1. [If not addressed:] When in the year do you make manufacturing design decisions for [PRODUCT GROUP]?
 2. At what point in the year, if at all, do you discuss the product features for upcoming models with retailers?
 3. When do you think is the best time for RPP to provide you with information about specification changes for the upcoming program year? Does this differ by product?
- Q6. What are the most important technologies or features coming down the road that we need to be aware of? These can be things that are going to increase or decrease the energy used by [PRODUCT].

1. How, if at all, do you expect overall energy use of [PRODUCT GROUP] to change in the next 1, 3 and 5 years? [PROBE for differences between products]
- Q7. When you think about [PRODUCT] is there any one change you think [MANUFACTURER NAME] or retailers could make to increase the number of energy efficient models? Is there any one change that would make it harder to increase the energy efficiency of models? [PROBE for differences between products]

D.3.3. Catalog Market Barriers

RPP offers incentives for sales of energy efficient products in certain categories. We'd like to understand what, if anything, keeps energy efficient models from penetrating the market.

- Q8. What are the most important reasons that manufacturers do not design [PRODUCT 1] to be more energy efficient?
1. What prevents them from including energy efficient technologies in a wider range of [PRODUCT GROUP] models?
- Q9. How, if at all, could RPP help overcome those challenges?
1. What other ways could energy efficiency program sponsors intervene in the market to overcome those challenges? Would this be more or less effective than RPP? Why do you say that?
 2. What other changes in the market do you think are necessary to increase the share of efficient products? [PROBE for differences between products]

D.3.4. Generating Contacts

- Q10. Finally, we hope to talk to component suppliers for this research. Can you help me with identifying some component supplier contacts?

D.4. Industry Organizations

D.4.1. Introduction

Thank you for taking the time to speak with me today. As I mentioned in my [phone call/email], we're working with PG&E to understand what prevents energy efficient products in certain categories from achieving greater market penetration. We're focused on [LIST PRODUCTS], which are included in the Retail Products Platform, abbreviated RPP, a program in which PG&E and other utilities are offering retailers incentives for each energy efficient unit they sell in the targeted product categories. Your perspective on the market for [LIST PRODUCTS OR PRODUCT GROUP] will help us understand whether RPP is the best approach for PG&E to increase uptake of efficient products.

I anticipate we will need about 30 minutes. Is this a good time, or should we schedule time in the next week or so?

Would you mind if I record our conversation? The recording is just to help with my note taking. We won't report anything in a way that would identify any individual respondent.

D.4.2. Product-Specific Barriers to Market Adoption

RPP offers incentives for sales of energy efficient products in certain categories. We'd like to understand what, if anything, keeps energy efficient models from penetrating the market. The following are products covered by RPP and the 'product groups' they fall under. For the subsequent questions, we will talk generally about all products, and when applicable talk about any differences between these product groups.

1. White goods
 - a. Freezers
 - b. Electric and gas dryers
 - c. Refrigerators or clothes washers
2. Heating, venting and cooling
 - a. Air purifiers/cleaners
 - b. Room air conditioners
3. Consumer electronics
 - a. Soundbars
 - b. UHD TVs

Q1. To start with, please tell me about the work your organization does related to energy efficiency?

1. What kinds of communications have you produced to inform your members about energy efficiency?
2. What are you hoping to accomplish with those messages?

3. How effective do you think those messages are?
- Q2. What motivates the manufacturers you work with to create energy efficient products?
1. What other private organizations or government agencies do you think have the most influence on improving the efficiency of products, and why do you think they've been successful?
 2. Are there any others success stories you think are important, or other lessons learned?
- Q3. What prevents manufacturers from designing products to be more energy efficient? [PROBE for differences between product groups]
1. Why do you think ENERGY STAR penetration isn't higher for these products? [PROBE for differences between products]
- Q4. What features are most important to consumers for these products? Where does energy efficiency fit into that list of important features? [PROBE for differences between products]
1. [If not addressed] Is energy efficiency something consumers think about or demand for these products? [PROBE for differences between products]
 2. How much does consumer demand drive EE improvements?
- Q5. How knowledgeable are consumers about energy efficiency of consumer electronics and white goods? [PROBE for differences between products]
1. How do consumers learn about energy efficiency of consumer electronics and white goods?
- Q6. Are energy efficient products more often high-end models than low-end models?
1. [If so:] To what extent does that reflect the cost of making the products energy efficient, and to what extent does it reflect bundling of other high-end features with energy efficiency?
 2. Why is that? What prevents manufacturers from including energy efficient technologies in a wider range of models? [PROBE for differences between product groups]
- Q7. What are the most important reasons consumers do not purchase more energy efficient models? [PROBE for differences between product groups]
- Q8. What prevents retailers from assorting and promoting a larger number of energy efficient models? [PROBE for differences between product groups]
- Q9. Thinking about all the reasons you just told me that consumers don't buy more efficient models, manufacturers don't produce more of them, and retailers don't assort and promote more of them, what are the most important reasons there are not more efficient models sold? [PROBE for differences between product groups]
1. Are there any other barriers you can think of?

- Q10. Is there any one change you think retailers or manufacturers could make to increase sales of energy efficient models? Is there any one change that would make it harder to increase sales of energy efficient models? [PROBE for differences between product groups]

D.4.3. Technology Trends

- Q11. What are the most important technologies or features coming down the road that might influence the energy use of [LIST RELEVANT PRODUCTS]? These can be things that are going to increase or decrease energy use. [PROBE for differences between products]
- Q12. What (if any) changes do you expect to see regarding the sales and market share of efficient models produced in the next 1, 3 and 5 years? [PROBE for differences between products]

D.4.4. Closing

- Q13. Is there anything else you think we should know about the barriers to improving efficiency of consumer products?

D.5. Component Supplier

D.5.1. Introduction

Thank you for taking the time to speak with me today. As I mentioned in my [phone call/email], we're working with PG&E to understand what prevents greater adoption of certain energy efficient appliances and consumer electronics products. Your knowledge about these products is integral to our research.

I anticipate we will need about 30 minutes. Is this a good time, or should we schedule time in the next week or so?

Would you mind if I record our conversation? The recording is just to help with my note taking. We won't report anything in a way that would identify any individual respondent.

- Q1. First, please tell me about your role at 3M? What types of products do you work on? What are they components of? What is your role in the production and marketing of those products?
- Q2. How do the products you work on impact the energy use of the devices they go into? Do you offer higher- and lower-efficiency options?
- Q3. What motivates you to make more efficient components?
- Q4. What prevents you from making them even more efficient?
- Q5. What motivates the product manufacturers you work with to select more efficient components?
- Q6. Are there certain sub-sets of products where manufacturers are looking for efficiency and others where it is less of a priority?
- Q7. Why don't manufacturers opt for efficient components for more of their models?
- Q8. What are the most important technologies or features coming down the road that we need to be aware of? These can be things that are going to increase or decrease the energy used by [PRODUCT].
 1. How, if at all, do you expect overall energy use of [PRODUCT GROUP] to change in the next 1, 3 and 5 years? [PROBE for differences between products]
- Q9. When you think about [PRODUCT] is there any one change you think [MANUFACTURER NAME] or retailers could make to increase the number of energy efficient models? Is there any one change that would make it harder to increase the energy efficiency of models? [PROBE for differences between products]
- Q10. How do you think RPP might impact your work?

Appendix E. Consumer Survey Instrument

E.1. First page

Respondents will have the option to take the survey in Spanish or English.

S0. In which language do you prefer to take this survey?

1. English [route to ENGLISH version]
2. Spanish [route to SPANISH version]

E.2. Introduction

[This is an online panel survey. The purpose of the introduction is to give a general idea of the survey topic rather than persuading their participation in the survey.]

We want to better understand how consumers like you use electric appliances and devices, and we need your help. This survey is for a California-wide study, and your responses will inform the development of products and services that utilities and energy suppliers may offer in the future. Please be assured that your responses are confidential and reported only in the aggregate.

Before we get started, we have a few questions to assure that we reach a wide range of people...

E.3. Screening [ASK ALL]

S1. What is your home zip code? [term NON – CA zips]

1. [ENTER 5 DIGITS]

S1A. Please select the company that provides your electric utility service in your home.

1. Pacific Gas & Electric (PG&E)
2. San Diego Gas & Electric (SDG&E)
3. Southern California Edison Co (SCE)
4. Other specify:
98. Don't know [TERMINATE]

S2. Do you or members of your household own your home or do you rent it?

[SINGLE RESPONSE]

1. Own/Buying

- 2. Rent/Lease
- 3. Occupy rent-free
- 98. Don't know [TERMINATE]
- 99. Prefer not to say [TERMINATE]

S3. In what year were you born? **[term if less than 18]**

- 1. [ENTER 4 DIGITS]

S4. What is the highest level of education you have completed?

[SINGLE RESPONSE]

- 1. Less than high school
- 2. High school graduate or equivalent (e.g., GED)
- 3. Some college
- 4. 4-year college degree
- 5. Some graduate school
- 6. Graduate or professional degree
- 98. Don't know [TERMINATE]
- 99. Prefer not to say [TERMINATE]

S5. What was your annual household income from all sources in 2015, before taxes?

[SINGLE RESPONSE]

- 1. Less than \$20,000 per year
- 2. \$20,000 to less than \$30,000
- 3. \$30,000 to less than \$40,000
- 4. \$40,000 to less than \$50,000
- 5. \$50,000 to less than \$60,000
- 6. \$60,000 to less than \$75,000
- 7. \$75,000 to less than \$100,000
- 8. \$100,000 to less than \$150,000
- 9. \$150,000 to less than \$200,000
- 10. More than \$200,000

98. Don't know [TERMINATE]

99. Prefer not to say [TERMINATE]

[QUOTA CHECK. THANK AND TERMINATE IF QUOTA IS FILLED.]

E.4. Recent Product Purchase and Plug-Load Profile

Great! We could really use your responses for our survey. Let's get started.

[ASK ALL]

Q1. Have you purchased each of these products in the last two years? If so, did you buy it as new or used?

[MATRIX QUESTION]

	RANDOMIZE	1 – Yes bought as new	2 – Yes bought as used	3 – No	98 – Don't know DK
1	Refrigerator				
2	Clothes Dryer				
3	Clothes Washer				
4	Air Purifier/Cleaner				
5	Room Air Conditioner				
6	Freezer				
7	Soundbar				
8	Ultra-HD TV				

[DISPLAY IF Q1_ANY=3 OR Q1_ANY=98]

Q2. Do you currently have any of these products in your home?

[MATRIX QUESTION]

	Logic	Feature	1 – Yes own	2 – No	98 – Don't know
1	DISPLAY IF Q1_1=3 OR 98	Refrigerator			
2	DISPLAY IF Q1_2=3 OR 98	Clothes Dryer			
3	DISPLAY IF Q1_3=3 OR 98	Clothes Washer			
4	DISPLAY IF Q1_4=3 OR 98	Air Purifier/Cleaner			
5	DISPLAY IF Q1_5=3 OR 98	Room Air Conditioner			
6	DISPLAY IF Q1_6=3 OR 98	Freezer			
7	DISPLAY IF Q1_7=3 OR 98	Soundbar			

	Logic	Feature	1 – Yes own	2 – No	98 – Don't know
8	DISPLAY IF Q1_8=3 OR 98	Ultra-HD TV			

[DISPLAY IF Q1_ANY<>1]

Q3. Do you plan on purchasing any of these products as new in the next two years?

[MATRIX QUESTION]

	Logic	Feature	1 – Yes	2 – No	98 – Don't know
1	DISPLAY IF Q1_1<>1	Refrigerator			
2	DISPLAY IF Q1_2<>1	Clothes Dryer			
3	DISPLAY IF Q1_3<>1	Clothes Washer			
4	DISPLAY IF Q1_4<>1	Air Purifier/Cleaner			
5	DISPLAY IF Q1_5<>1	Room Air Conditioner			
6	DISPLAY IF Q1_6<>1	Freezer			
7	DISPLAY IF Q1_7<>1	Soundbar			
8	DISPLAY IF Q1_8<>1	Ultra-HD TV			

E.5. Purchasing Decisions [ASK IF Q1_ANY=1 OR Q1_ANY=2]

[DISPAY LOGIC: Q4-Q12 LOOPED FOR EACH OF THE PRODUCT TYPE RECENTLY BOUGHT (Q1_ANY=1 OR Q1_ANY=2)]

[DISPLAY IF Q1_ANY=1 OR Q1_ANY=2]

Q4. Did you buy an ENERGY STAR [PRODUCT TYPE]? Generally, ENERGY STAR models have this [LOGO] on the packaging or directly on the [PRODUCT TYPE].

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know

[DISPLAY IF (Q1_ANY=1 OR Q1_ANY=2) AND Q4_ANY=1]

Q5. When buying your [PRODUCT TYPE], did you specifically look for an ENERGY STAR model?

[SINGLE RESPONSE]

1. Yes

- 2. No
- 98. Don't know

[DISPLAY IF Q1_ANY=1 OR Q1_ANY=2]

Q6. When making your decision on what type of [PRODUCT TYPE] to buy, where did you look for information? (Select all that apply)

[MULTIPLE RESPONSE] [RANDOMIZE]

- 1. Salesperson at the store
- 2. Contractor
- 3. Internet
- 4. Consumer Reports or other product-oriented magazines
- 5. Advertisement
- 6. Friend or family member
- 7. Electric or gas utility
- 8. Other specify: [ANCHOR]
- 9. I did not seek information [EXCLUSIVE] [ANCHOR]
- 98. Don't know [EXCLUSIVE] [ANCHOR]

[DISPLAY IF (Q1_ANY=1 OR Q1_ANY=2) AND TWO OR MORE RESPONSES FOR Q6_ANY]

Q7. It looks like you got information from more than one source. Of the sources you selected, which of these was the most influential in making your decision to buy your [PRODUCT TYPE]?

[SINGLE RESPONSE]

- 1. [PIPE IN SELECTED FROM Q6_ANY]
- 96. None [EXCLUSIVE]
- 98. Don't know

[DISPLAY IF Q1_ANY=1]

Q8. Where did you buy your [PRODUCT TYPE]?

[SINGLE RESPONSE] [RANDOMIZE]

- 1. At a big box retail store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.
- 2. At a local retail store

3. An online big box store such as BestBuy, Walmart, Costco, Home Depot, Sears, IKEA, etc.
4. An online-only retail store such as Amazon, Overstock.com, Abt.com, etc.
5. Other specify: _____ [ANCHOR]
98. Don't know [ANCHOR]

[DISPLAY IF (Q1_ANY=1 OR Q1_ANY=2) AND (Q8_ANY=1 OR Q8_ANY=2)]

Q9. Prior to buying your [PRODUCT TYPE] at the store, did you do any research on the types, features, or price of [PRODUCT TYPE] you might be interested?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know

[DISPLAY IF Q1_ANY=1 OR Q1_ANY=2]

Q10. Why did you select the specific model of [PRODUCT TYPE] you chose? (Select all that apply)

[MULTIPLE RESPONSE] [RANDOMIZE]

1. It was in my price range
2. It costs less to operate
3. It had the features I wanted
4. It had an ENERGY STAR label
5. I wanted the brand
6. It had good reviews
7. It was available
8. It was recommended to me
96. Other, please specify: [OPEN-ENDED RESPONSE] [ANCHOR]
98. Don't know [EXCLUSIVE] [ANCHOR]

[DISPLAY IF Q1_ANY=1 OR Q1_ANY=2]

Q11. Compared to other criteria like price and features, how would you rate the priority level of the energy consumption of the [PRODUCT TYPE] was to you in your selection of [PRODUCT TYPE]?

[SINGLE RESPONSE]

1. Low priority

- 2. Medium priority
- 3. High priority
- 98. Don't know

[DISPLAY IF (Q1_ANY=1 OR Q1_ANY=2) AND (Q10 Q11_ANY=1 OR Q10 Q11_ANY=2)]

Q12. The following is a list of common reasons why people don't select an energy efficient model when purchasing [pipe-in PRODUCT TYPE]. For each one, please tell us if it applies to your recent [pipe in PRODUCT TYPE] purchase.

[MATRIX QUESTION: SCALE]

Logic: RANDOMIZE	Yes	No
Energy efficient models were more expensive than I wanted to pay for		
Energy efficient models did not have a sufficient range of choices		
Most models, even without ENERGY STAR label, have better efficiency than what I had before		
Other features – color/aesthetic, size, functionality, etc. – took priorities to how efficient the model was		
Energy efficient models had less discount than non-energy efficient models		
I did not know how to or what to look for in energy efficient models		
I simply needed or wanted the [PRODUCT TYPE], and wasn't interested in energy efficiency		
[DISPLAY IF Q8=1 OR Q8=2] Retailor staff did not mention energy efficiency or recommend energy efficient models		
I didn't notice energy efficiency as a feature.		

[DISPLAY IF Q1_1=1 OR Q1_1=2]

Q13. Were the following features important to you when making your decision to buy your refrigerator?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Ice maker			
Spill-safe shelves			
Water filter			
Door open alarm			
Frost free			
Child lock			
Cantilever shelves			
Energy efficient			

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Other: [Please specify] [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_2=1 OR Q1_2=2) FOR CLOTHES DRYER]

[DISPLAY IF Q1_2=1 OR Q1_2=2]

Q14. Were the following features important to you when making your decision to buy your clothes dryer?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
End of cycle signal			
Noise reduction			
Automatic temperature control			
Steam function			
Moisture sensor			
Interior light			
Reversible door hinge			
Time remaining display			
Delay start			
Damp dry			
Large capacity			
Smart phone enabled			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_3=1 OR Q1_3=2) FOR CLOTHES WASHER]

[DISPLAY IF Q1_3=1 OR Q1_3=2]

Q15. Were the following features important to you when making your decision to buy your clothes washer?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Bleach dispenser			
Large capacity			
Delay start			
Vibration reduction			
Automatic temperature control			

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Extra rinse cycle			
End of cycle signal			
Stackable			
Internal water heater			
Time remaining display			
Front loading			
Smart phone enabled			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_4=1 OR Q1_4=2) FOR AIR PURIFIER/CLEANER] [DISPLAY IF Q1_4=1 OR Q1_4=2]

Q16. Were the following features important to you when making your decision to buy your air purifier/cleaner?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Filter included			
Filter indicator lights			
AHAM certified			
Ionizing			
App controlled			
Remote control			
Size or capacity			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_5=1 OR Q1_5=2) FOR ROOM AIR CONDITIONER]

[DISPLAY IF Q1_5=1 OR Q1_5=2]

Q17. Were the following features important to you when making your decision to buy your room air conditioner?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Remote control			
Timer			
Integrated fan			

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Integrated heater			
Filter indicator light			
Integrated dehumidifier			
Overload protection			
Sleep mode			
Auto shut off			
Smart phone enabled			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_6=1 OR Q1_6=2) FOR FREEZER]

[DISPLAY IF Q1_6=1 OR Q1_6=2]

Q18. Were the following features important to you when making your decision to buy your freezer?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Power on indicator light			
Interior lights			
Compact			
Full size			
Adjustable leveling legs			
Child lock			
Magnetic doors			
In door storage (upright only)			
Adjustable shelving (upright only)			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_7=1 OR Q1_7=2) FOR SOUNDBAR]

[DISPLAY IF Q1_7=1 OR Q1_7=2]

Q19. How important were the following features when making your decision to buy your soundbar?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Remote control			
Bluetooth enabled			

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Wireless			
Separate subwoofer			
HDMI outputs			
Wireless subwoofer connectivity			
Virtual surround sound			
Wi-Fi built in			
Smart phone enabled			
Other: (specify) [ANCHOR]			

[LOOP Q4 THRU Q12 IF (Q1_8=1 OR Q1_8=2) FOR ULTRA-HD TV]

[DISPLAY IF Q1_8=1 OR Q1_8=2]

Q20. Were the following features important to you when making your decision to buy your ultra-HD TV?

[MATRIX QUESTION, RANDOMIZE]

Feature: RANDOMIZE	1 – Important	2 – NOT important	98 – Don't know
Wall mountable			
Digital tuner			
High dynamic range			
V-chip			
Headphone jack			
Sleep timer			
Simulated surround sound			
Smart phone enabled			
Other: (specify) [ANCHOR]			

E.6. Attitudes and Awareness (AKAB and ODC segmentation Qs)

The next several questions are about how you use and think about energy in general.

[ASK ALL]

Q21. Please tell me if your household has already taken each of the following actions.

[MATRIX QUESTION: SCALE]

Logic: RANDOMIZE	1 – Yes	2 – No	97 - Came with the house	98 – Don't know
Installed an attic vent to keep the attic cooler				
Installed programmable thermostats				
Installed ceiling fans				
Installed motion detectors for lights				

[ASK ALL]

Q22. How much do you agree or disagree with the following statements?

On a scale of 1 to 7 where 1 is Strongly Disagree and 7 is Strongly Agree, how much you agree or disagree with the following two statements.

[MATRIX QUESTION: SCALE]

[LOGIC] Item RANDOMIZE	1 – strongly disagree	2	3	4	5	6	7 – strongly agree	98 Don't know
I compare prices of at least a few brands before I choose one								
I do NOT feel responsible for conserving energy because my personal contribution is very small								

[ASK ALL]

Q23. Have you heard of a carbon footprint? A carbon footprint is a measure of the energy you use throughout your life, either directly or indirectly. This includes but is not limited to the energy consumption from your home, your transportation, your diet, and your purchases.

[SINGLE RESPONSE]

1. Yes
2. No

[ASK ALL]

Q24. Which of the following would motivate you the MOST to save energy? [RANDOMIZE 1-6]

[SINGLE RESPONSE]

1. Saving money
2. Maintaining health
3. Protecting the environment
4. For the benefit of future generations

5. Reducing our dependence on foreign oil
6. Helping California lead the way on saving energy
98. Don't know

E.7. Demographics

We are almost done. We just have a few final questions about your home and the members of your household.

[ASK ALL]

Q25. What kind of house or building do you live in?

[SINGLE RESPONSE]

1. Single family detached house
2. Duplex, triplex, or four-plex
3. Apartment or condo building
4. Townhome
5. Manufactured or mobile home
6. Boat, RV, van, camper, or other mobile unit
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Prefer not to say

[ASK ALL]

Q26. Including yourself, how many of the people currently living in your home year-round are in the following age groups? **[RANGE: 0 – 9] [ITEMS 2 – 7 SHOULD HAVE AT LEAST 1 TO CONTINUE]**

1. _____ Less than 18 years old
2. _____ 18-24
3. _____ 25-34
4. _____ 35-44
5. _____ 45-54
6. _____ 55-64
7. _____ 65 or older

- 98. Don't know [EXCLUSIVE]
- 99. Prefer not to say [EXCLUSIVE]

[ASK ALL]

Q27. Which categories describe you? Please select all that apply.

- 1. American Indian or Alaska Native (For example, Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Native Village of Barrow Inupiat Traditional Government, Nome Eskimo Community, etc.)
- 2. Asian (For example, Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese, etc.)
- 3. Black or African American (For example, African American, Jamaican, Haitian, Nigerian, Ethiopian, Somalian, etc.)
- 4. Hispanic, Latino, or Spanish origin (For example, Mexican or Mexican American, Puerto Rican, Cuban, Salvadorian, Dominican, Colombian, etc.)
- 5. Native Hawaiian or other Pacific Islander (For example, Native Hawaiian, Samoan, Chamorro, Tongan, Fijian, Marshallese, etc.)
- 6. Middle Eastern or North African (For example, Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian, etc.)
- 7. White (For example, German, Irish, English, Italian, Polish, French, etc.)
- 8. Some other race, ethnicity, or origin
- 98. Don't know
- 99. Prefer not to say

[ASK ALL]

Q28. How many bedrooms do you have in your home? [ACCEPT 1-15]

- 1. _____
- 98. Don't know
- 99. Prefer not to say

[ASK ALL]

Q29. About when was this home/building first built?

[SINGLE RESPONSE]

- 1. Before the 1970s
- 2. 1970s

3. 1980s
4. 1990-1994
5. 1995-1999
6. 2000s
98. Don't know
99. Prefer not to say

[ASK ALL]

Q30. What is the primary language spoken in your home?

[SINGLE RESPONSE]

1. English
2. Spanish
3. Mandarin
4. Cantonese
5. Tagalog
6. Korean
7. Vietnamese
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Prefer not to say

These are all the questions we have today. Thank you so much for your time!!

End of survey