LBNL-53326

ENERGY STAR Product Specification Development Framework: Using Data and Analysis to Make Program Decisions

Marla McWhinney, Andrew Fanara, Robin Clark,
Craig Hershberg, Rachel Schmeltz, Judy Roberson

Energy Analysis Program
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory
University of California
Berkeley CA 94720

September 2003

This work was supported by the US Environmental Protection Agency, Office of Air and Radiation, Climate Protection Division through the US Department of Energy under Contract No. DE-ACO3-76SF00098.

Abstract

The Product Development Team (PD) in the US Environmental Protection Agency's ENERGY STAR Labeling Program fuels the long-term market transformation process by delivering new specifications. PD's goal is to expand the reach and visibility of ENERGY STAR as well as the market for new energy-efficient products. Since 2000, PD has launched nine new ENERGY STAR specifications and continues to evaluate new program opportunities.

To evaluate the ENERGY STAR carbon savings potential for a diverse group of products, PD prepared a framework for developing new and updating existing specifications that rationalizes new product opportunities and draws upon the expertise and resources of other stakeholders, including manufacturers, utilities, environmental groups and other government agencies. By systematically reviewing the potential of proposed product areas, PD makes informed decisions as to whether or not to proceed with developing a specification. In support of this strategy, PD ensures that new product specifications are consistent with the ENERGY STAR guidelines and that these guidelines are effectively communicated to stakeholders during the product development process. To date, the framework has been successful in providing consistent guidance on collecting the necessary information on which to base sound program decisions. Through the application of this framework, PD increasingly recognizes that each industry has unique market and product characteristics that can require reconciliation with the ENERGY STAR guidelines. The new framework allows PD to identify where reconciliation is needed to justify program decisions.

Table of Contents

About the ENERGY STAR Program

ENERGY STAR is a voluntary partnership between the U.S. Department of Energy (US DOE), the U.S. Environmental Protection Agency (US EPA), and industry. The primary goal of ENERGY STAR is to prevent air pollution by expanding the market for energy-efficient products through the application of the ENERGY STAR label (**Figure 1**). The label is a mechanism that allows consumers to easily identify efficient products that save energy and money. By removing information barriers that affect purchasing decisions and by raising environmental awareness, ENERGY STAR stimulates demand for high-efficiency products and transforms the market over time.

The ENERGY STAR program operates by developing Partnerships with organizations that manufacture, sell, or promote energy efficient products. Partnering with ENERGY STAR is completely voluntary. Each organization that chooses to participate signs a Partnership Agreement that obligates the organization to mandatory program commitments during the Partnership period. Each organization that signs the agreement is termed a Partner throughout participation in the Program.

For manufacturers that partner with ENERGY STAR, the program offers a means to differentiate and market their products, and the opportunity to join national promotional campaigns. The ENERGY STAR website also lists qualified products for each manufacturing Partner as outreach to consumers. The manufacturer can commit to the program for any of the product categories covered by ENERGY STAR. In exchange for these benefits, the Partnership agreement requires the following (ENERGY STAR website (2003)):

- The manufacturer must comply with the ENERGY STAR specification for the product(s) category selected. The specification defines each product's eligibility criteria in terms of an energy efficiency level

- The manufacturer must qualify at least one product within the first year of participation in an ENERGY STAR product category

- The manufacturer must comply with logo use guidelines

- The manufacturer must label products with the ENERGY STAR label clearly displayed on the top/front of the product, in product literature, and on the manufacturer website

- The manufacturer must send to EPA each year a list of qualified products and submit annually the sales of ENERGY STAR units to help in determining the market penetration of ENERGY STAR

- The manufacturer must keep an up-to-date program contact

In addition to partnering with manufacturers, ENERGY STAR also develops partnerships with retailers, utilities and regional energy efficiency sponsors, energy service and product providers to commercial and residential buildings, builders/raters/lenders/lenders of new homes, businesses that improve the energy efficiency of their facilities, and HVAC contractors. The ENERGY STAR website (www.energystar.gov) contains a listing of program requirements for each Partnership listed above.

Guidelines of the ENERGY STAR Program

Currently, there are over thirty-five ENERGY STAR product categories. For each product category, a unique specification describes the energy performance requirements that a product must meet to qualify for the label. Each new ENERGY STAR specification must be consistent with the overall program objectives while also recognizing any energy efficiency or marketing issues that are unique to that product or industry. The ENERGY STAR label was established to achieve the following objectives:

- To prevent air pollution, including the emissions of greenhouse gases, caused by inefficient use of energy,

- To make it easy for businesses and consumers, to identify and purchase products, homes, and buildings with enhanced efficiency that offer savings on utility bills while maintaining, if not enhancing, performance, features, and comfort.

To determine the feasibility for ENERGY STAR product categories and the performance-based specifications, EPA follows a set of six key principles known as the ENERGY STAR guidelines. Their application is used as guidance during the iterative product development process to achieve the desired balance among the principles.

- Significant energy savings can be realized on a national basis

- Product performance can be maintained or enhanced with increased energy efficiency

- Purchasers will recover their investment in increased energy efficiency within a reasonable time period

- Energy-efficiency can be achieved with several technology options, at least one of which is non-proprietary

- Product energy consumption and performance can be measured and verified with testing

- Labeling would effectively differentiate products and be visible for purchasers. Typically the specification is set top recognize the top quartile of energy performing models on the market.

All six principles of the ENERGY STAR guidelines are equally important and critical to the success of ENERGY STAR. These guidelines are shared with manufacturers and other interested parties during the product specification development process.

Manufacturers and stakeholders have a vested interest in understanding what products get selected for labeling, how the guidelines have been applied to an ENERGY STAR product, and ultimately where the energy efficiency specification is set. For

manufacturers and stakeholders wanting the label for their product or wanting to know why a product was selected for labeling, the underlying questions are often the same. **How does ENERGY STAR identify potential product categories to be covered by the program? Once identified, how does US EPA decide whether or not to proceed with developing an ENERGY STAR specification?** Although US EPA is very open with manufacturers during the specification development process, this decision-making framework has not yet been laid out in publication.

The goal of this paper is to summarize the ENERGY STAR product specification development framework and use two case studies to illustrate the application of this framework, showing how analysis and data are used to make program decisions.

US EPA's ENERGY STAR Product Specification Development

The focus of this paper is US EPA's Labeling Branch Product Specification Development (PD) efforts, although similar work is pursued by US DOE. The Product Specification Development team is part of the ENERGY STAR Labeling Branch, which labels individual products. This team does not cover ENERGY STAR Homes, Buildings, or the Home Improvement Program.

It is the task of US EPA's PD team to identify products where large gains in energy efficiency can be realized cost-effectively, and where the ENERGY STAR label can play a solid role in transforming the market. While this article focuses on the application of the label to new product categories, PD is also responsible for reassessing performance specifications as the market changes. Many elements of the PD framework laid out in this article can be applied to the revision and renegotiation of existing specifications.

As of 2002, the PD team launched nine new ENERGY STAR specifications and is currently in the process of evaluating new product opportunities. This recent growth in specification development has been accompanied by several challenges. By launching several specifications each year, PD has less time to develop detailed knowledge of each industry and less time to develop relationships with manufacturers before beginning the specification negotiation process. Also, continuing to broaden the portfolio of products covered by ENERGY STAR has led to diminishing returns in terms of realized carbon savings. Because projected carbon savings from the new products are at times considerably less than veteran products such as office equipment, determining what "carbon to chase" becomes an increasingly important decision.

US EPA's previous case-by-case approach to developing new specifications was not robust enough to meet the demand of developing numerous new specifications while also ensuring a consistent decision methodology. As a result, in 1999, US EPA created the PD team and instituted a new specification development framework that relies on rigorous market, engineering, and carbon savings analyses, as well as input from major stakeholders. At a time when ENERGY STAR is gaining momentum and market stature, this systematic approach identifies and resolves product issues that are inconsistent with the guidelines of the program.

Summary of PD's Recent Specification Development Decisions

Since 2000, each decision to proceed and develop product specifications was determined based on key product characteristics. Before exploring the details of PD's specification development framework, we summarize these key decisions. The larger

picture context will also help orient readers to driving forces behind PD's specification development (quantitative values are from Webber, 2003).

- Settop boxes: Settop boxes cover the following product categories: cable boxes, digital converters, internet access devices, video games, videophone boxes, cable modems, satellite boxes, wireless TV boxes, personal video recorders, and multifunction devices.

  In 2002, there were approximately 100 million settop box units in the U.S. This product is expected to achieve much growth through digital converters, digital cable, and convergence boxes with a projected growth to nearly 200 million units by the year 2010. By developing a specification in 2001 and getting into the market early, PD intended to curtail some of the projected energy growth by working with manufacturers in the design of products over the growth period (2002-2010). National carbon savings potential is high (0.25 MtC/yr in 2010) with moderate unit savings (15% compared to standard efficiency units)[1]. Though cable boxes are not yet sold retail, other products such as satellite receivers and video games are available as retail products. There was consumer electronics industry interest in expanding the ENERGY STAR label to settops. Because the efficiency potential is relatively high and products were inefficient at the specification launch, the specification was set to recognize a relatively small fraction of products currently on the market. For settops, the specification level was set tighter than the top 25% of products on the market.

- Traffic signals: The energy savings for traffic signals is large, with an associated unit savings of 90% (comparing LED to incandescent signals). The carbon savings potential for traffic signals is also high (0.11 MtC/yr in 2010). The emergence of this new and energy efficient technology offered ENERGY STAR an opportunity to help kick-start the market by providing purchasers with a mechanism for easily identifying efficient signals as well as marketing opportunities. Additionally, traffic signals offered the opportunity for PD to work with the ENERGY STAR Buildings program and their network of municipalities that regularly install and upgrade traffic signals. The specification recognizes LED traffic signals without excluding emerging technologies that might also meet the specification.

- Water coolers: The unit energy consumption of water coolers is high. Hot and cold coolers consume approximately 800 kWh/year and cold-only units consume 108 kWh/year. An ENERGY STAR program had much potential to reduce standby consumption for this product (nearly 90% of hot and cold cooler consumption is due to standby losses and 60% of cold-only cooler consumption is

[1] The efficiency potential represents the percentage reduction in the products annual energy consumption. Values are an average over all settop box product categories.

due to standby losses). With only three major manufacturers at the program start, water coolers offered a potential for quick market transformation. Additionally, water coolers are located prominently in homes and offices, which increases label visibility. Increasingly, these products are sold through retail distribution chains and are placed in homes. Water coolers have a high unit savings potential (45% savings compared to standard efficiency units) and because there was relatively little range in consumption between models and there was significant potential to reduce standby losses, the specification was set at a level that recognized 0% of products on the market (no products on the market met the specification at the specification launch).

- Dehumidifiers: The household consumption of dehumidifiers is high ranging by capacity from 500 kWh/yr to 4650 kWh/yr. There was substantial interest from manufacturers in developing a dehumidifier specification to round out their suite of ENERGY STAR appliances. Dehumidifiers are sold retail and in numerous stores where ENERGY STAR has partnerships. Although the unit savings is moderate for an average product (10% savings compared to standard efficiency units), there was a significant range in product performance between the best and worst performing models. This range signified a strong potential for product redesign and a role for ENERGY STAR in recognizing the most efficient subset of the market. The specification was set at approximately the top 25% of products in terms of energy efficiency.

- Ventilation fans: The ventilation specification applies to fans mounted in a bathroom, utility room ceiling or wall, or a kitchen rangehood fan. The market for ventilation fans is large (nearly 6 million units shipped in 2000) and there was a high unit savings (60% savings compared to standard efficiency units). Ventilation requirements on new homes offered an additional opportunity for ENERGY STAR and PD considered the possibility of expanding the ventilation specification in the future to capture this growing market. PD also considered that federal housing could potentially be a large purchaser in this product category. There was a high range in efficiency of products on the market and the specification was set at approximately top 25% of products in terms of energy performance.

- Ice machines: Initially EPA pursued this product to coordinate the ENERGY STAR label with the US DOE's Federal Energy Management Program (FEMP). However, this product was ultimately removed from the PD list due to low carbon potential and lack of industry interest.

- Commercial refrigerators and freezers: This product represented PD's segway into the Food Service Equipment market, which was a new audience representing much potential for additional product categories. There was high interest from manufacturers and at the specification launch, manufacturers representing 90% of the market signed the Partnership Agreement. The unit savings was high (40% savings compared to standard efficiency units) and the simple payback on

investment was 1-2 years. The range in efficiency of products on the market was high and the specification was set at approximately the top 25% of products in terms of energy performance.

- Telephony: The carbon potential for telephony products is high (0.49 MtC/yr in 2010) along with the unit savings (over 50% savings compared to standard efficiency). The installed base is large (125 million units) with over 40 million products shipped in 2000. The distribution chain of products covered is a direct one, including many retail stores where ENERGY STAR has partnerships. The specification was set at approximately the top 25% of products in terms of energy performance.

- Ceiling fans: The carbon potential for ceiling fans is high (0.65 MtC/yr in 2010) as is the unit savings potential (50% savings for lights and motor improvements compared to standard efficiency new unit with incandescent lighting). The market for ceiling fans is large with approximately 14 million fans shipped in 2000. Both manufacturers and retail partners had a high interest in developing an ENERGY STAR specification. Enthusiasm by retail partners was important since close to 50% of monetary sales are accounted for by Lowes and Home Depot (two ENERGY STAR Partners). PD also used marketing materials to communicate to consumers the opportunity of achieving additional energy savings by increasing the AC set point when properly using ceiling fans. There was a large range in efficiency between models and the specification was set at approximately the top 25% of energy performing products.

- Unitary HVAC: Carbon savings for this product is moderate 0.09 MtC/yr savings. This product offered PD the opportunity to build upon and strengthen its relationships with HVAC manufacturers. This product also helped PD strengthen ties with utility partners to expand their ongoing promotions of HVAC programs. The specification structure is disaggregated by capacity and the specification level, in terms of representing the top 25% of products, varies by capacity segment.

The PD Framework and Process

Now that we illustrated the key data behind each specification development decision, we devote this next section to process. "How does PD evaluate each product and what types of data are used to support the specification development decision?"

As noted, each product is unique and complex. Applying the PD specification development framework is like using a map. It allows PD to navigate through complex product issues by asking key and consistent product questions, which ultimately enables

PD to make the critical specification development decision. For manufacturers and other stakeholders, this section illustrates the steps in PD's process: where decisions are made, why the decisions are made, and what characteristics PD sees as critical to a successful program. The framework consists of four primary areas of product analysis:

1. Developing the initial list of potential products to be covered by ENERGY STAR
2. Prioritizing the product list
3. Analyzing the technical and market potential of high-priority products
4. Working with industry and other major stakeholders

Each area is described in more detail below.

Developing the List of Potential Products to be Covered by ENERGY STAR

The first stage in the PD process is to compile an initial list of potential products to be covered by ENERGY STAR (**Table 1**). The PD team utilizes four information channels to identify future product areas: the US DOE's Federal Energy Management Program (FEMP), input from industry and other stakeholders, ENERGY STAR program evaluations, and industry/literature review.

1. FEMP helps Federal agencies purchase energy efficient products. To simplify Federal purchasing of energy efficient products, FEMP identifies and recommends products in the top quartile of the market (in terms of energy performance). Table 1 shows areas of coordination between ENERGY STAR and FEMP.

2. ENERGY STAR has now achieved a level of market influence such that manufacturers and other stakeholders are on their own initiative contacting US EPA and seeking the label to promote their energy efficient products. This channel is key for allowing interested parties with specification ideas to feed into PD's process.

3. The PD team evaluates existing specifications to identify where additional carbon savings can be realized. To assess the untapped product potential, the PD team currently relies on a carbon savings model developed in response to the climate change action plan called CCAP (CCAP – Climate Change Action Plan). CCAP was developed by Lawrence Berkeley National Laboratory (LBNL) to track ENERGY STAR product labeling achievements to date and project future savings

through 2020 (Webber, C (2000)). CCAP allows the PD team to direct future efforts and quantify the additional savings due to program modifications.

4. The PD team also reviews a wide variety of literature to identify industry trends and new products and services with energy intensive or energy savings implications. The PD team also attends major trade shows to gather product information and establish industry contacts.

Screening the PD List and Prioritizing Products

Once the initial product list is developed, the PD team proceeds to screen the products using the CCAP model. **Table 2** shows projected savings for specifications recently launched (Webber, C (2002)). If the carbon savings for a product category is low compared to other prospective products, the PD team weighs the benefits of proceeding with the specification development and achieving the carbon reductions with the costs of developing the specification. As a result, products can be removed from the list or given a low-priority status (see laptop case study).

Once the products are screened, the remaining products are ranked according to priority. Products are given priority status based on several factors. The CCAP model is again used to assign products to a high-priority status if substantial national carbon savings can be gained. In addition to projected savings, initial industry feedback has the ability to assign high-priority status to a product or in some cases demote a product to low-priority. Finally, unique market/product characteristics play an integral role in developing priorities. Areas considered include brand visibility, difficulty and time required to transform the market, and the suitability of the ENERGY STAR label as a market transformation tool.

Because product specification development is an evolving process, priorities are rarely peremptory and reprioritization frequently occurs as the PD team becomes more educated about target industries and products are added to the list.

Analyzing Technical Potential of Specifications for New Products

Once a product becomes a priority, the product is assessed in order to evaluate its technical potential and reconcile any issues that conflict with ENERGY STAR guidelines or the specifications for other ENERGY STAR qualified products. **Figure 2** (Clark, R. 2002) illustrates the complete product development cycle. **Figure 3** illustrates just the process for evaluating potential products to be covered by ENERGY STAR, which ultimately leads to a decision of whether or not to proceed with developing a specification for the product.

Product Briefing and Market Assessment

This three-stage process begins with a product briefing and market assessment. The product briefing is designed to provide an overview of the technology and design of the product, allowing for enough familiarity so the PD team is able to effectively communicate with industry. Given the limited time available to become familiar with the industry and technology, the product briefing is a necessary and time compressed first-step in educating ENERGY STAR staff about the product.

After learning the technical and engineering basics, the PD team conducts a market assessment. The main goal of the market assessment is to establish first and early communication with primary industry contacts and to determine if significant market barriers to energy efficiency are present that will prove difficult to overcome using the ENERGY STAR label. By bringing industry into discussion during this stage, the PD

team identifies major program challenges early in the process and maximizes its time to build relationships with industry, which are necessary for success.

There are several key analysis areas that are critical to PD's decision to move forward with the specification development process:

1. **Who are the key industry players**? Identifying manufacturers that participate in ENERGY STAR in other product areas can facilitate the establishment of a positive working partnership. These manufacturers are already familiar with ENERGY STAR and see it as a value for their business. Both education and program buy-in can be easier in these cases when the manufacturer is already invested strategically in the program. PD does work with industries not previously involved with ENERGY STAR; however identifying their familiarity with the program as a potential issue early in the process is necessary since PD will need to invest more time in building solid relationships.

2. **What are the key product distribution chains**? ENERGY STAR works with numerous retail Partners such as Lowe's, Sears, and Home Depot. For products sold through retail distribution chains where ENERGY STAR has an influence, the relationship can help to promote ENERGY STAR qualified products. US EPA also evaluates products with complicated distribution chains and/or products where the end-user to be influenced is not the actual purchaser of the equipment or the one receiving the energy benefits, since in these areas, the possible role for ENERGY STAR is less straightforward. For complex distribution chains, PD decides early on whether they can or should have a role in the market.

3. **Has energy efficiency influenced the product market in the past**? To answer this question, the market assessment reviews any FEMP guidelines, relevant regulations or voluntary guidelines currently in place. In the case where there are existing regulations or guidelines, the industry has already been exposed to energy efficiency in product design, they often compete on the basis of energy efficiency such that the label can play an integral role in identifying their products, and there is a starting point upon which ENERGY STAR can build. In most cases, the regulation or guideline yields a predefined test procedure to measure energy consumption, as well as access to energy consumption data that manufacturers have reported over a period of time. For industries not exposed to energy efficiency in the past, PD needs to invest resources in working with the industry to collect energy consumption data and establish a test procedure.

4. **What are the market barriers to energy efficiency in the industry**? Potential market barriers are numerous and include items like distribution chain issues, industry sensitivity to price increases, product reliability issues, and potential issues with proprietary designs. Once market barriers are identified, PD evaluates

whether or not moving forward with a specification is the most appropriate mechanism for transforming the market.

5. **What are the important market trends influencing the industry**? PD identifies issues such as market size, projected market growth, the increasing energy consumption of products over time, and changing distribution patterns. For products with increasing growth in terms of sales or consumption, PD evaluates the goal of developing a specification now, which can reduce potential energy consumption growth.

There's no magic formula for determining what a product's specifications need to be in order to move forward with the specification development process; each product has unique market characteristics. What is critical is identifying the key issues that can affect a successful program and then collecting individual product data that fits within that framework. Each specification development decision is made on a product-by-product basis and ultimately reflects PD's decision that the label is an appropriate mechanism for transforming that product's market. If PD decides to move forward, it next conducts an engineering analysis.

Engineering Analysis

The PD team uses the engineering design analysis to assess energy efficiency options for each product category. The objective of the analysis is to review the standard product design and assess potential energy efficiency gains if products were redesigned to include more efficient components and technologies. US EPA relies on its own industry experts to use his/her knowledge of the industry to make this product evaluation. There are several key engineering analysis areas that are critical to PD's decision to move forward with the specification development process:

1. **What is the energy consumption of the product and what product components use energy?** This is the most basic information assessed during the engineering analysis. PD determines the average energy consumption of a product on the market. Results demonstrate if substantial energy consumption

exists at the household or national level. It then looks at the energy consumption of individual product components. Because energy efficiency is often achieved by installing more efficient components, PD first establishes the portion of the total product energy consumption that can be attributed to each component of a product's design.

2. **What is the technical potential for more energy efficient product design?** Once PD understands the energy consumption of the product, it assesses what energy efficiency technologies can be applied to reduce energy consumption. This assessment reviews applicable energy efficiency technologies and then combines this information with what PD knows about each components energy use. The result is a quantitative estimate of potential reductions in energy consumption. If at this point PD determines that more efficient designs are not possible or feasible given current technologies, PD does not move forward with the specification development process.

3. **How does product efficiency improvements translate into national savings?** PD compiles information such as product shipments, product lifetimes, usage patterns/modes, and any additional considerations such as installation issues or user behavior (such as programmable thermostat usage).

4. **What is the range in energy consumption between products currently on the market?** Once PD has determined that energy efficiency design options are feasible and available, it assesses the market to determine if, in fact, some products being manufactured are designed more efficiently then others. If PD determines that a range in energy consumption exists, PD will later use this information to help set the final specification and recognize the most efficient products. If PD determines that there is no range in energy consumption, the following decision will take place:

    - If all products on the market are currently using energy efficient designs, developing an ENERGY STAR specification for the product will result in limited savings since all products will qualify and little carbon reduction will be realized.

    - If all the products are currently "inefficient" and there is potential for significant savings from product redesign, the specification will often be set at a tight level. In these cases, the final specification recognizes a smaller subset of the market then the standard top 25% of energy performing products.

5. **How much time is needed to introduce product design changes to the market?** PD assesses the amount of time needed by manufacturers to implement product design changes and market their new efficient products. Results from this analysis will help PD identify a specification launch date if decided to move forward with the specification.

6. **What are potential technology barriers to introducing new efficient design options?** PD again assesses any industry cost issues, product reliability issues and proprietary technology issues. If PD is unable to reconcile these issues with ENERGY STAR guidelines, it will not move forward with the specification development process. PD also assesses available test procedures to measure energy efficiency.

7. **Are the energy efficient technology options cost-effective?** US EPA analyses the cost-effectiveness of the ENERGY STAR product specifications for a defined consumer population.

If the engineering analysis demonstrates that there is a potential for energy efficient design and there are no irreconcilable technology barriers, PD will move forward with the specification development process. At this point, information from both the engineering analysis and market assessment is incorporated into an updated CCAP estimate of carbon reductions.

The Specification Development Decision

Once all the analysis is completed, PD makes its specification development decision. If the results demonstrate that the ENERGY STAR label is an appropriate mechanism for transforming the product's market, there is significant energy efficiency potential, and there is a level of industry support, PD then reassesses the updated CCAP estimate. If the carbon savings potential is acceptable, PD moves forward and actually begins negotiating a specification. Information from the market assessment and engineering analysis helps drive the specification negotiation process.

Working with Industry

Collaborating with industry on the development of product specifications has been and continues to be a hallmark of ENERGY STAR. As such, ENERGY STAR has a demonstrated track record of working closely with individual companies as well as

entire industries and their representatives, such as trade associations. The PD team's involvement comes in many forms including manufacturer site visits by US EPA staff and talks given at industry conferences. In addition, the PD team has an open-door policy with respect to discussions with industry. Individual manufacturers and trade associations alike are encouraged to visit with and discuss issues of concern. This track record of cooperation has enabled the PD team to develop a level of trust with manufacturers that has been useful in ensuring frank discussions. By investing time early on in the relationships with new industries, all parties can better comprehend each other's goals, convictions, and challenges in the marketplace.

The PD team relies heavily on industry experts, such as product managers for major manufacturers, for information and suggestions. Given that many of the industries are fiercely competitive, the PD team has found that the industries police and scrutinize themselves very closely, putting less pressure on US EPA to do so. However, to ensure there is balance in the discussion and to verify industry information, US EPA utilizes its own non-industry experts and test data as well.

Case Studies

There is always a substantial amount of interest from manufacturers and stakeholders about specific product specification development decisions. We use two case studies to illustrate in detail how this process was applied to two recent PD decisions. The first case study shows in detail what data were used to support the decision to develop a dehumidifier specification and how data collected during the process ultimately determined where the specification was set. The second case study on

laptop computers illustrates PD's screening process and how using this process is key to prioritizing products.

Case Study 1: Using Data and Analysis to Develop an ENERGY STAR Specification for Dehumidifiers

In a 1998 LBNL report, miscellaneous electricity consumption was estimated at 235 TWh in 1995, approximately 25% of total residential electricity usage (Sanchez, 1998). Dehumidifiers were listed as one of the top 20 miscellaneous end uses, consuming 4.4 TWh of electricity. From 1996-2010, miscellaneous electricity was projected to grow by 115 TWh. Dehumidifiers were listed as the third largest miscellaneous end use in terms of projected absolute growth (5.8 TWh). Because of the importance of miscellaneous end-uses, US EPA was initially interested in investigating the potential for developing an ENERGY STAR specification for dehumidifiers.

Product Definition

The ENERGY STAR specification covers standard capacity units with capacities up to 35 L/day and high capacity units with capacities from 36 L/day to 57 L/day (US EPA, (2000))[2]. In this case study, we focus on standard dehumidifiers.

Market Assessment

Based on the market assessment, PD identified several strong market characteristics that influenced its decision to proceed and develop an ENERGY STAR

[2] Dehumidifiers covered by ENERGY STAR are defined as self-contained, electrically and mechanically refrigerated encased assemblies consisting of a) a refrigerated surface (evaporator) that condenses air from the atmosphere; b) a refrigerating system, including a motor; c) an air circulating fan; and d) a means for collecting and disposing of condensate (US EPA, (2000)).

specification. Whirlpool, Frigidaire and LG Electronics comprised approximately 80% of dehumidifier sales (**Figure 4**). All three manufacturers participated in ENERGY STAR in other product areas and currently compete on the basis of energy efficiency. Dehumidifiers also have a direct distribution chain, in which retail stores purchase standard capacity dehumidifiers directly from the manufacturers and then sell them to consumers (**Figure 4**). Currently, ENERGY STAR has retail partnerships with Sears, Wal-Mart, Home Depot, Best Buy, and Lowe's. Together, these retail stores comprise nearly 50% of dehumidifier sales (Clark, R et al., (2000)).

Finally, the Canadian Standards Association (CSA), in conjunction with Natural Resources Canada, had an energy efficiency requirement of 1.0 L/kWh (CAN/CSA-C749-94). US manufacturers that export dehumidifiers to Canada comply with this standard. This standard provided a platform on which to build the ENERGY STAR specification, offering a product definition, an efficiency measurement (energy factor, which is a measurement of liters of water removed per kWh), and a test procedure that was already recognized by leading US manufacturers.

Market barriers identified in the market assessment included increasing product cost and product reliability. Cost data was compared across models with varying energy efficiencies. Anecdotally, findings showed that cost was independent of efficiency levels (Cadmus Group, (1999a)).

Engineering Analysis and Test Data

A dehumidifier uses electricity to power a refrigeration compressor that runs the evaporator and condenser coils with a fan motor that draws air through the unit. The air is drawn past the evaporator, where moisture condenses on the coil. The air passes by a second coil, the condenser, where it is reheated. Moisture from the evaporator coil drains through a hose or is emptied by the user (Cadmus Group, (1999b)).

US EPA contractors began the engineering analysis by testing four units of varying capacities to determine the energy consumption and efficiency potential for dehumidifiers. The results showed that wattage varied by capacity, from 571 watts to 712 watts and that the compressor and fan were the primary energy consuming components (Cadmus Group, (1999b)). The results also showed that energy consumption/efficiency of each product varied across the four units tested. For smaller units (14.2 to 19 L), compressor energy use for the three units ranged from 35 watts/L/day to 40 watts/L/day. The larger 28.4 L unit used a rotary compressor and had a rating of 21watts/L/day. Fan energy use among the four units tested also varied from 2 watts/L/day to 5 watts/L/day. Based on these measurements, the following was determined regarding the technical potential of standard dehumidifiers: installing higher efficiency motors reduces the fan's energy consumption; higher efficiency compressors were available for use, especially on the larger capacity units; and matching the coil characteristics and airflow played a key role in determining the energy efficiency of a unit (Cadmus Group, (1999b)).

Using CAN/CSA-C749-94 test data obtained from several industry sources, PD was able to establish that the range in energy efficiency between models was quite large

(Figure 5). Based on these findings, PD determined that the energy efficiency potential for standard dehumidifiers was substantial and that there were no technology barriers to moving forward with the specification. Although the carbon savings is modest, industry interest, market characteristics, and the efficiency potential influenced PD's decision to move forward and develop a dehumidifier specification.

Setting the Specification

To set the final ENERGY STAR specification, PD relied on CAN/CSA-C749-94 test data that represented six US and Canadian manufacturers (Figure 5). From the data, PD determined that the range in efficiency could be used to set a specification and recognize the most efficient models currently on the market. It was determined that the energy efficiency of products varied across each capacity bin. Based on the review of the data, the market was divided into three capacity bins: ≤10L, 10 L < ≥ 25 L, and 25 L < ≥ 35 L. In keeping with the ENERGY STAR guidelines, the capacity bins were determined based on analyzing the product data and estimating the top quartile of energy performing models for each capacity segment. The final specification used the same product definition, efficiency criteria, and test procedure as the Canadian Standard.

Reconciling with the Energy Star Objectives

In the case of dehumidifiers, the product specification was set very close to the top quartile of energy efficient products, as identified by the test data and in keeping with the ENERGY STAR guidelines. Additionally, at the specification launch, models from several manufacturers were able to qualify under the specification meaning that the specification structure did not favor a particular technology, design, or company. US EPA began discussions with the manufacturers early in the process and visited the

headquarters and manufacturing facilities of four leading companies. Several manufacturers were enthusiastic about ENERGY STAR and their willingness to work with US EPA to develop the specification facilitated the process.

Case Study 2: Screening Products for the PD List, Laptop Computers

In 2002, commercial shipments of laptop computers totaled nine million units, nearly 25% of total commercial personal computer shipments (Gartner, 2001). Currently, laptop computers are covered by the ENERGY STAR specification for computers requiring the use of 15 watts or less in the sleep state. Because battery charge is an issue in laptops, these products often power down to a very low wattages in the sleep state. As a result, a large percentage of laptop computers comply with the 15-watt computer specification. With the hopes of distinguishing laptop computers using the ENERGY STAR label, manufacturers contacted US EPA about developing a separate specification for laptop computers. As a result, US EPA added laptop computers to the product specification development list based on manufacturer interest in combination with market share potential. US EPA then proceeded to screen the product by establishing a preliminary carbon savings (CCAP) estimate for a potential low power specification.

Product Testing for Off and Low Power States

In order to quantify potential savings from laptop computers, LBNL investigated the power consumed by recently marketed laptops in sleep and off states. To make this assessment, LBNL tested 21 laptop computers. The data were used to determine if a range in sleep/off power consumption existed among product models that could be used as a basis for an ENERGY STAR specification. LBNL's total sample consisted of data collected during two metering efforts. In July 2002, LBNL metered 12 laptop computers.

Of these twelve computers, all except one model had been acquired within three months prior to product testing. During Summer 2001, LBNL metered nine laptop computers. In the 2001 sample, six computers were acquired during 2001 and the remainder was acquired during 2000. Combining the test data yielded a comprehensive view of the market such that the dataset reflected new products on the market, a range in screen sizes, a range in product prices, and a range in manufacturers.

Results

A summary of the test procedure and the power state definitions can be found in Roberson, J (2001). The power state definitions are also consistent with that report. All laptops were metered with either no battery present or at 100% battery charge. **Table 3** shows a summary of the results. The results indicate that the top twenty five percent of laptops on the market (in terms of sleep state energy consumption) fall at or below one watt in the sleep state. Off power was also consistently low with the exception of two models.

Figure 6 shows the frequency distribution of sleep and off mode energy consumption. Eighty percent of the sample drew less than two watts of power in the sleep state and the off state. There were two models that were outliers in our sample for both off and sleep states.

These results demonstrate that there is little variation in energy consumption in off and sleep states between products and manufacturers in the dataset. Because most products on the market are already efficient (less than two watts), an ENERGY STAR

specification targeting low power states would play a limited role in achieving carbon reductions and creating a more efficient market[3].

Based on these results, laptop computers were moved to low priority on the PD list. However, this product has not been removed altogether since some opportunities may still exist outside of a traditional sleep/off power specification. The PD team is still continuing its research into power supplies, which if implemented across ENERGY STAR specifications for consumer electronics and office equipment, could reduce laptop energy consumption beyond the sleep state specification. PD is also continuing its research into battery charging efficiency, which may also have implications for laptop computers. PD also continues to collect data regarding sleep/off energy consumption.

Lessons Learned

The Product Specification Development Team in the US EPA's ENERGY STAR Labeling Branch fuels growth in ENERGY STAR by delivering new specifications. Since 2000, PD has developed nine new specifications and continues to evaluate new opportunities. To evaluate the ENERGY STAR potential for a diverse group of products, the PD team developed a framework and process for developing new and updating existing specifications that rationalizes new product opportunities and draws upon the expertise and resources of other stakeholders. Each specification development decision was reached by applying the new PD framework. In this article,

[3] With most products achieving a low power state of two watts, ENERGY STAR is limited in its ability to further reduce low power state energy consumption for laptop computers. Setting the specification at the top 25% of the market would create a one-watt specification: a reduction of only one watt for most products on the market.

we have used two case studies to illustrate the application of the PD framework. After three years of implementation, several lessons have been learned:

1. Stakeholders and interested parties are very active in US EPA's product specification development process, increasingly inquiring why a product is/is not covered and how the specification was developed. Careful documentation of the specification development process and consistent collection of information allows the PD team to justify program decisions.

2. The details of each individual product's technology and market are intricate. Developing a successful ENERGY STAR specification depends on asking the right questions about a product and then carefully collecting the pertinent data. The framework has been successful in providing consistent guidance on collecting the necessary information on which to base program decisions.

3. The PD team increasingly recognizes that each product is different. When investigating a new product, the PD team may discover a new element of the market and engineering analysis that needs to be added to the PD Framework. Additionally, the specification itself needs to be specific to a product, which can at times require reconciliation with the ENERGY STAR guidelines. Careful application of the framework allows the PD team to identify where reconciliation is needed to justify decisions.

4. It is important to bring stakeholders into the specification development process as early as possible. This allows the PD team enough time to build strong relationships with future Partners and encourages them to comment and contribute. In these instances, the final specification is more robust and manufacturers are often more enthusiastic about participating in ENERGY STAR when they feel they have been integral to the process.

5. Finally, developing a specification is never easy no matter what its engineering or market characteristics may be. Each party in the process has its own concerns ranging from issues with the specification level, to the specification effective date, to product categories covered. A successful specification delicately balances each of those concerns while also maximizing ENERGY STAR's impact.

Acknowledgements

We would like to thank the following individuals for their integral role in developing the ENERGY STAR specification for Dehumidifiers: Michael Thompson and Jurgen Pannock (Whirlpool Corporation), George Permaza (Frigidaire Home Products), Bonsang Koo and Steve (Se Woo) Park (LG Electronics), Wesley Fuller (W.C. Wood Company Limited), Thermastor Corporation, Anne Wilkins (Natural Resources Canada), and John Jiambalvo (ICF Consulting). We appreciate the engineering work of David Korn and Julio Rovio of The Cadmus Group. We would also like to thank Jonathan Koomey (LBNL) and John Busch (LBNL) for their comments on this article.

Works Cited

Appliance Magazine (1999) *Portrait of the U.S. Appliance Industry*, September.

The Cadmus Group, Inc. (1999a) *Preliminary market background report for residential dehumidifiers*. Prepared for the ENERGY STAR Program, Climate Protection Division, US Environmental Protection Agency. Washington, DC.

The Cadmus Group, Inc. (1999b) *Engineering analysis of dehumidifiers*. Prepared for the ENERGY STAR Program, Climate Partnership Protection Division, Office of Air and Radiation, US Environmental Protection Agency. Washington, DC.

Clark, R., Jiambalvo, J., Wall, G. (2000*) Industry and market research for Energy Star dehumidifier program*. Prepared for the Energy Star Program, Climate Partnership Protection Division, Office of Air and Radiation, US Environmental Protection Agency. Washington, DC.

Clark, R, Fanara, F. 2002. "ENERGY STAR Specifications: A Decade of Development and a Future of Growth*"*. *In Proceedings of the 2002 ACEEE Summer Studies on Energy Efficiency in Buildings*, Washington DC. American Council for an Energy Efficient Economy.

ENERGY STAR Website (2003). www.energystar.gov.

Gartner (2001) *Special report prepared for US Environmental Protection Agency*. Prepared for the Energy Star Program, Climate Protection Division, US Environmental Protection Agency. Washington, DC.

Roberson, J, Homan, G, Mahajan, A, Nordman, B, Webber, C, Brown, R, McWhinney, M, and Koomey, J (2002) *Energy use and power levels in new monitors and personal computers*. Lawrence Berkeley National Laboratory, Berkeley, CA. LBNL-48581, June.

Sanchez, M, Koomey, J, Moezzi, M, Meier, A, Huber, W. 1998. "Miscellaneous electricity use in US Homes: Historical Decomposition and Future Trends". *Energy Policy*. vol.26, no. 8. July. pp 585-593.

US EPA (2000) *ENERGY STAR program requirements for dehumidifiers, Partner commitments*. US Environmental Protection Agency. Washington DC.

Webber, C, Brown, R and Koomey, J. 2000. "Savings Estimates for the Energy Star Voluntary Labeling Program." *Energy Policy*, vol. 28, no. 15. December. pp 1137-1150.

Webber, C, Brown, R, McWhinney, M, and Koomey, J (2003) *Savings estimates for the ENERGY STAR voluntary labeling program 2002 status report*. Lawrence Berkeley National Laboratory, Berkeley, CA. LBNL-51319.

Table 1: ENERGY STAR New Specification Development Cycle

Phase 1 - Winter 2001	Phase II - Summer 2001	Phase III - Winter 2002	Specifications in Development
Settop Boxes - Tier 1: Jan 1, 2001; Tier 2, Jan 1, 2004	Commercial Solid Door Refrigerators & Freezers* - September1, 2001	Ceiling Fans - Tier 1: Jan 1, 2002; Tier 2: Oct. 1, 2003	Vending Machines
Traffic Signals - 2001	Ventilation Fans - June1, 2001	Telephony - Tier 1: Jan 1, 2002; Tier 2: Jan. 1, 2004	Commercial Cooking Equipment*
Water Coolers - September 1, 2000		Unitary HVAC* - Tier 1: Jan 1, 2002	Air Purifiers
Dehumidifiers - Jan 1, 2001			

1. FEMP commercial cooking products include gas fryers, holding food cabinets, gas griddles and pressureless steamers

* indicate products for which there was a FEMP guideline at the specification launch

Table 2: Carbon Savings for ENERGY STAR New Products

	2010 (MtC/year)
Ceiling fans	0.65
Telephony	0.49
Settops	0.25
Traffic Signals	0.11
Unitary HVAC	0.09
Commercial refrigeration	0.06
Ventilation fans	0.05
Dehumidifiers	0.03
Water Coolers	0.02

1. Savings estimates and methodology published in Webber, C (2003).

Table 3: Results of Power Measurements for Laptop Computers

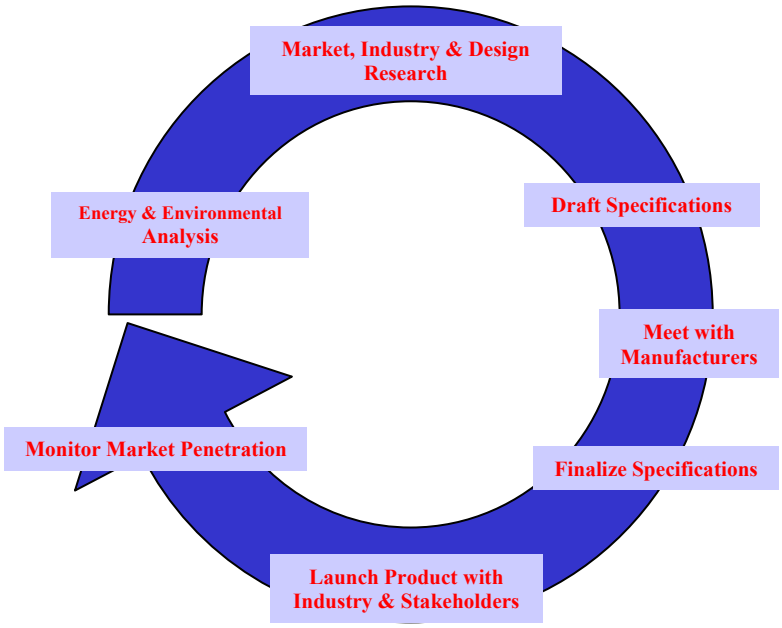
n	21	21	21
Laptop Computers	Off (W)	On (W)	Sleep (W)
min	0	14	0
max	9	42	8
average	2	23	2
25th percentile	0.8	19	1
50th percentile	1	22	2
75th percentile	2	28	2
median	1	22	2

1. Off: unit is plugged in, the power button is in the off position
2. On: power button is in the on position, the power indicator is green, and the processor is idle
3. Sleep: the lowest power level between on and off
4. Sample represents data from nine manufacturers
5. Screen sizes range from 12-16 in., model prices range from $1,000 - $3,100
6. For test procedure, see Roberson, J. 2002

Figure 1: ENERGY STAR Label (linkage phrase mark)

The ENERGY STAR linkage phrase mark is to be used in marketing materials to show that a company sells either ENERGY STAR qualified products or services that can deliver ENERGY STAR performance levels.

Figure 2: Process for Developing New Specifications



1. Taken from Clark, R (2002).
2. For more information on ENERGY STAR Product Development, www.ENERGYSTAR.gov

Figure 3: Summary of Product Specification Development Framework

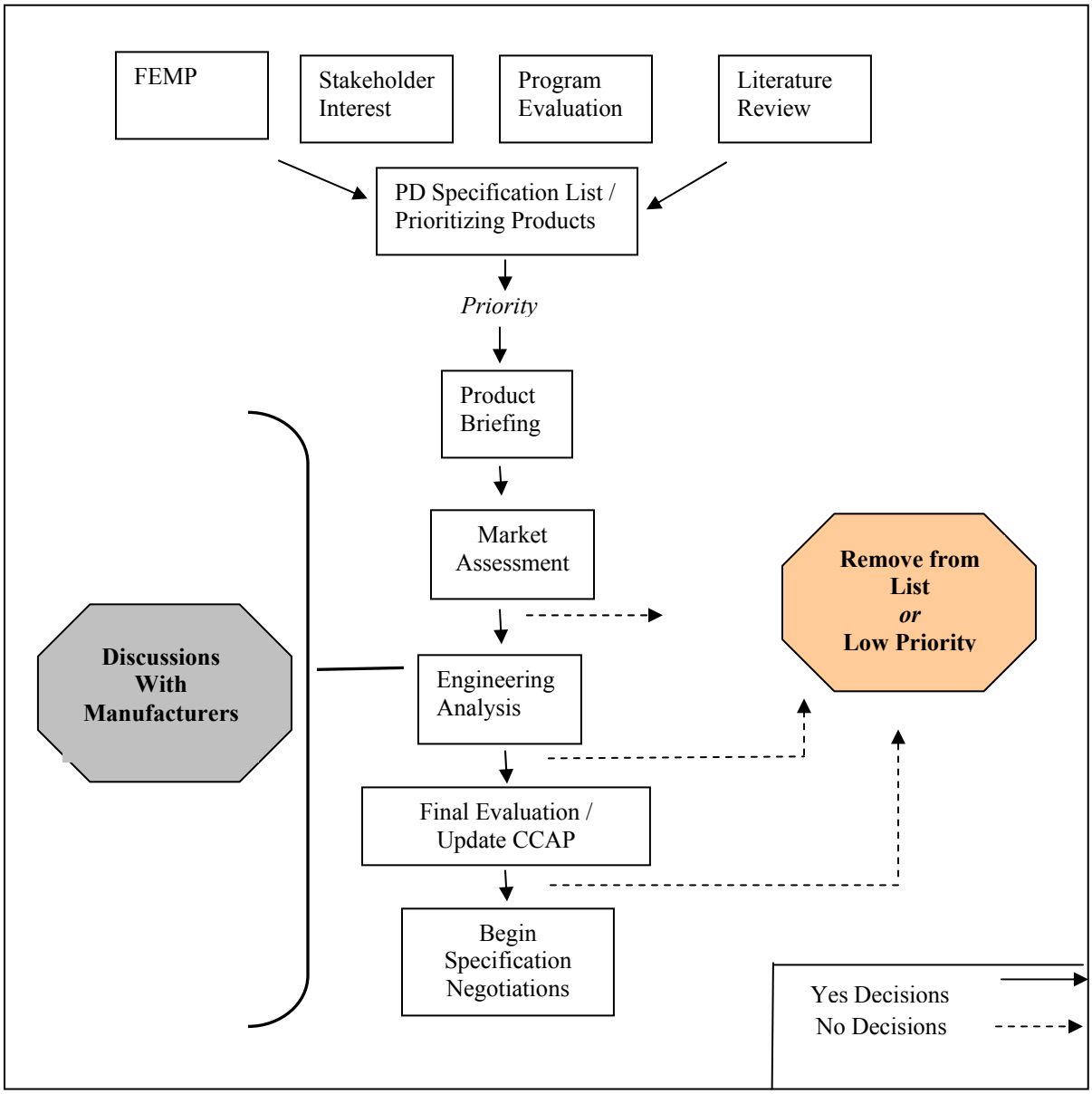
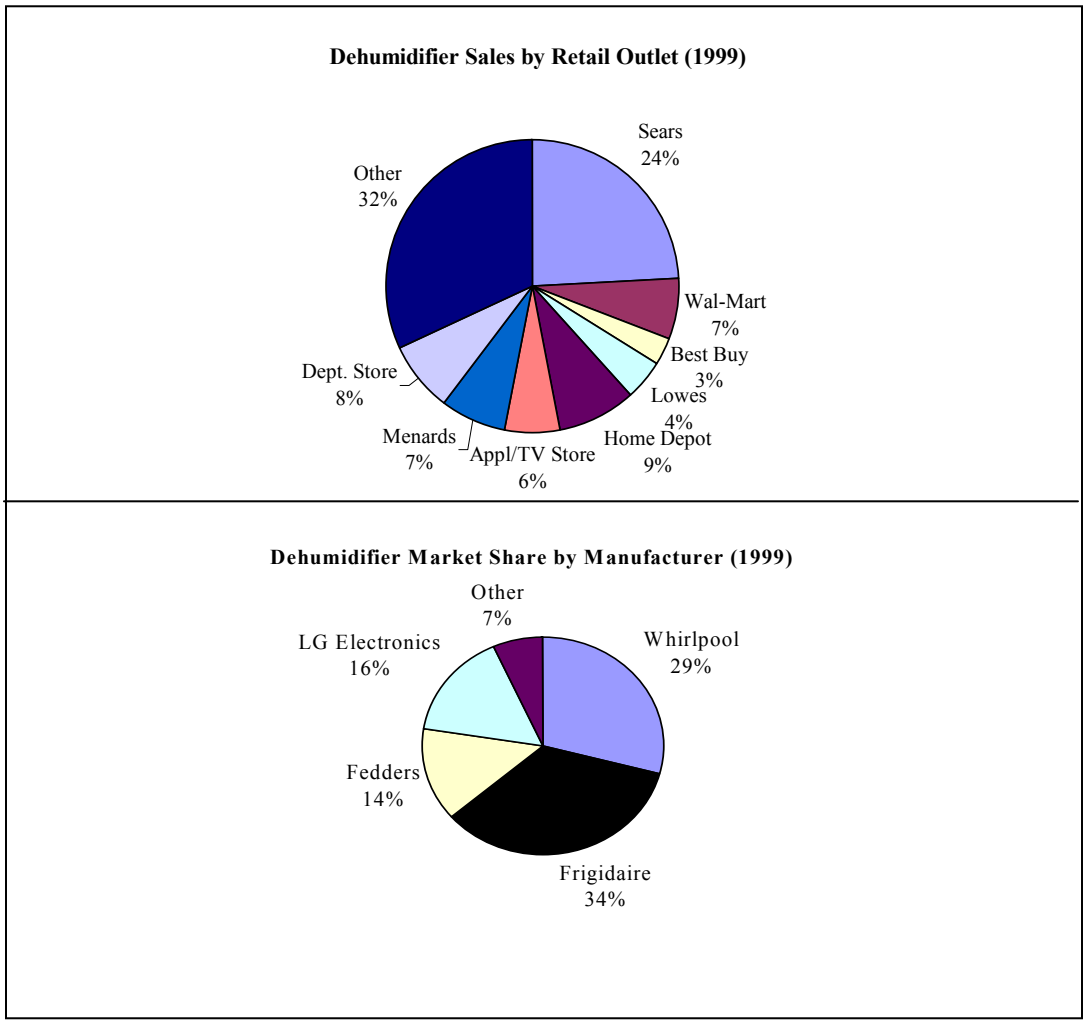
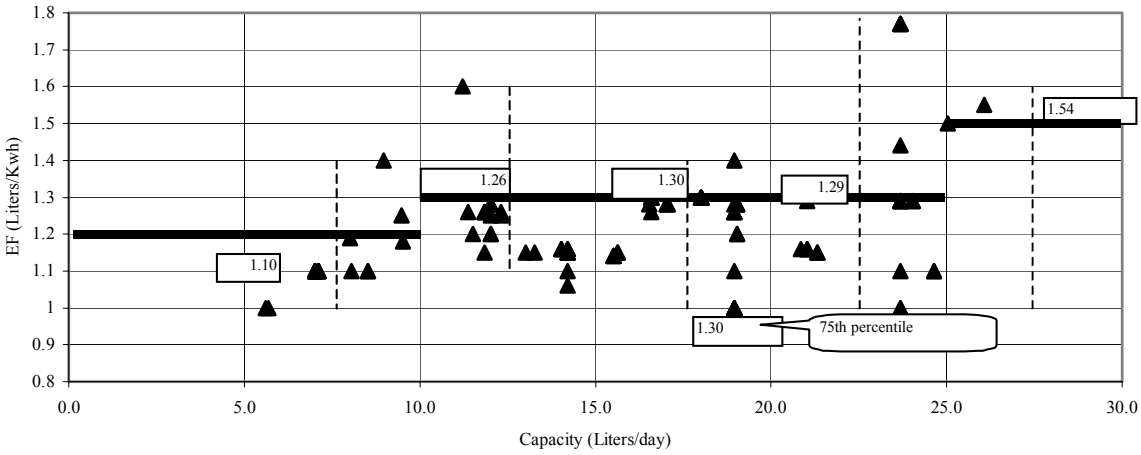


Figure 4: Dehumidifier Sales by Retail Market



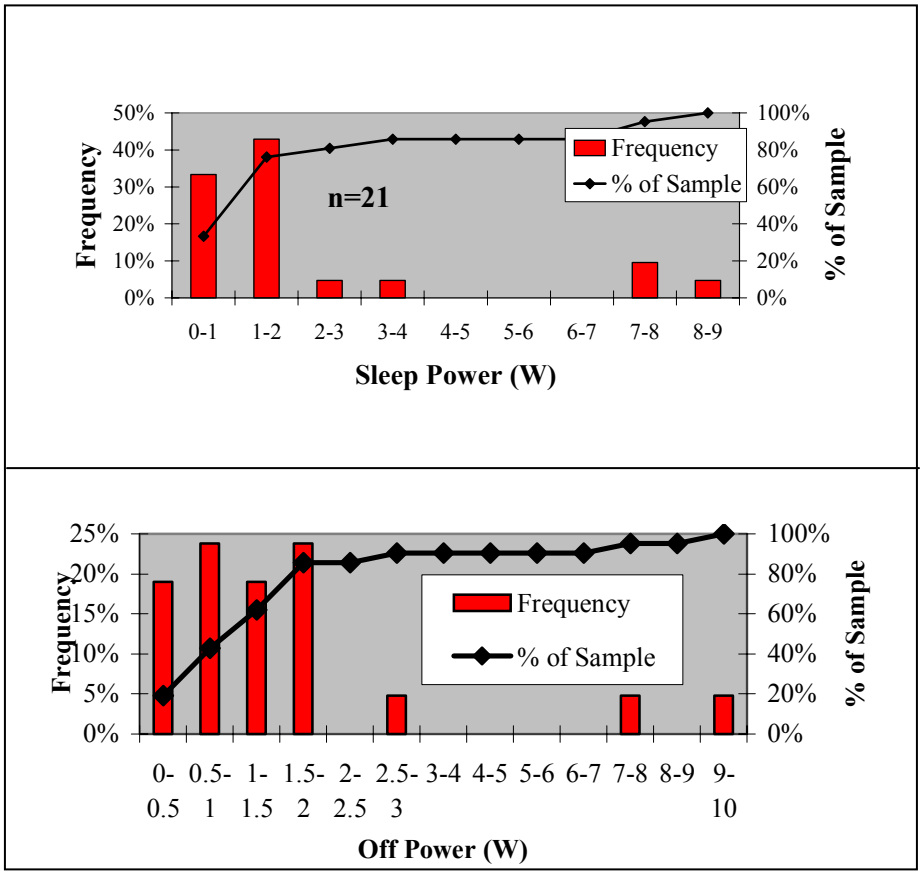
1. US EPA received updated market share information and retail sales information from Industry sources during the product development phase (2000).
2. Market share information may have changed since development of dehumidifier specification.

Figure 5: Energy Efficiency of Dehumidifiers



1. Bold line denotes ENERGY STAR specification levels.
2. Boxed numbers represent the top quartile of energy efficient products
3. Data from six US and Canadian manufacturers represented

Figure 6: Frequency Distribution of Sleep and Off Power



1. For detailed description of testing methodology and power state definitions, see Roberson, J (2002).