Does Tracking Market Penetration of ENERGY STAR® Appliances Give the True Picture of Energy Efficiency Trends?

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ABSTRACT

Recent efforts to track the market penetration of high efficiency residential appliances have focused on estimating the percentage of ENERGY STAR® qualified appliances sold at the retail level. For example, the Department of Energy and the Environmental Protection Agency, through their joint ENERGY STAR program, provide annual estimates of ENERGY STAR appliance sales, by state, based on reports from participating partners. In addition, California has developed a tracking system that reports quarterly ENERGY STAR sales using retail sales data from independent appliance vendors. These reports provide a dual function: tracking ENERGY STAR appliance penetration useful for retailers, program designers, planners, and evaluators and providing an overall assessment of the increase in the energy efficiency of appliances. Using ENERGY STAR appliance penetration can have some drawbacks when used as an indicator of changes in the overall efficiency of appliances. In particular, the ENERGY STAR specification changes over time and does not give detailed information about the actual average efficiencies of the units sold.

This paper will present an analysis of average energy factors compared to a percentage of ENERGY STAR qualified units for clothes washers, dishwashers, and refrigerators on a quarterly basis. The analysis is based on data collected from 1999-2002 from appliance retailers throughout California. The analysis will also address the impact of changes to the national energy use standards as well as changes to the ENERGY STAR specifications for these appliances.

Market Penetration

Market penetration refers to the extent to which a product or type of product has infiltrated a traditional marketplace. In the case of high efficiency residential appliances, market penetration can be discussed as market share. Market share tracking efforts, such as California's Residential Market Share Tracking (RMST) study, can provide information illustrating the penetration of energy efficient products as well as any changes on that penetration level over time.

Market share tracking refers to the systematic monitoring and periodic reporting of the percentage or ratio of sales of a defined set of products to the total sales of that product-type in a defined area (e.g., country, state, or region). The numerator of such an equation represents the number of units sold or installed in the relevant market that exceed a particular energy efficiency threshold, for example- the ENERGY STAR qualification level. The denominator of the market share equation represents the total population of all units sold or installed.

There are many ways in which this type of market share analysis can be valuable. It can help assess the achievement of market transformation programs. It may provide information on

specific program activities that may indicate whether the incremental benefits of program activity justify its cost. It may also be helpful in determining the effects of other external changes, such as economic downturns, on the market. Depending on the design and goals of a program, market share tracking may be used as a partial measure of program success.

Another measure of market penetration of high efficiency products over time can be an examination of the average efficiencies of units sold.

California

Assessment of the long-term success of California's energy efficiency programs made it necessary to develop a reasonably comprehensive system for tracking various indicators of market changes attributable to these efforts. Since California's statewide appliance program adopted the ENERGY STAR platform and coordinating incentives for consumer purchases of ENERGY STAR qualified clothes washers, dishwashers and refrigerators, the percentage of ENERGY STAR qualified units sold is a meaningful metric to program administrators.

Data to estimate market share and average efficiencies are obtained from appliance retailers serving the California market. The appliance market consists of two primary market channels: national retail chains and independent retailers (including regional chains as well as "Mom and Pop" stores). Sales data from all retailers are required to achieve an overall market perspective. Sales by national chains are provided by D&R International. Since the national chains account for a significant percentage of total appliance sales, the contribution of these data is important. These data are provided only as a quantity of ENERGY STAR qualified units sold and a total quantity sold. Sales by the independently owned storefronts and regional chains are obtained directly from the stores themselves. This direct recruitment has resulted in line-item sales data. Since each model number sold by participating independent (non-national) appliance retailers can be matched directly to its efficiency, average efficiencies over time can be calculated. Therefore, the RMST project expanded to include analysis that determines average energy factors for clothes washers, dishwashers, and refrigerators.

Energy Efficiency Standards

There are two important factors in the energy use of residential appliances. First, the federal government has energy use standards for appliances. Second, the DOE and Environmental Protection Agency (EPA) jointly promote the ENERGY STAR program. This program is a voluntary effort to increase awareness and availability of highly efficient products. All three types of residential appliances examined by the RMST effort in California are regulated by NAECA standards and have specifications for the ENERGY STAR program.

The federal standards are energy use thresholds. The ENERGY STAR program has its own energy use thresholds, which are voluntarily met by appliance manufacturers. These criteria are designed to identify and promote highly energy efficient products.[1]

[1] ENERGY STAR website. http://www.energystar.gov/index.cfm?c=about.ab_history

Clothes Washer Standards

For this purposes of this presentation, clothes washer efficiency is determined by a calculation for energy factor (EF). This formula is a simple equation seen below.

$$EF = \frac{\text{Tub Volume in Cubic Feet}}{\text{Annual Energy Usage}\,(\text{kWh})/\ \text{Cycles}}$$

The cycles used to be set at 392. This was an estimated average loads of laundry per year. Please note that the federal minimum energy efficiency standards have changed. These changes have been guided, in part, by the Super-Efficient Home Appliance Initiative (SEHA) standards created by the Consortium for Energy Efficiency (CEE). The change includes a switch to a modified energy factor (MEF), rather than standard energy factor. MEF is a new equation that takes into account the amount of dryer energy used in order to remove the remaining moisture content from the items washed.[2] MEF is not examined in the timeframe of the data contained. All clothes washer analysis concerns energy factor only. Table 1 describes previous and current federal and ENERGY STAR standards.

Table 1. Comparison of Federal and ENERGY STAR Clothes Washer Energy Standards

	1994 Standard	January 1, 2001 Standard	January 1, 2004 Standard	January 1, 2007 Standard
Federal Standard	1.18 EF	1.18 EF	1.04 MEF	1.26 MEF
Percent Improved	n/a	n/a	22% over 2001	35% over 2001
ENERGY STAR	2.50 EF	1.26 MEF (~ 2.50 EF)	1.42 MEF	n/a
California Standards	1.18 EF	1.18 EF	1.04 MEF	1.26 MEF

Dishwashers

Dishwasher efficiency ratings are based on estimated annual energy use (kWh) under "typical conditions" and an average quantity of loads, or cycles, per year. This EF rating is computed as follows:

$$EF = \frac{\text{Average Cycles per Year}}{\text{Annual Energy Usage}\,(\text{kWh})}$$

Table 2 presents the current energy efficiency standards and ENERGY STAR specification for dishwashers. As shown, all standard-sized dishwashers must have an EF equal to at least 0.46. However, it is important to understand that although the actual EF has not changed, the average cycle per year figure, which is used to calculate the EF, has been decreasing over the past few years. On June 17, 2002, the DOE decreased the number of cycles used to determine a dishwasher's EF, from 322 cycles to 264 cycles. In addition, on August 29,

[2] http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

2003, the number of cycles was further decreased to 215 cycles. The 215 cycle level took effect on February 24, 2004. As a result, without any alterations to the models available, the general EF of a given dishwasher will be lower, even though the actual number that defines the energy efficiency standard has not changed. Therefore, in order to maintain the same efficiency relationship to the federal energy standard, dishwashers must become more efficient. For instance, if a dishwasher used 500 kWh, its EF would have been 0.64 under the 322 cycle standard. Yet, for the same unit, its EF would be 0.528 with 264 cycles. Under the February 2004 cycle level of 215, the EF would be 0.43. Such a unit would shift from being ENERGY STAR qualified to not meeting the ENERGY STAR specification, if the manufacturer did not improve the efficiency of the unit.

Table 2. Dishwasher Energy Efficiency Standards and Program Requirements

	Current Standard
NAECA *	0.46
ENERGY STAR	0.58
California Standards	0.46

Refrigerators

Refrigerator energy use ratings are expressed in terms of expected annual energy use (kWh) under "typical conditions." Federal energy use standards vary by refrigerator configuration and are a function of the unit's adjusted volume (AV).[3] Table 3 includes formulas for computing the federally mandated maximum energy use requirements for each refrigerator configuration type. It also shows the requirements for a refrigerator to qualify for the ENERGY STAR label (at least 10% less kWh). Please note that the federal energy use standards for refrigerators changed on July 1, 2001.[4] The required energy use reductions from the former standard to the current standard vary by configuration, ranging between 27% and 32%. Additionally, the January 1, 2001 ENERGY STAR standard required refrigerators to use 10% less energy than the upcoming July 1, 2001 federal standard.

[3] Adjusted volume takes into account the differing temperatures between the refrigerator and freezer compartments with the following calculation: fresh volume plus (freezer volume times 1.63). The result is called the total adjusted volume and is used in the energy factor calculation.

[4] The new 2001 federal standard for refrigerators can be found in the following: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers and Freezers. *Federal Register*. Vol. 62, No. 81. April 28, 1997.

Table 3. Refrigerator Energy Use Standards and Program Requirements

	Current Standard
Federal Standard	
Manual defrost	8.82*AV+248.4
Partial defrost	8.82*AV+248.4
Automatic defrost, top mount without TTD	9.80*AV+276.0
Automatic defrost, side mount without TTD	4.91*AV+507.5
Automatic defrost, bottom mount without TTD	4.40*AV+459.0
Automatic defrost, top mount with TTD	10.2*AV+356.0
Automatic defrost, side mount with TTD	10.1*AV+406.0
ENERGY STAR Qualification	10% less kWh than the Federal standard
CALIFORNIA STANDARDS	Identical to Federal Std

TTD = through-the-door ice dispenser.
AV = Adjusted Volume = Fresh Volume + (1.63*Freezer Volume).
SEHA (Super-Efficient Home Appliance) initiative standards were created by the Consortium for Energy Efficiency (CEE)

Energy Efficiency Trends

Clothes Washers

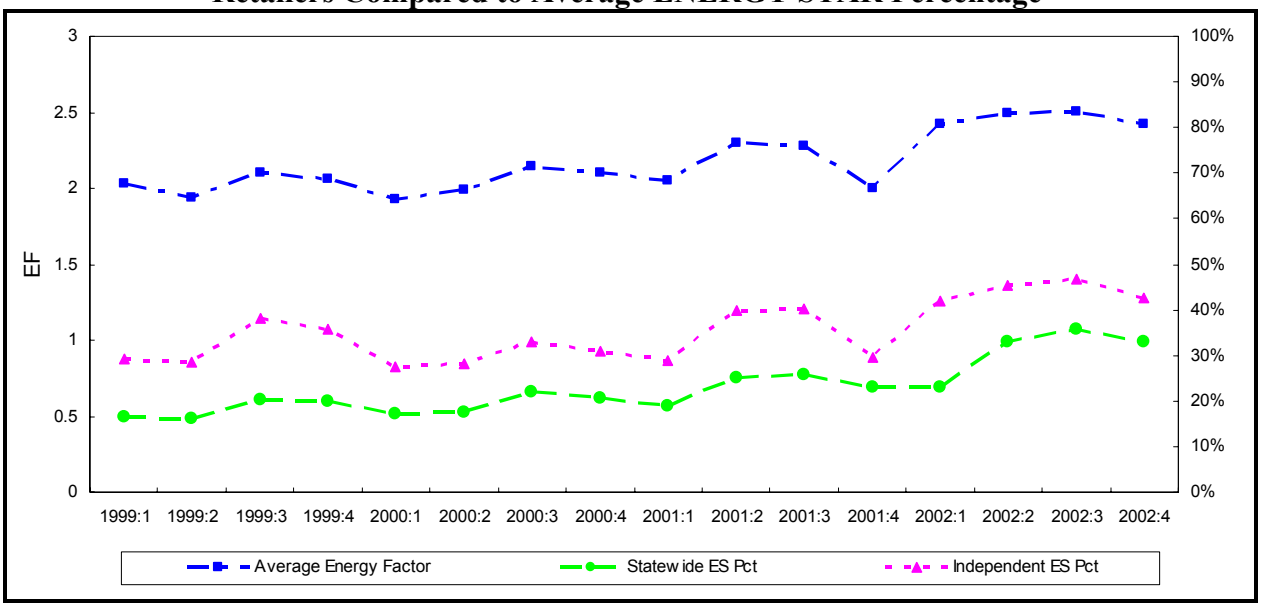
Over time, the market share of highly efficient residential appliances has grown in California. A good example of this trend can be seen by examining the sales data for clothes washers over time. Figure 1 illustrates several trends. It shows the average statewide percentage of ENERGY STAR qualified units sold. The statewide percentage includes sales data from both national chain and independent appliance retailers. The graph also illustrates the average ENERGY STAR market share for independent retailers only. This is important because Figure 1 also contains the trend line that indicates the average ENERGY FACTOR of clothes washers sold by independent retailers. Therefore, lines showing averages resulting from sales data obtained exclusively through independent retailers are both shown.

The graph indicates that the average energy factor of clothes washers grew between 2000 through 2002. As shown, it fluctuated from a low of 1.93 to a high of 2.50. Additionally, the average energy factor during 2002 was significantly higher than in the previous two years. The average market share of ENERGY STAR qualified clothes washers also increased during the time period examined.

It is important to understand that the ENERGY STAR threshold for clothes washers is 2.50 for the time period shown. The energy factor line only equals the ENERGY STAR threshold during the third quarter of 2002 when its value was 2.503. Yet, the ENERGY STAR market share was over 40% for independent appliance retailers throughout 2002. The average energy factor of these units is clearly increasing noticeably over time. However, since the average energy factor is not far above the ENERGY STAR threshold level, the efficiencies of the ENERGY STAR qualified units may not exceed that level by much. In other words, the ENERGY STAR qualified clothes washers being sold by independent retailers throughout California may not contain many super high efficiency units. Another scenario could be that there are virtually equal quantities of clothes washers that barely meet the federal requirement

and extremely efficient units being sold so that the average falls near the ENERGY STAR threshold level. However, due to the market share of ENERGY STAR qualified clothes washers, the second possibility seems less likely. Without the ability to compare the average energy factor and the average ENERGY STAR market share for the same group of retailers, the consideration of these possible market occurrences would not be possible. As the energy factor analysis continues in the future with comparisons to the ENERGY STAR percentage, this trend and others may become clear.

Figure 1. Average Energy Factor for Clothes Washers Sold By Independent Appliance Retailers Compared to Average ENERGY STAR Percentage

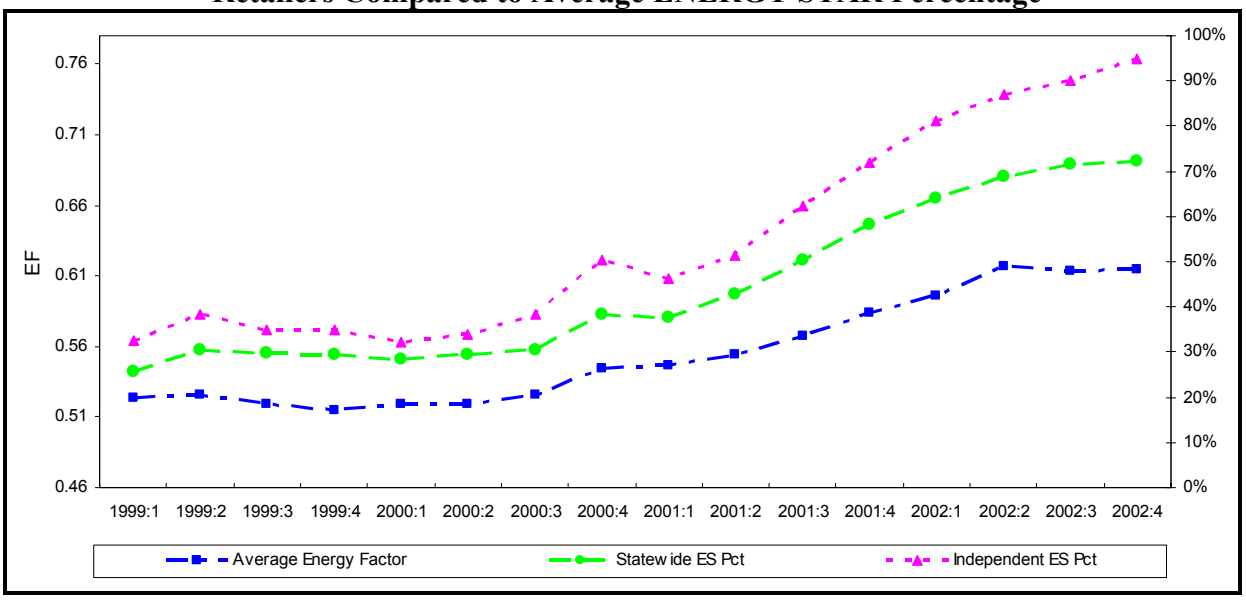


Dishwashers

Figure 2 presents the same information as Figure 1, except its focus is dishwashers. Again, the results support the concept that promoting high efficiency appliances increases their respective market share. The graph below shows substantial growth in the average energy factor of dishwashers throughout 2001 and the first two quarters of 2002. It also shows ENERGY STAR increases that occurred during the same timeframe. Please keep in mind that although the federal energy use and ENERGY STAR standard values did not change during the timeframe examined the actual average efficiencies of the units had to increase because the number of cycles used to calculate a dishwasher's efficiency decreased.

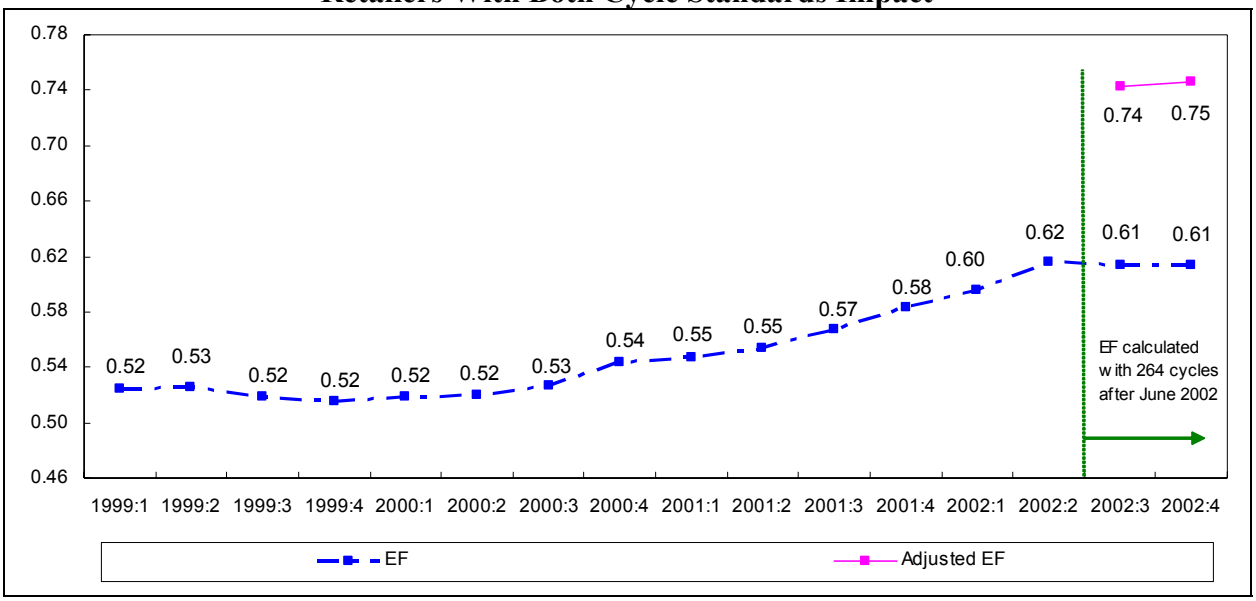
From the fourth quarter of 2001 through 2002, the average energy factor of dishwashers sold by independent appliance retailers surpassed the .58 ENERGY STAR threshold level. This is particularly interesting because the ENERGY STAR percentage for independents is over 80% in every quarter of 2002. By examining these two lines of data, it is clear that the average efficiencies of dishwashers sold in California during 2002 greatly surpassed both the federal and ENERGY STAR standards. However, these gains will begin to be offset by the changes to the cycles previously described.

Figure 2. Average Energy Factor for Dishwashers Sold By Independent Appliance Retailers Compared to Average ENERGY STAR Percentage



When the project team analyzed the average energy factor in the third and fourth quarter of 2002 against the two different cycle standards, there was an obvious difference due to the cycle change. Figure 3 illustrates the impact of these cycles' changes on the average energy factor of dishwashers sold by independent retailers throughout California. The "energy factor" line indicates a leveling off of the previously increasing average energy factor for dishwashers. This portion of that line is computed against the 264 cycle level that took effect in June 2002. The "Adjusted EF" line shows an average energy factor of .74 in the third quarter and .75 in the fourth. These figures demonstrate what the average energy factor for dishwashers would have been if computed with the previous 322 cycle standard. Clearly, this information is more indicative of the actual efficiency changes occurring in California's residential appliance market than the average ENERGY STAR percentage, which continued to climb in the same quarters. Again, the ability to determine and calculate energy factor provides more information than basic ENERGY STAR market share percentages.

Figure 3. Average Energy Factor for Dishwashers Sold By Independent Appliance Retailers With Both Cycle Standards Impact



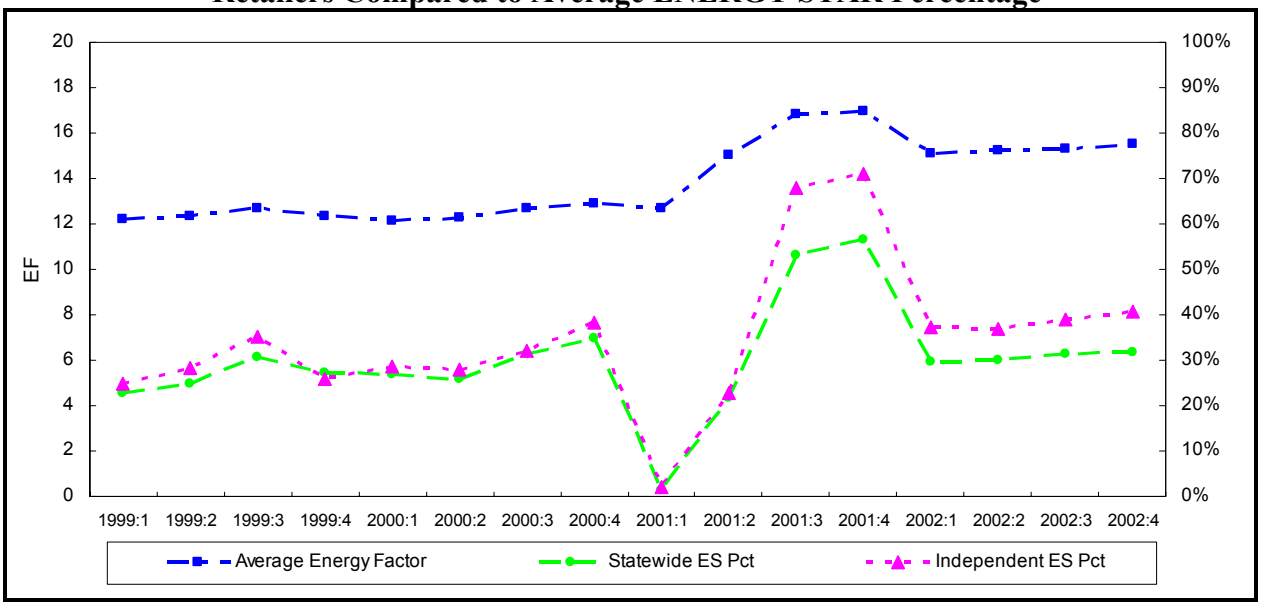
Refrigerators

Figure 4 is interesting due to the clear visual representation of the discrepancy during the first quarter of 2001 between the ENERGY STAR share and the average energy factor of refrigerators sold in that period. As shown, there is an abrupt decrease in market share to almost 0% during the first quarter of 2001. This is due to the lack of refrigerators available for purchase that met the new increased ENERGY STAR specification. The rapid growth in share from the first through to the third quarter of 2001 is attributable to manufacturers preparing for the federal standard change. As part of this preparation, refrigerators became available that met the new ENERGY STAR qualification. As this occurred, these units began to regain market share.

The difference between the 0% market share of ENERGY STAR qualified refrigerators in the first quarter of 2001 is markedly different than the average energy factor during the same quarter of 12.7. It is here that the deficiencies of analysis based strictly in ENERGY STAR market share can be seen. Additionally, the growth shown between the 0% market share in the first quarter to the high of 56% in the fourth quarter is intense. The growth in energy factor from 12.7 to 16.9 during the same period is both remarkable yet reasonable. The average energy factor analysis is likely to be more accurate in its portrayal of actual market occurrences.

During the third and fourth quarter of 2001, refrigerator sales were dominated by utility driven incentive programs for ENERGY STAR refrigerators. Then, in 2002, when the ENERGY STAR market share returns to more expected levels, the average energy factor in 2002 is still clearly higher than a modest efficiency increase would indicate. Therefore, it is possible that for independent appliance retailers in California some factor may be having longer lasting impacts on the general efficiencies of the refrigerators they are selling. This trend would not be seen without the average energy factor analysis.

Figure 4. Average Energy Factor for Refrigerators Sold By Independent Appliance Retailers Compared to Average ENERGY STAR Percentage



Conclusion

The ENERGY STAR program serves as a valuable tool on many levels. However, in situations where there is an ENERGY STAR specification change, analysis of ENERGY STAR market share alone does not accurately represent occurrences in the market. In order to have the most accurate assessment for any type of tracking or evaluation effort, energy factor analysis should be incorporated whenever feasible. The ability to determine average unit efficiencies over time is helpful, as this information can be used to justify future efficiency standards increases.

References

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