

Appliance Efficiency: A Tale of Two Perspectives

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ABSTRACT

Since 1993, the Energy Center of Wisconsin (ECW) has been conducting a biennial Appliance Sales Tracking study (AST)¹. These AST studies compile self-reported consumer attitudes and purchase behavior about household energy-consuming equipment. Where possible, equipment nameplate or other information is collected to determine equipment efficiency. Since 1997, the ECW has also been collecting furnace/air conditioner sales information directly from distributors. These data are reported quarterly by efficiency level. The sales data represent between 70 and 80% of furnace and central air conditioner sales in the state. The two studies provide rich longitudinal data to study trends over time. They also allow for the comparison of reported to independently measured efficiency levels.

The vast majority of consumers report purchasing a high efficiency unit regardless of the year, or appliance. Distributor sales and nameplate data are, for the most part, inconsistent with these self-reports. This paper discusses three possible reasons for differences between consumer perceptions and independent estimates of appliance efficiency. The analysis suggests that the consumer definition of high efficiency is different than that of energy and industry professionals. This discrepancy points to the need for easily identifiable indicators of high efficiency, such as ENERGY STAR[®], to help consumers in the selection of high efficiency products.

Introduction

Starting in 1993, the Energy Center of Wisconsin (ECW) initiated a biennial survey of Wisconsin households to track appliance purchases and consumer attitudes. Every two years approximately 3,000 households in Wisconsin respond to the survey, which covers the rate at which appliances are purchased, consumer attitudes, shopping experiences and other related information. Starting in 1997, ECW began collecting quarterly data from distributors on the sales of forced air furnaces and central air conditioners – the Furnace/Air Conditioner Distributor Sales Tracking. These two data sources allow us to compare consumer self-reports of appliance efficiency to independent estimates of efficiency. Self-reports are a reasonable indication of consumer perceptions of efficiency. They are also helpful in understanding consumer behavior.

Wisconsin has a population of 5.4 million people with roughly 2.1 million housing units (U.S. Census Bureau 2002). Table 1 shows the estimated number of each appliance purchased in Wisconsin annually, based on purchase rates reported by the 2001 AST respondents. Estimates of savings from appliance efficiency standards alone (for 2000) put the figure at 644 Petajoules nationally and 12.4 Petajoules for Wisconsin (Kooimey, et al 1998). The magnitude of potential savings from the purchase of more efficient appliances in Wisconsin and nationally is substantial.

¹ In 1999 and 2001 partial funding was provided by Wisconsin Focus on Energy.

Table 1. Percentage and Number of Wisconsin Households Purchasing Five Key Appliances

	2001 (n=3,000)	Approx. sales 2001
Furnace	3.6%	75,600
Air Conditioners	4.0%	84,000
Water heaters	5.9%	123,900
Refrigerators	8.6%	180,600
Clothes washers	7.7%	161,700
Total		627,801

The majority of AST respondents report purchasing a high efficiency unit regardless of the year or appliance. This paper explores three of five possible explanations for the self-reports of such a high percentage of purchases being for high efficiency products. It concludes with the implications of the findings on program planning and research.

Study Methods

The AST study collects data every two years from a random sample of approximately 3,000 Wisconsin households. For each data collection period, random digit dialing is used to identify respondent households. (Although not a panel, households are not screened for the unlikely event that a prior respondent is included.) All respondents answer a standard battery of demographic, attitudinal and purchase behavior questions. Awareness and understanding of the EnergyGuide and ENERGY STAR labels were included in the last two surveys. Respondents purchasing appliances complete detailed questions for each appliance purchased, for up to a total of three appliances. All other respondents are asked a series of lighting equipment questions. Response rates for the five data collection periods have ranged from 46 to 71%. The lowest response rates have been for the last two studies, where the number of “unable to contact” has increased substantially.

Several questions are asked of purchasers in the AST survey that relate to a particular appliance’s efficiency. Respondents are asked if the unit is high efficiency. Those who earlier reported being aware of ENERGY STAR are asked if the appliance had an ENERGY STAR label. Finally, purchasers of some appliances are asked to provide make and model number (nameplate) information for the appliance, so that efficiency can be determined from industry directories.

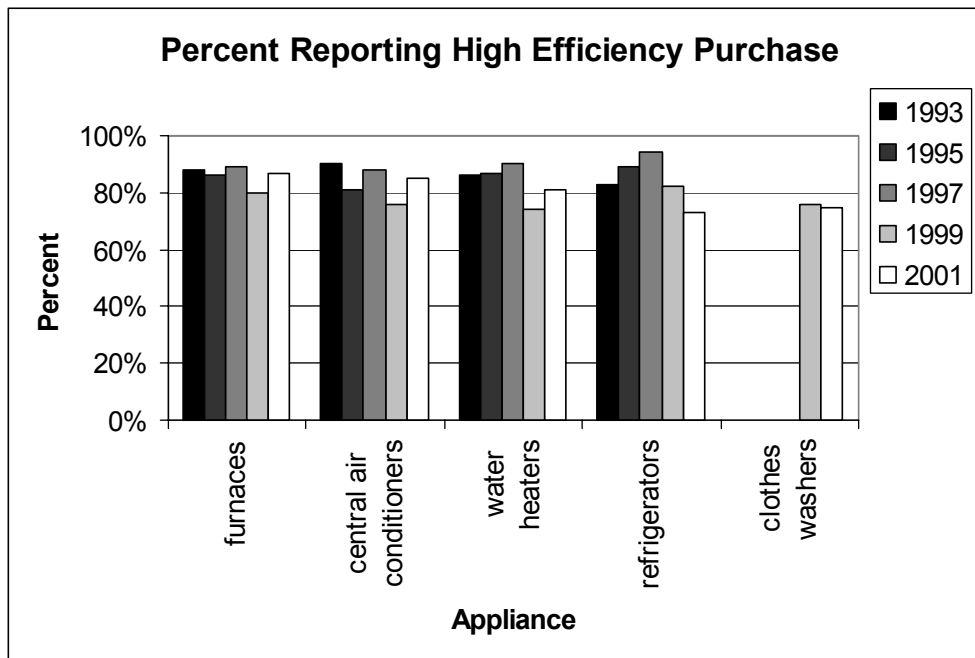
The Furnace and Central Air Conditioning Distributor sales tracking study relies on a panel of furnace and air conditioner distributors serving Wisconsin. These distributors provide quarterly sales data for 23 Wisconsin markets. Furnace sales data are collected for two different efficiency bins – furnaces with an annual fuel utilization efficiency (AFUE) of less than 90 percent, and those with an AFUE equal to or greater than 90 percent. Central air conditioners are tracked by seasonal energy efficiency ratio (SEER). These distributors represent more than 75 percent of annual sales of these products in Wisconsin.

Appliance Efficiency Levels – Self-Reports and Independent Estimates

Self-Reported Efficiency Levels – 1993-2001

In each of the Appliance Sales Tracking studies (1993-2001) and for each of the five appliances, respondents were asked “Is your new [appliance name] a high efficiency unit?” Figure 1 below shows that for five appliances² and all study years, an extremely high percentage (~70-90 %) of respondents report purchasing a high efficiency unit.

Figure 1. Reported High Efficiency by Appliance and Year



Source: Appliance Sales Tracking studies, 1993-2001

There are several possible and interrelated explanations for these responses.

1. The unit is high efficiency.
2. Respondents consider it high efficiency because it is more efficient than what is being replaced (or than older units).
3. The respondent doesn't know how – or has not bothered – to identify a high-efficiency unit.
4. The dealer or sales person told the respondent that it is a high-efficiency unit.
5. The respondent is providing the socially desirable answer.

The remainder of this section explores the first three potential explanations for the high level of self-reported purchases of high-efficiency units. We have not sufficiently analyzed the data to make a determination about the messages that the dealer or sales person

² Some appliances have been dropped from the study (room air conditioners) and other purchases added (clothes washers and lighting).

gave to the purchaser (Explanation 4). Preliminary analysis, however, indicates that there is a lot of variation in what consumers are told by salespeople. Addressing the effect of socially desirable answers on the responses is beyond the scope of this paper (Explanation 5).

Is It a High Efficiency Appliance?

Respondents were asked if they had purchased a high efficiency [appliance name] without being provided a definition of high efficiency. In the appliance and energy industry, appliances are considered high efficiency if they qualify as ENERGY STAR® products. While the specifications to qualify as ENERGY STAR vary by product, in general, ENERGY STAR equipment is that which is the most efficient of its product type. ENERGY STAR equipment is labeled so that shoppers can distinguish qualifying models from less efficient equipment. In this paper we use ENERGY STAR qualification to be synonymous with high efficiency.

This section discusses the relationship between self-reported and estimated energy efficiency for four of the appliances³. More than 70% of survey respondents report purchasing a high efficiency appliance, regardless of appliance or year (Table 2). Independent estimates of the percentage of these appliances that are high efficiency range from three to 83 percent. Except for furnaces, respondent self-reports of efficiency levels substantially overestimate the saturation of high efficiency appliances in the market.

Table 2. Self-Reports and Independent Estimates of High Efficiency Purchases

		1997	1999	2001
Furnaces	Reported (percent)	89	80	87
	Estimated (percent)	80	77	83
	<i>Difference</i>	+9	+3	+4
Central A.C.	Reported (percent)	88	76	85
	Estimated (percent)	3	8	12
	<i>Difference</i>	+85	+68	+73
Clothes Washer	Reported (percent)	Na	76	75
	Estimated (percent)	Na	15	24-42
	<i>Difference</i>	<i>Na</i>	+61	+33 – 51
Refrigerator	Reported	94	82	73
	Estimated (percent)	38	36	50
	<i>Difference</i>	+56	+46	+23

Source: Text below discusses the data sources for independent estimates

³ Water heaters were not included in this analysis because they are not included in the ENERGY STAR program.

Furnaces. AST self-reported efficiency levels for furnaces were compared to distributor sales tracking data. The distributor data track sales of furnaces in Wisconsin that are ENERGY STAR qualified – those with an Annual Fuel Utilization Efficiency (AFUE) equal to or greater than 90%. Table 2 shows that for furnaces, self-reports of efficiency from the Appliance Sales Tracking study closely match independent estimates based upon the distributor sales tracking data. The vast majority of respondents report purchasing a high efficiency unit, and a similar majority of units sold in Wisconsin are high-efficiency.

Central air conditioners. AST self-reported efficiency levels for central air conditioning systems were similarly compared to distributor sales tracking data. Central air conditioners with a Seasonal Energy Efficiency Ratio of 12 or greater are approximately 20% more efficient than minimum federal efficiency standards and are ENERGY STAR qualified. In 2001 85% of respondents reported purchasing a high efficiency unit, while distributors report that ENERGY STAR central air conditioners represent only 12% of sales in Wisconsin.

Clothes washers. Independently estimating the percentage of ENERGY STAR qualified clothes washers was more difficult in the absence of representative distributor or store sales data. Instead, consumer descriptions of the washer were used to obtain independent estimates. ENERGY STAR qualified clothes washers are those that are at least 50% more efficient than minimum government standards. Initially, most ENERGY STAR qualified clothes washers were front loading, but some newer ENERGY STAR washers are top-loading. This makes it somewhat difficult to determine ENERGY STAR qualification from physical descriptions.

In response to being asked if the clothes washer they purchased is high efficiency, 75% of respondents answered affirmatively. In addition, they were asked, “Is the door you put the clothes through on the TOP of the washing machine or on the FRONT panel?” Twenty-four percent of washers were described as front-loading and were considered ENERGY STAR units.

In addition, during the 2001 survey, respondents with top-loading machines were asked, “Is the clothes washer called a Calypso, an Ecosmart, a Gold High Efficiency, a Staber 2000, or a Resource Saver?” Respondents identifying one of these models as the clothes washer purchased (all ENERGY STAR products) represent an additional 18% of purchases. So, 75% of AST respondents report purchasing a high efficiency washer, but between 24 and 42% are independently estimated as ENERGY STAR qualified. Wisconsin’s ENERGY STAR program⁴ estimates 24% of clothes washer sales as ENERGY STAR products based on participating stores that provide sales data (Van de Grift, 2002) suggesting that the 24 % estimate is more realistic.

Refrigerators. Independent estimates of refrigerator efficiency in Table 2 are based on nameplate information provided by Appliance Sales Tracking respondents. Unfortunately, the majority of purchasers did not provide these data, limiting our confidence in the estimates. During a 1990 pilot study, however, we found that the range of efficiencies derived from model numbers was comparable to that found in site visits. Again, self-reported efficiency levels (75%) were substantially higher than independent estimates (50%) based on nameplate information.

⁴ Implemented by Wisconsin Energy Conservation Corporation and currently funded by Focus on Energy.

Overall. The above results suggest that self-reported data regarding a unit's efficiency status range from somewhat representative (in the case of furnaces, where there is less choice and therefore less room for error) to entirely inaccurate. In analyzing the AST data, it appears that regardless of the appliance, at least three-fourths of respondents will tell you that they are purchasing a high efficiency unit. This is true for furnaces, but not for the other three appliances.

Self-reports of high efficiency purchases prove, for the most part, to be inaccurate and so are poor indicators of the absolute penetration of high efficiency units. Since they are relatively invariant, we cannot use differences over time as an indication of trends in efficiency.

Is It More Efficient Than Older Units?

Another plausible explanation for why so many respondents report that their new unit is high efficiency is that the new unit is more efficient than older units (what they are replacing). Another way of looking at this is that consumers define high efficiency relative to what they have experienced (not relative to what is available in the marketplace). The assumption that a new unit is more efficient than an older unit is likely to be correct.

Furnaces. The lowest AFUE for a new furnaces is 82 percent. Most furnaces purchased 20 or more years ago (which is the short end of a furnace life expectancy) had AFUEs of less than 70 percent. New furnaces have AFUEs that range from 82- 93%. A small number of models on the market have even higher efficiencies.

Central air conditioners. Most Wisconsin households are installing central air-conditioning where it did not previously exist. In these cases, consumers may be comparing the efficiency of the new air conditioner to their assumptions about the efficiency of older units. Again, they are correct in assuming that newer units are substantially more efficient than older units. Prior to 1993 most central air conditioners had SEERs of around 5 or 6. The great majority of new central air conditioners have SEER levels of 10 or greater, with the highest efficiency units having a SEER of 17. The distributor sales tracking data show that units with a SEER of 13 or higher represent less than 2% of Wisconsin sales.

Clothes washers. Overall, clothes washer efficiencies have also improved, as a result of the minimum federal standards that took effect in mid-1994. These led to a 19% drop in the average energy consumption of washers sold in 1995, compared to those sold in 1993. Since that time, the average energy consumption of the washer models available has continued to decline. According to national sales-weighted data published by AHAM, clothes washers sold in 1999 used, on average, 10% less energy than those sold in 1994. Replacing a clothes washer that was more than 7 years old (in 2001) would most likely result in having a more efficient unit.

Refrigerators. Refrigerator efficiency levels have changed substantially in the past 20 years. All units on the market today are more efficient than units sold just 10-15 years ago due, in large part, to the National Appliance Energy Conservation Act (NAECA) of 1987 and the subsequent updating of minimum appliance efficiency standards for various products

(NAECA 1987). In addition, as efficiencies have increased, the “spread” of efficiency levels for products has narrowed. For example, the difference in operating cost between the lowest and highest units within a refrigerators size category are on the order of \$10 – 15 per year.

Figure 2 shows data from the Appliance Sales Tracking studies on the size, features and annual energy usage for refrigerators in Wisconsin. Since 1993 the average size of refrigerators has increased, the percent of refrigerators with extra features has increased, and yet the average energy usage has decreased. In other words, Wisconsin consumers are buying larger refrigerators with more features that use less energy. A national study showed that US appliances, after NAECA in 1987, were offering more features at a reduced cost, all other variables being kept constant. [Greening, et al 1996].

Respondent Does Not Know How to Identify a High Efficiency Unit

Despite the EnergyGuide and ENERGY STAR labels, consumers are still not clear on what is meant by high efficiency. There is evidence of confusion regarding what the EnergyGuide label means. (Egan, Thorne & Payne, 2000). In focus groups conducted by the Energy Center of Wisconsin and Focus on Energy some consumers assumed that the presence of an EnergyGuide label indicated that a unit was high efficiency (unpublished). Currently, recognition and understanding of the ENERGY STAR label is growing in Wisconsin, but still below 50%. (Tannenbaum and Feldman, 2001).

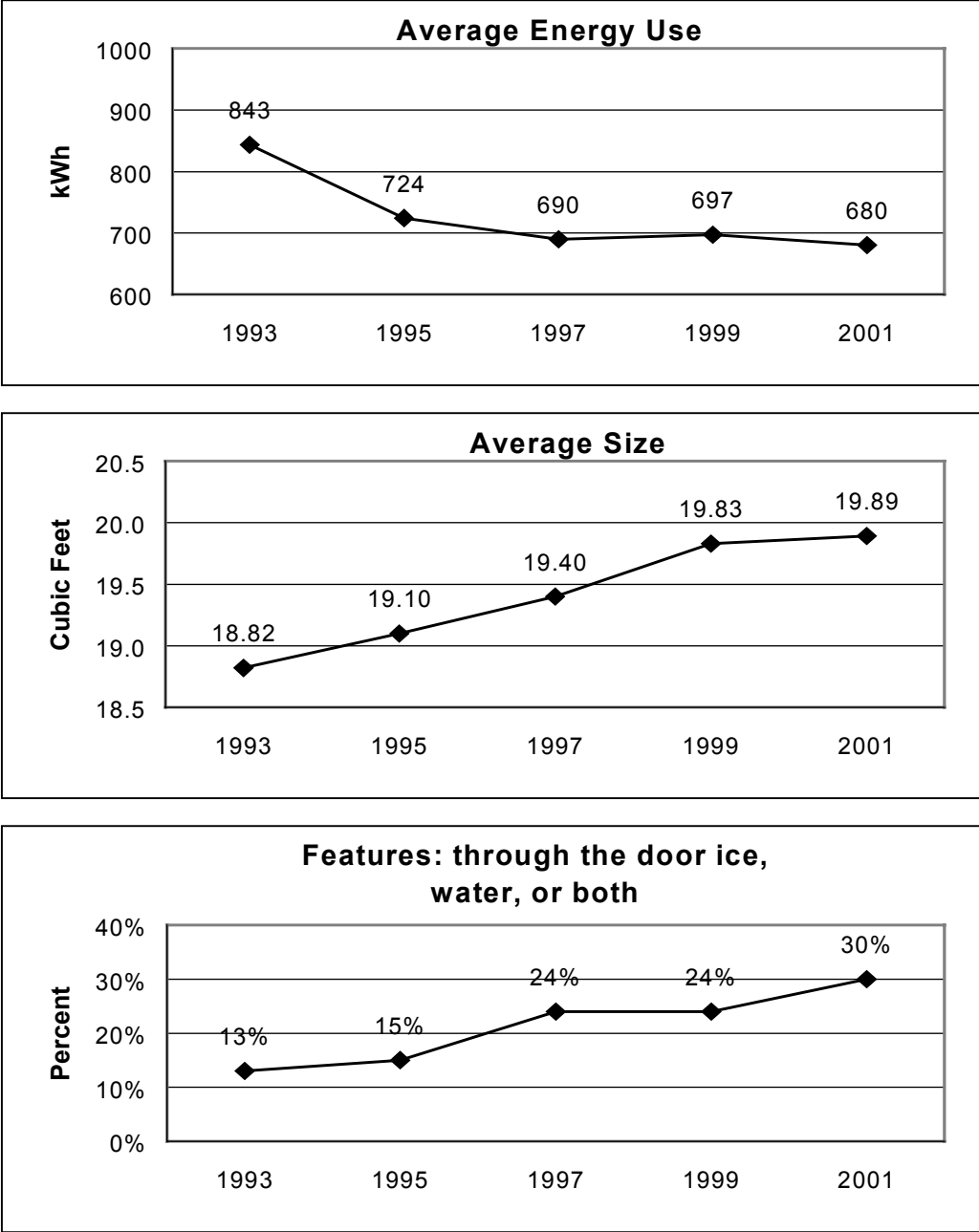
In the 1999 and 2001 Appliance Sales Tracking studies we asked respondents who reported familiarity with the ENERGY STAR label if the unit they purchased had an ENERGY STAR label, and then compared their response to nameplate information to determine if the unit qualified as ENERGY STAR. Tables 3- 6 below compare self-reports to independent estimates for individual purchases. From these data we can see how accurate respondents are in assessing the ENERGY STAR status of the appliance they purchased.

For furnaces, 64 percent of respondents accurately report that their furnace is an ENERGY STAR unit. Eight percent falsely report that they purchased an ENERGY STAR furnace and four percent report not purchasing an ENERGY STAR furnace, when in fact they did. Note that 20 percent of these respondents (aware of ENERGY STAR) purchased an ENERGY STAR furnace but did not know that they did. Given the low number of cases for the furnace analysis it would be inappropriate, however, to draw large conclusions from these data with confidence.

Again, the low number of cases for central air conditioners makes it difficult to draw many conclusions from the data. Nonetheless, these data suggest that consumers are not aware of ENERGY STAR qualification, or lack of, for the units they purchased. Most of those purchasing an ENERGY STAR unit were not aware that it was ENERGY STAR qualified.

The clothes washer data (Table 5) also indicate a low awareness of ENERGY STAR qualification for purchased equipment. More than one-half (28 of the 43%) who purchased an ENERGY STAR washer were not aware that it is an ENERGY STAR unit. In addition, almost one-half (40%) of those who did not purchase an ENERGY STAR washer reported that they had.

Figure 2. Changes in the Wisconsin Refrigerator Market, as Reflected in the AST



Source: Appliance Sales Tracking studies, 1993-2001

Table 3. Furnaces – Reported and Independently Estimated Purchase of ENERGY STAR (n = 25)

		Estimated	
		ENERGY STAR	Not ENERGY STAR
Reported	ENERGY STAR	64%	8%
	NOT ENERGY STAR	4%	4%
	Don't know	20%	0

Table 4. Central AC – Reported and Independently Estimated Purchase of ENERGY STAR (n=16)

		Estimated	
		ENERGY STAR	Not ENERGY STAR
Reported	ENERGY STAR	25%	13%
	NOT ENERGY STAR	25%	0%
	Don't know	31%	6%

Table 5. Clothes Washers – Reported and Independently Estimated Purchase of ENERGY STAR (n = 111)

		Estimated	
		ENERGY STAR	Not ENERGY STAR
Reported	ENERGY STAR	28%	28%
	NOT ENERGY STAR	3%	10%
	Don't know	12%	20%

Table 6: Refrigerators Reported and Independently Estimated Purchase of ENERGY STAR Units (n = 46)

		Estimated	
		ENERGY STAR	Not ENERGY STAR
Reported	ENERGY STAR	30%	28%
	NOT ENERGY STAR	2%	7%
	Don't know	20%	13%

The refrigerator data (Table 6) tell a similar story. More than one-half of those who purchased an ENERGY STAR washer were not aware that it is an ENERGY STAR unit. In addition, more than one-half of those who did not purchase an ENERGY STAR washer reported that they had.

These data show that self-reports of ENERGY STAR qualification are often inaccurate. First of all, one-third or more of respondents (except for furnace purchasers) report that they

do not know if what they purchased is an ENERGY STAR unit. And these are respondents who report being at least somewhat familiar with ENERGY STAR. Second, many respondents who purchase ENERGY STAR are not aware that they did so. Finally, respondents who did not purchase an ENERGY STAR unit may think that they did. The ENERGY STAR designation is not standing out in most consumers' minds.

Not shown, but perhaps more startling, is that a substantial percentage of respondents asked if their water heater had an ENERGY STAR label reported that it did. Water heaters are not currently included in the ENERGY STAR program. Clearly, consumers are not familiar enough with the ENERGY STAR label to accurately determine if their unit has the label.

Summary

Most consumers report purchasing a high efficiency appliance, regardless of year or appliance type. The three explanations discussed above are:

1. The unit is high efficiency.
2. Respondents consider it high efficiency because it is more efficient than what is being replaced (or than older units).
3. The respondent doesn't know – or has not bothered -- to identify a high-efficiency unit.

The first explanation does not hold true. According to independent estimates, most appliances purchased in Wisconsin (or by these respondents) do not meet ENERGY STAR standards. According to energy and industry professionals, they are not considered 'high efficiency.'

The interrelationship between the two remaining explanations makes it difficult to deem one more likely than the other, and there may be no substantive difference between the two. The ENERGY STAR program was designed to promote high efficiency products and make the identification easy for the consumer. A consumer that considers something high efficiency because it is more efficient than what is being replaced (Explanation 2) may not know how, or has not bothered, to identify a high efficiency unit (Explanation 3).

The consumer is correct in assuming that a unit purchased today is likely to be more efficient than what is being replaced, or than older units in general. Improvements in technology and appliance efficiency standards cause the mix of available appliances to be more efficient than older units. The industry and energy professional definition, ENERGY STAR qualified, is not based on the efficiency of older or existing equipment. Instead, it is relative to appliance efficiency standards or specific independent criteria, and represents the most efficient equipment available on the market.

Without identifying the criterion for high efficiency in advance — ENERGY STAR qualified — respondents use a different definition, but one that is not wholly inaccurate.

Implications for Program Planners

These data and analyses point to the need for a clear indicator of what is and is not high efficiency. Once consumers are motivated to purchase high efficiency equipment, they must be able to identify that which is.

ENERGY STAR qualification and labeling is the national program attempting to do this. The ENERGY STAR label indicates that this is one of the most efficient units of its type. The ENERGY STAR label is affixed to qualified appliances in addition to, or as part of, the EnergyGuide label. The EnergyGuide label provides the information necessary to determine how well a product compares to similar units on energy consumption. Other research, however, has pointed out consumer confusion regarding the EnergyGuide label and argued for a more categorical approach to the label (Egan, Thorne & Payne, 2000). The ENERGY STAR label is categorical in the most extreme sense – products either qualify or they don't.

Programs should promote ENERGY STAR as the symbol of high efficiency. Messages that promote energy efficiency, but do not provide clear guidance to consumers on how to effectively implement the message, may not obtain the desired results. At a minimum, greater promotion of ENERGY STAR may improve consumer awareness regarding their purchases (and improve self-reports). This is necessary, but not sufficient, to increase sales of high efficiency products. The impact that greater promotion will have on consumer behavior is difficult to determine. The ability to identify a high efficiency product can translate into action only if the consumer is motivated (or convinced) to buy a high efficiency product.

Implications for Researchers

The lessons for researchers are clear. Surveys are good tools for getting purchase rates for new and replacement equipment. They also allow one to capture attitudes regarding purchases and awareness of equipment differences. The data collected could also be correlated with demographic characteristics to identify key market sectors for programs and promotions.

Surveys and self-reports in general, however, are not good tools for determining realistic estimates of equipment efficiency or for identifying ENERGY STAR products. They have mixed results for obtaining nameplate information from respondents, depending on appliance type. The inaccuracy in efficiency estimates from survey data argues for the use of sales data to know what is being purchased and to observe market trends.

A combination of sales data and self-reports provides a richer understanding (than either approach alone) of what is happening in the market place. As usual, researchers should consider carefully the uses of the data prior to selecting a data collection approach. Sales data are important for accurately measuring the market impact of a program. Self-reported data are helpful in understanding consumer perceptions (and misconceptions) to better understand the quantified actions. Both are needed to more fully understand a market and effectively make changes to it.

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