

Tackling Efficiency Paradoxes: Responses to “Energy-Efficient” 10,000 sq. ft. Houses and 50-inch Televisions

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ABSTRACT

With a high level of public and regulatory pressure to increase energy savings and reduce greenhouse gas emissions, the time is ripe to further examine opportunities for introducing conservation elements into traditional energy efficiency programs. In this paper, the authors review prior discussions on the concepts of efficiency and conservation. They then pose three categories of approaches for how energy efficiency programs can include energy conservation: including both kinds of information in consumer labels for products and homes, incorporating size limitations into a future iteration of ENERGY STAR for Homes, and adding total energy consumption and other components into programs that target consumer products.

Introduction

***Paradox:** A statement that is seemingly contradictory or opposed to common sense and yet is perhaps true.¹*

The market is rife with energy efficiency paradoxes: large homes, large televisions, large refrigerators routinely earn the right to an energy efficiency or environmental endorsement label. And compared to similarly sized products, they are in fact more efficient. When viewed in comparison to all products that perform the same function regardless of size, however, they consume more energy. The trend remains one of ever-increasing energy consumption.

Efficiency programs are under increasing pressure from consumers and regulators to produce energy savings and reduce greenhouse gas emissions. If legislators mandate greenhouse gas emissions reductions,² they must be open to new approaches to achieving those reductions. The traditional focus on energy efficiency has resulted in a situation where homes are getting more efficient, while simultaneously getting bigger and using more energy.

One way to address this paradox is to add conservation concepts to energy efficiency programs. Energy efficiency is a concept of relative consumption. Previous authors have defined energy efficiency as providing more services per unit of energy (Harris et al. 2006). Conservation is a concept of absolute consumption, focusing on how much energy is consumed (Moezzi 1998). While efficiency is easily embraced by policy makers, conservation is often associated with sacrifice. Sacrifice is rarely a politically popular policy.

The new ENERGY STAR specification for televisions effectively illustrates the limitations of a focus solely on energy efficiency. A 50-inch television is considered energy

¹ Merriam-Webster Dictionary 2008 (www.merriam-webster.com).

² The Pew Center on Global Climate Change monitors state policy on greenhouse gas reductions. See <http://www.pewclimate.org/states-regions>.

efficient under this program if it uses no more than 318 watts of On Mode power. A 26-inch television is considered energy efficient if it uses no more than 90 watts of On Mode power. Thus, a smaller television that uses 100 watts, some 218 watts—or almost 400 kWh per year—less than the larger television is not energy efficient. It therefore will not receive the label that is recognized by some 74% of consumers (EPA 2008), a recognition bolstered by the substantial marketing push that the federal government and many energy efficiency programs supply for ENERGY STAR-labeled products.

There is no question that if a consumer is going to buy a big house or big television, we want it to be an energy-efficient one. It is essential that policy makers, energy efficiency programs, and industry continue to devise and support energy efficient products and services for all consumers. But it seems the market may be ready for a more expansive approach. And policy makers should be as well, since the decisions that they are making to exclusively support energy efficiency over conservation are in many instances working at odds with mandates to reduce emissions.

The authors wish to contribute to this dialog by presenting some specific measures as examples of ways that energy conservation and efficiency can complement each other in support of residential energy-efficiency programs.³ The focus is on three areas: providing additional information to consumers with the goal of prompting them to make less consumptive purchases, introducing metrics founded in conservation to the ENERGY STAR for Homes program, and adding conservation elements to energy efficiency programs that target consumer products.

Three Models Blending Conservation and Energy Efficiency

Consumer Labeling

Consumer labels that contain information related to both energy efficiency and conservation could be a valuable tool to efficiency programs, states, and other entities seeking to reduce energy consumption and greenhouse gas emissions. European product labels that include information about energy use have been found to be effective in influencing consumer purchasing patterns, have prompted actions by manufacturers and member states resulting in avoided consumer electricity costs, generated substantial energy savings, and improved the sales-weighted average efficiency of refrigeration appliances (Wiel and McMahon 2001, 150-51).

At this point in time in the United States,⁴ there are two primary labels that give consumers some level of information about a product's energy consumption and/or relative efficiency, the Energy Guide label and the ENERGY STAR label. While valuable, these tools could be enhanced to facilitate increased energy savings.

The Energy Guide label, developed and regulated by the Federal Trade Commission (FTC), appears on many of the products in the home.⁵ The label was recently revised⁶ and shows both an estimate of annual energy consumption and operating cost, though it still has the

³ Although this paper exclusively addresses residential products and services, this topic should have equal import for commercial and industrial programs.

⁴ Canada has similar labeling schemes, though they call the label we caption the Energy Guide the EnerGuide.

⁵ The products covered by the FTC's labeling rulemaking authority include refrigerators, refrigerator-freezers, freezers, dishwashers, water heaters, clothes washers, room air conditioners, furnaces, central air conditioners, heat pumps, fluorescent lamp ballasts, plumbing products, lighting products, pool heaters, and some other types of water heaters.

⁶ 72 Fed. Reg. 49,948 (2007), codified at 16 C.F.R. pt. 305.

shortcoming demonstrated by Harris et al. in the context of the Energy Guide label for refrigerators (Harris et al. 2006, 7-109-12). Refrigerators performing the same general function (i.e., chilling and freezing food) are grouped by configuration (e.g., top freezer, bottom freezer) and energy use is only compared to other, similarly configured models. This means that the consumer does not see, for example, that choosing a side-by-side refrigerator-freezer often entails an energy consumption penalty, compared with a bottom freezer model of similar size. The Energy Guide label also does not currently apply to many products, such as consumer electronics, that account for an increasingly large share of home energy use.⁷

The ENERGY STAR label, originally created in 1992, is a powerful force in consumer purchasing decisions in the U.S. The ENERGY STAR mark is near the very top of the list of consumer emblems ranked for influence on product purchases, with some 88 % reporting the ENERGY STAR had at least some influence and 28 % reporting it had tremendous influence (EPA 2005, 6). In a report published by EPA based on research conducted by the Consortium for Energy Efficiency in 2007, 74% of households recognized the ENERGY STAR label when shown the label, 76% of households had a high or general understanding of the label's purpose, and 62% of households associated the ENERGY STAR label with "efficiency or energy savings" (EPA 2008). The ENERGY STAR label is binary. A product bears the label or does not, without other differentiation with regard to energy use.

The above discussion of the new ENERGY STAR television specification and the following discussion of ENERGY STAR for Homes show some of the limitations of the ENERGY STAR label. The label itself only indicates the product is relatively more efficient than the products to which it is being compared. While the ENERGY STAR signals a product is a wise investment for a consumer (given an attractive payback that is often less than 5 years), it does not tell a consumer exactly how much more efficient (10% or 50%?)⁸ or to which products it is being compared. It also does not give an estimate of the total energy the product may use.

ENERGY STAR is exploring the opportunity for some differentiation in energy efficiency through pilot programs for "Save More With ENERGY STAR." These pilots provide a marketing tool for efficiency program administrators to create signage with a Save More With ENERGY STAR message for appliances that meet a national efficiency specification developed by the Consortium for Energy Efficiency (i.e., the Super-Efficient Home Appliances specifications) that is stricter than the ENERGY STAR specification. The pilot programs will be used to determine whether "Save More" conveys the intended message of advanced efficiency, increases local program effectiveness, leads to increased sales of super-efficient products, and avoids confusing customers without damaging the ENERGY STAR brand's integrity. At this point, this approach represents an increased opportunity to promote super-efficient products, but still does not provide the full bundle of energy use and comparative information that conservation-minded consumers may be seeking.⁹

Another possible approach would be to include a number indicating typical energy consumption within the ENERGY STAR label itself, similar to the number that appears on the

⁷ The Energy Independence and Security Act of 2007 extends the FTC's responsibility for providing information to consumers on energy consumption to televisions, set-top boxes, personal computers, computer monitors and stand-alone digital video recorders, some of the most consumptive products previously not subject to the labeling requirements. Pub. Law 110-140 sec. 325.

⁸ ENERGY STAR does provide some information on its website (www.energystar.gov), but the consumer must take the affirmative step of accessing it as part of the purchase process.

⁹ Provision of this type of information has never been intended for the ENERGY STAR label.

Energy Guide label. While the Energy Guide label does include the ENERGY STAR logo, it is not in the cyan blue that consumers have come to recognize. Additionally, the Energy Guide label does not appear on many ENERGY STAR-qualified products (see discussion above). As successful as the ENERGY STAR program has been,¹⁰ there appears to be an opportunity to capture even more energy savings, particularly for the segment of the market interested in additional energy savings information from a credible source.

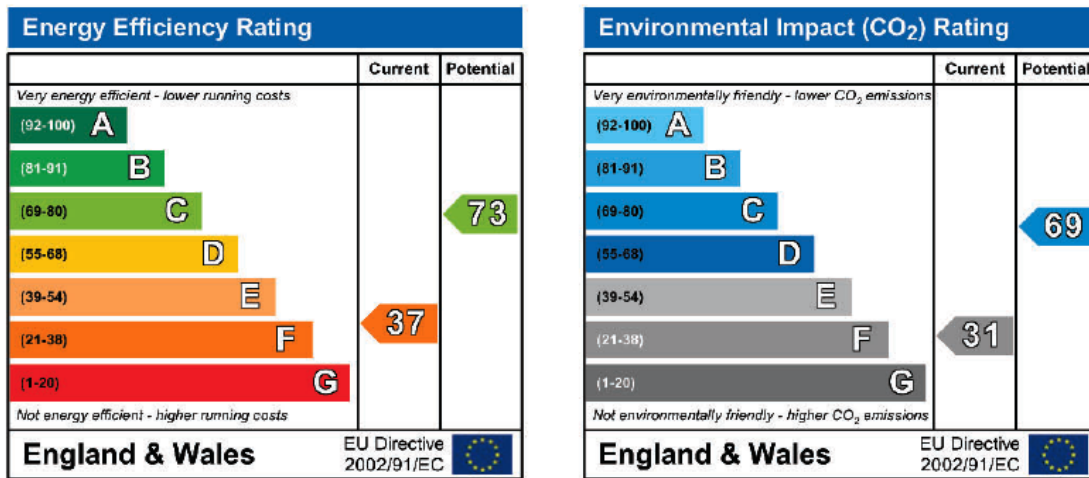
A big gap in energy consumption information for North American consumers at this point in time is for homes. The energy efficiency of a home (new or existing) and the energy consumption of a home are a function of its many parts: the shell, the heating and cooling equipment and the end uses (e.g., appliances, electronics). The ENERGY STAR label may be applied to qualifying new homes, but only on rare occasions to existing homes (e.g. gut rehab). There are many green labeling programs for new homes¹¹ that include some consideration of energy use and consumption, but energy may only be a small part in the house's right to bear the label.

The European Union provides a broader home labeling model. Under EU Directive 2002/91/EC, member states are required to ensure that energy performance certificates are made available to the owner or by the owner to the prospective buyer or tenant when buildings are constructed, sold or rented out. The energy performance certificate must include reference values such as current legal standards and benchmarks in order to make it possible for consumers to compare and assess the energy performance of the building. In addition, the certificate must be accompanied by recommendations for the cost-effective improvement of the energy performance. An example of a key component of such a certificate provided in England and Wales is depicted in Figure 1. Note that concepts relating to both energy efficiency (the Energy Efficiency Rating) and environmental impact ((CO₂) Rating) are presented side by side for both the current performance of the building and potential building performance if the recommended improvements were implemented.

¹⁰ In its 2006 Annual Report, EPA reports that in that year Americans, with the help of ENERGY STAR, avoided greenhouse gas emissions of 37.6 MMTCE and saved 170 billion kilowatt hours of electricity while saving more than \$14 billion on their energy bills (EPA 2007, 3-4).

¹¹ LEED for Homes, a program of the U.S. Green Building Council, is one such labeling program. Larger houses actually receive point deductions, but there is still a strong chance a small house that uses substantially less energy than a large house could qualify for the label. Furthermore, the energy metric used for many of the points is the HERS Index, again a measure of relative efficiency (see more later in this paper).

Figure 1: Information from Energy Performance Certificate



Source: Energy Saving Trust 2008

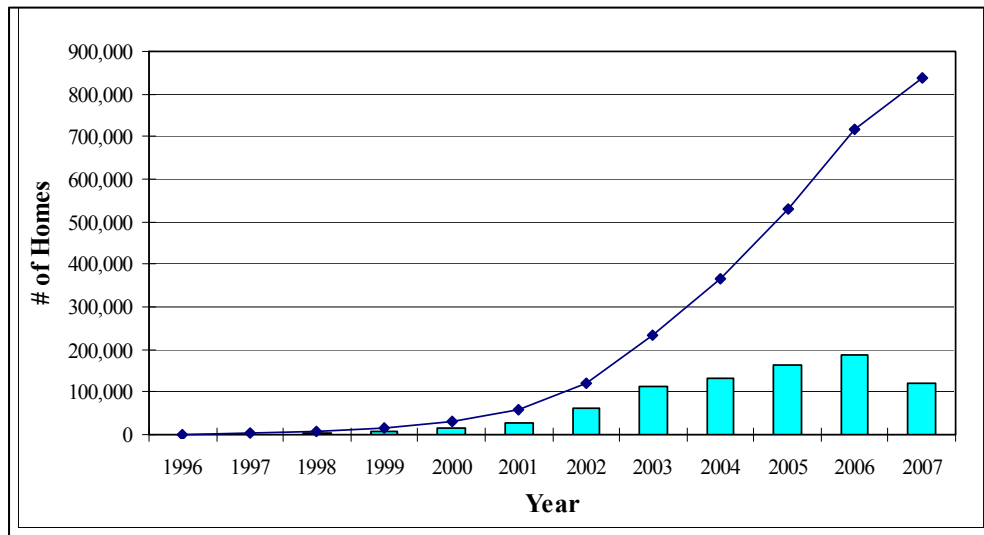
In this instance, the information has been generated through a regulatory mandate, and it would appear that whole building energy performance might be a category that should also be addressed by the FTC. This would be a complicated exercise given the variety in building codes and other policies across the United States. There are options as well for producing similar information through voluntary programs. It is important that the tool used to generate the performance ratings accounts for the best available energy technologies and construction practices to effectively support market transformation in this area.

The preceding discussion demonstrates that 1) there are gaps in consumer labeling regarding energy efficiency and energy use, and 2) filling those gaps with both energy efficiency and conservation information can help program providers meet their energy savings and greenhouse reduction goals. While there is undoubtedly a role for government (at a minimum the FTC and ENERGY STAR) to play in accomplishing this, there is an opportunity for energy efficiency programs to supplement this work, particularly in the realm of homes where differences in building codes render a government approach to labeling at the national level more problematic.

ENERGY STAR for Homes

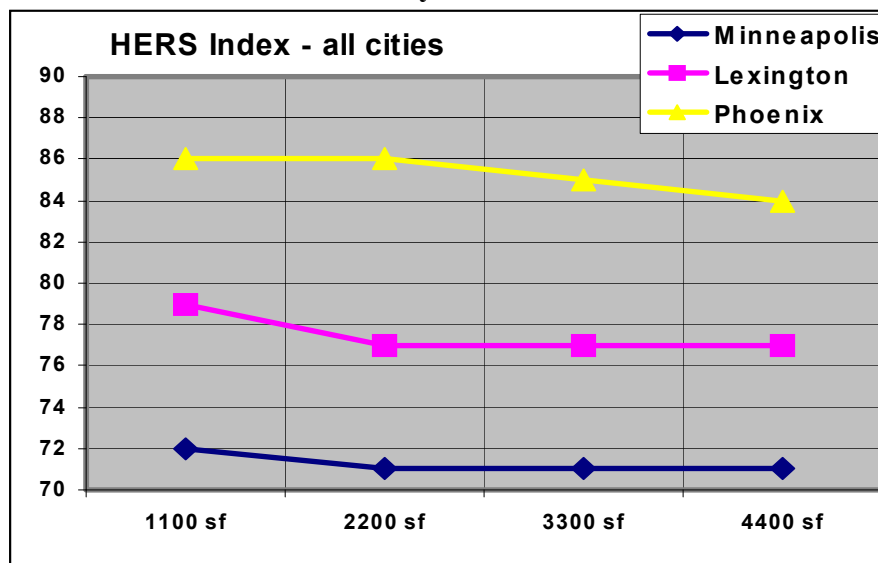
The ENERGY STAR for Homes program has experienced dramatic growth in the last decade including over 5,000 builder partners and more than 850,000 labeled homes by the end of 2007 (see Figure 2). To date, ENERGY STAR for Homes has been exclusively an efficiency program without consideration of the size or absolute energy consumption of homes in the program. Thus, a large 'Hummer Home' can earn the ENERGY STAR label as easily as a small one. In fact, the RESNET-approved Home Energy Rating System (HERS) software currently yields a perverse result where smaller homes are much more difficult to qualify for ENERGY STAR than extremely large homes. Figure 3 depicts results from for homes ranging in size from 1,100 square feet to 4,400 square feet with identical energy efficiency features showing lower scores (i.e., higher energy efficiency) for the larger homes. This issue has been recognized by RESNET, but there is no near-term correction forthcoming and that leaves the energy efficiency scoring process with a bias for larger homes.

Figure 2: ENERGY STAR for Homes Growth



Source: EPA ENERGY STAR for Homes tracking data 1996 to 2007

Figure 3: HERS Index Scores for Homes with Identical Energy Efficiency Specifications by Size



Source: EPA internal Rem-Rate analyses

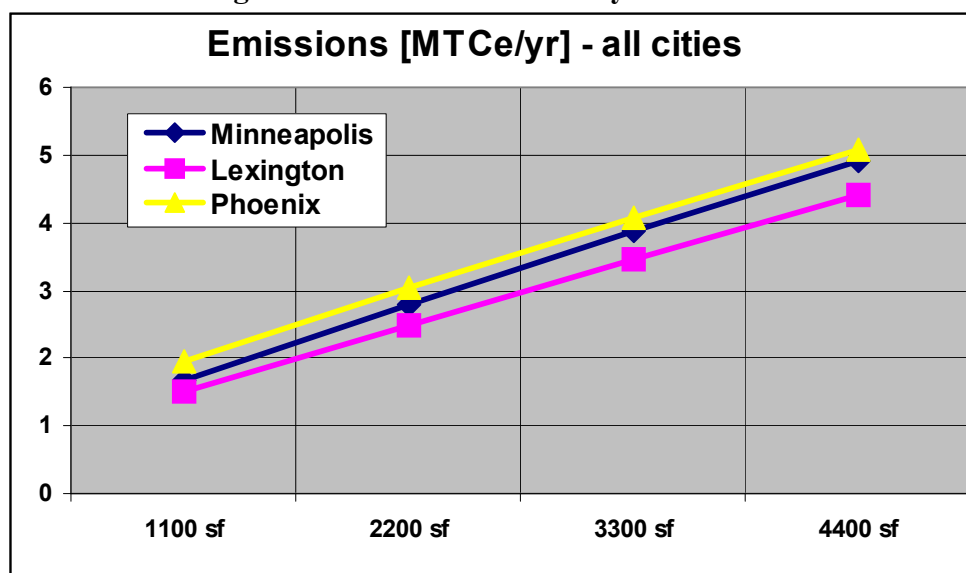
Very large ENERGY STAR homes are a very visible phenomenon and EPA has come under criticism from some stakeholders for not restricting home size as part of ENERGY STAR certification. Up to now, EPA has not believed it would be able to convince homebuyers seeking large homes to switch to smaller homes. Thus, the first specifications for ENERGY STAR accepted the role of helping to facilitate an efficient consumer choice without trying to influence consumer choice as to size. EPA also pursued an initial strategy for ENERGY STAR qualified homes of establishing both a consumer preference for the label and a market transformation process for targeted technologies. The first ENERGY STAR for Homes specification released in 1995, targeted energy efficiency measures such as tight ducts, air-tight construction, high-

performance low-E windows, and more efficient equipment, none of which were common practice at the time.

While it's true that large homes can earn the ENERGY STAR label, the policy to not restrict size has avoided controversy with the home building industry and spurred the program's impressive growth. This growth has led to unprecedented market adoption of the targeted technologies and construction practices. The results with envelope improvements, for example, are significantly greater than simple increases in R-value. In a study by Advanced Energy Corporation in Phoenix, Arizona, empirical energy savings based on six years of billing data for a sample of 7,000 homes revealed that homes with improved thermal envelopes had twice the energy savings of homes constructed to old ENERGY STAR specifications before these thermal envelope improvements were required (Swanson, Blasnik & Calhoun 2005).

Now that ENERGY STAR for Homes has fully matured, approaching one million labeled homes by the end of 2008, EPA is considering adapting the program to reflect the changed market, including a size limitation for the next round of specifications. One of the obvious reasons for doing this is the magnitude of potential energy savings. The results from detailed energy simulations for a variety of house sizes and geographic locations shown in Figure 4 demonstrate potentially one metric ton of annual carbon emission savings with 25 to 35 % size reductions.

Figure 4. Carbon Emissions by House Size



Source: EPA internal Rem-Rate analyses

One of the initial considerations for imposing a sizing limitation with ENERGY STAR Qualified Homes is to use a simple metric such as total maximum square foot per house, per bedroom (e.g., if the limit were 900 square feet /bedroom a three bedroom house could be 2700 sq. ft.). The next specification change is anticipated when external forces make it necessary to ensure ENERGY STAR delivers on its 'brand' promise of substantially better performance than standard code. In addition to a size limitation, forthcoming ENERGY STAR specifications are likely to include the best next available technologies, many of which do not get considered in current HERS rating and code analyses as discussed earlier.

To prepare for forthcoming specification changes, EPA anticipates an aggressive set of analytical studies evaluating energy efficiency technologies and construction practices followed by a comprehensive vetting process with stakeholders. What is always critical with ENERGY STAR is that the final specification must deliver cost-effective savings along with same or better performance. This means detailed market analyses will also be required to determine infrastructure readiness including compatibility with the production home building process.

As with earlier stages of ENERGY STAR for Homes, part of this new phase will involve simply helping builders to build better. Adding square footage to a house tends to add energy consumption, but does not necessarily make a home more attractive, comfortable or valuable. A variety of proven design strategies (e.g., open layouts, built-in furniture, varying ceiling heights, indoor/outdoor visual linkages, quality trim details, etc.) can make a home feel 25 to 35 % larger¹².

Looking at this growth process for ENERGY STAR labeled homes, it is apparent that energy efficiency programs often have a long-term strategy that must be considered. ENERGY STAR for Homes was driven to first establish a strong business proposition for the nation's home builders and to transform the market to targeted bundles of technologies and construction practices. With this success, broader goals for energy efficiency that address conservation principles as well can now be effectively leveraged, including size. This same proven track record is also leveraging other EPA builder initiatives including a complementary program for indoor air quality that helps to ensure homes are comprehensively equipped with effective measures that can improve the health and comfort of occupants.

Consumer Products and Energy Consumption

A range of factors drives the energy consumption of lighting, appliances, residential HVAC equipment, electronics, and other energy-using consumer products and different factors are important for different products. However, the way consumers choose and use these products always plays a key role in their energy consumption.

Energy efficiency programs are usually keyed to a product's design specification, with ENERGY STAR commonly setting the bar for incentive eligibility. Programs promote products that meet the efficiency specification and claim savings relative to the average efficiency of the products that the market would have provided without the program intervention. This approach is pretty good at lowering energy consumption when consumers use a product in regular, inflexible, and largely automatic ways. HVAC equipment may be the best example of a consumer product where energy consumption can be reduced by convincing the customer to buy a model with a more efficient design specification. Consumers can influence energy consumption by the choice of interior temperature, but in the same building and with the same climate, more efficient HVAC equipment will usually reduce energy consumption.

However, with most consumer products, the energy efficient design specification depends upon complimentary consumer behavior to yield lower energy consumption. Personal computers are a good example. The actual effect on energy consumption of choosing an ENERGY STAR qualified PC is highly dependent upon how the consumer uses the computer, what peripherals it is attached to, and the consumer's likelihood of disabling the default, energy-use-minimizing software the computer is shipped with.

¹² This is based on the personal experience of one of the authors with over 100 residential architectural projects. Additional excellent examples are provided in the "Not So Big House" book series by Sarah Susanka.

Perhaps the classic example of how consumer choices and uses can reduce the expected energy savings from efficiency improvements is refrigerators. Over the past 20 years there have been dramatic increases in refrigerator efficiency in terms of annual kWh consumed per cubic foot of cooled storage area. However, per household energy consumption due to residential refrigeration has not decreased dramatically overall due to trends such as the growth in average refrigerator size, in the number of refrigerators per household, and in the number of features (such as ice-making) that the average refrigerator offers (Barkenbus 2006). These trends occurred during a period when the number of people per household dropped and the frequency of restaurant visits per capita in the US increased. Both of these trends might have been expected to decrease the average size of refrigerators, the number of refrigerators per household, and household refrigeration energy consumption. Consumers chose otherwise.

Changing Consumer Choice and Use

Product efficiency program planners tend to assume they cannot change consumer choices and uses. Of course, the advertising industry has a much more ambitious approach to modifying consumer choice and use of products. One could argue that most of today's economy depends upon advertisers convincing consumers to choose and use products and services. Consumer product advertising campaigns are intended to sell products, but they can have significant impacts on energy consumption.

Energy consumption attributable to residential laundry in North America today is largely from water heaters for heating laundry water and clothes dryers for drying wet clothes. Clothes washers themselves have relatively low electricity consumption. Cold water laundry is currently common in North America (particularly in Quebec). This may be in part because in the 1960s and 70s, a major laundry detergent manufacturer introduced a product formulated for use in cold water and promoted the benefits of cold water laundry. However, by contrast in German-speaking countries, washing clothes in cold water is currently considered unhygienic and washing machines usually include an electric coil to heat wash water up to 90°C (194°F) at least for whites and linens. Recently, many washing machine manufacturers have introduced a similar high temperature “hygienic cycle” option on high-end machines in the North America market. Most of these models are also ENERGY STAR qualified.

The manufacturers of refrigerators and washing machines almost certainly are not intentionally increasing the energy consumption of their products. But energy consumption increases as manufacturers increase the value of products by adding energy consuming features. As described above under the labeling discussion, energy savings is losing the struggle for consumer attention to new product features and product size. However, there may be better ways to fight this battle.

Because some ENERGY STAR specifications are not stringent enough to meet all program providers' needs, some programs have adapted ENERGY STAR by setting higher efficiency levels for selected appliances.¹³ So far, this has usually involved simply strengthening the existing ENERGY STAR efficiency metric, such as only providing incentives for washers with Modified Energy Factor or MEF above 2.0, as opposed to the ENERGY STAR level of 1.72. “Save More with ENERGY STAR”, discussed above, recognizes this phenomenon.

¹³ This has been most common with clothes washers (VT, NY, OR, NJ) given the high market share for ENERGY STAR qualified models in some areas.

Another option for these programs might be to include a conservation element in the form of a maximum energy use limit in addition to the ENERGY STAR efficiency metric. Under the recently upgraded ENERGY STAR specification for refrigerators, the 773 currently qualified refrigerator models use an average (non-sales-weighted) of 470 kWh per year with the maximum at 680 kWh per year. However, if a program were to offer rebates on refrigerators rated at no more than 550 kWh per year, there would still be 520 models eligible for rebates at an average consumption of 412 kWh/year. Imposing this consumption limit would decrease the average size of eligible refrigerators from 18.6 to 16.8 ft³ and the maximum size of eligible models would drop from 30 to 26 ft³.

In summary, adding an absolute consumption limit of 550 kWh per year would save an additional average 12% of energy consumption and increase savings over the baseline from 48 to 106 kWh per year¹⁴ (again, non-sales weighted) compared to simply rebating all ENERGY STAR qualified models. The third of the ENERGY STAR qualified models with the highest consumption would no longer be eligible, but consumers would still have plenty of choices in all but the very biggest sizes. The consumption limit would also allow consumers eligible choices of all configurations and features. A consumption limit draws a line in the sand for manufacturers: future increases in size or added energy consuming features require increased efficiency in other areas in order to retain program eligibility.

In the same way that program providers can augment ENERGY STAR efficiency specifications with absolute energy consumption limits, they can also augment with other sources of product performance information. ENERGY STAR has been somewhat inconsistent when it comes to this area. ENERGY STAR specifications for most products deal only with the efficiency of energy use. However, the ENERGY STAR specifications for both CFLs and light fixtures include many components that have nothing to do with energy efficiency directly, but set levels for reliability and for light quality and output. These components of the spec help to ensure that ENERGY STAR qualified lighting products are acceptable substitutes for incandescent bulbs.

The ENERGY STAR specification for dishwashers currently sets no levels for washing effectiveness. Consumers who find that their ENERGY STAR dishwashers leave food on dishes will either start to pre-rinse them before loading or run them through a second dishwasher cycle, in both cases increasing energy consumption. Organizations like the Consumers Union perform regular testing of dishwashers for washing effectiveness and regularly find ENERGY STAR qualified models that do not do a very good job. There is no reason that an energy efficiency program should provide incentives for an ENERGY STAR qualified dishwasher that does not clean dishes well. In addition to saving energy, including product performance in program eligibility criteria helps protect the ENERGY STAR brand and the integrity of the energy efficiency program in the customer's eyes.

When Less Is More

Removing redundant second refrigerators is an obvious example of a conservation program activity that is already common, popular and effective. Such programs reduce the consumption of a service—the availability of cold storage area in the home—but program

¹⁴ Calculating the baseline for residential refrigerators is difficult, but using the maximum energy consumption mandated by federal minimum efficiency standards yields an average consumption of 518 kWh per year for the 773 models.

participants typically do not see this as a sacrifice. These programs are most successful with consumers who do not really need a second refrigerator, but the programs succeed by stressing the other benefits of removal like less wasted space and lower electricity bills. They also address the barriers of second refrigerator removal by eliminating hassle and cost.

Over the last few years television manufacturers have offered progressively larger and flatter screens for the consumer dollar. Consumers must often pay to dispose of old “tube” televisions, creating a disincentive to get rid of old sets. As a result, old TVs tend to accumulate and remain plugged in. In the same way that efficiency programs remove old refrigerators, they could also remove old televisions, or at least make it easier to dispose of them. Just as there are ancillary benefits from removing old refrigerators, removing old TVs, and possibly reducing television watching, may have benefits also. If there are, for example, studies showing improved school performance and reduced childhood obesity from reduced television watching, why not cite those studies when offering to reduce the cost and hassle of disposing of old TVs?

Energy efficiency program providers often have unique and effective channels to provide the public with information. Making sure that consumers are getting the full story about product energy and other performance is one way to help change consumer behavior. Many program providers provided the public with safety warnings about fires caused by halogen torchieres as part of the effort to replace them with more efficient alternatives. In cases of new features like the hygienic cycle on washing machines, why should program administrators be afraid to discuss the energy consumption implications if there is good data to support them? Information transfer does not have to be just about negative effects. Programs are currently experimenting with new consumer energy consumption feedback technologies such as Blue Line and The Energy Detective (TED). Early research suggests that providing quicker and more detailed electricity consumption information may lead to significant consumer conservation behavior. Program providers can also promote the most energy efficient products in each class, as Europe’s “Top Ten” initiative does¹⁵. Publicly funded energy efficiency programs have the ability to support these and other techniques to reach consumers and influence behavior in a way that conventional commercial product advertising does not.

Conclusion

There is a broader array of programmatic tools, some of them already tried and proven, which can be used to reduce energy consumption by promoting both efficiency and conservation. Energy efficiency program providers can continue to embrace ENERGY STAR and leverage its brand, while acknowledging and compensating for its limitations.

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¹⁵ <http://www.topten.info/>

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