Status and Future Directions of the ENERGY STAR Program

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ABSTRACT

In 1992 the U.S. Environmental Protection Agency (EPA) introduced ENERGY STAR®, a voluntary labeling program designed to identify and promote energy-efficient products, in order to reduce carbon dioxide emissions. Since then, the EPA, now in partnership with the U.S. Department of Energy (DOE), has expanded the program to cover nearly the entire buildings sector, spanning new homes, commercial buildings, residential heating and cooling equipment, major appliances, office equipment, commercial and residential lighting, and home electronics. This paper is based on our experience since 1993 in providing technical support to the ENERGY STAR program. We provide a snapshot of the ENERGY STAR program in the year 2000, including a general overview of the program, its accomplishments, and the possibilities for future development.

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1. The ENERGY STAR Labeling Program

This paper presents an overview of the ENERGY STAR® labeling program, operated jointly by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). These agencies sign agreements with program partners that allow the partners to promote products meeting certain energy-efficiency and performance criteria through use of the ENERGY STAR label. As the program is voluntary by design, partnerships are critical to the success of ENERGY STAR. EPA and DOE have focused their efforts in areas where efficiency improvements can be achieved cost-effectively, while offering the same or improved level of service (the ENERGY STAR label does not constitute an endorsement of the product by EPA or DOE). The mission of the ENERGY STAR program is to realize significant reductions in greenhouse gas emissions and energy consumption by promoting the purchase of energy efficient products and buildings. At its core, ENERGY STAR is an information and branding campaign, intended to make it easy for consumers to identify and purchase energy efficient products.[1] The goal of the program is to have widespread identification of the ENERGY STAR brand with the concepts of environmental protection and energy bill savings. The ENERGY STAR logo is illustrated in Figure 1. We have provided technical support to the ENERGY STAR program since 1993, and this paper is based on our experience in that role. This paper provides a snapshot of the ENERGY STAR program in the year 2000.

ENERGY STAR is an example of a market transformation program intended to cause long-lasting changes to markets for energy-consuming products, resulting in increased market

[1] The program also works with industries to seek out new opportunities where energy-efficient technologies are not available in the market, such as was the case for computers.

share for energy-efficient products. Market transformation programs evolved from traditional demand-side management programs (often referred to as resource acquisition programs), which focused on financial incentives to achieve immediate energy savings. Messenger [1] and Keating et al. [2] describe the evolution of market transformation programs and the differences between the two program types. In practice, the ENERGY STAR program has evolved into a hybrid of the two program types, with the Federal labeling effort still targeted at market transformation, combined with both market transformation and resource acquisition programs at the regional, state, and local levels.

The EPA launched the ENERGY STAR program in 1992 with the labeling of computers and monitors, followed by printers in 1993. The goal was to promote energy-saving features already common in laptop computers for use in desktop devices. In 1994, fax machines were introduced as an ENERGY STAR-labeled product category, and in 1995 copiers, transformers, residential heating and cooling equipment, thermostats, new homes, and commercial buildings were added to the labeling program. In 1996, DOE agreed to work jointly with EPA to promote energy efficient products using the ENERGY STAR logo. The DOE/EPA partnership was an important step in developing and expanding ENERGY STAR, because of DOE's depth of experience in developing and promoting energy efficient technologies. DOE introduced ENERGY STAR labels for refrigerators, room air conditioners and dishwashers. That same year marked the introduction of exit signs and insulation as labeled product categories. Scanners, multi-function devices and residential lighting fixtures were added to EPA's labeled products in 1997, followed by TVs and VCRs in 1998, and consumer audio and DVD players in 1999. DOE introduced an ENERGY STAR label for clothes washers in 1997, windows in 1998 and screw-in compact fluorescent lamps in 1999. The ENERGY STAR

label now covers over 30 consumer product categories [3]. EPA and DOE continue to research products and industries in search of new program opportunities, as well as update the program specifications for existing products as needed. Factors evaluated include the potential for improvements in unit energy savings, the size of the stock, turnover rates, the receptiveness of the industry, and the visibility of the product with consumers.

Compared to the annual energy consumption of standard new equipment, typical ENERGY STAR-labeled products can save the following percentage (depending on product type): office equipment, 30-70%; consumer electronics, 20-40%; residential heating and cooling equipment, 10-30%; residential and commercial lighting fixtures, 70-90%; and appliances, 10-50% [4].

EPA and DOE undertake many different types of program activities to promote ENERGY STAR products. These efforts are tailored to the particular markets for each product, and can include any of the following: 1) management and promotion of the overall ENERGY STAR brand; 2) setting and updating efficiency specifications for specific products, in conjunction with market players; 3) collaboration with other national, regional, state, and local energy efficiency programs; 4) contractor and builder sales training; 5) issuing building labels for energy efficient homes and commercial buildings; 6) developing and disseminating information about energy efficient products for consumers and product end-users; 7) working with retailers and distributors in the product distribution chain to promote energy-efficient products; 8) arranging preferred financing for ENERGY STAR-compliant products; and 9) developing software tools to help purchasers understand the benefits of ENERGY STAR-

compliant products. EPA and DOE activities to promote ENERGY STAR evolve over time as markets change and they gain experience in promoting ENERGY STAR[2].

2. ENERGY STAR Accomplishments and Challenges

The ENERGY STAR program has met with considerable success since its inception. In 1999 alone, for instance, Americans purchased more than 100 million ENERGY STAR-compliant products [6], representing approximately 20% market share for compliant products. We review selected accomplishments here, and illustrate instances where the program has needed to respond to changing market conditions.

Office equipment. ENERGY STAR has achieved the greatest market penetration in the office equipment market. Within a few years of the program launch, these labeled products soon dominated the market, largely due to President Clinton issuing Executive Order 12845 requiring that microcomputers, monitors and printers purchased by federal agencies be ENERGY STAR-compliant[3]. The sheer size of the federal market pushed manufacturers to participate in the program, and it was relatively easy for consumers to purchase ENERGY STAR-compliant products at the same price as standard products. Now we estimate that 95%

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[2] For up-to-date information about ENERGY STAR, see the program web site at www.energystar.gov. Wilson [5] summarizes the program's history.

[3] In 1999, Executive Order 13123 expanded the ENERGY STAR purchasing directive to all ENERGY STAR-labeled products.

of monitors, 80% of computers and 99% of printers sold are ENERGY STAR-compliant. Despite this success, energy savings cannot be achieved if the ENERGY STAR features are not properly activated by the end user. We assume that not all of the ENERGY STAR-compliant office products currently in operation are properly enabled and saving energy. The estimated enabling rate varies by product, from a low of 35% for PCs to 100% for fax machines. As power management controls improve over time, we assume that enabling rates will increase. Energy savings due to ENERGY STAR features are also affected by whether office equipment is manually turned-off at night. We have conducted office-equipment field audits to determine typical nighttime equipment turn-off rates in office buildings, and found that about 2/3 of computers and monitors are left on at night [7]. The ENERGY STAR program has recognized the challenge of getting end-users to enable power management in their office equipment. They have implemented several strategies to improve enabling rates, but additional effort will be needed to address this important issue.

Residential Heating and Cooling Equipment. Certain heating and cooling products have gained significant market share. ENERGY STAR-compliant models now comprise more than 30% of gas furnace sales and more than 20% of central air conditioner sales. Initially, the program focused its efforts on equipment manufacturers to ensure that ENERGY STAR-compliant products were available in the market. More recently, however, EPA has adjusted its program focus to the training of heating and cooling contractors to better sell energy-efficient products, because market research indicated that contractors are the key agent influencing the purchase decision . The program is being greatly assisted by state and utility

programs that are promoting ENERGY STAR-compliant heating and cooling products through information, training, and financial incentives.

New Homes. As of January 2000, over 14,000 homes have been built to meet the ENERGY STAR guidelines [8], exceeding the program goals for number of participating homes. This number is expected to nearly double by the end of 2000. The ultimate goal of the program is to have a substantial portion of the new homes built in this country meet the ENERGY STAR guidelines, which will require greater participation from large production builders. To achieve this goal, the focus is now on simplifying the program to make it easier and less costly for builders to participate, and increasing consumer awareness of the ENERGY STAR brand in the new home market [9].

Commercial Buildings. In 1998, EPA merged the Green Lights program, which had been promoting energy efficient lighting in commercial buildings since 1991, into the ENERGY STAR Buildings and Green Lights Partnership. In 1999, EPA developed a new performance rating system for commercial buildings that allows the most efficient office buildings to earn the ENERGY STAR label [10]. More than 100 office buildings were awarded the ENERGY STAR label in 1999. As of 2000, the label is available for schools as well. Currently, the ENERGY STAR program is focusing on increasing awareness of the label in the commercial building market, extending the performance rating system to cover additional building types, and working on innovative ways to promote the label, such as measurement and verification criteria for a standard offer.

Major Appliances. The ENERGY STAR program has had some notable successes in the appliance market. ENERGY STAR-compliant clothes washers have exceeded their sales goals by approximately 100%. Sears sold 750,000 ENERGY STAR-compliant appliances in 1999, and expects to sell at least 1 million units in 2000 [11]. The program focuses on working with the regional market transformation collaboratives (described below), while also recruiting and supporting retail program partners. DOE has proposed higher efficiency ENERGY STAR specifications for refrigerators and room air conditioners to take effect when revised Federal efficiency standards become effective in 2000 and 2001, respectively.

Home Electronics. For home electronics, ENERGY STAR focuses on reducing the power consumption of devices when they are not actively in use. Manufacturing partners have actively supported this program, leading to over one thousand ENERGY STAR-compliant TV, VCR, audio, and DVD models on the market. The high visibility of these products with consumers has also greatly aided the promotion efforts for the ENERGY STAR brand. Current program activities in this market include working with retail partners to promote these products, revising the specification for TVs and VCRs (in collaboration with the manufacturing partners) to modify the allowable standby power levels, and expanding the program to include standby-power specifications for set-top boxes.

Windows. The ENERGY STAR windows market share has rapidly increased in certain regions of the country. In the Pacific Northwest, programs run by the Northwest Energy Efficiency Alliance (NEEA) and utilities have increased the market share of energy-efficient residential windows from an estimated 10%-15% in 1997 to 44% in 1999. NEEA projects

ENERGY STAR market share of nearly 60% by the end of 2000 [12]. In other areas where the market for efficient windows is less developed, such as Florida, ENERGY STAR windows are gaining market share more slowly. The ENERGY STAR program is working with the Efficient Windows Collaborative[4] to promote efficient windows in these areas.

Residential and Commercial Lighting. Energy efficient residential light fixtures, commercial exit signs, and screw-in compact fluorescent lamps are all eligible for the ENERGY STAR label. In 1999, nearly 7 million ENERGY STAR-labeled residential fixtures were sold, exceeding the program goals. Likewise, ENERGY STAR-labeled exit signs now comprise about 80% of exit sign sales, and are expected to continue gaining market share.

Other Commercial-Sector Products. Commercial, industrial, and utility distribution transformers, as well as "cool" (high reflectivity) roofing materials are also eligible for the ENERGY STAR label. The ENERGY STAR program has had mixed success in promoting these products. In the case of transformers, restructuring of the utility industry has made it difficult to interest utility partners in purchasing more efficient products, but efficient commercial and industrial transformers have seen considerable market share increase. This success has largely been due to a product standard in Massachusetts and a building code in Minnesota requiring ENERGY STAR-compliant transformers. For commercial roofing, there have been some successful field trials of ENERGY STAR products, but most roofing specifiers and contractors are not aware of these products or do not see that the benefits outweigh the costs

[4] A collaborative effort of DOE, the Alliance to Save Energy, and the window industry.

of using an unfamiliar product [13]. EPA is developing information, software tools, and other strategies to address this situation.

Institutional Purchasing. For several years, EPA has been working with the Federal Energy Management Program (FEMP), the General Services Administration (GSA), state and local governments, and other large purchasers to include ENERGY STAR in purchasing specifications [14]. FEMP undertook several initiatives that make it easier for Federal purchasing agents to choose ENERGY STAR, such as identifying ENERGY STAR-compliant products in the GSA catalogs and producing materials to explain the benefits of energy efficient products to purchasers. FEMP is also working with the ENERGY STAR program to label additional products that are commonly purchased in the institutional sector.

International Agreements. Over the last several years EPA has licensed the ENERGY STAR trademark to several countries, including Japan, New Zealand, Australia, Taiwan, and the European Union. These agreements have been limited to the labeling of office equipment[5]. In addition, EPA maintains ongoing discussions with other countries that may adopt elements of the ENERGY STAR program. These international agreements are driven largely by the fact that many products promoted by ENERGY STAR are sold in global markets and manufactured by global corporations, thus a multinational program is the most effective

[5] Since this paper was originally accepted, EPA has signed a licensing agreement with the Canadian government giving them the right to label all products meeting the ENERGY STAR specifications that are sold in Canada. This represents a significant expansion of the licensing program beyond just office equipment.

approach. On the other hand, licensing the ENERGY STAR trademark requires that EPA expend resources to monitor and protect the use of its trademark in other countries. In the future, the biggest uncertainty about international licensing will be how much influence the licensees may have on the management of the ENERGY STAR program, and whether they will be allowed to apply the ENERGY STAR label to products not labeled in the U.S. (for example, mini-split air conditioners in east Asia).

3. ENERGY STAR Partnerships

The goals of the ENERGY STAR program are ambitious. Ultimately, EPA and DOE hope to change the standard way that energy-consuming equipment is purchased and buildings are built, operated, and renovated in this country. This far-reaching goal cannot be achieved simply through the actions of two Federal agencies, but rather requires the assistance and participation of market players and policy makers throughout the country. From its inception, the ENERGY STAR program has worked closely with partners such as manufacturers, homebuilders, building owners, and building contractors to help implement the program and carry the ENERGY STAR message. Increasingly, however, the program has enlisted additional allies to help market the brand and achieve its energy and pollution goals. It is helpful to think of this alliance as a national program “platform” or "infrastructure" that integrates and leverages other national, regional and local efforts. In this view, the foundation is the Federal ENERGY STAR program, providing the ENERGY STAR brand, performance specifications, assessment tools, and consumer awareness efforts. On top of this foundation, the program partners can build highly effective programs that focus on

specific markets or geographic areas. This collaborative method of program implementation requires more effort (compared to a program that only involved EPA or DOE efforts) at both the national and local level to ensure consistency and coordination in all marketing efforts, but offers the promise of more widespread and long-lasting transformation of markets.

With the evolving use of the ENERGY STAR brand, EPA and DOE have conducted a brand audit to identify the strengths and weaknesses of the brand and develop a strategy to increase the brand's effectiveness. The audit involved market research to determine how the brand is perceived by consumers. This has also provided a foundation for a planning process within the ENERGY STAR program to determine the future brand strategy. The brand audit found 30% awareness of the ENERGY STAR brand (without visual prompting), but low understanding about what the brand actually means [15]. The brand audit also found a high rate of claimed influence on purchases, among those who recognized the brand, and a high degree of knowledge about the brand among program allies. The area of concern revealed by the audit was a low awareness of the brand among the media. In summary, the audit found no major inconsistencies in the message being publicized in the various markets, and the ENERGY STAR branding efforts are generally on track. The challenge facing the program is to make the brand understandable and relevant to consumers, and improve the media's awareness and perception of the brand.

In light of these findings, EPA and DOE are updating their brand strategy. The preliminary results from this process include the following goals. In the next one to two years, the goals for the brand are: 1) to have consistency in the brand message publicized by EPA, DOE, and program partners, 2) develop a standard for consistent graphical display of the ENERGY STAR logo to use in its communications, and 3) to increase consumer awareness

and relevance by five to ten percentage points. In the longer term, the goal is for greater consistency among all the program partners so that ENERGY STAR appears to be one, unified campaign, and one brand is used in all product markets.

4. Synergy With Other Partnerships and Programs

Given a confluence of factors, such as electricity restructuring and a general shift to market transformation programs, the ENERGY STAR program has the opportunity for more partnerships to reach consumers directly. Some of these partnerships are formal agreements, in which EPA, DOE, and other institutions directly coordinate their programs. In other cases, the "partnership" is implicit, and the only interaction happens in the marketplace. In this way, ENERGY STAR can be seen as part of a broad array of methods for market transformation, which are most effective in combination. Table 1 reviews the various energy efficiency partnerships and programs that interact with ENERGY STAR and the mutual benefits they bring to and derive from the program.

Foremost among these partnerships are the regional market transformation collaboratives that have been formed to administer the energy-efficiency public benefits charges authorized as part of many states' electricity market restructuring. These collaboratives exist in California, the Pacific Northwest, the Northeast, and recently one has been formed in the Midwest[6]. In fact, EPA provided seed funding to start the Northeast Energy Efficiency

[6] We include in the category of regional collaboratives the work of the Consortium for Energy Efficiency (CEE) and independent utilities that are not members of the regional collaboratives. Originally founded in 1994

Partnership [16], and DOE has provided support for the new Midwest collaborative. In total, these collaboratives spend hundreds of millions of dollars on energy efficiency each year, a significant portion of which is being used to promote and subsidize the purchase of ENERGY STAR products (in addition to energy-efficient products not bearing the ENERGY STAR label). This partnership between the Federal government and the regional organizations is particularly complementary because the regional groups can employ program mechanisms (such as rebates) that are not available to the Federal government. Moreover, the majority of purchase decisions regarding energy-using equipment are made locally, and local institutions (such as utilities, governments, non-profits, etc.) are most appropriately placed to influence these decisions. The Federal government brings to this partnership a national brand that amplifies the effectiveness of local and regional programs, as well as an array of marketing materials, and an active "platform" upon which to build their programs.

ENERGY STAR also has a strong relationship with several other Federal energy programs. Technology research, development, and demonstration (RD&D) programs (such as DOE's Building America) provide a steady stream of demonstrated energy-efficiency technologies, thus expanding the choice and driving down the price of ENERGY STAR products. On the other end of the market diffusion curve, the Federal appliance standards program serves as a reference efficiency level for some ENERGY STAR products, thus simplifying the development of ENERGY STAR specifications. Also, while it is not a stated goal of the ENERGY STAR program, we believe that several of the recently announced Federal standard updates (such as

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to coordinate DSM programs among member utilities, CEE now plays a leading role in coordinating market tranformation programs among the regional collaboratives and utilities.

clothes washers) have been facilitated by the existence of an ENERGY STAR specification for those products.

Finally, we note the potential for a mutually supportive relationship between the Federal ENERGY STAR program and national, state, and local building codes. Thus far, this relationship has been limited to the ENERGY STAR new homes guidelines using the national Model Energy Code as a reference baseline for rating the energy efficiency of new homes. In the future, it is possible that building codes could simplify some prescriptive requirements by requiring ENERGY STAR-compliant products, while code compliance would be improved for buildings receiving the ENERGY STAR label.

5. Program Evaluation

The ENERGY STAR program has been in place long enough to warrant evaluation for several of the product categories. Formal evaluations are being planned or conducted for office equipment, residential heating and cooling equipment, new homes, and a retrospective evaluation of the Green Lights program. In addition, DOE collects sales tracking data from the retail partners on an ongoing basis, allowing measurement of market share impacts for appliances and other retail products. The evaluation studies will be used to verify savings claims, improve the accuracy of future savings estimates, and improve program design.

In general, the program evaluations are focusing on market impacts of the ENERGY STAR program rather than energy savings impacts. Market impacts are measured either through direct market effects (e.g., market share data collected from partners) or proximal measures (e.g., partner perceptions of the program or stated purchasing behavior). For those products

that could have widely varying regional energy savings, such as new homes or heating and cooling equipment, the ENERGY STAR program is contemplating more rigorous measurement of energy savings impacts. In the case of office equipment, field measurements of operating patterns, enabling rates, and power levels in various operating modes will be conducted.

In addition to the EPA and DOE evaluations, the regional collaboratives are evaluating many of their programs that promote ENERGY STAR. Because the collaboratives and utilities are spending public benefits funds to promote ENERGY STAR, they usually must quantify the impact of the program to justify the expenditures to state regulatory and legislative bodies. EPA and DOE will draw on these regional evaluations to assist in their own evaluation process. In addition, EPA and CEE have made an effort to coordinate these regional and national evaluation efforts, in order to reduce costs and maximize effectiveness.

6. Energy and Pollution Impact Estimates

To understand the aggregate effect of the ENERGY STAR Program, we estimate energy and pollution impacts for the period from 1993 to 2010. These impact estimates (both past and future) are based on engineering models, using inputs derived from empirical studies wherever possible (such as office-equipment power levels from metering studies). The impact estimates are not based on systematic evaluation studies involving field metering of energy consumption or comparison to control groups. The stock of in-place ENERGY STAR-qualifying units is derived from shipment data provided by trade organizations, manufacturers, and retailers. Webber, Brown, and Koomey [4] provide more details about the analysis methodology.

Since 1993, when ENERGY STAR-labeled computers, monitors and printers became available, we estimate that the program has saved 1.5 exajoules (cumulative) through 2000, resulting in an energy bill savings of $10 billion and carbon emissions reduction of 26 million metric tonnes[7]. These savings represent about 0.5% of total building-sector carbon emissions over the 1993-2000 period [17]. Figure 2 shows the primary energy savings achieved since 1993, broken down by major product category. Figure 3 shows that over 80% of these savings are attributable to ENERGY STAR office equipment, since those products were among the first launched and have been very successful in gaining market share. Office equipment products also have relatively short economic lifetimes (we assume four years for computers, monitors and fax machines, five years for printers and six years for copiers), which means that most of the units in the stock have been purchased since the launch of the program.

We also project ENERGY STAR Program savings for the period 2001 to 2010. Our forecast is based on EPA's and DOE's market penetration goals. We use year-by-year forecasts of energy prices and carbon emission factors to calculate energy bill savings and carbon emissions reductions. This forecast represents the best estimate of the long-term aggregate savings achievable by ENERGY STAR programs given the market penetration goals and unit energy savings estimates of the individual programs.

We project that annual primary energy savings will grow from 0.5 exajoules in 2001 to 1.6 exajoules in 2010 (see Table 2). Carbon emissions are reduced by 20 million metric

[7] Note that these savings estimates include only labeled products and residential buildings, excluding ENERGY STAR-labeled commercial buildings [4].

tonnes in 2010 alone. The cumulative primary energy saving for the 2001-2010 period is 11 exajoules–equivalent to $70 billion (undiscounted) in energy savings and representing a decrease in carbon emissions of 150 million metric tonnes for the period. This represents about 4% of total carbon emissions for the residential and commercial sectors over the same period.[8] Figure 2 shows cumulative savings from 2001 to 2010, broken down by major product category. Office equipment accounts for almost 50% of cumulative future savings, reflecting the growing savings impact of other labeled products (Figure 3). Keep in mind that these savings estimates are derived from engineering models, rather than empirical evaluation studies, and are therefore subject to significant uncertainty. While we have not formally assessed the uncertainty in our estimates of achieved savings, a simple scenario analysis of future savings showed that varying just two factors (ENERGY STAR market penetration and electricity carbon-emission factor) over a plausible range leads to approximately +/-30% variation in carbon emission savings [4].

7. Future developments

The ENERGY STAR program will evolve over time as markets change and EPA and DOE expand the reach of the program. Here we speculate on how the program could evolve, but keep in mind that this does not necessarily represent EPA's or DOE's views.

EPA and DOE continue to explore additional products for labeling, in order to expand the scope of the ENERGY STAR program. In general, products are selected based on their

[8] Total residential and commercial carbon emissions for 2000, 2005, and 2010 were obtained from US DOE

potential for significant energy savings, the receptiveness of the industry, the potential for collaboration with other partners, and the visibility of the product with consumers [20]. As of summer 2000, EPA is working on finalizing ENERGY STAR specifications for set-top boxes, ventilation fans, water coolers, and traffic signals. Additional specifications are expected by the end of 2001 for commercial reach-in refrigerators, ceiling fans, residential dehumidifiers, commercial unitary HVAC equipment, industrial motors, and wall-pack transformers. Although extension of the brand appears to be an easy way to achieve additional energy savings, this desire needs to be balanced with the reality of EPA and DOE's ability to administer the programs effectively given limited staffing, and the need to keep the brand focused on products that perform well and deliver significant savings. Additionally, some have argued over the years that ENERGY STAR should become a broader environmental label to promote, for instance, "green" power [21]. In the foreseeable future, however, EPA and DOE plan to keep the program focused on energy efficiency. This focus maintains the integrity of the brand in the consumer's mind, and is also consistent with the enabling legislation (1990 Clean Air Act Amendments) under which the program operates.

From its inception, ENERGY STAR has been known best for labeling products. However, this approach ignores the need to address buildings as systems, rather than simply components, in order to maximize energy savings and other benefits from energy efficiency upgrades. For ENERGY STAR, this requires "integrating" strategies that encourage building owners to systematically upgrade their buildings rather than taking a piecemeal approach. The ENERGY STAR Buildings program was designed this way from the start, and its use of a

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[18, 19]. Carbon emissions for 2001-2004 and 2006-2009 were estimated using linear interpolation.

whole-building benchmarking tool gives building owners an incentive to meet the criteria in the most cost-effective way, usually requiring an analysis of the building as a system. Likewise on the residential side, for New Homes the ENERGY STAR label is awarded based on reductions in consumption for several end uses. In the home improvement market, EPA is developing an ENERGY STAR Home Improvement Program that will encourage homeowners to take a systematic approach to upgrading their home's energy efficiency. The program will involve many strategies, including a consumer web site providing customized recommendations about what upgrades make sense in a given house. EPA is exploring various options for setting labeling criteria for existing homes, including a whole-house benchmarking tool similar to that for commercial buildings, but the program design has not been finalized. All of these integrating programs face several hurdles to overcome. First, there is a lack of market infrastructure for whole-building upgrades. The field of building science is still in its infancy, with much of the expertise concentrated in a few research centers around the country. In order for whole-building design and retrofits to become more common, there must be a network of trained (and possibly certified) individuals throughout the country–a task that will take years to achieve. Second, building owners tend to focus on component upgrades as a sufficient solution to making a building more energy efficient. This is partly due to the fact that existing buildings are usually replaced one component at a time (e.g., when a particular component fails), and partly due to a lack of understanding on the part of building owners about how individual building components affect overall building performance. Finally, building owners often do not believe that the promised benefits (energy and non-energy) will be realized from whole-building upgrades. These all represent formidable challenges for ENERGY STAR, because they require not just changing consumer

preferences in an existing market but, in a sense, creating an entirely new market for a product (whole-building energy performance) that has not existed until recently.

Another "integration" strategy that ENERGY STAR may pursue in the future is cross-marketing packages of individual products. For instance, an "ENERGY STAR kitchen" campaign would jointly promote the ENERGY STAR-labeled products found in kitchens. The New York State Energy Research and Development Agency (NYSERDA) has developed and is piloting a program to do just this. A cross-marketing program has the potential to increase sales of ENERGY STAR products because product purchases tend to happen in clusters at important points in a building's life-cycle, such as initial occupation, a change in ownership, or renovation. Purchasers may be amenable to selecting multiple ENERGY STAR-labeled products at one time, although this concept needs to be verified through market testing.

Another example of extending the ENERGY STAR brand beyond just products is the idea of labeling services, such as heating and cooling duct sealing. As a component of its ENERGY STAR Home Improvement Program, EPA has developed a specification for energy efficient ducts. This program is different from other labeled products in that ducts are a house component that are site-assembled and exhibit great variation in energy performance from house to house. Thus, an effective specification must include on-site duct performance testing. This differs significantly from the other ENERGY STAR product specifications, which are usually based on laboratory testing protocols applied to manufactured products. EPA will pilot test the ENERGY STAR duct label in late 2000. Additional services, such as building air sealing, may be considered for future labeling.

In the past, the aggregate cost-effectiveness of the ENERGY STAR program has not been an important criterion for evaluating program effectiveness. This is due to the voluntary nature

of the program, which tends to attract program participants that self-select for cost-effectiveness, and the fact that many ENERGY STAR-labeled products (such as office equipment) have no cost premium over standard new products. In the future, the program will be looking more closely at cost-effectiveness, both for use in product marketing and to assess program effectiveness.

An important challenge for the ENERGY STAR program is to develop a conceptual framework to evaluate the effectiveness of its activities. Given the wide scope of the program, the cost of assessing national program impacts for all products using traditional program evaluation methods would be prohibitive. On the other hand, information about program effectiveness is needed to justify continued program expenditures and to help the program evolve. Given these competing demands, a prudent evaluation strategy should focus first on the products with bigger estimated impact (e.g., office equipment). By conducting an uncertainty analysis of the estimated program impacts, it is also possible to identify those factors that most strongly affect the program's impact (such as office equipment enabling rates), and focus more effort on measuring those factors.

The ENERGY STAR program is critically dependent on partnerships and alliances for its success, because in practice ENERGY STAR has become an amalgam of Federal, regional, state, and local programs. Coordination with these program partners is essential for both the implementation and evaluation of the ENERGY STAR program. This coordination requires greater planning than that required for a program implemented by a single agency, but also brings additional resources (including funding, social networks, and information) that would otherwise not be available to a Federal program.

8. Summary

Since 1992, ENERGY STAR has grown from a program focusing on personal computers to a multinational program promoting over 30 products across commercial and residential markets, with thousands of program partners. Over this time, ENERGY STAR has become a brand recognized by a significant number of consumers, as well as a collaborative effort that is uniting a variety of separate market transformation programs. The success of ENERGY STAR thus far is due in equal part to the vision and guidance of EPA and DOE, and the hard work of the program partners–manufacturers, retailers, contractors, builders, building owners, utilities, and industry allies. In the future, EPA and DOE hope to increase the program's energy savings by increasing the strength of the brand, labeling new products, and improving the program mechanisms and alliances. If our forecasts are borne out, the ENERGY STAR program could save about 4% of building-sector carbon emissions by the year 2010.

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Figure Captions

Figure 1. The ENERGY STAR logo.

Figure 2. Cumulative primary energy savings (exajoules) for ENERGY STAR target market penetration.

Figure 3. Percent of cumulative primary energy savings for ENERGY STAR target market penetration, by product category.

Tables

Table 1. Synergistic Relationship Between ENERGY STAR and Other Energy-Efficiency Partnerships and Programs.

Program	Advantages Provided to ENERGY STAR	Advantages for Other Program
Regional market transformation collaboratives and utility programs	Promote ENERGY STAR in the marketplace with marketing, training, and rebates	National brand-marketing campaign; consistent program efficiency specifications
Federal Energy Management Program	Instrumental in getting Executive Orders promoting ENERGY STAR; Working to integrate ENERGY STAR into federal purchasing system	Eases process of setting purchasing specifications; provides identifiable brand in Federal purchasing market
Federal energy RD&D programs	Demonstrate technologies that cost-effectively meet ENERGY STAR guidelines (larger pool of ENERGY STAR -compliant products and processes)	Provides path for market adoption of technologies beyond the demonstration phase
Federal appliance standards	Standard test procedures; reference efficiency levels for some ENERGY STAR products	Initial market experience with energy-efficient products and technologies
Building codes	Prescriptive codes could specify ENERGY STAR levels for some building components; Model Energy Code provides baseline for ENERGY STAR homes	Near 100% code compliance for ENERGY STAR homes and buildings; referencing ENERGY STAR simplifies code writing

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Table 2. Annual savings due to ENERGY STAR programs[a,b].

Type of Savings	Units	1995	2000	2005	2010
Primary Energy	exajoules	0.0	0.5	1.0	1.6
Retail Energy Bills[c]	billion 1998$	0.2	3.1	6	11
Carbon	MtC	0.6	9	13	20

Notes to Table 2:

[a] Values are derived from calculations documented in Webber et al. [4].

[b] These savings estimates do not include the ENERGY STAR buildings program.

[c] Energy bill savings are undiscounted.

Table 3. Cumulative savings due to ENERGY STAR programs[a,b].

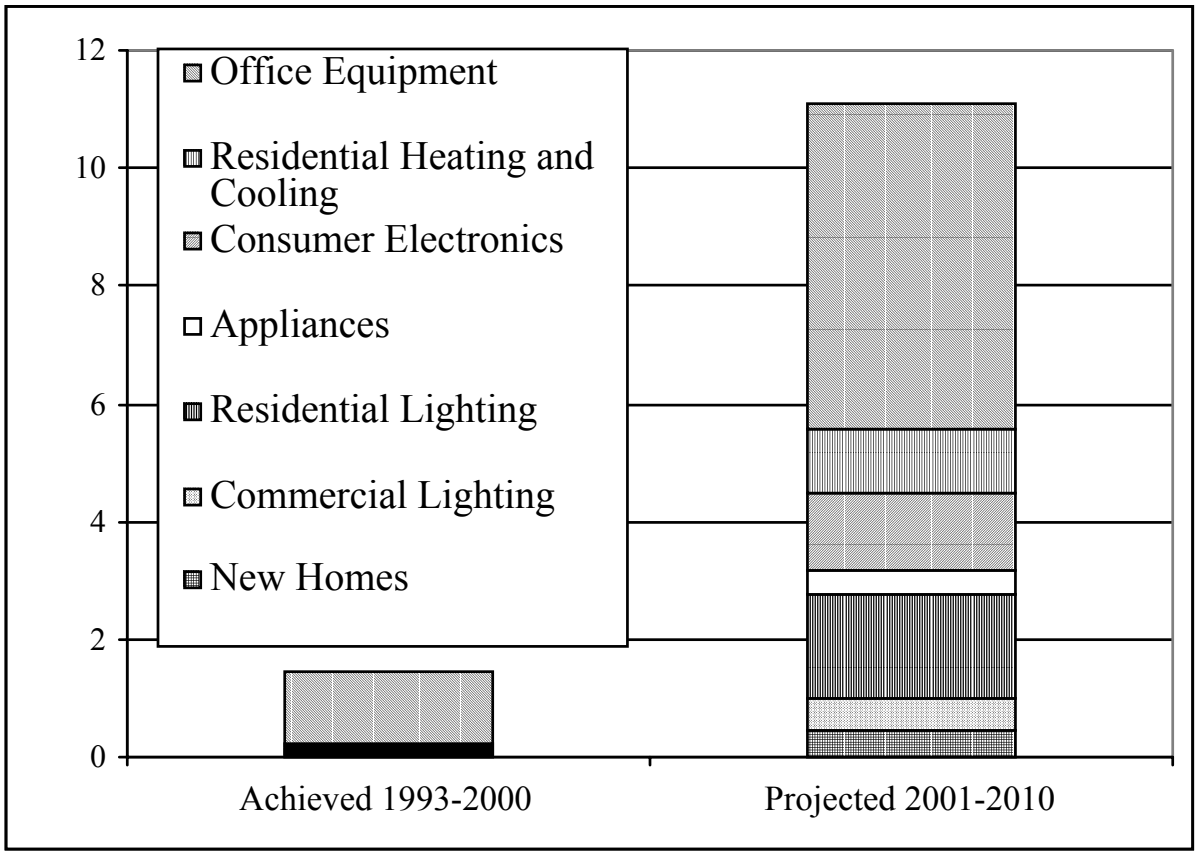
Type of Savings	Units	1993-2000	2001-2010
Primary Energy	exajoules	1.5	11
Retail Energy Bills[c]	billion 1998$	10	70
Carbon	MtC	26	150

Notes to Table 3:

[a] Values are derived from calculations documented in Webber et al. [4].

[b] These savings estimates do not include the ENERGY STAR buildings program.

[c] Energy bill savings are undiscounted.


12
10
8
6
4
2
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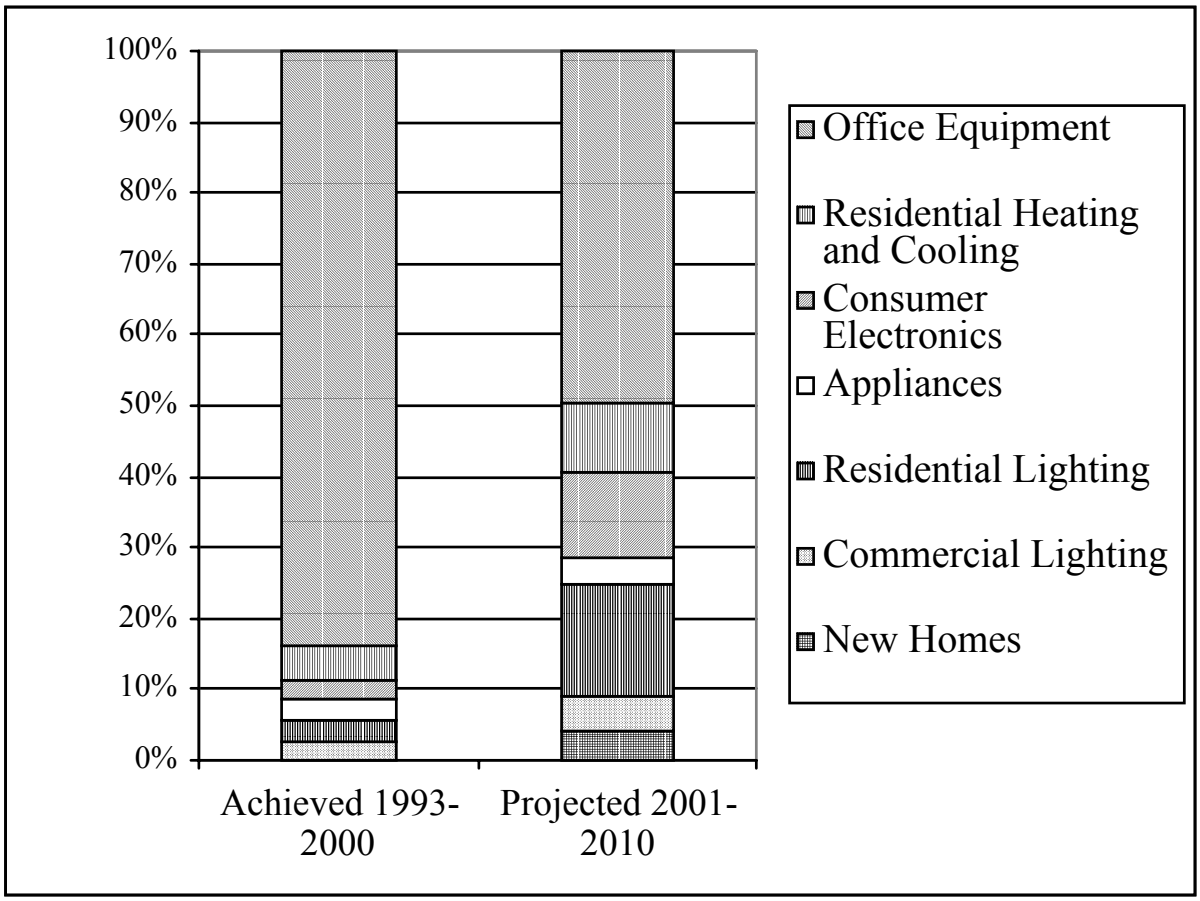
Office Equipment
Residential Heating and Cooling
Consumer Electronics
Appliances
Residential Lighting
Commercial Lighting
New Homes
Achieved 1993-2000
Projected 2001-2010


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Achieved 1993-2000
Projected 2001-2010
Office Equipment
Residential Heating and Cooling
Consumer Electronics
Appliances
Residential Lighting
Commercial Lighting
New Homes