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Savings Estimates for the ENERGY STAR® Voluntary Labeling Program

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ABSTRACT

ENERGY STAR® is a voluntary labeling program designed to identify and promote energy-efficient products, buildings and practices. Operated jointly by the Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE), ENERGY STAR labels exist for more than thirty products, spanning office equipment, residential heating and cooling equipment, commercial and residential lighting, home electronics, and major appliances. This report presents savings estimates for a subset of ENERGY STAR labeled products. We present estimates of the energy, dollar and carbon savings achieved by the program in the year 2006, what we expect in 2007, and provide savings forecasts for two market penetration scenarios for the periods 2007 to 2015 and 2007 to 2025.

The target market penetration forecast represents our best estimate of future ENERGY STAR savings. It is based on realistic market penetration goals for each of the products. We also provide a forecast under the assumption of 100 percent market penetration; that is, we assume that all purchasers buy ENERGY STAR-compliant products instead of standard efficiency products throughout the analysis period.

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Introduction

This paper presents past and predicted savings for the ENERGY STAR® labeling program, a program operated jointly by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). Since 1992, the ENERGY STAR label has been used to promote high efficiency office equipment, heating and cooling equipment, appliances, lighting, windows, transformers, buildings, and commercial kitchen equipment, among other product areas. The ENERGY STAR program also encompasses a new homes program, a home improvement program, and a commercial buildings program. This analysis focuses only on labeled products. Table 1 shows EPA's product labels and related programs and indicates which are covered by this report.

Our forecast of future savings now extends through 2025. We include both a 100 percent market penetration case and a target market penetration case using the market share goals used by EPA and DOE. This report details the status of the model as implemented in the November 2006 spreadsheets.

The ENERGY STAR® Labeling Program

ENERGY STAR is a voluntary labeling program operated jointly by EPA and DOE. Those agencies enter into agreements with manufacturers that allow the manufacturers to promote products that meet certain energy-efficiency and performance criteria through use of the ENERGY STAR label. EPA and DOE have focused their efforts in areas where efficiency improvements can be achieved while offering the same or improved level of service. However, the ENERGY STAR label does not constitute an endorsement of the product by EPA or DOE.

The EPA launched the ENERGY STAR program in 1992 with computers and monitors. In 1993, the program was extended to include printers. The goal was to promote energy-saving features already common in laptop computers for use in desktop devices. These labeled products soon dominated the market, largely due to President Clinton's Executive Order 12845 in 1993, which required that microcomputers, monitors and printers purchased by federal agencies be ENERGY STAR-compliant. The sheer size of the federal market pushed manufacturers to participate in the program. In 1994, fax machines were added to the labeling program, followed by copiers, residential heating and air conditioning equipment, thermostats, and transformers in 1995.

In 1996, DOE agreed to work jointly with EPA to promote energy efficient products using the ENERGY STAR logo. Because energy efficiency involves both environmental protection and energy policy, the DOE/EPA partnership was an important step in developing and expanding ENERGY STAR.

Also in 1996, EPA introduced labels for exit signs, insulation and residential boilers. The following year, scanners, multi-function devices[1] and residential lighting fixtures were added to EPA's labeled products, and clothes washers were added to DOE's suite of products. In 1998 EPA introduced ENERGY STAR TVs and VCRs and DOE introduced an ENERGY STAR label for windows. EPA began

[1] The term multifunction device (in the context of office equipment) refers to a device that combines copying, printing, scanning and/or fax functions in a single device. Under the ENERGY STAR program the term refers to the subset of such devices that have multi-page copying as their primary function. Digital copiers that can be upgraded to have printing functions are also covered.

labeling ENERGY STAR consumer audio, DVD players, and roof products in 1999 while DOE took on screw-based compact fluorescent lamps. Water coolers and traffic signals were added to EPA's labeling program in 2000, followed by set-top boxes, dehumidifiers, ventilation fans, ceiling fans, and reach-in refrigerators and freezers in 2001 and telephony in 2002. In 2003, EPA introduced commercial fryers, commercial hot food holding cabinets, and commercial steam cookers. Refrigerated beverage vending machines and air cleaners were added to the program in 2004, and in 2005 external power supplies and battery charging systems.

Several of these products are not included in this analysis (see Table 1). Two labeled products were omitted because they have been dropped from the program: gas-fired heat pumps in 2000 (the product was no longer commercially available) and insulation in 2001 (insulation was incorporated in EPA's Home Improvement Program and was dropped as an individual product label). Windows have not yet been added to the analysis. The ENERGY STAR Homes, Buildings, and Home Improvement programs, while part of the ENERGY STAR family of programs, are separate from ENERGY STAR labeled products and are not addressed in this report.

Table 1. ENERGY STAR Products and Programs

Product	Start/End Yr.	Product	Start/End Yr.
Computers……..	1992	TVs…….……	1998
Monitors……..	1992	VCRs…….…….	1998
Printers……	1993	TV-VCRs……	1998
Fax machines……	1994	Audio Equipment……	1999
Copiers……	1995	DVD Players	1999
Air-Source Heat Pumps…….	1995	Roofs…….……..	1999
Geothermal Heat Pumps……	1995	CFLs…….……	1999[a]
Central Air Conditioning…….	1995	Traffic Signals……	2000
Gas Furnaces…….	1995	Bottled Water Coolers…….	2000
Oil Furnaces……	1995	Exhaust Fans…….……..	2001
Programmable Thermostats……	1995	Ceiling Fans……	2001
Transformers…….……	1995	Dehumidifiers……..	2001
Gas Boilers…….	1996	Commercial Refrigerators and Freezers	2001
Oil Boilers……..	1996	Set-top Boxes…….	2001-200X[b]
Exit Signs……	1996	Telephony……..	2002
Dishwashers……	1996[a]	Hot Food Holding Cabinets……	2003
Room Air Conditioners…….	1996 [a]	Commercial Steam Cookers……	2003
Residential Refrigerators…….……	1996 [a]	Commercial Fryers…….	2003
Clothes Washers…….……	1997 [a]	Cold Beverage Vending Machines…….	2004
Scanners……..	1997	Air Cleaners ……..	2004
MFDs…….	1997	External Power Adapters……	2005
Residential Lighting Fixtures……	1997	Battery Charging Systems …….	2005
Gas-Fired Heat Pumps……	1995-2000	Windows…….	1998[a]
Homes…….……	N	Buildings…….	N
Insulation…….	1996-2001	Home Improvement Program...…….	N

[a]DOE Product

[b]With the exception of digital television adapters, set-top boxes have been dropped from the Energy Star Program. Set-top boxes are included in the analysis, but except for digital television adapters, sales of Energy Star products are zero after 2004.

EPA and DOE continue to research products and industries in search of new program opportunities. Factors evaluated include the potential for improvements in unit energy savings, the size of the stock, turnover rates and the structure of the industry (Sanchez, et al. 2000).

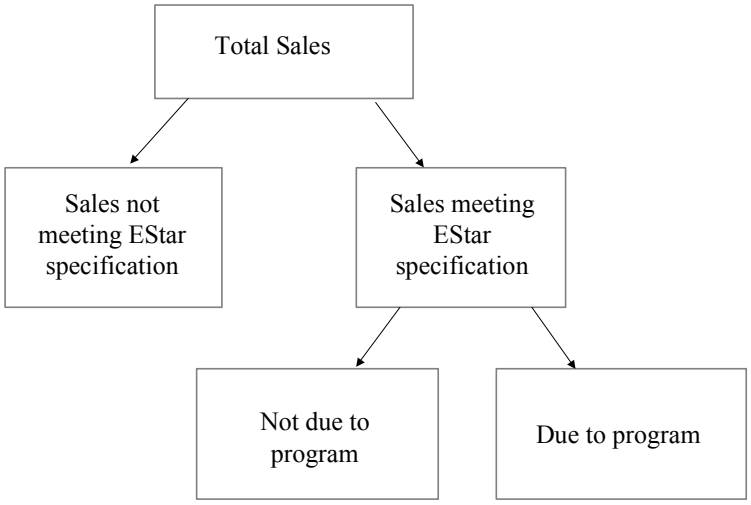
Historically, the focus of the ENERGY STAR program has been on energy savings and carbon emissions reductions. During California's energy crisis in 2000, however, interest shifted to the impact of conservation programs on electrical system reliability. The peak impacts of an ENERGY STAR label depend on the timing of the savings (do they occur on or off peak), which in turn depends on the daily usage pattern of the labeled product. The products with high peak savings may therefore be different from the products with high annual energy savings. The current interest in reliability has not changed how EPA and DOE choose products for labeling; however, it has added an additional dimension to evaluating the program.

Methodology

At the core of the ENERGY STAR savings calculations is a stock accounting that calculates the number of ENERGY STAR units in place each year that can be attributed to the ENERGY STAR program. We segment sales of each product first into non-ENERGY STAR and ENERGY STAR units. Sales of ENERGY STAR-qualifying units are further divided into those that would have been sold even without the program and those that can be attributed to the program. The ENERGY STAR savings forecast includes only the savings for ENERGY STAR units attributable to the program. Figure 1 illustrates the sales segmentation.

The market share of ENERGY STAR units not due to the program is a forecast based on historic efficiency trends. "Business-as-usual" is represented by non-ENERGY STAR sales and ENERGY STAR sales not due to the program, and is characterized both by a unit energy consumption and a market share for each segment. Business-as-usual efficiency improvements can be modeled directly as a change in the annual unit energy consumption (UEC) of either of these segments. We can also model business-as-usual efficiency improvements as a shift over time from non-ENERGY STAR units to ENERGY STAR units not due to the program.

Figure 1. Segmentation of product sales in the CCAP model



In general, we rely on a forecast of increasing market share of ENERGY STAR units not due to the program to capture changes in business-as-usual efficiencies (see below). This is because for most

products there is insufficient data on historic efficiency trends to create a credible UEC forecast.[2] For most products the annual unit energy consumption for non-ENERGY STAR units is assumed to be constant unless the ENERGY STAR requirement is tightened or (if applicable) the efficiency standard for the product changes during the forecast period.[3] In cases where both the non-ENERGY STAR UEC and the ENERGY STAR UEC are changing over time, it is possible for unit energy savings to increase, decrease or remain the same.

Even though we do not fully model efficiency improvements in non-ENERGY STAR units, the average efficiency of "business-as-usual" units changes over time based on our forecast of the market share of ENERGY STAR units not due to the program. For example, from 1996 to 2000, the UEC for non-ENERGY STAR refrigerators was 744 kWh/year and the UEC for ENERGY STAR refrigerators was 595 kWh per year (note that both the minimum efficiency standard and the ENERGY STAR requirement changed in 2001). The business-as-usual market share of ENERGY STAR refrigerators was forecast to increase from 8 percent to 10 percent over this period. The weighted average business-as-usual energy consumption declined from 731 to 728 kWh/year over this period.

Some products have ENERGY STAR features, such as low power modes when the device is idle, that do not accrue savings unless the feature is enabled.[4] In the past, manufacturers sometimes shipped devices with ENERGY STAR features disabled. Manufacturers are now required to ship units enabled, so no user action is required to achieve energy savings. However, users may disable features for various reasons, such as slow recovery times from low-power modes or (for PCs) incompatibility with computing networks. Metering of ENERGY STAR computers suggests that less than ten percent have their power-saving features enabled (Roberson et al. 2004). To account for the enabling factor, we calculate separate UECs for products that are enabled and products that are not enabled and then calculate a weighted average UEC based on our estimate of the enabling rate.

Using annual installations of energy-saving units due to the program, we calculate the number of ENERGY STAR units in place in each year (due to the program) by applying a simple retirement model. Devices are assumed to remain in place and accrue savings for a period equal to the average lifetime of the product (given in Table 4 below), then are retired.

Because the unit energy savings (UES) for some products changes over time, we cannot simply multiply the number of ENERGY STAR units (due to the program) in place in each year by a single UES to get aggregate annual energy savings. Instead, we calculate the energy savings for each year's ENERGY STAR sales and then use our retirement function to add up the savings for all the equipment vintages in place in a given year. Aggregate energy bills are estimated using year-by-year energy prices from US DOE (1996a, 1996b, 1997b, 1998b, 1999, 2000, 2001, 2003, 2005, 2006), shown in

[2] VCRs, telephony and exit signs are exceptions to this, and we do model the average efficiency of non-ENERGY STAR units does changing over time.

[3] While we do not speculate about future changes to standards, we do account for the effects of past, present, and finalized future standards. Standards are considered to be part of the reference case for the purpose of analyzing the effects of the ENERGY STAR Program.

[4] All of the savings for PCs, scanners, copiers, fax machines, and MFDs come from features that need to be enabled. Monitors and vending machines have low power modes that must be enabled, but also have active power savings. Programmable thermostats are assumed to save energy only if they are enabled (that is, programmed for automatic setback).

Table 2. Energy bill savings are discounted at a 4 percent real discount rate. Carbon emissions reductions are calculated from energy savings using year-by-year carbon emissions factors. Electric heat rates (also US DOE) and carbon emissions factors for electricity (Cadmus 1998) are also shown in Table 2.

Table 2. Best Estimate Energy Prices and Carbon Emissions Factors by Year[a]

Year	Commercial Electricity Price 2004$/kWh	Residential Electricity Price 2004$/kWh	Gas Price 2004$/ MBtu	Oil Price 2004$/ MBtu	Price Source	Carbon Emissions Factor for Electricity kg C/kWh	Carbon Source	Electric Heat Rate Btu/kWh	Electric Heat Rate Source
1993	0.095	0.102	8.02	7.28	c	0.203	m	11019	c
1994	0.094	0.101	7.86	7.13	d	0.203	m	10948	d
1995	0.088	0.098	7.72	7.00	e	0.203	m	10970	e
1996	0.087	0.096	7.59	6.89	f	0.203	m	10866	f
1997	0.085	0.094	7.51	6.81	g	0.203	m	10978	g
1998	0.084	0.091	7.40	6.71	h	0.203	m	10891	h
1999	0.079	0.090	7.24	6.57	i	0.203	m	10784	i
2000	0.079	0.088	7.07	6.42	j	0.203	m	11181	j
2001	0.084	0.091	7.07	6.42	j	0.203	m	11030	j
2002	0.081	0.088	6.83	6.20	k	0.203	m	11008	k
2003	0.082	0.089	9.43	9.85	k	0.203	n	10997	k
2004	0.080	0.089	10.40	13.62	l	0.203	n	10957	l
2005	0.087	0.098	12.30	14.31	l	0.203	n	10938	l
2010	0.076	0.085	10.33	12.85	l	0.168	n	10754	l
2015	0.074	0.083	9.80	12.73	l	0.141	n	10538	l
2020	0.075	0.083	10.16	13.55	l	0.135	n	10349	l
2025	0.077	0.084	10.76	14.23	l	0.135	n	10237	l

Notes to Table 2:

[a]Carbon coefficients for natural gas and oil are assumed to be constant throughout the period at 14.4 kg C/MBtu for natural gas and 19.75 kg C/MBtu for oil. Carbon emissions factors for electricity are marginal, not average.

[b]All prices have been converted to 2004 dollars using implicit GDP deflators from the Department of Commerce (2000).

[c]US DOE (1996a)

[d]US DOE (1996b)

[e]US DOE (1997b)

[f]US DOE (1998b)

[g]US DOE (1999)

[h]US DOE (2000)

[i]US DOE (2001)

[j]US DOE (2003)

[k]US DOE (2005)

[l]US DOE (2006)

[m]Cadmus (1998)

[n]EPA (2003).

The following equations summarize our calculations for savings in year t.

$$\text{Annual Energy Savings in Year t} = \sum_{n=t-L}^{t} X_n UES_n$$

$$\text{Annual Energy Bill in Year t (Undiscounted)} = AES_t P_t$$

$$\text{Annual Carbon Savings in Year t} = AES_t C_t$$

where

X_n = The number of ENERGY STAR units sold in year *n* due to the program

UES_n = The unit energy savings of units sold in year *n* (in kWh or MBtu)

L = product lifetime

AES_t = The aggregate annual energy savings in year *t* (in kWh or MBtu)

P_t = The energy price in year *t* (in $/kWh or $/MBtu)

C_t = The carbon emissions factor in year *t* (in kg/kWh or kg/MBtu)

When looking at reliability, the savings that matter most are those that occur when the system is constrained, typically during periods of peak demand. In most parts of the country, peak demand is driven by high summer cooling loads. ENERGY STAR room air conditioner savings tend to occur on peak, while the auto-off feature of ENERGY STAR copiers tends to save energy off peak. Other products, such as TVs, accrue fairly level savings through peak and off-peak periods.

Peak power reductions are estimated from aggregate energy savings using a conservation load factor (CLF) that relates average load savings to peak load savings for a conservation measure. CLFs for each ENERGY STAR product are shown in Table 5. Conservation load factors were obtained from previous research (when available), developed from time-of-day metered data or based on assumed time-of-day and seasonal operating patterns (if no metered data were available). A CLF of one indicates that energy savings are distributed evenly across peak an off-peak periods (e.g. ENERGY STAR TVs). CLFs of less than one indicate that savings are greater during peak periods (e.g. central and room air conditioners), while CLFs of more than one indicate that savings occur mostly off-peak (e.g. copier low-power and auto-off modes). Conservation load factor methodology is detailed in Koomey et al. (1990).

Several ENERGY STAR specifications have been revised since their introduction to a more stringent efficiency level. After each specification changed it is assumed that unit energy savings increase, but fewer models qualify at the new level, at least until manufacturers have a chance to revamp their product line to meet the new specification. The question arose, what happens to the models that met the old specification but not the new one? There are three possibilities: they are replaced by models that are less efficient than the old specification (recidivism), they continue to be made or are replaced by models of similar efficiency (market transformation), or they are replaced by models meeting the new specification. If recidivism is widespread, saving may be lower under the new specification than the old. There are currently no empirical data available that would resolve this question. We incorporated market transformation effects into the model, working under the

assumption that there is no recidivism. If future program evaluations determine that recidivism occurs, partial or total recidivism could be analyzed using the same modeling framework.

Forecasting Issues

Office Equipment. The EPA launched the ENERGY STAR program in 1992 with computers and monitors. In 1993, the program was extended to include printers. The goal was to promote energy-saving features already common in laptop computers for use in desktop devices. These labeled products soon dominated the market, largely due to President Clinton's issuance of Executive Order 12845 in 1993 requiring that microcomputers, monitors and printers purchased by federal agencies be ENERGY STAR-compliant. The sheer size of the federal market pushed manufacturers to participate in the program. Based on data presented in Gartner (2001) we estimate that 98 percent of computers currently sold are ENERGY STAR-compliant, and that —prior to the addition of the active power requirement to the Energy Star monitor specification— a similarly large fraction (95 percent) of monitors were compliant. 2005 ENERGY STAR sales for LCD and CRT monitors are manufacturer reported data provided to EPA as part of the calendar year 2005 sales data collection (ICF 2006).

ENERGY STAR-labeled office equipment includes computers, monitors, fax machines, printers, copiers, scanners and multi-function devices (MFDs). The program has historically focused on reducing the power consumed by these devices when not in active use. ENERGY STAR devices automatically enter a low-power mode and/or turn themselves off after a period of inactivity. To qualify for the ENERGY STAR label, devices must incorporate low-power and/or auto-off modes, and must meet power consumption limits in those modes. In some cases, default power-saving settings are specified, such as the length of the idle period necessary to trigger a lower-power mode or a maximum recovery time from low power modes.

Beginning in January 2005 EPA recently added a requirement that monitors meet an active power specification in addition to the existing low power requirement. This new active power specification was included in this forecast. Beginning in April 2007, imaging equipment will need to meet a total energy consumption specification (expressed as kWh/week), which differs from the past mode-based approach. On July 20, 2007, computers will need to meet an idle mode requirement in addition to the traditional sleep/standby requirements. Additionally, the new computer specification provides criteria for three new product categories in addition to desktops: laptops, video games (included in the desktop computer definition), and workstations. The revised imaging equipment and computer specification is included in this forecast.

For our analysis of commercial office equipment, we used operating patterns derived from equipment audits at various locations (Piette et al. 1995; Nordman et al. 1998, Webber et al. 2001, Roberson et. al 2004). These sources provided both the time spent in each operating mode (e.g. active/idle, standby, suspend and off), and the percent of ENERGY STAR devices that were actually enabled. Another key input was the percent of units left on after working hours. Recent nighttime audits of office buildings found that 64 percent of computers, 68 percent of CRT monitors, 82 percent of LCD monitors, 85 percent of laser printers (77 percent of all printers), 52 percent of copiers and 80 percent of MFDs were left on at night (Roberson et al. 2004). Three years earlier a similar study found that 56 percent of computers, 68 percent of monitors, 75 percent of printers and 82 percent of copiers and MFDs were left on at night (Webber et al. 2001). For residential computers

and monitors, we used data from Media Metrix (2001) describing average usage of a large sample of residential computer users. Residential turn-off rates are taken from Roth et al. 2006 (80% of computers left on at night).

Baseline unit energy consumptions were calculated by multiplying the time spent in each power mode by the power consumption in each mode, then summing over all power modes. The unit energy consumption for ENERGY STAR products was calculated essentially the same way, although some of these products have additional power modes. ENERGY STAR products may also have different usage patterns than standard products (because of features like auto-off) and lower power levels in certain operating modes. Office equipment shipment data were obtained from IDC (2006), Gartner (2001), IDC (2001), and Guo et al. (1998). The unit energy savings were applied to forecasts of ENERGY STAR-compliant devices to obtain aggregate savings.

As noted above, taking account of enabling rates was particularly important for office equipment. A significant number of ENERGY STAR devices, particularly computers, fail to save energy because either their power management features are not enabled or external factors (such as computer network connections) keep the device from entering low power modes. Enabling rates (or, more accurately, power management "success rates"[5]) were obtained from the nighttime audits mentioned above. Only 6 percent of computers were observed to be in low-power mode (Roberson et al. 2004). Table 3 shows the office equipment enabling rates assumed in the analysis. Because of different usage patterns, computers and monitors were modeled separately for homes and offices. Shipments to homes were obtained from Gartner (2001).

In the present version of CCAP the unit lifetimes for residential computers and monitors was reduced from 8 to 5 years. The 8-year lifetime was originally chosen to reconcile conflicting shipment and stock data; essentially, shorter lifetime assumptions produced stock estimates that were inconsistent with published data, using the best shipment data we had available. It was time to review this assumption, and a comparison of current shipment and stock data confirmed that the 8-year life was too high. A 5-year life produced stock estimates consistent with RECS. This did not effect shipments but did affect energy and carbon savings estimates because a shorter lifetime means the stock of Energy Star units in place is smaller.

[5] A device is said to be enabled if its power management settings indicate that the device has been programmed to go into a low-power state. Since, as discussed, some of these devices will nevertheless fail to enter a low-power state, the term "success rate" more accurately describes the share of devices that succeed in entering a low-power state. Because this distinction is not widely understood, we use the term "enabling" throughout the paper to mean the share of devices that are successfully power managing.

Table 3. Enabling Rates for ENERGY STAR Office Equipment

Product	1993	1994	1995	1996	1997	2000	2005	2010	2015	2020	2025
Copiers	NA	NA	76%	76%	76%	76%	29%	29%	29%	29%	29%
Facsimile	NA	NA	90%	90%	90%	90%	90%	90%	90%	90%	90%
Printers	80%	90%	96%	96%	96%	96%	95%	95%	95%	95%	95%
Scanners	NA	NA	NA	NA	90%	90%	60%	60%	60%	60%	60%
Notebooks	NA	NA	NA	NA	NA	NA	NA	17%	19%	20%	21%
Office Multifunction	NA	NA	NA	NA	67%	77%	55%	59%	61%	61%	61%
Office CRT Monitors	10%	15%	15%	59%	59%	59%	76%	77%	78%	79%	80%
Office LCD Monitors	10%	15%	15%	59%	59%	59%	80%	81%	82%	83%	84%
Office Desktops	10%	15%	15%	10%	5%	5%	7%	8%	10%	11%	13%
Residential Multifunction	NA	NA	NA	NA	NA	97%	94%	96%	96%	97%	97%
Residential CRT Monitors	10%	15%	15%	59%	59%	59%	71%	71%	71%	71%	71%
Residential LCD Monitors	10%	15%	15%	59%	59%	59%	75%	75%	75%	75%	75%
Residential Desktops	10%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%

Notes to Table 3:
a) Enabling rates shown here represent the percent of ENERGY STAR-compliant devices assumed to be correctly configured for power management and successfully saving energy.
b) Enabling rates for 1997 to 2002 are from Webber et al. (2001); rates for 2003 are from Roberson et al. (2004). For all products except office PCs and office monitors, enabling rates are expected to remain flat after 2003. Office PC and monitor enabling rates are expected to increase over time due to outreach efforts by EPA. Enabling for multifunction devices changes over time due to the changing mix of products (speed and imaging technology).
c) Beginning in 2007, savings for imaging products (including non-Inkjet/standard format copiers, printers, multi-function, facsimile) are based off of a total energy consumption (kWh/wk) criteria provided in the Energy Star Requirements for Imaging Equipment (EPA 2006) and enabling rates are not explicitly factored into the savings equation at this point. Enabling rates provided in table for information purpose only.

Residential Heating and Cooling (HVAC). The HVAC program covers air-source heat pumps, geothermal heat pumps, central air conditioners, gas and oil furnaces, gas and oil boilers, and programmable thermostats. For heating and cooling equipment, ENERGY STAR eligibility is based solely on efficiency, measured by standard test procedures such as AFUE or SEER.[6] Programmable thermostats qualify for the ENERGY STAR label because they automate what people often fail to do manually: set back their thermostats at night or when they are out of the house. Several issues arose in analyzing heating and cooling equipment, including multiple fuel types, technology substitution and program interactions.

The market shares for ENERGY STAR central air conditioners and air-source heat pumps from 1996 to 2000 are from ARI (2001). Shipments of programmable thermostats are estimated based on stocks reported in the 1997 Residential Energy Consumption Survey (RECS; US DOE 1999). The market share forecast for geothermal heat pumps is an LBNL estimate, although 1995 and 1996 shipments were taken from US DOE (2000). Geothermal heat pumps are an intrinsically efficient technology, and all units are assumed to meet the ENERGY STAR efficiency level. Because of this, and because geothermal heat pumps are not yet in widespread use, increased sales of this products are modeled as displacing shipments of established products. For our model we assume they displace air-source heat pumps. We first received shipment data for gas and oil fired furnaces in 2003 (ICF, 2003). In this forecast, we've updated 2005 ENERGY STAR sales for furnaces, central air conditioners, air-source

[6] AFUE is average fuel utilization efficiency and SEER is seasonal energy efficiency ratio.

heat pumps, geothermal heat pumps, boilers, and unitary HVAC to reflect data submitted to EPA by manufacturers during the calendar year 2005 sales data collection effort (ICF 2006).

Energy bill and carbon savings both depend on the type of fuel used. In addition to their primary fuels, gas and oil furnaces consume electricity to operate fans. Programmable thermostats save energy according to the type of HVAC installed in the home. For these products, we segmented the analysis by fuel type and then added the component savings together (electricity was converted to primary energy).

Because programmable thermostats reduce the operating hours of heating and cooling equipment, they must be analyzed in conjunction with HVAC equipment to avoid double-counting savings from thermostats and efficient equipment. Because we calculate thermostat savings as a percentage of total heating and cooling energy, thermostat savings should be lower if ENERGY STAR-compliant HVAC equipment is in place. Conversely, if there is a programmable thermostat in place, replacing old equipment with an ENERGY STAR model will save less than if the thermostat was a standard one. For simplicity, we assumed that HVAC equipment is chosen first and therefore ENERGY STAR HVAC receives its full measure of savings. Programmable thermostat savings were calculated from a forecast of HVAC energy use that took into account the increasing market penetration of ENERGY STAR HVAC (we assumed the choice of a programmable thermostat was independent of the choice of ENERGY STAR HVAC). Programmable thermostat savings are therefore net of ENERGY STAR HVAC savings.

While Energy Star Homes are not covered by this report, the effects of that program are taken into account when estimating savings for Energy Star HVAC equipment. Since Energy Star HVAC equipment is often part of an Energy Star home and counted toward its savings. Sales of Energy Star HVAC that are attributed to the Homes program are not included in this report (which is concerned specifically with sales due to Energy Star's product labeling program).

Consumer Electronics. For TVs, VCRs, and audio equipment, ENERGY STAR focuses on reducing devices' standby power. Savings are typically assumed to accrue in both active and standby mode, since standby functions like remote control and memory are powered whether the device is on or off. The power savings are only a few watts per unit, but the number of units is large. There are approximately 260 million TVs (NRDC 2005), 120 million VCRs, and 10 million TV/VCR combination units in U.S. homes (Rosen and Meier 1999). In addition, 41 percent of US homes had a DVD player as of 2003 (*Appliance* 2004). We estimate that some 54 million audio devices are sold each year, including amplifiers, receivers, tuners, CD players, cassette players, equalizers, radios, mini-systems, rack systems and laserdiscs. Car audio and portable audio products are not included in this total, since they are not covered under the program. In previous forecasts, we only included CDs and mini-systems. In this forecast, we added home theaters and audio separates to the analysis.

The TV forecast takes into account new screen technologies. The analysis was divided into the following product classes: CRT, projection, LCD and plasma TVs. Digital cable ready TVs with POD slots are not currently included in the analysis because no baseline power data or US shipment data is readily available for these products. TV monitors are also excluded from the model due to a limited availability of data. The incorporation of TV product classes was necessitated in part by the

changing market for television, and in part by the upcoming specification revision. To support the new analysis, we found new data sources for energy use by technology and usage per television set from a variety of sources including CNET, ECOS consulting, and NRDC. New TV shipment data by product class (from Isupply) was incorporated into the model.

DVD savings only reflect stand- alone products since DVD/VCRs are included under the VCR category.

The biggest difficulty in modeling the TV/VCR and audio category is the limited information available for certain product classes defined by the Energy Star specification. Since there is no baseline power data available for digital ready TVs or TV monitors, these classes have been excluded from analysis despite the fact that existing models within these classes are qualifying under the Energy Star program. Additionally, DVD/VCRs are theoretically included under the VCR category even though power estimates for the category have not been updated to reflect DVD/VCRs (all baseline wattages represent only VCR units). To incorporate these technologies, metering data needs to be collected to quantify program effects for these new product classes.

The set-top box specification was discontinued after 2005 for all but digital to analog converters (DTA). DTA shipments are assumed to decrease to 0 after 2012 (because the market will have fully transitioned to digital and those needing adapters for older sets will have already purchased them). The free rider market penetration for all set-top box products was reduced to zero.

In this forecast, we updated the 2005 Energy Star sales with data collected from manufacturers during EPA's calendar year 2005 data collection effort (ICF 2006). We updated data for TVs, TV/VCRs, VCRs, DVDs, audio equipment (CDs, mini-systems, home theater and audio separates). Based on the new Energy Star 2005 sales, the forecast was adjusted downward for CRT TVs, VCRs, DVDs, and mini-systems.

Telephony. Telephony equipment consists of answering machines plus cordless telephones and telephone combination units, either of which may include digital spread spectrum (DSS) functionality. Initial sales estimates came from *Appliance* (May 2002). Sales estimates for 2001, 2004, and 2005, which reflect the disaggregation by technology come from CEA (CEA 2005). The energy use by non-Energy Star units is calculated from Rosen et al. 2001. Growth in the unit sales of answering machines is from CEA (2006). In this forecast, we updated the 2005 Energy Star sales with data collected from manufacturers during EPA's calendar year 2005 data collection effort (ICF 2006).

External Power Supplies. Battery Chargers were added to the CCAP model in this version. Battery chargers can be either an independent device ("universal battery chargers) or an accessory specific to some other appliance. We modeled, in addition to freestanding or "universal" types, battery chargers for floor care, kitchen appliances, personal care, and power tools. These are the categories analyzed in the Cadmus metering dataset and those are the reported shipment category breakdowns in ICFs market summary report. The baseline and energy star unit energy consumption estimates are from test data compiled by Cadmus for each of the five categories. Total unit shipments are from ICFs Battery Charger Market Report.

In this forecast, we updated the 2005 Energy Star sales for external power supplies with data collected from manufacturers during EPA's calendar year 2005 data collection effort (ICF 2006). Based on the 2005 Energy Star sales data, we lowered our initial forecast of units that both qualified for the Energy Star program prior to the program development and actively participate in the program at its launch (our program free rider variable).

Residential Lighting. The ENERGY STAR program promotes energy-efficient residential lighting fixtures and compact fluorescent lamps (CFLs). ENERGY STAR fixtures include fixtures designed to take only pin-based CFLs, electronically ballasted tube fluorescent fixtures, and outdoor fixtures that incorporate motion sensors and photocells.

We analyze the residential lighting fixture market in two segments, indoor fixtures and outdoor fixtures.[7] Initial shipment data for indoor fixtures and outdoor fixtures were from the U.S. Department of Commerce (1997).

Even though prices of CFLs have fallen significantly in recent years, they are still not cost-effective in low-use fixtures. However, we recognize that some CFLs do end up in low-use applications (for example, if the consumer needs a long-life lamp for a hard-to-reach socket). We therefore split indoor fixtures into three usage bins (less than one hour per day, one to three hours per day, and more than three hours per day) for this analysis. We assume a high market penetration among high-use fixtures, since CFLs are generally cost effective at that level of use, but lower penetrations for medium- and low-use fixtures. Unit energy consumption for high-use indoor fixtures was taken from the Baseline Residential Lighting Energy Use Study (described in Vorsatz et al 1997). For the 100 percent penetration scenario, we assumed that 100 percent of high-use fixtures were replaced, 50 percent of medium-use fixtures and 10 percent of low-use fixtures. Torchieres have been eliminated as separate product and rolled into the indoor fixture analysis.

Our analysis of outdoor fixtures focused on motion sensor- and photocell-equipped fixtures. Baseline energy consumption was again taken from the Baseline Residential Lighting Energy Use Study. As with indoor fixtures, we focused on high-use fixtures, although for different reasons. Outdoor fixtures, especially around entryways, are often left on all night for security. Motion sensor fixtures are particularly suited for this type of application. A motion sensor was assumed to reduce usage to one hour per day.

In addition to dedicated CFL fixtures, compact fluorescent lamps themselves are covered by an ENERGY STAR specification. Like indoor fixtures, CFLs were analyzed by usage bin. The analysis was complicated by the fact that CFLs have a significantly longer lifetime (10,000 hours) than incandescent lamps (usually estimated at 750 to 1,500 hours, we use 1,500 hours for this analysis). Because a CFL lasts longer, one CFL replaces one current plus several future incandescent lamp purchases. The larger the market share of CFLs, the fewer total lamps will be sold (because they need to be replaced less often). This problem required a more elaborate stock accounting than had been done for the other products.

[7] Formerly, torchieres were split out from indoor fixtures because of the rapid growth of high-wattage halogen fixtures using 300 to 500 watts. That market trend seems to have run its course, however, and sales of halogen torchieres have declined somewhat. We therefore no longer split out torchieres.

In this forecast, we updated the 2005 Energy Star sales to reflect data collected for calendar year 2005 by EPA as part of its ongoing sales data collection (ICF 2006). This data includes both indoor and outdoor fixtures.

Commercial Lighting. Commercial lighting products covered by ENERGY STAR labels include exit signs and traffic signals. Both of these products have ample opportunity for efficiency improvements, particularly through the use of LEDs. The advantages of LEDs go beyond energy efficiency. Since LEDs last many times longer than incandescent lamps, maintenance costs can be sharply reduced.

Although exit signs may seem like a small niche in the commercial lighting market, they were an ideal target for an ENERGY STAR program. Exit signs must be lit 24 hours a day. Most signs used incandescent lamps for illumination, which consumed about 40 watts. ENERGY STAR exit signs must consume less than five watts. Because of the importance of visibility during emergencies, the program also includes visibility and luminance requirements.

Calculating energy savings for exit signs was fairly straightforward. However, there is some uncertainty associated with the size of the stock, shipments and lifetime. The lifetime for some light sources (LED and electroluminescent) are reported to be 20 years or more, but because efficacy may degrade over time we use a more conservative ten-year lifetime.

Because retrofits are the primary driver of LED traffic signal sales, we based our analysis for these products on stock replacement rather than estimating the ENERGY STAR share of units shipped, as we did with other products. Red and green traffic signals were modeled separately because of differences in cost effectiveness. Green signals have shorter duty cycles and green LEDs are more expensive than red LEDs, making it less cost effective to replace a green incandescent signal with an LED signal. Yellow (amber) signals are not analyzed because of their very short duty cycles, although LED signals do have a small share of the yellow signal market.

In this forecast, we updated the 2005 Energy Star sales to reflect data collected for calendar year 2005 by EPA as part of its ongoing sales data collection (ICF 2006). This data includes traffic signals and exit signs.

Residential Appliances. ENERGY STAR appliances for the home include refrigerators, freezers, clothes washers, dishwashers, room air conditioners (RACs), dehumidifiers, ceiling fans and exhaust fans.

After HVAC and water heating, large appliances constitute the largest energy end-uses in a typical home. Like some of the HVAC products, refrigerators, freezers, clothes washers, dishwashers, and room air conditioners (RACs) are already subject to federal minimum efficiency standards. The ENERGY STAR program is intended to expand the market for products that significantly exceed the minimum standard. To earn an ENERGY STAR label, refrigerators and freezers must be 10 percent more efficient than standards, dishwashers must be 25 percent more efficient and RACs must be 10 percent more efficient than standards. The clothes washer specification is set so that the devices

must be horizontal axis or equivalent efficiency to qualify. The minimum efficiency standard for clothes washers was tightened in 2004 and will be again in 2007.

To obtain energy use for these ENERGY STAR devices, we first calculated unit energy consumption for units just meeting the federal minimum efficiency standards. The average energy consumptions for refrigerators and RACs (under both existing and new efficiency standards) were weighted according to the distribution of products by product class and capacity (Wenzel et al. 1997, US DOE 1995b, US DOE 1997a). In the case of dishwashers and clothes washers a prototypical model was used to calculate energy consumption. Where ENERGY STAR criteria were specified in terms of percent efficiency improvement over standards, the appropriate percentages were then applied to obtain ENERGY STAR energy consumption.

A large share of the energy consumption by clothes washers and dishwashers is due to the use of household hot water, which may be heated using gas, oil, LPG or electricity. (Because oil and LPG water heaters represent only a small fraction of water heaters, they were treated together with gas water heaters for this analysis). The test procedures for these products include both the electricity used by the device itself (motor, controls, etc.) and energy (fuel or electric) used for water heating. The test procedure for clothes washers also includes dryer energy, since remaining moisture content in the load at the end of a wash cycle varies by washer and affects the amount of energy required to dry the load.[8] Dryers may also be gas or electric. We therefore analyzed dishwasher energy savings in three parts: machine energy, which accrued to all devices, electric water heating energy, which accrued to devices installed in electric water heating homes, and gas water heating energy, which accrued to devices installed in gas water heating homes (oil and LPG water heating homes were also included here). Similarly, clothes washer savings are analyzed in five parts: machine, electric water heating, gas water heating, electric drying and gas drying. The shares of water heating by fuel type were taken from US DOE (1999). Unit energy consumption and savings for clothes washers and dishwashers included machine energy and weighted-average water heating energy for all fuels, expressed as primary energy.

Dehumidifiers are not covered by appliance standards. For these, the ENERGY STAR requirement was specified in terms of kWh of energy used per liter of water removed from the air. Baseline efficiencies were obtained from Cadmus (1999). The new dehumidifier specification was incorporated into the model. The new specification involves additional product classes and new worksheets were added to CCAP reflecting these. Due to the reorganization of product classes and capacity bins, we reallocated both total US shipments and Energy Star unit sales. Since both shipments and Energy Star sales were reallocated, it is impossible to reproduce last year's results under the new approach. We revised 2002 shipment data.

Ceiling fans and exhaust fans arguably could have been grouped with HVAC equipment. However, because these products are not covered by minimum efficiency standards, they are instead included with appliances. Ceiling fan UEC data was taken from Calwell and Horowitz (2001). Information on exhaust fan usage was unavailable; usage was simply assumed to be one hour per day for the types

[8] The Department of Energy changed the test procedure for clothes washers several years ago. Through 2003 the standard was based on energy factors which measure energy per wash cycle for machine and water heating energy. The 2004 and 2007 standards are based on modified energy factors (MEF), which include dryer energy. The current ENERGY STAR specification is expressed in terms of MEF.

of fans covered by the program (rangehood fans and bathroom and utility room exhaust fans). Exhaust fans are divided into low use, high use, fan lighting, rangehood fans, and rangehood lighting. Exhaust fan power levels were obtained from product literature from manufacturers. The baseline efficiency assumptions are from Cadmus (2000)

Air Cleaners are based on the unit capacity expressed as clean air delivery rate (CADR). Units are divided into bins of 51-100, 101-150, 150-200, 200-250 and over 250 CADR. The modeling start year is 2004. Shipment data is taken from ICF (2002). Baseline product wattage is from a manufacturer test dataset submitted during the specification development process through AHAM. Energy Star wattages are extrapolated from the efficiency criteria (CADR per watt) for each CADR category. Our savings assume a 8,760 hr/yr duty cycle. Unit lifetime is form Appliance (1998).

In this forecast, we included the 2007 Energy Star specifications for dishwashers and clothes washers. We updated the 2005 Energy Star sales to reflect data collected for calendar year 2005 by EPA as part of its ongoing sales data collection (ICF 2006) for dehumidifiers, air cleaners, exhaust fans, and ceiling fans. We updated 2005 Energy Star sales for clothes washers, dishwashers, refrigerators, and RAC based on data provided by D&R International.

Commercial Appliances. Since 2000, Energy Star has expanded significantly into commercial appliances. In 2003, bottled water coolers and commercial refrigerators and freezers were joined by hot food holding cabinets, gas and electric steamers, and gas and electric fryers as Energy Star labeled products. Cold beverage vending machines were added in 2004 and refurbished cold beverage vending machines were incorporated into the program beginning in 2006.

The program covers cold-only and hot/cold bottled water coolers. Efficiencies are specified in terms of kWh per day. Baseline efficiencies were obtained from Cadmus (2000).

Data for commercial refrigerators and freezers was taken from A. D. Little (1996) and Cadmus (2001). Only solid door refrigerators and freezers are covered. The program covers refrigerator/freezers and ice cream freezers under separate specifications, but due to insufficient data, these product classes are not modeled separately. Efficiencies are again expressed as kWh per day.

The specifications for fryers and steamers include a cooking efficiency (the quantity of energy input into the food expressed as a percent of the energy input to the appliance) and an idle rate, expressed in Btu/hr (gas appliances) or watts (electric). Hot food holding cabinets have only an idle energy rate requirement, expressed in watts per cubic foot. Data for commercial cooking equipment was obtained from the Food Service Technology Center (Fisher 2003).

We updated the 2005 Energy Star sales to reflect data collected for calendar year 2005 by EPA as part of its ongoing sales data collection (ICF 2006) for water coolers, commercial refrigerators and freezers, hot food holding cabinets, fryers, steamers, and vending machines. We also added refurbished vending machines to the analysis.

Recent Changes to the Model

The results of this model have been presented in five earlier reports (Webber et al. 1999, 2002, 2003, 2004, 2005, and 2006). Several important changes have been made to the program and the model since the 2006 status report.

No significant changes to the model were made for this report.

Results

Table 4 shows annual unit energy and energy bill savings, average product lifetime, and lifetime energy and energy bill savings for each product. These estimates form the basis of the calculation of savings to date and the forecasts of future savings. ENERGY STAR commercial steam cookers have the highest absolute per unit savings; followed by geothermal heat pumps, hot food holding cabinets, air source heat pumps, commercial refrigeration, and fryers. Ranked by percentage savings, however, CRT monitors take the lead at 92 percent savings for units that are turned-off at night and enabled during the day. Other products with at least 50 percent savings are all other office products with the exception of facsimile machines, residential lighting fixtures, traffic signals, CFLs, exhaust fans, audio equipment, TV/VCR/DVD combination units, DVD players, telephony, hot food holding cabinets, and commercial steamers.

Table 4. Annual and Lifetime Savings per Unit for ENERGY STAR® Devices Sold in 2006

Equipment Type	Annual Energy Savings	Annual Unit Primary Energy Savings	Annual Bill Saving due to Energy Star	Product Lifetime	Lifetime Primary Energy Savings	Lifetime Energy Bill Savings, undiscounted
	%	Million Btu	2004$/yr	Years	Million Btu	2004$
Office Equipment						
- Office PC	81%	4.61	$36.35	4	18.37	$137.38
- Office CRT Monitor	92%	4.84	$38.16	4	19.29	$144.26
- Office LCD Monitor	88%	2.91	$22.96	4	11.61	$86.80
- Home PC	59%	2.00	$17.45	4	7.98	$65.21
- Home CRT Monitor	74%	1.42	$12.40	5	7.07	$57.38
- Home LCD Monitor	56%	0.65	$5.63	5	3.21	$26.05
- Fax	40%	1.40	$11.06	4	5.59	$41.82
- Copier (1)	55%	10.08	$79.39	6	59.94	$439.25
-Multifunction Device	71%	6.99	$55.06	6	41.57	$304.67
- Scanner	76%	1.28	$10.12	4	5.12	$38.26
- Printer	76%	3.10	$24.41	5	15.39	$113.86
Consumer Electronics						
- TVs	28%	0.83	$4.09	9	7.38	$33.31
-VCRs	35%	0.20	$1.76	7	1.40	$11.26
-TV/VCR/DVD	89%	0.74	$6.45	7	5.12	$41.15
-DVD Player	59%	0.34	$3.00	7	2.38	$19.14
-Audio Equipment	58%	0.59	$5.18	8	4.11	$41.57
-Telephony	55%	0.19	$1.61	7	1.28	$10.29
-Set-top Box	23%	0.33	$3.30	7.	2.31	$21.08
-External Power Supplies	34%	0.13	$1.44	5	0.65	$8.42
-Battery Charging Systems	34%	0.08	$0.77	7	0.52	$4.83
Heating and Cooling						
- Furnace (Gas or Oil)	15%	12.85	$143.32	18	229.93	$2,273.43
- Central Air Conditioner	14%	4.10	$35.73	14	56.03	$446.83
- Air-Source Heat Pump	8%	10.41	$154.15	12	122.36	$1657.37
- Geothermal Heat Pump	30%	56.91	$495.88	15	831.43	$6,635.27
- Boiler (Gas or Oil)	6%	6.06	$71.21	20	121.18	$1,256.88
- Programmable Thermostat	14%	14.76	$158.16	15	218.85	$2089.98
- Unitary HVAC	6%	NA	NA	15	NA	NA
Residential and Commercial Lighting						
- Fixtures	73%	0.67	$6.02	20	13.01	$107.20
- CFLs	66%	0.94	$8.28	(4)	5.64	$43.15
- Exit Sign	8%	0.28	$23.42	10	2.78	$210.56
- Traffic Signal	89%	4.84	$38.17	10	47.64	$343.14
Residential Appliances						
- Room Air Conditioners	10%	0.69	$5.99	13	8.73	$69.61
- Dehumidifiers	6%	0.68	$5.90	12	7.96	$63.42
- Air Cleaners	46%	3.98	$34.70	9	35.32	$282.62
- Exhaust Fans	73%	0.63	$5.52	10	6.23	$49.78
- Ceiling Fans	47%	1.02	$8.87	10	10.01	$79.93
- Dishwashers	26%	1.12	$10.70	13	14.57	$123.78
- Refrigerators	15%	0.86	$7.51	19	15.83	$126.90
- Clothes Washers	31%	2.74	$25.74	14	38.34	$320.44
Commercial Appliances						
- Water Coolers	45%	2.57	$20.27	10	25.31	$182.29
- Commercial Refrigeration	37%	19.00	$149.70	10	186.87	$1,345.94
- Hot Food Holding Cabinets	58%	43.78	$353.99	15	639.72	$4,717.10
- Fryers	15%	17.66	$296.21	11	197.10	$2,723.52
- Steamers	54%	77.66	$744.71	10	776.64	$6,679.00
- Vending Machines	26%	10.19	$80.28	14	139.19	$838.90
Other						
- Utility Transformers	0%	0.00	$0.00	32	0.00	$0.00
- C&I Transformers	0%	0.00	$0.00	32	0.00	$0.00
- Residential Roofing (1000 sq ft)	n/a	1.02	$7.56	20	19.41	$135.20
- Commercial Roofing (1000 sq ft)	n/a	2.05	$14.40	7	14.16	$92.14

Notes next page

Notes to Table 4:

a) Annual savings are relative to standard new unit, with the following qualifications: Geothermal heat pump is compared to air-source heat pump and electric water heater. Residential lighting fixtures are compared to a standard incandescent fixture. For HVAC, the standard energy bills are derived from 1990 RECS consumption data. All savings are for specifications that apply in 2003.

b) Electricity is converted to primary energy using a conversion factor of 10,938 Btu/kWh (US DOE 2000).

c) Yearly U.S. average energy prices are given in Table 2. Lifetime energy bill savings are calculated using the stream of future energy prices.

d) Lifetimes are the average lifetime for each product. Computer, monitor, copier, printer and fax lifetimes are from Koomey et al. (1995) (the short lifetimes for computers reflects rapid obsolescence for those products); scanner lifetimes are assumed to be the same as those of fax machines; TV, VCR, DVD, and audio product lifetimes are from *Appliance* (1996); telephony and dehumidifier lifetimes are from *Appliance* (1998); settop box lifetimes are assumed to be similar to other electronics products; gas furnace, central air conditioner, air-source heat pump and boiler lifetimes are from Lewis and Clarke (1990); geothermal heat pump lifetime is an LBNL estimate; thermostat lifetime is the weighted average of HVAC lifetimes; lifetimes for residential lighting fixtures are based on a ballast life of 40,000 hours and 2,000 hours of use per year; traffic signal life is from Suozzo and Nadel (1998); exit sign life is from National Lighting Product Information (1994); clothes washer, dishwasher, refrigerator, and room air conditioner lifetimes are from Wenzel et al (1997); commercial refrigeration lifetimes are from A.D. Little (1996); water coolers lifetimes are assumed to be the same as commercial refrigeration; exhaust fans and ceiling fan lifetimes are taken from Cadmus (1999); hot food holding cabinet life is from Zabrowski (2003); steamer, fryer and vending machine lifetimes are from ICF (2002a, b, and c, respectively); commercial and industrial transformer life is from Thomas et al. (2002).

e) Lifetime energy savings may not equal the product of annual energy savings and product lifetime due to rounding.

f) Usage assumptions for home computers and monitors differ from office computers and monitors, resulting in different unit savings.

g) Dishwashers energy savings include machine energy and water heating energy. Clothes washer savings include machine, water heating and dryer energy. Water heating and dryer energy are a weighted average of gas and electric equipment energy.

h) The savings for clothes washers given here are lower than the percent savings over efficiency standards specified by the ENERGY STAR program (50 percent) because here we are comparing to standard new units, which are more efficient than the minimum standard. Clothes washer savings are from US DOE (1998a).

i) CFL lifetime is assumed to be 10,000 hours.

j) Office equipment savings are calculated as follows: PCs represent desktop/side models – savings reflect baseline vs. Energy Star (enabled and turned-off at night computer); CRT and LCD monitor savings reflect baseline vs. Energy Star enabled and turned-off at night monitor; facsimile savings reflect baseline vs. Energy Star enabled (left on) facsimile; copier savings reflect baseline vs. Energy Star enabled and turned-off at night copier; MFD savings reflect baseline vs. Energy Star enabled and turned-off at night copier; printer savings reflect baseline vs. Energy Star enabled and turned-off at night printer; scanner savings reflect baseline vs. Energy Star enabled and turned-off at night scanner.

k) Unitary HVAC given as NA because savings are not calculated as per unit (we calculate per square foot savings instead)

Tables 5 shows the annual energy, dollar, and carbon savings for 2006 as well as the peak demand reduction due to the program. The increased market penetration for existing products and specification revisions are increasing annual savings at a rapid rate. Annual savings in 2006 were 1,194 trillion Btu, 21.2 MMTC, and $10.3 billion dollars (undiscounted). These figures represent increases of 1.8 MMTC, 135 Tbtu, and $991 million dollars over the 2005 savings. These figures also represent an increase of $751 million dollars, 96 trillion Btu and 1.7 MMTC over the 2006 forecast in the last status report. The peak demand reduction due to the ENERGY STAR labeling program was 18.1 gigawatts in 2006.

There were increased savings in most program areas. The largest increase occurred in Heating and Cooling, where the large increase in savings was due to the 2005 Energy Star sales data showing many more Energy Star units than had been previously estimated for unitary HVAC, CAC, and air source heat pumps. The second largest increase occurred in commercial roofing due to the 2005 Energy Star sales data. Office equipment went up slightly due to the incorporation of the imaging and computer specification. In the case of computers, the binning changes on desktop computers to accommodate more powerful computer models resulted in increased program savings.

Table 6 shows the forecast for saving expected in 2007. By 2007, energy savings are expected to reach 1,340 trillion Btu and $11 billion dollars. Peak demand reduction is modeled as increasing to 20.8 gigawatts in 2007.

Market Penetration scenarios.

We provide savings forecasts for two cases: a target market penetration case, using EPA's and DOE's market penetration goals for ENERGY STAR devices, and a 100 percent market penetration case, assuming that all shipments are ENERGY STAR-compliant (but not necessarily enabled, see below) from 2005 onward.

Table 5. Annual Savings in 2006

Program	Equipment Type	Primary Savings	Energy Bill Savings, Undiscounted	Carbon Emissions Avoided	Conservation Load Factor	Peak Load Savings
		Trillion Btu	Million $2004	MtC		GW
Office Equipment	- Computers & Monitors	234.99	$1,867	4.22	1.18	2.481
	- Fax	6.45	$55	0.12	1.03	0.065
	- Copier	5.32	$42	0.10	5.81	0.022
	-Multifunction Device	40.95	$323	0.74	0.77	0.560
	- Scanner	14.08	$119	0.25	0.32	0.466
	- Printer	203.9	$1,648	3.66	7.44	0.527
	Subtotal	505.68	$4,073	9.08	0.96	4.221
Consumer Electronics	- TVs	51.23	$446	0.82	1.00	0.536
	-VCRs	13.14	$115	0.24	1.00	0.137
	-TV/VCR/DVD	12.61	$110	0.23	1.00	0.132
	-DVD Player	13.74	$120	0.25	1.00	0.144
	-Audio Equipment	16.51	$145	0.30	1.00	0.173
	-Telephony	8.07	$70	0.14	1.00	0.084
	-Set-top Box	1.06	$9	0.02	0.76	0.034
	-External Power Supplies	2.00	$17	0.04	1.00	0.021
	-Battery Charging Systems	0.03	$0.27	0.00	1.00	0.000
	Subtotal	118.38	$1,031	2.13	0.98	1.261
Heating & Cooling	- Furnace (Gas or Oil)	58.09	$649	0.88	-	-
	- Central Air Conditioner	29.62	$258	0.53	0.15	2.066
	- Air-Source Heat Pump	22.65	$197	0.41	0.15	0.566
	- Geothermal Heat Pump	3.37	$29	0.06	0.15	0.027
	- Boiler (Gas or Oil)	2.83	$37	0.05	-	-
	- Programmable Thermostat	51.2	$547	0.84	0.15	0.750
	- Unitary HVAC	25.55	$201	0.46	0.15	1.782
	Subtotal	193.31	$1,919	3.22	0.18	5.191
Res and Com Lighting	- Fixtures	90.29	$787	1.62	1.02	0.922
	- CFLs	115.69	$1,008	2.08	1.02	1.181
	- Exit Sign	5.61	$44	0.10	1.00	0.059
	- Traffic Signal	14.11	$111	0.25	1.00	0.148
	Subtotal	225.70	$1,950	4.05	1.02	2.309
Residential Appliances	- Room Air Conditioners	14.26	$124	0.26	0.15	0.994
	- Dehumidifiers	3.32	$29	0.06	0.42	0.083
	- Air Cleaners	1.75	$15	0.03	1.00	0.018
	- Exhaust Fans	1.12	$10	0.02	1.02	0.011
	- Ceiling Fans	2.01	$18	0.04	1.02	0.021
	- Dishwashers	25.81	$247	0.44	0.77	0.252
	- Refrigerators	18.98	$165	0.34	0.95	0.208
	- Clothes Washers	39.04	$373	0.66	0.66	0.447
	Subtotal	106.29	$981	1.84	0.45	2.035
Commercial Appliances	- Water Coolers	7.69	$61	0.14	0.70	0.121
	- Commercial Refrigeration	4.61	$36	0.08	0.95	0.051
	- Hot Food Holding Cabinets	0.41	$3	0.01	0.95	0.004
	- Fryers	0.34	$4	0.00	0.95	0.000
	- Steamers	0.18	$2	0.00	0.95	0.001
	- Vending Machines	1.59	$13	0.03	0.95	0.017
	Subtotal	14.82	$118	0.26	0.78	0.195
Other	- Utility Transformers	0.06	$0.50	0.00	1.00	0.001
	- C&I Transformers	0.98	$8	0.02	0.77	0.013
	- Residential Roofing	0.66	$5	0.01	0.15	0.084
	- Commercial Roofing	27.75	$195	0.52	0.15	2.814
	Subtotal	29.45	$208	0.55	0.15	2.912
TOTAL		1,193.63	$10,281	21.15	0.56	18.124

Notes on next page

Notes to Table 5

a) Columns may not total due to rounding.

b) Electricity is converted to primary energy using a conversion factor of 10,913 Btu/kWh (US DOE).

c) Energy bills are calculated using yearly U.S. average energy prices. See Table 2.

d) Carbon emissions for electricity are from Cadmus (1998). See Table 2.

e) CLFs for clothes washers and dishwashers are derived from PG&E and SCE summer load shape from Ruderman et al. (1989, Table D-1 to D-5 and D-7 to D-11, p. D-1 to D-12). Dehumidifier CLF take from usage patterns from AD Little (1998). Water cooler CLF derived from metered load data from Rovi (2001). CLFs for cooling technologies and refrigeration equipment are taken from Koomey et al. (1990). Roofs are assumed to have the same CLF as cooling technologies. Commercial cooking equipment is assumed to have the same CLF as commercial refrigeration. Residential lighting CLFs are based on load profiles taken from an October 1979 report by the CEC. CLFs for exit signs and traffic signals equal one because they operate 24 hours a day. CLFs for consumer electronics equal one because savings are assumed to accrue whether the device is on or off. Office equipment CLFs are derived from assumed operating patterns (Piette et al. 1995, Nordman et al. 1998, and recent printer and scanner metered data). Ceiling fans are assumed to have the same CLF as residential lighting. Exhaust fans encompass several products. The CLF represents a weighted average of intermittent fans (assumed the same as lighting), continuously operated fans (CLF of 1), and rangehood fans (assumed the same as cooking equipment, Ruderman et al., 1989).

Table 6. Expected Annual Savings in 2007

Program	Equipment Type	Primary Savings	Energy Bill Savings, Undiscounted	Carbon Emissions Avoided	Conservation Load Factor	Peak Load Savings
		Trillion Btu	Million $2004	MtC		GW
Office Equipment	- Computers and Monitors	228.05	$1,748	3.96	1.18	2.225
	- Fax	5.70	$45	0.10	1.03	0.058
	- Copier	4.63	$35	0.08	5.81	0.024
	-Multifunction Device	42.44	$320	0.74	0.77	0.579
	- Scanner	15.75	$126	0.27	0.32	0.523
	- Printer	235.06	$1,810	4.08	7.51	0.730
	Subtotal	531.63	$4,084	9.22	1.00	4.138
Consumer Electronics	- TVs	62.16	$509	1.08	1.00	0.651
	-VCRs	9.63	$79	0.17	1.00	0.101
	-TV/VCR/DVD	13.67	$112	0.24	1.00	0.143
	-DVD Player	15.90	$130	0.28	1.00	0.167
	-Audio Equipment	18.38	$151	0.32	1.00	0.193
	-Telephony	9.61	$79	0.17	1.00	0.101
	-Set-top Box	1.29	$11	0.02	0.79	0.041
	-External Power Supplies	5.77	$46	0.01	1.00	0.060
	-Battery Charging Systems	0.13	$1	0.00	1.00	0.001
	Subtotal	136.54	$1,117	2.37	0.98	1.456
Heating & Cooling	- Furnace (Gas or Oil)	70.24	$747	1.05	-	-
	- Central Air Conditioner	32.21	$264	0.56	0.15	2.250
	- Air-Source Heat Pump	25.24	$207	0.44	0.15	0.632
	- Geothermal Heat Pump	4.62	$38	0.08	0.15	0.037
	- Boiler (Gas or Oil)	3.56	$43	0.06	-	-
	- Programmable Thermostat	55.67	$562	0.90	0.15	0.811
	- Unitary HVAC	34.07	$257	0.59	0.15	2.379
	Subtotal	225.60	$2,117	3.68	0.18	6.110
Res and Com Lighting	- Fixtures	107.87	$883	1.87	1.02	1.103
	- CFLs	133.89	$1,097	2.32	1.02	1.369
	- Exit Sign	5.93	$45	0.10	1.00	0.062
	- Traffic Signal	14.70	$111	0.25	1.00	0.154
	Subtotal	262.38	$2,136	4.55	1.02	2.688
Residential Appliances	- Room Air Conditioners	16.91	$139	0.29	0.15	1.181
	- Dehumidifiers	5.29	$43	0.09	0.42	0.133
	- Air Cleaners	2.59	$21	0.04	1.00	0.027
	- Exhaust Fans	1.49	$12	0.03	1.02	0.015
	- Ceiling Fans	2.93	$24	0.05	1.02	0.030
	- Dishwashers	31.59	$286	0.52	0.77	0.309
	- Refrigerators	22.11	$181	0.38	0.95	0.243
	- Clothes Washers	44.41	$400	0.73	0.66	0.514
	Subtotal	127.33	$1,106	2.15	0.45	2.452
Commercial Appliances	- Water Coolers	9.64	$73	0.17	0.70	0.152
	- Commercial Refrigeration	6.28	$47	0.11	0.95	0.069
	- Hot Food Holding Cabinets	0.54	$4	0.01	0.95	0.006
	- Fryers	0.47	$5	0.01	0.95	0.000
	- Steamers	0.33	$3	0.01	0.95	0.002
	- Vending Machines	2.48	$19	0.04	0.95	0.027
	Subtotal	19.73	$151	0.34	0.78	0.256
Other	- Utility Transformers	0.06	$0.5	0.00	1.00	0.001
	- C&I Transformers	0.98	$7	0.02	0.77	0.013
	- Residential Roofing	0.87	$56	0.02	0.15	0.111
	- Commercial Roofing	35.11	$237	0.63	0.15	3.567
	Subtotal	37.03	$250	0.67	0.15	3.693
TOTAL		1,340	$10,961	22.97	0.54	20.793

Notes next page.

Notes to Table 6:
a) Columns may not total due to rounding.
b) Electricity is converted to primary energy using a conversion factor of 10,896 Btu/kWh (US DOE).
c) Energy bills are calculated using yearly U.S. average energy prices. See Table 2.
d) Carbon emissions for electricity are from Cadmus (1998). See Table 2.
e) Peak load savings are calculated using the CLFs shown in Table 5.

Target Market Penetration Case. This case 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. The target market penetration case uses unit savings estimates and year-by-year penetration targets with the best available estimates of inputs such as energy prices and carbon emission factors. The target market penetrations are based, in part, on the price premium for ENERGY STAR units. Because ENERGY STAR computers are no more expensive than non-ENERGY STAR devices, they are expected to represent a large share of the market (90 percent or more) by 2015. In contrast, high efficiency heating and cooling equipment is significantly more expensive than standard equipment.

Table 7 and Table 8 show the cumulative savings under target market penetrations for the periods 2007-2015 and 2007-2025, respectively. All the products together are expected to save 18.2 quadrillion Btu (quads) by 2015, growing to 49 quads by 2025. Through 2015, computers are monitors are projected to be the largest source of savings, with printers close behind. The large projected savings are primarily due to the significant market share of ENERGY STAR devices, the revised computer and imaging equipment specifications that address active/idle power, and steep growth in the overall number of units in place. CFLs and residential lighting fixtures are neck and neck for the third highest savings.

By 2025, the same four products (computers and monitors, printers, residential fixtures and CFLs) take the top four slots. Although residential fixtures and CFLs have only a moderate penetration, the number of units shipped each year is large, resulting in a large number of ENERGY STAR units in place, each with a high unit savings.

100 Percent Market Penetration. Our 100 percent market penetration scenario shows the savings that could be achieved if everyone bought ENERGY STAR equipment instead of standard equipment from 2007 to 2015. Because geothermal heat pumps are a new technology without a defined baseline market share, they are modeled as replacing a share of the markets for more traditional technologies. Geothermal heat pumps are assumed to displace half of non-ENERGY STAR air-source heat pumps. The 100 percent penetration forecast for air-source heat pumps takes into account this loss of market to geothermal heat pumps. As noted above, among residential lighting fixtures only high-use fixtures are assumed to achieve 100 percent market penetration in this scenario. Medium- and low-use

fixtures are assumed to have maximum market penetrations of 50 percent and 10 percent, respectively. Similarly, for CFLs we assume a maximum penetration of 50 percent for medium-use fixtures and 25 percent for low-use applications.

The 100 percent market penetration scenario should not be interpreted as a technical potential, because although we assume that all units sold are ENERGY STAR, we do not assume that all units sold are properly enabled. Studies have noted less than 100 percent enabling rates of ENERGY STAR features in office equipment, particularly copiers, computers and monitors (see Table 3).

The cumulative savings for the 100 percent market penetration scenario are shown in Tables 9 and 10. Together the programs could save 47 quads from 2007 to 2015, growing to 126 quads by 2025. These correspond to a total energy bill savings of $282 billion through 2015 and $632 billion through 2025 (present value, discounted at a 4 percent real discount rate). These totals are about three times the savings in the target market penetration case. The largest savings in the 100 percent market penetration 2015 case is due to CFL's, followed by residential lighting fixtures, computers, printers, and external power supplies. By 2025 the largest share of savings are attributed to residential lighting fixtures, followed by CFLs, computers and furnaces (gas and oil fired).

These cumulative figures represent an increase in of 84 MMTC (2007 to 2015) and 192 MMTC (2007-2025) compared to estimates from our last update. Nearly half of the increase in cumulative savings is due to the revised computer and imaging equipment specifications.

Table 7. Cumulative Savings 2007-2015, Target Market Penetrations

Program	-Equipment	Primary Energy Savings Trillion Btu	Energy Bill Savings Million $2004 Undiscounted	Energy Bill Savings Million $2004 Discounted	Carbon Avoided MMTC
Office Equipment	- Computers and Monitors	3,066	$22,295	$16,535	45.86
	- Fax	48	$374	$246	0.75
	- Copier	51	$366	$237	0.78
	-Multifunction Device	627	$4,444	$2,828	9.36
	- Scanner	191	$1,459	$944	2.88
	- Printer	2,950	$21,533	$13,832	44.38
	Subtotal	6,934	$50,472	$34,622	104.01
Consumer Electronics	- TVs	864	$6,817	$5,518	12.96
	-VCRs	41	$323	$280	0.64
	-TV/VCR/DVD	160	$1,259	$1,026	2.41
	-DVD Player	143	$1,127	$934	2.18
	-Audio Equipment	177	$1,400	$1,159	2.71
	-Telephony	121	$955	$774	1.82
	-Set-top Box	14	$111	$92	0.21
	-External Power Supplies	192	$1,443	$1,141	2.83
	-Battery Charging Systems	12	$95	$73	0.17
	Subtotal	1,724	$13,530	$10,996	25.94
Heating & Cooling	- Furnace (Gas or Oil)	1,101	$10,791	$8,689	16.00
	- Central Air Conditioner	400	$3,158	$2,562	6.01
	- Air-Source Heat Pump	347	$2,737	$2,209	5.19
	- Geothermal Heat Pump	91	$715	$569	1.34
	- Boiler (Gas or Oil)	45	$500	$407	0.72
	- Programmable Thermostat	589	$5,585	$4,600	8.93
	- Unitary HVAC	626	$4,428	$3,541	9.29
	Subtotal	3,198	$27,914	$22,578	47.49
Res and Com Lighting	- Fixtures	1,690	$13,330	$10,698	25.18
	- CFLs	1,748	$13,795	$11,187	26.27
	- Exit Sign	45	$320	$269	0.69
	- Traffic Signal	116	$828	$697	1.79
	Subtotal	3,599	$28,272	$22,851	53.94
Residential Appliances	- Room Air Conditioners	232	$1,834	$1,173	3.49
	- Dehumidifiers	123	$972	$609	1.82
	- Air Cleaners	59	$461	$290	0.87
	- Exhaust Fans	27	$216	$137	0.41
	- Ceiling Fans	71	$556	$347	1.04
	- Dishwashers	547	$4,676	$2,959	8.05
	- Refrigerators	309	$2,441	$1,558	4.63
	- Clothes Washers	500	$4,246	$2,750	7.47
	Subtotal	1,869	$15,402	$9,823	27.78
Commercial Appliances	- Water Coolers	159	$1,125	$906	2.37
	- Commercial Refrigeration	116	$821	$658	1.73
	- Hot Food Holding Cabinets	15	$107	$83	0.22
	- Fryers	11	$105	$84	0.15
	- Steamers	17	$145	$111	0.25
	- Vending Machines	71	$502	$363	1.04
	Subtotal	389	$2,806	$2,206	5.76
Other	- Utility Transformers	1	$4	$3	0.01
	- C&I Transformers	9	$62	$51	0.13
	- Residential Roofing (per 1000 ft^2)	16	$110	$88	0.24
	- Commercial Roofing (per 1000 ft^2)	437	$2,787	$2,272	6.65
	Subtotal	462	$2,962	$2,414	7.03
TOTAL		18,175	$141,358	$105,490	271.94

See notes after Table 10.

Table 8. Cumulative Savings 2007-2025, Target Market Penetrations

Program	-Equipment	Primary Energy Savings Trillion Btu	Energy Bill Savings Million $2004 Undiscounted	Energy Bill Savings Million $2004 Discounted	Carbon Avoided MMTC
Office Equipment	- Computers and Monitors	8,834	$65,580	$38,386	121.74
	- Fax	95	$739	$410	1.36
	- Copier	118	$850	$454	1.65
	-Multifunction Device	1,586	$11,422	$5,957	21.97
	- Scanner	408	$3,162	$1,711	5.74
	- Printer	7,137	$58,785	$30,553	99.47
	Subtotal	18,177	$140,539	$77,471	251.94
Consumer Electronics	- TVs	2,180	$17,422	$11,995	30.28
	-VCRs	53	$422	$352	0.81
	-TV/VCR/DVD	379	$3,028	$2,110	5.29
	-DVD Player	309	$2,473	$1,760	4.37
	-Audio Equipment	384	$3,073	$2,187	5.43
	-Telephony	371	$2,977	$1,984	5.11
	-Set-top Box	29	$233	$167	0.41
	-External Power Supplies	403	$3,049	$2,226	5.61
	-Battery Charging Systems	35	$275	$192	0.47
	Subtotal	4,144	$32,972	$22,973	57.79
Heating & Cooling	- Furnace (Gas or Oil)	3,430	$33,807	$22,466	49.06
	- Central Air Conditioner	952	$7,610	$5,292	13.28
	- Air-Source Heat Pump	888	$7,108	$4,862	12.31
	- Geothermal Heat Pump	322	$2,587	$1,683	4.39
	- Boiler (Gas or Oil)	120	$1,341	$918	1.91
	- Programmable Thermostat	1,293	$12,342	$8,764	18.99
	- Unitary HVAC	1,951	$14,080	$9,355	26.72
	Subtotal	8,956	$78,876	$53,340	126.67
Res and Com Lighting	- Fixtures	5,844	$46,925	$30,626	79.82
	- CFLs	4,657	$37,286	$25,425	64.54
	- Exit Sign	76	$545	$414	1.10
	- Traffic Signal	108	$764	$720	1.70
	Subtotal	10,685	$85,520	$57,186	147.15
Residential Appliances	- Room Air Conditioners	601	$4,812	$2,507	8.34
	- Dehumidifiers	387	$3,104	$1,563	5.30
	- Air Cleaners	193	$1,550	$772	2.64
	- Exhaust Fans	77	$618	$316	1.06
	- Ceiling Fans	258	$2,067	$1,017	3.50
	- Dishwashers	1,614	$13,976	$7,110	22.48
	- Refrigerators	871	$6,974	$3,577	12.02
	- Clothes Washers	1,049	$8,841	$4,822	14.79
	Subtotal	5,050	$41,943	$21,683	70.12
Commercial Appliances	- Water Coolers	419	$3,021	$2,057	5.80
	- Commercial Refrigeration	323	$2,330	$1,570	4.45
	- Hot Food Holding Cabinets	97	$704	$426	1.29
	- Fryers	40	$401	$258	0.57
	- Steamers	96	$813	$503	1.32
	- Vending Machines	284	$2,054	$1,174	3.84
	Subtotal	1,258	$9,323	$5,988	17.27
Other	- Utility Transformers	1	$8	$6	0.02
	- C&I Transformers	18	$130	$94	0.26
	- Residential Roofing (per 1000 ft^2)	57	$403	$261	0.76
	- Commercial Roofing (per 1000 ft^2)	1,070	$6,956	$4,814	14.80
	Subtotal	1,146	$7,498	$5,174	15.83
TOTAL		49,417	$396,671	$243,816	686.77

See notes after Table 10.

Table 9. Cumulative Savings 2007-2015, 100% Market Penetration

Program	-Equipment	Primary Energy Savings	Energy Bill Savings Million $2004		Carbon Avoided
		Trillion Btu	Undiscounted	Discounted	MMTC
Office Equipment	- Computers and Monitors	4,638	$33,706	$24,673	69.37
	- Fax	50	$388	$255	0.78
	- Copier	57	$406	$262	0.86
	-Multifunction Device	745	$5,279	$3,369	11.14
	- Scanner	217	$1,660	$1,076	3.28
	- Printer	3,113	$22,728	$14,639	46.94
	Subtotal	8,820	$64,168	$44,274	132.38
Consumer Electronics	- TVs	1,838	$14,483	$11,475	27.11
	-VCRs	86	$678	$563	1.31
	-TV/VCR/DVD	250	$1,972	$1,589	3.74
	-DVD Player	215	$1,699	$1,386	3.25
	-Audio Equipment	378	$2,977	$2,395	5.64
	-Telephony	514	$4,048	$3,222	7.61
	-Set-top Box	481	$3,789	$2,983	7.06
	-External Power Supplies	2,392	$17,995	$14,240	35.23
	-Battery Charging Systems	110	$868	$684	1.62
	Subtotal	6,265	$48,510	$38,536	92.56
Heating & Cooling	- Furnace (Gas or Oil)	2,148	$21,054	$16,734	31.33
	- Central Air Conditioner	1,315	$10,361	$8,189	19.36
	- Air-Source Heat Pump	1,087	$8,558	$6,769	16.00
	- Geothermal Heat Pump	121	$955	$7856	1.79
	- Boiler (Gas or Oil)	110	$1,209	$961	1.75
	- Programmable Thermostat	1,775	$16,766	$13,382	26.63
	- Unitary HVAC	1,288	$9,103	$7,224	19.01
	Subtotal	7,844	$68,006	$54,016	115.86
Res and Com Lighting	- Fixtures	7,572	$59,621	$46,968	111.13
	- CFLs	9,249	$73,150	$61,321	142.77
	- Exit Sign	65	$460	$380	0.98
	- Traffic Signal	116	$828	$697	1.79
	Subtotal	17,002	$134,058	$109,366	256.68
Residential Appliances	- Room Air Conditioners	390	$3,072	$1,938	5.78
	- Dehumidifiers	185	$1,457	$910	2.72
	- Air Cleaners	314	$2,470	$1,531	4.59
	- Exhaust Fans	187	$1,471	$914	2.74
	- Ceiling Fans	932	$7,333	$4,545	13.62
	- Dishwashers	796	$6,805	$4,287	11.70
	- Refrigerators	605	$4,770	$2,999	8.96
	- Clothes Washers	884	$7,345	$4,661	13.06
	Subtotal	4,293	$34,723	$21,784	63.17
Commercial Appliances	- Water Coolers	211	$1,493	$1,194	3.13
	- Commercial Refrigeration	220	$1,556	$1,235	3.25
	- Hot Food Holding Cabinets	194	$1,368	$1,075	2.84
	- Fryers	71	$700	$550	1.02
	- Steamers	120	$964	$7857	1.75
	- Vending Machines	195	$1,374	$950	2.85
	Subtotal	1,011	$7,455	$5,761	14.85
Other	- Utility Transformers	1	$4	$3	0.01
	- C&I Transformers	9	$62	$51	0.13
	- Residential Roofing (per 1000 sq ft)	211	$1,444	$1,131	3.10
	- Commercial Roofing (per 1000 sq ft)	1,486	$9,448	$7,522	22.12
	Subtotal	1,706	$10,958	$8,708	25.36
TOTAL		46,939	$367,878	$282,446	700.85

See notes after Table 10.

Table 10. Cumulative Savings 2007-2025, 100% Market Penetration

Program	-Equipment	Primary Energy Savings	Energy Bill Savings Million $2004		Carbon Avoided
		Trillion Btu	Undiscounted	Discounted	MMTC
Office Equipment	- Computers and Monitors	11,436	$84,654	$49,950	158.82
	- Fax	97	$754	$420	1.39
	- Copier	131	$944	$504	1.84
	-Multifunction Device	1,812	$13,046	$6,852	21.18
	- Scanner	448	$3,467	$1,892	6.32
	- Printer	7,342	$60,353	$31,527	102.58
	Subtotal	21,265	$163,218	$91,144	296.13
Consumer Electronics	- TVs	5,449	$43,619	$28,016	74.61
	-VCRs	128	$1,013	$794	1.86
	-TV/VCR/DVD	605	$4,839	$3,219	8.41
	-DVD Player	484	$3,866	$2,619	6.78
	-Audio Equipment	947	$7,573	$5,013	13.13
	-Telephony	1,232	$9,837	$6,538	17.06
	-Set-top Box	1,428	$11,432	$7,5296	19.51
	-External Power Supplies	4,383	$33,160	$23,721	61.48
	-Battery Charging Systems	209	$1,654	$1,175	2.92
	Subtotal	14,864	$116,993	$78,361	205.77
Heating & Cooling	- Furnace (Gas or Oil)	7,984	$79,165	$49,129	114.72
	- Central Air Conditioner	4,660	$37,386	$23,392	63.35
	- Air-Source Heat Pump	3,566	$28,577	$18,091	48.62
	- Geothermal Heat Pump	475	$3,814	$2,351	6.44
	- Boiler (Gas or Oil)	400	$4,484	$2,789	6.39
	- Programmable Thermostat	5,768	$55,303	$35,082	83.83
	- Unitary HVAC	4,335	$31,301	$19,739	59.09
	Subtotal	27,188	$240,030	$150,573	382.43
Res and Com Lighting	- Fixtures	30,331	$243,742	$149,507	410.48
	- CFLs	10,709	$84,557	$69,444	162.09
	- Exit Sign	128	$919	$644	1.82
	- Traffic Signal	108.4	$764	$692	1.70
	Subtotal	41,276	$329,982	$220,287	576.07
Residential Appliances	- Room Air Conditioners	1,217	$9,752	$4,920	16.66
	- Dehumidifiers	604	$4,838	$2,423	8.23
	- Air Cleaners	1,033	$8,276	$4,119	14.05
	- Exhaust Fans	594	$4,756	$2,388	8.09
	- Ceiling Fans	3,002	$24,044	$12,048	40.87
	- Dishwashers	2,479	$21,473	$10,834	34.45
	- Refrigerators	2,133	$17,126	$8,455	29.05
	- Clothes Washers	2,594	$21,634	$11,037	35.83
	Subtotal	13,657	$111,898	$56,224	187.24
Commercial Appliances	- Water Coolers	581	$4,187	$2,722	8.00
	- Commercial Refrigeration	637	$4,585	$2,955	8.73
	- Hot Food Holding Cabinets	765	$5,532	$3,407	10.35
	- Fryers	241	$2,394	$1,507	3.45
	- Steamers	397	$3,224	$2,037	5.50
	- Vending Machines	652	$4,705	$2,619	8.88
	Subtotal	3,273	$24,628	$15,248	44.90
Other	- Utility Transformers	1	$8	$6	0.02
	- C&I Transformers	18	$130	$90	0.26
	- Residential Roofing (per 1000 sq ft)	876	$6,138	$3,746	11.46
	- Commercial Roofing (per 1000 sq ft)	3,963	$25,753	$16,764	54.00
	Subtotal	4,858	$32,029	$20,606	65.73
TOTAL		126,381	$1,018,777	$632,443	1,758.28

See notes next page.

Notes to Tables 7-10:
a) Columns values may not add up to total due to rounding.
b) Target market penetrations represent EPA's and DOE's best estimates of the percent of equipment shipped that is ENERGY STAR. These estimates are based on past market penetrations, manufacturer commitments, and EPA's and DOE's long-term goals. The 100 percent market penetration scenario assumes all equipment shipped from 2004 onward is ENERGY STAR-compliant.
c) Electricity is converted to primary energy using conversion factors given in Table 2.
d) Cumulative bill savings do not take into account increased investment costs. Cumulative bill savings are discounted using a 4 percent real discount rate.
e) Yearly U.S. average energy prices are from US DOE (1996a, 1996b, 1997b, 1998b, 1999, 2000, and 2001). See Table 2.
f) Carbon emissions for electricity are from Cadmus (1998) and EPA (2003). See Table 2.

Energy Star specifications developed or revised after year 2000 require Energy Star partners to report sales data for Energy Star units sold during each calendar year. Energy Star first obtained sales data for calendar year 2001. Since that time, an increasing number of products have become a part of the calendar year sales data collection process. Table 11 shows Energy Star sales and market share for 2005.

Table 11. ENERGY STAR Market Shares for 2005

Equipment Type	Total Energy Star Shipments	Source Code	Total US Shipments	Source Code	Energy Star Market Share
	1000s	See notes	1000s	See notes	%
Office Equipment					
- Office PC	36,673.97	a	37,631.52	g	97.5
- Office CRT Monitor	3,652.76	b	3,652.76	h	100.0
- Office LCD Monitor	11,430.62	b	19,571.20	h	58.4
- Home PC	23,307.13	a	31,925.48	g	73.0
- Home CRT Monitor	2,334.08	b	2,334.08	h	100.0
- Home LCD Monitor	7,303.41	b	12,505.80	h	58.4
- Fax	1,323.12	a	1,337.80	i	98.9
- Copier (1)	83.33	a	92.59	a	90.0
-Multifunction Device	3,132.06	a	3,349.20	a	93.5
- Scanner	7,259.28	c	9,074.10	j	80.0
- Printer	37,960.04	a	38,075.50	a	99.7
Consumer Electronics					
- TVs *(doesn't include component TV or TV monitors)*	10,245.16	b	26,349.82	k	38.9
-VCRs	3,077.11	d	10,986.63	d	28.0
-TV/VCR/DVD	3,700.61	b	6,697.66	d	55.3
-DVD Player	3,776.41	b	11,755.53	d	32.1
-Mini-Systems	1,302.43	e	6,010.45	d	21.7
-Home Theater	827.80	d	3,807.00	d	21.7
-Audio Separates	436.30	d	2,068.17	d	21.1
-Compact Disc Player	0.57	b	598.13	d	0.10
-Answering Machines	0.00	b	4,387.14	l	0.0
-Cordless Phones	1,714.98	b	23,945	l	7.2
-DSS Cordless Phones	4,411.16	b	9,806.52	l	45.0
-Combination Phones	2,050	b	7,577.40	l	27.1
-DSS Combination Phones	6,488.12	b	14,638.23	l	44.3
-Additional Handsets	2,265.49	b	3,203.34	l	70.7
-Set-top Box	2.98	b	3,453.19	c	0.1
-External Power Supplies	16,211.00	b	436,281.30	c	3.7
Heating and Cooling					
- Oil Furnace	7.60	b	111.24	j	6.8
- Gas Furnace	1,312.30	b	3,512.46	j	37.4
- Central Air Conditioner	1,245.73	b	6,471.00	j	19.3
- Air-Source Heat Pump	583.99	b	2,136.53	j	27.3
- Geothermal Heat Pump	32.52	b	42.24	m	77.0
- Gas Boiler	55.09	b	224.19	j	24.6
- Oil Boiler	83.43	b	162.47	j	51.4
- Programmable Thermostat	2,207.84	c	6,396.15	n	34.5
- Unitary HVAC	196.29	b	694.91	c	28.3
Residential and Commercial Lighting					
- Indoor Fixtures	7,466.18	b	190,564.27	o	3.9
- Outdoor Fixtures	3,0587.50	b	28,054.67	o	10.9
- CFLs	80,606.68	b	1,477,452.03	o	5.5
- Exit Sign	1,954.73	b	3,923.92	p	49.8
- Traffic Signal	654.07	b	8,840.00	q	7.4
Residential Appliances					
- Room Air Conditioners	4,186.28	f	8,032.00	j	52.1
- Dehumidifiers	1,800.49	b	1,957.00	j	92.0
- Air Cleaners	208.58	b	1,629.40	r	12.8
- Exhaust Fans	828.99	b	6,199.46	s	13.4
- Ceiling Fans	3,521.20	b	19,800.00	j	17.8
- Dishwashers	5,980.08	f	7,291.00	j	82.0
- Refrigerators	3,666.43	f	11,134.00	j	32.9
- Clothes Washers	3,362.51	f	9,225.00	j	36.5
Commercial Appliances					
- Water Coolers	726.36	b	1,074.79	t	67.6
- Commercial Refrigeration	104.17	b	236.68	u	44.0
- Hot Food Holding Cabinets	10.63	b	110.71	v	9.6
- Fryers	5.77	b	82.14	w	7.0

- Steamers	4.4	b	40.12	w	11.0
- Vending Machines	68.58	b	246.05	x	27.9
Other					
- Utility Transformers	0	b	1,353.08	y	0.0
- C&I Transformers	64.69	b	264.03	y	24.5
- Residential Roofing (1000 sq ft)	0.24	b	4.45	z	5.5
- Commercial Roofing (1000 sq ft)	3.46	b	15.30	z	22.6

Notes to Table 11:

* Columns values may not add up to total due to rounding. Unitary HVAC expressed as million sq. ft.

a) Gartner 2001

b) ICF 2006

c) LBNL estimate

d) CEA reported Energy Star sales data for 2004 and 2005 as well as total US Shipments (2004/5). In 2005, CEA only reported stand-alone VCR shipments, to get all 2005 shipments (VCR/DVD-now the majority of the market), we needed to add CEA's 2005 standalone VCR estimate to the 2004 CEA Energy Star VCR/DVD combination unit sales

e) Reflects CEA shipments for 2005 plus non-CEA Partners that reported to ICF 2006

f) D&R Energy Star sales data 2006

g) IDC (2006) Worldwide PC Forecast 2006-2010; Residential/Commercial split taken from Gartner 2001

h) IDC (2003) Worldwide PC Monitor Forecast and Analysis 2002-2007; Residential/Commercial split taken from Gartner 2001

i) CEA Market Research, 2004. U.S. Consumer Electronics Sales & Forecasts 1999-2004. Consumer Electronics Association. January; Res/com split taken from Gartner 2001

j) Appliance Magazine (2006). 54th Annual Appliance Industry Forecast.

k) iSupply (2005)

l) CEA 2005. Domestic Sales of Corded and Cordless Telephones and Answering Machines. Report 530

m) Based off of Survey of Geothermal HP Manufacturers (2004)

n) Based off of RECS 2001 programmable thermostat stock

o) Based off densities obtained in Vorsatz (1997) and residential floor stock (US DOE 2001)

p) Based off of exit sign stock as reported in Conway, K., P. Boyce, Andrew Bierman, Josepgh Ceterski and Burr Ruttledge. 1996. Exit Signs. Prepared for BPA, NYSERDA and EPA. May.

q) Strategies Unlimited 2004

r) ICF Draft Air Cleaner Industry and Market Research Analysis. 2001.

s) Cadmus, June 1999, Preliminary Market Background Report for Residential Ventilation Fans.

t) Cadmus 1999. Preliminary Market Background Report for Water Coolers. September.

u) The Cadmus Group, "Preliminary Market Background Report for Commercial Reach-In Refrigerators and Freezers." March 1, 2001

v) David Zabrowski, Food Service Technology Center (spreadsheet HFC Data_needs_assessment.xls) –hfhc

w) NAFEM (the North American Association of Food Equipment Manufacturers), "Size and Shape of the Industry Study: Primary Cooking Equipment."

x) Vending Market and Industry Final Draft. ICF 2005.

y) Based off of ORNL. 1996. Determination Analysis of Energy Conservaiton Standards for Distribution Transformers. ORNL-6847.

z) Based off of 2002 sales from The National Roof Contractors Association

Limitations of the Analysis

Our estimates of unit energy consumptions for office equipment and consumer electronics are calculated from underlying usage patterns and power consumption estimates. We face limitations on two fronts: First, there have been limited data collected for many of these products. As more information has become available, we have updated our forecasts, and we will continue to do so in the future. New information may change our estimates significantly. Second, there is great diversity in power consumption within each product category, and we lack the data to create a precise shipment-weighted average energy consumption.

Our analysis focuses exclusively on the ENERGY STAR Program and does not attempt to rigorously reconcile the projected effects of the program with the existence of other overlapping efficiency programs.

Procurement programs and utility rebate programs now often use the ENERGY STAR label to identify qualifying products, reducing the costs of designing and operating these programs while helping to boost the market share of ENERGY STAR products. This analysis does not attempt to account for these interactions, and therefore the savings presented here include savings that might legitimately be claimed by other energy conservation programs. Sorting through the universe of efficiency programs to assess all potential interactions was beyond the scope of this analysis. Care should be taken, therefore, in combining these savings forecasts with those of other programs.

Although our analysis takes into account existing and finalized future federal minimum efficiency standards, we chose not to speculate about possible future standards and how they might affect the savings due to the various ENERGY STAR labels in the future. Such standards would probably trigger a tightening in the ENERGY STAR requirement, which would reduce the number of products qualifying for a label. A stringent enough standard could even eliminate the need for an ENERGY STAR label. The products affected by federal minimum efficiency standards include central air conditioners, heat pumps, room air conditioners, furnaces, boilers, refrigerators, clothes washers and dishwashers.

Technological developments already on the horizon will likely force us to revise our forecast in the not-too-distant future. The rapid adoption of new television technologies (e.g. plasma, LCD and DLP) is undoubtedly changing TV power consumption. DVD players are rapidly supplanting VCRs in the market. We believe that EPA and DOE will try to leverage their existing partnerships with manufacturers to extend the ENERGY STAR label to new technologies. The face of office equipment is also changing as portable devices and wireless communication technologies take hold. While we try to capture the effects of existing trends, the future of many technologies is too nebulous to predict in a way that could be incorporated into this analysis.

The savings presented here are for the U.S. only. Since many of the ENERGY STAR products, notably office equipment, are marketed internationally, the global effects of the program may be significantly higher.

Our analysis extends only to 2025, and we made no attempt to account for savings that might accrue after that time.

Conclusions

ENERGY STAR has already proven successful in its established programs, having saved, by our estimates, more than 1,194 trillion Btus of energy and prevented carbon emissions of 21.1 million metric tons in 2006 alone. Based on our analysis here, the continuation of those programs and the addition of new programs in appliances and home electronics have the potential to greatly reduce carbon emissions over the next 20 years. As EPA and DOE continue to work to improve savings through consumer education, partnerships with manufacturers, new product labels, and tightening requirements for existing products, the ENERGY STAR program may be able to achieve even higher savings in the future. If ENERGY STAR-labeled products could achieve 100 percent market penetration, $282 billion could be saved from estimated energy bills through 2015 (present value, at a 4 percent real discount rate).

References

A.D. Little, 1996. *Energy Savings Potential for Commercial Refrigeration Equipment*. Prepared for US DOE Office of Building Technology. June.

AD Little, 1998. *Electricity Consumption by Small End Uses in Residential Buildings*. Prepared for the US DOE Office of Building Technology. August.

AHAM. 2002. Excel Spreadsheet: "*Appliance_Shipment_Trends_1991-2001.xls*". Air Cleaners

Appliance, 1995. "Statistical Review." April, pp 45-48.

Appliance, 1996. "A Portrait of the U.S. Appliance Industry 1996." September, pp 85-91.

Appliance, 1998. "A Portrait of the U.S. Appliance Industry 1998." September, pp 67-73.

Appliance, 2003. "50th Annual Report: Statistical Review." May, pp 47-50.

Appliance, 2004. "27th Annual Portrait of the U.S. Appliance Industry." September, pp P1-P7.

Appliance, 2006. "54th Annual Appliance Industry Forecast."

Cadmus (the Cadmus Group, Inc.) and Energy Systems Consulting, Inc., 1998. *Regional Electricity Emissions Factors*. Prepared for the U.S. Environmental Protection Agency. May.

Cadmus (the Cadmus Group, Inc.). 1999. *Preliminary Market Background Report for Residential Ventilation Fans*. Prepared for the U.S. Environmental Protection Agency. June.

Cadmus (the Cadmus Group, Inc.). 1999. *Preliminary Market Background Report for Residential Dehumidifiers*. Prepared for the U.S. Environmental Protection Agency. September.

Cadmus (the Cadmus Group, Inc.). 2000. *Product Testing and Analysis of Water Dispensers*. Prepared for the U.S. Environmental Protection Agency. February.

Cadmus (the Cadmus Group, Inc.). 2001. *Preliminary Market Background Report for Commercial Reach-In Refrigerators and Freezers*. Prepared for the U.S. Environmental Protection Agency. March.

Calwell, C., 1999. "Customers Turn Out for Torchiere Trade-In." *Home Energy*, 16(2), pp 32-35.

Calwell, C. and C. Granda, 1999. *Halogen Torchiere Market Transformation: A Look at Progress to Date and Future Strategies*. Natural Resources Defense Council. September.

Calwell, C. and N. Horowitz. 2001. "Ceiling Fans: Fulfilling the Energy Efficiency Promise." *Home Energy*, January/February 2001, pp 24-29.

CEA Market Research. 2004. *U.S. Consumer Electronics Sales & Forecasts, 1999-2004*. January.

CEA Industry Sales Statistics. 2005. Domestic Sales of Corded and Cordless Telephones and Answering Machines. Report 530 (2005).

CEA Industry Energy Star Sales data. 2004-2005. Energy Star Report 2005.xls.

Conway, K., P. Boyce, Andrew Bierman, Josepgh Ceterski and Burr Ruttledge. 1996. Exit Signs. Prepared for BPA, NYSERDA and EPA. May.

Fisher, Don. 2003. Personal communication: email exchange, March-June 2003.

Floyd, D. and C. Webber. 1998. "Leaking Electricity: Individual Field Measurements of Consumer Electronics." In *Proceedings of the 1998 Summer Study on Energy Efficiency in Buildings*. Washington DC: American Council for an Energy Efficient Economy.

Gartner. 2001. Special Report on PCs. Prepared for the Environmental Protection Agency Energy Star Program. November.

Guo, J. L., L. H. Lapera, A. Manning, P. Nappakaokeskui, M. Wyche, 1998. *Fall 1998 Report Forecasts: The Computer Hardware Industry*. Syracuse University Press. http://istweb.syr.edu/~ist775/spring98/hardware/profile_98.html.

ICF. 2001. Draft Air Cleaner Industry and Market Research Analysis. Prepared for the Environmental Protection Agency Energy Star Program.

ICF. 2002a. *Steamer Engineering Analysis*. Prepared for the Environmental Protection Agency Energy Star Program.

ICF. 2002b. *Fryer Engineering Analysis*. Prepared for the Environmental Protection Agency Energy Star Program.

ICF. 2002c. *ENERGY STAR® Product Development for Refrigerated Beverage Vending Machines Industry & Market Research and Analysis*. Prepared for the Environmental Protection Agency Energy Star Program.

ICF. 2003. *Energy Star Market Penetration Report Calendar Year 2002*. April.

ICF. 2005. *Vending Market and Industry Final Draft Report*. Prepared for the Environmental Protection Agency Energy Star Program.

ICF. 2006. *Energy Star Market Penetration Report Calendar Year 2005 (Final Draft)*. August.

IDC, 2003. *Worldwide PC Monitor Forecast and Analysis 2003-2007: It's a Flat-out Success*. December.

IDC, 2006. *Worldwide PC Forecast and Analysis 2006-2010: report number 201194.* April.

Isaacs, David (EIA/CEMA), 1998. Personal communication, discussion with Stephan Sylvan of EPA, September 3, 1997.

iSuppli. 2005. "*LCD TV Shipments Soar*." Television Systems Market Tracker-Q42005.

Koomey, Jonathan, Arthur H. Rosenfeld, and Ashok K. Gadgil. 1990. "Conservation Screening Curves to Compare Efficiency Investments to Power Plants." *Energy Policy*. vol. 18, no. 8. October. p. 774-782.

Koomey, Jonathan, Michael Cramer, Mary Ann Piette and Joseph Eto, 1995. *Efficiency Improvements in U.S. Office Equipment: Expected Policy Impacts and Uncertainties*. Lawrence Berkeley Laboratory. LBL-37383. December.

Lewis, J. E. and A. Clarke, 1990. *Replacement Market for Selected Commercial Energy Service Equipment* (Topical Report: Phase 1B--Commercial). Gas Research Institute. GRI-89/0204.02. June.

Lyra Research, Inc., 1998. *Single-Function Fax Machine Forecast*. Prepared exclusively for Environmental Protection Agency. March.

Media Metrix. 2001. *Softscan 3Q2001*.

NAFEM (the North American Association of Food Equipment Manufacturers), "Size and Shape of the Industry Study: Primary Cooking Equipment," ca 2003

National Lighting Product Information, 1994. Specifier Reports: Exit Signs. Volume 2, Number 2. Troy, NY: Lighting Research Center, Rensselaer Polytechnic Institute. March.

National Roof Contractors Association, 2002. "*2002-03 NRCA Market Survey*."

Nordman, B., M.A. Piette, B. Pon and K. Kinney, 1998. *It's Midnight...Is Your Copier On?: Energy Star Copier Performance*. Lawrence Berkeley National Laboratory. LBNL-41332, February.

NRDC. 2005. "Tuning into Energy Efficiecy: Prospects for Saving Energy in Televisions." Natural Resources Defense Council. January.

ORNL. 1996. "*Determination Analysis of Energy Conservaiton Standards for Distribution Transformers*." ORNL-6847.

Piette, M.A., M. Cramer, J. Eto and J. Koomey, 1995. *Office Technology Energy Use and Savings Potential in New York*. Completed for the New York State Energy Research and Development Authority and Consolidated Edison by Lawrence Berkeley Laboratory. Contract #1955-EEED-BES-93, also LBL-36752. January.

Roberson, J., B. Nordman, R. Brown, C. Webber, J. Koomey. 2000. *Measured Low Power Levels in Personal Computers, Vintage 1990-2000*. Memo to Andrew Fanara and Marla Sanchez of EPA, July 14.

Roberson, J., G. Homan, A. Mahajan, B. Nordman, C. Webber, R. Brown, M. McWhinney, and J. Koomey. 2002. *Energy Use and Power Management in New Personal Computers and Monitors*. Lawrence Berkeley National Laboratory, LBNL-48581. July.

Roberson, J. A., C. Webber, M. McWhinney, R. Brown, M. Pinckard, Busch, J. 2004. *After-hours power status of office equipment and energy use of miscellaneous plug-load equipment*. Lawrence Berkeley National Laboratory, LBNL-53729 Rev. May

Rovi, J. 2001. *Personal Communication*. Excel file containing metered water cooler data received 5/14/01 via Email.

Rosen, K. and A. Meier. 1999. *Energy Use of Televisions and Videocassette Recorders in the U.S.* Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-42393. March.

Roth, Kurt et al. 2006. "*US Residential Information Technology Consumption in 2005 and 2010*". Prepared by Tiax LLC for US DOE. Final Report. March.

Ruderman, H., J. Eto, K. Heinemier, A. Golan, and D. Wood. 1989. *Residential End-Use Load Shape Data Analysis: Final Report.* Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-27114. April.

Sanchez, M., J. Koomey, M. Moezzi, A. Meier, and W. Huber, 1998. *Miscellaneous Electricity Use in the U.S. Residential Sector*. Lawrence Berkeley National Laboratory. LBNL-40295, April.

Sanchez, M., A. Fanara, and R. Schmeltz, 2000. "New Product Development: The Pipeline for Future ENERGY STAR® Growth." In Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 6:343-354. American Council for an Energy Efficient Economy, Washington, DC.

Strategies Unlimited. 2004. "*LED Traffic Signal Shipment spreadsheet*".

Suozzo, M. and S. Nadel. 1998. *Selecting Targets for Market Transformation Programs: A National Analysis*. American Council for an Energy Efficient Economy, Washington, DC. August.

Thomas, A., M. Shincovich, S. Ryan, D. Korn, J. Shugars. 2002. "Replacing Distribution Transformers: A Hidden Opportunity for Energy Savings." In *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. American Council for an Energy Efficient Economy, Washington, DC.

U.S. Department of Commerce, 1997. *Electric Lighting Fixtures--1996*. Current Industrial Reports MA36L(96)-1. Bureau of the Census. September.

U.S. Department of Commerce, 2000. Implicit GDP Deflator. Bureau of Economic Analysis, http://www.bea.doc.gov/bea/dn1.htm. March 6.

US DOE, U.S. Department of Energy, 1995a. *Monthly Energy Review*. DOE/EIA-0035(95/05). Energy Information Administration. May.

US DOE, U.S. Department of Energy, 1995b. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Refrigerators, Refrigerator/Freezers and Freezers*. Washington, DC.: US Department of Energy, Energy Efficiency and Renewable Energy, Office of Codes and Standards. DOE/EE-0064. July.

US DOE, U.S. Department of Energy, 1996a. *Annual Energy Outlook 1996 with Projections to 2015*. DOE/EIA-0383(96). Energy Information Administration. January.

US DOE, U.S. Department of Energy, 1996b. *Annual Energy Outlook 1997 with Projections to 2015*. DOE/EIA-0383(97). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 1997a. *Technical Support Document for Energy Conservation Standards for Room Air Conditioners*. US Department of Energy, Energy Efficiency and Renewable Energy, Office of Codes and Standards. http://www.eren.doe.gov/buildings/codes_standards/reports/index.htm. September.

US DOE, U.S. Department of Energy, 1997b. *Annual Energy Outlook 1998 with Projections to 2020*. DOE/EIA-0383(98). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 1998a. *Preliminary Technical Support Document: Energy Efficiency Standards for Consumer Products: Clothes Washers (TSD)*. Washington, DC: US Department of Energy, Energy Efficiency and Renewable Energy, Office of Codes and Standards. October.

US DOE, U.S. Department of Energy, 1998b. *Annual Energy Outlook 1999 with Projections to 2020*. DOE/EIA-0383(99). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 1999. *Annual Energy Outlook 2000 with Projections to 2020*. DOE/EIA-0383(2000). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 1999. *Life Cycle Cost of Clothes Washers*. Excel Spreadsheet lcccw_10_0001.xls created by Peter Biermeyer of LBNL. Downloaded from http://www.eren.doe.gov/buildings/codes_standards/applbrf/clwasher.html. March.

US DOE, U.S. Department of Energy, 1999. *A Look at Residential Energy Consumption in 1997*. DOE/EIA-0632(1997). Energy Information Administration. November.

US DOE, U.S. Department of Energy, 2004. *Residential Energy Consumption Survey 2001: Housing Characteristics Data Tables*. Energy Information Administration. http://www.eia.doe.gov/emeu/recs/recs2001/detail_tables.html.

US DOE, U.S. Department of Energy, 2000. *Annual Energy Outlook 2001 with Projections to 2020*. DOE/EIA-0383(2001). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 2001. *Annual Energy Outlook 2002 with Projections to 2020*. DOE/EIA-0383(2002). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 2003. *Annual Energy Outlook 2003 with Projections to 2025*. DOE/EIA-0383(2003). Energy Information Administration. December.

US DOE, U.S. Department of Energy, 2005. *Annual Energy Outlook 2005 with Projections to 2025*. DOE/EIA-0383(2005). Energy Information Administration. http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html. December.

US DOE, U.S. Department of Energy, 2006. *Annual Energy Outlook 2006 with Projections to 2025*. DOE/EIA-0383(2006). Energy Information Administration. December.

US DOE, Energy Information Administration. 2006. "*Survey of Geothermal Heat Pump Shipments, 2004*." EIA Form EIA-902. March. http://www.eia.doe.gov/cneaf/solar.renewables/page/ghpssurvey.html

US EPA, U.S. Environmental Protection Agency, 2006. *Imaging Equipment Program Requirements – final criteria*.

Vorsatz, D., L. Shown, J. Koomey, M. Moezzi, A. Denver, and B. Atkinson, 1997. *Lighting Market Sourcebook for the U.S.* Lawrence Berkeley National Laboratory, LBNL-39102. December.

Webber, C., J. Roberson, R. Brown, C. Payne, B. Nordman, J. Koomey. 2001. *Field Surveys of Office Equipment Operating Patterns*. Lawrence Berkeley National Laboratory, LBNL-46930. September.

Webber, C., R. Brown, J. Koomey. 1999. "Savings Estimates for the ENERGY STAR® Voluntary Labeling Program." *Energy Policy* 28(2000)1137-1149.

Webber, C., R. Brown, A. Mahajan and J. Koomey. 2002. *2002 Status Report. Savings Estimates for the ENERGY STAR® Voluntary Labeling Program*. Lawrence Berkeley National Laboratory, LBNL-48496. February.

Wenzel, T., J. Koomey, G. Rosenquist, M. Sanchez and J. Hanford, 1997. *Energy Data Sourcebook for the U.S. Residential Sector*. Lawrence Berkeley National Laboratory, LBNL-40297. September.

Zabrowski, D. 2003. *Personal Communication.* Excel spreadsheet "HFHC Data Needs Assessment" received via email 6/2/2003.