

**SET-TOP BOXES: OPPORTUNITIES AND
ISSUES IN SETTING EFFICIENCY STANDARDS**

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ABSTRACT

The potential exists for substantial energy savings from more efficient set-top boxes (STBs), including digital TV converter boxes, cable boxes, and satellite receivers/tuners. Much of this potential is driven by the scheduled conversion to digital broadcasting in 2007, which will require analog television sets to use some type of set-top box (either a digital converter box, or a digital cable box or satellite tuner that also serves as a converter) to display programming. The growing interest in digital cable and satellite programming and their expanding services also presents an opportunity for new policies and programs to curtail the energy consumption of STBs.

This report presents findings and savings estimates from research into the rapidly evolving market for STBs. Topics covered include descriptions of various STBs and related technologies; a summary of the STB market; estimates of current and future STB energy use; descriptions of current program activity in the United States and abroad targeting STBs; options for minimum-efficiency standards for STBs; and an analysis of the potential savings from STB standards. Recommendations for mandatory minimum-efficiency standards on STBs are outlined along with suggestions for improving voluntary labeling programs.

INTRODUCTION

The potential exists for substantial energy savings from more efficient set-top boxes (STBs), including digital TV converter boxes, cable boxes, and satellite receivers/tuners. Much of this potential is driven by the scheduled conversion to digital broadcasting in 2007, which will require analog television sets to use some type of set-top box (either a digital converter box, or a digital cable box or satellite tuner that also serves as a converter) to display programming. The shift to digital broadcasting is already driving an increased volume of new television sales, including sales of HDTV-ready (also called HDTV-compatible) units¹ that will be able to display digital programming with full resolution (unlike analog sets), but still require use of some type of STB to convert the digital signal. Early analysis of the national energy savings achievable through standards for some STBs (digital cable boxes, satellite receivers, and digital TV converters) projected large savings on the order of 17 TWh and 85 trillion Btu in 2010 (ACEEE 2002). In addition, these early analyses revealed the need for further research on market trends and technical developments affecting the overall energy consumption of STBs. This report presents findings and updated savings estimates from more detailed research into the rapidly evolving market for STBs.

The report is divided into five main sections:

- Descriptions of various STBs and related technologies;
- Summary of the STB market including available data on current product saturations and shipments, and expert opinions and projections on future sales and technology trends;
- Estimates of current and future STB energy use based on market trends, available data on various operating modes, projections of the level of standby energy consumption achievable for different boxes, and technical options for reducing standby power;
- Description of current program activity targeting STBs, options for minimum-efficiency standards for STBs, and a revised analysis of the potential savings from STB standards at the national and state level; and
- Recommendations for mandatory standards on STBs.

PRODUCT DESCRIPTIONS

The U.S. Congress has mandated transition of television broadcasts from the analog spectrum to digital transmission. At this point, there is some uncertainty about the date of the conversion— although Congress set a target date of January 1, 2007, it also allowed for a delay in the transition until 85% of households are equipped to view digital programming. The Federal Communications Commission (FCC) has mandated that all new TV sets include a digital tuner as of 2007; legacy analog sets will require a digital TV converter box to display digital programming. In response to concerns that the transition will be delayed due

¹ HDTV (high-definition television) is the term applied to the highest quality digital TV display format, offering the best digital picture and sound quality available. Other digital display formats include enhanced definition (EDTV) and standard definition (SDTV), which also offer improved picture and sound relative to analog sets. Most digital programming is optimized for viewing on an HDTV display and the consumer electronics companies are focusing their efforts on products with HDTV displays.

to slow consumer adoption, the FCC is considering strategies for accelerating consumer action. Similar transitions are underway in Europe, Asia, and Australia.

The question of whether a given household will need a STB to watch TV after the transition depends on the type of transmission the viewer receives (i.e., broadcast, cable, or satellite) the type of TV set in use; and which, if any, additional features and services the viewer wishes to access. Table 1 summarizes the STB options available for each transmission source and type of TV set. For the purposes of this report, STBs are categorized according to the transmission signal source. The STBs relevant to each category have unique operating parameters related to their end function and/or the broadcast method under which they operate. Detailed information on the various STBs follows the table.

Table 1: Set-Top Box Options for Viewing Digital TV

Signal Source	Analog TV	HD-Ready TV	HDTV with Integrated Tuner
Cable	Digital cable box with internal digital TV converter (DTC)	- Digital cable box with internal tuner OR - Digital “cable-ready” HDTV tuner	- If digital “cable ready” DTV, no box OR - Digital cable box (for additional advanced functions or if DTV not “cable-ready”)
Satellite	Satellite receiver with internal DTC	Satellite receiver with internal HDTV tuner	Satellite receiver
Broadcast (Terrestrial)	DTC	HDTV tuner	No box needed

Note: Consumers may have additional STBs (including digital video recorder [DVR], game console, etc.) or a multi-function cable or satellite box may include these functions.

Broadcast TV

Broadcast TV (also referred to as over-the-air or terrestrial) refers to the traditional method of viewing free over-the-air signals captured with an antenna mounted on the TV and/or rooftop. Over the past thirty years, the number of households relying on free broadcast TV has steadily declined as viewers have increasingly turned to subscription-based pay TV that offers a much larger selection of programming along with better reception. The digital conversion will require both free broadcast TV and pay subscription TV to shift from the analog spectrum to all digital transmission. In order to view free digital broadcast TV, consumers must either purchase a digital TV with integrated tuner (DTV) or use a STB. The type of STB depends on the television set being used:

- *HDTV tuner for HDTV-ready (or “HDTV-compatible”) televisions:* At this time, the vast majority of HDTV sets sold are basically digital monitors (labeled HDTV-ready or HDTV-compatible) unable to display digital programming without a separate tuner. Integrated sets, which have a built-in tuner, are becoming more widely available and are anticipated to match HDTV-ready shipments as of 2007 when the FCC’s tuner mandate takes effect. An HDTV tuner is needed to display over-the-air digital broadcasts. For pay TV subscribers, a digital cable box or satellite receiver with HD capabilities will perform the tuner function for HDTV-ready sets so a separate tuner STB will not be needed. The

leading cable providers already offer HD digital cable boxes to their customers for an additional monthly fee. Satellite receivers with HD tuners are also available.

- *Digital TV converter (or adapter):* The standard televisions found in most homes use the analog NTSC format to display programming. These sets will require a digital TV converter box to display any digital programming in the analog NTSC format. At this time, consumers must use a digital TV converter for over-the-air digital broadcasts and some HD programming from a cable or satellite provider. In most cases, however, consumers subscribing to digital cable or satellite will not need a separate converter box to convert digital programming—the converter will be built into their cable or satellite STB.

HDTV tuners manufactured by several consumer electronics companies including Motorola, Samsung, LG Electronics, and Funai (under the Sylvania brand) are available in the United States through the traditional retail outlets for consumer electronics products. Digital TV converters, on the other hand, have not yet developed much of a market in the United States, although more than 15 manufacturers (including leading consumer electronics firms and smaller manufacturers) are marketing products in the U.K.; many of these firms are likely to introduce products in the United States. In addition, several cable box manufacturers, notably Motorola and Pace Micro Technology, have announced plans to introduce digital TV converters. The HDTV tuners mentioned above also function as digital to analog converters, but given the high price point—typically \$300 or more—it is unlikely that these products will develop as large a market as simple converters for use with analog TV sets. The Pace and Motorola products are expected to be priced at \$35 to \$90; this price range is supported by experience from the robust U.K. market. Digital TV converters are most likely to be sold through retail outlets, although some cable system operators may also make them available to their customers.

Cable TV

Cable is the leading source of television programming for U.S. viewers. Approximately 72 million households subscribe to cable programming (NCTA 2003). Cable systems are also undergoing a shift from analog to digital programming. While the majority of cable subscribers continue to receive analog programming (52 million or 72% in 2003), the number of digital cable subscribers is rapidly growing in response to the expanded programming options available on digital cable (e.g., increased channels, video-on-demand, etc.) and efforts by cable system operators to reduce the cost differential between the services. At present, most TV sets are equipped to receive analog cable without a STB, although an analog cable box is required for some premium channels and services. For the purposes of this report, analog cable boxes are omitted from the discussion. Given changes in the market leading to the digital broadcast conversion, manufacturers are not developing new products in this category and no new shipments are projected as of 2004—providers will simply continue to service remaining customers with the existing stock. For our intents and purposes, the product can be considered obsolete.

Digital cable reception, on the other hand, requires a digital cable box. Subscribers with analog TV sets need the digital cable box to convert programming to an analog signal. For

subscribers with HDTV-ready sets, a standard digital cable box can be used to view programming in standard definition or most cable operators now offer digital cable boxes with HD tuners integrated for viewing high-definition programming. At this time, few DTVs with integrated tuners are available with digital-cable-ready capabilities, but this should change in the near future. Recent estimates suggest an average of 1.5 digital cable boxes per subscriber household (U.S. Warburg LLC 2003).

In the United States, digital cable box sales are dominated by just two companies, Motorola and Scientific-Atlanta, each garnering more than 40% of the U.S. market. The remainder is manufactured by Pioneer and Pace Micro Technology, which supply digital cable boxes to several leading U.S. cable systems, and to a much lesser extent, Sony and Panasonic. A handful of other companies manufacture digital cable boxes for markets outside of North America and may eventually break into the U.S. market. Cable system operators (e.g., Comcast, Time Warner, etc.) work with the manufacturers to ensure that the STBs will work with their head-end broadcast equipment and to specify the STB functions and services that they want to offer their customers. Despite attempts to create a retail market for cable boxes (see “Market Issues and Trends,” below), virtually all cable boxes in use in the United States are purchased by cable system operators who then lease the boxes to their customers for a monthly fee ranging from \$4 to \$10 per box. Cable system operators pay between \$170 and \$575 per box depending on features and capabilities, with basic digital cable boxes ranging from \$170 to \$250.

Satellite TV

Approximately 21 million households subscribe to digital satellite services (DirecTV and DISH Network), also referred to as direct-to-home (DTH) or direct broadcast satellite (DBS). Reception requires installation of a small satellite dish and a receiver/decoder STB. Although new receivers with multiple tuners are available (allowing viewers in two rooms to watch different channels from a single STB), the majority of subscribers who wish to view programming in separate rooms have an STB in each room. All programming is transmitted digitally—the STB converts the digital signal to analog for viewing on analog TV sets. Like digital cable, digital satellite STBs are now available with HD tuners for subscribers with HDTV-ready sets.

More than a dozen firms manufacture digital satellite STBs for use with DirecTV and DISH Network services.² Both services offer their basic satellite dish and receiver systems free of charge with a one-year service commitment; DISH also allows customers to lease a basic receiver for \$5 per month. Alternatively, advanced digital satellite STBs with a built-in DVR, HD capability, and other features are available directly through the service provider or retail outlets from \$99 to \$999.

² Major manufacturers include General Electric, Hughes, LG Electronics, Mitsubishi, Panasonic, Philips, Proscan, RCA, Samsung, Sony, Toshiba, and Zenith.

Other

Broadband telephony providers are entering the market in response to competition from cable operators that now offer integrated video, voice, and data services. Video-over-DSL (digital subscriber line), now available in some markets, requires use of an Internet protocol (IP) STB. This technology is expanding rapidly in other countries, but is expected to experience limited adoption in the United States where cable is a much stronger player (ABI Research 2003). Other popular STBs include digital video recorders (DVRs, also known as personal video recorders or PVRs, such as TiVo), game consoles, videophones, and Internet access devices (e.g., WebTV). Given the limited penetration of most of these products to date and the rapidly evolving designs and capabilities in new products, we do not cover these products in greater detail in this report.

MARKET ISSUES AND TRENDS

The STB market is rapidly evolving and further change is anticipated in response to the digital TV conversion and the introduction of increasingly advanced STBs that integrate the functions of several STBs into single multi-function devices including integration of DVRs, game consoles, and high-speed modems into cable boxes and satellite receivers. While there is general agreement that the market will undergo significant change in the next several years, no consensus has emerged over the pace of change or the types of products that will prevail in the coming years.

Several policy changes enacted by the Federal Communications Commission (FCC) are spurring changes in the products and services available to consumers. In addition to the mandated broadcast conversion from analog to digital, FCC regulations were amended in 1999 to allow consumers to purchase cable boxes (or TVs, VCRs, and other devices with built-in cable decoders) directly from retailers. This ruling would create the first consumer-direct market for cable boxes that have traditionally been leased from the cable provider for a monthly fee; however, the vast majority of consumers continue to lease their cable boxes. More recently, FCC entered into a 2003 agreement with cable companies and TV manufacturers to establish standards for digital cable ready TV sets. Under the agreement, “plug-and-play” DTV sets will work with a direct connection to subscribers’ cable lines and eliminate the need for separate cable boxes to decode and display cable programming. The first wave of these products is already on the market. While these products will eliminate the need for basic cable STBs, consumers interested in increasingly popular interactive features such as video-on-demand, impulse pay-per-view, data-enhanced programming, and operator enhanced program guides will still need STBs. The manufacturers and cable operators are working on two-way “plug-and-play” standards that will allow these interactive features—until that standard is developed, this rule is not expected to have a significant impact on STB sales.

Uncertainty over consumer response to these changes contributes to the differences in projections of STB sales. ACEEE collected and summarized sales projections for these products from a range of sources, including the consumer electronics industry (manufacturer and trade associations), market analysts, cable and satellite service providers, and others.

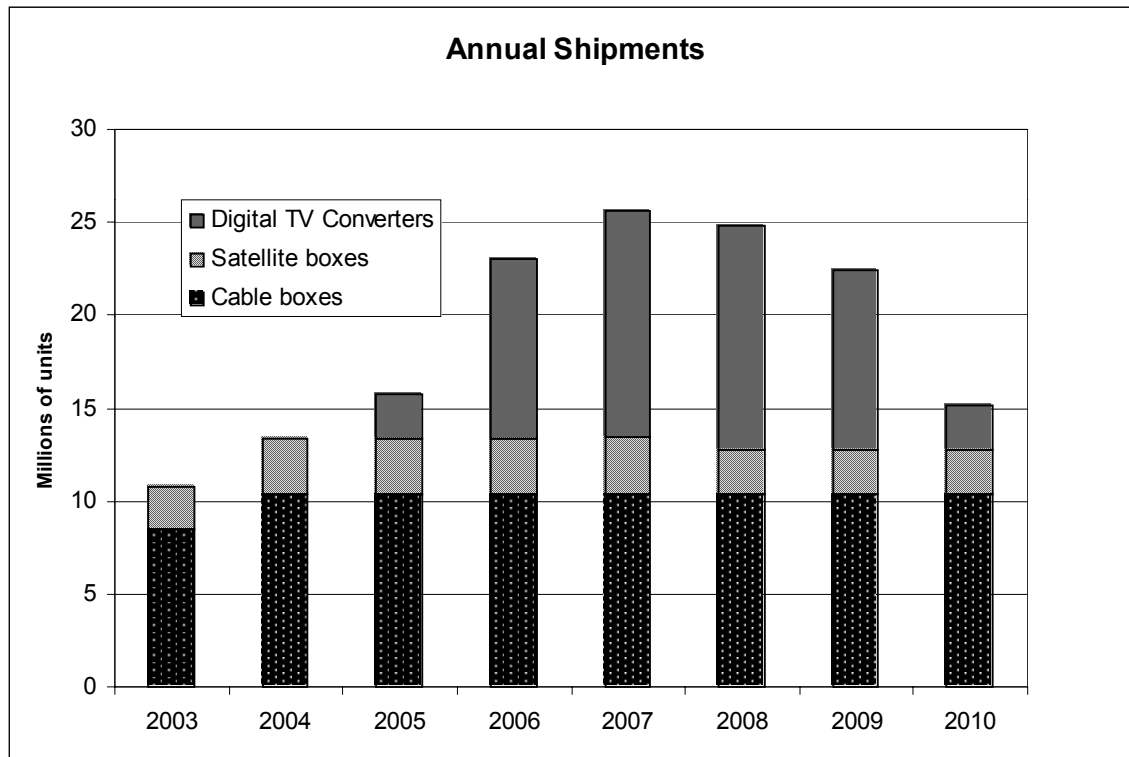
Table 2 provides data on the current stock of STBs and estimates of product stock in 2010. Sales forecasts vary widely from source to source reflecting differences in opinion over the rate of adoption of DTVs and associated products. ACEEE used these sources to develop our own “best estimate” of product sales over the period of 2004 to 2010, as shown in Figure 1.

Table 2: 2003 and 2010 Set-Top Box Stock

Product	2003 Stock (millions)	2010 Stock (millions)
HDTV tuner	1.0	10
Digital TV Converter (DTC)	N/A	48.5
Analog cable box	30	0
Digital cable box	35	65
Direct Broadcast Satellite (DBS)	32	42
IP STB	0.5	2.0

Sources: ACEEE estimates based on data from ABI Research, Credit Lyonnais Securities, U.S. Warburg, Yankee Group, and industry representatives

Figure 1: Estimated Annual Set-Top Box Shipment, 2003–2010



Sources: ACEEE estimates based on data from ABI Research, Credit Lyonnais Securities, U.S. Warburg, Yankee Group, and industry representatives

To arrive at these estimates, we made a number of assumptions about the types of STBs in use each year based on the current stock of each type of TV set, the number/types of pay TV subscriptions, and current and future sales trends. For example, we assume shipments of digital cable boxes to remain relatively stable over the period as digital cable continues to replace analog cable, but little overall growth in the number of cable subscribers is

anticipated.³ The number of digital cable boxes per household declines very slightly as digital cable ready TV sets hit the market between 2005 and 2007. Satellite experiences modest growth for the first few years, then declines slightly as the total number of satellite subscribers stabilizes. Finally, shipments of digital TV converters are only noticeable beginning in 2005, increasing rapidly with a peak in 2007 and 2008 in response to the broadcast conversion, then falling off as more of the analog TV stock is replaced.

ENERGY USE ESTIMATES

Annual energy consumption of STBs depends on the power consumption in each operating mode and the amount of time the STB spends in each mode. For STBs, the key operating modes currently defined in the United States are:

- *Active mode:* The product is turned on and performing a primary function (e.g., receiving, sending, processing, translating, and/or recording signals). The power requirement in this mode is typically greater than the power requirement in standby/low-power mode. However, for many STBs metered to date, the difference between active and standby/low-power mode energy consumption is negligible (i.e., a difference of only 1–2 watts for cable and satellite boxes).
- *Standby/low-power mode:* A low-power state that the product enters while connected to a power source. In this mode, the product may or may not be turned “OFF,” but is capable of responding to a signal from a remote control or the provider network and may continue to perform some other functions. The STB may receive data from the network in this mode, but does not act on it.

Determining the operating mode and obtaining good measurements can be quite complicated for STBs, particularly for those products that maintain regular communications with the provider network. Table 3 provides information from measurements performed to date.

Table 3: Typical STB Power Consumption

Device	Active (W)	Standby/Low-Power (W)
Digital cable box	23	22
Satellite receiver	18	17
Digital TV converter	17	8
HDTV tuner	NA	NA

Sources: Harrison 2004; NAECC 2004; Rosen, Meier, and Zandelin 2001

Unfortunately, there are some important limitations to this data. For cable and satellite STBs, many of the measurements were performed in a laboratory or retail setting. In these instances, the STB was plugged into the power source and then metered when turned “on” for active mode and turned “off” for standby/low-power mode. Although some of the measurements were performed when the STB was connected to its provider network, few, if any, measurements accounted for power consumption over the full product cycle (e.g., when

³ Although overall shipments of digital cable boxes remains relatively stable, the product mix changes as multi-function STBs claim an increasing portion of total cable box shipments. One recent study estimates that multi-function devices incorporating some combination of DVDs DVR, home theater, and gaming console will outsell each of the individual devices by 2008 (ABI 2004).

downloading program guides, exchanging security keys with the service provider, etc.). As a result, little data is available on power consumption during the typical product cycle or the amount of time each device typically spends performing these functions. Efforts now underway at Lawrence Berkeley National Laboratory (LBNL) will collect a more rigorous set of measurements and, in the process, develop an improved protocol for effective testing and reporting of STB power consumption under real-world operating conditions. Results of this research effort should be available in the summer of 2004 (Hershberg 2004).

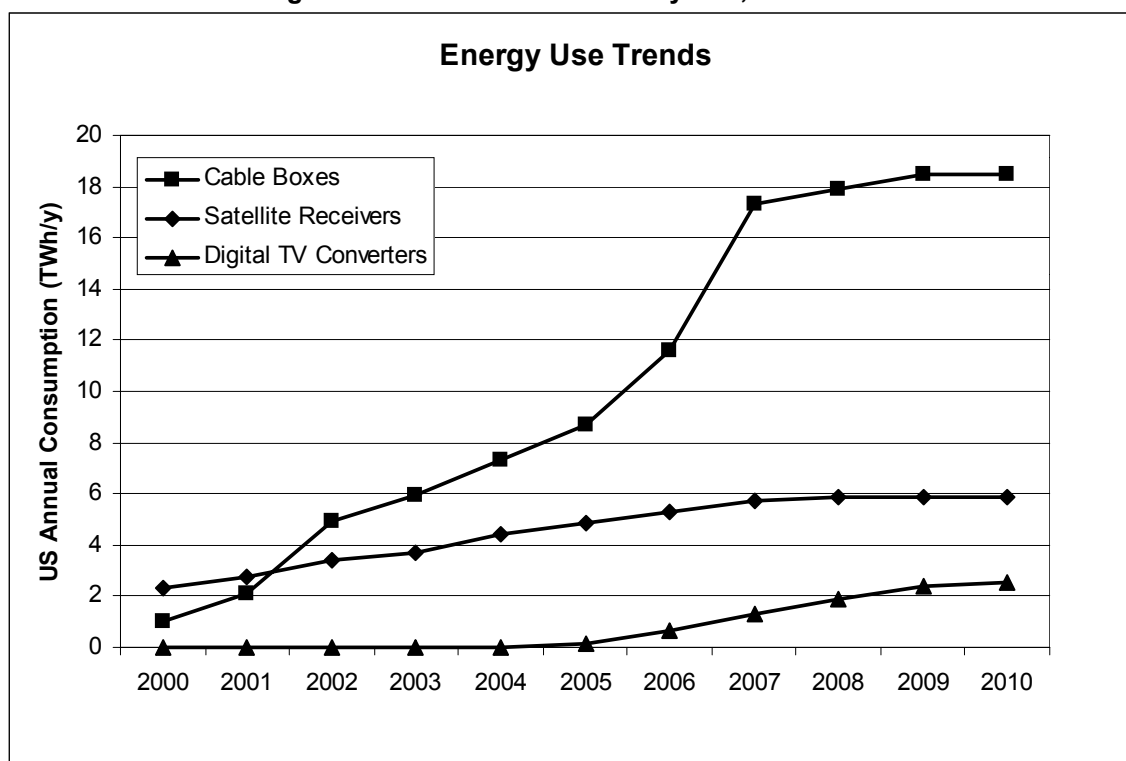
For digital TV converters, few products are currently available in the United States so we use data on products currently marketed in the U.K., where an estimated 2.5 million households have purchased digital TV converters (Wells 2003), and recent data from Australia on average digital TV converter standby power (NAEEEC 2004). Until products are available and metered in the United States, we will use these data, recognizing that our savings estimates may need to be revised.

In the meantime, we rely on the data in Table 3 to calculate per unit and national energy consumption estimates as well as projections of future energy consumption based on our “best estimate” sales projections and assuming a “business as usual” scenario (i.e., no program or policy interventions) as shown in Figure 2. According to our projections, cable boxes, satellite receivers, and digital TV converters (including multi-function units) will account for 27 TWh or 2.4% of U.S. residential electricity use in 2010 in the absence of any coordinated action to improve product efficiency. On a per unit basis, a digital cable box uses roughly 200 kWh per year. Given industry estimates of an average of 1.5 digital cable boxes per subscriber household—a number that is expected to grow—the average household energy use of cable boxes is close to 300 kWh. For the growing number of subscribers with two or more cable boxes, annual energy use approaches or exceeds 400 kWh per year or a third of the annual cost of the boxes’ rental.

TECHNICAL OPTIONS FOR IMPROVING STB EFFICIENCY

Options for improving the energy performance of STBs include specification of more efficient components such as power supplies, flash memory, displays, and circuitry; use of software to better control STB operation by turning off power to components or functions that are not in use; and the development of improved communications protocols that optimize the amount of time STBs exchange data with the cable or satellite networks and allow the STBs to enter a sleep mode when not in contact with the networks. Manufacturers are already incorporating some of these strategies in some STB products, while others will require additional research and product redesign. Changes in communications protocols and any STB software with a user interface will require collaboration between the STB manufacturers and the cable and satellite service providers that specify product features.

The incremental cost for these efficiency measures is expected to be rather modest. For this analysis, we conservatively assume an incremental cost of \$5 per unit.

Figure 2: National STB Electricity Use, 2000–2010

EFFICIENCY PROGRAMS, STANDARDS OPTIONS, AND SAVINGS POTENTIAL

The energy use estimates above demonstrate the significant contribution of STBs to U.S. energy consumption in the coming decade. Fortunately, there is a growing interest in addressing energy consumption from these devices. Several of these efforts are outlined below.

ENERGY STAR® Set-Top Box Program

The U.S. Environmental Protection Agency (EPA) launched the ENERGY STAR Set-Top Box program in 2001. The current Tier 1 specification requires standby power consumption of 3 watts or less for Category 1 devices including digital TV converters, Internet access devices, video game consoles, and videophone boxes. Category 2 devices must consume 15 watts or less and include digital cable and satellite boxes, wireless TV boxes, and DVRs. Multifunction devices that combine these and/or other functions comprise Category 3 and can consume up to 20 watts in standby. In addition, satellite boxes are allowed an additional 5 watts over the base 15 watts for each low noise block converter (LNB) sold with the box—of the 7 satellite boxes currently on the ENERGY STAR list, 3 are sold without LNBs, 2 are sold with 1 LNB, and 2 are sold with 3 LNBs. At present, six of thirteen manufacturing partners have listed digital TV converters/HDTV tuners (3 models), digital cable boxes (8 models), satellite boxes (7 models), multifunction devices (1 model), and DVRs (1 model) (EPA 2004).

The Tier 2 specification, originally scheduled to take effect on January 1, 2004, has been put on hold and will be revised before it takes effect. At this time, it is not clear what the Tier 2 specification will be or when it will be implemented. EPA is awaiting new product metering data being compiled by LBNL and consulting with manufacturers on appropriate Tier 2 levels in hopes of releasing a draft Tier 2 specification by the fall of 2004 (Hershberg 2004). The Electronics Industries Association (EIA) is working with its members to develop recommendations for ENERGY STAR. The group has expressed interest in an approach similar to the European Union Code of Conduct (discussed below) that would set a base power consumption specification for broadcast, cable, and satellite STBs with additive power allowances for each additional function (e.g., DVR, game console, and Internet access devices) (Linnell 2004).

European Union Code of Conduct

The European Union Code of Conduct for Digital TV Services (CoC) is a voluntary agreement developed by the European Commission in consultation with STB and TV manufacturers and a leading European pay TV service provider. As of 2005, participants to the CoC have agreed upon the power consumption levels outlined in Table 4. In addition to STBs, the CoC also establishes specifications for digital TVs with integrated tuners for broadcast, digital, or satellite signals. The CoC sets maximum power consumption levels for standby active and standby passive mode for stand-alone STBs and standby passive and on mode for digital TV converters defined as:

- *Standby passive:* The appliance is connected to a power source, which fulfills not the main function but can be switched into another mode with the remote control unit or an internal signal.
- *Standby active:* In addition to the conditions for standby passive, the appliance can be switched into another mode with an external signal or is receiving a minimal level of data from an external source, but is not acting on this data.
- *On:* The appliance is connected to a power source and fulfills a main function, including acting on data received.

Table 4: EU Code of Conduct Power Levels (W)

Device	Cable	Terrestrial	Satellite
Stand-alone STB	<u>2003–2005</u> Standby passive: 6W Standby active: 9W	<u>2003–2005</u> Standby passive: 6W Standby active: 9W	<u>2003–2005</u> Standby passive: 6W Standby active: 9W
	<u>2006–2007</u> Standby passive: 3W Standby active: 7W	<u>2006–2007</u> Standby passive: 3W Standby active: 6W	<u>2006–2007</u> Standby passive: 3W Standby active: 8W
Simple digital TV converters	<u>2005–2006</u> Standby passive: 2W On: 11W	<u>2005–2006</u> Standby passive: 2W On: 11W	<u>2005–2006</u> Standby passive: 2W On: 14W

The CoC sets allowances for additional components integrated into STBs and digital TVs with integrated tuners or cable/satellite receivers. Each additional feature is given a maximum power consumption allowance; however, the total maximum power consumption

in standby active mode may not exceed 15 watts for STBs regardless of the number of additional features. Table 5 provides a list of added features and maximum power allowances.

Table 5: EU CoC Additive Power Allowances

Feature	Maximum Power Consumption for Additional Feature (W)
Internal hard disk drive	2.2
IEEE 1394 Interface	0.8
Ethernet interface 100Mbit	0.4
Wireless interface	0.7
Serial USB interface	0.3
Home automation interface	0.4
ADSL modem	2.0
Extra cable modem	0.7
Additional LNB feed	1.3
Additional tuner	2.0
Powered remote IR receiver	0.25

Source: EC 2003

Other International Activity

Action to address the growth in energy consumption from STBs is ramping up in other regions as the number of STBs in use grows. As part of a larger National Standby Strategy, Australia is considering adoption of the ENERGY STAR program for STBs as well as a mandatory standard (NAEEEC 2004). The Korean government has established a STB power consumption target of 3 watts as part of the Korea Standby Power Program (MOCIE 2004). China has also announced plans to regulate the energy use of STBs (Meier 2004). Also of note, is the performance of STBs used in Japan. Although STBs are not currently included in Japan's Top Runner efficiency program, cable and satellite STBs on the market in Japan exhibit standby passive power consumption of approximately 2 watts (Meier 2004).

In response to growing interest and activity, the International Energy Agency (IEA) convened a workshop in May 2004 to explore the global implications of STB energy consumption and opportunities for coordination among manufacturers, service providers, policy makers, and other interested parties. A summary of the meeting and its outcomes is available from the IEA (IEA 2004)

Minimum-Efficiency Standards

The voluntary efforts outlined above can contribute to ongoing efforts to develop a market for energy-efficient STBs. However, there are limitations to this approach for some STB products—limitations that can be effectively addressed by the adoption of minimum-efficiency standards.

For example, standards can lock-in savings for the near term while uncertainties over products that are rapidly evolving are settled. In the case of cable and satellite, initial standards could be enacted for basic cable and satellite STBs first. Standards for

multifunction cable and satellite STBs could be established later when the technology has matured. To achieve maximum savings, initial standards for cable and satellite STBs should include devices with integrated HDTV tuners and digital-to-analog converters.

Standards are also a useful tool for addressing the lack of consumer choice in the STB market. Despite the 1999 FCC ruling allowing consumers to purchase their own cable boxes, a market for these products has not emerged. Given the rapid changes in the market, such a market is unlikely to emerge in the near term, so consumers will continue to lease cable STBs from their cable service provider without much input on model specifics, such as energy use or ENERGY STAR qualification. Similarly, many satellite service providers offer consumers free satellite STBs in return for long-term service contracts.

Furthermore, standards can ensure that the energy impact of the digital conversion is minimized by demanding an achievable level of performance for DTCs; a product that has not yet hit the market in substantial numbers, but has the potential for explosive short-term growth while presenting manufacturers with little ongoing concern for product development and improvement. To capture maximum savings, standards for DTCs should not only establish a maximum standby power consumption, but include language to ensure that the product goes into a low-power or standby mode when the TV or VCR is not operating (i.e., when no conversion is needed). If the product does not enter a low-power mode, it must meet the same maximum power requirement in active mode.

Evidence from product measurements, discussions with manufacturers, and the current existence of ENERGY STAR Tier 1 qualified products demonstrate that the Tier 1 levels for digital cable and satellite boxes are achievable (i.e., 15 watts for digital cable and satellite STBs), whereas the Tier 1 level for digital TV converters (3 watts) can be tightened to 1 watt. Standards at this level would produce savings of approximately 3.6 TWh in 2010 and 1.6 TWh in 2020 as shown in Table 6. Savings decline over the period of 2010 to 2020 as digital TV converters are phased out of use and multi-function devices account for a larger portion of cable and satellite STBs. Estimated energy savings translate into annual energy bill savings of \$57 million. The benefit-to-cost ratio of standards equals 3.1 for digital cable and satellite boxes and 5.6 for digital TV converters. Associated pollution savings are summarized in Table 7.

These savings estimates are significantly lower than earlier savings estimates, reflecting a better understanding of the likely market for the products under consideration. Based on our research and discussions with industry experts, annual shipments of digital cable and satellite boxes were scaled back to account for the growing share of multi-function devices. Similarly, the annual shipments estimate for digital TV converters was reduced in recognition of the rate of adoption of DTV and the fact that this capability will be incorporated in cable and satellite boxes, eliminating the need for a separate converter for many sets.

Table 6: National Energy Savings from STB Standards

Product	Energy Savings in 2010 (TWh)	Energy Savings in 2020 (TWh)	Cumulative Savings 2006 to 2030 (TBtu)
Digital cable and satellite STBs	1.35	1.36	352
Digital TV converters	2.29	0.25	211

Notes: Savings assume that 35% of current cable and satellite STB and 10% of digital TV converter shipments meet the proposed standard.

Table 7: Pollutant Savings from STB Standards

Product	Carbon Reduction in 2020 (1,000 MT)	NO _x Reduction in 2020 (MT)	SO ₂ Reduction in 2020 (MT)	PM ₁₀ Reduction in 2020 (MT)
Digital cable and satellite STB	264	777	3,259	43
Digital TV converters	49	145	609	8

RECOMMENDATIONS

Based on our analysis, ACEEE recommends that states consider enactment of minimum-efficiency standards for STBs. At this time, no federal pre-emption exists for this category of products. More specifically, recommended standards would:

- Set maximum standby power consumption levels for stand-alone digital cable and satellite boxes including those units that incorporate HDTV tuners and/or digital to analog conversion capabilities equal to the Tier 1 ENERGY STAR specification (i.e., 15W);
- Set maximum standby power consumption levels for digital TV converters at 1W; and
- Require digital TV converters to enter a standby/low-power mode when the TV, VCR, or other device to which it is connected is turned off.

While we anticipate a growth in the stock of other STBs (e.g., multi-function devices, DVRs, game consoles, etc.), these products are evolving rapidly and it is unclear what products will be on the market in the a few years. As a result, standards for these products are not recommended at this time, although they may be warranted at a later time. Furthermore, the results of additional product metering underway may justify adoption of a second-tier standard mandating a lower standby power maximum or establishing separate levels for standby active and standby passive.

In the meantime, we also recommend that ENERGY STAR consider adoption of the EU Code of Conduct as a model for the Tier 2 ENERGY STAR specification. Of particular interest is differentiation between standby active and standby passive modes. In terms of specific qualifying levels, the CoC provides a useful guide as a starting point in determining appropriate levels for the ENERGY STAR program.

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