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Energy savings assessment for digital-to-analog converter boxes

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ABSTRACT

The Digital Television (DTV) Converter Box Coupon Program was administered by the U.S. government to subsidize purchases of digital-to-analog converter boxes, with up to two $40 coupons for each eligible household. In order to qualify as Coupon Eligible Converter Boxes (CECBs), these devices had to meet a number of minimum performance specifications, including energy efficiency standards. The Energy Star Program also established voluntary energy efficiency specifications that are more stringent than the CECB requirements. In this study, we measured the power and energy consumptions for a sample of 12 CECBs (including 6 Energy Star labeled models) in-use in homes and estimated aggregate energy savings produced by the energy efficiency policies. Based on the 35 million coupons redeemed through the end of the program, our analysis indicates that between 2500 and 3700 GWh per year are saved as a result of the energy efficiency policies implemented on digital-to-analog converter boxes. The energy savings generated are equivalent to the annual electricity use of 280,000 average US homes.

1. Introduction

On June 12, 2009, the United States switched from analog to digital over-the-air television broadcasting for all full-power stations. The US has about 110 million households with TVs (Nielsen, 2009) and was the largest market to have made the transition. Many consumers had not yet purchased digital televisions that were able to receive the digital signals. In February 2008, at least 13 million households in the United States had analog televisions that could receive only analog broadcast signals (Nielsen, 2008). There was widespread concern that these households would not be prepared for the transition and would be unable to receive a television signal.

In order to facilitate the Digital Television (DTV) transition, the Digital Television Transition and Public Safety Act of 2005 authorized the National Telecommunications and Information Administration (NTIA) to establish a DTV Converter Box Coupon Program (Federal Register, 2007). Eligible households could receive up to two $40-coupons, between January 1, 2008 and July 31, 2009 (expiring 90 days after they were issued), toward Digital-to-Analog converter box (DTA) purchases. These $40-coupons covered most of the converter box cost, which was typically $50–60.[1] Through December 2009, about 35 million coupons were redeemed from the NTIA coupon program (NTIA, 2009).

In 2004, there was concern regarding the potential energy impacts of DTAs (Meier, 2004). These boxes were expected to continuously draw as much as 20 W, or 180 kWh/yr. For example, ten million boxes, each drawing 15 W, would add 1300 GWh per year to national electricity consumption. Several studies described at the 2004 and 2007 International Energy Agency (IEA) workshops indicated that the boxes could be manufactured to consume much less energy at only a modest increase in cost (Dale, 2004). The California Energy Commission therefore initiated hearings to establish minimum efficiency standards for DTAs. Other states were poised to enact similar standards.

Negotiations among the major stakeholders resulted in an agreement that proposed mandatory regulations would be withdrawn but that coupon-eligible DTAs must also meet certain energy efficiency requirements. Separate from the NTIA coupon program, the Energy Star program established voluntary energy efficiency specifications that were more stringent. Energy Star compliant DTAs were also required to comply with all NTIA coupon program specifications.

Few, if any, energy-using products have entered widespread use as rapidly as the DTA. The increase in electricity consumption from a new product is also unprecedented. About 79% of countries around the world have not started the DTV transition, and 42% may do so in the near future (Tarr, 2009). It is therefore worthwhile to document the DTA's energy impacts and estimate the energy savings resulting from the efficiency requirements established through NTIA and Energy Star. This information will also help demand forecasters as these units are gradually removed and replaced with digital televisions. To estimate these impacts, our study combines field measurements with NTIA data.

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[1] The NTIA defined the "Coupon Eligible Converter Box" (CECB) DTA as a "Stand-alone device that does not contain features or functions except those necessary to enable a consumer to convert any channel broadcast in the digital television service into a format that the consumer can display on television receivers designed to receive and display signals only in the analog television service, but may also include a remote control device (NTIA, 2007)".

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2. Energy efficiency policies

2.1. Origins of DTA performance levels

The rising energy use of set-top boxes (STBs) was first noted in 1997 (Harrison, 1997) and began to appear regularly in studies of energy use in homes thereafter. In 2001, STBs were recognized as an important contributor to standby power consumption in California and as an important target for energy-saving policies. The IEA convened a workshop in 2004 to address energy use of STBs. By that time, the first digital transitions of over-the-air television were underway in Berlin and Italy. Participants in the workshop recognized that DTAs and "complex" set-top boxes were fundamentally different devices and that each required unique energy efficiency strategies. Furthermore, huge numbers of DTAs would soon appear in the marketplace and energy guidelines were critical. The IEA workshop participants recommended maximum power levels for DTAs. Within months, these levels (or slight variants) were adopted by many government agencies and organizations, including Energy Star, the European Code of Conduct, and the Australian Greenhouse Office.

2.2. Performance levels established by NTIA and Energy Star

In the US, energy efficiency standards were set for over-the-air DTAs at the national level through the implementation of the NTIA coupon program. All coupon-eligible DTAs had to comply with the following energy efficiency standards set by NTIA (2007):

- Sleep state power consumption of no more than 2 W, measured in accordance with industry standard CEA-2013-A.[2]
- Capability to switch from On state to Sleep state (or auto-power down) after 4 h of user inactivity.

The voluntary standards implemented by the Energy Star program required that DTAs meet stricter energy efficiency standards in addition to complying with the NTIA coupon program. In essence, the additional standards required are (Environmental Protection Agency (EPA), 2007):

- On mode power consumption of no more than 8 W, measured using Section 6 of CEA-2022,[3] and Sleep mode power consumption of no more than 1 W using Annex A of CEA-2013-A.
- DTAs "may come out of Sleep mode in order to scan for program and system information or private data. When doing so, DTAs may exceed the 1 W Sleep mode requirement for no longer than one hour in an eight-hour period."

The California Energy Commission (CEC) had also adopted its own energy efficiency standards for DTAs. The CEC required converter boxes to have On and Sleep mode power consumption of no more than 8 and 1 W, respectively, but had no requirement on the auto-power down feature, unlike the NTIA coupon program (CEC, 2007a). In October 2007, the CEC repealed its existing efficiency standard on DTAs, because the NTIA coupon program was believed to generate an equivalent or greater level of energy efficiency (CEC, 2007b).

2.3. Digital cable transition

Households served by cable television are also undergoing a digital transition. For example, Comcast Cable is upgrading their Expanded Basic Cable, which includes 30–50 channels, to digital signals (Comcast, 2009a), and the upgrade is expected to last through the year 2010 (Comcast, 2009b). To continue viewing these channels, service providers give customers with analog televisions the option to obtain a digital transport adapter or digital cable box (Comcast, 2009b). The digital transport adapter has the primary function of converting digital cable signals to analog, whereas a digital cable box carries more functions such as on demand and pay-per-view. Alternatively, customers can replace their analog televisions with new, digital units at their own cost.

NTIA did not offer coupons for purchasing cable DTAs because it was assumed that the cable service providers would provide them for free (which they did). By being outside of the NTIA coupon program, cable DTAs were not covered by performance requirements. In addition, this meant that cable DTAs were not covered by the coupon reporting requirements. For this reason, our analysis excludes cable DTAs; however, we report measurements on two units for comparison.

3. Methodology

3.1. General

The goal of this study is to assess the effectiveness of energy efficiency standards applied to coupon-eligible DTAs, through power and energy measurements in home settings. The power consumption data collected are applied to an assumed usage pattern to generate an average annual energy consumption. This "policy case" annual energy consumption is then subtracted from a "reference case" annual energy consumption to estimate energy savings generated by the energy efficiency policies. The "reference case" annual energy consumption is computed based on a baseline power consumption, which is expected if the energy efficiency policies did not exist; details of how this baseline power consumption was obtained are discussed in the following sections. Finally, the average energy savings per converter box is multiplied by the number of coupon-eligible DTAs sold in order to estimate aggregate energy savings.

To collect data on power and energy consumption, a sample of 12 coupon-eligible DTAs (6 of which are Energy Star labeled) were selected for 24 h continuous measurements with the Power Line Meter (PLM).[4] Most of the DTAs metered were available in the market in May 2009, weeks before the DTV transition. The sample size is relatively small but well represents the population of DTAs for a number of reasons. Because all coupon-eligible DTAs are required to comply with NTIA specifications, they have limited and consistent functionality. This is unlike products such as digital televisions where a wide range of models and different features are available. In addition, market research information up to the first quarter of 2009 indicated that 13 brands of coupon-eligible DTAs accounted for 90% of total sales (DTC, 2009). Lastly, large numbers of coupon-eligible DTAs were sold in big national retail stores, such as Walmart, Target, Radio Shack, and Best Buy, and each of these stores only carried a couple models at a time. All these factors suggest that DTA functionality and model variety are more

[2] Consumer Electronics Association (CEA). ANSI CEA-2013-A "Digital Set-Top Box Background Power Consumption", July 2007.

[3] Consumer Electronics Association (CEA). ANSI CEA-2022 "Digital Set-Top Box Active Power Consumption Measurement", August 2007.

[4] The Power Line Meter, model PLM1-LP, is a single phase power multi-meter manufactured by Electronic Product Design, Inc. in Oregon, USA. Power is supplied to the load via a permanent power cord exiting the rear panel and a 4 A, 120 V outlet on the front panel. Connection to a computer for data recording is through a serial connector.