Not so intractable after all? Lessons from a midstream Energy Efficiency pilot targeting set-top boxes

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ABSTRACT

In 2014, Southern California Edison (SCE) undertook a randomized control trial (RCT) to test uptake of energy efficient Set-Top Boxes (STBs), in an effort to accelerate their adoption. Currently, consumers have little or no choice in the STB they receive. STBs are especially attractive targets for energy savings since they are generally powered "on" 24 hours per day. Furthermore, current technology is limited to either having no stand-by savings functionality or offer only limited reductions in power demand when in stand-by mode. Newer technology is now becoming available that can be expected to yield lower usage of these devices. However, current voluntary agreements and developing technology standards only address new installations. They do little to achieve savings in the existing installed base. Therefore, the current experiment focused on accelerated replacement of inefficient STBs in the existing customer base of service providers.

The pay-TV provider and SCE identified 6,700 customers with the highest savings potential in the installed-base for a RCT pilot experiment. Customers receiving the offer upgraded their STBs at a five times higher rate than the control group. While energy consumption per STB declined, the number STBs per household increased, yielding a net increase in electricity consumption per household. This may have been due to the way the offer was structured. The pilot provided experimental evidence of program uptake, and built relationships at the distributor level for future scaling of STB programs. We discuss lessons learned from the pilot and provide guidelines to maximize savings and minimize the naturally occurring rebound for others designing similar mid-stream consumer electronics programs.

Introduction

A recent pilot program, was designed to target a previously underappreciated section of the consumer electronics market: Set-Top Boxes (STBs) These products consume a large amount of energy, due to their always-on design and high saturation in residential homes. Service providers who typically provide STB equipment are vertically integrated firms that provide pay-TV service, as well as all necessary software and hardware to their customers. Thus, currently, consumers have little or no choice in the STB they receive. Due to the proprietary nature of the STB industry, very little information is available on the web, in the market, or in studies that report on the composition and usage of STBs currently installed in customers' homes. Additionally, since pay-TV providers are not responsible for paying energy use in customers' homes, a split incentive exists wherein customers have limited choice in the procurement of more energy efficient STBs, and service providers do not pay for the energy consumption in homes, and therefore have little incentive to enhance the energy efficiency features of the equipment they offer.

STBs are especially attractive targets for energy savings. According to one recent study, STBs have the fourth highest technical potential for energy savings among residential consumer electronics (Research Into Action & EMI 2012). Current STB technology either has no or limited stand-by savings functionality, or offers almost no savings in stand-by mode compared to on-mode.[1] Because STBs require persistent connectivity to facilitate programming guide updates, downloading of shows, software upgrades, and security provisioning, most STBs have very little energy savings whether they are turned on (to display TV content) or turned off. Deeper energy savings are not likely to occur until "deep sleep" features can be enabled to turn off the Digital Video Recorder (DVR) features while maintaining a low power level to sustain network connectivity and resume full operation in a reasonable level of time for customer acceptance (Research Into Action & EMI 2012). Additionally, because consumers essentially lease an STB from their pay-TV provider, and therefore have little to no influence over the product selection and availability of models, they pay little attention to the energy savings from STBs. This means that there are opportunities for raising customer awareness, acceptance, and knowledge about more energy-efficient options, as well as for testing customer interest in more-efficient STBs to raise awareness among service providers.

Due to the vertically integrated nature of this market, few efforts have been made to incentivize energy-efficient STB models. However, newer technology is now becoming available under ENERGY STAR specification version 4.1 that has the potential to lower energy usage among these devices. In late 2012, pay-TV service providers worked with the National Resources Defense Council (NRDC), and the American Council for and Energy-Efficient Economy to establish new efficiency standards for all future STBs (NRDC & ACEEE 2012). The voluntary agreement took effect on January 1st, 2014.However, these efforts only address new installations and will do little to achieve savings in the existing STB installed base, which can potentially remain on the grid for another five to eight years. Estimates based on existing field studies and market research data assumed a replacement rate of 12.5% for cable STBs (implying an eight year replacement cycle) and 20% for satellite STBs (implying a 5 year replacement cycle), although the paper does not disclose the source of these assumptions (Hardy et al. 2012). A sales data-based estimate yielded a STB lifecycle of approximately 6 years (Urban, Tiefenbeck & Roth 2012). Finally, by dividing the U.S. installed base of 224 million STBs in 2012 by the estimate of total STBs shipped in 2012, yields a lifecycle of 6.45 years, which is consistent other lifecycle estimates (ENERGY STAR 2013, D&R International 2014).

Trends in STB Technologies

In 2012, eleven pay-TV providers, representing more than 90% of the pay-TV market, signed a voluntary agreement that established new efficiency standards for all STBs starting in 2014 (NRCD & ACEEE 2012). As part of the agreement, these service providers report the STB models they procure each year. The 2013 Annual Report on the Voluntary Agreement includes information on the STB models service providers of all types procured in 2013 (D&R International 2014). CableLabs, a research and development organization that the cable industry funds, publishes information about the STB models that cable signatories to the Voluntary Agreement have procured since the beginning of 2014.[2]

The ability to deliver HD content has become a standard feature in STBs. Across service provider types, 99% of the STB models procured in 2013 were HD. In both 2013 and 2014, all of the models cable providers procured were HD (D&R International 2014, energy.cablelabs.com). Almost all models service providers procured (94%) also had advanced video processing capabilities.[3] As a result

[1] Because STBs require persistent connectivity to facilitate programming guide updates, downloading of shows, software upgrades, and security provisioning, most STBs have very little energy savings whether they are turned on (to display TV content) or turned off. Deeper energy savings are not likely to occur until "deep sleep" features can be enabled to turn off the Digital Video Recorder (DVR) features while maintaining a low power level to sustain network connectivity and resume full operation in a reasonable level of time for customer acceptance (ACEEE 2004, NCTA 2013)

[2] *CableLabs Energy Reporting*. Accessed February 18, 2015. http://energy.cablelabs.com/.

[3] Advanced video processing allows STBs to encode and decode both audio and video signals (D&R International 2014)

of the prevalence of HD and advanced video processing capabilities in STBs, the Environmental Protection Agency (EPA) eliminated allowances for these features in the ENERGY STAR Version 4.1 STB specification, instead accounting for them in the base allowance (U.S. Environmental Protection Agency 2014).

DVR, multi-room, and multi-stream capabilities also appear to be increasing, based on a comparison of cable providers' procurements in 2013 with their procurement in 2014 (Table 1). This is consistent with survey findings that multi-room systems are becoming more common (Fraunhofer 2014). Although pay-TV providers are procuring these multi-room systems on their own, they are likely procuring a set quantity to meet the needs of new customers or to replace non-functional STBs among existing customers. For households with multiple stand-alone STBs, a mid-stream program that incentivizes the early replacement of these stand-alone STBs to server/thin client models could accelerate the rate of replacement of existing stand-alone STBs with multi-room systems.

Table 1: Features Included in STBs Cable Providers Procured in 2013 and 2014 (D&R International 2014)

FEATURE	2013 PROCUREMENT		2014 PROCUREMENT		PERCENT DIFFERENCE (2014-2013)
	Models (n=41)	Percent	Models (n=37)	Percent	
Digital Video Recorder	19	46%	19	51%	**5%**
High Definition (HD)	41	100%	37	100%	0%
Multi-room	13	32%	16	43%	**11%**
Multi-stream for Cable and Satellite	18	44%	18	49%	**5%**

STB Efficiency Opportunities

There are two primary opportunities to reduce the energy use of STBs: reducing standby power use by incorporating low power sleep modes, and replacing secondary STBs in users' homes with thin clients that use less energy than a stand-alone STB to access content from a central server STB.

Sleep Mode

High stand-by power use is one factor that has attracted efficiency advocates' attention to STBs (NRDC 2011). When they are not displaying video content, STBs continue to use energy for downloading security updates, program guides, and software updates, tasks pay-TV service providers argue are necessary to allow the STB to start quickly when a user presses the power button (Goldberg 2012). The cable industry is working to develop STBs with a sleep mode that uses significantly less power than the powered-on mode. In 2012, the National Cable & Telecommunications Association anticipated that cable STBs with a "functional deep sleep" mode would be available for testing on the market by December 2014 (Goldberg 2012).

As part of the Voluntary Agreement, cable providers (and some internet-TV providers) committed to deploying new STBs with a "light sleep" capability and updating software on some existing STBs to enable light sleep. In a light sleep state STBs take steps to reduce energy consumption; for example stopping hard drives from spinning after a period of inactivity (D&R International 2014). Similarly, satellite providers are committed to deploying STBs with automatic power-down capabilities, which go into an off or sleep mode if there is no user activity.

Various pay-TV service types face unique challenges in incorporating low energy sleep modes into their STBs, and these have the potential to limit the widespread implementation of this capability. For example, unlike cable and internet-TV connections, which can deliver broadband internet service, satellite connections are unable to transmit information from the customer's home to the service provider. As a result, while cable and internet-TV providers may reduce STB standby power use by storing program guide information in the cloud, satellite providers must download this information onto the user's STB (Hardy et al. 2012).

Multi-Room Configurations

Efficiency advocates have identified shifting households with multiple stand-alone STBs to a configuration in which a central STB acts as a server, receiving the signal entering the home and providing content to one or more thin client devices in other rooms, as an opportunity for energy savings (NRDC 2011). EPA sought to encourage adoption of this type of configuration in developing the ENERGY STAR Version 4.1 specification (U.S. Environmental Protection Agency 2012). In their comments on the Version 4.1 specification revision process, pay-TV service providers also recognized multi-room configurations as an energy saving opportunity (Joseph 2013, Goldberg 2012).
These have become more prevalent in recent years, and service providers anticipate that their penetration will continue to grow. As noted earlier, a survey of consumer electronics in U.S. homes found an increase in prevalence of multi-room DVR servers and thin clients from 2011 to 2012 (Fraunhofer 2014).

The Pilot

SCE, together with a pay-TV service providers, implemented a pilot aimed at increasing the uptake of energy-efficient STBs among its customers. SCE offered an incentive to to cover part of the cost of upgrading customers' current STB to an ENERGY STAR (Version 3.0) certified STB. The service providers covered the remaining costs, making the upgrade free to the customer. Customers selected to be part of this pilot were those who had not upgraded their STBs or service package in the past two years. SCE worked with service providers to identify approximately 6,700 customers with pre-ENERGY STAR 3.0 STBs to participate in the pilot.

To evaluate the net impacts from the pilot, SCE randomly assigned 3,000 customers to the control condition and 3,700 customers to the experimental condition. Customers in the experimental condition received one or more calls from their service provider, informing them of the benefits of upgrading to an ENERGY STAR certified STB, mentioning SCE's involvement with the offer, and offering them a replacement ENERGY STAR certified STB. The service providers offered one year of free high-definition (HD) to all customers in the experimental condition if they upgraded to an ENERGY STAR Version 3.0 HD STB. If a customer had multiple STBs and expressed interest in a central control server with small peripheral STBs, known as a thin client, the service provider allowed the customer to upgrade to a thin client (with a monthly fee). Customers in the control condition were not contacted by SCE or the service providers, but upgrades were tracked as a baseline comparison. Customers receiving the upgrade offer upgraded their STBs at a higher rate than the control group, increasing the baseline replacement rate of about 1% to 9% for those receiving the upgrade offer.

Pilot Findings

The pilot resulted in 376 customers upgrading their STBs, 25 from the control condition, and 351 from the experimental condition. Due to the use of an RCT design, we can assume that the control condition's upgrade rate of 1% of represents the natural upgrade rate for customers upgrading their STBs without any promotional intervention that involved SCE or co-branded messages. We also can assume that the 8% net upgrade rate among the experimental condition is primarily due to the pilot's promotional offer (Table 2).

Table 2: Upgrade Rates by Pilot Condition

CONDITION	TOTAL N	UPGRADERS	UPGRADE RATE
Experimental	3,700	351	9%
Control	3,000	25	1%
Net	-	-	8%

When upgrading their STBs, most pilot participants, irrespective of pilot condition (control or experimental), increased the number of STBs in their home (Table 3).

Table 3: Change in Number of STBs in Home for Pilot Upgraders

CHANGE IN NUMBER OF STBS (POST-PRE)	CONTROL		EXPERIMENTAL	
	Count	Percent	Count	Percent
Did not Increase # of STBs	5	20%	88	25%
Increased # of STBs	20	80%	263	75%

Participants who upgraded had an average of 1.3 STBs in their home prior to the pilot. After the pilot, these participants had an average of 2.7 STBs in their home – resulting in about a two-fold increase in the number of STBs in the home. Since both the control and experimental conditions increased their STBs at similar rates, the increase in STBs is not due to the offer, but rather, a natural behavior for any customer upgrading their STBs (95% CIs control: [1.99, 1.12], experimental [1.47, 1.22]).[4]

The pilot offer influenced customers in the experimental condition to upgrade their STBs to HD and Digital Video Recorder (DVR) STBs at a higher rate than customers in the control condition. Conversely, customers in the control condition upgraded their STBs to a server and thin client system at a higher rate than customers in the experimental condition (Table 4). This may be due to the way the replacement offer was presented to customers in the experimental condition. Customers in the control condition were not called and did not receive an offer from service provider representatives. Thus, all customers who upgraded their STBs from the control condition called their service provider and asked for an upgrade. In contrast, experimental condition customers interested in server and thin clients were told that there would be an additional $25 “Advanced Receiver Services” fee and a $6 fee per box if more than one box was installed. While these costs were the same for the control group, customers in the experimental condition were called and offered a free STB and then informed of the fees after they expressed interest. Also, the cost to upgrade to a stand-alone HD STB(s) was free for the first 12 months, while the cost to upgrade to a stand-alone DVR or HD DVR STB(s) had a monthly fee of $10 for the DVR feature if customer upgraded from a non-DVR STB.[5]

[4] Thin clients and servers were both included as STBs for this statistic. For example, one server plus two thin clients would add up to three STBs for this statistic.

[5] A minority (12%) of those in the experimental condition had a non-DVR STB(s) and only eight of these individuals without DVR feature selected stand-alone DVR or HD DVR STB(s) and paid $10 monthly charge (about 2% of the total experimental group).

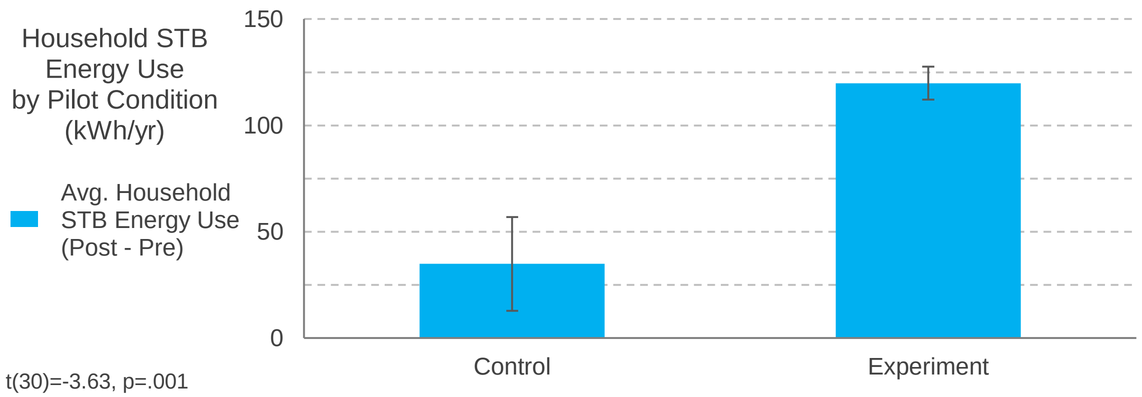
Table 4: Difference in Uptake of STBs with Specific Features by Condition

Difference in # of STBs	Control			Experiment			Independent Samples t-test*		
	Mean	SD	N	Mean	SD	N	t	DF	p-value
DVR (Between Pre and Post pilot)	0.24	0.60	25	1.08	1.03	351	-6.37	29	0.00
HD (Between Pre and Post pilot)	0.28	0.54	25	1.82	1.03	351	-12.65	30	0.00
Thin Client (Between Pre and Post pilot)	1.84	1.52	25	0.38	0.98	351	4.75	25	0.00

*All statistical tests in Table 4 are independent samples t-tests that do not assume equal variances. We chose to not assume equal variances due to the large difference in sample sizes between the two groups.

To measure the energy savings – or increases – resulting from the pilot, we used ENERGY STAR's Total Energy Consumption (TEC) calculations.[6] STB TECs calculate the annual energy (kWh/yr) for each STB model in the pilot. The combination of an increase in STBs for all upgraders, as well as an increase in uptake of key STB features such as HD and DVR, resulted in an increase in energy consumption for both control and experimental conditions. On average, each upgrader in the control condition increased their energy consumption by 35 kWh, while experimental condition upgraders increased their energy consumption by 120 kWh. While both groups increased their average household STB energy use, the marketed offer caused a significantly larger increase in household STB energy use for customers in the experimental condition (Figure 1).

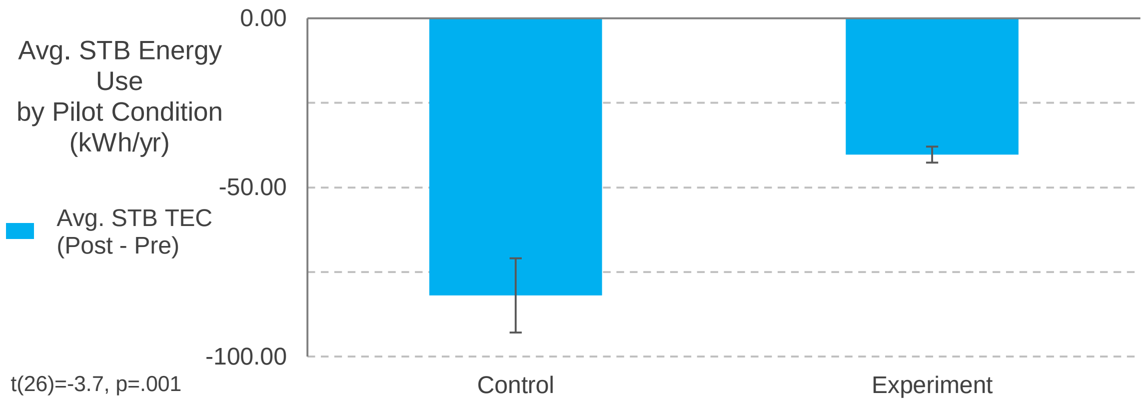
Figure 1: Change in Average Household STB Energy Use by Condition



On a per-device basis, energy consumption between pre and post pilot shows a reduction in energy consumption per STB (-40 kWh per STB in the experimental condition, and -82 kWh per STB in the control condition). Similar to findings above, the marketed offer caused a significantly smaller decrease in average STB consumption (Figure 2). Thus, the marketed offer drove customers in the experimental condition to trade in individual STBs on a one-to-one basis. In contrast, customers in the control condition, traded in their individual STBs for a server and several thin clients – which use markedly less energy than individual STBs.

[6] http://www.energystar.gov/ia/partners/product_specs/program_reqs/Set-top_Box_Program_Requirements.pdf

Figure 2: Change in Average STB Energy Consumption by Condition



There are many reasons why customers in the experimental condition may have increased their total household STB energy consumption. To identify the most important predictors of this increase in energy consumption, we conducted a regression analysis for all customers who upgraded their STBs in the experimental condition. The analysis revealed that three variables predict changes in energy consumption (Table 5). The model used in this study is as follows:

Change in Energy Consumption = Change in STB # + Change in DVR # + Change in HD # + Change TC # + Retention of Pre-ES 3.0

The model significantly predicted the change in energy consumption (R^2 =.79, SE of estimate = 67.45, $F(5,345)=253.1$, $p<.0001$). Increasing the number of STBs in the home is the largest predictor of increase in average energy consumption. If households retain more of their old STBs (pre ENERGY STAR 3.0 models), they are more likely to see an increase in energy consumption. Conversely, if customers adopt a central control server and increase the number of thin clients in their home, they are more likely to reduce energy consumption. Increasing the number of HD STBs or DVR STBs does not predict changes in energy consumption.

Table 5: Regression Model Findings*

PREDICTOR	BETA	SE	T-STAT	P-VALUE	IMPACT
Total units in home	98.920	5.220	18.95	.000	↑
Increase in # of Units with DVR feature	9.755	6.611	1.48	.141	↑
Increase in # of Units with HD feature	-12.371	7.914	-1.56	.119	↓
Increase in # of Server + Thin Client units	-63.294	6.405	-9.88	.000	↓
Retention of Pre ENERGY STAR Version 3.0	16.643	4.803	3.47	.001	↑

* The direction of the arrows indicates whether the feature increased energy use or decreased energy use.

Estimating Program Potential

To estimate the technical and achievable energy savings potential in SCE's service territory, we gathered the following data: 1) STB installed base data; 2) a list of non-certified and ENERGY STAR Version 2.0, 3.0, and 4.1 certified models; and 3) estimated energy usage (kWh/year) of each STB model.[7] The STB installed base data were provided to us by the participating pay-TV providers. These data are confidential not publicly available. We accessed the list of certified ENERGY STAR models and energy usage estimates from ENERGY STAR's website.[8] To ensure that certain details of the STB installed base data remain confidential, we restrict our reporting to percentages and energy savings values in the following sections.

Table 6 lists the nine replacement scenarios we calculated.[9] Based on the installed base of existing STBs in SCE territory, the technical savings potential ranged from -15% to 27% across several replacement scenarios listed in.[10] Scenario 4-C provides the largest technical energy savings potential over the assumed life of the equipment. This scenario replaces existing HD, DVR, and HD DVR stand-alone STBs, regardless of the ENERGY STAR certification level, with ENERGY STAR Version 4.1 multi-room configuration system.

Scenario 1-B (replacing existing pre-ENERGY STAR 3.0 STBs with ENERGY STAR Version 4.1 comparable STBs) provides the second largest technical energy savings potential over the assumed life of the equipment. However, for a program considering incentivizing early replacement of STBs, providing an incentive to a customer to upgrade an existing STB to an energy-efficient but comparable model will be difficult, especially if the customer has a basic SD model, service providers no longer procure basic SD models. Thus, scenarios modelling replacement of existing stand-alone STBs with energy-efficient STBs with HD capability (our Scenarios 2-4) are more realistic for a program to consider.

Table 6: Technical Potential of Each Scenario

SCENARIO	REPLACE FROM	REPLACE TO	% SAVINGS OVER BASELINE
1-A	Pre-ENERGY STAR (ES) 3.0 models	ES 3.0 STBs, like-with-like replacement [a]	8.5%
1-B	Pre-ES 3.0 models	ES 4.1 STBs, like-with-like replacement	19.0%
2-A	Pre-ES 3.0 models	ES 3.0 STBs with HD capability [b]	3.3%
2-B	Pre-ES 3.0 models	ES 4.1 STBs with HD capability	8.7%
3-A	Pre-ES 3.0 models	ES 3.0 STBs with HD DVR capability [c]	-15.2%
3-B	Pre-ES 3.0 models	ES 4.1 STBs with HD DVR capability	2.4%
4-A	Pre-ES 3.0 models	ES 4.1 Server/Thin client system (HD DVR capability) [d]	17.3%
4-B	Pre-ES 3.0 models	ES 4.1 Thin client(s) for only customers already having a server [e]	6.6%
4-C	HD, DVR, or HD DVR stand-alone models	ES 4.1 Server/Thin client system (HD DVR capability) [f]	27.0%

[a] Like-with-Like" replacement means that pre-ENERGY STAR Version 3.0 DVR STBs, for example, are replaced with ENERGY STAR Version 3.0 or 4.1 DVR STBs. This replacement scenario assumes customers added no additional features, except in one instance. Nearly all new STBs entering the market have HD features, and the ENERGY STAR base allowance for 4.1 specification includes HD capability. So, replacing pre-ENERGY STAR Version 3.0 basic SD model with the 4.1 model that would be SD is not a realistic scenario.

[b] This scenario assumes that pre-ENERGY STAR Version 3.0 models without HD features are replaced with an ENERGY STAR 3.0 or 4.1 HD STBs. For example, a box with a DVR feature would be replaced with a box with an HD DVR feature.

[c] This scenario assumes that pre-ENERGY STAR Version 3.0 basic SD STBs, for example, are replaced with an ENERGY STAR Version 3.0 or 4.1 HD DVR box. An HD DVR box includes all the features a customer may want.

[7] The evaluation team was able to obtain some model-level STB data for SCE territory as of December 2014. In this document, we refer to this database as the "installed base" of STBs in SCE territory.

[8] http://www.energystar.gov/productfinder/product/certified-set-top-boxes/results

[9] All scenarios used ENERGY STAR TEC estimates to estimate savings potential. The TEC formulas include estimates for hours STBs are in sleep versus on mode as well as the number of hours the STB is on annually.

[10] We replaced pre-ENERGY STAR Version 3.0 or 4.1 models with ENERGY STAR Version 3.0 or 4.1 models. Each scenario specifies the type of models we replaced.

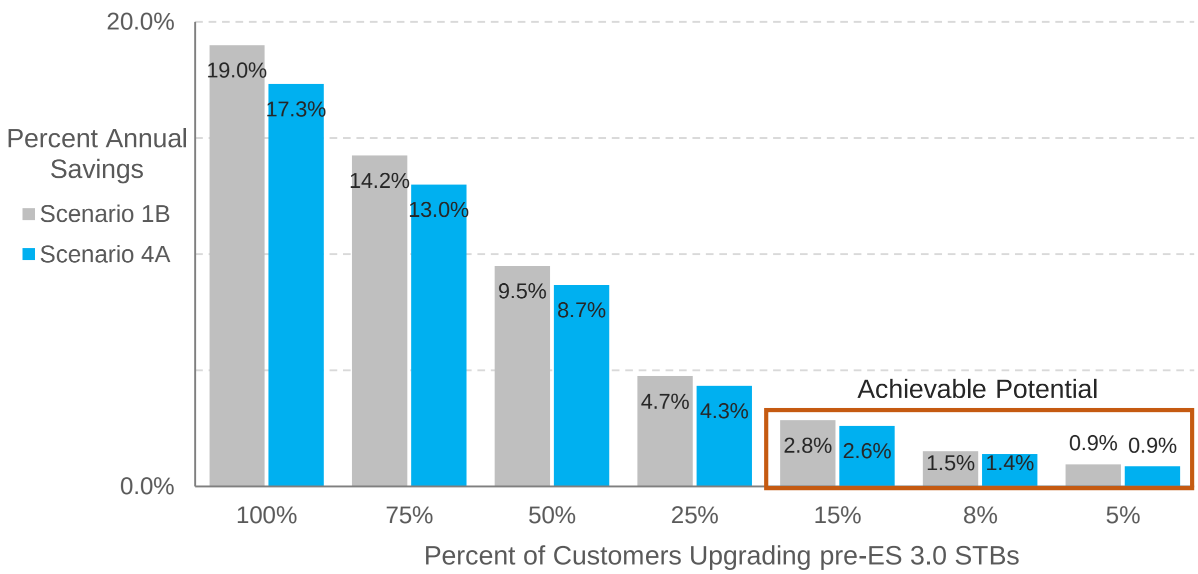
[d] This scenario assumes pre-ENERGY STAR Version 3.0 stand-alone STBs are replaced with a server and thin client system (a multi-room configuration STB technology that meets ENERGY STAR Version 4.1 specification). If the customer already had a server, then the customer's pre-ENERGY STAR Version 3.0 stand-alone STBs, if any, is assumed to be replaced with thin clients. If the customer had an older pre-ENERGY STAR Version 3.0 certified server, then that server is assumed to be replaced with a 4.1 model.

[e] This scenario examines energy savings potential if only those customers who had a server and pre-ENERGY STAR Version 3.0 stand-alone STB(s) replaced their stand-alone STBs with thin clients.

[f] This scenario assumes all HD, DVR, or HD DVR STBs are replaced with a server and thin client systems, regardless of their ENERGY STAR designation. If the customer already had the latest server, then the customer's existing stand-alone STBs are assumed to be replaced only with thin clients. If the customer had pre-ENERGY STAR Version 3.0 certified server, then the server is assumed to be replaced with a 4.1 model. Only customers with two to five STBs were included in this scenario.

The achievable savings potential, which we calculated by assuming that 8% of customers can be induced to upgrade their STBs (per the Pilot results), ranged from -1.4% to 2.4% of baseline usage across the replacement scenarios. The technical potential findings for Scenario 4-C and 1-B, shown in Figure 3. These two scenarios provided the largest achievable energy savings potential across the life of the equipment. In addition to estimating the achievable potential at 8%, we modeled higher and lower achievable potentials (15% and 5%) to estimate potential changes to the offer presented to customers. The 4-C scenario is a more realistic scenario for a program to consider because that scenario replaces existing HD, SD, or HD DVR STBs with newer but HD-capable technology, whereas the 1-B scenario replaces existing STBs with newer but comparable technology in terms of features. From the survey data with experimental upgraders, we learned that customers upgraded because they wanted an STB with advanced features (HD in particular).

Figure 3: Achievable Potential of Scenarios 1B and 4C



Additionally, if we assume that customers increase the number of STBs in a home by one unit when upgrading their equipment, the savings potential is positive only for the scenarios where: 1) existing pre-ENERGY STAR Version 3.0 STBs are replaced by a stand-alone ENERGY STAR Version 4.1 STB (either a comparable or an HD model)); or, 2) existing pre-ENERGY STAR Version 3.0 STBs or STBs with advanced features are replaced by a server and thin client system. When we assume that customers increase the number of units in a home by two after upgrading their equipment, the energy savings potential, although is reduced, and is only positive when existing pre-ENERGY STAR Version 3.0 STBs or STBs with advanced features are replaced by a server and thin client system.

Conclusions

The STB pilot upgrade offer was effective in stimulating uptake of efficient boxes. Customers receiving the upgrade offer in the pilot upgraded their STBs at an 8% higher rate than the control group, increasing the baseline replacement rate of about 1% to 9% for those receiving the upgrade offer. Yet, customers in the pilot, irrespective of pilot condition, increased the number of STBs in their household when they upgraded their STBs, suggesting this was natural consumer behavior. Also, while both groups increased their average household STB energy use, the offer led to a larger increase in household STB energy use for customers in the experimental condition. This is, presumably, due to the way the marketed offer was framed to customers. The offer mentioned thin clients only after customers expressed interest, and then mentioned the additional monthly costs for the thin clients after customers were originally offered a free upgrade. Nevertheless, the pilot showed that customers are interested in upgrading their STBs and that, with incentives focused on server/thin clients, future pilots can save energy. Table 8 provides a list of recommendations to assure savings for future STB pilots and programs.

Table 7: Summary of Conclusions and Recommendations

CONCLUSION	RECOMMENDATION
Customers naturally increase the number of STBs when they make upgrades	Provide incentives for the number of boxes already present in the home. Focus program on server/thin client STBs rather than individual boxes
Server/Thin client STB replacements provide the largest technical and achievable potential	Incent server/thin client STBs Focus solely on customers with multiple STBs in their home

Conclusion 1: Customers naturally increase the number of STBs when they make upgrades

The STB pilot upgrade offer resulted in the installation of more energy efficient boxes. Average per-box energy consumption declined as a result of the pilot. However, the STB pilot upgrade offer, although effective in stimulating uptake of efficient boxes, caused a significant increase in household STB energy use. This occurred because the offer, as presented, allowed customers to add one or more additional energy-efficient box(es) as part of the offer and customers in the experimental group infrequently selected server and thin client upgrade option.

A regression analysis of upgraders in the experimental condition revealed that an increase in the total number of STBs among upgraders, as well as customer retention of some pre-ENERGY STAR 3.0 boxes, resulted in an increase in energy consumption for the experimental group, whereas upgrading to a server and thin client system resulted in a decrease in energy consumption. Increasing the number of STBs (also which occurred in the control condition at a similar rate) and upgrading to a server and thin client system (which was much more frequent in the control condition) had the biggest impact on energy usage among customers in the experimental condition. The pilot upgrade offer, as presented to customers, allowed customers to add additional STBs for free unless they selected server and thin client system or a stand-alone DVR-capable STB if they had no DVR STB before. The additional monthly fees for upgrading to a server and thin client system were much higher than if upgrading to a DVR-capable STB from a non-DVR STB.

Recommendation 1 An STB replacement program should take into consideration the customers' current configuration of existing STBs and the natural inclination of consumers to increase the number of STBs, and consequently focus on dis-incentivizing the acquisition of any additional units.

Recommendation 2: An STB replacement program should focus incentives server and thin client boxes rather than individual boxes.

Conclusion 2: Server and Thin client STB replacements provide the largest technical and achievable potential

Installation of ENERGY STAR Version 4.1 certified multi-room configuration STB is the highest energy savings opportunity for an early replacement STB program. A program targeting early replacement of STBs should focus on replacing existing stand-alone STBs with the latest ENERGY STAR Version 4.1 HD-capable technologies. We estimated the energy savings potential for several scenarios that involve replacing existing STBs with various types of energy efficient STB models. Across these replacement scenarios, replacing existing any HD STB with ENERGY STAR Version 4.1 server and thin clients systems provides the largest achievable energy savings potential. Replacing existing pre-ENERGY STAR 3.0 STBs with ENERGY STAR Version 4.1 server and thin clients systems provides the second largest achievable energy savings potential. Also, these two scenarios allow for savings even when customers increase the number of boxes in their home.

Recommendation 3: Any STB program designed to incentivize early replacement of STBs should consider restrict incentives to ENERGY STAR Version 4.1 boxes, listed in order of highest to lowest energy savings opportunity:

- A central control server and thin client system
- ENERGY STAR Version 4.1 stand-alone STBs with HD capability
- ENERGY STAR Version 4.1 STBs with HD DVR capability

Replacing existing STBs with ENERGY STAR Version 4.1 certified server and thin client systems yields the greatest energy savings when more boxes are replaced and when the boxes replaced have more advanced features.

As features are added (HD, HD DVR) energy consumption increases. The server-thin client model provides HD DVR with less energy consumption than two or more stand-alone HD DVR STBs. With four or more units in the home, the server-thin client model provides HD DVR for equivalent or less energy than stand-alone HD STBs. With five or more units in the home, the server-thin client model provides HD DVR for equivalent or less energy than stand-alone basic STBs.

Recommendation 4: Any STB program designed to incentivize early replacement of STBs should consider offering an incentive only to homes with multiple STBs. An STB program should also focus on targeting replacement of STBs with advanced features such as HD DVR, which use more energy.

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