Final Report

Set-Top-Box Pilot and Market Assessment

April 30, 2015

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Executive Summary

In 2014, Southern California Edison (SCE) implemented an experimental Set-Top-Box (STB) pilot to test the uptake of energy-efficient STBs among SCE's customers. Currently, customers have little or no choice in the STB they receive from Pay-TV service providers – vertically integrated firms that usually provide all necessary software and hardware to their customers. Due to the proprietary nature of the data on STBs, very little information is available on the internet, in the market, or even in studies reporting on the composition and usage of STBs currently installed in customers' homes.

This report documents findings from the STB pilot and market research activities, conducted to support SCE's effort to promote energy-efficient STBs to residential customers with existing STBs. Specifically, this study had three research objectives: 1) evaluating the performance of the experimental pilot; 2) examining literature and available data on the STB market in California and SCE territory; and 3) estimating the technical and achievable energy savings potential of replacing less efficient STBs with energy-efficient models in installed base of STBs in SCE territory. For estimating technical and achievable energy savings potential, we were able to obtain some model-level STB data for SCE territory as of December 2014 (we refer to this data as the STB "installed base" in the text). Although this dataset does not cover all service providers in SCE territory, it still provided valuable insights into the savings potential.

Please note we determined the energy savings for each model replaced in the pilot and the STB installed base using Total Energy Consumption (kWh/year) estimates provided by the Pay-TV service provider(s). Service providers, prior to associating the ENERGY STAR® pre-ENERGY STAR name or certification level with any of their products, must obtain written certification of ENERGY STAR qualification from a Certification Body recognized by the Environmental Protection Agency (EPA) for their STB products. As part of this certification process, STBs must be tested in a laboratory recognized by EPA to perform STB testing. Thus, the engineering energy savings estimates of ENERGY STAR certified models, which were relevant to this study and provided by the service provider(s), were likely independently verified by a recognized EPA laboratory.

Below we present a summary of the research approach and key findings, conclusions, and recommendations from the pilot, market assessment, and technical and achievable energy savings potential analyses.

Summary of the Research Approach

To meet the research objectives referenced above, we conducted several research activities: 1) analysis of the STB experimental pilot data; 2) surveys with those participating in the pilot; 3) literature review of the publicly available STB data and/or studies; and 3) analysis of the SCE STB installed base. SCE STB installed base included customer data from only a subset of service providers; the dataset included STB model data of less than a quarter of Pay-TV subscribers in SCE territory.

Table ES-1 displays the research approach relative to each of the research questions.

Table ES-1: Research Questions Identified in RFP by Data Collection/Analysis Activity

RESEARCH QUESTION	QUANTITATIVE ANALYSIS			QUALITATIVE ANALYSIS
	Experiment * (n=6,700)	SCE STB Install Base Analysis	Customer Survey (n=86)	Literature Review
Can this program accelerate the adoption of higher efficiency STBs in the installed base of older STBs? If yes, what is the counterfactual?	X			
What are the characteristics of the installed base for STBs?		X		X
What is the state of the STB market?	X	X	X	X
How can customers be incentivized to demand energy efficient STBs in a vertically integrated market?	X		X	X
Is this an effective channel for accelerating adoption of energy efficiency STBs?		X	X	X
How satisfied are customers participating in the pilot with their experience?			X	
What is the technical and achievable energy savings potential if SCE pursued replacement of old and inefficient STBs with ENERGY STAR Version 3.0 or 4.1 certified models?		X		

* SCE offered an incentive to select service provider customers in SCE territory to cover part of the cost of upgrading the customer's current STB to an ENERGY STAR Version 3.0 Certified STB. The service provider(s) covered any remaining costs not covered by SCE, making the upgrade free to the customer. SCE identified 6,700 customers with pre-ENERGY STAR 3.0 STBs to participate in the pilot, and randomly assigned 3,000 customers to the control condition and 3,700 customers to the experimental condition.

Key Findings, Conclusions, and Recommendations

The STB pilot upgrade offer was effective in stimulating uptake of efficient boxes. Those in the experimental group receiving the upgrade offer upgraded their STBs at a eleven times higher rate than the control group, increasing the baseline replacement rate of 1% to about 9% among those receiving the upgrade offer.[1]

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. Analysis of pre and post pilot data shows a reduction in average energy consumption per STB (-40 kWh per STB in the experimental condition, and -82 kWh per STB in the control condition). We attribute the smaller decrease in average STB consumption for the experimental group to the way the pilot offer was

[1] Customers in the experimental condition with pre-ENERGY STAR Version 3.0 STBs received one or more calls from the service provider informing them of the benefits of upgrading to an ENERGY STAR Version 3.0 STB, mentioning SCE's involvement with the offer, and offering them a free replacement to an ENERGY STAR Version 3.0 STB. Customers did incur some additional charges if they upgraded to a box or system with the most advanced features.

presented to customers. Customers in the experimental condition upgraded their STBs to a multi-room STB system (a central control server that communicates with several receivers called thin clients) at a much lower rate in response to the pilot offer compared to customers in the control condition. Server and thin client technology is more energy efficient than stand-alone ENERGY STAR Version 3.0 or 4.1 certified STBs when replacing multiple STBs (an important point we discuss in detail below). The lower uptake of the server and thin client technology among those in the experimental condition could be a consequence of additional fees associated with the server upgrade option, whereas stand-alone STB upgrade options were free (except for one)[2] to the customers in the experimental group.

Irrespective of pilot condition (experimental or control), customers in the pilot increased the number of STBs in their household when they upgraded their STBs, suggesting this was natural consumer behavior. Participants had an average of 1.3 STBs in their home prior to the pilot, whereas after the pilot, participants had an average of 2.7 STBs in their home –about a two-fold increase in STBs for participants who upgraded their STBs. Since customers in both the control and experimental conditions increased the number of STBs at similar rates, the increase in STBs is not due to the offer, but rather appears to be a natural behavior for any customer wanting to upgrade their STBs.

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.

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. Although both groups increased their average household STB energy use, the marketed offer caused a significantly larger increase in household STB energy use among customers in the experimental condition (Figure ES-1). 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.

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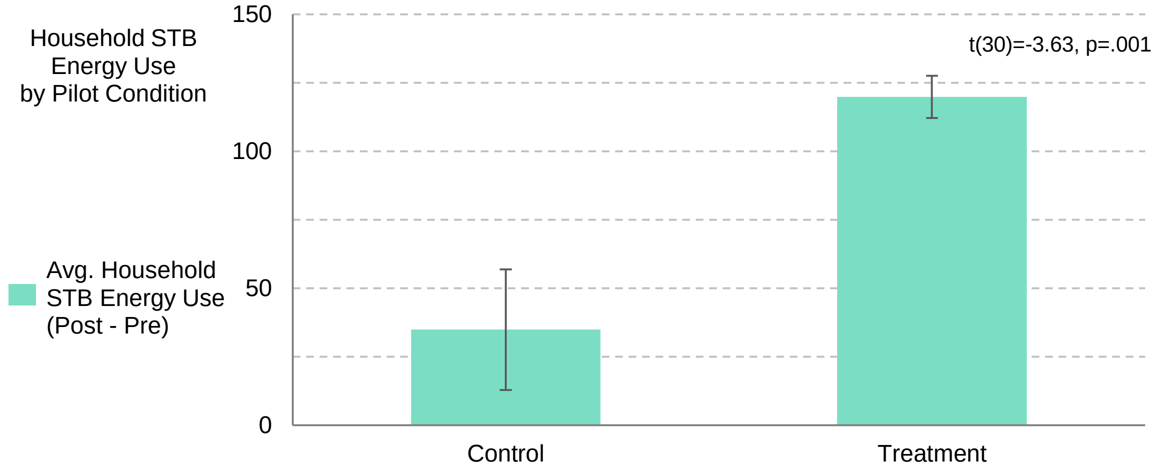
2 The pilot upgrade offer allowed customers to add additional STBs for free unless they selected server and thin client system or a DVR-capable stand-alone STB if they had no DVR STB before. The additional monthly fee for upgrading to a server and thin client system was much higher than if upgrading to a DVR-capable stand-alone STB from a non-DVR STB.

Figure ES-1: Impacts to Average Household STB Energy Use by Condition



- **Recommendation:** 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 incentivizing the one-to-one replacement of existing customer STBs without incentivizing any additional units. That is, a program should incentivize customers to replace their existing boxes but not incentivize any additional boxes they may wish to install as part of the upgrade.
- **Recommendation:** An STB replacement program should re-assess the incentive offer for the server and thin client technology upgrade option.

To assess the energy savings potential of the two recommendations referenced above, we estimated technical and achievable energy savings potential of replacing existing, less efficient stand-alone STB models with ENERGY STAR Version 3.0 or 4.1 models or a multi-room server and thin client system. We assumed one-to-one replacement of customers' STBs, and we modeled energy savings potential if the number of boxes increased after the upgrade. Technical potential is defined as the energy savings of replacing all pre-ENERGY STAR Version 3.0 STBs or STB models with advanced features in the Southern California STB installed base[3] with ENERGY STAR Version 3.0 or 4.1 certified models. The achievable potential is defined as the energy savings that could reasonably be achieved assuming customer response rate to an upgrade offer would be similar to the response rate observed in the pilot. The STB pilot, which tested the effectiveness of SCE's STB upgrade offer, resulted in a replacement rate of about 9% among those exposed to the upgrade offer.

3 The installed base included all non-certified models and ENERGY STAR Version 2.0, 3.0, and a few 4.1 certified models of a subset of service providers operating in SCE territory. For technical and achievable potential modeling, all scenarios replaced pre-ENERGY STAR Version 3.0 models with ENERGY STAR Version 3.0 or 4.1 certified STBs, except for the scenario where we replaced all existing stand-alone STBs with advanced features (regardless of the ENERGY STAR designation) with ENERGY STAR Version 4.1 server and thin client system.

Installation of ENERGY STAR Version 4.1 certified server and thin client system is the highest energy savings opportunity for an early replacement STB program.

Using the available Southern California STB installed base data, the technical energy savings potential ranged from -15% (-42.6 GWh per year) to 27% (75.5 GWh per year) of baseline usage and achievable energy savings potential ranged from -1.4% (-3.8 GWh per year) to 2.4% (6.8 GWh per year) across the replacement scenarios listed in Table ES-2. The scenario that replaces existing STBs with specific features (HD, DVR, and HD DVR), regardless of their ENERGY STAR designation, with ENERGY STAR Version 4.1 server and thin clients systems (Scenario 4-C) provides the largest achievable energy savings potential.

The scenario that replaces pre-ENERGY STAR Version 3.0 stand-alone STBs with ENERGY STAR Version 4.1 stand-alone STBs with comparable features had the second largest annual and lifetime energy savings potential. However, we feel it is not practical for a program that incentivizes the early replacement of STBs to limit participation to customers replacing their existing STB with an energy-efficient model but not allow them to add features, especially for customers with a basic SD STB. Service providers no longer procure basic SD STBs. Across service provider types, 99% of the STBs procured in 2013 were HD, indicating that the ability to deliver HD content is becoming a standard feature in STBs. Thus, scenarios modeling a replacement of existing stand-alone STBs with energy-efficient STBs with HD capability (the highlighted scenarios in Table ES-2) are more realistic scenarios for a program to consider.

The scenario that replaces existing pre-ENERGY STAR 3.0 STBs, regardless of their features, with ENERGY STAR Version 4.1 server and thin client systems (Scenario 4-A) had the third largest achievable energy savings potential, at 4.4 GWh per year and 12.7 GWh over the expected life of the equipment.

Not surprisingly, increasing the number of household STBs reduces the savings potential. Sensitivity analysis revealed that if customers increase the number of STB units by one when they upgrade their equipment, this would likely yield negative savings potential for all of the scenarios, except for scenarios where we replace existing STBs with either stand-alone ENERGY STAR Version 4.1 STBs (a comparable or an HD model) or a server and thin client system. If we assume customers increase the number of units by two after upgrading their equipment, then there is only one scenario with positive savings potential: replacing existing STBs with a server and thin client system.

Table ES-2: Technical and Achievable Potential of Each Scenario

REPLACE LESS EFFICIENT MODELS	REPLACE TO NEWER ENERGY STAR (ES) MODELS	TECHNICAL POTENTIAL			ACHIEVABLE POTENTIAL		
		Percent Savings Over Baseline	Annual GWh Savings	Lifetime GWh Savings	Percent Savings Over Baseline	Annual GWh Savings	Lifetime GWh Savings
Pre-ES 3.0 models	3.0 STBs, like-with-like replacement [a]	8.5%	23.9	69.6	0.8%	2.1	6.3
Pre-ES 3.0 models	4.1 STBs, like-with-like replacement	19.0%	53.1	154.7	1.7%	4.8	13.9
Pre-ES 3.0 models	3.0 STBs with HD capability [b]	3.3%	9.3	27.1	0.3%	0.8	2.4
Pre-ES 3.0 models	4.1 STBs with HD capability	8.7%	24.3	70.8	0.8%	2.2	6.4
Pre-ES 3.0 models	3.0 STBs with HD DVR capability [c]	-15.2%	-42.6	-124.2	-1.4%	-3.8	-11.2
Pre-ES 3.0 models	4.1 STBs with HD DVR capability	2.4%	6.7	19.5	0.2%	0.6	1.8
Pre-ES 3.0 models	4.1 Server/Thin client system (HD DVR capability) [d]	17.3%	48.4	141.2	1.6%	4.4	12.7
Pre-ES 3.0 models	4.1 Thin client(s) if customer already had a server [e]	6.6%	18.5	54.0	0.6%	1.7	4.9
HD, DVR, or HD DVR models	4.1 Server/Thin client system (HD DVR capability) [f]	27.0%	75.5	220.1	2.4%	6.8	19.8

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. Therefore, replacing pre-ENERGY STAR Version 3.0 basic SD model with the 4.1 model that would be SD is no longer feasible.

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.

d This scenario assumes pre-ENERGY STAR Version 3.0 stand-alone STBs are replaced with a server and thin client systems. If the customer already had a server, then we only replaced customer’s pre-ENERGY STAR Version 3.0 stand-alone STBs with thin clients. If the customer had pre-ENERGY STAR Version 3.0 certified server, then we replaced that server 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.

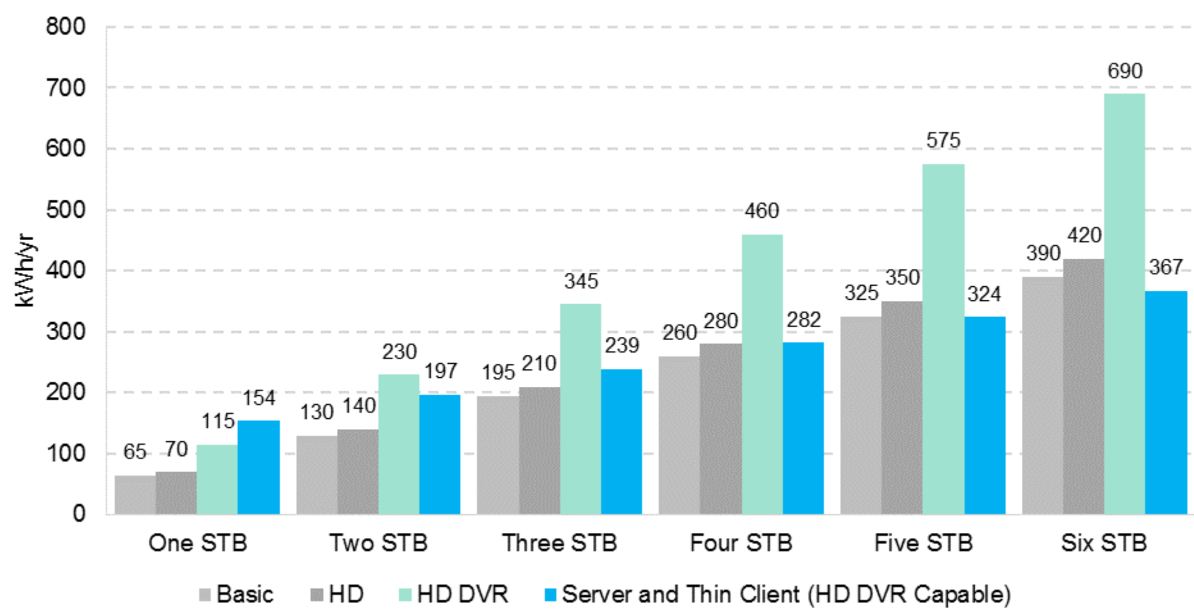
f This scenario assumes HD, DVR, or HD DVR STBs are replaced with a server and thin client systems, regardless of their ENERGY STAR designation. Only customers with between two and five STBs were included in this scenario, these customers had to have at least one HD, DVR, or HD DVR STB. If the customer already had a server, then we only replaced customer’s existing stand-alone STBs with thin clients. If the customer had pre-ENERGY STAR Version 3.0 certified server, then we replaced that server with a 4.1 model.

- **Recommendation:** Any STB program designed to incentivize early replacement of STBs should consider these ENERGY STAR Version 4.1 replacement technologies, 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 greater energy savings when more boxes are replaced and when the replaced boxes have more advanced features.

Figure ES-2 compares the total energy consumption (kWh/year) of four ENERGY STAR 4.1 model types (stand-alone basic STB, stand-alone HD STB, stand-alone HD DVR STB, and server/thin client) for different numbers of units in the home (one to six STBs). As expected, as features are added (HD, HD DVR) energy consumption increases. A server, which uses 154 kWh/year, on average, can function as a STB without any clients; a client, which uses 43 kWh/year, on average, cannot function without a server. As shown in the figure, 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, the server-thin client model provides HD DVR capability while using about the same energy as stand-alone HD STBs without the DVR capability. With five or more units, the server-thin client model provides HD DVR capability while using less energy than stand-alone basic STBs.

Figure ES-2: ENERGY STAR 4.1 Model Average kWh/year by Number of STBs and Model Types



- **Recommendation:** Any STB program designed to incentivize early replacement of STBs should consider offering an incentive to only those homes with multiple STBs.

- **Recommendation:** An STB program should focus on targeting replacement of STBs with advanced features such as HD DVR, which use more energy.

Overall, although ENERGY STAR Version 3.0 STB technologies have penetrated the market, there may be an immediate program opportunity to accelerate adoption of ENERGY STAR Version 4.1 STBs that could lay the groundwork for longer-term engagement in the STB market. In 2012, eleven leading Pay-TV providers entered into a Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes, committing that by 2014, 90% of the STBs they procure would meet ENERGY STAR Version 3.0 specifications.

Although the Voluntary Agreement does not address the STBs already installed in Pay-TV subscribers' homes, ENERGY STAR Version 3.0 Certified STBs have likely achieved significant penetration of the installed base through the natural replacement cycle. Given estimates of a five-to-eight-year replacement cycle for STBs, as many as half the STBs in the installed base may have been replaced in the past three years, a timeframe during which ENERGY STAR 3.0 STBs accounted for the vast majority of shipments. The Southern California STB installed base was consistent with this estimate, with customers who had all ENERGY STAR Version 3.0 models comprising nearly half (42%) of the records. Another quarter (25%) had a mix of ENERGY STAR Version 3.0 and pre-3.0 models.

Under the Voluntary Agreement, service providers agreed that, beginning in 2017, at least 90% of the STBs they procure will meet a higher efficiency standard that is similar, but not identical, to the ENERGY STAR Version 4.1 specification that became effective in December 2014. Currently, however, penetration of ENERGY STAR Version 4.1 STBs is well below this target. According to service provider reporting, 47% of the STBs they procured in 2013 met the Voluntary Agreement's higher efficiency standards. Cable providers procured a larger assortment of individual STB models that appear to meet the ENERGY STAR Version 4.1 requirements in 2014 than 2013, but these models represented less than one-third of all the individual models they procured. As of the end of January 2015, there were 25 STB models qualified under ENERGY STAR 4.1, compared with 132 qualified models under Version 3.0 when the specification changed.

Like other consumer electronics products, STB technology changes rapidly. In the Voluntary Agreement, service providers agreed to work to develop lower energy sleep modes for STBs, a goal research groups like the CalPlug Initiative at the University of California Irvine are also pursuing. Given these efforts, it is likely that more efficient STB technologies will be available by the time the more stringent standards take effect under the Voluntary Agreement in 2017. Given its mission to recognize only the highest performing models, it is also likely that EPA will revise the ENERGY STAR specification for STBs prior to 2017. A program that entered the market seeking to accelerate adoption of ENERGY STAR 4.1 STB models would be well positioned to promote new, more efficient STB technologies and higher efficiency standards that recognize them when they become available. To phrase it differently, an STB program can adapt in what it is incentivizing as technology changes.

- **Recommendation:** An STB program should focus on accelerating early replacement of ENERGY STAR Version 4.1 models in the short term while advocating for the development of – and promoting – still more stringent standards in the medium and long term. While there is opportunity to accelerate adoption of ENERGY STAR Version 4.1 STBs in the next few years, these boxes are likely to become mainstream among STBs in the next several years.

1. Introduction

1.1. Background

The STB pilot under the Plug Load and Appliances program targets a previously underappreciated section of the consumer electronics market: STBs. These products consume a significant amount of energy, due to their always-on design and their ubiquity in residential settings. 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 data on STBs, 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 barrier 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. They have the fourth highest technical potential for energy savings among residential consumer electronics according to the BCE-HEER Process Evaluation Study.[4] STBs are generally in on-mode 24 hours per day, and current technology either has no or limited stand-by savings functionality or offers almost no savings in stand-by mode compared to on-mode.[5] Additionally, because consumers have little to no influence over the product selection and availability of models from Pay-TV service providers, customers pay little attention to the brand and energy savings from STBs because STBs are essentially a "leased product" used to access the Pay-TV content. This means that there are opportunities for raising customer awareness, acceptance, and knowledge about more energy efficient options as well as testing customer interest in more efficient STBs to raise awareness to service providers.

Due to the vertically integrated nature of this market, relatively few efforts have been made to incentivize energy-efficient STB models. Newer technology is now becoming available under ENERGY STAR specification version 4.1 that should result in lower energy usage among these devices. Voluntary agreements among Pay-TV service providers in combination with emerging ENERGY STAR standard setting efforts are revealing upstream energy savings opportunities for

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4 Research Into Action and Energy Market Innovations. 2012. *Program and Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) / Business & Consumer Electronics (BCE)*. http://www.calmac.org/publications/HEER__BCE_083012_FINAL.pdf.

5 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.

new STBs. These agreements and standards together with the California Plug Load Research Center's "5W5s" Initiative, funded by the California Energy Commission to develop the next-generation energy-efficient STB prototype, demonstrate how active content providers, manufacturers, utilities, and academics are in developing energy efficiency solutions for STBs and ultimately transforming the STB market. However, these efforts only address new installations and will do little to achieve savings in the existing STB installed base.[6]

1.2. Research Objectives and Approach

SCE launched an experimental pilot program in 2014 to explore the energy savings potential of more energy efficient STBs in their service territory. This study evaluated SCE's STB pilot data as well as the STB installed base data from service provider(s). The overall study objectives were to assess the performance of the experimental pilot, estimate the technical and achievable potential of replacing existing STBs with more energy-efficient models, and characterize the current STB market in California and SCE territory. Thus, the study was designed to:

- Assess replacement rates in the intervention group during the experimental pilot compared to a control group
- Calculate the actual savings achieved for the intervention group compared to the control group
- Estimate technical and achievable energy savings potential for replacing existing but older boxes with ENERGY STAR Version 3.0 or 4.1 certified boxes[7]
- Characterize the STB market in California and SCE territory

Table 1-1 displays the research approach relative to each of the research questions.

6 In 2012, the California Plug Load Research Center (CalPlug) started developing a prototype of next-generation energy-efficient STBs. The CalPlug's technology advancement panel set a goal of "5W5s," which is to develop an STB prototype that uses less than five watts of power during "light sleep mode" and less than five seconds to fully wake up. For more information, see the calplug.org website.

7 We developed several STB replacement scenarios for which we estimated technical and achievable energy savings potential. In all but one scenario (scenario 4-C), the older boxes were defined as ENERGY STAR Version 2.0 certified or non-certified STBs. In scenario 4-C, we replaced HD, DVR, or HD DVR STBs, regardless of the ENERGY STAR designation, with the latest ENERGY STAR Version 4.1 certified server and thin client system. For more details, see Chapter 4.

Table 1-1: Research Questions Identified in RFP by Data Collection/Analysis Activity

RESEARCH QUESTION	QUANTITATIVE ANALYSIS			QUALITATIVE ANALYSIS
	Experiment (n=6,700)	SCE STB Install Base Analysis	Customer Survey	Literature Review
Can this program accelerate the adoption of higher efficiency STBs in the installed base of older STBs? If yes, what is the counterfactual?	X			
What are the characteristics of the installed base for STBs?		X		X
What is the state of the STB market?	X	X	X	X
How can customers be incentivized to demand energy efficient STBs in a vertically integrated market?	X		X	X
Is this an effective channel for accelerating adoption of energy efficiency STBs?		X	X	X
How satisfied are customers participating in the pilot with their experience?			X	
What is the technical and achievable energy savings potential if SCE pursued replacement of old and inefficient STBs with ENERGY STAR Version 3.0 or 4.1 certified models?		X		

2. Set-Top-Box Pilot

SCE together with one or more Pay-TV service providers implemented a pilot aimed at increasing the uptake of energy-efficient STBs among SCE's customers. SCE offered an incentive to select service provider customers in SCE territory to cover part of the cost of upgrading the customer's current STB to an ENERGY STAR Version 3.0 Certified STB. The service provider(s) covered any remaining costs not covered by SCE, 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, as identified by service provider(s). SCE then worked with the service provider(s) to identify approximately 6,700 customers with pre-ENERGY STAR 3.0 STBs to participate in the pilot. To support an experimental approach for the STB 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 provider(s) provided some customers who had multiple STBs the option to upgrade to a central control server with small peripheral STBs (a "thin client"). If a customer opted for a central control server with thin client(s), the service provider included an additional monthly fee on the customer's bill. The service provider(s) also offered one year of free high-definition (HD) for all standard definition customers in the experimental condition if they upgrade to an ENERGY STAR Version 3.0 HD STB. Customers receiving the upgrade offer upgraded their STBs at an eleven times higher rate than the control group, increasing the baseline replacement rate of about 1% to 9% for those receiving the upgrade offer.

This section documents findings from the analyses of:

- Experimental outcome data from customers who upgraded their STBs
- Review of a sample of the service provider's sales calls and offer script
- Data from a survey with customers in the pilot

2.1. Key Findings

The following are key findings from the STB pilot:

- Customers in the pilot, irrespective of pilot condition (experimental or control) increased the number of STBs in their household when they upgraded their STBs.
- Regression analysis found that an increase in average energy consumption is related to increases in total STBs in the home and in HD STBs. The analysis also revealed a lack of uptake in thin clients and that pre ENERGY STAR Version 3.0 STBs were allowed to be newly installed in the home.

- For experimental upgraders, receiving a free STB upgrade and HD service were the most appealing aspects of the replacement offer. Most experimental upgraders reported they would not be willing to pay a portion, or all, of the replacement cost of their STB.
- Customers most commonly associated the replacement offer with their service provider or a partnership between their service provider and SCE.
- Nearly all experimental upgrades reported being satisfied with the replacement offer and would recommend it to family and friends. Among the minority who expressed dissatisfaction, most reported experiencing an unexpected increase in their monthly service provider bill. However, we lack relevant data to link the self-reported increase in the monthly bill to the pilot.

2.2. Experimental Outcomes Findings

This section provides findings from experimental outcome data. This analysis only includes energy savings estimates and uptake behaviors from customers who upgraded their STBs during the pilot. This includes customers in both the experimental and control conditions.

2.2.1. Methods

For our analysis of the experimental outcome data, the service provider(s) provided us with customer-level data for the 376 customers who upgraded their STBs during the pilot. The data included model numbers for each STB used by customers prior to the pilot as well as model numbers for each STB used after the pilot. Customers did retain some of the STB models they had prior to the pilot. Please note that the ability to identify the baseline condition for the replaced equipment is a major benefit of working with service providers. Service providers can provide STB model number data that would be costly to obtain for other consumer electronic devices. (For example, a TV retailer program would have to ask customers to report the model number and/or type of TV replaced, which would likely require intercepting customers either before or immediately after they purchased their new TV.)

Using STB model number data, we determined the energy savings for each model using Total Energy Consumption (TEC) estimates and feature data provided by the service provider(s).[8] To understand the difference between energy efficient STB uptake by pilot upgraders, we took the difference between the number of STBs in the home after the pilot and the number of STBs in the home prior to the pilot. A positive number for this metric indicates an increase in the number of STBs in the home after the pilot ended. We used this post-pilot minus pre-pilot method to capture change due to the pilot in several other areas as well – TEC, and features such as HD, digital video recording (DVR), or thin client.

[8] TEC: Total Energy Consumption = kWh/yr.

2.2.2. Findings

The pilot resulted in 376 customers upgrading their STBs, 25 from the control condition, and 351 from the experimental condition. Because of random assignment, we can assume that the control condition's upgrade rate of 1% provides an accurate estimate of 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 upgrade rate of 9% among the experimental condition is primarily due to the pilot's promotional offer (Table 2-1).

Table 2-1: Upgrade Rates by Pilot Condition

CONDITION	TOTAL N	UPGRADERS	UPGRADE RATE
Experimental	3,700	351	9%
Control	3,000	25	1%
Total	6,700	376	6%

When upgrading their STBs, most pilot participants, irrespective of pilot condition (control or experimental), increased the number of STBs in their home (Table 2-2).

Table 2-2: 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%
Total	25	100%	351	100%

Participants had an average of 1.3 STBs in their home prior to the pilot, while after the pilot; participants had an average of 2.7 STBs in their home – resulting in about a two-fold increase in STBs for participants who upgraded their STBs. 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.[9]

Table 2-3: Total and Average Number of STBs in Home Before and After Pilot

CONDITION	PRE PILOT		POST PILOT	
	Total # of STBs	Avg # of STBs in Home	Total # of STBs	Avg # of STBs in Home
Control	32	1.28	71	2.84
Experimental	457	1.30	928	2.64
Total	489	1.30	999	2.66

9 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.

The pilot offer did influence customers in the experimental condition to upgrade their STBs to HD and DVR STBs at a higher rate than customers in the control condition. Interestingly, 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 2-4). This may be due to the way the replacement offer was presented to customers in the experimental condition. The script describing the offer revealed that service provider representatives were instructed to explain to those in the experimental condition interested in upgrading to a server and thin client system that there would be an additional $25 "Advanced Receiver Services" fee and a $6 fee per box if more than one box was installed. In contrast, 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.[10]

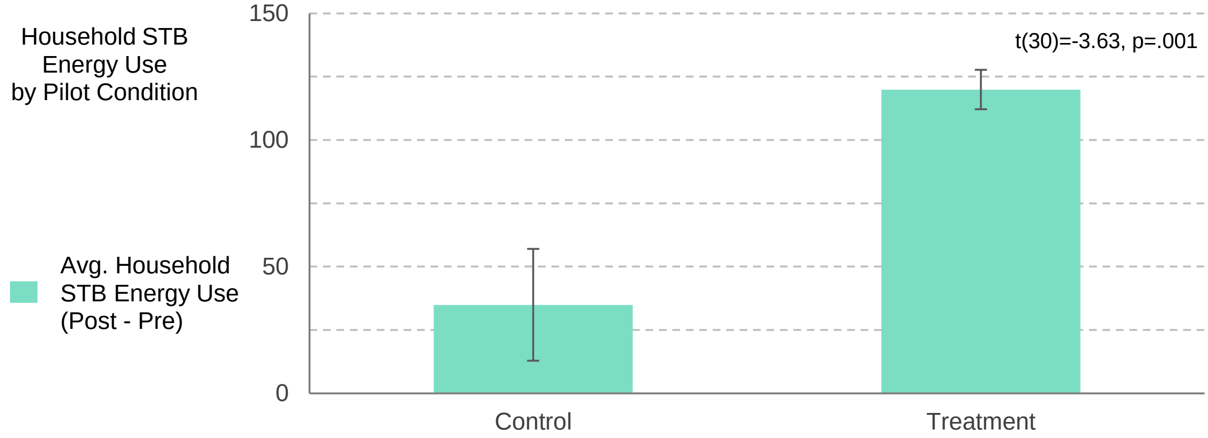
Table 2-4: Difference in Uptake of STBs with Specific Features by Condition

DIFFERENCE IN # OF STBS WITH…	CONTROL			EXPERIMENT			STATISTICS		
	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	35.13	0.00
HD (Between Pre and Post pilot)	0.28	0.54	25	1.82	1.03	351	-12.65	37.91	0.00
Thin Client (Between Pre and Post pilot)	1.84	1.52	25	0.38	0.98	351	4.75	25.44	0.00

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 2-1).

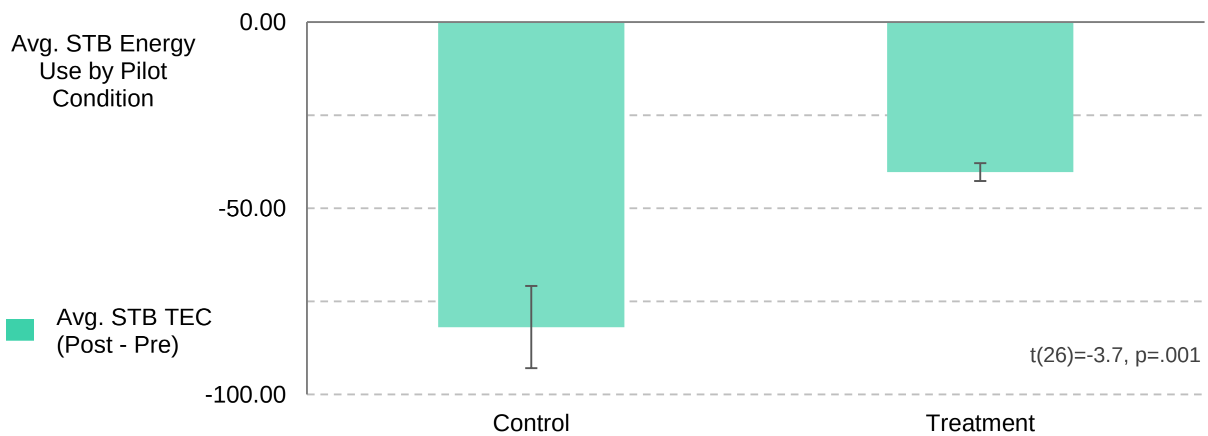
[10] A minority (12%) of those in the experimental condition had a non-DVR STB(s) and only eight of these individuals without DVR feature selected stand-alone DVR or HD DVR STB(s) and paid $10 monthly charge (about 2% of the total experimental group).

Figure 2-1: Impacts to Average Household STB Energy Use by Condition



Energy consumption for individual STBs 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 2-2).

Figure 2-2: Impacts to 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. Regression analysis revealed that four variables predict changes in energy consumption (Table 2-5).[11] Increasing the number of STBs in the home is the largest predictor of increase in average energy consumption. If households retain more pre-ENERGY STAR Version 3.0 STBs, they are more likely to see an increase in TEC.

11 Regression formula: ChangeTEC = ChangeSTB# + ChangeDVR# + ChangeHD# + ChangeTC# + ChangePreES3.0, Model Statistics: $F(5,345)=253.1$, $p<.0001$, with an R-squared of .79.

Conversely, if customers adopt a central control server and increase the number of thin clients in their home, they are more likely to reduce household TEC. Increasing the number of HD STBs or DVR STBs does not predict changes in TEC.

Table 2-5: Regression Model Findings*

INCREASE IN # OF …	IMPACT ON HOUSEHOLD STB ENERGY USE
Total units in home	
Units with DVR feature	
Units with HD feature	
Server + Thin Client units	
Units that are Pre ENERGY STAR Version 3.0	

* Both red and green arrows indicate the feature was a significant predictor of household STB energy use in the regression model. The direction of the arrows indicates whether the feature increased energy use or decreased energy use.

2.3. Review of Service Provider(s) Phone Calls and Script

2.3.1. Methods

We reviewed eight recorded phone calls between the service provider representatives and customers to determine if the presentation of the offer deviated from pilot design. We also reviewed the calling script used by service provider representatives.

The phone script used by the service provider representatives included four main steps:

- First, the representative introduces the replacement STB offer to the customer, including mentioning SCE's involvement and potential electricity savings.
- The representative then informs the customer about the free replacement STB offer, including 12 months of free HD service.
- The representative then confirms number of STBs the customer currently has, determining if the customer has HD TVs or plans to upgrade their TV in the next six months, and then asks which STBs the customer would like to replace.
- The representative then informs the customer of the value of the replacement boxes and mentions the energy savings that will result from the new STBs. (Please note that it is not typical of service providers to inform their customers of energy usage and/or savings associated with STBs, when promoting or providing information on newer STBs.)
- Finally, the representative requests the customer to pay the cost of delivery and handling of the new STB(s). If the customer declines the offer because of the delivery and handling fee, the script instructs the representative to waive the fee.

2.3.2. Findings

Overall, we found that the service provider(s) presented the offer to customers in a professional manner and generally did not deviate from the conversation script. However, we did observe two potential issues with the presentation of the offer to customers that may have affected savings potential.

First, we did not observe any calls where representatives provided an option to customers to upgrade to an energy-efficient standard definition (SD) STB over an HD STB. Instead, representatives presented customers with two options: 1) upgrade to a HD STB, or 2) upgrade to an HD receiver with DVR capabilities. We found that representatives presented the two HD options to customers even if they indicated they did not have, or did not know if they had, HD TVs in their home. Market data, discussed in Chapter 3, revealed that HD content has become a standard feature in STBs, indicating that SD STBs are becoming an obsolete technology. This is one possible explanation as to why service provider(s) emphasized HD-capable STBs to the customers in the pilot. They are likely no longer offering an upgrade to an SD STB due to the transition to STB with HD capability.

Second, we found that representatives did not present customers with the option of upgrading their STB to a central control server and a thin client system, even though some customers would have benefited from having this type of a system (i.e., a customer who had a STB DVR and other STBs in their home). Please note that the script describing the offer revealed that service provider representatives were instructed to explain to those interested in upgrading to a server and thin client system that there would be an additional $25 "Advanced Receiver Services" fee and a $6 fee per box if more than one box is installed. 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 HD DVR STB(s) had a monthly fee of $10 for the DVR feature if customer upgraded from a non-DVR STB.

2.4. Customer Survey Findings

This section provides findings from a survey conducted with customers who participated in a pilot program. Participants in the pilot program were either from the control condition (i.e. participants that did not receive an offer to upgrade their STBs but did so on their own), or from the experimental condition (i.e. participants that received the pilot offer to upgrade their existing STBs). The purpose of the survey was to understand customers' motivations for replacing or not replacing their STBs, awareness of STB energy consumption, experience with the pilot, and awareness of SCE.

2.4.1. Methods

We conducted telephone surveys with the following customer groups:

- **Experimental upgraders:** customers in the experimental condition who accepted the replacement offer.

- **Experimental non-upgraders:** customers in the experimental condition who did not accept the replacement offer.
- **Natural upgraders:** customers who did not receive the replacement offer, but upgraded their STB within three months prior to survey fielding.

Table 2-6 provides a summary of the survey disposition. We conducted interviews in July and August of 2014, and ultimately completed the survey with 86 customers. Interviews lasted seven to ten minutes.

Table 2-6: Survey Disposition by Customer Group

GROUP	POPULATION	NUMBER OF CALLS	LANGUAGE BARRIER	DID NOT RECALL OFFER - REFUSED	COMPLETED
Experimental Upgraders	351	360	38	2	56
Experimental Non-upgraders	3,348	613	25	11	22
Natural upgraders	25	62	4	N/A	8
Total	**3,724**	**1,035**	**67**	**13**	**86**

2.4.2. Findings

2.4.2.1. Demand for Energy Efficient STBs

For experimental upgraders, receiving a free STB upgrade and HD service were the most appealing aspects of the replacement offer (Table 2-7). A smaller number of experimental upgraders reported the energy savings associated with the new STB was an appealing aspect of the replacement offer.

Table 2-7: Appealing Aspects of Replacement Offer to Experimental Upgraders (n=54; Multiple Responses Allowed)*

ASPECT	COUNT	PERCENT
Free STB	31	57%
HD Service	20	37%
Energy savings	12	22%
Upgraded technology/new features	7	13%
Discount on service provider bill	3	6%
Other**	5	9%

* Two experimental upgraders did not receive this question; one did not recall the offer and one reported not accepting the offer.

** Other responses included wanting to get service in an additional room, wanting to participate to help the pilot program, being told the customer had to do it, general concern for the environment, and nothing (one mention each).

Most experimental upgraders (69%) reported they would not be willing to pay a portion of the replacement cost of their STB. About half (8 of 17) of the experimental upgraders who did express a willingness to pay cited a specific dollar amount. The amounts provided ranged from $10 to $100, with most offering between $10 and $25. Experimental upgraders who reported a willingness to pay but did not cite a specific dollar amount reported they did not know how much they would pay.

2.4.2.2. Accelerating Adoption of Energy Efficient STBs

The replacement offer was less appealing to experimental non-upgraders. Over two-thirds (68%) of experimental non-upgrader survey respondents did not recall the replacement offer. According to the service provider(s), representatives were unable to contact all customers in the experimental group, which may explain the low level of awareness of the replacement offer.

Two control group upgraders reported receiving an offer for a free replacement STB; however, upon further investigation, we determined the offer they received was unrelated to the pilot program.

Nearly all (97%) of those who recalled the replacement offer reported the offer included a free STB. Additionally, about one-third (31%) of those who recalled the offer reported it including one year of free HD service, all of whom were experimental upgraders.

Customers most commonly associated the replacement offer with their service provider or a partnership between their service provider and SCE (Table 2-8). Experimental upgraders were more likely than experimental non-upgraders to report the offer was associated with a partnership between their service provider and SCE.

Table 2-8: Companies Associated with STB Replacement Offer

COMPANY	EXPERIMENTAL NON-UPGRADERS		EXPERIMENTAL UPGRADERS	
	Count	Percent	Count	Percent
The service provider(s)	2	29%	24	42%
Both the service provider(s) and SCE	1	14%	16	31%
SCE	1	14%	9	15%
Other	2	29%	1	2%
Don't know	1	14%	5	10%
Total	**7**	**100%**	**55***	**100%**

* One experimental upgrader did not recall the replacement offer.

2.4.2.3. Experimental Non-upgraders

About one-third (7 of 22) experimental non-upgraders recalled the replacement offer. Among those that recalled the offer, half (4 of 7) reported declining the offer because they did not see a need to upgrade their STB. The remaining experimental non-upgraders reported not accepting the offer because of concerns with the extra costs associated with the offer (two mentions), customer service problems, and because they were considering another paid TV service (one mention each).

Among experimental non-upgraders who recalled the offer, about half (4 of 7) had no suggestions on making the offer more enticing. Those who suggested changes to the offer mentioned concerns about bill increases, poor customer service, and a desire for lower monthly bills (one mention each).

2.4.2.4. Customer Satisfaction with STB Pilot

Nearly all (87%) experimental upgraders reported being satisfied with the replacement offer (reported a "4" or a "5" on a five-point scale). Of those experimental upgraders who expressed dissatisfaction with the offer, most (6 of 7) reported experiencing an unexpected increase in their monthly service provider bill.

More than half (54%) of experimental upgraders reported experiencing a problem with the replacement offer or with their new STB (Table 2-9). Please note that SCE had no influence in how the service provider(s) dealt with any problems associated with the replacement offer or the new STB. Most commonly, experimental upgraders reported unanticipated charges on their bill (22%), followed by problems with the STB (19%) or its installation (11%). Five respondents that mentioned unanticipated charges provided a specific dollar amount, most often $10 per month, although one reported a $5 monthly charge and another reported a $30 monthly charge.[12] Two upgraders who reported unanticipated charges stated that they attempted to return their new STBs, but their service provider informed them they had signed a one-year contract and would be assessed a termination fee of approximately $500. The pilot replacement offer did not ask for a contract extension for customers who upgraded their STBs. This finding may suggest the service provider(s) did not communicate all the terms of the offer to the call center, or representatives failed to communicate the terms to the customers, as it was envisioned by the pilot. Please note that the service provider(s) had no opportunity to review the accuracy of these claims by the customers and that we lack relevant data to directly link the self-reported monthly charges to the pilot.

Table 2-9: Problems Encountered by Experimental Upgraders (n=54; Multiple Responses Allowed)

PROBLEM	COUNT	PERCENT
No Problems	25	46%
Had unanticipated bill charges	12	22%
Issues with the STB	10	19%
Installation issues	6	11%
Other*	3	6%

* Other includes unexpected termination fees (two mentions) and customer service issues (one mention).

12 We were unable to determine the exact reason for the increase in customers' bills; however, it may be associated with the cost of upgrading from standard definition to a HD digital video recorder (DVR), which was $10 per month.

Most upgraders reported satisfaction with the features and performance of their new STB (80% each providing a “4” or “5” on a five-point scales; Figure 2-3). Consistent with upgraders’ ratings of satisfaction with the new features of their STBs, most (84%) reported either “always” or “often” using at least one of the new features (i.e., HD or DVR). Upgraders (both natural and experimental) who reported paying an installation fee or upgraded without the offer were less satisfied with the price they paid.

Figure 2-3: Satisfaction with STB Aspects

* Features included HD service and DVR capabilities.

Most (83%) experimental upgraders reported that they would recommend the offer to family or friends. Most (5 of 7) of those that reported they would not recommend the offer were among the respondents reporting unanticipated charges.

Survey findings suggest STB energy use is largely invisible to users. Fewer than 10% of upgraders reported thinking about how much energy their STB uses, and, of the six who had considered their STB’s energy use, all but one were unable to rate their satisfaction with the energy use of their new, more efficient, models. The one remaining upgrader reported being “extremely satisfied” with the energy use of their new STB. While few experimental upgraders reported considering their STB’s energy use, a larger minority (12 of 56) reported turning off or unplugging their STBs.

2.4.2.5. Customer Motivations for Upgrading or Not Upgrading

Most (83%) experimental upgraders reported accepting the offer because the STB was free (Table 2-10). Obtaining new STB functionality and replacing a nonfunctional STB also were common motivations reported by experimental upgraders (34% and 23%, respectively). One experimental upgrader who mentioned new STB functionality reported upgrading to a thin client STB. All of the remaining experimental upgraders who mentioned new functionality upgraded their SD STB to an HD STB.

Table 2-10: Motivations for Accepting Offer (n=47; Multiple Responses Allowed)

MOTIVATION	COUNT	PERCENT
Free STB offer	39	83%
New STB functionality	16	34%
Old STB was broken or no longer functional	11	23%
Energy usage/Wanted a more energy efficient STB	6	13%
Told to upgrade to an HD receiver	3	6%
Other*	3	6%

* Other includes reduction in monthly bill, already considering upgrading, and because they purchased a new TV set (one mention each).

Experimental upgraders were more likely to report considering replacing their STB prior to receiving the replacement offer than the experimental group that did not upgrade. About one-quarter (27%) of experimental upgraders reported considering replacing their STB, while none of the seven experimental non-upgraders who recalled the offer reported considering replacing their STB prior to receiving the offer.

Similar to experimental upgraders, most natural upgraders (5 of 8) reported new functionality as a motivating factor for replacing their STB. All but one natural upgrader reported the new function in their STB was HD service. No natural upgraders reported the energy usage of their STB as being a motivating factor for its replacement.

3. STB Market Characterization

The Pay-TV STB market includes STB models that three types of service providers distribute to their subscribers:

- Cable providers (e.g. Comcast, Time Warner, and Charter) transmit content over fiber optic cable to neighborhood nodes and from those nodes to subscribers' homes via coaxial cable.
- Internet protocol TV (IPTV) providers (e.g. AT&T U-verse and Verizon Fios) are typically telecommunications companies and transmit TV content over existing broadband networks.
- Satellite providers (e.g. DirecTV and DISH Network) transmit content to subscribers' homes via satellite. [13]

This chapter characterizes the STB market using data from publicly available documents including ENERGY STAR specification revision documents, Pay-TV service provider reporting related to voluntary efficiency commitments, market research data, and energy efficiency industry literature. This chapter presents findings on aspects of the STB market including:

- The current installed base of STBs in California and SCE territory
- Trends in STB technologies
- Efficiency standards related to STBs and the primary opportunities to improve STB efficiency
- Changes in the STB supply chain

3.1. STB Installed Base

This section begins by estimating the current STB installed base in California and SCE territory, followed by findings related to the STB product lifecycle and replacement cycle.

3.1.1. California STB Installed Base

Overall, 89% of households in California with televisions have Pay-TV service; 55% of households have cable or IPTV, and 34% have satellite service (Table 3-1). Penetration of each type of Pay-TV service varies across the state, with cable penetration ranging from 33% of households in the El Centro media market to 76% of households in the San Diego media market

[13] Hardy, et al. 2012. "Pay-Television In-Home Equipment: National Energy Consumption, Savings Potential, and Policy Barriers and Opportunities." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy. http://www.aceee.org/files/proceedings/2012/data/papers/0193-000294.pdf.

and satellite penetration ranging from 18% of households in the San Diego media market to 53% in the Chico-Redding media market (see Appendix D for cable and satellite penetration by media market). In most areas, cable penetration exceeds satellite penetration, although there are more satellite subscribers than cable subscribers in the Chico-Redding, Fresno-Visalia, and El Centro media markets.[14]

Table 3-1: Proportion of TV Households with Pay-TV Service

SERVICE TYPE	LOWEST PENETRATION (MARKET)	HIGHEST PENETRATION (MARKET)	STATEWIDE WEIGHTED AVERAGE PENETRATION
Cable*	33% (El Centro)	76% (San Diego)	55%
Satellite**	18.2% (San Diego)	52.8% (Chico-Redding)	34%

Source: Nielsen data presented in "TVB - ADS, Wired-Cable and Over-The-Air Penetration by DMA." Accessed February 10, 2015. http://www.tvb.org/research/media_comparisons/4729/ads_cable_dma.

* Includes both cable and IPTV subscribers

** Primarily direct broadcast satellite, but also includes satellite master antenna, microwave multi distribution system, and large satellite dishes.

Studies estimate that Pay-TV households have an average of between 1.3 and 2.5 STBs.[15] A national survey conducted by the Fraunhofer Center for Sustainable Energy and sponsored by the Consumer Electronics Association found that, in 2013, cable subscribers averaged fewer STBs per household than satellite or IPTV subscribers.[16] This is consistent with the 2012 U.S. installed base estimates used to calculate an energy use baseline in the Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes (Voluntary Agreement, for more information see Section 3.3.2), normalized for the number of subscribers to each Pay-TV service type at the end of 2012.[17, 18]

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14 "TVB - ADS, Wired-Cable and Over-The-Air Penetration by DMA." Accessed February 10, 2015. http://www.tvb.org/research/media_comparisons/4729/ads_cable_dma.

15 Hardy, et al. 2012. "Pay-Television In-Home Equipment: National Energy Consumption, Savings Potential, and Policy Barriers and Opportunities." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy. http://www.aceee.org/files/proceedings/2012/data/papers/0193-000294.pdf.
Urban, Tiefenbeck, and Roth. 2012. "Televisions, Computers, and Set-Top Boxes: The Big Three of 2010 Home Consumer Electronics Energy Consumption." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy.
Fraunhofer USA Center for Sustainable Energy Systems. 2014, June. *Energy Consumption of Consumer Electronics in U.S. Homes in 2013.* Consumer Electronics Association.

16 Fraunhofer USA Center for Sustainable Energy Systems. 2014, June. *Energy Consumption of Consumer Electronics in U.S. Homes in 2013.* Consumer Electronics Association.

17 In 2012, eleven Pay-TV providers, representing more than 90% of the Pay-TV market, signed a Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes (discussed further in Section 3.3.2 below).

18 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

Table 3-2: Average Number of STBs per Household by Pay-TV Service Type

SERVICE TYPE	AVERAGE NUMBER OF STBS PER HOUSEHOLD	
	Fraunhofer Center Estimates [a]	Voluntary Agreement Base Case [b]
Cable	1.8[c]	2.09
Satellite	1.99	2.31
Telco	2.32	2.92

[a] Source: Fraunhofer USA Center for Sustainable Energy Systems. 2014, June. *Energy Consumption of Consumer Electronics in U.S. Homes in 2013.* Consumer Electronics Association.

[b] Source: National STB installed base estimates by service provider type listed in D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf To obtain estimates of STBs per household, national installed base estimates were divided by number of subscriber households by Pay-TV service type from Leichtman Research Group. "Industry by the Numbers." *Research Notes*. Q1 2013. https://web.archive.org/web/20150218235106/http://www.leichtmanresearch.com/research/notes04_2013.pdf.

[c] Survey data adjusted to include cable DTA STBs.

Applying these findings to Nielsen's estimates of Pay-TV subscribership and market size for California's 12 media markets yields a statewide estimate of 20.8 million STBs installed in California homes based on the Fraunhofer Center's estimates or 24.4 million STBs based on estimates from the Voluntary Agreement base case (Table 3-3).

Table 3-3: Estimated Number of STBs by California Media Market (all figures in thousands)

MEDIA MARKET [a]	NUMBER OF STBS (X1,000)	
	Using Fraunhofer Center Estimates	Using Voluntary Agreement Base Case Estimates
Los Angeles	9,226.4	10,883.9
San Francisco-Oakland-San Jose	4,321.7	5,083.6
Sacramento-Stockton-Modesto	2,333.5	2,737.1
San Diego	1,911.4	2,252.3
Fresno-Visalia	940.8	1,101.8
Santa Barbara - Santa Maria - San Luis Obispo	408.0	478.4
Monterey-Salinas	390.1	457.6
Bakersfield	375.6	440.1
Chico-Redding	319.1	373.5
Palm Springs	282.7	332.5
Yuma-El Centro	174.6	204.4
Eureka	95.5	112.2
Statewide	**20,779.4**	**24,408.2**

[a] Based on Nielsen audience data listed on "TVB - ADS, Wired-Cable and Over-The-Air Penetration by DMA." Nielsen data combines cable and IPTV subscribership. Estimates of cable and IPTV subscribership listed here assume 81% of the combined subscribership are cable households and 19% are IPTV households, based on market penetration of top cable and IPTV providers listed in Leichtman Research Group. "Industry by the Numbers." *Research Notes.* Q4 2014. http://www.leichtmanresearch.com/research/notes12_2014.pdf.

These estimates are 14% and 34% higher than those suggested by the 2012 California Lighting and Appliance Saturation Survey (CLASS). Multiplying the CLASS survey's estimates of the average number of STBs per home by the number of occupied housing units in California yields an estimate of 18.2 million STBs. Reasons for this discrepancy are not clear.[19]

3.1.2. SCE Installed Base

The evaluation team was able to obtain some model-level STB data for SCE territory as of December 2014. This data does not cover all service providers in the territory; it includes STB model data of less than a quarter of Pay-TV service subscribers in SCE territory. Although the dataset is not comprehensive, it does provides a window into the nature of the STB installed base in SCE's territory. In this document, we refer to this database as the "installed base" of STBs in SCE territory. The characteristics of the installed base are provided in aggregate to ensure certain details remain confidential.

3.1.2.1. STB and Customer Characteristics

Much of the installed base is concentrated among a relatively small number of models. While the installed base STBs represent over 100 different models, the majority of the installed base is concentrated among a much smaller number, with the 10 most prevalent models accounting for more than 80% of the installed base and the 20 most prevalent models for 99%. Basic STBs, without HD or DVR functionality, make up the largest portion of the installed base (Table 3-4).

Table 3-4: SCE Installed Base by STB Type

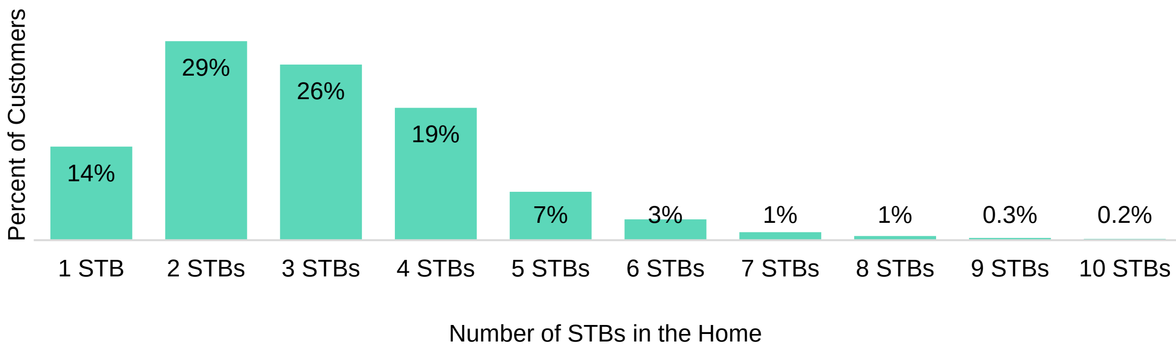
STB TYPE	INSTALLED BASE OF STBS Percent
Basic	25%
HD	20%
Client	19%
HD DVR	18%
HD DVR Server	11%
DVR	5%
Other	0%
Total	**100%**

While a small proportion of the installed base has a large number of STBs, most have three or fewer. The average number of STBs per household in the dataset was 3.0, but that average reflects a small proportion of households with large numbers of boxes. Only one-third (32%) of

19 One possible explanation is that CLASS averages appear to include all homes, including those without TVs. Thus, Nielsen's estimate of TV households may be an artificially low multiplier.

the households had more than three STBs. Nearly half (42%) of households in SCE territory have one or two STBs (Figure 3-1).

Figure 3-1: Distribution of Customers with One or Multiple STBs in the Installed Base



For most households, switching to a multi-room server-based system would bring DVR functionality to TVs that do not already have it. Households with DVR capability usually had only one box with that capability built in, most often a HD DVR. Households with non-DVR STBs most often had multiple boxes without integrated DVR functionality. Households with thin client STBs were most likely to have at least two boxes of that type; a majority of households with basic STBs also had more than one (Table 3-5).

Table 3-5: Prevalence of Multiple STBs by Type, Among Households with at Least One STB of that Type

STB TYPE	AVERAGE NUMBER OF BOXES PER HOME	% OF HOMES WITH >1 BOX
	STBS WITH INTEGRATED DVRS	
HD DVR	-	29%
DVR	-	23%
HD DVR Server	-	0.1%
Any DVR	**1.5**	**30%**
	STBS WITHOUT INTEGRATED DVRS	
Thin Client*	-	66%
Basic	-	57%
HD	-	47%
Other	-	16%
Any Non-DVR	**2.2**	**68%**

Note: For confidential purposes, we only report an average for any DVR or any non-DVR in this table.

* Thin client can display content recorded on a DVR, but the components of the DVR are not part of thin client. Thin client receives DVR content from the server.

3.1.2.2. Energy Efficiency of Installed Base

One-fourth of the STBs in subscribers' homes in SCE territory meet the current ENERGY STAR specification. More than 80% of STBs were qualified under either the current specification or a previous one (Table 3-6).

Table 3-6: Installed Base by ENERGY STAR Certification Level

ENERGY STAR VERSION	EFFECTIVE DATES	PERCENT OF INSTALLED BASE
4.1	12/19/2014 – Present	25%*
3.0	9/1/2011 – 12/9/2014	37%
2.0	1/1/2009 – 9/1/2011	23%
Not Certified	N/A	15%

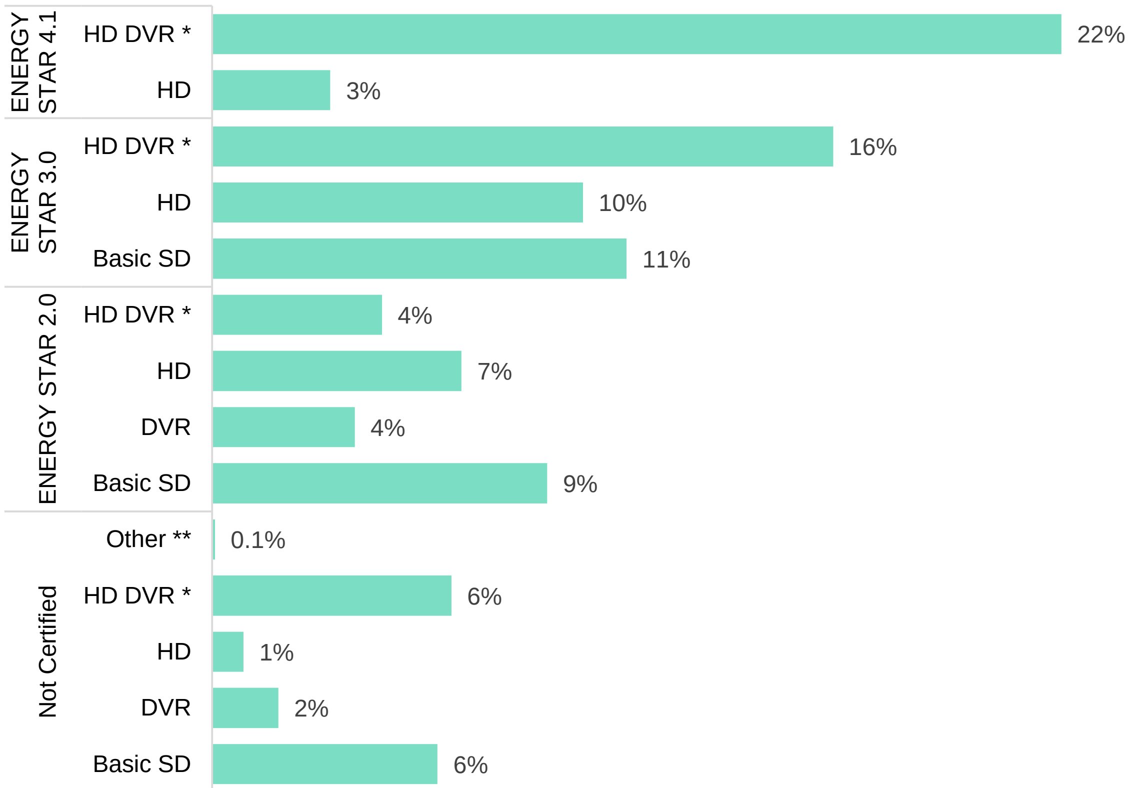
* In the installed base, we re-classified these models from ENERGY STAR Version 3.0 to 4.1 because they were listed on ENERGY STAR Version 4.1 Qualified Product List. Please note that because installed base was received in December 2014, a month prior to the time the ENERGY STAR Version 4.1 specification took effect, the installed base, and later analyses do not include the ENERGY STAR Version 4.1 designation for these models.

The 15% of STBs in the installed base that are not ENERGY STAR certified likely include both models produced prior to the launch of the Version 2.0 ENERGY STAR specification and newer models that did not receive ENERGY STAR certification.[20]

About one-third (38%) of all STBs in the installed base were considered to be inefficient models or models with an ENERGY STAR certification level below 3.0 (Figure 3-2).

20 EPA suspended the ENERGY STAR specification for STBs between 2005 and 2009.

Figure 3-2: Distribution of STBs by Model Type and ENERGY STAR Certification



* Servers and thin clients were both included in this statistic because servers and thin clients have HD DVR capabilities.

** Other includes hospitality systems and other specialty STB types.

Just over half (58%) of households in the installed base had pre-ENERGY STAR Version 3.0 model(s) or a mix of ENERGY STAR Version 3.0 and pre-3.0 models (Table 3-7). Among those with a mix of ENERGY STAR Version 3.0 and pre-3.0 models, about half (52%) had two or three STBs in their homes.

Table 3-7: Distribution of Customers with ENERGY STAR Version pre-3.0 and 3.0 Models

CUSTOMERS WITH	PERCENT
All ENERGY STAR Version 3.0 models	42%
All pre-ENERGY STAR Version 3.0 models	25%
Mix of ENERGY STAR Version 3.0 and pre-3.0 models	33%

3.1.2.3. Central Control Server with Thin Clients

A subset of the boxes in the database were central control servers with thin clients. Currently, central control servers make up approximately 13% of installed base dataset in SCE territory. Client devices make up approximately 12% of the installed base, with households having, on average, a single server and approximately two thin clients.

Table 3-8: Penetration of Multi-Room Server Systems in SCE Territory

STB TYPE	PERCENT OF SCE INSTALLED BASE	AVERAGE BOXES PER HOME
Server	13%	1.00
Thin Client	12%	2.01

3.1.3. Replacement Cycle and Product Lifecycle

Estimates of the replacement cycle for STBs range from five to eight years. A 2012 paper based on existing field studies and market research data assumes 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.[21] Another 2012 paper uses sales data to estimate a STB lifecycle of approximately 6 years.[22] Dividing the Voluntary Agreement base case estimate of a U.S. installed base of 224 million STBs in 2012 by ENERGY STAR's estimate of total 2012 STB shipments yields a lifecycle of 6.45 years, which is consistent with these reports.[23]

While some STB models may remain on the market longer, most are updated every year. In comments on the ENERGY STAR specification revision process, a service provider reported it does not plan to update its latest model of central server STB, which was released at the end of 2012, until the middle of 2015.[24] Nonetheless, cable providers' reporting suggests the majority of the STB models service providers procure in a given year are new to the market. In 2014, cable providers reported procuring 37 STB models, most of which (27 models or 73%), they did not report procuring in 2013 (Table 3-9).

[21] Hardy, et al. 2012. "Pay-Television In-Home Equipment: National Energy Consumption, Savings Potential, and Policy Barriers and Opportunities." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy. http://www.aceee.org/files/proceedings/2012/data/papers/0193-000294.pdf.

[22] Urban, Tiefenbeck, and Roth. 2012. "Televisions, Computers, and Set-Top Boxes: The Big Three of 2010 Home Consumer Electronics Energy Consumption." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy.

[23] *ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2012 Summary.* U.S. Environmental Protection Agency, 2013. https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2012_USD_Summary_Report.pdf?20d9-5e6d.; D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

[24] Kuriacose. 2013, April. "DirecTV Comments on ENERGY STAR Set-Top Box Draft 1 Version 4.1 Specification." http://www.energystar.gov/sites/default/files/specs//Directv_Comments_STBs_Draft1V4_Public.pdf.

Table 3-9: 2014 Cable Provider STB Procurement

PROCUREMENT PERIOD	ENERGY STAR LEVEL	COUNT	PERCENT
New models procured in 2014	*4.1*	*7*	*19%*
	3.0	*14*	*38%*
	Not Qualified	*6*	*16%*
	Total	**27**	**73%**
Models procured in 2013 and 2014	*4.1*	*4*	*11%*
	3.0	*4*	*11%*
	Not Qualified	*2*	*5%*
	Total	**10**	**27%**
All Models		**37**	**100%**

Source: D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

3.2. Trends in STB Technologies

Two sources of data provide information about trends in STB technologies: service providers' reporting of their procurement in compliance with the Voluntary Agreement and a review of changes in the ENERGY STAR specification for STBs. Industry literature and market research provide additional support for many of the findings these data sources suggest.

3.2.1. Service Provider Procurement Data

In 2012, eleven Pay-TV providers, representing more than 90% of the Pay-TV market, signed the Voluntary Agreement (discussed further in Section 3.3.2 below). 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.[25] 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.[26]

It is important to note that these data sources list only the models service providers procured; they do not provide information about the number of units of each model that each service provider procured. For example, the Voluntary Agreement Annual Report states that in 2013, 85% of the STBs service providers procured met the ENERGY STAR Version 3.0 requirements.

25 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

26 "Industry Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes (STBs): Cable Signatory STBs." *CableLabs Energy Reporting*. Accessed February 18, 2015. http://energy.cablelabs.com/.

A slightly lower percentage of the individual models service providers procured (81%) met the requirements, suggesting service providers procured a larger number of units of models that met the requirements than those that did not.[27] Nonetheless, an examination of the STB models service providers procured offers some information about STB technologies.

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. The vast majority of models service providers procured (94%) also had advanced video processing capabilities. As a result 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 (discussed further below).[28]

DVR, multi-room, and multi-stream capabilities also appear to be increasing, based on a comparison of cable providers' procurement in 2013 with their procurement in 2014 (Table 3-10). This is consistent with the Fraunhofer Center's survey findings that multi-room systems are becoming more common.[29] Please note that the increasing adoption of multi-room systems is an energy saving opportunity (see Section 3.4.2 and Section 4.8). Although evidently 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. A program that incentivizes the early replacement of STBs could accelerate the rate of replacement of existing stand-alone STBs with multi-room systems. As discussed in Section 4.8, our technical and achievable potential modeling revealed a positive and substantial energy savings potential when existing and functional stand-alone STBs were replaced with multi-room systems.

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27 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

28 U.S. Environmental Protection Agency. 2014, January. "Draft 2 Version 4.1 Set-Top Box Comment-Response Document." http://www.energystar.gov/sites/default/files/specs//Draft%202%20Version%204.1%20Set-top%20Box%20Comment-Response_0.pdf.

29 Fraunhofer USA Center for Sustainable Energy Systems. 2014, June. *Energy Consumption of Consumer Electronics in U.S. Homes in 2013.* Consumer Electronics Association.

Table 3-10: Features Included in STBs Cable Providers Procured in 2013 and 2014

FEATURE	2013 PROCUREMENT Models (n=41)	2013 PROCUREMENT Percent	2014 PROCUREMENT Models (n=37)	2014 PROCUREMENT Percent
Advanced video processing	37	90%	32	86%
CableCARD	35	85%	28	76%
Digital Video Recorder	19	46%	19	51%
Data Over Cable Service Interface Specifications (DOCSIS)	29	71%	22	59%
DOCSIS 3.0	Not Reported		7	19%
High Definition (HD)	41	100%	37	100%
Home Network Interface	12	29%	10	27%
Multi-room	13	32%	16	43%
Multi-stream for Cable and Satellite	18	44%	18	49%
Transcoding	Not Reported		4	11%

For satellite customers, the penetration of DVRs has increased rapidly over the past three years. CLASS survey findings, adjusted based on Nielsen audience estimates to reflect cable and satellite households (listed in Table 3-11), suggest that in 2012 cable and satellite households in California averaged 0.49 and 0.01 STBs with HD and DVR capabilities, respectively.[30] A majority of the STB models satellite providers reported procuring in 2013 (12 of 21) had HD and DVR capabilities, suggesting that STB replacement is likely increasing the installed base of satellite HD DVRs.[31]

Table 3-11: Average Number of STBs per Subscriber, Based on CLASS 2012 Data Adjusted for Pay-TV Subscribership

STB TYPE	CABLE	SATELLITE
Standard	0.67	0.46
HD	0.61	0.81
Multifunction DVR	0.08	Not Reported
HD Multifunction DVR	0.49	0.01

* CLASS data list average number of STBs per household for all households in California. To adjust for Pay-TV subscribership, we multiplied CLASS estimates by the number of occupied housing units in California to obtain an estimate of the California STB installed base. To obtain an estimate of subscribers by Pay-TV service type, we multiplied the number of occupied housing units in California by the average 2012 market share of that Pay-TV type based on Nielsen data.

30 The CLASS web tool reports the average number of STBs of each type for all homes, regardless of Pay-TV service. To obtain averages for satellite households specifically, we multiplied the CLASS averages by Nielsen's estimate of the total number of TV households in California to estimate the total number of STBs of each type; we then divided these totals by Nielsen estimates of the number of satellite households.

31 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf; "Industry Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes (STBs): Cable Signatory STBs." *CableLabs Energy Reporting*. Accessed February 18, 2015. http://energy.cablelabs.com/.

3.2.2. ENERGY STAR Specification Comparisons

As part of the ENERGY STAR specification development process, EPA and stakeholders negotiate reasonable energy consumption targets for STB base functionality with adders for additional product features. We compared these incremental energy use allowances between the Version 3.0 specification, which took effect in September 2011, and the Version 4.1 specification, which took effect in December 2014, which provides some insight into recent changes in STB technologies. Appendix E provides a full comparison of allowances between specifications.

The amount of energy required to provide additional STB functionality has largely remained constant or increased. Among the seven incremental energy use allowances for additional functionality that are present in both the Version 3.0 and Version 4.1 specifications, only one allowance decreased; most (4 of 7) did not change, and two, the inclusion of a home network interface and the capability to provide content to devices in multiple rooms, were granted increased allowances.

STBs have taken on new functionality, largely related to home networking. ENERGY STAR Version 4.1 includes nine incremental energy use allowances not included in Version 3.0, five of which are related to home networking. These functions include the ability for the STB to communicate with a wireless home area network and the ability to function as a router or wireless access point.

Although allowances for base functionality decreased only slightly, if at all, they drove increases in efficiency requirements by incorporating functionality that formerly received an additional allowance. In Version 4.1, the base functionality energy use allowances for cable STBs did not change from Version 3.0; for satellite STBs, the base allowances decreased by 5 kWh/year (7%), and for IP STBs, the base allowances increased by 15 kWh/year (30%). Nonetheless, in Version 4.1 these allowances incorporated advanced video processing and the ability to display at HD resolution, which had qualified for additional allowances under Version 3.0 (12 kWh/year and 25 kWh/year respectively). As a result, to meet the Version 4.1 requirements, the base level STB configurations service providers procured in 2013 would have to be, on average, 20% more efficient than would be required to meet Version 3.0 requirements (Table 3-12).

Table 3-12: Change in Energy Use Requirements between ENERGY STAR Version 3.0 and Version 4.1 STB Specifications

SERVICE PROVIDER TYPE	NUMBER OF STB CONFIGURATIONS PROCURED IN 2013	AVERAGE REDUCTION IN ALLOWABLE TEC	
		kWh/Year	Percent
Satellite	4	41.0	26%
Cable	15	28.7	19%
IP	3	13.3	12%
Total	**22**	**28.8**	**20%**

The ability to display content at 4K/Ultra HD resolutions is likely to become increasingly common in new STBs. The ENERGY STAR Version 4.1 specification includes new allowances for Ultra HD resolution and High Efficiency Video Processing (HEVP), a compression technology that facilitates Ultra HD transmission of video. In their comments on the Version 4.1 specification, the National Cable and Telecommunications Association (NCTA) stated that Pay-TV service providers were motivated to include these features in anticipation that Ultra HD TV penetration and demand for Ultra HD content would increase during the lifecycle of the STBs they deploy during the next few years.[32] STB market analysts anticipate that worldwide shipments of STBs with Ultra HD and HEVP capabilities will grow from a combined 60,000 in 2014 to 48 million Ultra HD boxes and 88 million HEVP boxes by 2020.[33] The energy use implications of incorporating Ultra HD and HEVP into STBs are not clear. In their comments on the ENERGY STAR specification, manufacturers argued for the inclusion of an additional allowance for Ultra HD and HEVP and that it should apply to thin clients.[34] Yet, manufacturers did not advocate for changes to EPA's proposed allowance of 5 kWh/year for Ultra HD and 15 kWh/year for HEVP.

3.3. STB Energy Efficiency Standards

Two standards influence the energy efficiency of STBs: ENERGY STAR specifications and the service providers' Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.

3.3.1. ENERGY STAR

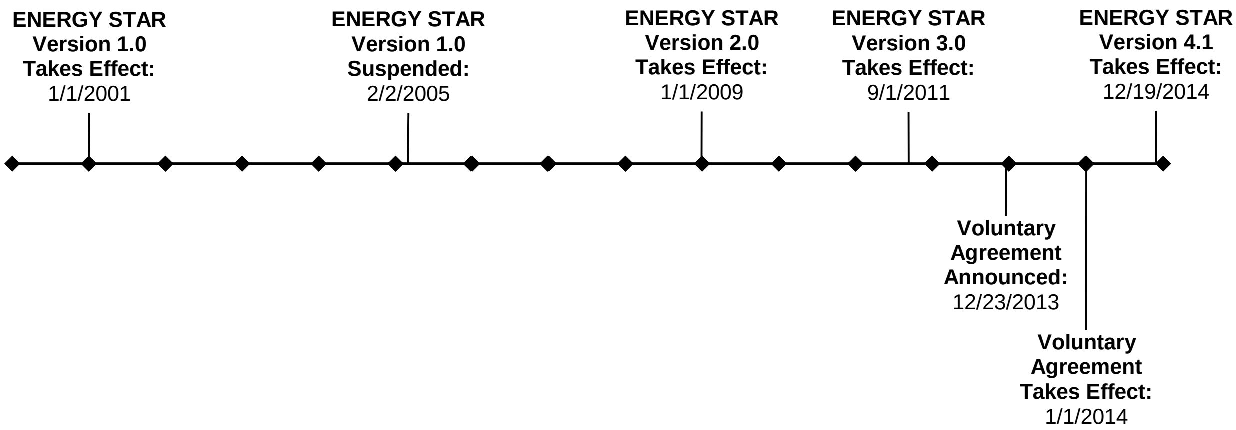
EPA launched the first ENERGY STAR specification for STBs (Version 1.0) in 2001. EPA suspended that specification in 2005 based on findings that there was little variation in energy use across STBs, and adopting a sleep mode in STBs, the primary opportunity for energy savings, was not practical given then-current technology. In 2007, EPA began the process of developing a new ENERGY STAR specification for STBs (Version 2.0), which took effect in 2009. Since then, EPA has revised the STB specification twice, most recently for Version 4.1, which took effect late in 2014 (Figure 3-3).

32 Goldberg. 2013, April. "NCTA Comments on ENERGY STAR Specification for Set-Top Boxes Version 4.1." http://www.energystar.gov/sites/default/files/specs//NCTA_Comments_STBs_Draft1V4_Public.pdf.

33 "UltraHD and HEVC Set-Top Box Shipments to Explode." *ABI Research.* 2014, November. https://www.abiresearch.com/press/ultrahd-and-hevc-set-top-box-shipments-to-explode.

34 U.S. Environmental Protection Agency. 2014, April. "Final Draft Version 4.1 Set-Top Box Comment-Response Document." http://www.energystar.gov/sites/default/files/specs//Final%20Draft%20Version%204.1%20Comment-Response%20Document.pdf; U.S. Environmental Protection Agency, "Draft 2 Version 4.1 Set-Top Box Comment-Response Document."

Figure 3-3: ENERGY STAR STB Specification Timeline



There are currently relatively few STB models qualified under ENERGY STAR Version 4.1. At the end of January 2015 there were 25 Pay-TV STB models qualified under the ENERGY STAR Version 4.1 specification, most of which (14 of 25) were satellite STBs. Two manufacturers (Cisco Systems and ARRIS Group) also offered qualified STBs for IPTV providers. No cable STBs were qualified for ENERGY STAR Version 4.1.

There are likely STBs on the market that meet the ENERGY STAR Version 4.1 specification but do not appear on the ENERGY STAR Qualified Product List. Industry reporting around the Voluntary Agreement suggests that some STB models that appear to meet ENERGY STAR Version 4.1 specifications have not completed the qualification process necessary to appear on the ENERGY STAR Qualified Product List. Service provider signatories to the Voluntary Agreement reported that, in 2013, 47% of the STBs they purchased met the agreement’s Tier 2 requirements, which are similar, but not identical, to the ENERGY STAR Version 4.1 specification.[35] In addition, based on the feature sets and typical energy consumption values listed, 23 of the 80 models service providers reported procuring in 2013 appear to meet Version 4.1 requirements, including eight models that cable providers procured. Cable providers procured 11 models that seem to meet the requirements, but do not appear on the ENERGY STAR Qualified Products List in 2014.

3.3.2. Voluntary Agreement

As noted above (Section 3.2.1), in 2012, eleven leading service providers signed a Voluntary Agreement to reduce the energy consumption of STBs. Through the Voluntary Agreement, service providers committed that between 2014 and 2016, 90% of the STBs they procure will meet the ENERGY STAR Version 3.0 specification. Beginning in 2017, the service providers

35 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

committed that 90% of the STBs they procure will meet a higher efficiency standard that is similar, but not identical, to the ENERGY STAR Version 4.1 specification.[36]

Pay-TV providers developed the Voluntary Agreement in response to the U.S. Department of Energy (DOE)'s 2011 decision to begin the process of setting mandatory efficiency standards for STBs.[37] The Voluntary Agreement allowed more flexibility for service providers than would have been likely under federal regulations.[38] The Voluntary Agreement also gained the support of efficiency advocates by putting efficiency standards into effect more quickly than would have been possible through regulation.[39] Shortly after the release of the Voluntary Agreement, DOE withdrew its proposed rule makings related to STBs.[40]

As noted above, Pay-TV providers report on their procurement as part of the Voluntary Agreement. This reporting provides some indication of how the Voluntary Agreement has impacted the STB market.

Meeting the Voluntary Agreement will not require Pay-TV providers to drastically alter their practices. Service providers reported that, in 2013, 85% of their STB purchases met the ENERGY STAR Version 3.0 specification and 47% met the higher efficiency standard set to take effect in 2017, which are similar to ENERGY STAR Version 4.1 requirements.[41]

In the Voluntary Agreement's first year in effect, cable providers continued to procure inefficient STB models, but likely purchased a smaller number of units of these models. In both 2013 and 2014, cable providers procured eight models that did not meet the ENERGY STAR Version 3.0 specification, although the number of models meeting the more stringent ENERGY STAR Version 4.1 specification actually increased from 2013 to 2014 (Table 3-13).[42] Thus, assuming cable provider signatories complied with the Voluntary Agreement in 2014, it is likely that the proportion of their total STB purchases that met the ENERGY STAR Version 3.0 specification

36 Ibid.

37 Fitzgerald. 2014, January. "Expanded Set-Top Box Voluntary Agreement a Win for Service Providers and Consumers." *CableLabs.* http://www.cablelabs.com/stb-va/.

38 Ibid.

39 Horowitz. 2013, December. "Historic Agreement to Slash Energy Use by Set-Top Boxes Will Save $1 Billion Annually." Natural Resources Defense Council. *Switchboard, from NRDC*. http://switchboard.nrdc.org/blogs/nhorowitz/historic_agreement_to_slash_en.html.

40 "DOE Withdraws Proposed Rulemaking (Test Procedure) and Proposed Coverage Determination (Energy Conservation Standard) for Set-Top Boxes." *Energy.Gov Office of Energy Efficiency & Renewable Energy*. 2013, December. http://energy.gov/eere/buildings/articles/doe-withdraws-proposed-rulemaking-test-procedure-and-proposed-coverage.

41 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

42 The research team determined each model's ENERGY STAR level through a comparison of reported typical energy consumption (TEC) values and ENERGY STAR maximum allowable TEC levels based on the feature sets listed. To achieve ENERGY STAR certification, manufacturers must submit models to an independent testing laboratory, which, in turn, must report the model's qualification to EPA. Thus, models that appear qualified based on their reported TEC may not appear on an ENERGY STAR Qualified Product List.

increased.[43] This suggests providers purchased a disproportionately small number of units of the less efficient STB models.

Table 3-13: Comparison of Cable Provider STB Model Procurement in 2013 and 2014

ENERGY STAR LEVEL	2013 PROCUREMENT MODELS	2013 PROCUREMENT PERCENT	2014 PROCUREMENT MODELS	2014 PROCUREMENT PERCENT
Not Certified	8	20%	8	22%
Version 3.0	25	61%	18	49%
Version 4.1	8	20%	11	30%
Total	**41**	**100%**	**37**	**100%**

While most of the STBs service providers procured in 2013 complied with the Voluntary Agreement, models that did not comply used notably more energy than comparable compliant models. For example, cable providers procured STBs in 14 different configurations in 2013. For four of those configurations, cable providers both procured STBs that met the ENERGY STAR Version 3.0 specification and STBs that did not meet the specification. Among those four configurations, the models that met the ENERGY STAR specification ranged from an average of 14% to an average of 25% more efficient than the models that did not meet the specification. The difference in energy usage between compliant and non-compliant models was greater for satellite STBs, with the two configurations for which compliance varied ranging from an average of 34% to an average of 63% lower energy use for compliant models. Table 3-14 summarizes the average differences in energy use between compliant and non-compliant with the same features by service provider type.

Table 3-14: Average Energy Savings of STBs Compliant with Voluntary Agreement over Similar Non-Compliant Models

SERVICE PROVIDER TYPE	NUMBER OF MODEL CONFIGURATIONS PROCURED IN 2013		AVERAGE SAVINGS* (MODELS WITH VARIATION IN COMPLIANCE)	
	Total	With variation in ENERGY STAR Version 3.0 compliance	kWh/yr	Percent
Satellite	5	2	99	48%
Cable	14	4	41	20%
IPTV	3	0	N/A	N/A

* Based on reported Total Energy Consumption.

43 As noted above, across service provider types, 85% of the STBs Pay-TV service providers procured in 2013 met ENERGY STAR Version 3.0 specifications. If cable providers' procurement was consistent with this industry-wide average, the proportion of STBs service providers procured that met the specification would have needed to increase in 2014 to meet the Voluntary Agreement's requirement that 90% of STBs meet ENERGY STAR Version 3.0.

3.4. 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.

3.4.1. Sleep Mode

High stand-by power use is one factor that has attracted efficiency advocates' attention to STBs.[44] When they are not displaying video content, STBs continue to use energy 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.[45] The cable industry is working to develop STBs with a sleep mode that uses significantly less power than the boxes' 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.[46]

As part of the Voluntary Agreement, cable providers and some IPTV 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, like stopping hard drives from spinning, after a period of inactivity.[47] Similarly, satellite providers committed to deploying STBs with automatic power down capabilities, which go into an off or sleep mode if there is no user activity.[48]

Various Pay-TV service types face unique challenges in incorporating low energy sleep modes into their STBs that have the potential to limit the widespread implementation of this capability. For example, unlike cable and IPTV 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 IPTV providers may reduce STB standby power use by storing program guide information on the cloud, satellite providers must download this information onto the user's STB.[49]

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44 *Better Viewing, Lower Energy Bills, and Less Pollution: Improving the Efficiency of Television Set-Top Boxes.* Natural Resources Defense Council. 2011, June. http://www.nrdc.org/energy/files/settopboxes.pdf.

45 Goldberg. 2012, April. "NCTA Comments on ENERGY STAR Specification for Set-Top Boxes Version 4.0." http://www.energystar.gov/sites/default/files/specs//private/4-1_Comments_NCTA_4-2012.pdf.

46 Ibid.

47 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

48 Ibid.

49 Hardy, et al. 2012. "Pay-Television In-Home Equipment: National Energy Consumption, Savings Potential, and Policy Barriers and Opportunities." ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA: American Council for an Energy Efficient Economy. http://www.aceee.org/files/proceedings/2012/data/papers/0193-000294.pdf.

3.4.2. 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.[50] EPA sought to encourage adoption of this type of configuration in developing the ENERGY STAR Version 4.1 specification.[51] 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.[52]

Multi-room STB configurations have become more prevalent in recent years, and service providers anticipate their penetration will continue to grow. 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.[53]

3.5. STB Supply Chain

While some cable subscribers have shifted over the past five years to satellite and IPTV service, the overall proportion of California households with Pay-TV service has remained relatively constant. Penetration of cable service decreased from 53.3% in November 2009 to 43.3% in July 2014 before rebounding slightly at the end of 2014 to 44.3% in November. Increases in satellite and IPTV penetration offset these decreases in cable penetration, with penetration of satellite service growing from a statewide average of 31.8% of homes in February 2010 to 35.8% of homes in November 2013 before decreasing to 33.7% by November 2014. IPTV penetration also grew from 4.3% in November 2009 to 10.4% in November 2014. Despite these shifts in penetration by Pay-TV service type, the total proportion of California TV households with Pay-TV service has remained relatively constant, fluctuating between 88.4% and 90.1% between November 2009 and November 2014. These data do not support some industry analysts' predictions that Pay-TV subscribership will decline as viewers "cut the cord," cancelling their Pay-TV service in favor of online streaming video services. Nonetheless, cord cutting may increase in the future as new streaming video services allow viewers to access a wider range of content, including live TV.[54]

50 *Better Viewing, Lower Energy Bills, and Less Pollution: Improving the Efficiency of Television Set-Top Boxex*.

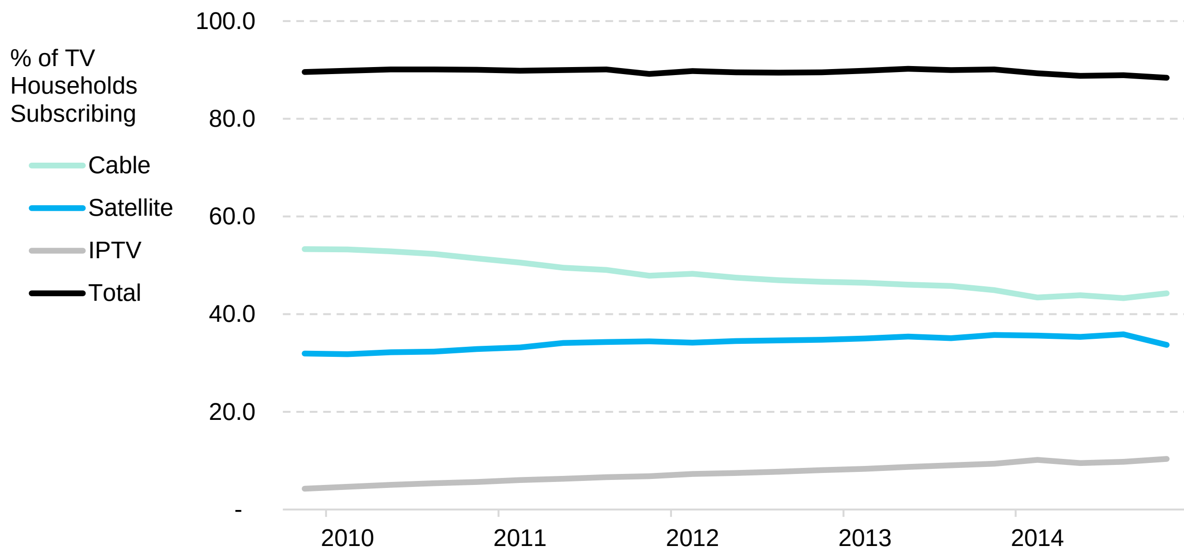
51 U.S. Environmental Protection Agency. "ENERGY STAR Set-Top Boxes Version 4.1 Specification Review Stakeholder Webinar." April 5, 2012. http://www.energystar.gov/sites/default/files/specs//private/STB_V4_Webinar_2012_04_05.pdf.

52 Joseph. "DirecTV Comments on ENERGY STAR Set-Top Box Version 4.1 Specification Review."; Goldberg. 2013, April. "NCTA Comments on ENERGY STAR Specification for Set-Top Boxes Version 4.1." http://www.energystar.gov/sites/default/files/specs//NCTA_Comments_STBs_Draft1V4_Public.pdf.

53 Fraunhofer USA Center for Sustainable Energy Systems. 2014, June. *Energy Consumption of Consumer Electronics in U.S. Homes in 2013.* Consumer Electronics Association.

54 Kafka. 2015, January. "Will HBO on the Web Pull the Plug on Pay-TV? Survey Says: Yep!" *Re/code.* http://recode.net/2015/01/22/will-hbo-on-the-web-pull-the-plug-on-pay-tv-survey-says-yep/.

Figure 3-4: Proportion of California TV Households with Pay-TV Service, November 2009 to November 2014



* Penetration figures from "TVB - ADS, Wired-Cable and Over-The-Air Penetration by DMA." Nielsen data reported in TVB combine cable and IPTV subscribership. Disaggregated figures presented here are based on quarterly nation-wide market share of top providers reported in Leichtman Research Group, "Industry by the Numbers," *Research Notes*, volumes from Q4 2009 to Q4 2014.

Pay-TV providers have proposed two mergers that could bring about significant consolidation in the industry if they receive government approval. In February 2014, Comcast announced a deal to acquire Time Warner Cable. Comcast and Time Warner are the two largest U.S. cable providers; together they serve approximately one-third of all U.S. Pay-TV subscribers and more than two-thirds (68%) of cable subscribers.[55] In February 2015, the CPUC approved Comcast's takeover of Time Warner as well as Charter Communications' and Bright House Systems' operations in California if the company agrees to meet requirements around broadband internet access and equity.[56] Following Comcast's announcement, in May 2014, AT&T, the leading U.S. IPTV provider, announced a merger with DirecTV, the leading satellite provider.[57] Together, the two companies serve 26% of all U.S. Pay-TV subscribers.[58] Federal regulators are currently reviewing both mergers.

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55 Leichtman Research Group. 2014. "Industry by the Numbers." *Research Notes*, Q4 2014. http://www.leichtmanresearch.com/research/notes12_2014.pdf.

56 James. 2015, February. "Comcast-Time Warner Cable Merger Wins Preliminary California Endorsement." *Los Angeles Times.* http://www.latimes.com/entertainment/envelope/cotown/la-et-ct-comcast-time-warner-cable-merger-wins-california-endorsement-20150213-story.html.

57 "Pay-TV Consolidation: Who Are the Potential Winners and Losers?," *Knowledge@Wharton*. 2014, May. http://knowledge.wharton.upenn.edu/article/pay-tv-consolidation-potential-winners-losers/.

58 Leichtman Research Group. 2014. "Industry by the Numbers." *Research Notes*, Q4 2014. http://www.leichtmanresearch.com/research/notes12_2014.pdf.

Mergers between Pay-TV providers have the potential to influence the STB market. The top five STB vendors (Arris, Cisco, Technicolor, Pace, and Echostar) account for 37% of global STB revenues, and most primarily focus on only one or two types of Pay-TV service (cable, satellite, and IPTV). Pay-TV provider mergers may create pressure for consolidation among STB manufacturers, particularly those focused on a single service provider type.[59] Analysts also suggest that, as Pay-TV providers merge, there may be demand for fewer unique STB models but larger unit volumes of each model produced.[60]

There appears to be little exclusivity between STB manufacturers and IPTV and cable service providers. Pay-TV service providers procured STBs from eight manufacturers in 2013. With the exception of the two satellite providers, which both procured self-branded STBs, and one manufacturer that provided only one model, manufacturers worked with multiple service providers. The manufacturer that provided the largest number of models – Cisco – provided STBs to all but one of the nine cable and IPTV service provider signatories to the Voluntary Agreement. Likewise, all but two of the cable and IPTV service provider signatories to the Voluntary Agreement procured STBs from multiple manufacturers in 2013. One service provider (Comcast) procured STBs from six of the eight manufacturers, while all the others that worked with multiple manufacturers procured STBs from three manufacturers.

59 "Set-Top Box Vendor Consolidation Required to Meet Demands of Merged Operators Such as AT&T-DirecTV." *ABI Research*. 2014, May. https://www.abiresearch.com/press/set-top-box-vendor-consolidation-required-to-meet-.

60 "Broadcom Extends Market Share by 4% to Nearly 49% in Set-Top Box IC Market." *ABI Research*. 2014, May. https://www.abiresearch.com/press/broadcom-extends-market-share-by-4-to-nearly-49-in.

4. Technical and Achievable Potential

This chapter presents technical and achievable energy savings potential of replacing existing, less efficient STB models with more efficient models.

- **Technical Potential** is the theoretical maximum amount of energy and capacity that could be displaced by efficiency, regardless of cost and other non-technical barriers that may prevent the installation or adoption of an energy efficiency measure. Technical potential is only constrained by factors such as technical feasibility and applicability of measures.
- **Achievable Potential** is the energy savings that can feasibly be achieved through program and/or interventions. Achievable potential reflects real world market constraints such as the effectiveness of a program or an intervention in the marketplace in inducting change.

For the purposes of this study, technical potential is defined as the energy savings of replacing all pre-ENERGY STAR Version 3.0 or 4.1 STB models, where appropriate, in the dataset of Southern California STBs with ENERGY STAR Version 3.0 or 4.1 certified models. Although this dataset does not cover all service providers in SCE territory, it still provides insights into the savings potential. The achievable potential is defined as the energy savings that could reasonably be achieved assuming customer response rate to an upgrade offer would be similar to the response rate observed in the pilot. The STB pilot, which tested the effectiveness of SCE’s STB upgrade offer, revealed a replacement rate of about 9% among those exposed to the upgrade offer and a replacement rate of about 1% among those in the control condition (not exposed to the upgrade offer).

4.1. Summary of the Methods

To estimate technical and achievable energy savings potential, we gathered the following data required to perform this analysis: 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.[61]

Next, we performed five distinct analytic tasks:

- First, we reviewed the quality of the STB installed base data. This assessment resulted in a removal of 2.4% of customer records from the installed base. These records had missing STB model-level data or had data for more than 10 STBs. Customer records listing more than 10 STBs were likely commercial properties as it is unlikely that residences had that many STBs.

[61] 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.

- Second, certain records in the installed base had partial model-level ENERGY STAR certification level and energy usage data. Specifically, STB models were listed in the records (e.g., X model), while sub-model differentiation was missing (e.g., whether the model was X-1 or X-2). For the records where sub-model data was missing, we imputed missing data from the available model-level data (see Appendix C for more details on how this was conducted).
- Third, in collaboration with SCE and by using insights from the experimental STB pilot, we developed several STB replacement scenarios for which we estimated technical and achievable energy savings potential. Each scenario replaces existing pre-ENERGY STAR Version 3.0 models with more efficient ENERGY STAR Version 3.0 or 4.1 certified models.
- Fourth, we established the baseline against which the impacts of the replacement scenarios could be measured. The total energy usage (kWh/year) of the STBs in the installed base served as the "baseline."
- Last, we estimated technical and achievable energy savings potential of each replacement scenario. The technical savings potential was estimated by subtracting, from the baseline, the total energy usage of the installed base if pre-ENERGY STAR Version 3.0 certified models were replaced with the equipment specified in each replacement scenario. The achievable savings potential was calculated by assuming a replacement rate of 9% if SCE offered an incentive for an existing STB upgrade. This represents an upper bound for the achievable savings potential. For more details about the method and assumptions, see Appendix C.

Please note that the installed base data is confidential. To ensure certain details remain confidential, we only report percentages and energy savings values in the following sections.

4.2. Key Findings

Based on the installed base of existing STBs in SCE territory, the technical savings potential ranged from -15% to 27% across the replacement scenarios listed in Table 4-1.[62] Scenario 4-C provided the largest technical energy savings potential of 75.5 GWh per year and 220.1 GWh per the 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.

The scenario that replaces existing pre-ENERGY STAR 3.0 STBs with ENERGY STAR Version 4.1 comparable STBs (Scenario 1-B) provided the second largest technical energy savings potential of 53.1 GWh per year and 154.7 GWh per the life of the equipment. However, for a program considering incentivizing early replacement of STBs, providing an incentive to a customer to upgrade its existing STB to an energy-efficient but comparable model will be

62 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.

difficult, especially if customers have a basic SD model. Service providers no longer procure basic SD models. Across service provider types, 99% of the STBs procured in 2013 were HD (see Chapter 3 for more details on this trend), indicating that the ability to deliver HD content is becoming a standard feature in STBs. Thus, scenarios modelling a replacement of existing stand-alone STBs with energy-efficient STBs with HD capability (our scenarios 2-4) are more realistic scenarios for a program to consider than our scenario 1 – 1-A or 1-B.

Table 4-1: Technical Potential of Each Scenario

SCENARIO	REPLACE FROM	REPLACE TO	PERCENT SAVINGS OVER BASELINE	ANNUAL GWH SAVINGS	LIFETIME GWH SAVINGS
1-A	Pre-ENERGY STAR (ES) 3.0 models	ES 3.0 STBs, like-with-like replacement [a]	8.5%	23.9	69.6
1-B	Pre-ES 3.0 models	ES 4.1 STBs, like-with-like replacement	19.0%	53.1	154.7
2-A	Pre-ES 3.0 models	ES 3.0 STBs with HD capability [b]	3.3%	9.3	27.1
2-B	Pre-ES 3.0 models	ES 4.1 STBs with HD capability	8.7%	24.3	70.8
3-A	Pre-ES 3.0 models	ES 3.0 STBs with HD DVR capability [c]	-15.2%	-42.6	-124.2
3-B	Pre-ES 3.0 models	ES 4.1 STBs with HD DVR capability	2.4%	6.7	19.5
4-A	Pre-ES 3.0 models	ES 4.1 Server/Thin client system (HD DVR capability) [d]	17.3%	48.4	141.2
4-B	Pre-ES 3.0 models	ES 4.1 Thin client(s) for only customers already having a server [e]	6.6%	18.5	54.0
4-C	HD, DVR, or HD DVR stand-alone models	ES 4.1 Server/Thin client system (HD DVR capability) [f]	27.0%	75.5	220.1

[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.

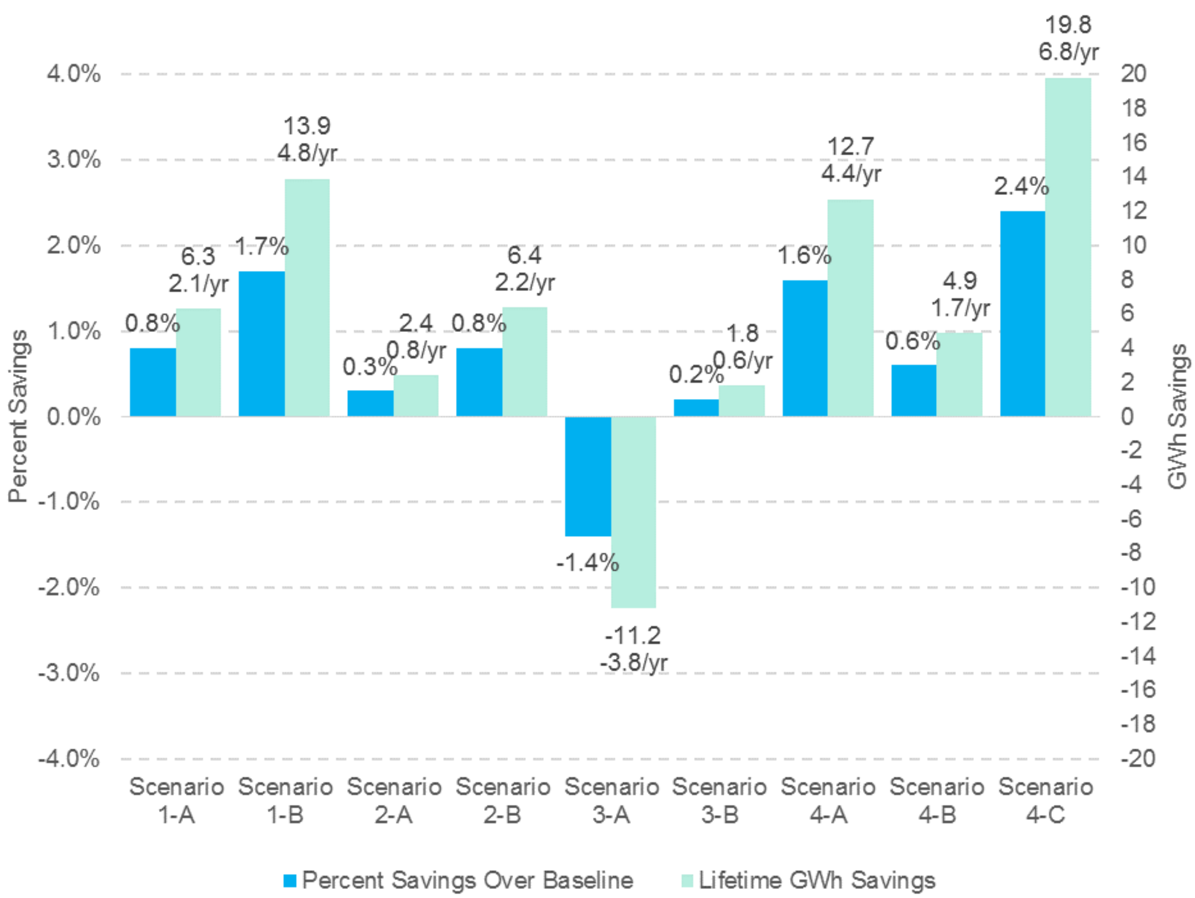
[d] This scenario assumes pre-ENERGY STAR Version 3.0 stand-alone STBs are replaced with a server and thin client system (a multi-room configuration STB technology that meets ENERGY STAR Version 4.1 specification). If the customer already had a server, then we only replaced the customer's pre-ENERGY STAR Version 3.0 stand-alone STBs, if any, with thin clients. If the customer had an older pre-ENERGY STAR Version 3.0 certified server, then we replaced that server 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 we only replaced customer's existing stand-alone STBs with thin clients. If the customer had pre-ENERGY STAR Version 3.0 certified server, then we replaced that server 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 9% of customers upgraded their STBs), ranged from -1.4% to 2.4% of baseline usage across the replacement scenarios (Figure 4-1). Similar to the technical potential findings, Scenario 4-C and 1-B provided the largest achievable energy savings potential of 19.8 and 13.9 GWh per the life of the equipment. 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).

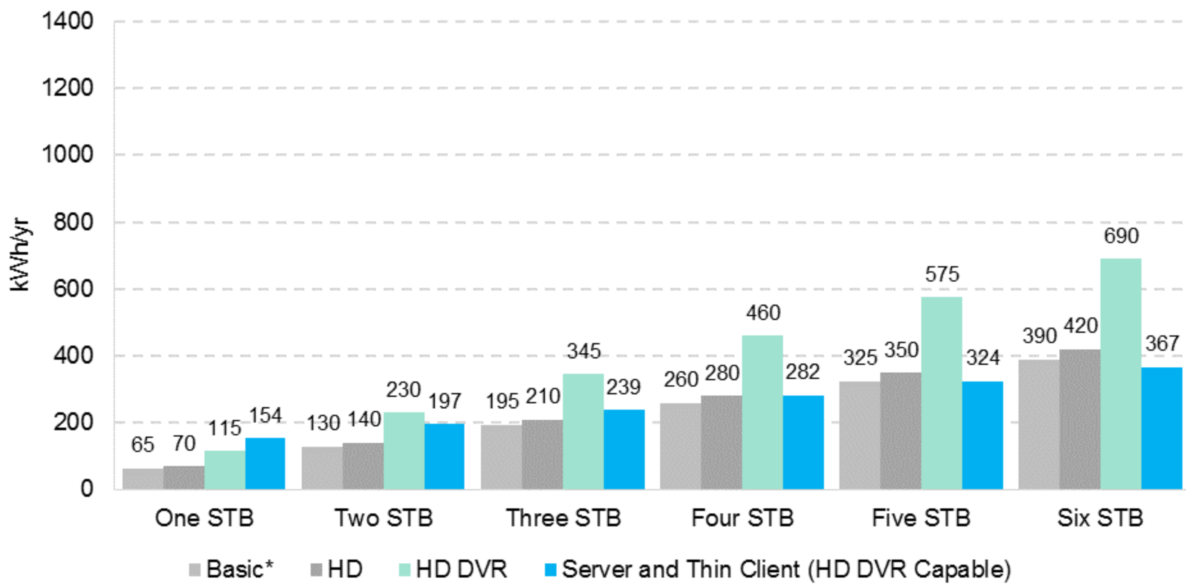
Figure 4-1: Achievable Potential of Each Scenario



If customers increase the number of units by one after upgrading, this will yield negative savings potential for all of the scenarios, except for the scenarios where we replaced existing STBs with either stand-alone ENERGY STAR Version 4.1 STBs (a comparable or an HD model) or an ENERGY STAR Version 4.1 server and thin client system. If customers increase the number of units by two after upgrading, this will yield positive savings potential for only one scenario: replacing existing STBs with a server and thin client system.

Figure 4-2 compares the total energy consumption (kWh/year) of three ENERGY STAR 4.1 model types (basic, HD, HD DVR, and server/thin client) for different numbers of units in the home (one to six STBs). As expected, as features are added (HD, HD DVR) energy consumption increases. A server, which uses 154 kWh/year, on average, can function as a STB without any clients; a client, which uses 43 kWh/year, on average, cannot function without a server. As shown in the figure, 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, the server-thin client model provides HD DVR for equivalent or less energy than stand-alone HD STBs. With five or more units, the server-thin client model provides HD DVR for equivalent or less energy than stand-alone basic STBs. The findings are similar for ENERGY STAR Version 3.0, as shown in a subsequent section.

Figure 4-2: ENERGY STAR 4.1 Model Average kWh/year by Number of STBs and Model Types

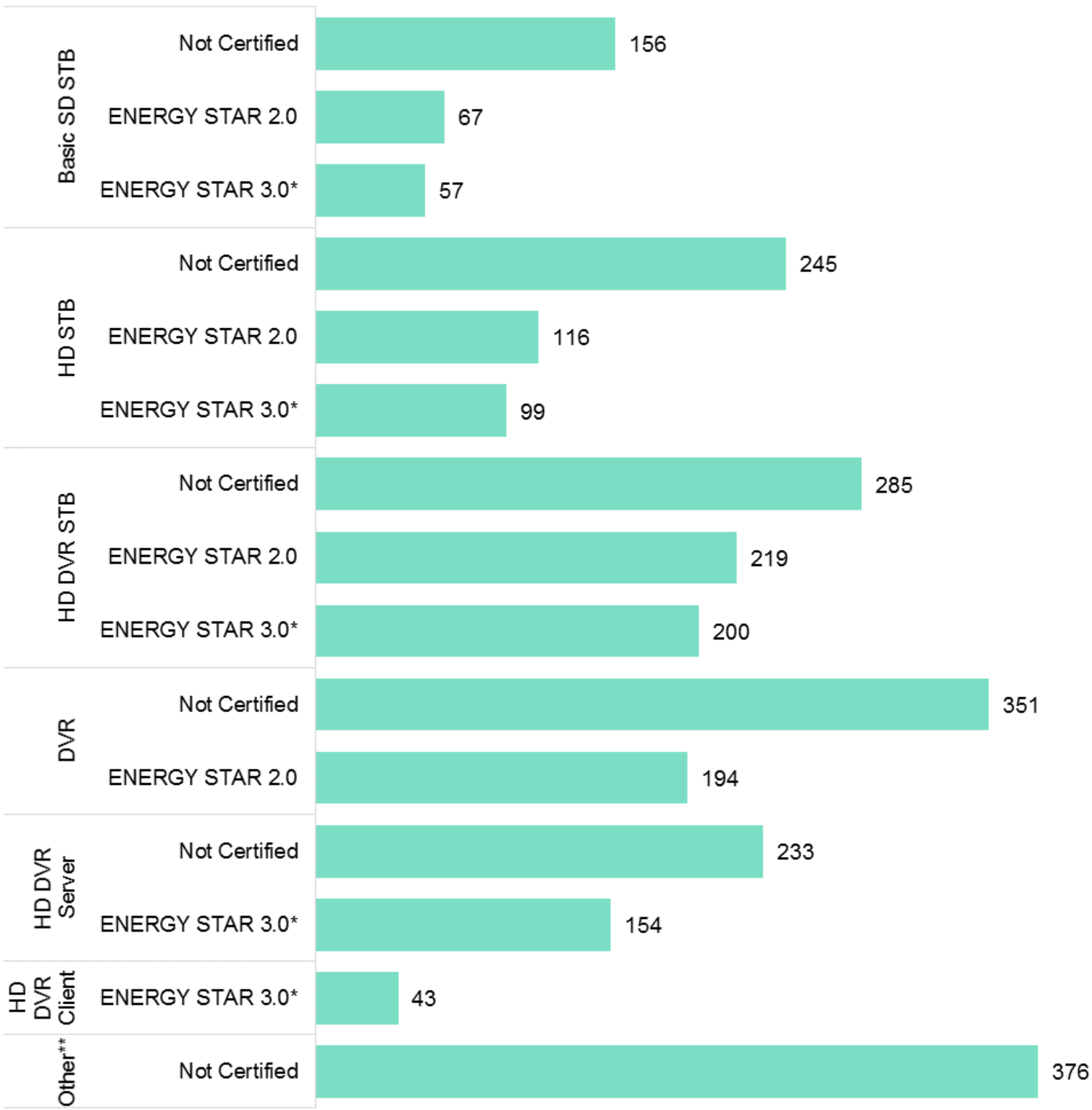


* The average kWh/year value for the ENERGY STAR Version 4.1 basic STBs was slightly higher than the ENERGY STAR Version 3.0 basic kWh/year average. The ENERGY STAR base allowance explains this unexpected finding. The Version 3.0 basic model is a standard definition model (no inclusion of HD or other features in its base allowance), whereas the ENERGY STAR base allowance for 4.1 specification included HD capability.

4.3. Baseline and STB Model Energy Usage Characteristics

The installed base, which included a listing of all STB models in customer homes from a subset of service providers, uses 279.3 GWh per year in SCE territory. Figure 4-3 provides the average kWh by STB model type and ENERGY STAR certification level. Pre-ENERGY STAR Version 3.0 STBs in the installed base used an average of 150 kWh per year, whereas efficient STB models with ENERGY STAR Version 3.0 certification used an average of 87 kWh per year.

Figure 4-3: Average kWh/Year Used by STB Model Type and ENERGY STAR Certification



* A few of the ENERGY STAR Version 3.0 labeled models in the installed base met the ENERGY STAR Version 4.1 certification level. The installed base included data as of December 2014, before the new ENERGY STAR Version 4.1 specification was released. Some models in the installed base labeled ENERGY STAR Version 3.0 already qualified as ENERGY STAR Version 4.1.

** Other includes hospitality systems and other specialty STB types.

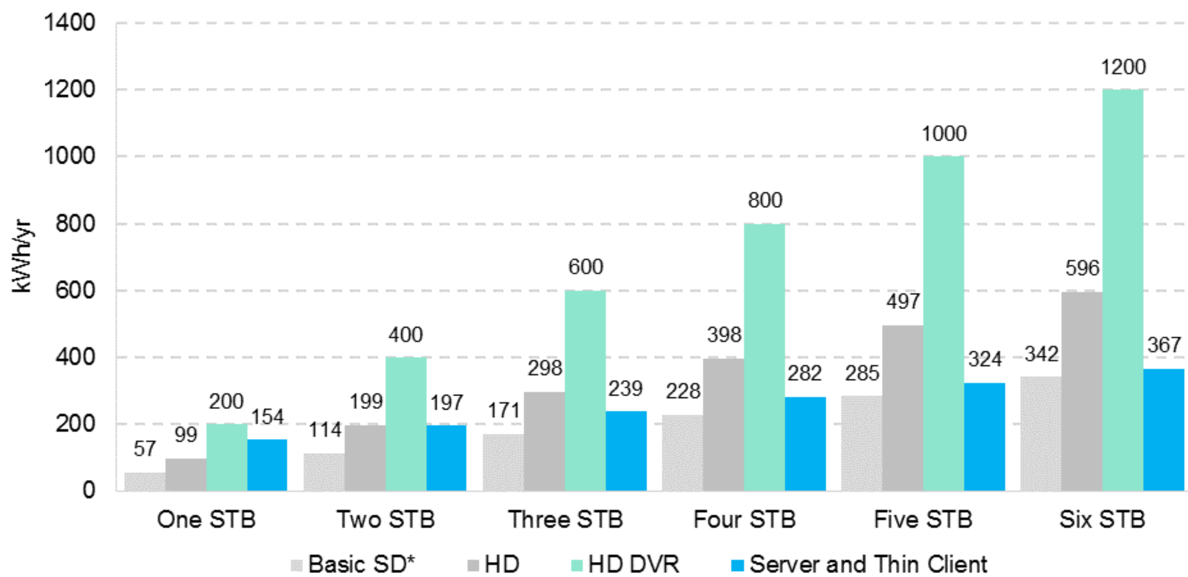
4.4. Comparing Energy Usage of the Efficient STB Technologies

Prior to estimating technical and achievable potential of the STB replacement scenarios, we examined the energy usage of the most efficient STB technologies considered in this study:

- A central server, thin client system (an ENERGY STAR 4.1 certified technology where one box is a server that communicates with up to eight receivers called thin clients)[63]
- An ENERGY STAR Version 3.0 stand-alone STB (there is no transmission of the signal to other boxes)
- An ENERGY STAR Version 4.1 stand-alone STB (there is no transmission of the signal to other boxes)

Figure 4-4 provides the comparison for ENERGY STAR Version 3.0 that we presented in the Key Findings section for ENERGY STAR Version 4.0. In all comparisons by number of units, the server-thin client model is even more advantageous than illustrated previously; this is because the server-thin client model meets the ENERGY STAR Version 4.1 specification, which represents a considerable increase in efficiency compared with ENERGY STAR Version 3.0.

Figure 4-4: ENERGY STAR 3.0 STB Model Energy Usage Compared to Server-Thin Client System, by Number of STBs in the Home



* The newest ENERGY STAR Version 4.1 specification for base allowances includes HD capability.

63 There are two versions of this technology: a pre-ENERGY STAR Version 2.0 certified system and an ENERGY STAR Version 4.1 certified system (a system that also met the ENERGY STAR Version 3.0 standard prior to ENERGY STAR 4.1 standard release in January 2015). In this study, we focus only on the ENERGY STAR Version 4.1 system.

4.5. Scenario 1 - Like-with-Like Replacement of STBs

This section presents technical and achievable energy savings potential for “Like-with-Like” replacement of pre-ENERGY STAR Version 3.0 STBs with two types of efficient STB models: ENERGY STAR Version 3.0 and Version 4.1 stand-alone STBs. These scenarios resulted in the replacement of 38% of all STBs in the installed base.

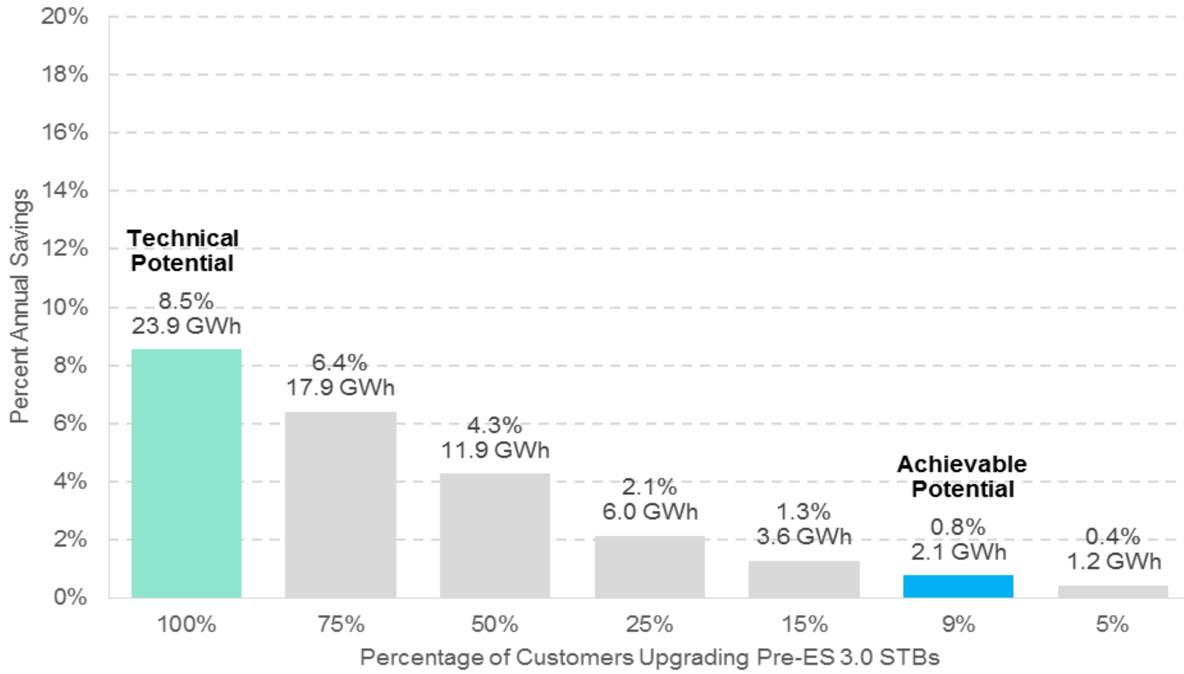
Like-with-Like replacement means that a pre-ENERGY STAR Version 3.0 DVR STB is replaced with an ENERGY STAR Version 3.0 or 4.1 DVR STB. This replacement scenario assumes no added features, to the extent possible. The ENERGY STAR base allowance for 4.1 specification includes HD capability, whereas prior base allowance for 3.0 specification included only basic SD capability. This means that replacing pre-ENERGY STAR Version 3.0 basic SD model with a 4.1 model that would be SD is not a realistic scenario.

4.5.1. Replacing with ENERGY STAR Version 3.0 STB Models

As previously noted, technical potential is the maximum energy savings achieved if all pre-ENERGY STAR Version 3.0 STBs were upgraded, while the achievable potential is the feasible energy savings achieved given the proportion of customers that are likely to upgrade their pre-ENERGY STAR Version 3.0 STBs due to the program or an intervention. Experimental STB pilot data revealed that 9% of customers upgraded their STBs when presented with the free upgrade offer from SCE and their service provider.

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 STBs with comparable ENERGY STAR Version 3.0 STBs is 23.9 GWh and 2.1 GWh per year, respectively (Figure 4-5).

Figure 4-5: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models, Like-with-Like



We also estimated the technical and achievable *lifetime* energy savings potential of this scenario by assuming an Expected Useful Life (EUL) of the equipment in the installed base to be 6 years. This means that about 17% of STBs in the installed base will be replaced with newer and (our model assumes) more efficient models annually (the "natural" replacement rate).[64] Thus, the energy savings over the lifetime of the replaced equipment, if the equipment is replaced because of the program or an intervention, can be counted only for the remaining EUL of the equipment that was replaced (for more details see Appendix C).[65]

Lifetime technical and achievable energy savings potential is 69.6 GWh and 6.3 GWh, respectively (Table 4-2).

64 When assuming an EUL of six years, we assume that 100% of the new equipment stock will be replaced in 6 years. For this to happen, 17% of the stock needs to be replaced each year (16.67% multiplied by 6 years = 100%).

65 This assumption accounts for the equipment that is replaced due to failure.

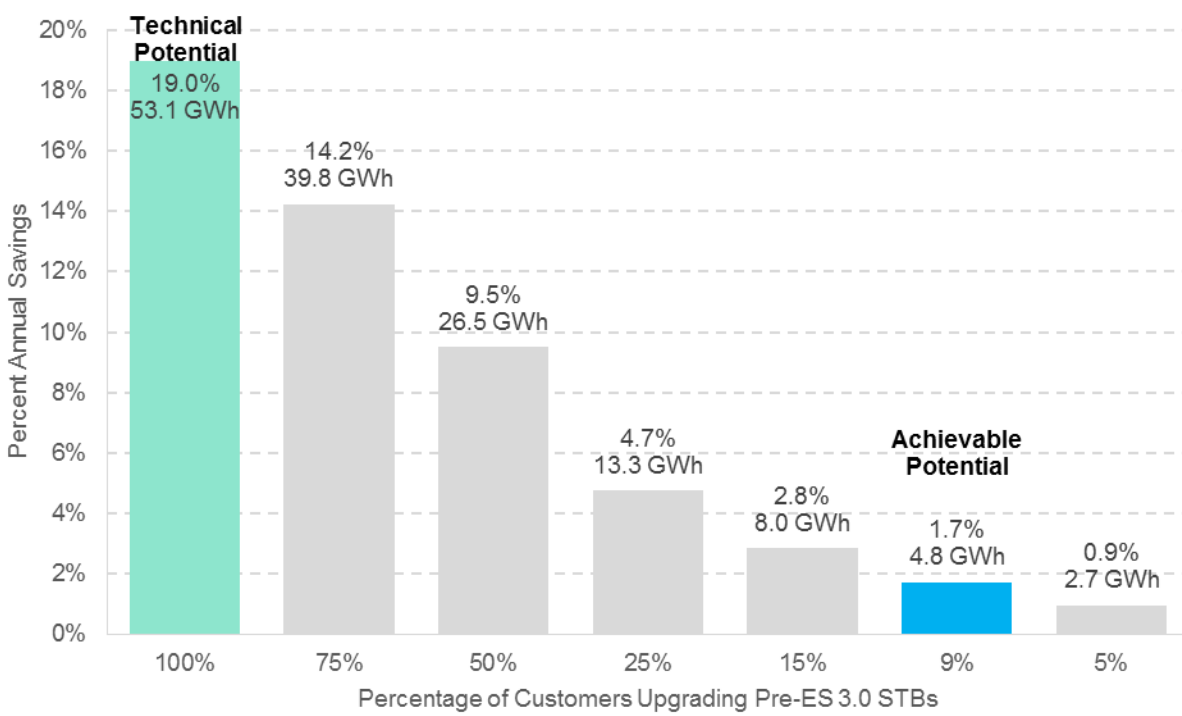
Table 4-2: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models, Like-with-Like

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	8.5%	69.6
75%	6.4%	52.2
50%	4.3%	34.8
25%	2.1%	17.4
15%	1.3%	10.4
9% (Achievable Potential)	0.8%	6.3
5%	0.4%	3.5

4.5.2. Replacing with ENERGY STAR Version 4.1 STB Models

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 STBs with comparable ENERGY STAR Version 4.1 STBs is 53.1 GWh and 4.8 GWh per year, respectively (Figure 4-6).

Figure 4-6: Replacing Pre-ENERGY STAR 3.0 Models with 4.1 Models, Like-with-Like



Lifetime technical and achievable potential is 154.7 GWh and 13.9 GWh, respectively, when replacing with ENERGY STAR Version 4.1 STBs (Table 4-3).

Table 4-3: Replacing Pre-ENERGY STAR 3.0 Models with 4.1 Models, Like-with-Like

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	19.0%	154.7
75%	14.2%	116.1
50%	9.5%	77.4
25%	4.7%	38.7
15%	2.8%	23.2
9% (Achievable Potential)	1.7%	13.9
5%	0.9%	7.7

4.5.3. Sensitivity Analysis

From the pilot, we know that customers had an average of 1.3 STBs in their home prior to the pilot, while after the pilot, customers had an average of 2.7 STBs in their home – resulting in about a two-fold increase in STBs for participants who upgraded their STBs. 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 its STBs. Given this insight, we conducted sensitivity analysis to assess the impact on technical and achievable energy savings potential if we assume that customers increase the number of STBs when upgrading their existing units.

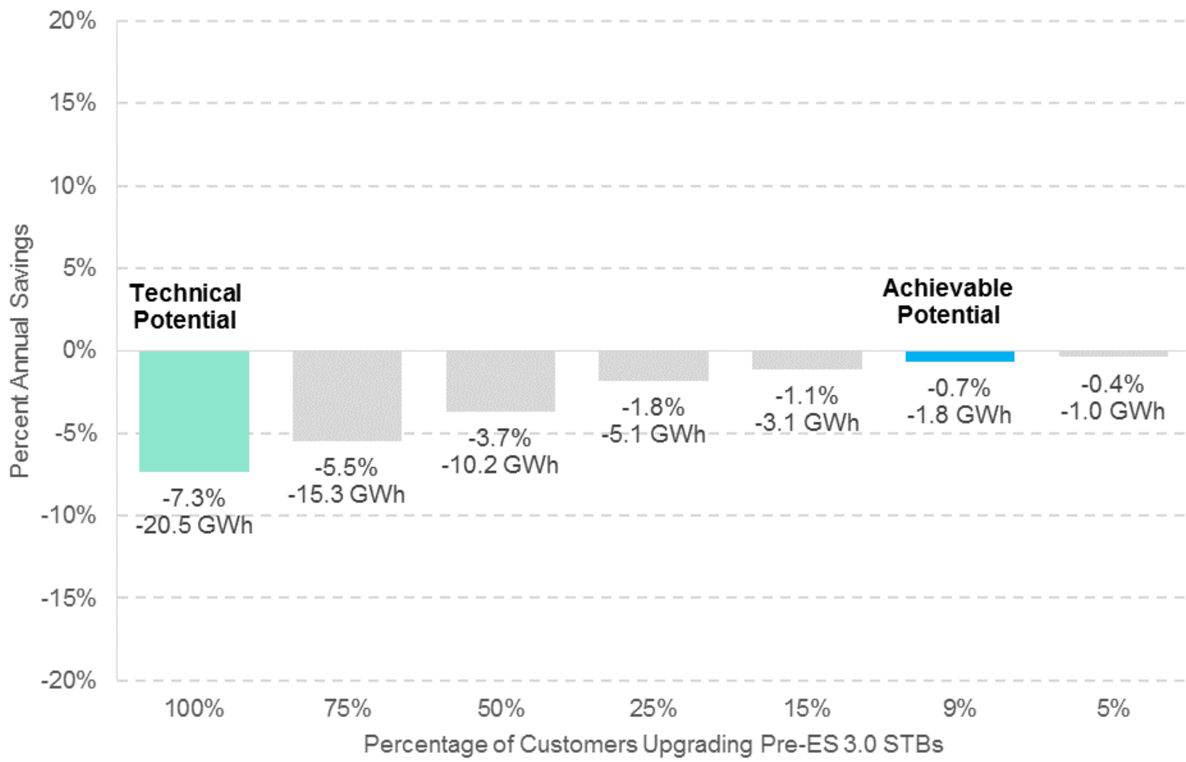
We know from the experimental data that 75% of those in the experimental condition increased their number of STBs. For the sensitivity analysis, we assumed that 75% of customers who had less than ten existing STBs and upgraded their equipment would add one or two additional STBs. If the addition of one STB resulted in negative savings potential, we did not conduct the analysis to estimate the impact of the addition of two boxes on energy savings estimates.

4.5.3.1. Replacing with ENERGY STAR Version 3.0 STB Models

For this scenario, we assumed the additional STB would have a kWh/year value that was the average kWh/year of ENERGY STAR Version 3.0 basic SD, HD, HD DVR, and Version 4.1 certified servers. (Note that the servers in the installed base labeled ENERGY STAR Version 3.0 already qualified as ENERGY STAR Version 4.1.)

This scenario resulted in an addition of up to 340,622 STBs to the installed base. This increase of STBs resulted in negative savings or technical and achievable potential of -20.5 GWh and -1.8 GWh per year, respectively (Figure 4-7).

Figure 4-7: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models and Adding One STB, Like-with-Like



The addition of one ENERGY STAR Version 3.0 STB by 75% of customers who upgraded their equipment similarly resulted in negative lifetime technical and achievable potential of -59.6 GWh and -5.4 GWh, respectively (Table 4-4).

Table 4-4: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models and Adding One STB, Like-with-Like

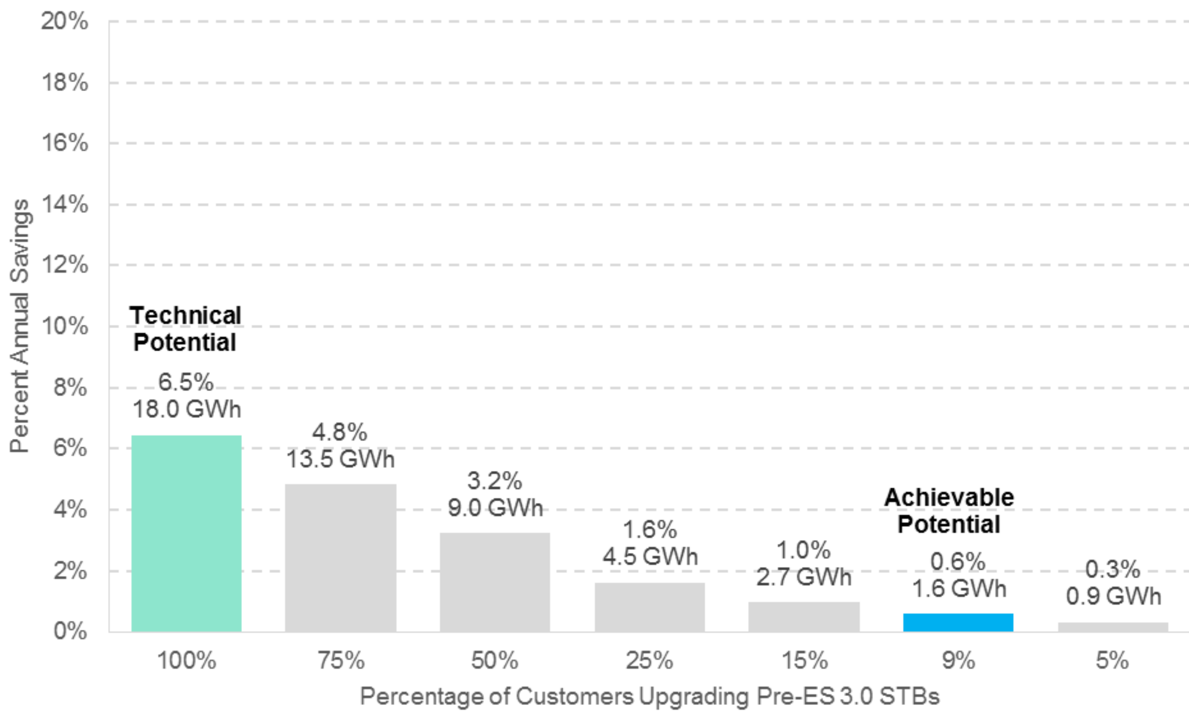
PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-7.3%	-59.6
75%	-5.5%	-44.7
50%	-3.7%	-29.8
25%	-1.8%	-14.9
15%	-1.1%	-8.9
9% (Achievable Potential)	-0.7%	-5.4
5%	-0.4%	-3.0

4.5.3.2. Replacing with ENERGY STAR Version 4.1 STB Models

For this scenario where we assume 75% of customers would add one additional STB when upgrading equipment, we assumed the additional STB would have a kWh/year value that was the average kWh/year of ENERGY STAR Version 4.1 basic SD, HD, DVR, HD DVR, and servers.

This scenario resulted in an addition of up to 340,622 STBs to the installed base. Unlike the previous scenario with Version 3.0, the Version 4.1 scenario of increased STBs generated positive savings compared to baseline, yet fewer savings than Scenario 1-B that does not increase total STBs. The technical and achievable potential are 18.0 GWh and 1.6 GWh per year, respectively (Figure 4-8).

Figure 4-8: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding One STB, Like-with-Like



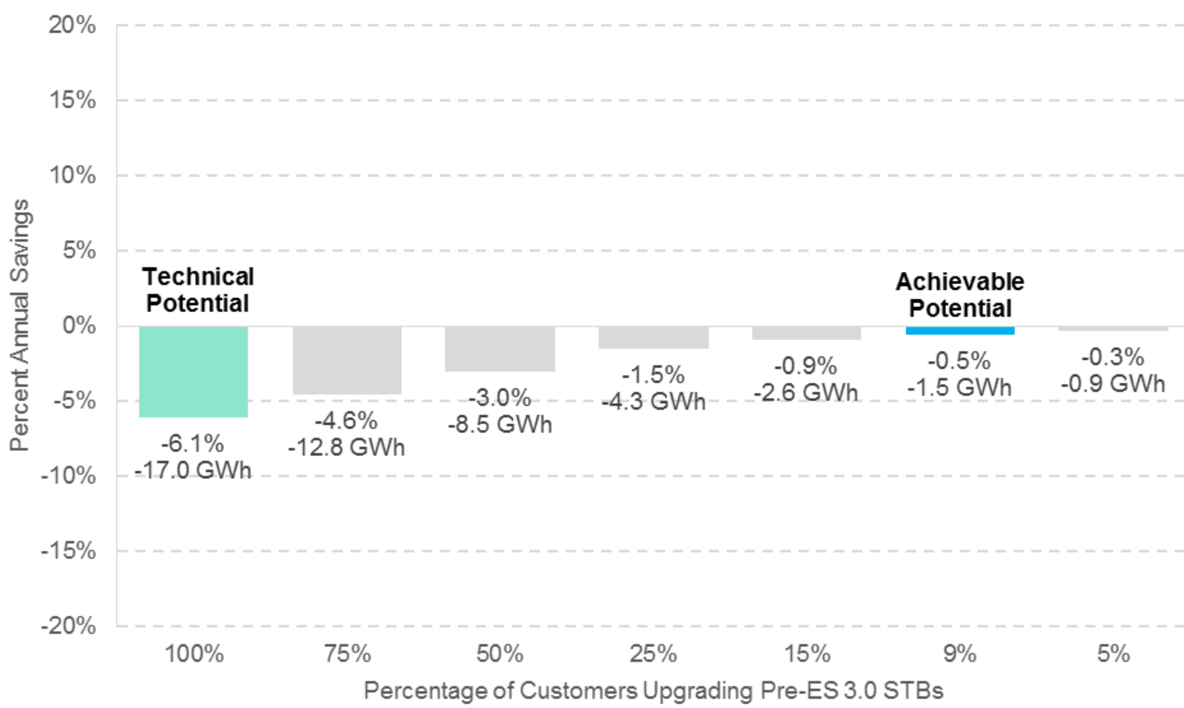
The addition of one ENERGY STAR Version 4.1 STB by 75% of customers who upgraded their equipment reduced – compared to Scenario 1-B - the lifetime technical and achievable potential to 52.6 GWh and 4.7 GWh, respectively (Table 4-5).

Table 4-5: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 models and Addition of One STB, Like-with-Like

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	6.5%	52.6
75%	4.8%	39.4
50%	3.2%	26.3
25%	1.6%	13.1
15%	1.0%	7.9
9% (Achievable Potential)	0.6%	4.7
5%	0.3%	2.6

Since the addition of one ENERGY STAR Version 4.1 STB did not result in negative savings potential, we estimated the impact on energy savings potential by adding two ENERGY STAR Version 4.1 STBs to 75% of the customers who upgraded their equipment. This scenario resulted in the addition of up to 681,245 STBs to the installed base. This increase of STBs resulted in negative savings or technical and achievable potential of -17.0 GWh and -1.5 GWh per year, respectively (Figure 4-9).

Figure 4-9: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding Two STBs, Like-with-Like



The addition of two ENERGY STAR Version 4.1 STBs by 75% of customers who upgraded their equipment further reduced lifetime technical and achievable potential to -49.6 GWh and -4.5 GWh, respectively (Table 4-6).

Table 4-6: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding Two STBs, Like-with-Like

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-6.1%	-49.6
75%	-4.6%	-37.2
50%	-3.0%	-24.8
25%	-1.5%	-12.4
15%	-0.9%	-7.4
9% (Achievable Potential)	-0.5%	-4.5
5%	-0.3%	-2.5

4.6. Scenario 2 – Upgrading to HD-capable STBs

This section presents technical and achievable energy savings potential of replacing pre-ENERGY STAR Version 3.0 STBs with ENERGY STAR Version 3.0 and 4.1 STBs by assuming that models without HD capability are replaced with HD-capable models. These scenarios resulted in the replacement of 38% of all STBs in the installed base.

We developed these Version 3.0 and Version 4.1 replacement scenarios because 99% of the STB models procured in 2013 had HD capability, indicating that the HD feature is becoming a standard feature in STBs (see Chapter 3 for more details on this trend). Table 4-7 describes which pre-ENERGY STAR Version 3.0 models we replaced and which ENERGY STAR Version 3.0 or 4.1 models we used for replacement.

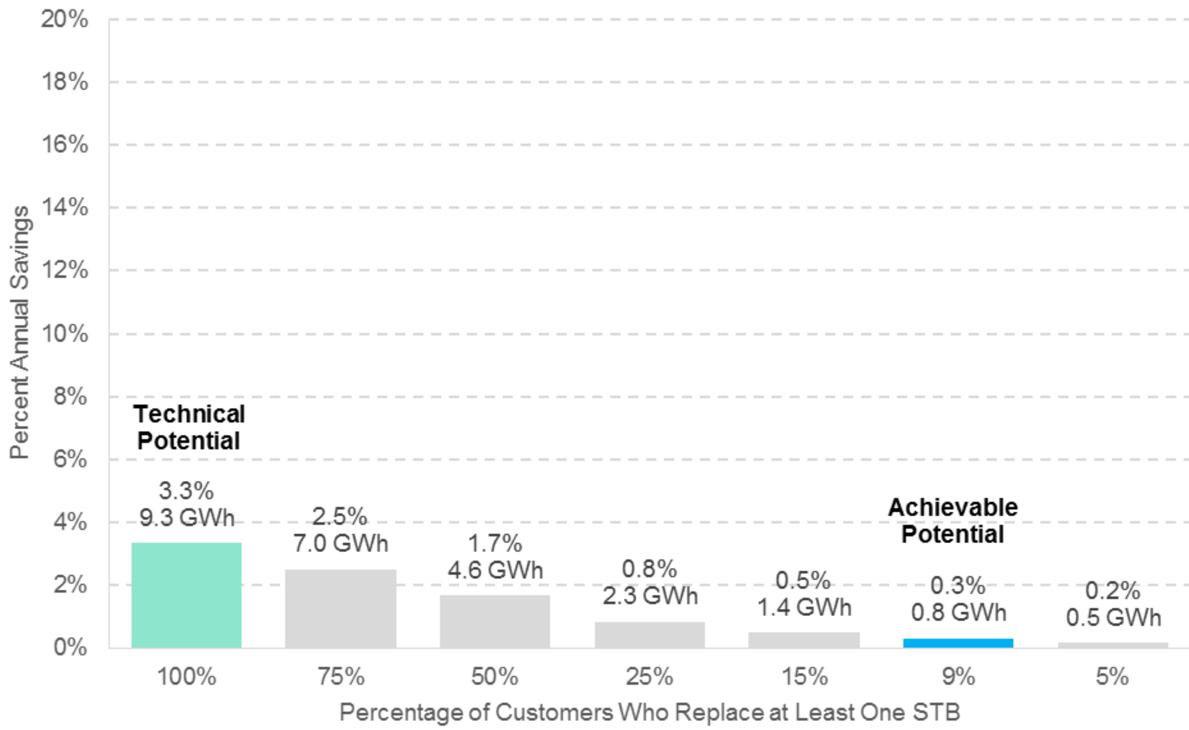
Table 4-7: Original Pre-ENERGY STAR Version 3.0 Models and HD Replacement Models

ORIGINAL MODEL	REPLACEMENT MODEL
Pre-ES 3.0 Basic SD	ES 3.0 or 4.1 HD
Pre-ES 3.0 HD	ES 3.0 or 4.1 HD
Pre-ES 3.0 DVR	ES 3.0 or 4.1 HD DVR
Pre-ES 3.0 HD DVR	ES 3.0 or 4.1 HD DVR
Pre-ES 3.0 Server	4.1 Server (HD DVR-capable)

4.6.1. Replacing with ENERGY STAR 3.0 HD-Capable STB Models

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 STBs with ENERGY STAR Version 3.0 HD-capable STBs (scenario 2-A) is 9.3 GWh and 0.8 GWh per year, respectively (Figure 4-10).

Figure 4-10: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models, Upgrading to HD Where Applicable



Lifetime technical and achievable potential is 27.1 GWh and 2.4 GWh, respectively, when replacing with ENERGY STAR Version 3.0 STBs with HD capability (Table 4-8).

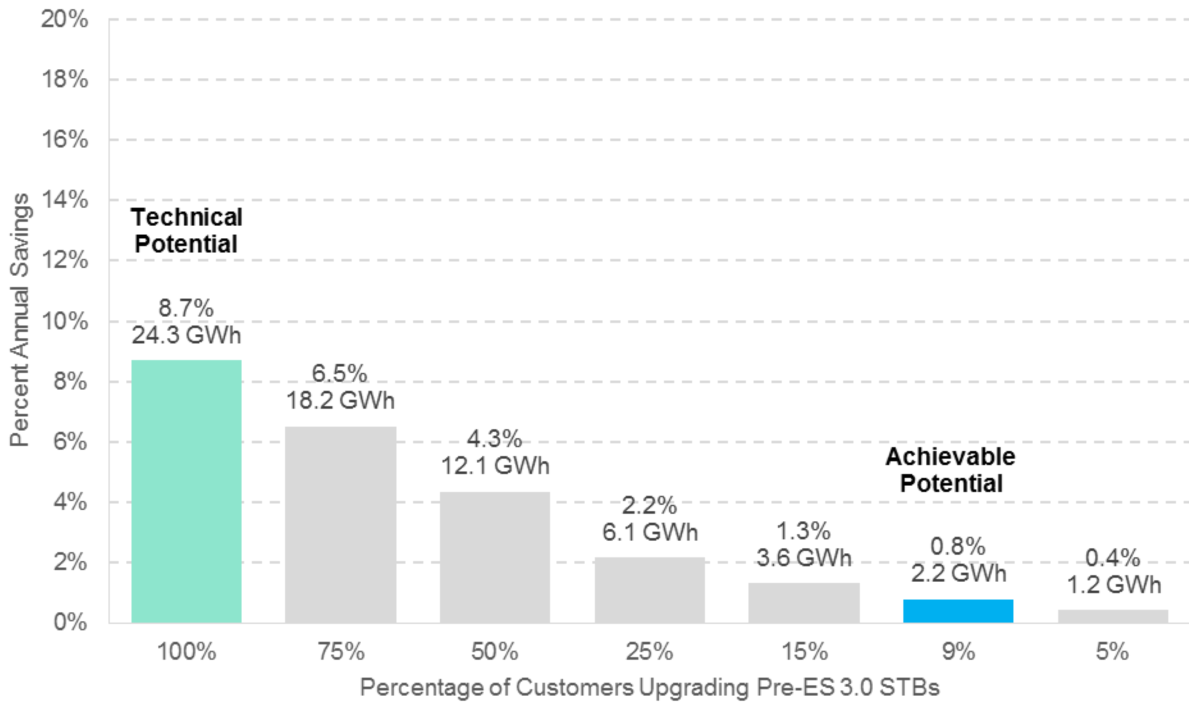
Table 4-8: Replacing Pre-ENERGY STAR 3.0 Models with 3.0 Models, Upgrading to HD Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	3.3%	27.1
75%	2.5%	20.3
50%	1.7%	13.6
25%	0.8%	6.8
15%	0.5%	4.1
9% (Achievable Potential)	0.3%	2.4
5%	0.2%	1.4

4.6.2. Replacing with ENERGY STAR 4.1 HD-Capable STB Models

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 STBs with ENERGY STAR Version 4.1 HD-capable STBs is 24.3 GWh and 2.2 GWh per year, respectively (Figure 4-11).

Figure 4-11: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models, Upgrading to HD Where Applicable



Lifetime technical and achievable potential is 70.8 GWh and 6.4 GWh, respectively, when replacing with ENERGY STAR Version 4.1 STBs with HD capability (Table 4-9).

Table 4-9: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models, Upgrading to HD Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	8.7%	70.8
75%	6.5%	53.1
50%	4.3%	35.4
25%	2.2%	17.7
15%	1.3%	10.6
9% (Achievable Potential)	0.8%	6.4
5%	0.4%	3.5

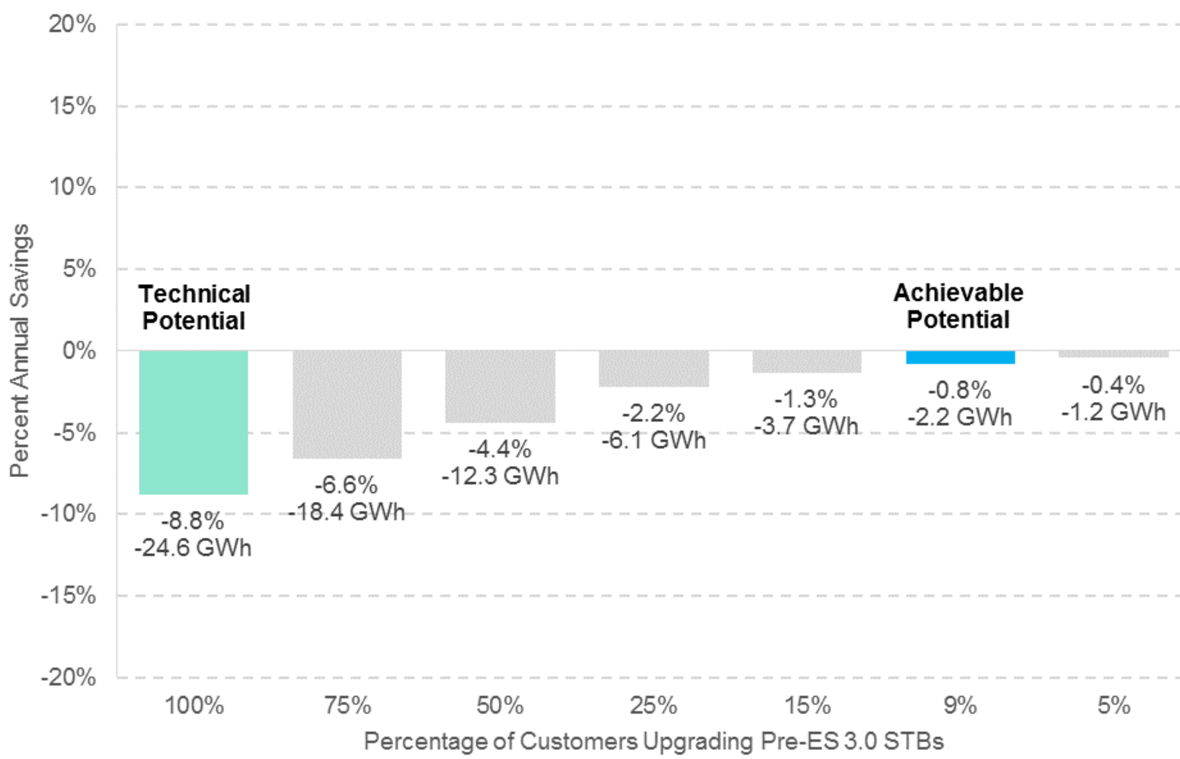
4.6.3. Sensitivity Analysis

4.6.3.1. Replacing with ENERGY STAR Version 3.0 STB HD Models

For this scenario where we assume 75% of customers would add one additional STB when upgrading equipment, we assumed the additional STB would have a kWh/year value that was the average kWh/year of ENERGY STAR Version 3.0 HD models.

This scenario resulted in an addition of up to 340,622 STBs to the installed base. This increase of STBs resulted in negative savings or technical and achievable potential of -24.6 GWh and -2.2 GWh per year, respectively (Figure 4-12).

Figure 4-12: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models and Addition of One STB, Upgrading to HD Where Applicable



The addition of one ENERGY STAR Version 3.0 HD STB by 75% of customers who upgraded their equipment similarly resulted in negative lifetime technical and achievable potential of -71.6 GWh and -6.4 GWh, respectively (Table 4-10).

Table 4-10: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models and Addition of One STB, Upgrading to HD Where Applicable

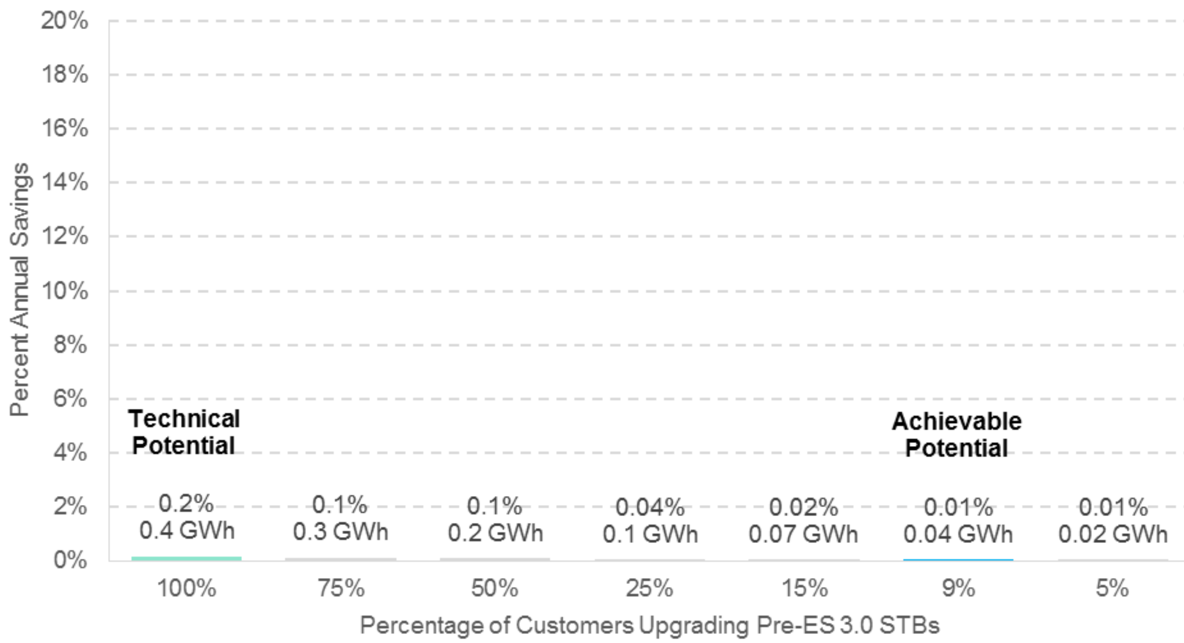
PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-8.8%	-71.6
75%	-6.6%	-53.7
50%	-4.4%	-35.8
25%	-2.2%	-17.9
15%	-1.3%	-10.7
9% (Achievable Potential)	-0.8%	-6.4
5%	-0.4%	-3.6

4.6.3.2. Replacing with ENERGY STAR Version 4.1 STB HD Models

For this scenario where we assume 75% of customers would add one additional STB when upgrading equipment, we assumed the additional STB would have a kWh/year value that was the average kWh/year of ENERGY STAR Version 4.1 HD models.

This scenario resulted in an addition of up to 340,622 STBs to the installed base. Unlike the previous scenario with Version 3.0, the Version 4.1 scenario of increased STBs generated positive savings compared to baseline, yet fewer savings than Scenario 2-B that does not increase total STBs. The technical and achievable potential are 0.4 GWh and 0.04 GWh per year, respectively (Figure 4-13).

Figure 4-13: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding One STB, Upgrading to HD Where Applicable



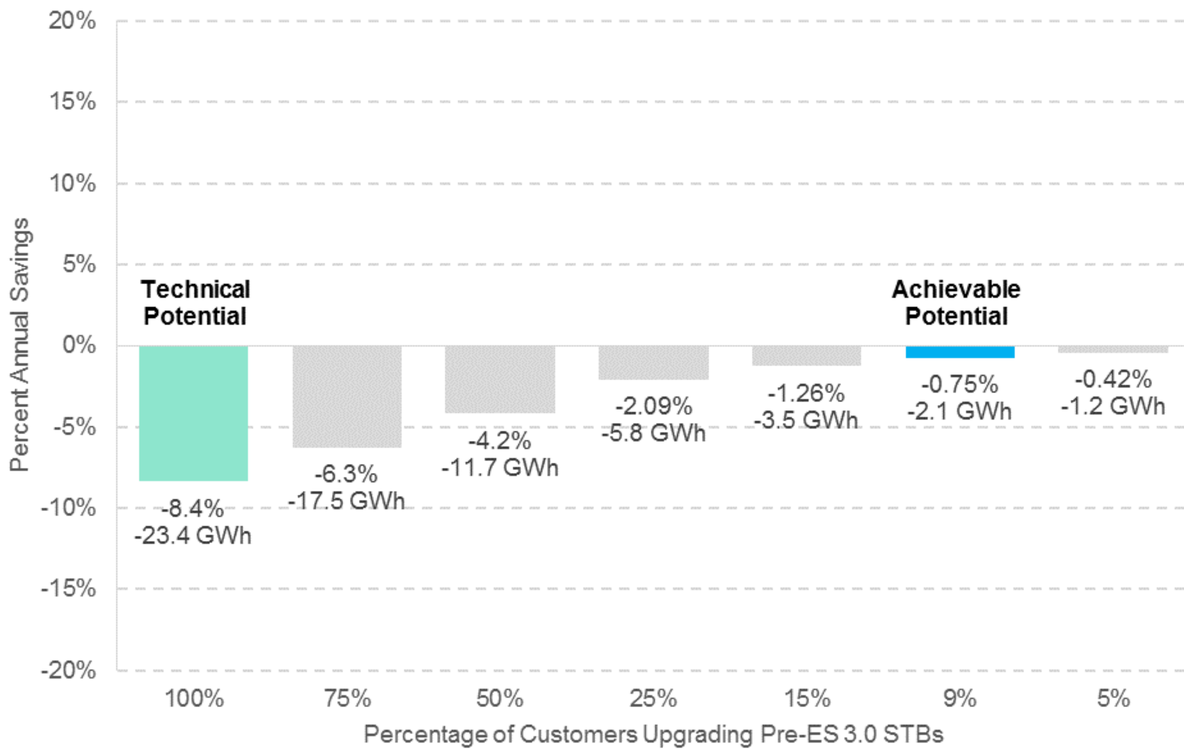
The addition of one ENERGY STAR Version 4.1 HD STB by 75% of customers who upgraded their equipment similarly reduced – compared to Scenario 2-B – lifetime technical and achievable potential to 1.3 GWh and 0.1 GWh, respectively (Table 4-11).

Table 4-11: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding One STB, Upgrading to HD Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	0.2%	1.3
75%	0.1%	1.0
50%	0.1%	0.7
25%	0.04%	0.3
15%	0.02%	0.2
9% (Achievable Potential)	0.01%	0.1
5%	0.01%	0.06

Since the addition of one ENERGY STAR Version 4.1 HD STB did not result in negative savings potential, we estimated the impact on energy savings potential by adding two ENERGY STAR Version 4.1 HD STBs to 75% of the customers who upgraded their equipment. This scenario resulted in the addition of up to 681,245 STBs to the installed base. This increase of STBs resulted in negative savings or technical and achievable potential of -23.4 GWh and -2.1 GWh per year, respectively (Figure 4-14).

Figure 4-14: Replacing Pre-ENERGY STAR 3.0 Models with 4.1 Models and Adding Two STBs, Upgrading to HD Where Applicable



The addition of two ENERGY STAR Version 4.1 HD STBs by 75% of customers who upgraded their equipment similarly resulted in negative lifetime technical and achievable potential of -68.2 GWh and -6.1 GWh, respectively (Table 4-12).

Table 4-12: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding Two STBs, Upgrading to HD Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-8.4%	-68.2
75%	-6.3%	-51.2
50%	-4.2%	-34.1
25%	-2.1%	-17.1
15%	-1.3%	-10.2
9% (Achievable Potential)	-0.8%	-6.1
5%	-0.4%	-3.4

4.7. Scenario 3 – Upgrading to STBs with the Most Features

This section presents technical and achievable energy savings potential of replacing pre-ENERGY STAR Version 3.0 STBs with the ENERGY STAR Version 3.0 or 4.1 STBs by assuming that models without HD DVR capabilities are replaced with HD DVR-capable models. These scenarios resulted in the replacement of 38% of all STBs in the installed base.

We developed these Version 3.0 and Version 4.1 replacement scenarios because HD and DVR STB features appear to be penetrating the market (see Chapter 3 for more details on this trend). Additionally, HD DVR features are the maximum features one can have. Table 4-13 describes which pre-ENERGY STAR Version 3.0 models we replaced and which ENERGY STAR Version 3.0 and 4.1 models we used for replacement.

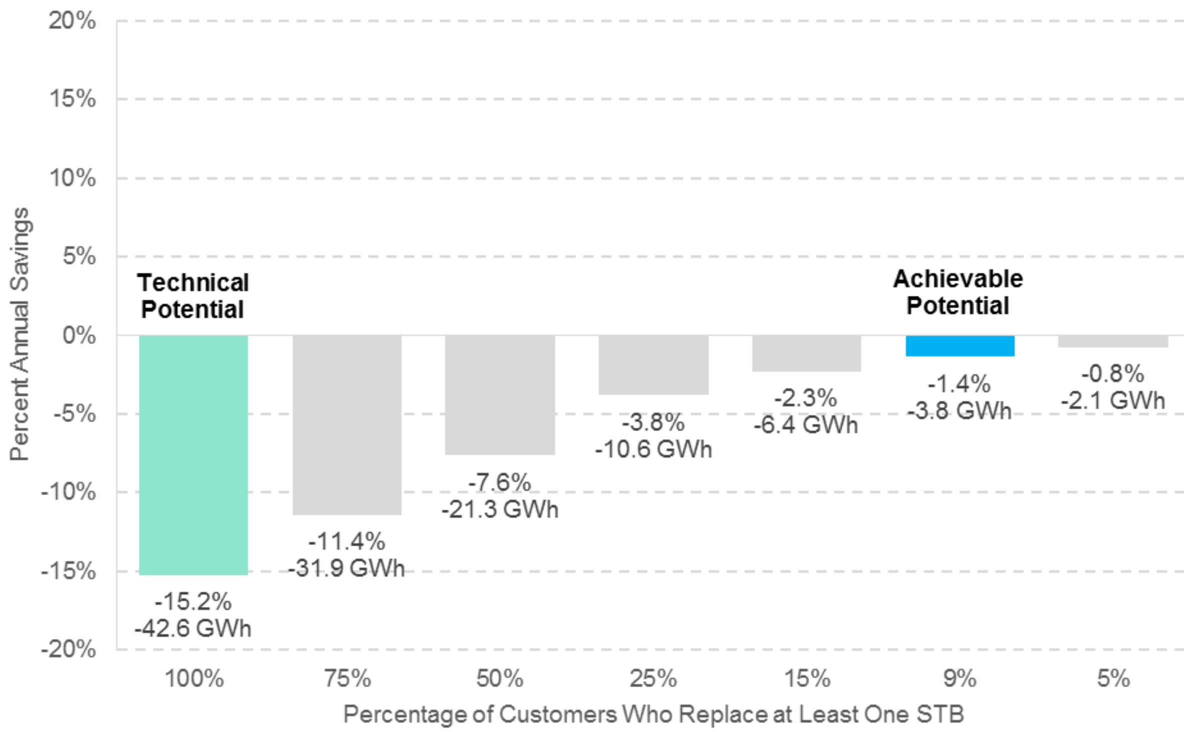
Table 4-13: Original Pre-ENERGY STAR Version 3.0 Models and HD DVR Replacement Models

ORIGINAL STB	REPLACEMENT STB
Pre-ES 3.0 Basic SD	ES 3.0 or ES 4.1 HD DVR
Pre-ES 3.0 HD	ES 3.0 or ES 4.1 HD DVR
Pre-ES 3.0 DVR	ES 3.0 or ES 4.1 HD DVR
Pre-ES 3.0 HD DVR	ES 3.0 or ES 4.1 HD DVR
Pre-ES 3.0 Server	ES 4.1 Server

4.7.1. Replacing with ENERGY STAR 3.0 HD DVR Capable STB Models

The replacement of pre-ENERGY STAR Version 3.0 STBs with ENERGY STAR Version 3.0 HD DVR-capable STBs resulted in negative savings. Technical and achievable energy savings potential of this scenario is -42.6 GWh and -3.8 GWh per year, respectively (Figure 4-15).

Figure 4-15: Replacing Pre-ENERGY STAR Version 3.0 Models with 3.0 Models, Upgrading to HD DVR Where Applicable



Lifetime technical and achievable potential is -124.2 GWh and -11.2 GWh, respectively, when replacing with ENERGY STAR Version 3.0 STBs with HD DVR capability (Table 4-14).

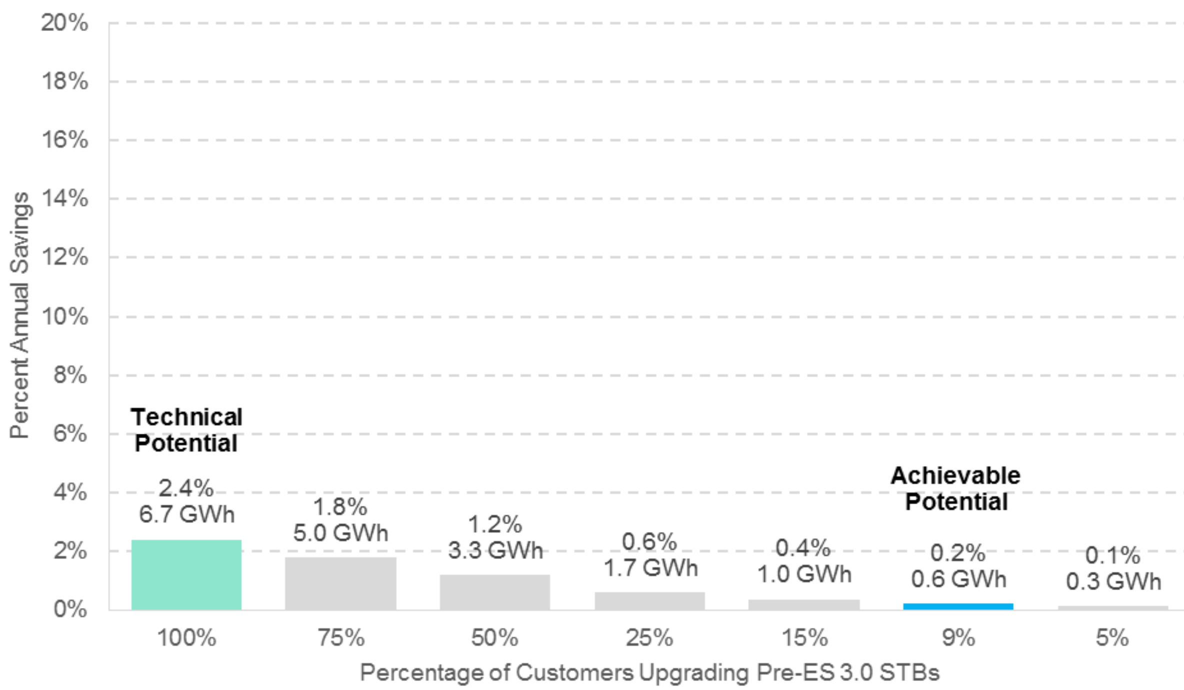
Table 4-14: Replacing Pre-ENERGY STAR 3.0 Models with 3.0 Models, Upgrading to HD DVR Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-15.2%	-124.2
75%	-11.4%	-93.1
50%	-7.6%	-62.1
25%	-3.8%	-31.0
15%	-2.3%	-18.6
9% (Achievable Potential)	-1.4%	-11.2
5%	-0.8%	-6.2

4.7.2. Replacing with ENERGY STAR Version 4.1 HD DVR Capable STB Models

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 STBs with ENERGY STAR Version 4.1 HD DVR-capable STBs is 6.7 GWh and 0.6 GWh per year, respectively (Figure 4-16).

Figure 4-16: Replacing Pre-ENERGY STAR 3.0 Version Models with 4.1 Models, Upgrading to HD DVR Where Applicable



Lifetime technical and achievable potential is 19.5 GWh and 1.8 GWh, respectively, when replacing with ENERGY STAR Version 4.1 STBs with HD DVR capability (Table 4-15).

Table 4-15: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models, Upgrading to HD DVR Where Applicable

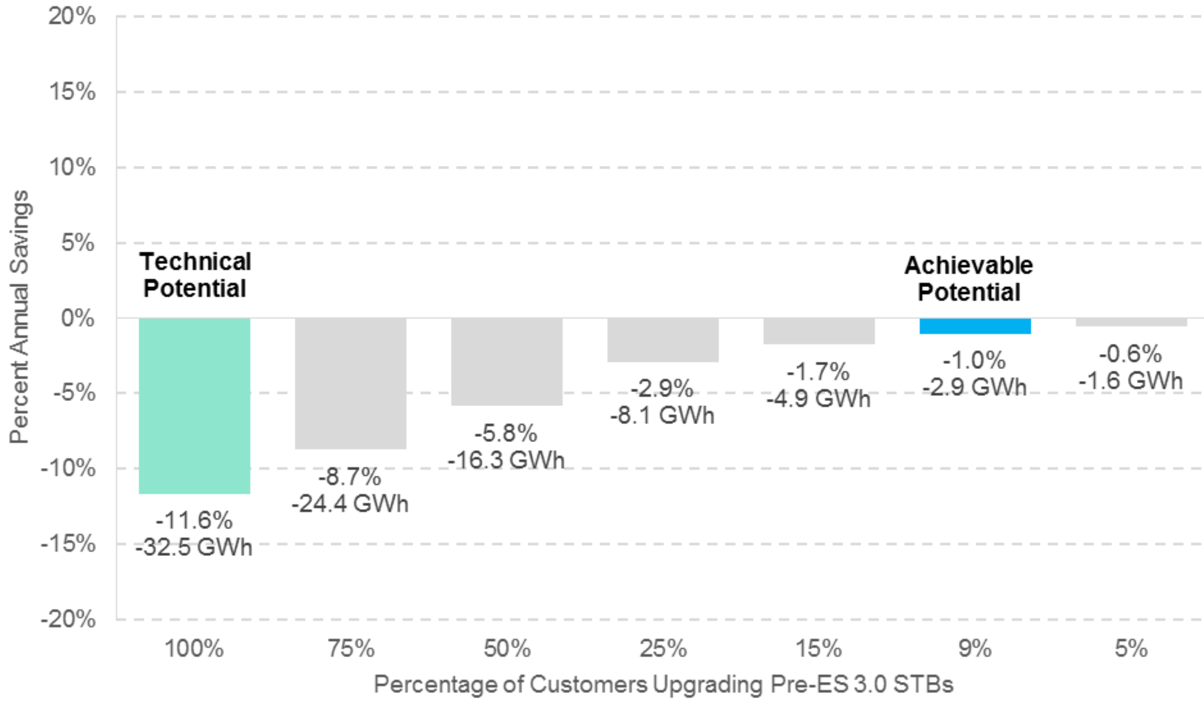
PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	2.4%	19.5
75%	1.8%	14.6
50%	1.2%	9.7
25%	0.6%	4.9
15%	0.4%	2.9
9% (Achievable Potential)	0.2%	1.8
5%	0.1%	1.0

4.7.3. Sensitivity Analysis

Because a replacement scenario involving ENERGY STAR Version 3.0 HD DVR units resulted in negative energy savings (see Section 4.7.1), we only conducted sensitivity analysis for the replacement scenario involving ENERGY STAR Version 4.1 HD DVR units. For this scenario where we assume 75% of customers would add one additional STB when upgrading equipment, we assumed the additional STB would have a kWh/year value that was the average kWh/year of ENERGY STAR Version 4.1 HD DVR models

This scenario resulted in an addition of up to 340,622 STBs to the installed base. This increase of STBs resulted in negative savings or technical and achievable potential of -32.5 GWh and -2.9 GWh per year, respectively (Figure 4-17).

Figure 4-17: Replacing Pre-ENERGY STAR 3.0 Models with 4.1 Models and Adding One STB, Upgrading to HD DVR Where Applicable



The addition of one ENERGY STAR Version 4.1 HD DVR STB by 75% of customers who upgraded their equipment similarly resulted in negative lifetime technical and achievable potential of -94.8 GWh and -8.5 GWh, respectively (Table 4-16).

Table 4-16: Replacing Pre-ENERGY STAR Version 3.0 Models with 4.1 Models and Adding One STB, Upgrading to HD DVR Where Applicable

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% (Technical Potential)	-11.6%	-94.8
75%	-8.7%	-71.1
50%	-5.8%	-47.4
25%	-2.9%	-23.7
15%	-1.7%	-14.2
9% (Achievable Potential)	-1.0%	-8.5
5%	-0.6%	-4.7

4.8. Scenario 4– Replacing with Multi-room Configuration System

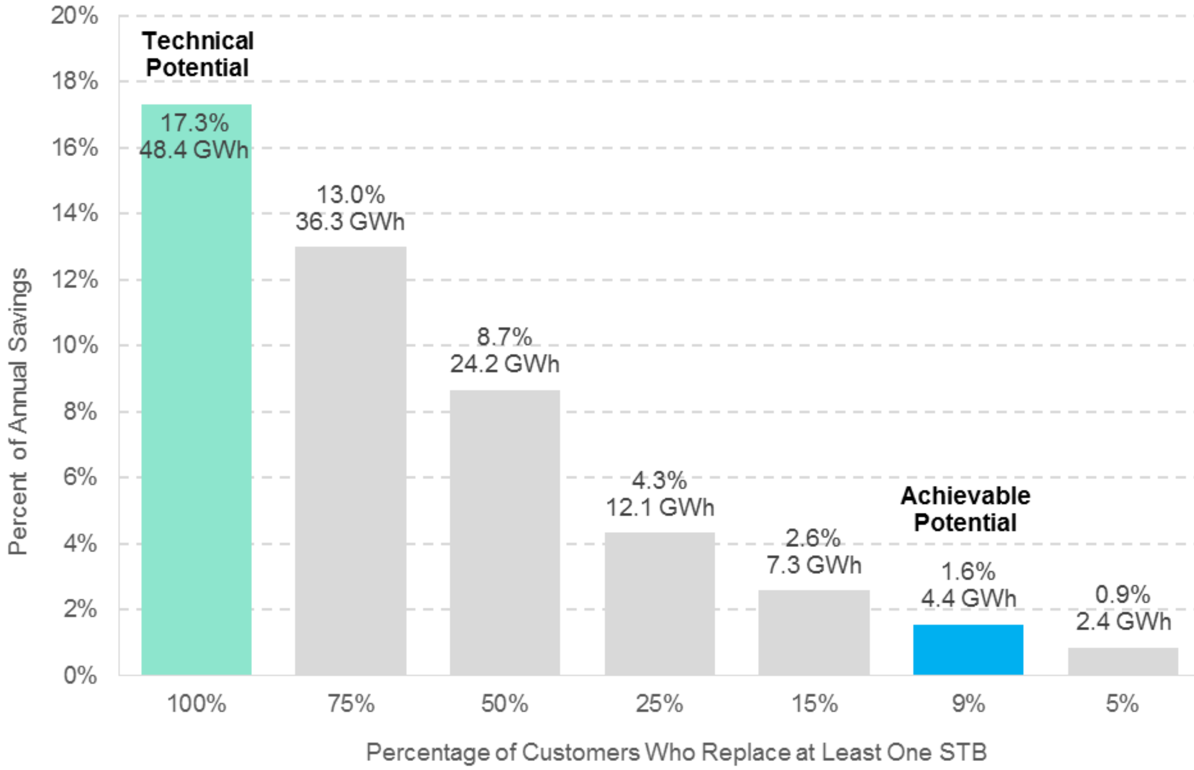
4.8.1. Replacing With Server and Thin Client Systems

This section presents technical and achievable energy savings potential of replacing pre-ENERGY STAR Version 3.0 STBs with a server and thin client system (this technology is ENERGY STAR Version 4.1 certified). We assume customers with pre-ENERGY STAR Version 3.0 stand-alone STBs will replace one STB with a server and all remaining STBs with thin clients. If the customer already had a server, then we only replaced the customer’s pre-ENERGY STAR 3.0 box(es) with thin clients, up to the number of boxes currently installed. If the server was pre-ENERGY STAR Version 3.0, we replaced that server with a 4.1 model. When there were more than eight STBs in a home identified for replacement, we replaced two of them with servers and all remaining STBs with thin clients because a server only communicates with up to eight thin clients.

We developed this scenario (4-A) because this technology is one of the most efficient technologies among the technologies we explored in this study. This scenario resulted in the replacement of 38% of all boxes in the installed base.

Technical and achievable energy savings potential when replacing existing pre-ENERGY STAR Version 3.0 STBs with a server and thin client system is 48.4 GWh and 4.4 GWh per year, respectively (Figure 4-18).

Figure 4-18: Replacement of Existing Pre-ENERGY STAR Version 3.0 STBs with Servers and Thin Clients



Lifetime technical and achievable potential is 141.2 GWh and 12.7 GWh, respectively, when replacing pre-ENERGY STAR Version 3.0 STBs with a server and thin client system (Table 4-17).

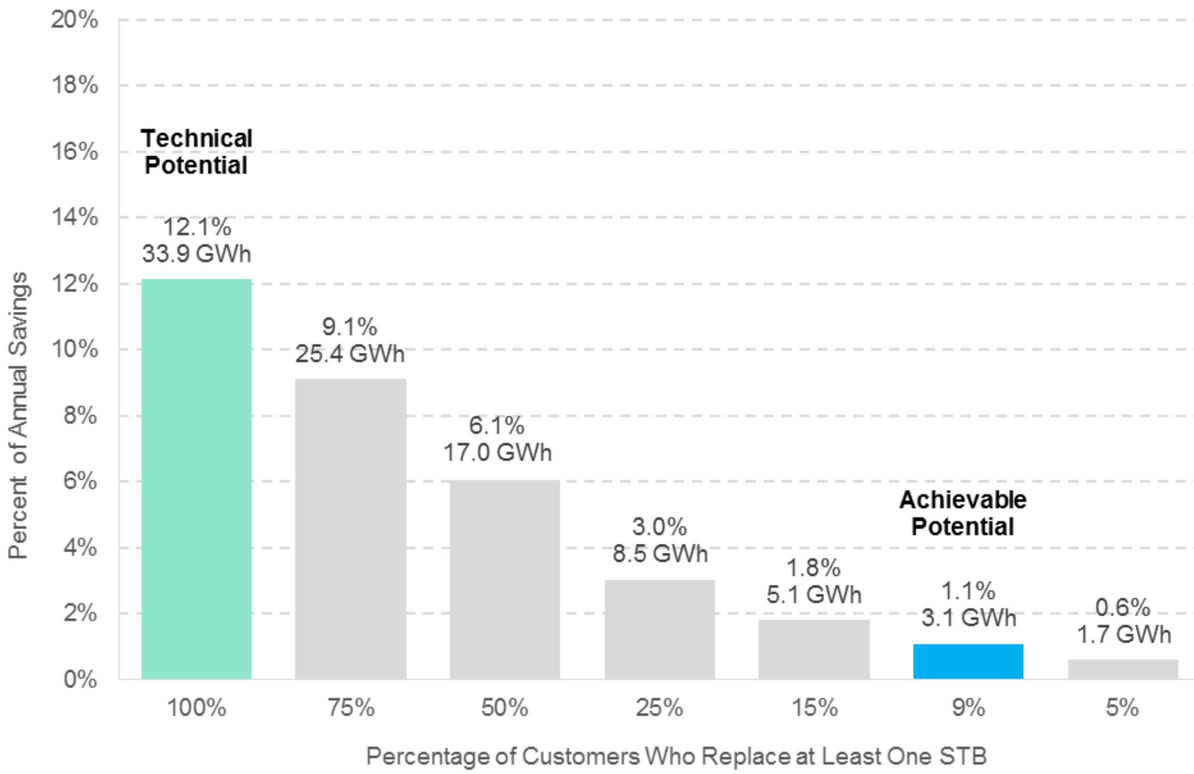
Table 4-17: Replacing Pre-ENERGY STAR Version 3.0 Models with Servers and Thin Clients

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	17.3%	141.2
75%	13.0%	105.9
50%	8.7%	70.6
25%	4.3%	35.3
15%	2.6%	21.2
9% - Achievable Potential	1.6%	12.7
5%	0.9%	7.1

4.8.1.1. Sensitivity Analysis for Scenario 4-A

The addition of one thin client by 75% of those that upgraded equipment resulted in positive but reduced – compared to scenario 4-A – technical and achievable potential of 33.9 GWh and 3.1 GWh per year, respectively (Figure 4-19). Scenario 4-A does not increase total number of units.

Figure 4-19: Replacement of Existing Pre-ENERGY STAR Version 3.0 STBs with Servers and Thin Clients and Adding One Thin Client



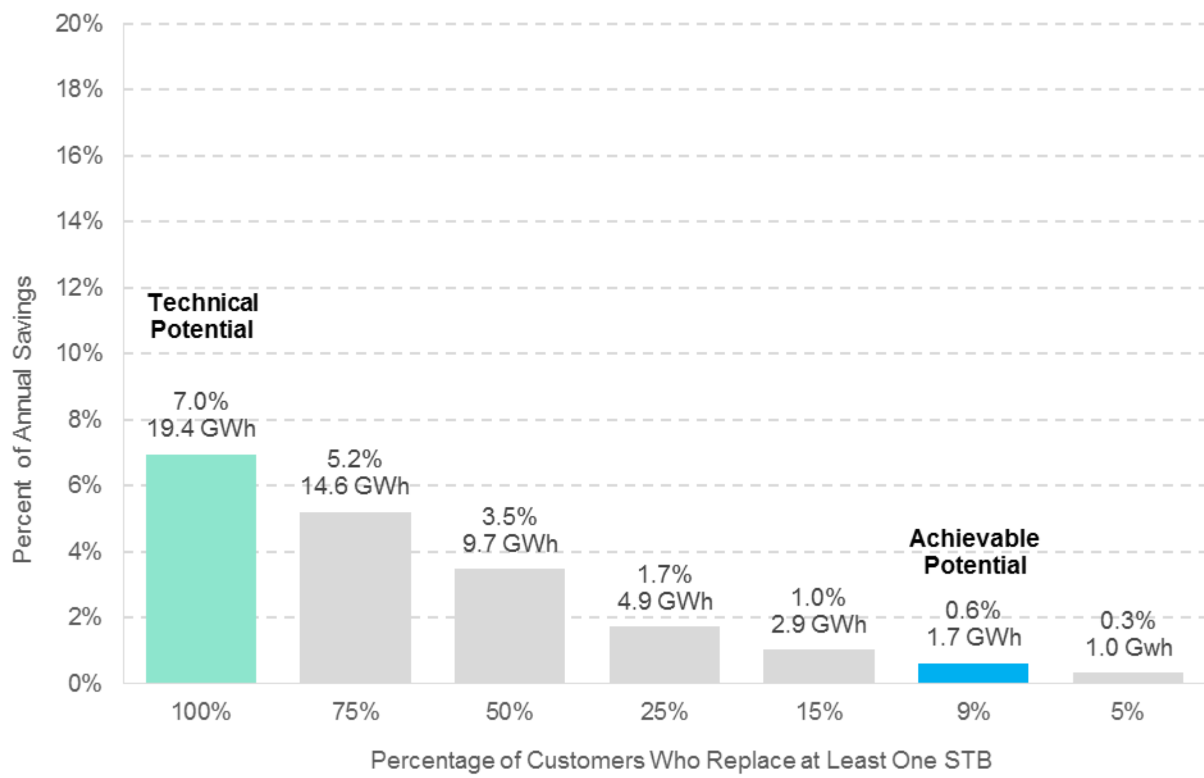
The addition of one thin client by 75% of those that upgraded equipment similarly resulted in positive but reduced – compared to scenario 4-A – lifetime technical and achievable potential of 98.9 GWh and 8.9 GWh, respectively (Table 4-18).

Table 4-18: Replacement of Existing Pre-ENERGY STAR Version 3.0 STBs with Servers and Thin Clients and Adding One Thin Client

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	12.1%	98.9
75%	9.1%	74.2
50%	6.1%	49.5
25%	3.0%	24.7
15%	1.8%	14.8
9% - Achievable Potential	1.1%	8.9
5%	0.6%	4.9

The addition of two thin clients by 75% of those that upgraded equipment further reduced technical and achievable energy savings potential to 19.4 GWh and 1.7 GWh per year, respectively (Figure 4-20). The annual savings remained positive after the addition of two thin clients.

Figure 4-20: Replacement of Existing Pre-ENERGY STAR Version 3.0 STBs with Servers and Thin Clients and Adding Two Thin Clients



The addition of two thin clients by 75% of those that upgraded equipment similarly further reduced lifetime technical and achievable energy savings potential to 56.7 GWh and 5.1 GWh, respectively (Table 4-19). The lifetime savings remained positive after the addition of two thin clients.

Table 4-19: Replacement of Existing Pre-ENERGY STAR Version 3.0 STBs with Servers and Thin Clients and Adding Two Thin Clients

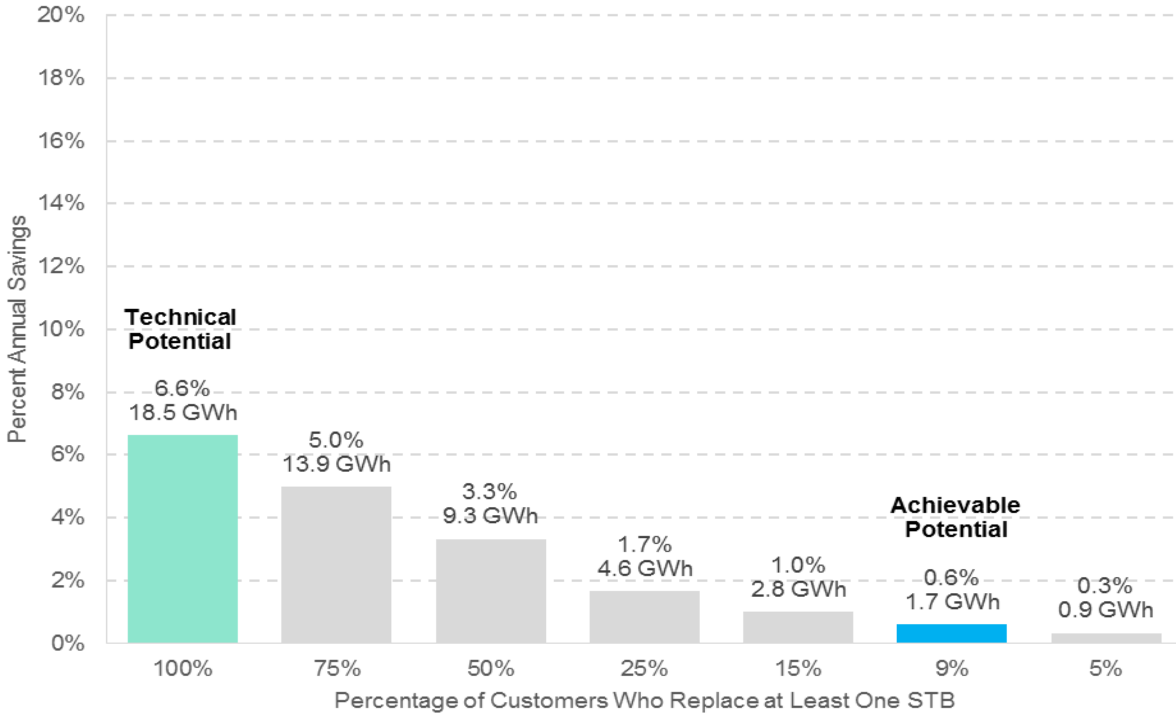
PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	7.0%	56.7
75%	5.2%	42.5
50%	3.5%	28.3
25%	1.7%	14.2
15%	1.0%	8.5
9% - Achievable Potential	0.6%	5.1
5%	0.3%	2.8

4.8.2. Replacing With Thin Clients If Customers Had an Existing Server

We also estimated technical and achievable energy savings potential of replacing pre-ENERGY STAR Version 3.0 and Version 3.0 STBs with thin clients for only those customers with an existing server. This could be an easy energy savings opportunity for a program incentivizing STB upgrades. This scenario (4-B) resulted in the replacement of 7% of all boxes in the installed base.

Technical and achievable energy savings potential when replacing pre-ENERGY STAR Version 3.0 and Version 3.0 STBs with thin clients for only those customers with an existing server is 18.5 GWh and 1.7 GWh per year, respectively (Figure 4-21).

Figure 4-21: Replacement of Existing STBs with Thin Clients (Those That Had Existing Servers)



Lifetime technical and achievable potential is 54.0 GWh and 4.9 GWh, respectively, when replacing pre-ENERGY STAR Version 3.0 and Version 3.0 STBs with thin clients of only those customers with an existing server (Table 4-20).

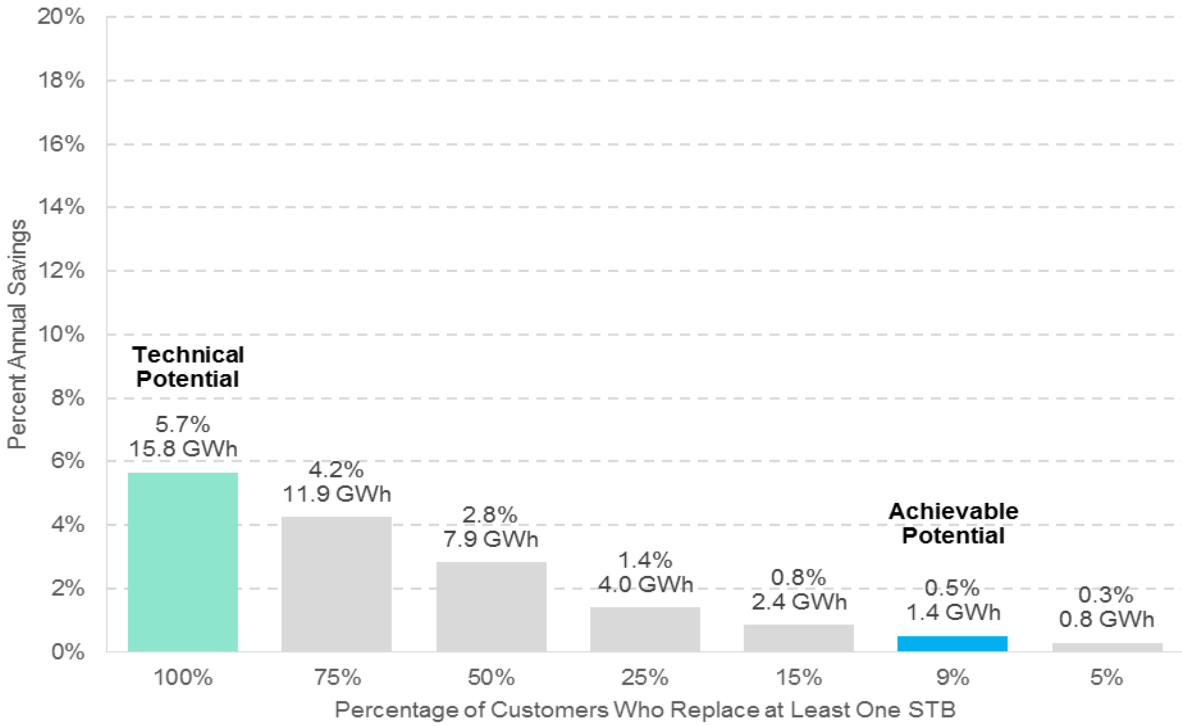
Table 4-20: Replacement of Existing STBs with Thin Clients (Those That Had Existing Servers)

PERCENT OF CUSTOMERS REPLACING EXISTING STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	6.6%	54.0
75%	5.0%	40.5
50%	3.3%	27.0
25%	1.7%	13.5
15%	1.0%	8.1
9% - Achievable Potential	0.6%	4.9
5%	0.3%	2.7

4.8.2.1. Sensitivity Analysis for Scenario 4-B

The addition of one thin client by 75% of those that already had a server resulted in positive but reduced – compared to scenario 4-B – technical and achievable potential of 15.8 GWh and 1.4 GWh per year, respectively (Figure 4-22).

Figure 4-22: Replacement of Existing STBs with Thin Clients and Adding One Thin Client (Those That Had Existing Servers)



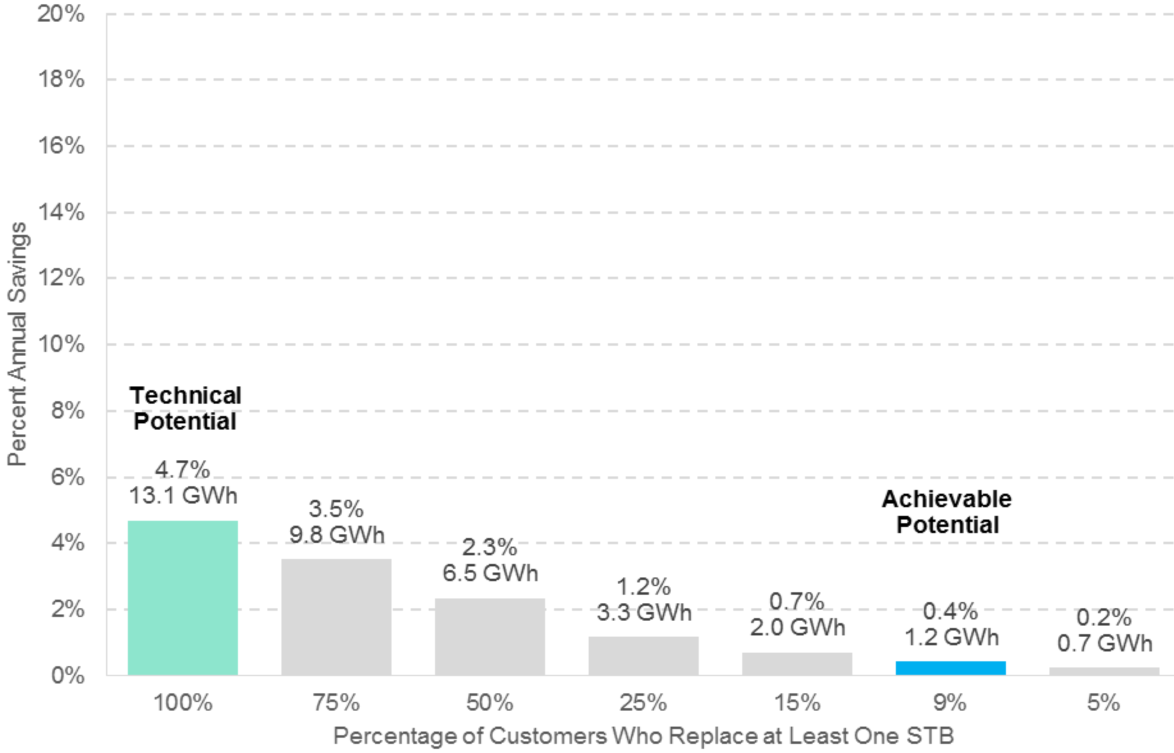
The addition of one thin client by 75% of those that already had a server similarly resulted in positive but reduced – compared to scenario 4-B – lifetime technical and achievable potential of 46.1 GWh and 4.1 GWh, respectively (Table 4-21).

Table 4-21: Replacement of Existing STBs with Thin Clients and Adding One Thin Client (Those That Had Existing Servers)

PERCENT OF CUSTOMERS REPLACING EXISTING STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	5.7%	46.1
75%	4.2%	34.6
50%	2.8%	23.0
25%	1.4%	11.5
15%	0.8%	6.9
9% - Achievable Potential	0.5%	4.1
5%	0.3%	2.3

The addition of two thin clients by 75% of those that already had a server further reduced technical and achievable energy savings potential to 13.1 GWh and 1.2 GWh per year, respectively (Figure 4-23).

Figure 4-23: Replacement of Existing STBs with Thin Clients and Adding Two Thin Clients (Those That Had Existing Servers)



The addition of two thin clients by 75% of those that already had a server further reduced lifetime technical and achievable energy savings potential to 38.1 GWh and 3.4 GWh, respectively (Table 4-22).

Table 4-22: Replacement of Existing STBs with Thin Clients and Adding Two Thin Clients (Those That Had Existing Servers)

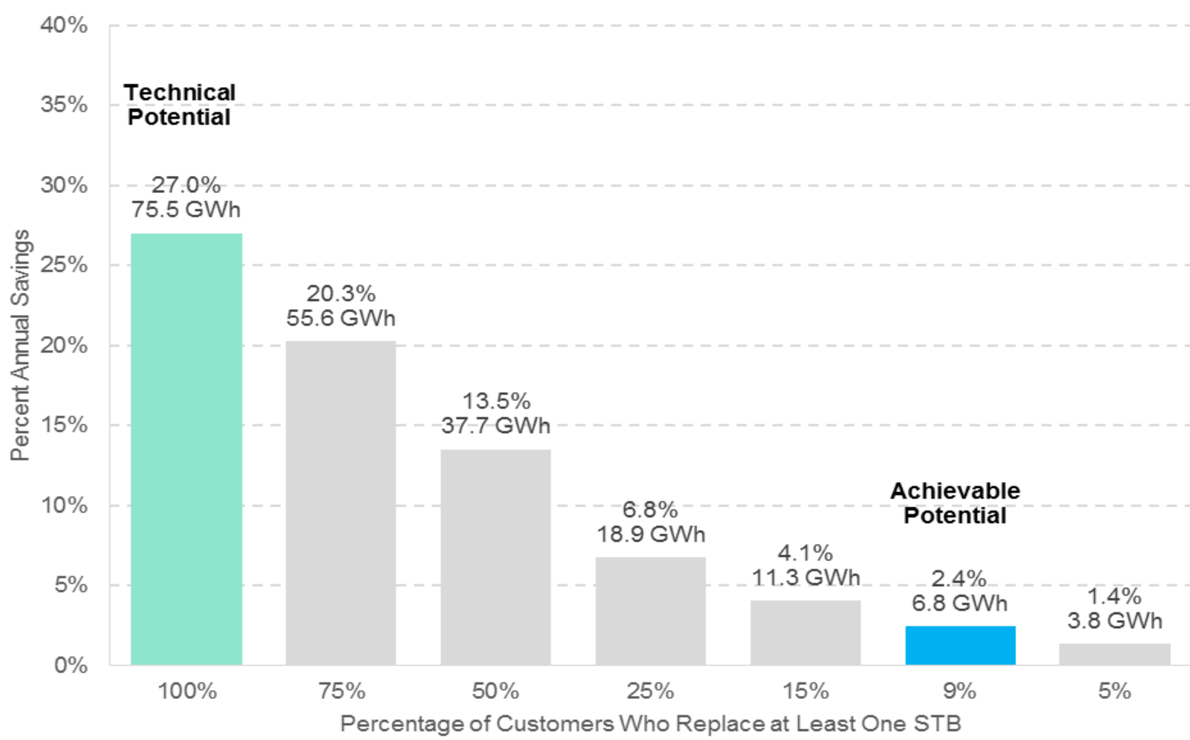
PERCENT OF CUSTOMERS REPLACING EXISTING STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	4.7%	38.1
75%	3.5%	28.6
50%	2.3%	19.1
25%	1.2%	9.5
15%	0.7%	5.7
9% - Achievable Potential	0.4%	3.4
5%	0.2%	1.9

4.8.3. Replacing With Server and Thin Clients If Customers Had STBs With Advanced Features

To maximize the energy savings potential of replacing stand-alone STBs with server and thin client system, we estimated technical and achievable energy savings potential of replacing HD, DVR, and HD DVR stand-alone STBs, regardless of their ENERGY STAR designation, with ENERGY STAR Version 4.1 server and thin client systems. For this scenario, we only included those customers with multiple STBs (between two and five STBs); these customers had to have at least one HD, DVR, or HD DVR box for us to replace all their boxes with the server and thin client system. If the customer had an existing ENERGY STAR Version 3.0 server (also which meets ENERGY STAR Version 4.1 specifications), then we only replaced the customer's stand-alone STBs with thin clients, up to the number of boxes currently installed. If the server was pre-ENERGY STAR Version 3.0, we replaced that server with an ENERGY STAR Version 4.1 model. This scenario (4-C) resulted in the replacement of 49% of all boxes in the installed base.

Technical and achievable energy savings potential when replacing HD, DVR, or HD DVR STBs with server and thin client systems is 75.5 GWh and 6.8 GWh per year, respectively (Figure 4-24).

Figure 4-24: Replacement of Existing HD, DVR, or HD DVR STBs with Servers and Thin Clients



Lifetime technical and achievable potential is 220.1 GWh and 19.8 GWh, respectively, when replacing HD, DVR, or HD DVR STBs with a server and thin client system (Table 4-17).

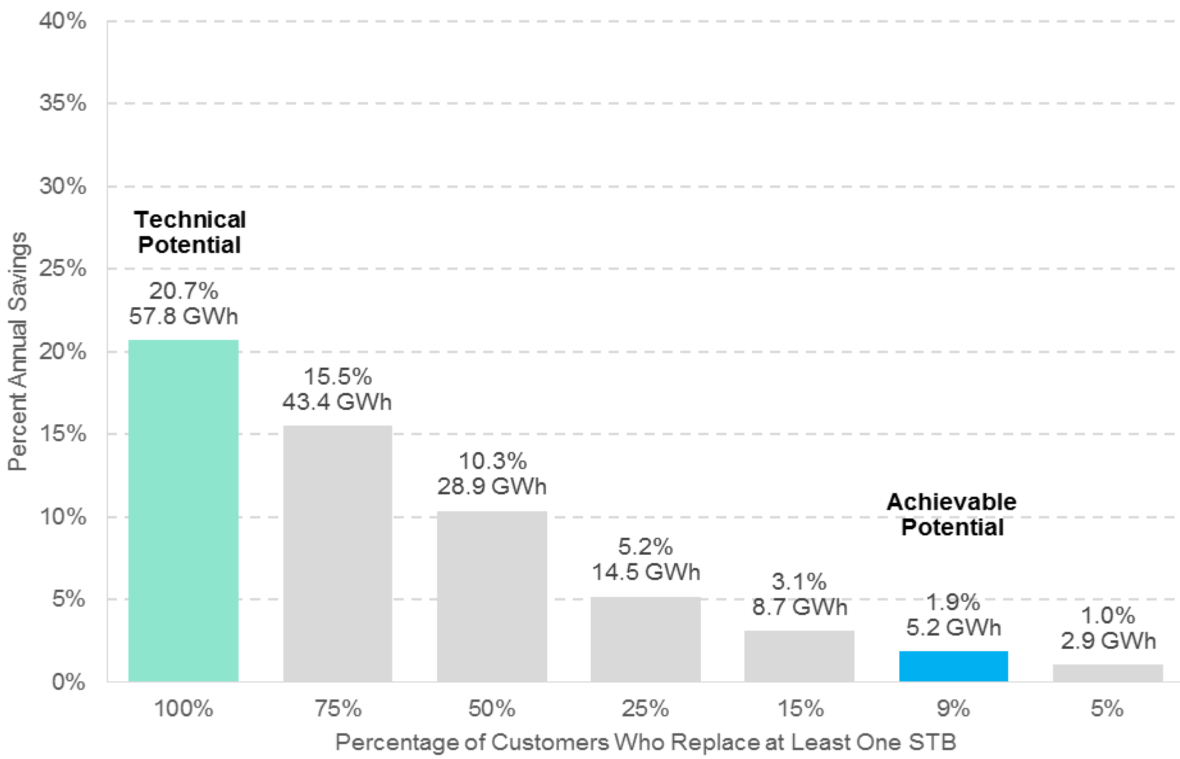
Table 4-23: Replacing HD, DVR, or HD DVR STBs with Servers and Thin Clients

PERCENT OF CUSTOMERS REPLACING PRE-ES 3.0 STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	27.0%	220.1
75%	20.3%	165.1
50%	13.5%	110.0
25%	6.8%	55.0
15%	4.1%	33.0
9% - Achievable Potential	2.4%	19.8
5%	1.4%	11.0

4.8.3.1. Sensitivity Analysis for Scenario 4-C

The addition of one thin client by 75% of those that upgraded equipment resulted in positive but reduced – compared to scenario 4-C – technical and achievable potential of 57.8 GWh and 5.2 GWh per year, respectively (Figure 4-19).

Figure 4-25: Replacement of Existing HD, DVR, or HD DVR STBs with Servers and Thin Clients and Adding One Thin Client



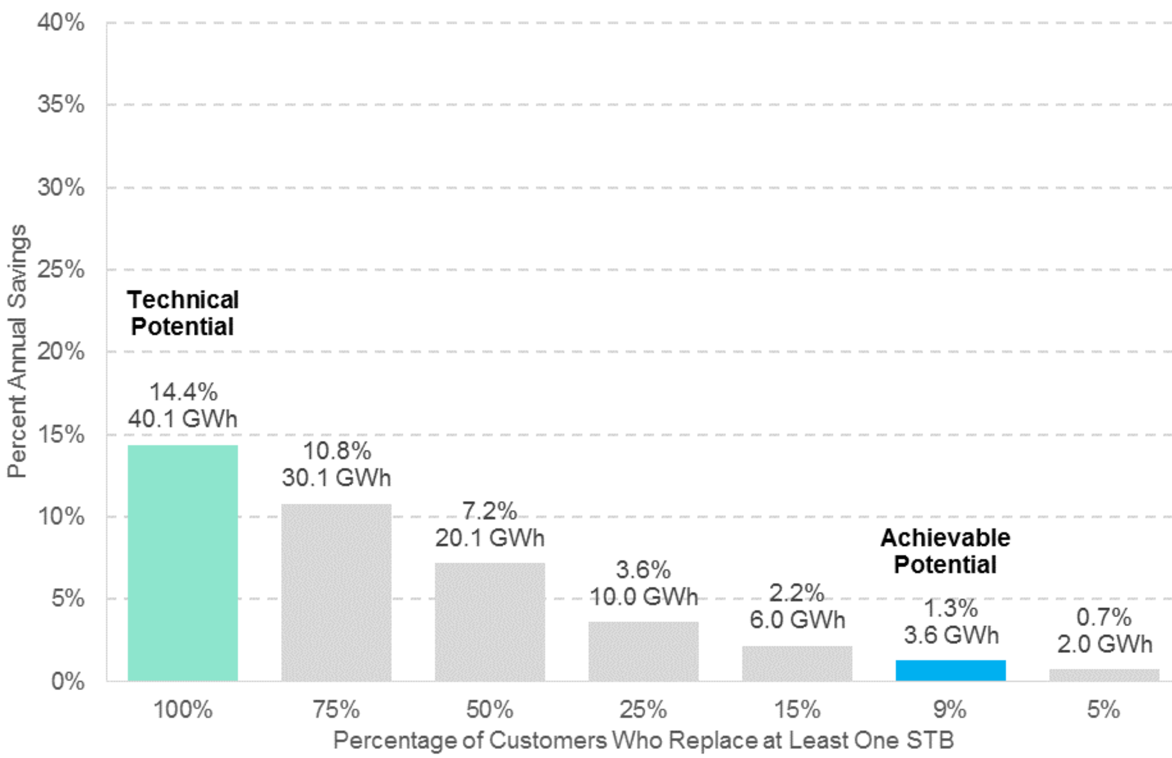
The addition of one thin client by 75% of those that had existing HD, DVR, or HD DVR STBs similarly resulted in positive but reduced – compared to scenario 4-C – lifetime technical and achievable potential of 168.6 GWh and 15.2 GWh, respectively (Table 4-21).

Table 4-24: Replacement of Existing HD, DVR, or HD DVR STBs with Thin Clients and Adding One Thin Client

PERCENT OF CUSTOMERS REPLACING EXISTING STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	20.7%	168.6
75%	15.5%	126.4
50%	10.3%	84.3
25%	5.2%	42.1
15%	3.1%	25.3
9% - Achievable Potential	1.9%	15.2
5%	1.0%	8.4

The addition of two thin clients by 75% of those that had existing HD, DVR, or HD DVR STBs further reduced technical and achievable energy savings potential to 40.1 GWh and 3.6 GWh per year, respectively (Figure 4-23).

Figure 4-26: Replacement of Existing HD, DVR, or HD DVR STBs with Servers and Thin Clients and Adding Two Thin Clients



The addition of two thin clients by 75% of those that had existing HD, DVR, or HD DVR STBs further reduced lifetime technical and achievable energy savings potential to 117.1 GWh and 10.5 GWh, respectively (Table 4-22).

Table 4-25: Replacement of Existing STBs with Thin Clients and Adding Two Thin Clients (Those That Had Existing Servers)

PERCENT OF CUSTOMERS REPLACING EXISTING STBS	PERCENT SAVINGS OVER THE BASELINE	TOTAL GWH SAVED (LIFETIME)
100% - Technical Potential	14.4%	117.1
75%	10.8%	87.8
50%	7.2%	58.5
25%	3.6%	29.3
15%	2.2%	17.6
9% - Achievable Potential	1.3%	10.5
5%	0.7%	5.9

4.9. Ranking of STB Replacement Scenarios

Table 4-26 provides a summary of the nine replacement scenarios described in the prior sections ranked by potential energy savings (ranking of “1” denotes the scenario with the best energy savings opportunity and ranking of “9” denotes the scenario with the least energy savings opportunity). We based the rankings on both the potential savings estimates and whether the scenario could be implemented in the marketplace given the most recent market trends noted in Chapter 3.

Scenarios replacing existing STBs with the server and thin client system were ranked as the most promising scenarios. The scenario that replaces existing STBs with specific features (HD, DVR, or HD DVR) with ENERGY STAR Version 4.1 server and thin clients systems (Scenario 4-C) provides the largest achievable energy savings potential, at 6.8 GWh per year and 19.8 GWh per the life of the equipment. The scenario that replaces existing pre-ENERGY STAR 3.0 STBs, regardless of their features, with ENERGY STAR Version 4.1 server and thin client systems (Scenario 4-A) was ranked as the second most promising energy savings opportunity, with achievable energy savings potential at 4.4 GWh per year and 12.7 GWh per the life of the equipment.

Scenarios 1-A and 1-B, which replace existing pre-ENERGY STAR Version 3.0 models with an energy-efficient but comparable models, were ranked as less opportunistic scenarios in Table 4-26. It is especially difficult to replace SD STB equipment with comparable equipment. The STB technology is evolving from basic SD STBs to STBs with more advanced features. Across service provider types, 99% of the STBs procured in 2013 were HD (see Chapter 3 for more details on this trend), indicating that the ability to deliver HD content is becoming a standard feature in STBs. Additionally, HD together with DVR feature appear to be penetrating the market (see Chapter 3 for more details on this trend). Thereby, scenarios modelling a replacement of existing stand-alone STBs with comparable but energy-efficient models, while assuming customers will not add features (our scenarios 1-A through 1-B), are no longer realistic scenarios to consider for an early replacement STB program.

Table 4-26: Technical Potential of Each Scenario, Ranked by Potential Energy Savings

REPLACEMENT SCENARIO	TECHNICAL POTENTIAL		ACHIEVABLE POTENTIAL		RANK ORDER (By Potential Savings)
	Percent Savings Over Baseline	**Annual GWH Savings** (Lifetime GWh Savings)	**Percent Savings Over Baseline**	**Annual GWH Savings** (Lifetime GWh Savings)	
Scenario 4-C: Replace HD, DVR, or HD DVR with 4.1 Server/Thin client system (HD DVR capability)	27.0%	**75.5** (220.1)	2.4%	**6.8** (19.8)	1
Scenario 4-A: Replace pre-ES 3.0 models with 4.1 Server/Thin client system	17.3%	**48.4** (141.2)	1.6%	**4.4** (12.7)	2
Scenario 2-B: Replace pre-ES 3.0 models with 4.1 STBs with HD capability	8.7%	**24.3** (70.8)	0.8%	**2.2** (6.4)	3
Scenario 4-B: Replace pre-ES 3.0 models with 4.1 Thin client(s) if customer already had a server	6.6%	**18.5** (54.0)	0.6%	**1.7** (4.9)	4
Scenario 2-A: Replace pre-ES 3.0 models with 3.0 STBs with HD capability	3.3%	**9.3** (27.1)	0.3%	**0.8** (2.4)	5
Scenario 3-B: Replace pre-ES 3.0 models with 4.1 STBs with HD DVR capability	2.4%	**6.7** (19.5)	0.2%	**0.6** (1.8)	6
Scenario 1-B: Replace pre-ES 3.0 models with 4.1 STBs, like-with-like replacement	19.0%	**53.1** (154.7)	1.7%	**4.8** (13.9)	7
Scenario 1-A: Replace pre-ES 3.0 models with 3.0 STBs, like-with-like replacement	8.5%	**23.9** (69.6)	0.8%	**2.2** (6.3)	8
Scenario 3-A: Replace pre-ES 3.0 models with 3.0 STBs with HD DVR capability	-15.2%	**-42.6** (-124.2)	-1.4%	**-3.8** (-11.2)	9

5. Conclusions and Recommendations

This chapter describes the evaluation team's overall conclusions and recommendations for the STB pilot, market characterization assessment, and technical and achievable energy savings potential analyses.

5.1. Effectiveness of the Pilot

Conclusion 1: 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 a eleven times higher rate than the control group, increasing the baseline replacement rate of about 1% to 9% for those receiving the upgrade offer.

Conclusion 2: Customers in the pilot, irrespective of pilot condition (experimental or control), increased the number of STBs in their household when they upgraded their STBs, suggesting this was natural consumer behavior.

Conclusion 3: 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. Analysis of pre and post pilot data shows a reduction in average energy consumption per STB (-40 kWh per STB in the experimental condition, and -82 kWh per STB in the control condition). We attribute the smaller decrease in average STB consumption for the experimental group to the way the pilot offer was presented to customers. Customers in the experimental condition upgraded their STBs to a multi-room STB system (a central control server that communicates with several receivers called thin clients) at a much lower rate in response to the pilot offer compared to customers in the control condition. Server and thin client technology is more energy efficient than stand-alone ENERGY STAR Version 3.0 or 4.1 certified STBs when replacing multiple STBs. The lower uptake of the server and thin client technology among those in the experimental condition could be a consequence of additional fees associated with the server upgrade option, whereas stand-alone STB upgrade options were free (except for one option) to the customers in the experimental group.

Conclusion 4: 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.

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. 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:** If feasible, 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 incentivizing the one-to-one replacement of customers' STBs without incentivizing any additional units. That is, a program should incentivize customers to replace their existing boxes but not incentivize any additional boxes they may wish to install as part of the upgrade. It is important to note that service providers partnering with utilities to deliver an early STB replacement program will likely not be able to institute a rule that upgraders cannot add boxes, if they pay for the boxes themselves.

> **Recommendation 2:** An STB replacement program should re-assess the incentive offer for the server and thin client technology upgrade option.

5.2. Replacement Technology with the Highest Technical and Achievable Potential

Conclusion 5: Installation of ENERGY STAR Version 4.1 certified multi-room configuration STB systems (a central control server that communicates with several receivers called thin clients) 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. Across service providers, 99% of the STBs procured in 2013 were HD, indicating that the ability to deliver HD content is becoming a standard feature in STBs. We estimated the energy savings potential of several scenarios that replace existing stand-alone STBs with either stand-alone HD or HD DVR models or a server and thin client system that is HD DVR-capable. Across these replacement scenarios, replacing existing HD, DVR, and HD DVR STBs (regardless of their ENERGY STAR certification level) with ENERGY STAR Version 4.1 server and thin clients systems provides the largest achievable energy savings potential, at 6.8 GWh per year and 19.8 GWh per the life of the equipment. 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, at 4.8 GWh per year and 12.7 GWh per the life of the equipment.

Additionally, when we assume customers would increase the number of STBs in a home by one unit after upgrading their equipment, the savings potential is positive for only 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 reduced, 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.

Recommendation 3: Any STB program designed to incentivize early replacement of STBs should consider these ENERGY STAR Version 4.1 replacement technologies, 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

Conclusion 6: 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 at home, the server-thin client model provides HD DVR for equivalent or less energy than stand-alone HD STBs. With five or more units at 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 could consider offering an incentive to only those homes with multiple STBs.

- **Recommendation:** An STB program should focus on targeting replacement of STBs with advanced features such as HD DVR, which use more energy.

5.3. Key Market Trends

Conclusion 7: While ENERGY STAR Version 3.0 STB technologies have penetrated the market, there may be an immediate program opportunity to accelerate adoption of ENERGY STAR Version 4.1 STBs that could lay the groundwork for longer-term engagement in the STB market. In 2012, eleven leading Pay-TV providers entered into a Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes, committing that by 2014, 90% of the STBs they procure would meet ENERGY STAR Version 3.0 specifications.[66]

[66] D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

While the Voluntary Agreement does not address the STBs already installed in Pay-TV subscribers' homes, ENERGY STAR Version 3.0 Certified STBs have likely achieved significant penetration of the installed base through the natural replacement cycle.[67] Given estimates of a five-to-eight-year replacement cycle for STBs, as many as half the STBs in the installed base may have been replaced in the past three years, a timeframe during which ENERGY STAR 3.0 STBs accounted for the vast majority of shipments.[68] The data available to the evaluators on a portion of Southern California STB installed base was consistent with this estimate, with customers who had all ENERGY STAR Version 3.0 models comprising nearly half (42%) of the records. Another quarter (25%) had a mix of ENERGY STAR Version 3.0 and pre-3.0 models.

Under the Voluntary Agreement, service providers agreed that, beginning in 2017, at least 90% of the STBs they procure will meet a higher efficiency standard that is similar, but not identical, to the ENERGY STAR Version 4.1 specification. Currently, however, penetration of ENERGY STAR Version 4.1 STBs is well below this target. According to service provider reporting, 47% of the STBs they procured in 2013 met the Voluntary Agreement's higher efficiency standards.[69] Cable providers procured a larger assortment of individual STB models that appear to meet the ENERGY STAR Version 4.1 requirements in 2014 than 2013, but these models represented less than one-third of all the individual models they procured.[70] As of the end of January 2015, there were 25 STB models qualified under ENERGY STAR 4.1, compared with 132 qualified models under Version 3.0 when the specification changed.

Like other consumer electronics products, STB technology changes rapidly. In the Voluntary Agreement, service providers agreed to work to develop lower energy sleep modes for STBs, a goal research groups like the CalPlug Initiative at the University of California Irvine are also pursuing. Given these efforts, it is likely that more efficient STB technologies will be available by the time the more stringent standards take effect under the Voluntary Agreement in 2017. Given its mission to recognize only the highest performing models, it is also likely that EPA will revise the ENERGY STAR specification for STBs prior to 2017. A program that entered the market seeking to accelerate adoption of ENERGY STAR 4.1 STB models would be well positioned to promote new, more efficient STB technologies and higher efficiency standards that

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67 Section 3.3.2 provides additional detail on the Voluntary Agreement.

68 In 2012, manufacturers reported to ENERGY STAR that 88% of the STBs they shipped met the Version 3.0 specification. In their reporting related to the Voluntary Agreement, service providers reported that 85% of the STBs they procured in 2013 met ENERGY STAR Version 3.0. Assuming service providers complied with the Voluntary Agreement, in 2014, the proportion of STBs service providers procured meeting ENERGY STAR Version 3.0 increased to at least 90%. Sources: *ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2012 Summary.* U.S. Environmental Protection Agency, 2013. https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2012_USD_Summary_Report.pdf?20d9-5e6d.; D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

69 D&R International, Ltd. 2014, August. *2013 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Set-Top Boxes.* Silver Springs, MD: National Cable and Telecommunications Association. https://www.ncta.com/sites/prod/files/VoluntaryAgreementforOngoingImprovementtotheEnergyEfficiencyofSet-TopBoxes.pdf

70 Service providers' publicly-available reporting related to the Voluntary Agreement does not include the number of units of each model procured.

recognize them when they become available. To phrase it differently, an STB program can adapt in what it is incentivizing as technology changes.

Recommendation 5: An STB program should focus on accelerating adoption of ENERGY STAR Version 4.1 models in the short term while advocating for the development of – and promoting – still more stringent standards in the medium and long term. While there is opportunity to accelerate adoption of ENERGY STAR Version 4.1 STBs in the next few years, these boxes are likely to become mainstream among STBs in the next several years.

5.4. Future STB Research

In this section, we discuss future STB research activities any program administrator could execute if planning to implement an early replacement STB program or a pilot.

Future STB research studies should examine whether an incentive offer could be designed to accelerate a server and thin-client system upgrades at a higher rate than the normal replacement rate, if the incentive offer only covers part of the cost and/or was bundled with other services (e.g. purchasing new premium channels).

- **Rationale:** More than half of the survey respondents who participated in the pilot reported they would not be willing to pay a portion of the upgrade cost, which suggests that the uptake of the incentive offer could decline if the offer covered only part of the cost. Bundling the incentive offer with another but planned offer from a service provider, could mitigate a potential decline in the uptake of the incentive offer, if the incentive covered part of the upgrade cost.

  The current study also lacks information on what the upgrade rate would have been if the incentive offer more visibly presented the option of upgrading to a server and thin client system. Service provider representatives did not present customers with the option of upgrading their STB to a server and thin client system. Rather, customers had to ask whether they could upgrade to a server and thin client system before learning that this was an option.

Future STB research studies also should examine whether an incentive offer utilizing a different delivery mechanism (either mail or email instead of "over the phone" approach) would lead to a server and thin-client upgrade at a higher rate than the normal replacement rate.

- **Rationale:** Using service providers' representatives to present the incentive offer to customers over the phone, an approach the STB pilot used, could be costlier than delivering that offer via email or direct mail. Labor costs are typically higher when using over the phone approach than email or direct mail channels.

Last, future STB research should validate engineering kWh/year energy savings estimates of only those STB technologies a program is considering incentivizing.

- **Rationale:** This will allow program staff to know whether expected energy savings estimates based on engineering kWh/year values can be trusted. There are two approaches to validating engineering energy savings estimates: billing analysis and metering.

STB usage is too small to see with billing analysis, so we do not recommend this approach. We know from this study that pre-ENERGY STAR Version 3.0 STBs in the installed base used an average of 150 kWh per year, whereas efficient STB models with ENERGY STAR Version 3.0 certification used an average of 87 kWh per year. A difference of about 63 kWh between the older and more efficient models is less than 1% of the average yearly SCE household energy use.

Metering the specific end-use, such as the STB, on the other hand, is possible, however, costly. The most cost-effective approach would be to meter a select set of STB models (the most common in SCE households) for the baseline and the STB models likely to be promoted by the program.

Appendices

Appendix A. Validation of Random Assignment

This appendix catalogs the statistical tests used to assess similarity between the two experimental groups in the Set-Top Box experiment: Control and Experiment.

A.1. Background Information and Assumptions

Southern California Edison (SCE) staff randomly assigned select service provider(s) customers to one of two groups: control and experiment. SCE staff developed their random assignments by estimated income level, whether the customer had one STB or more than one STB (2 to 5 STBs), and the total energy usage of all STBs in the home. SCE grouped total STB energy usage into three categories: Low, Medium and High usage categories.[71]

In order to verify that the control and experiment groups are similar, we:

- Calculated the smallest effect size needed to detect differences between the groups
- Evaluated whether the smallest detectible effect size was small enough to detect very small differences between groups

If we determined that the effect size was small enough, we conducted a series of t-tests and chi-square tests to assess whether there were any statistically significant differences between the control and experiment groups.

By calculating the smallest effect size that a statistical test can detect, and by evaluating whether this effect size is so small that it is essentially meaningless, we can show that the statistical test we conduct is powerful enough to find group differences if they exist. If **all** statistical comparisons between experiment and control groups render a statistically non-significant result **and** can detect a very small effect, we will assume that customers were randomly assigned and any subsequent analyses can argue for the causal nature of the intervention.

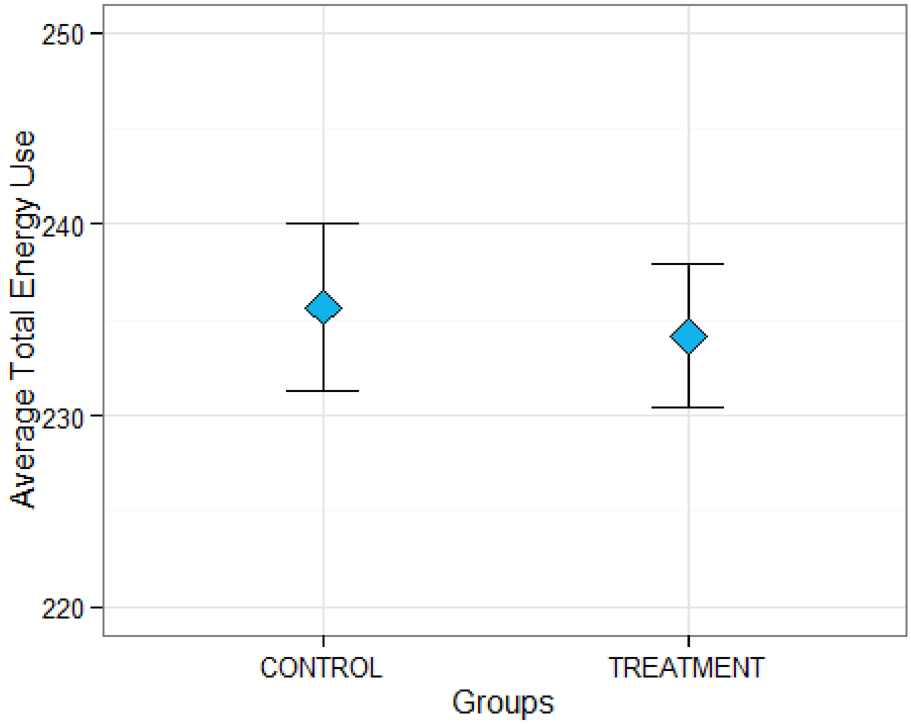
A.2. Assessment of Random Assignment

A.2.1. Graphical Comparison of STB Energy Use between Groups

The average total energy used for all STBs in the home look equivalent between both groups (Figure A-1). The 95% confidence intervals for the control and experiment groups for total STB energy use (pre-experiment) almost completely overlap, indicating very similar average STB energy use in both groups.

71 SCE estimated income level using the proportion of population that are CARE eligible by zip code.

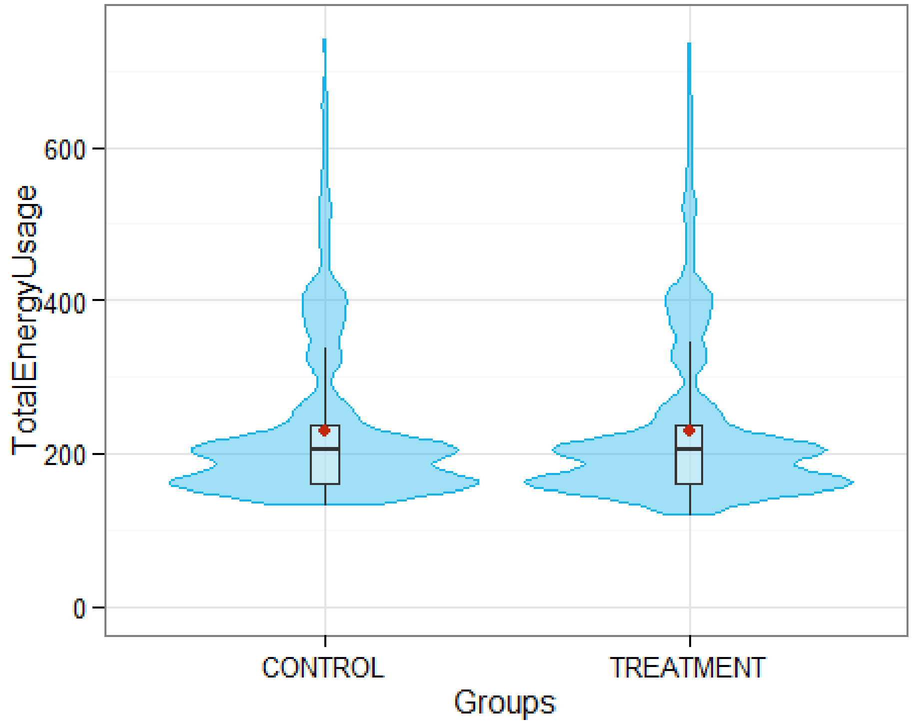
Figure A-1: 95% Confidence Interval for Average Total STB Energy Use by Group



The bean plot below (Figure A-2) shows near identical distributions of total STB energy use between groups.[72] Note that the outline (the density distribution) of the plot for the experimental condition almost completely mirrors the control group. Also, the means (the red dots in the figure) and the boxplots for both groups are nearly identical, again suggesting that experiment and control groups have the same level of total STB energy use and are therefore comparable.

[72] Bean plots are an alternative to boxplots and density plots. Bean plots shift a density plot 90 degrees and mirror the density plot to create a violin-looking graph. The bean plot allows for an easier and more consistent comparison between distributions.

Figure A-2: Bean Plot of Total Energy Use by Group



A.2.2. Testing Differences in STB Energy Use between Groups

Statistical tests are constructed to reject a null hypothesis. We, however, are concerned with showing equivalency between the two randomly assigned groups (i.e., confirming the null hypothesis). We can show similarity between the groups. To do so we must: a) be sure that our statistical test is powerful enough to detect very small differences between groups, and b) be sure that the statistical tests fail to reject the null hypothesis in **all** statistical tests we conduct.

For the following t-tests, the minimal effect size we can detect is **d=0.07** with the following assumptions:

- Power of .8
- Alpha level of .05
- Two-tailed t-test
- Unbalanced groups (n_1=3,000, and n_2=3,699)

This effect size indicates we will be able to detect very small differences between groups. As mentioned earlier, if all t-tests – and all remaining statistical tests – are non-significant, we can conclude that the randomly assigned groups are equivalent and causality can be inferred from experimental results.

We ran a t-test to examine whether there are differences in deemed energy usage for all pre-experiment STBs in a household by group. The resulting statistic yields non-significant results, t(6289)=0.5103 p=0.6099.

We also ran a series of t-tests to examine whether there are differences in individual model energy usage by group (Table A-1). No test yielded a significant difference between the control and experiment groups.

Table A-1: t-statistics and p-values for Individual STB Energy Use

STB IN HOUSEHOLD	T-STAT	DF	P-VALUE
1st STB	0.60	6,261	0.551
2nd STB	-0.26	6,447	0.796
3rd STB	1.20	6,287	0.231
4th STB	0.15	6,342	0.884
5th STB	0.41	6,154	0.681

A.2.3. Testing Differences in Estimated Income Levels

We ran a t-test to see whether there are differences in estimated income by group. The income metric estimates income level using the proportion of population that are CARE eligible by zip code.

The resulting statistic yields non-significant results, t(6411)=-0.2398 p=0.8105.

A.2.4. Testing Differences in Number of STBs between Groups

Table A-2 shows the count of STBs for each household by experimental group. For the following chi-square test, the minimal effect size we can detect is **w=0.042** with the following assumptions:

- Power of .8
- Alpha level of .05
- df=4
- Sample size of 6,699

This effect size is very small. If this chi-square test – and all other statistical tests - are non-significant, we can conclude that the randomly assigned groups are equivalent and causality can be inferred from experimental results.

Table A-2: Number of STBs in Household by Group

NUMBER OF STBS IN HOME	CONTROL	EXPERIMENT
1	2,322	2,861
2	478	620
3	140	145
4	50	62
5	10	11

The resulting statistical test yields non-significant result, $\chi^2(4, N=6{,}699)=2.9336$, p=0.569.

A.2.5. Testing Differences in STB Manufacture Dates between Group

Table A-3 shows the count of model 1 STBs by group. For the following chi-square test, the minimal detectible effect size we can detect is **w=0.047** with the following assumptions:

- Power of .8
- Alpha level of .05
- df=8
- Sample size of 6,699

This effect size is very small. If this chi-square test – and all other statistical tests – are non-significant, we can conclude that the randomly assigned groups are equivalent and causality can be inferred from experimental results.

Table A-3: Counts by Group by Year of STB Manufacture

MODEL 1 YEAR OF MANUFACTURE	CONTROL	EXPERIMENT
No Information	564	669
2000	0	1
2005	204	248
2006	257	329
2007	612	745
2008	424	512
2009	683	851
2010	219	302
2011	37	42

The resulting statistical test yields non-significant result, $X^2(8, N=6{,}699) = 3.419$, p=0.9054.

We could not conduct chi-square tests for models 2 through 5 manufacturer years by group since several cells yield expected counts less than five. These small expected counts violate chi-square assumptions. We will continue assuming that both the control and experimental groups have similar years of manufacturer for models 2 through 5.

A.2.6. Comparing Geographical Dispersion between Groups

A quick review of the customer counts by County show that both groups have similar geographic dispersion (Figure A-3 and Table A-4).

Figure A-3: Ratio of Control to Experiment by County with Average STB Energy Use

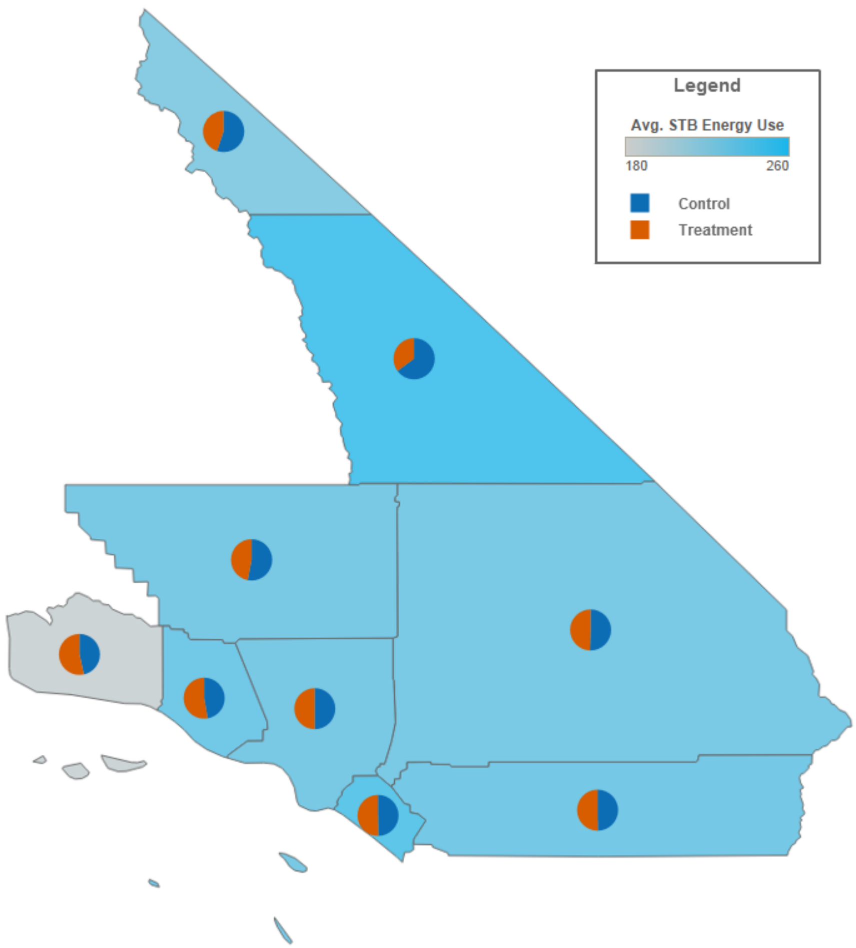


Table A-4: Participant Counts by County with Hypothetical Control Counts (If Control n=3,699)

COUNTY	CONTROL	CONTROL (AS IF IT ADDED UP TO 3,699)	EXPERIMENT
Inyo	21	26	14
Kern	33	41	36
Los Angeles	1,393	1,718	1,714
Mono	4	5	4
Orange	467	576	583
Riverside	260	321	322
San Bernardino	647	798	785
Santa Barbara	12	15	17
Ventura	162	200	224
Grand Total	**2,999**	**3,699**	**3,699**

A.3. Conclusions

Power analyses for all t-test and chi-square tests yielded small detectible effect sizes and high statistical power. This means that all statistical tests conducted for this analysis should have been able to detect very small differences between groups. As suggested earlier, if all statistical tests had the potential to detect small differences between groups, and if all statistical tests were non-significant – showing no differences between groups – the research team can conclude valid random assignment. Results from all statistical tests conducted by the research team yielded non-significant results. The research team, therefore, concludes that the two groups are statistically equivalent. Thus, we can assume that any statistically significant differences in uptake rates and STB energy use between groups resulting from the experiment are causal in nature.

Appendix B. Additional Survey Findings

Section 2.4 and this appendix provide findings from a survey conducted with SCE customers who participated in a pilot program that facilitated the replacement of existing pre-ENERGY STAR Version 3.0 STBs. The purpose of the survey was to understand customers' motivations for replacing or not replacing their STBs, awareness of STB energy consumption, experience with the pilot, and awareness of SCE.

Section 2.4 documents key findings from the survey, whereas this appendix presents findings not reported in Chapter 3.

B.1. Additional Results

We conducted telephone surveys with the following customer groups:

- **Experimental upgraders:** customers in the experimental condition who accepted the replacement offer.
- **Experimental non-upgraders:** customers in the experimental condition who did not accept the replacement offer.
- **Natural upgraders:** customers who did not receive the replacement offer, but upgraded their STB within three months prior to fielding the survey.

Throughout this section, we note any differences in responses between customer groups and any demographic differences, when they exist.

B.1.1. STB and TV Usage

Both experimental and natural upgraders reported having their new STB between one and six months, with experimental non-upgraders reporting having their STB for about six years. We did not find the age of the customer' STB to be associated to their willingness to upgrade. Most survey respondents (80%) reported leaving their STB plugged in or on at all times.

The most common way survey respondents reported using their STB was to watch live TV programing (93%) followed by recording shows to watch later (78%; Table B-1). Those respondents that reported using their STB to record shows to watch later were significantly younger than those who reported not using this feature.

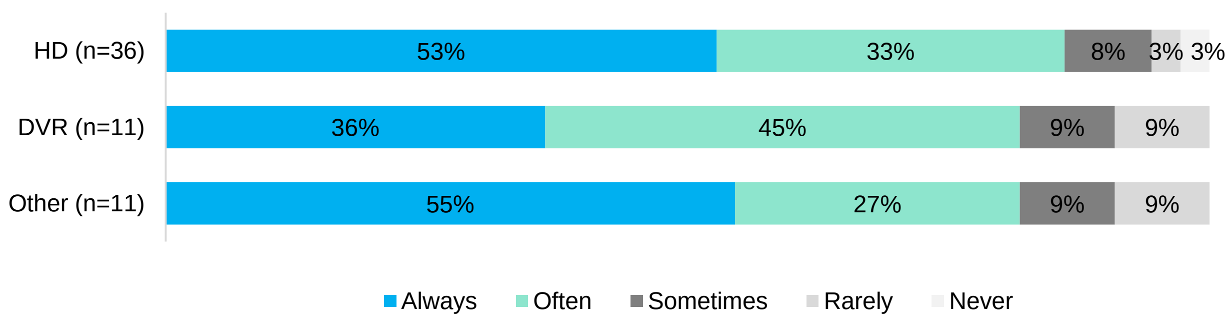
Table B-1: STB Usage (n=86; Multiple Responses Allowed)

USE	COUNT	PERCENT
Watch live programming	80	93%
Record shows to watch later	67	78%
Watch movies and shows On Demand	13	15%
Stream shows from the internet	15	17%
Other*	2	2%

* Other includes watching DVDs and YouTube (one mention each).

Among those upgraders who reported their new STB had features their old STB did not have, most reported using the features either "always" or "often" (Figure B-1).

Figure B-1: Frequency of Use of New STB Features



Most respondents (86%) did not use other devices other than their service provider's STB to view content on their TV. Respondents who used other devices to view TV content most often used streaming media devices (Table B-2).

Table B-2: Other Devices Used by Customers (n=12; Multiple Responses Allowed)

DEVICE	COUNT
A streaming media device (e.g. Apple TV, Roku, or Google Chromecast)	5
Blu-ray player	2
Computer connected to the TV	2
Game console	2
Other*	3

* Other includes Kindle Fire, Netflix, and Smartphone (one mention each).

Survey respondents reported having paid TV service at their home between two and 30 years, or an average of 15 years. Respondents reported having their service provider's service at their home for about half the time they had paid TV service (an average of 8 years).

Survey respondents reported having between one and five TVs in their household, with an average of two TVs (Table B-3). This finding is consistent with the average number of TVs in U.S. households (2.24 TVs per household).[73]

Table B-3: Number of TVs in Home

TVS		COUNT	PERCENT
1		15	17%
2		35	41%
3		25	29%
4		9	10%
5		2	2%
	Total	**86**	**100%**

On average, survey respondents reported having their TV(s) turned on in their household for nine and a half hours per day (Table B-4). Please note that the survey asked respondents the total time they had their TV(s) on, and not the total time they spent watching TV. Respondents could have their TV(s) on for various purposes: watching content, having TV on for background noise, or listening to music, which is now possible with STBs or other streaming devices. Additionally, nearly half (41%) of the survey sample were 65 years old or older. The U.S. polling data reveals that, on average, older individuals (65 years old or older) spend about 7 hours per day watching live TV.[74]

Table B-4: Average Time TV (s) Turned On

NUMBER OF TVS IN THE HOME		AVERAGE TIME TV IS ON (HOURS)
One TV		5
Two TVs		9.3
Three TVs		8.9
Four or more TVs		17.4
	Total	**9.5**

Most upgraders (84%) reported not changing how much TV their household watched since upgrading their STB. The five upgraders that reported an increase in TV usage provided an estimate between a half hour and four hours per day. Three upgraders reported a slight decrease in their TV usage since upgrading their STB.

73 The Nielsen Company. 2013, December. Retrieved from: *http://www.statisticbrain.com/television-watching-statistics/.*

74 The Nielsen Company. 2014, September. "*Shifts in Viewing: The Cross-Platform Report*." Retrieved from: *http://www.nielsen.com/us/en/insights/reports/2014/shifts-in-viewing-the-cross-platform-report-q2-2014.html.*

B.1.2. Demographics

Survey respondents reported having between one and five household members, including the respondent, with an average of two household members (Table B-5).

Table B-5: Number of Household Members

HOUSEHOLD MEMBERS	COUNT	PERCENT
1 – Respondent only	19	22%
2	37	43%
3	13	15%
4	11	13%
5	4	5%
Refused	2	2%
Total	**86**	**100%**

Overall, about three-quarters (74%) of survey respondents reported having at least some college education, with one-fifth (21%) reporting having a graduate of professional degree (Table B-6).

Table B-6: Educational Attainment

EDUCATION LEVEL	COUNT	PERCENT
Less than high school graduate	3	3%
High school graduate or equivalent	15	17%
Some college (including Associates degree, trade or technical school)	22	26%
College degree (Bachelor's degree)	23	27%
Graduate or professional degree or higher	18	21%
Refused	5	6%
Total	**86**	**100%**

Survey respondents were generally older, with the about two-thirds (62%) reporting being 55 years or older (an average of 61 years old; Table B-7).[75]

75 Although we attempted to contact respondents during evenings and weekends, we conducted the majority of calling during business hours, which could partially account for this higher age demographic.

Table B-7: Respondent Age

AGE	COUNT	PERCENT
Less than 34 years old	7	8%
35 to 44	6	7%
45 to 54	12	14%
55 to 64	18	21%
65 years old or older	35	41%
Refused	8	9%
Total	**86**	**100%**

Slightly over half (55%) of survey respondents were female with the remaining being male (44%) or the interviewer was unsure of the respondent's gender.

Appendix C. Technical and Achievable Potential Analytic Methods

We analyzed SCE's STB installed base to estimate technical and achievable energy savings potential if SCE pursued replacements of existing STB models with the latest ENERGY STAR Version 3.0 or 4.1 certified models. This appendix describes the data cleaning procedures and analytic methods used for developing technical and achievable potential estimates.

C.1. SCE STB Installed Base Data Cleaning

The STB installed base data available to the evaluator covered a portion of the STBs in SCE's territory and served as the baseline for estimating the technical and achievable energy savings potential. While examining this data, the evaluation team made a couple of decisions:

- We removed customers with more than 10 STBs from the installed base. These records were likely commercial properties since it was suspect that residences had that many STBs.
- We removed records with missing STB models and energy usage values. This information was necessary for estimating the technical and achievable potential of each replacement scenario.

These decisions resulted in 2.4% of customers being excluded from the installed base.

C.2. SCE Installed Base Data Imputation

Certain records in the installed base had partial information on STB models and associated energy usage values. Specifically, STB models were listed in the records (e.g., X model), while sub-model differentiation was missing (e.g., whether the model was X-1 or X-2 sub-model). For these records, we imputed sub-model and energy usage (kWh/year) values from the available data. Specifically, we randomly assigned equal proportion of models to each sub-model type, if sub-models had different ENERGY STAR certification levels. If sub-models had the same ENERGY STAR certification levels, we averaged the kWh/year values across sub-models and applied that average to records with only the model but no sub-model information. Please note that the ENERGY STAR certification level and energy usage values were associated with each sub-model and provided to us separately from the installed base data.

C.3. Establishing Baseline Energy Usage

To the installed base we appended the annual energy usage (kWh/year) of each STB listed in each customer record. For example, if a customer record listed five STBs, all five STBs had associated energy usage values. We estimated the total STB annual energy usage of the current installed base (the "baseline") by summing annual energy usage values of all STBs in the installed base. This is depicted by the following equation:

Equation 1: Baseline Total Energy Consumption (TEC) = $\sum TEC_{STB}$

Where: TEC_{STB} = the kWh/year value of each STB in the installed base

C.4. Technical Energy Savings Potential Calculation

For technical potential, which represents replacement of existing STBs at the customer level, the equation is:

Equation 2: Technical Energy Savings Potential = $\sum TEC_{STB} - \sum TEC_{STB\_r}$

Where: TEC_{STB} = the kWh/year value of each STB in the installed base (the "baseline")

TEC_{STB_r} = the kWh/year value of each STB in the installed base after we replaced existing STBs with efficient STB model(s), as specified by each scenario

Please note that for each ES 3.0 replacement model we used the average kWh/year value since these models had multiple sub-model types we needed to consider. For each ES 4.1 replacement model (also that had different sub-models), we used SCE's average ES 4.1 kWh/year value.

C.5. Achievable Energy Savings Potential Calculation

The achievable potential is defined as the energy savings that can feasibly be achieved given the estimated effectiveness of SCE's STB upgrade offer. The STB pilot, which tested the effectiveness of SCE's STB upgrade offer, revealed the replacement rate of about 9% for those exposed to the upgrade offer. Thus, for the achievable potential, the equation is:

Equation 3: Achievable Energy Savings Potential = 0.09 x Technical Potential

C.6. Lifetime Energy Savings Potential

Hardy (2013) estimated STB lifetime based on expert opinion and by modelling the distribution of STB product lifetime as a cumulative Weibull distribution.[76] Hardy's findings indicate a mean of about 6 years (5.69 years) for the Expected Useful Life (EUL) with a minimum lifetime of 1

[76] Hardy. 2013. *Set-top Boxes and Small Network Equipment. Response to California Energy Commission 2013 Pre-Rulemaking Appliance Efficiency*. Docket Number: 12-AAER-2A.

year and maximum lifetime of 12 years. We use this information and assume STB EUL of 6 years, which means that 17% of STBs are replaced each year (the "natural" replacement rate).

To estimate lifetime energy savings, we first determined the number of program years for which savings could be counted by each vintage category of STB (Table C-; vintage is based on EUL of 6 years). Please note that equipment is replaced throughout the year for each vintage category. For the last year of life for a given vintage category, we assume equipment is replaced in the middle of the year rather than at the end of the year. We also assume that equipment had to have at least 1 year of EUL left for savings to be counted, which means that for the oldest equipment, where there is less than one year of EUL left, program will not claim any savings.

Table C-1: Counting Lifetime Savings by Equipment Vintage

VINTAGE OF STB EQUIPMENT – ASSUMING EUL OF 6 YEARS	COUNTING PROGRAM SAVINGS ("1", "0.5", & "0" MEANS SAVINGS ARE COUNTED FOR THE WHOLE YEAR, HALF A YEAR, OR NOT COUNTED AT ALL, RESPECTIVELY)					
	Program Savings – Year 1	Program Savings – Year 2	Program Savings – Year 3	Program Savings – Year 4	Program Savings – Year 5	Program Savings – Year 6
6 years old (oldest)	0	0	0	0	0	0
5 years old	1	0.5	0	0	0	0
4 years old	1	1	0.5	0	0	0
3 years old	1	1	1	0.5	0	0
2 years old	1	1	1	1	0.5	0
1 years old (newest)	1	1	1	1	1	0.5

Next, we developed equations for calculating lifetime energy savings potential by taking into the account all the assumptions referenced above:

Equation 4: Technical Lifetime Energy Savings Potential = (0 x NRR x ΔTEC)+ (1.5 x NRR x ΔTEC)+ (2.5 x NRR x ΔTEC)+ (3.5 x NRR x ΔTEC)+ (4.5 x NRR x ΔTEC)+ (5.5 x NRR x ΔTEC)

OR

Technical Lifetime Energy Savings Potential = 17.5 x NRR x ΔTEC

Where: NRR= the natural replacement rate of 0.17

$$\Delta TEC = \sum TEC_{STB} - \sum TEC_{STB\_r}$$

Where: TEC_{STB} = the kWh/year value of each STB in the installed base (the "baseline")

TEC_{STB_r} = the kWh/year value of each STB in the installed base after we replaced existing models with efficient STB models, as specified by each scenario

Equation 5: Achivable Lifetime Energy Savings Potential = 0.09 x Achievable Lifetime Energy Savings Potential

Appendix D. Pay-TV Service Type Penetration by California Media Market

Table D- lists the number and proportion of households with a television in each of the 12 California media markets that subscribes to cable or IPTV (combined) or satellite.

Table D-1: Cable/IPTV and Satellite Penetration by California Media Market, November 2014

MEDIA MARKET	TV HOUSEHOLDS	CABLE/IPTV		SATELLITE	
		Count	Percent	Count	Percent
Los Angeles	5,523,800	2,850,281	52%	1,916,759	35%
San Francisco-Oakland-San Jose	2,476,860	1,577,760	64%	666,275	27%
Sacramento-Stockton-Modesto	1,345,960	639,331	48%	562,611	42%
San Diego	1,054,350	805,523	76%	191,892	18%
Fresno-Visalia	568,900	211,062	37%	271,365	48%
Santa Barbra-Santa Maria-San Luis Obispo	230,230	108,208	47%	101,762	44%
Monterey-Salinas	224,080	108,231	48%	92,769	41%
Bakersfield	221,840	112,029	51%	81,859	37%
Chico-Redding	187,920	64,081	34%	99,222	53%
Palm Springs	154,320	102,623	67%	44,136	29%
Yuma-El Centro	109,420	36,218	33%	53,178	49%
Eureka	58,630	31,426	54%	17,999	31%
Statewide	**12,156,310**	**6,646,772**	**55%**	**4,099,827**	**34%**

Source: Cable/IPTV and satellite penetration figures from Nielsen data listed at: Ibid. TV household figures from Nielsen data listed at: “TVB - Market Profiles,” accessed March 2, 2015, http://www.tvb.org/markets_stations.

Appendix E. ENERGY STAR Energy Use Allowance Comparison

Table E- provides a comparison of energy use allowances between the ENERGY STAR Version 3.0 STB specification (effective September 1, 2011 to December 18, 2014) and the ENERGY STAR Version 4.1 STB specification (effective December 18, 2014 to present).

Table E-1: Comparison of STB Energy Use Allowances from ENERGY STAR Version 3.0 Specification to ENERGY STAR Version 4.1 Specification

FEATURE	DEFINITION*	ENERGY USE ALLOWANCE	
		Version 3.0	Version 4.1
	BASE FUNCTIONALITY		
Cable	A STB or DVG that can receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system with Conditional Access (CA) or a STB or [Displayless Video Gateway (DVG)] capable of receiving cable service after installation of a CableCARD or other type of Conditional Access system.	60	60
Satellite	A STB or DVG that can receive and decode video content as delivered from a MVPD satellite network.	70	65
Cable Digital Transport Adapter	A minimally configured Cable STB that can receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system.	35	40
Internet Protocol (IP)	A STB or DVG that can receive television/video signals encapsulated in IP packets.	50	65
Terrestrial	A STB that can receive television signals over the air (OTA) or via community cable distribution system without Conditional Access (CA).	22	18
Thin-client/Remote	A STB that can receive content over an HNI from another STB or DVG, but is unable to interface directly to the MVPD network.	35	30
Over the Top IP (e.g. Roku, Chromecast, Amazon Fire TV)	An IP STB that cannot receive signals from a Multichannel Video Programming Distributor (MV PD) as defined in Title 47 U.S. Code § 522.	Not Included	10

FEATURE	DEFINITION*	ENERGY USE ALLOWANCE Version 3.0	ENERGY USE ALLOWANCE Version 4.1
ADDITIONAL FUNCTIONALITY			
Advanced Video Processing	The capability to encode, decode, and/or transcode audio/video signals in accordance with standards H.264/MPEG 4 or SMPTE 421M.	12	Not Included
CableCARD	The capability to decrypt premium audio/video content and services and provide other network control functions via a plug-in Conditional Access module that complies with the ANSI/SCTE 28 HOST-POD Interface Standard.	15	15
Digital Video Recorder (DVR)	A feature that records television signals on a hard disk drive (HDD) or other non-volatile storage device integrated into the STB or DVG for playback at an arbitrary time. A DVR includes features such as: Play, Record, Pause, Fast Forward (FF), and Fast Rewind (FR). STBs or DVGs that only support buffering or a Service Provider network-based "DVR" service are not considered DVR STBs or DVGs for purposes of this specification. The presence of DVR functionality does not mean the device is defined to be a STB or DVG.	45	45
DOCSIS	The capability to distribute data and audio/video content over cable television infrastructure in accordance with the CableLabs® Data Over Cable Service Interface Specification.	20	20
DOCSIS 3 (Applicable until 12/29/2015)		Not Included	11
High Definition (HD)	The capability to transmit or display video signals with resolution greater than or equal to 720p.	25	Not Included
High Efficiency Video Processing (HEVP)	Video decoding providing compression efficiency significantly higher than H.264/AVC, for example HEVC (H.265).	Not Included	15
Thin Client High Efficiency Video Processing (TC HEVP)		Not Included	5
Home Network Interface	An interface with external devices over a local area network (example: Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wireless-Fidelity or WiFi), Multimedia over Coax Alliance (MoCA), HomePNA alliance (HPNA), IEEE 802.3, HomePlug AV) that is capable of transmitting video content.	10	17
MIMO Wi-Fi HNI: for each 2.4 GHz Spatial Stream	IEEE 802.11n/ac and related MIMO enabled Wi-Fi functionality that supports more than one spatial stream in both send and receive. When using the notation MIMO AxB: A is considered the number of spatial streams while B is the number of antennas supported. A spatial stream is an independent and separately encoded data signal.	Not Included	3
MIMO Wi-Fi HNI: for each 5 GHz Spatial Stream)		Not Included	10

FEATURE	DEFINITION*	ENERGY USE ALLOWANCE Version 3.0	ENERGY USE ALLOWANCE Version 4.1
Multi-room	The capability to provide independent live audio/video content to multiple devices (2 or more Clients) or support pause/time-shifting capability for otherwise standalone IP or Thin client STBs within a single family living unit. This definition does not include the capability to manage gateway services for multi-subscriber scenarios.	40	56
Multi-stream - Cable/Satellite	A STB or DVG feature that allows the device to receive multiple independent streams of video content for use with one or more Clients, one or more directly connected Display Devices, or a DVR, etc. This definition does not include the capability to manage gateway services for multi-subscriber scenarios.	16	16
Multi-stream - Terrestrial/IP		8	6
Removable Media Player	The capability to decode digitized audio/video signals on DVD or Blu-ray Disc optical media.	8	Not Included
Removable Media Player/Recorder	The capability to decode and record digitized audio/video signals on DVD or Blu-ray Disc optical media.	10	Not Included
UltraHD Resolution	The capability to transmit or display video signals with a minimum output resolution of 3840×2160 pixels in progressive scan mode at minimum frame rate of 24 fps (abbreviated 2160p24).	Not Included	5
Access Point	The capability to provide wireless network connectivity to multiple clients. For the purposes of this specification, Access Point functionality includes only IEEE 802.11 (Wi-Fi) connectivity.	Not Included	8
Router	The capability to determine the optimal path along which network traffic should be forwarded. Routers forward packets from one network to another based on network layer information. Router functionality includes Access Point functionality.	Not Included	27
Telephony	The ability to provide analog telephone service through one or more RJ11 or RJ14 jacks.	Not Included	4

* Definitions are as listed in ENERGY STAR Version 4.1 specification for all allowances included in Version 4.1. Definitions for allowances not listed in the Version 4.1 specification are as listed in the ENERGY STAR Version 3.0 specification.

Sources: U.S. Environmental Protection Agency, "ENERGY STAR Program Requirements for Set-Top Boxes: Partner Commitments," October 31, 2014, http://www.energystar.gov/sites/default/files/FINAL%20Version%204.1%20Set-top%20Box%20Program%20Requirements%20for%20Manufacturers%20%28Rev%20Oct-2014%29.pdf. U.S. Environmental Protection Agency, "ENERGY STAR Program Requirements for Set-Top Boxes: Partner Commitments," August 12, 2011, http://www.energystar.gov/sites/default/files/specs//private/STB_Version_3_Program_Requirements_Manufacturer_0.pdf.

Appendix F. STB Pilot Survey

F.1. Introduction

Hi, my name is __________, and I'm calling from Research Into Action on behalf of Southern California Edison (SCE). I'm calling because SCE recently partnered with your Pay-TV service provider to help SCE customers replace aging TV receivers – the boxes used to receive a signal and display programming on your TV. SCE would like to better understand your experience with your TV receiver.

Are you the person in your household most likely to receive information and offers from your Pay-TV service provider?

[IF NEEDED]

- We're not selling anything
- I only need about 10 minutes
- This is the box that your Pay-TV service provider provided to you – it's connected to your TV and is what you use to change the channel or record shows
- Research Into Action does not share any opinions or comments you share with us and they will be reported only after all personally identifying information has been removed. Please be assured that no sales or promotional solicitation will occur during the interview or afterwards as a result of your participation.

[IF CORRECT PERSON] Great. Your opinions are valuable and will be anonymous.

[IF ANOTHER PERSON IS MORE APPROPRIATE] May I please speak to the person who is most likely to communicate with your Pay-TV service provider? [REPEAT INTRO AND CONTINUE]

[IF NOT A GOOD TIME] Ask for call back day/time

F.2. Use and Replacement

[ASK ALL]

Q1. First, I'd like to understand how you use your receiver. Do you use your receiver to… *Interviewer: prompt with responses for each, do not read 97-99*

[MATRIX QUESTION]

[LOGIC] Item	Yes	No	96 Other, specify	97 NA	98 DK	99 RF
Watch live programming						
Record shows to watch later						
Watch movies and shows On Demand						
Stream shows from the internet via services like Hulu or Netflix						
Other?						

[ASK ALL]

Q2. Have you replaced your receiver in the last three months?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

98. Don't know
99. Refused

[IF Q2=1]

Q3. How long have you had your new receiver?

1. Response Text [*RECORD NUMBER, SPECIFY DAYS, WEEKS, OR MONTHS*]
2. Not yet installed

[*Do not read:*]

98. Don't know
99. Refused

[IF Q2=2]

Q4. About how long have you had your receiver?

[SINGLE RESPONSE]

1. Response Text [RECORD NUMBER, SPECIFY, WEEKS, MONTHS, OR YEARS]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q2=1]

Q5. And about how long did you have your old receiver – the one before your recent replacement?

[SINGLE RESPONSE]

1. Response Text [RECORD NUMBER, SPECIFY, WEEKS, MONTHS, OR YEARS]

[*Do not read:*]

98. Don't know
99. Refused

F.3. Offer

[IF Q2=1]
Q6. Why did you decide to replace your receiver? [*Do not read, select all that apply*]

[MULTIPLE RESPONSE]

1. Was offered a free receiver from SCE/ your Pay-TV service provider
2. The old receiver was no longer functional
3. Wanted functionality not available in previous receiver (for example HD or DVR)

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q6 ≠ 1 or Q2=2]
Q7. Do you recall receiving an offer recently for a free replacement receiver?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know
99. Refused

[IF Q7≠1 AND RESPONDENT IS IN EXPERIMENTAL GROUP]
Q8. Is there anyone else in your household who might have received an offer for a free replacement receiver?

[SINGLE RESPONSE]

1. Yes
2. No *[Thank and terminate]*

[*Do not read:*]

98. Don't know *[Thank and terminate]*
99. Refused *[Thank and terminate]*

[IF Q8=1]
Q9. Can I speak with that person?

[SINGLE RESPONSE]

1. Yes – person is available [*Reread introduction and resume survey at Q7 with new respondent]*
2. *Yes – person is not available now [Attempt to schedule a time to speak with new respondent, when reached reread introduction and resume at Q7]*
3. *No [Thank and terminate]*

[*Do not read:*]

98. Don't know
99. Refused

[IF Q6= 1 or Q7=1]
Q10. What was included in the offer? [*Do not read, select all that apply*]

1. A free receiver
2. One year of free HD

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q6= 1 or Q7=1]
Q11. If you recall, who offered you the replacement receiver?

[SINGLE RESPONSE]
[*Do not read:*]

1. Southern California Edison/SCE/my utility
2. My Pay-TV service provider /my television service provider
3. Southern California Edison and your Pay-TV service provider together
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q11 = 1 OR Q11 = 2 OR Q11 = 96]

Q12. Was anyone else involved in providing the offer?

[*Do not read:*]

1. Southern California Edison/SCE/my utility
2. My Pay-TV service provider /my television service provider
3. No one else was involved
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q6= 1 or Q7=1]
Q13. Before receiving this offer, had you considered replacing your old receiver?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[If Q7=1]
Q14. Did you accept the offer for the free replacement receiver?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

98. Don't know
99. Refused

[If Q6=1 or Q14=1]
Q15. If the offer required you to pay for a portion of the receiver's cost, how much would you have been willing to pay?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q14 = 1 OR Q6=1]
Q16. Were you charged a fee for the installation of your new receiver?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q14=2]
Q17. Why did you choose not to take the offer to upgrade your receiver?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q14=2]
Q18. What, if anything, would have made the offer too good to pass up?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q6=1 OR Q14=1]
Q19. What was appealing about the offer to upgrade your receiver?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]
98. Don't know
99. Refused

[IF Q6=1 OR Q14=1]
Q20. Using a scale from 1 to 5, where 1 is ‘not at all satisfied’ and 5 is ‘extremely satisfied,’ how satisfied were you with the offer to replace your receiver?

[SINGLE RESPONSE]

1. 1
2. 2
3. 3
4. 4
5. 5

[*Do not read:*]
98. Don't know
99. Refused

F.4. New Receiver

[IF Q2=1]
Q21. What features, if any, does your new receiver have that your old one did not have?

[MULTIPLE RESPONSE]

1. HD
2. DVR
3. “Server” receiver that supports peripheral receivers
4. No new capabilities

[*Do not read:*]
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q21=1 OR Q21=2 OR Q21=3 OR Q21=96]
Q22. How frequently does your household use the new features you mentioned? For each feature, please tell me if your household always, often, sometimes, rarely, or never uses it when you watch TV. *Interviewer: prompt with responses for each, do not read 97-99*

[MATRIX QUESTION]

[Ask for each capability selected in Q21]	Always	Often	Sometimes	Rarely	Never	96 Other, specify	97 NA	98 DK	99 RF
HD									
DVR									
"Server" receiver supporting peripheral receivers									
Other									

[IF Q6=1 OR Q7=1]
Q23. Before the offer to upgrade your receiver, had you ever thought about how much energy your receiver uses?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

98. Don't know
99. Refused

[IF Q6≠1 AND Q7≠1]
Q24. Have you ever thought about how much energy your receiver uses?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

98. Don't know
99. Refused

[If Q23=1 or Q24=1]
Q25. What brought your receiver's energy use to your attention?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q2=1]
Q26. Now I'd like to hear more about your satisfaction with your experience. Using a scale from 1 to 5 where 1 is 'not at all satisfied' and 5 is 'extremely satisfied', how satisfied are you with:

1. The performance of the new receiver
2. [IF Q21 = 1, 2 OR 3]The new features in your receiver [include NA]

3. [IF (Q11 ≠ 1 AND 3) AND (Q6 ≠ 1 AND Q12 ≠ 1)] The price you paid for the new receiver, including installation
4. [IF Q23 = 1 or Q24 = 1] The energy consumption of your new receiver

[IF Q6= 1 OR Q14=1]
Q27. SCE is evaluating the offer to replace people's receivers to see if they could broaden its appeal. I'd like to hear your feedback on the offer itself. If SCE and other cable and satellite service providers made this offer available to their customers, would you recommend it to your family and friends?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q6= 1 OR Q14=1]
Q28. Now that you have received your new receiver, what, if anything, about the offer of a new receiver and the experience of getting it could have been improved?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[IF Q7=1 AND Q14=2]

Q29. What, if anything, about your current receiver do you not like? [*Do not read, select all that apply*]

1. Nothing
2. Performance
3. Lack of functions
4. Energy consumption
5. Appearance
6. Compatibility with your television or other devices
7. Other:
98. Don't know
99. Refused

F.5. Demographics

Thank you, we're almost done. I have just a few more questions for classification purposes only.

[ASK ALL]

Q30. How many televisions do you have in your home?

[SINGLE RESPONSE]

1. Response Text [FORCE NUMERIC RESPONSE]

[*Do not read:*]

9998. Don't know
9999. Refused

[ASK ALL]

Q31. Thinking of the TV that your household uses the most, about how many hours is that TV on during a typical day? [If NEEDED: Your best estimate is fine.]

[SINGLE RESPONSE]

1. Response Text [FORCE NUMERIC RESPONSE]

[*Do not read:*]

9996. Other, please specify: [OPEN-ENDED RESPONSE]
9998. Don't know
9999. Refused

[IF 0 > 1]

Q32. AND NOW THINKING OF THE TV YOUR HOUSEHOLD USES NEXT MOST OFTEN, ABOUT HOW MANY HOURS IS THAT TV ON DURING A TYPICAL DAY? [If NEEDED: Your best estimate is fine.]

1. [FORCE NUMERIC RESPONSE]

[*Do not read:*]

98. DON'T KNOW
99. REFUSED

[IF 0 > 2]

Q33. Now, thinking of all the rest of the TVs in your household, in total, about how many hours are they on during a typical day? [If NEEDED: Your best estimate is fine.]

1. [FORCE NUMERIC RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]
Q34. Do you leave your receiver(s) plugged in or on at all times?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q2 =1]

Q35. HOW, IF AT ALL, HAS THE AMOUNT OF TV YOUR HOUSEHOLD WATCHES ON A TYPICAL DAY CHANGED SINCE YOU GOT YOUR NEW RECEIVER?

1. IT HAS INCREASED: [SPECIFY AMOUNT OF HOURS]
2. IT HAS DECREASED: [SPECIFY AMOUNT OF HOURS]
3. IT HAS NOT CHANGED
98. DON'T KNOW
99. REFUSED

[IF Q35 =1 OR Q35 = 2]
Q36. Why did the amount of TV your household watches [increase/decrease]?

1. [OPEN-ENDED RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]
Q37. Does anyone in your household use a device other than your service provider's receiver to play streaming media content from the Internet on a TV screen?

[SINGLE RESPONSE]

1. Yes
2. No

[*Do not read:*]

98. Don't know
99. Refused

[IF Q37 = 1]

Q38. What kind of devices does your household use?

[Y/N – READ ALL]

1. A streaming media device like Apple TV, Roku, or Google Chromecast
2. The TV's built-in internet connectivity
3. A game console
4. A computer connected to the TV

[*Do not read:*]

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[ASK ALL]

Q39. How long have you had your service provider's service at your home?

1. [OPEN-ENDED RESPONSE; SPECIFY WHETHER YEARS OR MONTHS]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]

Q40. And how long have you had any type of paid TV service, like cable or satellite, at your home?

1. [OPEN-ENDED RESPONSE; SPECIFY WHETHER YEARS OR MONTHS]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]

Q41. Including yourself, how many people normally live in your household? Please don't include anyone who is just visiting, away at college, or away in the military. Do include all household members, including children.

1. [FORCE NUMERIC RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]

Q42. What is the highest level of education you have completed?

1. Less than high school graduate
2. High school graduate or equivalent (e.g. GED)
3. Some college (including Associates degree, trade or technical school)
4. College degree (Bachelor's degree)

5. Graduate or professional degree or higher
98. Don't know
99. Refused

[ASK ALL]

Q43. And finally, in what year were you born?

1. [FORCE NUMERIC RESPONSE]

[*Do not read:*]

98. Don't know
99. Refused

[ASK ALL]

Q44. Gender [do not ask, record]

1. Female
2. Male
3. Unclear

Thank you for your time.