



**Connecticut Consumer Electronics
Potential Study
Quantitative Literature Review
*Study R84***

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**Submitted to:
Connecticut Energy Efficiency Board**

**Submitted by:
NMR Group, Inc.**

Contents

EXECUTIVE SUMMARY	I
1 INTRODUCTION.....	1
2 METHODS AND BACKGROUND	2
2.1 METHODOLOGY	2
2.2 PRODUCT CATEGORIES AND ENERGY CONSUMPTION.....	3
2.3 SPECIFICATIONS, RECOGNITIONS, AND STANDARDS.....	5
3 ENERGY SAVINGS OPPORTUNITIES	8
3.1 METHODOLOGY FOR ESTIMATING SAVINGS	9
3.2 TELEVISIONS	10
3.3 SET-TOP BOXES	13
3.4 PERSONAL COMPUTERS.....	15
3.5 NETWORK EQUIPMENT	18
3.6 GAME CONSOLES	20
3.7 ADVANCED POWER STRIPS.....	23
4 MARKET CONSIDERATIONS	24
4.1 ENERGY STAR MARKET PENETRATION.....	24
4.2 PRODUCT-SPECIFIC CONSIDERATIONS	25
4.3 ESTIMATED TECHNICAL ENERGY SAVINGS POTENTIAL	28
5 CONCLUSIONS AND RECOMMENDATIONS.....	30
5.1 OVERALL FINDINGS	30
5.2 TELEVISIONS	32
5.3 SET-TOP BOXES.....	33
5.4 PERSONAL COMPUTERS.....	34
5.5 NETWORK EQUIPMENT	35
5.6 GAME CONSOLES	36
5.7 ADVANCED POWER STRIPS.....	36
APPENDIX A ACRONYMS.....	1
APPENDIX B REFERENCES	1

Tables

TABLE 1: CONSUMER ELECTRONICS PRODUCT CATEGORIES – ANNUAL ENERGY USAGE AND INSTALLED BASE	4
TABLE 2: ENERGY EFFICIENCY SPECIFICATIONS, RECOGNITION EFFORTS, AND STANDARDS BY PRODUCT CATEGORY	7
TABLE 3: ENERGY SAVINGS OPPORTUNITIES – TELEVISIONS.....	11
TABLE 4: ENERGY SAVINGS OPPORTUNITIES – SET-TOP BOXES.....	14
TABLE 5: ENERGY SAVINGS OPPORTUNITIES – PERSONAL COMPUTERS	16
TABLE 6: ENERGY SAVINGS OPPORTUNITIES – NETWORK EQUIPMENT	19
TABLE 7: ENERGY SAVINGS OPPORTUNITIES – GAME CONSOLES	21
TABLE 8: CONSUMER ELECTRONICS PRODUCT CATEGORIES – ENERGY STAR MARKET PENETRATION (2013).....	24
TABLE 9: ESTIMATED US TV ENERGY CONSUMPTION FROM 1995 TO 2013.....	26
TABLE 10: ESTIMATED TECHNICAL ENERGY SAVINGS POTENTIAL FROM IDEAL POWER MANAGEMENT ON INSTALLED DESKTOP PCs	29
TABLE 11: ACRONYMS	1

Executive Summary

In 2013, residential consumer electronics consumed 169 TWh or 12% of total residential electricity consumption for the US. Together, five product categories represent three-quarters of the total US residential energy consumption of consumer electronics: televisions (TVs), set-top boxes (STBs),¹ personal computers (PCs), network equipment,² and video game consoles (game consoles).³

To identify the potential for a residential consumer electronics program in Connecticut, NMR Group, Inc. (NMR) conducted a literature review for the Energy Efficiency Board (EEB).⁴ To this end, NMR researched literature published between 2012 and 2014 and used this information to estimate potential energy savings associated with consumer electronics measures. In addition to reporting these findings, this report, to some extent, contextualizes the savings measures within the confines of market barriers that might affect willingness to participate, market trends that might increase chances of free ridership, and saturation rates that might limit the technical potential for a program to make an impact in the territory.

Many of the findings suggest that the EEB may benefit from commissioning a more detailed consumer electronics potential study in the future. Ideally, a future study would provide greater detail on both program and energy savings potential through one of the following methods: 1) qualitative research involving activities such as in-depth interviews; 2) quantitative research, potentially using surveys with market actors, performing home site visits, or conducting secondary data analyses, if possible; or 3) both types of research.

NMR focused on the top five energy-consuming consumer electronics products (listed above) that could yield reasonably high per-unit or per-household energy savings. For each product category, the team found at least one measure that could be implemented in the near term. Some of the most promising measures and NMR's suggested considerations and recommendations related to these measures are as follows:

¹ STBs are devices whose primary function is to receive TV signals so that programs can be watched or recorded. STBs vary in type and functionality: cable, satellite, internet-protocol, media streaming, smart TV equipment, etc.

² Residential network equipment generally refers to two primary equipment types: 1) broadband access devices, which connect subscribers with high-speed internet, and 2) local area network (LAN) devices, such as routers, that allow consumer electronics within the household to communicate with each other.

³ Fraunhofer USA Center for Sustainable Energy Systems (Fraunhofer). "Energy Consumption of Consumer Electronics in U.S. Homes in 2013." June 2014.

⁴ To date, neither the United Illuminating Company (UI) nor Connecticut Light and Power (CL&P, a Northeast Utilities Company) (collectively referred to as the Companies) administers a consumer electronics energy efficiency incentive program. The Companies' current efforts for consumer electronics include guidance on the Energize Connecticut Website to visit TopTen USA's (TopTen) Website for listings of the most energy-efficient products (these include televisions, displays, and personal computers). While not formally announced, the TopTen program is expected to draw to a close in the near future so program efforts drawing on it will need to be revised. *Source:* Energize Connecticut. "ENERGY STAR Retail Products: Save with ENERGY STAR Products." Accessed July 2, 2014. <http://energizect.com/residents/programs/energy-star%C2%AE-appliances>.

- **Televisions (TVs).** The team estimated that replacing older installed TV models with new “best-in-class” models could offer sizable savings over the installed base. Depending on size, upgrading to new ENERGY STAR® Most Efficient TVs could offer 38% savings in UEC when compared to standard new TV models (Section 3.2). If the EEB wishes to address TVs through a consumer electronics program, it might consider investigating the potential of offering TV recycling programs and incentives based on labels and recognition programs directed at end-users, retailers, and distributors. Because of high ENERGY STAR market penetration (Section 2.3), it may be preferable that models eligible for program incentives meet efficiency levels greater than ENERGY STAR’s minimum specifications or leverage ENERGY STAR’s Most Efficient list, which recognizes the highest efficiency TVs.
- **Set-top boxes (STBs).** The following two measures for reducing STB energy consumption stand out as potential near-term measures that do not require partnerships with groups like manufacturers or media service providers and appear realistic to implement: 1) Reconfiguring high-consuming multi-room STB configurations by replacing the non-primary devices with low-power thin-client devices that have the same functionality could potentially reduce annual UEC of those non-primary units by 52%; 2) Selecting ENERGY STAR models could offer savings of 45% over standard models (Section 3.3).⁵ NMR concludes that addressing STBs through end-user incentives, however, may be inappropriate due to certain market dynamics. First, on top of already high ENERGY STAR market penetration, an important voluntary agreement signed by media service providers will likely result in even higher market penetration of ENERGY STAR models (Section 2.3). Second, consumers may not be able to opt for energy-efficient STB models or engage in energy savings behaviors due to the level of control that media service providers have over STB model selection and time spent in off modes (Section 4.2).
- **Personal Computers (PCs).** NMR found that optimizing power management settings for the installed base of desktop PCs could possibly result in savings of 144 kWh/year among installed desktop PCs (Section 3.4) and, if successfully implemented in all households where the measure is not already implemented, it could have the technical potential to save 43.4 GWh/year in Connecticut as a whole (Section 4.3).⁶ If the EEB were to use this intervention, it might like to use consumer education campaigns on optimizing power management and/or use direct-installation efforts, perhaps as part of a home energy audit visit for another program. However, some factors, such as decreasing desktop PC sales and increasing efficiency of laptop PCs, could present diminishing opportunities to

⁵ If the Companies have interest in pursuing this further, a potential next step could be to conduct interviews with media service providers operating in Connecticut to learn about the types of devices that they currently offer or provide.

⁶ The team emphasizes that achieving participation in 100% of households without the measure already implemented is an unrealistic scenario.

claiming sizable program savings and achieving adequate participation rates for a PC program (Section 4.2).

- **Network Equipment.** Replacing the installed base of network equipment⁷ with high efficiency equipment may generate notable savings (34%) (Section 3.5). Running equipment recycling opportunities and offering incentives based on labeling and recognition programs directed at end-users, retailers, and distributors could facilitate implementing this measure. Additional research characterizing common configurations and household usage patterns would offer further insight into savings opportunities at the household and state levels; further research on network equipment market trends would also be essential.
- **Video Game Consoles (Game Consoles).** NMR advises against offering incentives for the purchase and sale of energy-efficient models of game consoles. Program efforts targeting game consoles may quickly become obsolete, in part because there are few game console models and manufacturers; even if one manufacturer increases the efficiency of its only model, program efforts to incentivize the purchase of energy-efficient models could result in easy free ridership. As a near-term effort, game console efficiency might be addressed through consumer education campaigns. For example, measures to decrease the consumption of game consoles, such as disabling connected standby, could provide savings of up to 100 kWh/year (Section 3.6).

In addition to the measures listed above, it may be worth further exploring the savings opportunities that advanced power strips (APSS) (also known as smart strips) could offer for each of these product categories. One study found that households could save 346 kWh/year, on average, by using highly sophisticated APSS with their home entertainment equipment (Section 3.7).⁸

⁷ Residential network equipment generally refers to two primary equipment types: 1) broadband access devices, which connect subscribers with high-speed internet, and 2) local area network (LAN) devices, such as routers, that allow consumer electronics within the household to communicate with each other.

⁸ For more details, see <http://www.nyserda.ny.gov/-/media/Files/EERP/Residential/Energy-Efficient-and-ENERGY-STAR-Products/Power-Management-Research-Report.pdf>.

NMR urges the EEB to take several influential factors into account in the process of considering or designing a consumer electronics program.

- First, while a measure might technically be able to reduce a product's energy consumption, it may be challenging to implement the measure given market dynamics. For example, the measure may have a limited appeal to market actors or may quickly become obsolete because of expected market changes.
- The EEB should keep abreast of changes in voluntary specifications and standards and factor them into any program-planning processes to reduce possibilities of free ridership and redundancy, increase savings opportunities, and streamline programs by leveraging specification structures.
- Staying informed of other relevant industry initiatives that could potentially be leveraged or could somehow diminish the importance or relevance of a potential program is also crucial to take into account in program planning. For example, during NMR's research, it came across an important collaborative effort between ENERGY STAR, program sponsors, retailers, and other stakeholders called the Retail Plug-Load Portfolio (RPP). RPP seeks to establish a nationwide suite (or platform) of ENERGY STAR products around which to target incentives.⁹

Researching these types of factors and staying informed could help drive decisions about which product categories to address and which measures are needed to address them.

Another essential area of future research may include a characterization of the consumer electronics equipment currently installed in Connecticut homes. The EEB may find it useful to conduct a saturation study in Connecticut like the one NMR conducted in Massachusetts¹⁰ (Section 4.3) to help determine the technical potential savings for implementing measures that are estimated to yield high per-unit or per-household energy savings. This quantitative research could involve telephone surveys with customers or home site visits to collect data on characteristics like the number and types of units installed or in use in Connecticut homes.¹¹

While this report did not conduct direct research on program implementation methods, the EEB may wish to examine the program models currently employed by other program administrators if it wishes to move forward with consumer electronics. For example, one program in New York uses a direct installation method with APSs that it has found to be successful. Other program administrators have also been offering direct incentive opportunities. It is in the evaluation

⁹ For more information see www.caltf.org/s/RPP-overview-presentation_Updated-9-17-ro0t.pptx.

¹⁰ In 2012, NMR conducted a consumer electronics saturation study for Massachusetts Program Administrators. For more details, see http://ma-eeac.org/wordpress/wp-content/uploads/Massachusetts-Residentail-Retail-Products_Consumer-Electronics-Saturation.pdf.

¹¹ A research effort involving home site visits could potentially be performed in conjunction with another study that involves collecting data on household characteristics through home site visits, such as a socket saturation study.

team's opinion that any program planning efforts in Connecticut would benefit from learning about the efforts of other programs.

1 Introduction

To identify the potential for a residential consumer electronics program in Connecticut, the Energy Efficiency Board (EEB) requested that NMR Group, Inc. (NMR) review relevant literature to assess the savings opportunities for the consumer electronics market. Currently, neither the United Illuminating Company (UI) nor Connecticut Light and Power (CL&P, a Northeast Utilities Company) (collectively referred to as the Companies) administers a consumer electronics energy efficiency incentive program.¹²

The primary objective of this literature review is to report estimated potential energy savings associated with consumer electronics measures. The report also includes some broad findings of how the consumer electronics market's dynamics might impact the effectiveness of program implementation.

The study focuses on consumer electronics product categories that, in 2013, represented the greatest source of potential savings from consumer electronics. Together, five product categories represent three-quarters of the total US residential energy consumption of consumer electronics: televisions (TVs), set-top boxes¹³ (STBs), personal computers (PCs), network equipment,¹⁴ and video game consoles (game consoles).¹⁵

¹² The Companies' current efforts for consumer electronics include guidance on the Energize Connecticut Website to visit TopTen's Website for listings of the most energy-efficient products (these include televisions, displays, and personal computers). While not formally announced, the TopTen program is expected to draw to a close in the near future so program efforts will need to be revised. *Source:* Energize Connecticut. "ENERGY STAR Retail Products: Save with ENERGY STAR Products." Accessed July 2, 2014. <http://energizect.com/residents/programs/energy-star%C2%AE-appliances>.

¹³ STBs are devices whose primary function is to receive TV signals so that programs can be watched or recorded. STBs vary in type and functionality: cable, satellite, internet-protocol, media streaming, smart TV equipment, etc.

¹⁴ Residential network equipment generally refers to two primary equipment types: 1) broadband access devices, which connect subscribers with high-speed internet, and 2) local area network (LAN) devices, such as routers, that allow consumer electronics within the household to communicate with each other.

¹⁵ Fraunhofer USA Center for Sustainable Energy Systems (Fraunhofer). "Energy Consumption of Consumer Electronics in U.S. Homes in 2013." June 2014.

2 Methods and Background

This section describes NMR’s approach to conducting this literature review and offers some background on consumer electronics and energy consumption.

2.1 Methodology

From June through September of 2014, NMR collected and analyzed existing literature that addressed the residential consumer electronics energy efficiency market. This literature review helps to identify the potential for a residential consumer electronics program in Connecticut. It is the first step in exploring the program and energy savings potential from consumer electronics in Connecticut.

By conducting a literature review, NMR sought to achieve the following objectives:

- To identify current factors affecting the energy efficiency of residential consumer electronics products and related savings opportunities
- To offer broad details characterizing, to some extent, the current state of the consumer electronics market—in particular for the products that account for the greatest proportions of residential electricity use
- To provide the EEB with recommendations on which products may make the strongest candidates for inclusion in a consumer electronics program, and possibly to suggest approaches for the design of a consumer electronics program in Connecticut
- To offer suggestions for a more detailed future consumer electronics potential study that will provide the EEB with greater detail on both program and energy savings potential from a possible consumer electronics program

The consumer electronics market is challenging to track, given the rapid development of new technologies and evolving consumer demands. As a result, some of the material presented here may become obsolete in the near term. The team attempted to limit the review only to literature published after 2011.¹⁶

¹⁶ One study was published in 2010; the team used this publication due to an absence of more recent data on the topic.

2.2 Product Categories and Energy Consumption

Fraunhofer USA Center for Sustainable Energy Systems (Fraunhofer) estimated that consumer electronics products represented 12% of the annual US residential electricity consumption in 2013, calculating that this sector accounted for 169 terawatt hours (TWh) of use that year.¹⁷

Table 1 presents findings related to the primary consumer electronics categories that Fraunhofer addressed in its research. The table lists energy consumption, unit energy consumption (UEC), average number of devices per household, and the percentage of households with the product installed or owned.

NMR chose to focus its research on the top five energy-consuming consumer electronics: TVs, STBs, PCs, network equipment, and game consoles; together, these products represent three-quarters of the total residential energy consumption of consumer electronics. Using Fraunhofer results, NMR calculated that the average household consumes between 9 kWh/year and 432 kWh/year for individual product categories (Table 1).

¹⁷ Fraunhofer. “Energy Consumption of Consumer Electronics in U.S. Homes in 2013.”

Table 1: Consumer Electronics Product Categories – Annual Energy Usage and Installed Base

Product Category	Typical Annual Energy Consumption (TWh/year)	Unit Energy Consumption (kWh/year)	Average Number of Units per Household (119M households)	Average Household Energy Consumption (kWh/year)*	Estimated Percentage of US Households with Product Installed or Used
Televisions	50	166	2.6	432	97%
Set-Top Boxes	31	105	1.7	179	85% (with pay-TV)
Personal Computers – <i>Desktop</i>	16	186	1.4	260	63%
Personal Computers – <i>Laptop</i>	4.9	53	1.9	101	65%
Network equipment	12	58	1.7*	99	75% – broadband access devices 62% – LAN devices
Game consoles	11	88	1.1*	97	51%
Home audio equipment	6.7	19 – speaker docks 75 – shelf stereos	1.8 – speaker docks 1.2 – shelf stereos	34 – speaker docks 90 – shelf stereos	45% – speaker docks 46% – shelf stereos
Computer monitors	5.6	58	0.8*	46	42%
Computer speakers	2.6	42	0.5*	21	18% – subwoofer 35% – without subwoofer
Mobile computing devices	1.4	4.5 – smartphones 6.1 – tablets	2.1 – smartphones 1.5 – tablets	9 – smartphones 9 – tablets	66% – smartphones 57% – tablets
Other devices	28				
Total	169				

Source: Fraunhofer. “Energy Consumption of Consumer Electronics in US Homes in 2013.”

Note: While figures are drawn from or based on Fraunhofer’s publication, the reader may note that some of these figures do not perfectly align with other figures presented in later sections of the report. This is as a result of the varying assumptions and testing methods that researchers used to estimate energy consumption. In following sections, NMR made every attempt to focus on a single source for each savings measure explored.

* NMR estimated these figures using Fraunhofer’s research results by employing the following formulas: [Installed Base / 119M Households = Number of Units per Household] and [UEC * Number of Devices per Household = Household Energy Consumption]. NMR’s figures should be interpreted with caution because they rely on secondary data and may not take into account the complexities that would be involved in creating estimates from primary data sources.

2.3 Specifications, Recognitions, and Standards

In considering a consumer electronics program, the EEB should be aware of voluntary specifications and standards. Factoring these efforts into a program-planning process reduces possibilities of free ridership and redundancy, increases savings opportunities, and streamlines programs by leveraging specification structures.

- **Specifications and Recognition Efforts.** Models are rewarded with the ENERGY STAR label if they meet ENERGY STAR specifications.¹⁸ ENERGY STAR addresses all of the product categories examined in this report: It has specifications for TVs, STBs, PCs, and network equipment and has a recognition program for game consoles. It is currently in the process of enhancing specifications for TVs and PCs and recently advanced STB specifications, which will go into effect in December of 2014.^{19,20} For recognition of the most efficient models on the market, ENERGY STAR addresses TVs in its Most Efficient products lists.^{21, 22}

¹⁸ Currently, there is another recognition program: TopTen USA (TopTen) which identifies and lists the ten most energy-efficient models on the market within a product category; for consumer electronics it recognizes TVs, PCs, and computer monitors in its energy efficiency recognition program. While not formally announced, the TopTen program is expected to draw to a close in the near future so this report does not address savings opportunities associated with it. *Sources:* 1) Correspondence with a Northeast Energy Efficiency Partnerships (NEEP) staff member. October 20, 2014 and 2) TopTen. Website. Accessed July 1, 2014. <http://www.toptenusa.org>.

¹⁹ ENERGY STAR. “All Certified Products.” Accessed July 1, 2014. http://www.energystar.gov/certified-products/certified-products?c=products.pr_find_es_products&s=mega.

²⁰ ENERGY STAR. “Game Console Version 1.0 Recognition Program.” Accessed July 3, 2014. https://www.energystar.gov/products/specs/game_console_version_1_0_recognition_program_pd.

²¹ In 2011, ENERGY STAR established “ENERGY STAR Most Efficient,” which recognizes the top 10% of efficient models for selected product categories. The Most Efficient program also recognizes computer monitors which are not examined in this report.

²² ENERGY STAR. “ENERGY STAR Most Efficient 2014.” Accessed July 1, 2014. http://www.energystar.gov/?c=most_efficient.me_index.

- **Voluntary Standards.** Voluntary standards are those that are agreed to by participating entities but have no legal or other ramifications if not met by their signatories. One highly publicized initiative, finalized in December of 2013, targets the advancement of energy efficiency for STBs through voluntary standards. The US Department of Energy (DOE), media service providers, device manufacturers, other industry representatives, and energy efficiency advocates signed the Set-top Box Energy Conservation Agreement. The agreement obligates service provider²³ and manufacturer signatories to encourage and improve the energy efficiency of STBs through a number of means. Specifically, this agreement requires that, starting in 2014, at least 90% of the new STBs purchased and deployed by participating companies meet ENERGY STAR Version 3.0 specifications.^{24,25}
- **Mandatory Standards.** Mandatory energy efficiency standards prohibit models that do not meet the standards from being sold in the market within their area of jurisdiction. According to the Appliance Standards Awareness Project, no federal minimum energy efficiency standards are in place for TVs, STBs, PCs, network equipment, or game consoles.

On June 7, 2011, Connecticut General Assembly passed the energy reform legislation SB 1243. The bill makes energy efficiency standards for TVs (in addition to compact audio players, DVD players, and DVD recorders).²⁶ This makes Connecticut one of only three states with energy efficiency standards for TVs. No state standards exist for STBs, PCs, network equipment, or game consoles; however, California is in the process of developing standards for network equipment and game consoles.²⁷ Given that manufacturers' products are generally sold in more than one state, standards set in one state can influence the market for products sold in other states by increasing the efficiency levels of all available products even in the states not directly affected by the legislation.

²³ Most, but not all, of the media service providers in Connecticut were signatories, such as Cablevision Systems Corp., Comcast Cable Communications, LLC., Charter Communications, Inc, and Cox Communications, Inc. Other smaller media service providers in Connecticut, such as MetroCast, were not signatories.

²⁴ US DOE. "US Energy Department, Pay-Television Industry and Energy Efficiency Groups Announce Set-Top Box Energy Conservation Agreement; Will Cut Energy Use for 90 Million US Households, Save Consumers Billions." Press Release. December 23, 2013. Accessed June 12, 2014. <http://www.energy.gov/articles/us-energy-department-pay-television-industry-and-energy-efficiency-groups-announce-set-top>.

²⁵ ENERGY STAR Version 4.1 will go into effect at the end of 2014; however, the stipulation in the agreement is still based on Version 3.0.

²⁶ Brownrudnick. "Connecticut Energy Reform Legislation – Summary of SB 1243." 2011. http://www.brownrudnick.com/uploads/114/doc/Brown_Rudnick_Connecticut_Energy_Reform_Legislation_Summary_of_SB_1243_6-11.pdf.

²⁷ 1) Appliance Standards Awareness Project. "Products." Accessed July 2, 2014. <http://www.appliance-standards.org/products#residential>. 2) NRDC. "California Moving Forward on 15 New Appliance Efficiency Standards." Pierre Delforge's Blog. March 19, 2014. Accessed January 11, 2015. http://switchboard.nrdc.org/blogs/pdelforge/california_moving_forward_on_1.html.

Table 2 presents additional details organized by product category.

Table 2: Energy Efficiency Specifications, Recognition Efforts, and Standards by Product Category

Product Category	ENERGY STAR Specifications	Recognition Efforts	Voluntary Standards	Mandatory Standards
Televisions	Version 6.1 – Effective June 2013 (7.0 in process)	TopTen* and ENERGY STAR Most Efficient	None	No federal standards; Connecticut, California, and Oregon have their own standards
Set-Top Boxes	Version 3.0 – Effective September 2011; (Version 4.1 – Effective December 2014)	None	Set-top Box Energy Conservation Agreement signed December 2013	None**
Personal Computers	Version 6.0 – Effective June 2014 (6.1 in process)	TopTen*	None	None
Network Equipment	Version 1.0 – Effective November 2013	None	None	None†
Game Consoles	None	ENERGY STAR Version 1.0 Recognition Program – Released March 2013	None	None†

Sources: 1) ENERGY STAR. “All Certified Products.” 2) ENERGY STAR. “ENERGY STAR Most Efficient 2014.” 3) TopTen. Website. 2014. 4) ENERGY STAR. “Game Console Version 1.0 Recognition Program.” 5) US DOE. “Set-Top Box Energy Conservation Agreement.” 6) Appliance Standards Awareness Project. “Products.” 7) US DOE. “Rulemaking for Set-top Boxes Energy Conservation Standards and Test Procedure.” Accessed July 2, 2014. http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/33 8) US Office of Energy Efficiency & Renewable Energy. “Standards and Test Procedures.” Accessed August 14, 2014. <http://energy.gov/eere/buildings/standards-and-test-procedures>. 9) NRDC. “California Moving Forward on 15 New Appliance Efficiency Standards.”

* While not formally announced, the TopTen program is expected to draw to a close in the near future so this report does not address savings opportunities associated with it.

** Shortly after the Set-top Box Energy Conservation Agreement became official, US DOE withdrew a proposal for STB standards.

† California has proposed standards to be ruled on in 2015 with draft standards for network equipment and game consoles due in February.

3 Energy Savings Opportunities

The primary objective of this literature review is to outline estimates of energy savings measures for consumer electronics. This section investigates savings measures for the five key product categories of interest: TVs, STBs, PCs, network equipment, and game consoles. It also devotes some discussion to one energy-saving technology in particular—APs.²⁸ Product by product, the sections present energy savings measures, the savings associated with the measures, high-level explanations of savings calculations, and potential program implementation approaches.

Despite having the potential to generate savings, some measures presented may not be realistic for programs to address in the short term. For example, measures that would involve influencing manufacturers or policymakers are more likely longer-term savings opportunities, whereas measures like downstream or midstream incentives, consumer education campaigns, or recycling programs are comparatively easier for a program to address in the short term. The measures included in this section are categorized as either long-term or short-term based on the suggested strategies for addressing them.

For nearly all product categories, offering midstream or downstream incentives for ENERGY STAR models is a method for achieving savings. However, it is worth noting preemptively that ENERGY STAR has a high market penetration rate among consumer electronics products. Three of the product categories that NMR investigated in this report were included in ENERGY STAR's market penetration report for 2013: TVs, STBs, and PCs. TVs (84%) and STBs (89%) had the highest market penetration in 2013.²⁹ High market penetration rates increase the likelihood of program free ridership. As a result, the team suggests that if programs incorporate the ENERGY STAR label into their program design, they may wish to require that models reach a certain percentage in efficiency over ENERGY STAR's minimum requirement or that they are recognized by ENERGY STAR Most Efficient (if applicable). Section 4 discusses this and additional considerations of the market that might influence the effectiveness of a program design.

²⁸ Similar to standard power strips, APs provide savings over standard power strips through some form of master switch that turns power outlets on or off.

²⁹ ENERGY STAR market penetration is the ratio of ENERGY STAR units shipped to the number of total units shipped in a given year within the US. *Source:* ENERGY STAR. "ENERGY STAR Unit Shipment and Market Penetration Report: Calendar Year 2013 Summary." Accessed August 12, 2014. https://www.energystar.gov/index.cfm?c=partners.unit_shipment_data

3.1 Methodology for Estimating Savings

NMR largely relied on the following four sources that suggested savings measures and quantified their associated savings for the five product categories of interest:

- Northwest Energy Efficiency Alliance (NEEA) published savings calculation tools for TVs, STBs, and PCs. These tools were made available in 2012, but they make projections for each year through 2014.
- Natural Resources Defense Council (NRDC) conducted research on the energy consumption and savings possibilities associated with network equipment and game consoles.
- Northeast Energy Efficiency Partnerships (NEEP) published a report outlining a strategy for the Northeast states to address the energy efficiency of consumer electronics. The report offers quantitative consumption and savings figures as well as a market assessment and recommendations.
- ENERGY STAR's product-specific web pages report the percentages of savings available from selecting ENERGY STAR models over standard models.

NMR made every effort to use the calculations of previous researchers to estimate energy savings both in terms of kilowatt hours and savings percentages. However, in many instances, NMR needed to perform its own calculations to arrive at either the kilowatt hours or savings percentages. The information presented in this section does its best to clarify where NMR made these estimates and how the team went about making the calculations.

Given that these publications drew on differing research methods, calculation inputs are sometimes inconsistent across sources. These differences are not surprising, considering the rapid changes in this market and the variation in equipment configurations. To minimize confusion and “stay true” to a research group's methods, NMR attempted to limit calculation inputs for a given savings measure to as few sources as possible. One example of this approach is as follows:

- NEEA estimated that TV brightness optimization could save 35 kWh/year per installed TV.
- NMR's next step was to translate the 35 kWh/year to a percentage saved by comparing it with the average UEC of an installed TV.
- In the process of making this calculation, NMR noted vast differences in estimated average UEC among the installed base of TVs: NEEA estimated it to be 256 kWh/year per TV, while Fraunhofer estimated it to be 166 kWh/year per TV.

- To estimate percentage of consumption saved resulting from implementing brightness optimization, NMR compared NEEA’s savings estimate (35 kWh/year) to NEEA’s own UEC estimate (256 kWh/year), arriving at 14% potential savings ($35 / 256 = 14\%$).³⁰

3.2 Televisions

Table 3 lists measures that could be taken to reduce TV energy consumption (As shown in the table, NEEA investigated the savings associated with most of these measures). The measures are varied, including selecting new models based on labeling and recognition, replacing the installed base of TVs, or a number of specific technical changes to the design of TVs. Measures 1 and 2 may have the potential to generate the most savings. The first measure suggests the purchase of models that are labeled or recognized as energy-efficient instead of purchasing *new* standard models; for example, selecting new ENERGY STAR Most Efficient 60” TVs might offer 38% savings in UEC compared to standard new TV models of the same size. Replacing older installed TV models larger than 32” (Measure 2—early retirement) with new “best-in-class” 42” models that are included in ENERGY STAR’s Most Efficient list could offer 35 kWh/year UEC over the installed base. Both of these measures could be addressed in the short term—such as through incentives based on labels and recognition programs directed at end-users, retailers, and distributors and TV recycling programs—and, therefore, could result in claimable savings.

³⁰ As described previously, NMR used Fraunhofer’s energy consumption and related figures to help identify the product categories on which to focus this report; Fraunhofer’s study focused on energy consumption and usage of all of the product categories of interest. Fraunhofer’s UEC estimates are generally different from those of the other researchers. Because Fraunhofer does not address savings measures and the issues discussed here, NMR chose to limit utilizing Fraunhofer’s consumption estimates in this section to increase consistency in estimates within a savings measure.

Table 3: Energy Savings Opportunities – Televisions

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
1) Labeled or Recognized Models	Purchase TV models meeting ENERGY STAR specifications or percentages above ENERGY STAR specifications or recognized by ENERGY STAR Most Efficient.	43 kWh/year or more than 25% savings in average UEC of <i>new</i> units (if purchasing ENERGY STAR)	-ENERGY STAR estimated that ENERGY STAR models are, on average, more than 25% more energy-efficient than standard models. -For example, the 2014 Connecticut Program Savings Document estimated that 40” ENERGY STAR TV models represent 43 kWh/year in UEC savings over standard 40” models.	Midstream and downstream incentives for models meeting ENERGY STAR specifications or percentages above ENERGY STAR specifications, or recognized by ENERGY Most Efficient*
		70 kWh/year or more than 38% savings in average UEC of <i>new</i> units (if purchasing ENERGY STAR Most Efficient)	For example, NEEP reported that ENERGY STAR Most Efficient 60” TV average UEC is 113 kWh/year. They compare this to “baseline” TVs of the same size which consume 183 kWh/year, offering savings of 70 kWh/year.	
2) Early Retirement	Overhaul existing TV fleets to replace older, less efficient models with new best-in-class high efficiency models.	35 kWh/year or 31% savings in average UEC of <i>replaced</i> units	-NEEA estimated that TVs larger than 32” manufactured before 2006 (prior to the passing of Connecticut’s 2011 TV efficiency standard) and used for 3 hr/day consume 113 kWh/year. They suggested replacing those units with best-in-class TVs and assumed that new TVs are used 5 hr/day. -Fraunhofer reported that the weighted average TV size was 34”, so NMR researched the energy consumption of best-in-class models around this size. NEEP reported that ENERGY STAR Most Efficient 42” TV average UEC is 78 kWh/year.**	TV recycling incentive program in combination with midstream and downstream incentives for models included in ENERGY STAR Most Efficient list
3) Brightness Optimizing	Manually optimize the brightness settings on installed TVs so they are only as bright as they need to be and will, in effect, use less energy.	35 kWh/year or 14% savings in average UEC of <i>installed</i> units	NEEA estimated that the average installed base UEC is 256 kWh/year and that optimizing brightness in the installed base would save 35 kWh/year. †	Consumer education campaigns to adjust settings; direct installation of adjusted settings
4) Automatic Brightness Control (ABC) Capability	Increase penetration of TVs with an ABC feature that adjusts the brightness of the screen based on the brightness of the room to decrease consumption.	8 kWh/year or 12% savings in average UEC of <i>new ENERGY STAR</i> units <i>without ABC</i>	NEEA estimated that the average new ENERGY STAR TV that does not currently include the ABC feature uses 69 kWh/year. They found that including ABC in ENERGY STAR models could save nearly 8 kWh/year.	Consumer education campaigns to enable ABC; midstream and downstream incentives for the purchase/sale of ABC-enabled units

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
5) Occupancy Sensing Technology	Include occupancy sensing technology that employs Auto-Power Down (APD) to automatically turn off the unit if no one is in the room.	13 kWh/year or 11% savings in average UEC of <i>new</i> units	NEEA estimated that the average new TV UEC is 121 kWh/year, and offering occupancy sensing technology could save 13 kWh/year.	Partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)
6) Efficiency Tips	Add efficiency tips to TV settings menus.	12 kWh/year or 10% savings in average UEC of <i>new</i> units	NEEA estimated that the average new TV UEC is 121 kWh/year, and adding efficiency tips could save 12 kWh/year.	

Sources: 1) Northwest Energy Efficiency Alliance (NEEA). “Energy Savings Opportunities and Market Descriptions for Four Residential Consumer Electronics Products: NEEA TV Savings Calculation Tool.” Spreadsheet. September 2012. Accessed August 4, 2014. <http://neea.org/resource-center/market-research-and-evaluation-reports?topic=532330ab-8fe1-4a25-bfe7-ad8cc53f2e28&sort=PublicationDate+DESC> 2) ENERGY STAR. “Televisions for Consumers: Overview.” Accessed August 4, 2014. <http://www.energystar.gov/certified-products/detail/televisions> 3) Northeast Energy Efficiency Partnerships (NEEP). “Business & Consumer Electronics: A Strategy for the Northeast.” August 2013. http://neep.org/Assets/uploads/files/market-strategies/BCE/2013%20BCE%20Strategy_FINAL.pdf 4) United Illuminating (UI) and Connecticut Light & Power Company (CL&P). “Connecticut Program Savings Document: 9th Edition for 2014 Program Year.” January 6, 2014. Received July 22, 2014. 5) Fraunhofer. “Energy Consumption of Consumer Electronics in US Homes in 2013.”

Note: 1) Measures shaded in grey are longer-term options; measures without shading are those which the Companies could, if desired, implement in the shorter term and do not require influencing manufacturers, legislators, or other entities. 2) NMR calculated savings for measures using several secondary sources; therefore, results should be interpreted with caution, as figures do not align across sources. 3) The implementation strategies reflect a mixture of suggestions from the literature and NMR’s own insights.

* Midstream incentives refer to incentives directed at retailers or distributors for the shipping, sale, or purchase of a given product, and downstream incentives refer to incentives directed at end-users or customers for the purchase of a given product.

** Consumers purchasing new TVs are reportedly opting for larger sized TVs more frequently—thus possibly reducing the estimated savings. *Source:* NMR. “Massachusetts Consumer Electronics Potential Qualitative Research Study.”

† NEEA associated TVs manufactured before 2006 with a UEC of 113 kWh/year. In looking at the *entire* installed base of TVs, they estimated that the average UEC of the installed base of TVs is 256 kWh/year. This vast discrepancy may be attributed to the likely increases in size and expansion of higher-consuming features in recent years. NEEA also makes the assumption that older TVs are used for fewer hours per day when compared to new TVs (3hr vs. 5hr) which may also impact consumption.

3.3 Set-Top Boxes

Table 4 presents measures that could decrease the energy consumption associated with STBs. The measure that apparently represents the greatest savings—although likely not a feasible program strategy—would involve entirely eliminating the use of pay-TV service that uses cable or satellite STBs. NEEA suggests that this could reduce a household’s energy consumption by 180 kWh/year—a 90% savings. A more realistic measure—reconfiguring high-consuming multi-room STB configurations by replacing the non-primary devices with low-power “thin-client” devices with the same functionality—could reduce annual UEC of those non-primary units by 52%. Another effective way to reduce STB consumption would be through selection of ENERGY STAR models: ENERGY STAR reports that ENERGY STAR STBs offer savings of 45% over standard models.³¹

These three top-saving measures could be addressed similarly to those suggested for TVs, including recycling programs, midstream (directed at retailers, media service providers, and distributors), and downstream incentives, and consumer education campaigns. Measure 4, incorporating “light sleep,” would likely require cooperation and partnerships with media service providers, policymakers, specification and standard setting entities, and manufacturers—all longer-term approaches.

³¹ The Set-top Box Energy Conservation Agreement attempts to ensure that 90% of deployed/purchased units shall meet ENERGY STAR V3.0 specifications—meaning that addressing ENERGY STAR V3.0 may be irrelevant because of changes in market share. ENERGY STAR V4.1 specifications for STBs, which go into effect at the end of 2014, could present additional potential savings. It is unclear how much more savings these models will create.

Table 4: Energy Savings Opportunities – Set-Top Boxes

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
1) Pay-TV Discontinuation	Remove the need for cable and satellite STBs by transitioning households to media streaming devices.	180 kWh/year or 90% savings in average <i>household</i> consumption	NEEA estimated that the average <i>household</i> energy consumption from cable and satellite STBs is 200 kWh/year, whereas two Apple TVs, which could eventually replace pay-TV service as their capabilities continue to expand, together consume 20 kWh year.*	Consumer education campaign; midstream and downstream incentives for purchasing/selling media streaming devices; STB recycling program
2) Multi-Room STB Replacement	Replace secondary/additional STB units with low-power thin-client boxes.	64 kWh/year or 52% savings in average UEC of <i>replaced</i> units	NEEA estimated that high definition (HD)** STB UEC is 124 kWh/year and thin-client UEC is 60 kWh/year.	Midstream and downstream incentives for purchasing/selling/deploying low-power thin-client boxes; STB recycling program
3) Labeled Models	Purchase STB models meeting ENERGY STAR specifications or percentages above those specifications.	54 kWh/year or 45% savings in average UEC of <i>new</i> units	-ENERGY STAR published that ENERGY STAR models represent a 45% savings over standard models. -The Connecticut Program Savings Document indicated that ENERGY STAR STBs represent 54 kWh/year UEC savings over standard models.	Midstream and downstream incentives for purchase/sale/deployment of STB models meeting ENERGY STAR specifications or percentages above those specifications
4) Incorporation of “Light Sleep” Mode	Reduce power level in sleep mode through a light sleep mode.	More than 25 kWh/year or 20% savings in average installed HD STB UEC	-NCTA reported that downloading light sleep software on STBs that do not already have the feature increases savings by more than 20%. -NEEA estimated that HD STB UEC is 124 kWh/year. -For the purposes of analysis, NMR assumed that the average HD STB does not have a light sleep mode feature and applied a figure of 20% savings to estimate 25 kWh of possible savings.	Upstream incentives; partnership with media service providers, policymakers, specification and standard setting entities, and manufacturers (non-incentive based)

Sources: 1) NEEA. “Energy Savings Opportunities and Market Descriptions for Four Residential Consumer Electronics Products: NEEA Media Savings Calculation Tool.” Spreadsheet. September 2012. Accessed June 10, 2014. <http://neea.org/resource-center/market-research-and-evaluation-reports?topic=532330ab-8fe1-4a25-bfe7-ad8ce53f2e28&sort=PublicationDate+DESC> 2) ENERGY STAR. “Set-top Boxes & Cable Boxes for Consumers.” Accessed August 4, 2014. http://www.energystar.gov/certified-products/detail/set_top_boxes_cable_boxes 3) UI and CL&P. “Connecticut Program Savings Document: 9th Edition for 2014 Program Year.”

Note: 1) Measures shaded in grey are longer-term options; measures without shading are those that the Companies could implement in the shorter-term and that do not require influencing manufacturers, legislators, or other entities. 2) NMR calculated savings for measures using several secondary sources; as a result, results should be interpreted with caution. 3) The implementation strategies reflect a mixture of suggestions from the literature and NMR’s own insights.

* Satellite and cable STBs provide live programming by turning a satellite signal into content or delivering content through cables that can be shown on a TV/display. Media streaming devices such as Apple TV can often be referred to as STBs; they connect to a TV and wireless network to stream content without having to store or download any video files, but the content generally is not “live,” as it is from a satellite or cable provider. While NEEA had estimated savings using the assumption that two Apple TVs would replace a household’s cable or satellite pay-TV, other media streaming devices could also be explored, such as Roku or Google Chromecast. The savings of these or other media streaming devices are not explored in this research.

** High definition STBs refer to STBs that allow televisions to display the picture in high resolution, presenting a clearer picture with a greater number of pixels.

3.4 Personal Computers

Table 5 shows suggested savings measures for PCs. Based on research, optimizing power management settings (adjusting settings to increase efficiency) for the installed base of desktop PCs could possibly result in savings of 144 kWh/year for installed desktop PCs. The second largest technical savings opportunity was the purchase of ENERGY STAR desktop PCs over standard desktop PC models, offering savings of 77 kWh/year in average UEC.

The first measure—achieving ideal power management on the installed base—would need to be addressed through consumer education and/or direct installation efforts. The second measure—encouraging the sale of models meeting or exceeding ENERGY STAR labels—could be implemented by offering incentives to end-users, retailers, and distributors. The other measures would probably need to be part of a long-term program strategy, involving partnerships with policymakers, specification and standard setting entities, and manufacturers; these approaches would likely not result in program claimable savings.

Table 5: Energy Savings Opportunities – Personal Computers

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
1) Power Management Installation (Desktop PCs Only)	Achieve ideal power management on residential installed base.	144 kWh/year or 28% savings in average UEC of installed <i>desktop</i> PCs	<p>-Energy Center of Wisconsin estimated that the power management savings opportunities for desktop PCs were 2-396 kWh/year based on the usage patterns of PCs. For example, with PCs that are not turned on very often (15% of the market), power management could create 2 kWh/year in savings and TVs that are set to have long idle periods (40% of the market), power management could save 213 kWh/year.</p> <p>-NMR weighted the percentage of units Energy Center of Wisconsin reported that were associated with the different usage types, arriving at a weighted savings of approximately 167 kWh/year in UEC and a weighted total consumption without measure of 348 kWh/year. Using these figures, NMR assumed that the measure represented 48% savings <i>at the time of publishing</i> (2010).</p> <p>-NEEA assumed that savings opportunities associated with this measure would decrease by 5% each year because of retiring old units, estimating that an average UEC savings of 144 kWh/year could be achieved in 2014 (the most recent year for which they made estimates).</p> <p>-NMR applied NEEA’s annual savings opportunity reduction rate (-5%), arriving at a 28% savings amount for 2014.</p>	Consumer education campaigns to adjust power management settings; direct installation of optimized power management settings
2) Labeled or Recognized Models	Purchase models meeting ENERGY STAR specifications or percentages above those specifications.	77 kWh/year or 32%, and 23 kWh or 31% savings in average UEC of new desktop and laptop PCs, respectively	<p>-NEEP reported that the standard desktop PC UEC is 239 kWh/year and that of the standard laptop PC is 66 kWh/year.</p> <p>-NEEP indicated that ENERGY STAR desktop PCs consume 162 kWh/year and laptop PCs consume 52 kWh/year.</p>	Upstream and downstream incentives for purchasing/selling models meeting ENERGY STAR specifications or percentages above those specifications
3) Power Supply Improvement (Desktop PCs Only)	Increase the efficiency of internal power supplies that convert AC power from the outlet to the DC power that is used by the PC.	31 kWh/year or 13% average UEC savings of <i>new desktop</i> PCs	<p>-NEEA estimated that the typical desktop PC requires 93 Watts, and when its internal power supply is improved it requires 85 Watts. Assuming units are in an idle state 45% of the time, NEEA calculated that improving the power supply could reduce desktop PC UEC by 31 kWh/year.</p> <p>-NEEA assumed that 10% of devices sold currently have this improved internal power supply efficiency. However, for the purposes of analysis, NMR compared NEEA’s estimated 31 kWh/year savings to NEEP’s baseline estimate of desktop PC consumption of 239 kWh/year, resulting in an estimated savings of 13%.</p>	Partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
4) Voltage Regulator Improvement (Desktop PCs Only)	Increase the efficiency of voltage regulators by going from the typical linear type of voltage regulator to a switching type.	29 kWh/year or 12% savings in average UEC of <i>new desktop</i> PCs	<p>-NEEA estimated that the typical desktop PC voltage regulator requires 31 Watts, and when it has been changed with a “switching” type, the voltage regulator requires 24 Watts. Assuming units are in an idle state 45% of the time, NEEA calculated that changing the voltage regulator could reduce desktop PC UEC by 29 kWh/year.</p> <p>-NEEA assumed that 1% of devices sold currently have switching voltage regulators. However, for the purposes of analysis, NMR compared NEEA’s estimated 29 kWh/year savings to NEEP’s baseline estimate of desktop PC consumption of 239 kWh/year, resulting in an estimated savings of 12%.</p>	

Sources: 1) NEEP. “Business & Consumer Electronics: A Strategy for the Northeast.” 2) NEEA. “Energy Savings Opportunities and Market Descriptions DDC42BF7F151.” Spreadsheet. September 2012. Accessed June 10, 2014. <http://neea.org/resource-center/market-research-and-evaluation-reports?topic=532330ab-8fe1-4a25-bfe7-ad8cc53f2e28&sort=PublicationDate+DESC> 3) Energy Center of Wisconsin. “Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes: A technical and behavioral field assessment.” May 2010. Accessed August 5, 2014. <http://www.ecw.org/publications/electricity-savings-opportunities-home-electronics-and-other-plug-devices-minnesota> 4) UI and CL&P. “Connecticut Program Savings Document: 9th Edition for 2014 Program Year.”

Note: 1) Measures shaded in grey are longer-term options; measures without shading are those that the Companies could implement in the shorter-term and that do not require influencing manufacturers, legislators, or other entities. 2) NMR calculated savings for measures using several secondary sources; therefore, results should be interpreted with caution. 3) The implementation strategies reflect a mixture of suggestions from the literature and NMR’s own insights.

3.5 Network Equipment

Table 6 shows potential measures to reduce the energy consumption of network equipment.³² Despite the fact that the UEC savings for these network equipment measures are fairly small, ranging from 3 kWh/year to 20 kWh/year, homes with network equipment often have more than one device—typically a modem and router configured together.³³ As such, greater savings opportunities are likely present. The biggest potential saver is apparently what is termed “next-generation” equipment—it includes advanced technologies (not yet available) that reduce power draw so that only the required amount of energy for a given activity is drawn at the time of the activity (often referred to as power scaling or voltage scaling); NRDC reported that this could save 80% of current network equipment consumption. This advancement would not be something that a program could incorporate in its near-term program strategy.

Other, more immediate program-relevant measures, like replacing the installed base with equipment as efficient as the top 25% of current equipment, also have the potential to generate notable amounts of savings (34%). More research examining common configurations, household ownership and usage patterns, and the role of media service providers would be helpful for gaining further insight into the savings opportunities at the household level.

As with measures for other product categories, near-term programmatic strategies for the other measures listed below could involve running equipment recycling opportunities, and offering incentives based on labels and recognition programs directed at end-users and midstream actors, like retailers, distributors, and media service providers. These strategies could possibly result in claimable savings.

³² Residential network equipment generally refers to two primary equipment types that allow users to use the internet and share data and information across devices: 1) broadband access devices, which connect subscribers with high-speed internet, and 2) local area network (LAN) devices, such as routers, that allow consumer electronics within the household to communicate with each other.

³³ NRDC. “Small Network Equipment Energy Consumption in US Homes: Using less energy to connect electronic devices.” NRDC Issue Paper. IP: 13-0-B. June 2013. Accessed August 12, 2014. <http://www.nrdc.org/energy/files/residential-network-IP.pdf>

Table 6: Energy Savings Opportunities – Network Equipment

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
1) Advanced Power Reduction Measures	Design devices to reduce overall power needs using power islands, voltage scaling, etc., so that only the required amount of energy to perform the activity at hand is drawn.	47 kWh/year or 80% savings in average UEC of devices	-NRDC reported that reducing overall power needs through using power islands, voltage scaling, and other technological adjustment could save up to 80% of network equipment system power. -By weighting the network equipment devices' UECs by the number of units for each device type in the country (provided by NRDC), NMR estimated that the average network equipment device UEC is currently 59 kWh/year.	Partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)
2) Current Fleet Replacement	Replace inefficient installed network equipment with equipment equivalent to the top 25% of current equipment.	20 kWh/year or 34% savings in average UEC of installed devices	-NRDC reported that if the average network equipment device were as efficient as the 25% top efficient devices, the total network equipment consumption would decrease by 2.8 TWh/year from 8.3 TWh/year. This represents a 34% savings. -NMR applied that percentage to its weighted average annual UEC 59 kWh/year of the current fleet of installed network equipment.*	Midstream and downstream incentives for purchasing/selling the highest efficiency equipment; equipment recycling program
3) Energy Efficient Ethernet (EEE)	Use EEE to enable systems to enter sleep mode whenever power is not needed.	3-12 kWh/year or 5-20% savings in average UEC of devices	-NRDC reported that EEE technology could save 5-20% in savings. -NMR applied those percentages to its weighted average annual UEC 59 kWh/year of the current fleet of installed network equipment.*	Midstream and downstream incentives for purchasing/selling equipment with EEE technology
4) Labeled Models	Replace current devices with models meeting ENERGY STAR specifications or percentages above those specifications.	12 kWh/year or 20% savings in average per unit UEC of devices	-ENERGY STAR estimated that ENERGY STAR models represent a 20% savings over standard models. -NMR applied that percentage to its weighted average annual UEC 59 kWh/year of the current fleet of installed network equipment.*	Midstream and downstream incentives for purchasing/selling models meeting ENERGY STAR specifications or percentages above those specifications

Sources: 1) NRDC. “Small Network Equipment Energy Consumption in US Homes: Using less energy to connect electronic devices.” NRDC Issue Paper. IP: 13-0-B. June 2013. Accessed August 12, 2014. <http://www.nrdc.org/energy/files/residential-network-IP.pdf> 2) ENERGY STAR. “Small Network Equipment for Consumers.” Accessed August 12, 2014. http://www.energystar.gov/certified-products/detail/small_network_equipment

Note: 1) Measures shaded in grey are longer-term options; measures without shading are those that the Companies could implement in the shorter-term and that do not require influencing manufacturers, legislators, or other entities. 2) NMR calculated savings for measures using several secondary sources; therefore, results should be interpreted with caution. 3) The implementation strategies reflect a mixture of suggestions from the literature and NMR’s own insights.

* NMR could not find UEC figures for units that exclude the population of products with the specified efficiency level or technology integrated. Therefore, the average UEC of inefficient products may be higher and the measure listed could represent greater saving (in terms of kWh) than what is reported above.

3.6 Game Consoles

Table 7 shows energy savings measures for game consoles. The team primarily reported on NRDC's findings investigating technical changes that could be made to increase the efficiency of *Xbox One* (Xbox) and *PlayStation 4* (PS4). All of the measures to increase the efficiency of game consoles could be made on the manufacturer's end, but nearly all (three of four) could be addressed in the near term through consumer education campaigns.

For both Xbox and PS4, the greatest savings could be achieved through disabling “connected standby” (where the console is off but is connected to the network, thus enabling it to launch into active modes quickly and provide other functions)—potentially saving 100 kWh/year in Xbox UEC and 55 kWh/year in PS4 UEC. Second most effective would be usage of Auto-Power Down (APD) where, ideally, devices would turn themselves off sooner than they currently do; NRDC suggested that game consoles be set to turn off after one hour, possibly achieving 89 kWh/year in savings for Xbox and 50 kWh/year for PS4. Both of these could be incorporated into consumer education campaigns.

Table 7: Energy Savings Opportunities – Game Consoles

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
1) Connected Standby Disabling	Disable <i>connected</i> standby (where the console is off but is connected to the network, enabling it to launch into active modes quickly and provide other functions).	100 kWh/year or 43%, and 55 kWh or 31% savings in average UEC of Xbox and PS4 units, respectively	<p>-NRDC learned that Xbox units spend about 18 hours/day in standby and PS4 units spend about 19 hours/day in standby, respectively requiring 15.7 and 8.5 Watts in that mode. NRDC estimated that, if they were not in connected standby, they would require less than one Watt each while in standby.</p> <p>-NMR calculated that they respectively consume 103 kWh/year and 59 kWh/year in connected standby, but would consume only 3 kWh/year while in “disconnected” standby (using 0.5 Watts as a proxy to estimate power for standard standby).</p>	Consumer education campaigns; partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)
2) APD Usage	Set APD to turn off after one hour or less as default and/or eliminate notifications to remove APD.	89 kWh/year or 38%, and 50 kWh/year or 27% savings in average UEC of Xbox and PS4 units, respectively	<p>-NRDC suggested that APD occur after one hour in standby.</p> <p>-NMR calculated that Xbox and PS4 respectively consume 103 kWh/year and 59 kWh/year in connected standby (see Measure 1). NMR then estimated new consumption level for the devices (during the 18 and 19 hours they currently spend in standby) if they each spent only two hours/day in connected standby (and the remaining standby time in “off”) using these formulas:</p> <ul style="list-style-type: none"> • <i>Xbox</i>: $(15.7 \text{ Watts} * 2 \text{ Hours} * 0.365) + (0.5 \text{ Watts} * 16 \text{ Hours} * 0.365) = 14 \text{ kWh/year}$ • <i>PS4</i>: $(8.5 \text{ Watts} * 2 \text{ Hours} * 0.365) + (0.5 \text{ Watts} * 17 \text{ Hours} * 0.365) = 9 \text{ kWh/year}$ 	
3) TV-Mode Power Reduction	Reduce Xbox TV-Mode power by configuring it so the console does not need to be on during TV watching or by designing the device to use low power levels in that mode.	79 kWh/year or 27% savings in average UEC of Xbox units	NRDC estimated that if users watch TV for 5 hours/day and their Xbox units are configured as “TV controllers,” they would consume 289 kWh/year. They found that if at least 30% of owners set up their Xbox units to connect to their TVs through a different port than that of their STB (so the game console does not need to be on to watch TV), then the average Xbox UEC would decrease to 210 kWh/year.	

Savings Measure	Description	Estimated Savings Potential	Assumptions for Savings Estimates	Suggestions or Example(s) of Implementation Strategies
4) Video Streaming Power Reduction	Match power levels of more efficient devices like Apple TV to watch videos or avoid watching videos through game consoles.	63 kWh/year or 35%, and 40 kWh or 17% savings in average UEC of Xbox and PS4 units, respectively	<p>-NRDC reported that Xbox uses 74 Watts and PS4 uses 89 Watts to stream an HD movie. In contrast, NRDC found that media streaming devices like Apple TV use fewer than 2 Watts to stream HD movies. They reported that Xbox and PS4 are respectively used in the video streaming mode for 2.37 hours/day and 1.24 hours/day, on average.</p> <p>-NMR calculated that Xbox uses 64 kWh/year and PS4 uses 40 kWh/year in video streaming mode. NMR, as a proxy, applied a power level of 1.5 Watts to Xbox and PS4's usage averages and assumed that users only watch HD movies, finding that using streaming devices like these would result in annual consumption of 1.3 kWh/year and 700 Watts/year, respectively.</p>	Consumer education campaigns; partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)
5) Power Scaling Improvements	Only draw the amount of power needed to perform a given activity within each active mode.	48 kWh/year or 21%, and 33 kWh or 18% savings in average UEC of Xbox and PS4 units, respectively	<p>-NRDC reported that video game consoles use 112-137 Watts in game play, 74-89 Watts in video streaming, and 72-88 Watts in navigation or TV mode.</p> <p>-Based on the average usage figures that NRDC reported in each mode, NMR estimated that the Xbox UEC in active modes (game play, video streaming, and navigation/TV modes) is 129 kWh/year and PS4's is 120 kWh/year.</p> <p>-Applying NRDC's suggested change in power scaling to a difference of 80% between the lowest consuming active mode (navigation/TV) and the highest consuming (game play), NMR calculated that the Xbox's active mode UEC would be 87 kWh/year and PS4's would be 81 kWh/year (this would keep the gaming mode power stable but reduce the power of the two less intensive modes).</p>	Partnership with policymakers, specification and standard setting entities, and manufacturers (non-incentive based)
6) USB Charging Power Reduction	Ensure that the capability that allows users to charge extraneous devices through USB during standby only draws energy while charging devices.	21 kWh/year or 11% savings in average UEC of PS4 units	<p>-NRDC reported that PS4's USB charging capability in standby results in the device's consumption being 3 Watts more than it would be if this were not a feature.</p> <p>-NMR calculated that if PS4 units are in standby for about 19 hours/day (as reported by NRDC) and this feature were removed, then their standby mode consumption would reduce to 38 kWh/year from 59 kWh/year.*</p>	

Source: Natural Resources Defense Council (NRDC). "The Latest-Generation Video Game Consoles: How much energy do they waste when you're not playing?" NRDC Issue Paper. IP: 14-04-B. May 2014. Accessed July 14, 2014. <http://www.nrdc.org/energy/game-consoles/>

Note: 1) Measures shaded in grey are longer-term options; measures without shading are those that the Companies could implement in the shorter-term and that do not require influencing manufacturers, legislators, or other entities. 2) NMR calculated savings for measures using several secondary sources; therefore, results should be interpreted with caution. 3) The implementation strategies reflect a mixture of suggestions from the literature and NMR's own insights.

* NRDC points out that entirely removing this feature could encourage users to leave their units in active mode so that they can charge devices (in effect, potentially drawing more energy than would otherwise be used).

3.7 Advanced Power Strips

During its 2012 qualitative potential study for the Massachusetts Program Administrators, NMR addressed advanced power strips (APS) (also known as smart strips) as a potential key program measure for reducing overall consumer electronics energy consumption. The team reported that savings from APSs will diminish as the efficiency of other devices advances and that claiming the savings associated with them is challenging because user behavior continues to play a large part in their effectiveness.

From the Massachusetts potential study, the team did, however, learned that the New York State Energy Research and Development Authority (NYSERDA) found it effective to directly install APSs during one of its home energy assessment programs because direct installation ensures that the units are properly set up to maximize savings opportunities.³⁴ Further, a Lockheed Martin, Inc., and Energy Solutions study conducted in late 2009 and early 2010 found that households could save 106 kWh/year, on average, by using APSs with their consumer electronics equipment.³⁵

More recently, the California Plug Load Research Center (CalPlug) performed a study to estimate the potential energy savings from a very sophisticated category of APSs, referred to as “Tier 2” APSs. Tier 2 APSs are able to identify the hours in which a user is absent while the device is on (not in standby mode) and then turn off the device.³⁶ CalPlug’s study examined the usage of Tier 2 APSs with devices found in a standard “family room” in the US—the configurations included TVs, STBs, and game consoles.³⁷ When used with these home entertainment devices, Tier 2 APSs could save a household 346 kWh/year, representing savings of 48% to 53% per year in an average US “residential AV environment.”³⁸

³⁴ NMR. “Massachusetts Consumer Electronics Potential Qualitative Research Study.” October 23, 2012. <http://ma-eeac.org/wordpress/wp-content/uploads/MA-Consumer-Electronics-Potential-Qualitative-Research-Study.pdf>.

³⁵ Lockheed Martin, Inc. and Energy Solutions. “Advanced Power Strip Research Report.” August 2011. Accessed March 20, 2012. <http://www.nyserda.ny.gov/-/media/Files/EERP/Residential/Energy-Efficient-and-ENERGY-STAR-Products/Power-Management-Research-Report.pdf>.

³⁶ A less sophisticated APS, in comparison, may only be able to sense that a TV is off and then as a result turn off the power provided to its peripheral devices.

³⁷ This excludes the other product categories examined in this study: PCs and network equipment.

³⁸ California Plug Load Research Center (CalPlug). “Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive.” May 7, 2014. Accessed January 11, 2015. http://www.efi.org/docs/studies/calplug_tier2.pdf.

4 Market Considerations

The energy savings opportunities presented in the previous section must be considered within the context of market dynamics, which might impact the effectiveness of a program or its ability to successfully implement or address measures. In this section, NMR reports ENERGY STAR market penetration and other product category-specific market considerations that have the potential to limit or disrupt program intervention.

4.1 ENERGY STAR Market Penetration

ENERGY STAR partners are required to supply ENERGY STAR with their US shipment data at the end of each year. Their data offer insight into ENERGY STAR market penetration in the country by comparing the number of ENERGY STAR units shipped to the number of total units shipped in a given year. Three of the product categories that NMR investigated in this report were included in ENERGY STAR's market penetration report for 2013: TVs, STBs, and PCs. Of the three, TVs (84%) and STBs (89%) had the highest market penetration in 2013 (Table 8).

The EEB may wish to consider these penetration rates in any potential plans to leverage ENERGY STAR labeling in program incentive specifications. High market penetrations may indicate a higher potential for free ridership. The market penetration rates available do not distinguish between models that are percentages or levels more efficient than ENERGY STAR; therefore, the rates do not offer concrete evidence for programs to avoid leveraging the ENERGY STAR label. It is also useful to consider that these penetrations are likely to change soon given new ENERGY STAR specifications that have already gone into effect in 2014 (PCs, June 2014), are going into effect later in 2014 (STBs, December 2014), or are in development stages (TVs).

Table 8: Consumer Electronics Product Categories – ENERGY STAR Market Penetration (2013)

Product Category	Number of Units Shipped in 2013	% of Units Shipped with ENERGY STAR Label
Televisions	32,944	84%
Set-Top Boxes	36,349	89%
Personal Computers*	45,688	55%
<i>Desktops</i>	8,248	25%
<i>Laptops (and tablet)</i>	36,158	74%

Source: ENERGY STAR. "ENERGY STAR Unit Shipment and Market Penetration Report: Calendar Year 2013 Summary."

Note: ENERGY STAR market penetration data do not include network equipment. Additionally, ENERGY STAR does not label game consoles.

* ENERGY STAR's PC category includes desktop PCs, laptop PCs, tablets, small-scale servers, thin clients, and workstations.

During NMR’s research, it came across an important collaborative effort between ENERGY STAR, program sponsors, retailers, and other stakeholders called the RPP. RPP seeks to establish a nationwide suite (or platform) of ENERGY STAR products around which to target incentives.³⁹ Efforts like these are important to keep in mind for program designers when considering using the ENERGY STAR brand; it is possible that they could potentially be leveraged or could somehow diminish the importance or relevance of a potential program.

4.2 Product-Specific Considerations

In addition to taking ENERGY STAR market penetration into account, the team recommends that the Companies consider other market dynamics related to the product categories investigated in this report. During its 2012 study for Massachusetts Program Administrators, NMR discovered a number of market opportunities and barriers for specific product categories that are relevant to program design and planning. The bullets below describe some of the key findings.⁴⁰

- **Televisions**

- Most market actors view energy efficiency as a low priority relative to their usage and purchasing patterns, promotion techniques, and design approaches. For example, customers are increasingly opting for TVs that are larger and have advanced features (such as ultra-high definition), both of which contribute to increased energy consumption. These dynamics could result in a market barrier for programs to focus on addressing through program activities. However, programs should be aware that these dynamics can also present a challenge for successful program implementation.
- As a whole, nationwide TV energy consumption has declined by 23% since 2010. Fraunhofer attributed this to a decrease in the installed base of TVs, replacement of the less-efficient older (cathode ray tube or CRT) TVs, and the increases in per-unit efficiency.⁴¹ Table 9, captured from Fraunhofer’s 2014 report, shows this trend.

³⁹ For more information see www.caltf.org/s/RPP-overview-presentation_Updated-9-17-ro0t.pptx.

⁴⁰ For more comprehensive explanations and additional factors, please review the report: NMR. “Massachusetts Consumer Electronics Potential Qualitative Research Study.”

⁴¹ Fraunhofer USA Center for Sustainable Energy Systems (Fraunhofer). “Energy Consumption of Consumer Electronics in U.S. Homes in 2013.” June 2014.

Table 9: Estimated US TV Energy Consumption from 1995 to 2013

Year	Units [millions]	Power [W]		Usage [h/yr]		UEC [kWh/yr]	AEC [TWh/yr]	Source
		Active	Off	Active	Off			
2013	301	90	1.6	1,606	7,154	166	50	Current
2010	353	104	3.0	1,392	7,368	183	65	FhCSE 2011
2009	342	105	3.3	1,392	7,368	188	64	FhCSE 2011
2006	275	111	4.0	1,882	6,878	244	67	TIAX 2008
2006*	237	98	4.0	1,882	6,878	222	53	TIAX 2007
2004*	234	100	3.9	1,278	7,483	156	37	NRDC 2005
1998*	212	75	4.5	1,443	7,317	150	31	LBNL 1999
1997*	229	60	4.0	1,460	7,300	117	27	ADL 1998
1995*	191	77	4.0	1,498	7,262	141	26	LBNL 1998

* Analog TVs only.

Source: Fraunhofer USA Center for Sustainable Energy Systems (Fraunhofer). “Energy Consumption of Consumer Electronics in U.S. Homes in 2013.” June 2014.

Note: NMR did not conduct new market research for this report; however, given the relevance of this market trend it was determined that this new finding (not included in the Massachusetts 2012 report) be discussed here.

- Due to rapid market changes and the plethora of extraneous devices, estimates for TV-specific savings may not be reliable. For example, if a TV has audio equipment, a game console, and an STB connected to it, estimating the savings associated with only the TV unit does not fully reflect the energy consumption associated with the TV’s usage. Programs might consider that such factors can present barriers to accurately claiming program savings.
 - One study in the Northwest, described in NMR’s 2012 Massachusetts report, showed that retailers are stocking energy-efficient models more and more. This makes products available, but also limits the need for programs to offer midstream incentives.
 - At the time of NMR’s 2012 report, state-level TV regulations were in the process of development in Massachusetts, New York, Washington, and Wisconsin (in fact, as shown in this literature review, Connecticut is one of three states with its own regulations as well—see Section 2.3). As a result, manufacturers may be producing fewer inefficient models due to fewer locations where they can sell inefficient models. Fewer inefficient models on the market will increase opportunities for free ridership and limit program savings impact.
 - Despite upcoming advances in TVs’ energy efficiency specifications, researchers and market actors projected that energy efficiency levels will not dramatically increase in coming years. They explained that technical advances that could achieve notable savings, especially with the increasing popularity of advanced features, would require extensive cost and time that manufacturers may not be willing to expend; as such, addressing TVs may not represent substantial savings.
- **Set-Top Boxes**

- STB efficiency cannot be completely or comprehensively addressed through increasing efficiency of the devices alone because media service providers can offset the efficiency of an STB unit through increases in consumption that are enabled through software updates. At the same time, some media service providers have the ability to improve the efficiency of some already deployed units through software updates.
- The Set-top Box Energy Conservation Agreement attempts to ensure that 90% of deployed/purchased units meet ENERGY STAR V3.0 specifications, meaning that addressing ENERGY STAR V3.0 may be irrelevant (also discussed in this literature review—see Section 2.3). Therefore, the installed base of STBs will have increasingly higher levels of efficiency. As a result, even if program efforts leverage ENERGY STAR V4.0, program claimable savings will not be as high as they may have been prior to the development of the agreement.
- Customers may not have control over the STB unit they purchase or use because the units are often provided by the customers' media service providers. Thus, incentives directed at end-users may result in low participation rates.
- Customers may not take advantage of available energy efficiency features even if the media service provider or manufacturer sets energy saving settings as defaults (e.g., customers may select higher-consuming settings). It is difficult for efficiency programs to monitor behaviors like these, which makes it difficult to reliably determine the savings resulting from program efforts.
- Media streaming (through devices like Apple TV) is becoming more popular, resulting in consumers using their STBs less frequently or not having pay-TV service at all. This trend may make addressing STBs obsolete.
- **Personal Computers**
 - Laptop PC sales are increasing as desktop PC sales decline. As such, targeting desktop PCs may quickly become irrelevant and result in low participation rates.
 - Laptop PC models are becoming increasingly more efficient, possibly resulting in limited program claimable savings.
 - Increases in cloud computing may reduce home PC energy consumption by shifting power requirements to data centers, thereby making end-user incentive programs obsolete.
- **Game Consoles**
 - There are few game console manufacturers. As such, engaging a large share of these manufacturers in discussions about energy efficiency measures may be easier than doing so for other product categories. This may also mean that if even one manufacturer increases the efficiency of its only model, program efforts to incentivize the purchase of energy-efficient models will result in free ridership.
 - Because there are few game console models, consumers have limited choice to select higher efficiency models, and programs have fewer models to promote.

- Customers have gained interest in game console models that happen to be more energy-efficient. This dynamic may also make program efforts irrelevant.

NMR did not address network equipment in its 2012 Massachusetts study, so this could be an area for future study of market trends. Because NMR conducted that study in 2012, it is possible that the market trends for the other products listed above have dramatically changed or disappeared or that new trends have emerged. The purpose of NMR’s research presented in this 2014 report has been largely to quantify potential program savings. In future research, the EEB may wish to reassess the trends listed above and search for other emerging patterns.

4.3 Estimated Technical Energy Savings Potential

The savings estimates in Section 3 focus on household and unit-level savings, but these measures cannot be applied to all households or measures in practice. Aside from market trend challenges (Section 4.2) and the level of willingness to participate (achievable potential), technical factors can limit the success of implementing the measures—such as high energy efficiency saturation rates⁴² or limitations in existing infrastructure in the market to which a measure could be applied.

In 2012, NMR conducted a consumer electronics saturation study for the Massachusetts Program Administrators (referred to hereafter as the Massachusetts 2012 Saturation Study). Drawing on findings from 150 site visits in Massachusetts homes, the study reports the types of consumer electronics that Massachusetts customers use, the characteristics of those products, and the configurations of products that customers use together. In an effort to explore how the household and per-unit savings described in this 2014 literature review might eventually be applied to the state as a whole, the team extrapolated the Massachusetts 2012 Saturation Study findings to one of the measures presented in Section 3.⁴³ The purpose of this exercise is to determine, if all customers and market actors were willing to implement a given measure, what savings could technically be achieved in the state as a whole.

Given that the scope of this research effort does not include a technical potential study, the team limited its investigation of this topic to one possible measure presented earlier in this report—PC power management.⁴⁴ These findings should be interpreted with caution, given that the estimate does not use recent saturation data specific to Connecticut, plus it only represents the technical potential, and thus does not account for cost-effectiveness screening (economic potential) or market acceptance (achievable potential).

⁴² In this sense, “saturation rates” refers to the number of households or units where a device has already been installed or is in use.

⁴³ The team determined that using findings from the Massachusetts market was appropriate given that it is a neighboring state. For more details, see http://ma-eeac.org/wordpress/wp-content/uploads/Massachusetts-Residential-Retail-Products_Consumer-Electronics-Saturation.pdf

⁴⁴ The team chose to illustrate this concept using this specific measure because it offers substantial per-unit savings and because relevant and applicable Massachusetts saturation data were readily available.

The Massachusetts 2012 Saturation Study found that the average number of desktop PC units per household in Massachusetts was 0.5 and that 55% of desktop PC units had power management enabled. As presented in Table 5 in Section 3.4, the literature shows that achieving ideal power management in an already installed desktop unit could result in 144 kWh/year savings per unit. Assuming that Connecticut has the same saturation rates as Massachusetts, the team estimates that 43.4 GWh/year could technically be saved in Connecticut by achieving ideal power management in the entire installed base of desktop PCs in the state—this averages to 32 kWh/year/household. Table 10 shows the process that the team used to estimate these savings.

Power management optimization could possibly be implemented using a direct-install approach performed during home energy audits⁴⁵ or through consumer education campaigns. Like other measures, NMR assumes that long-term or short-term persistence could prove challenging if end-users find that power management settings are impacting their productivity or ease of use.

Table 10: Estimated Technical Energy Savings Potential from Ideal Power Management on Installed Desktop PCs

	Element	Amount	Unit	Source
A	Number of Households (HH) in Connecticut	1.4 Million	Households	USCB
B	Average Number of Desktop Units per HH in Massachusetts	0.5	Desktop Units/HH	NMR (2012 Saturation Study)
C	Total Desktop Units in Connecticut	669,930	Desktop Units	[A * B]
D	Percentage of Desktop Units without Power Management enabled in Massachusetts	45%	Percent of Units	Massachusetts 2012 Saturation Study
E	Total Desktop Units without Power Management enabled in Connecticut	301,469	Desktop Units	[C * D]
F	Average Estimated Number of Desktop Units with Power Management enabled per HH	0.2	Desktop Units/HH	[E / A]
G	Average Savings from Enabling Power Management	144	kWh/year/unit	NEEA
H	Percentage Energy Savings from Enabling Power Management	28%	Percent Savings/unit	Extrapolated from NEEA (2012) (Table 5)
I	Average Desktop Energy Consumption without Power Management Enabled	513	kWh/year/unit	[G / H]
J	Total Desktop PC Energy Consumption with Power Management Enabled in Connecticut	155 Million	kWh/year	[E * I]
K	Technical Potential Savings in Connecticut	43 Million	kWh/year	[H * J]
L	Average Technical Potential Savings per HH	32	kWh/year/HH	[K / E]

Sources: 1) NEEA. “Energy Savings Opportunities and Market Descriptions DDC42BF7F151.” 2) NMR. “Massachusetts Residential Retail Products: Consumer Electronics Saturation.” October 23, 2012. Accessed September 20, 2014. http://ma-eeac.org/wordpress/wp-content/uploads/Massachusetts-Residential-Retail-Products_Consumer-Electronics-Saturation.pdf

⁴⁵ Such as through the Home Energy Solutions or Home Energy Solutions-Income Eligible Programs.

5 Conclusions and Recommendations

The literature revealed that, while there are distinct UEC savings and household savings that could be achieved through energy efficiency measures, these measures need to be considered within the context of market barriers that might affect willingness to participate, market trends that might increase chances of free ridership, and saturation rates that might limit the technical potential for a program to make an impact in the territory. A more detailed future consumer electronics potential study would provide the EEB with greater detail on both program and energy savings potential from a possible consumer electronics program. This section presents overall findings and those directly related to specific product categories, as well as more details about the nature of future research.

5.1 Overall Findings

Energy Consumption. The top five energy-consuming consumer electronics in 2013 in the US were TVs, STBs, PCs, network equipment, and game consoles. Together, they represent three-quarters of the total residential energy consumption of consumer electronics for that year (169 TWh).

ENERGY STAR Penetration. In 2013, the majority of TV (84%) and STB (89%) shipments were ENERGY STAR models. High market penetrations may indicate a higher potential for free ridership with programs that leverage ENERGY STAR for incentive eligibility. However, these penetrations are likely to change soon, given new ENERGY STAR specifications that have already gone into effect during 2014 (PCs, June 2014), are going into effect later in 2014 (STBs, December 2014), or are in development stages (TVs).

- **Recommendation:** Program approaches that incorporate the use of ENERGY STAR may need to require that eligible models meet efficiency levels that are percentages greater than ENERGY STAR's minimum specifications. For TVs, they might also consider leveraging ENERGY STAR's Most Efficient list. If implementing a program that utilizes ENERGY STAR, program managers would benefit from remaining abreast of specification changes.

Market Trends and Barriers. While a measure might technically be able to reduce a product's energy consumption, it may be challenging to implement the measure. For example, the measure may have a limited appeal to market actors or may quickly become obsolete due to expected market changes.

- **Recommendation:** In future research, the EEB may wish to reassess the market trends described in this report and search for other emerging patterns that might influence future program success. The team suggests doing this through either 1) qualitative research, with activities such as in-depth interviews or comprehensive

literature reviews; or 2) quantitative research, potentially using surveys with market actors or conducting secondary data analyses, if possible.

Technical Energy Savings. Because market trends can indicate market actors' willingness to participate in and/or engage with program efforts, studies like the Massachusetts 2012 Saturation Study can help determine what savings could technically be achieved in the state as a whole if all relevant customers and market actors were willing to implement a given measure. In this report, NMR applied Massachusetts 2012 Saturation Study findings to the savings for one measure presented in this literature review to gauge its technical potential as an illustration of how the savings figures presented here could be applied to Connecticut as a whole. While the Massachusetts 2012 Saturation Study findings can give some sense of the technical potential in Connecticut, they are not specific to Connecticut and they are two years old, so they may be obsolete due to the rapidly changing nature of this market.

- **Recommendation:** The EEB may find it useful to conduct a saturation study in Connecticut like the Massachusetts 2012 Saturation Study. This effort could help the EEB determine the technical potential savings for implementing measures that are estimated to yield high per-unit or per-household energy savings. This quantitative research could involve telephone surveys with customers or home site visits that collect data on characteristics like the number of units and types of units installed or in use in Connecticut homes.⁴⁶ Alternatively, technical potential savings estimates could be made by applying savings figures to national saturation rates (e.g., number of units per-household presented in Table 1).

Implementation Strategies. NMR learned of a number of measures that could yield reasonably high per-unit or per-household energy savings if implemented successfully. The team offers implementation strategies including recycling programs; midstream and downstream incentives; consumer education campaigns; direct installation; and partnerships with policymakers, specification and standard setting entities, and manufacturers. The last strategy, involving partnerships with stakeholder groups, is likely a longer-term strategy, whereas implementation approaches using midstream and downstream incentives, for example, could likely be implemented in the near-term.

- **Recommendation:** The EEB may wish to examine the program models currently employed by other program administrators if it wishes to move forward with consumer electronics. It is in the evaluation team's opinion that any program planning efforts in Connecticut would benefit from learning about the incentive

⁴⁶ A research effort involving home site visits could potentially be performed in conjunction with another study that involves collecting data on household characteristics through home site visits, such as a socket saturation study.

efforts of other programs; characterizing other programs could be done through performing in-depth interviews and/or qualitative literature reviews.

The conclusions and recommendations that follow highlight measures that could realistically be implemented in the near-term.

5.2 Televisions

Estimated TV Savings. The energy-saving measures for TVs that are presented in this report may have the potential to generate unit-level savings ranging from 10% to 38%.

- The purchase of models that are labeled or recognized as energy-efficient instead of new standard models may have high savings opportunities; for example, selecting new ENERGY STAR Most Efficient 60” TVs might offer 38% savings in UEC when compared to standard new TV models of the same size.
- One measure—replacing older installed TV models with new best-in-class models that are included in ENERGY STAR’s Most Efficient list—could offer 31% savings in annual UEC over the installed base.
 - **Recommendation:** Investigate offering TV incentives based on labels and recognition programs directed at end-users, retailers, and distributors and TV recycling programs. In determining the feasibility of these program approaches or any others described in this report, the EEB should explore cost-effectiveness—comparing factors such as measure life and savings to the costs involved in implementing the offering.

Claiming TV Savings. Some TV market dynamics could increase free ridership potential and/or present a barrier to calculating and yielding program savings.

- Retailers are stocking energy-efficient models, thereby making such products available, but also limiting the need for programs to offer midstream incentives.
- US TV energy consumption increased by 23% from 2010 to 2013, potentially signaling a decrease in available program savings.
- Increasing the rigor of state-level TV energy efficiency regulations, such as those in Connecticut, may encourage manufacturers to produce fewer inefficient models due to fewer locations where they can sell such models. This could also limit program savings impact; however, it should be noted that regulations like these would not necessarily have an immediate impact on the market—in the team’s experience, once regulations like these are enacted it often takes a few years for the regulation to be implemented fully.

- Rapid market changes and the plethora of extraneous devices with varying configurations and usage patterns, such as with STBs, may make estimates for TV-specific savings unreliable.
 - **Recommendation:** If program managers design programs that promote energy-efficient TVs, they might consider that factors like these can present barriers to accurately claiming program savings.

5.3 Set-top Boxes

Estimated STB Savings. Three measures for reducing STB energy consumption stood out as potential near-term measures that do not *necessarily* involve partnerships with groups like manufacturers or media service providers.

- Entirely eliminating the use of cable or satellite pay-TV services could reduce a household's energy consumption by 180 kWh/year, a 90% savings. While media streaming is increasing in popularity, NMR assumes that the potential barriers involved in transitioning the majority of households to a new technology interface, the limitations of current service infrastructure, and political implications may prove challenging for a program to overcome or address.
- Reconfiguring high-consuming multi-room STB configurations by replacing the non-primary devices with low-power thin-client devices with the same functionality could reduce annual UEC of those non-primary units by 52%.
- Another effective way to reduce STB consumption would be selection of ENERGY STAR models: ENERGY STAR reported that ENERGY STAR STBs offer savings of 45% over standard models.
 - **Recommendation:** These three top-saving measures could be implemented through recycling programs, midstream and downstream incentives, and consumer education campaigns. If the EEB determines that it is beneficial to address STBs, promoting thin-client devices and ENERGY STAR models would be most appropriate for program efforts. The market environment should of course be considered in potentially incorporating any of these measures into a program design; for example, the second measure—reconfiguring multi-room STB configurations—would require collaboration with media service providers and would require that they be permitted to make configuration changes like these under the regulations to which they are subject.

STB Market Dynamics. Some market dynamics may indicate that addressing STBs is not prudent in terms of claimable savings and market barriers.

- The Set-top Box Energy Conservation Agreement, which attempts to ensure that 90% of deployed/purchased units meet ENERGY STAR V3.0 specifications, may limit a program’s claimable savings because it will likely result in high market saturation.⁴⁷ However, the emergence of a new ENERGY STAR STB specification, due to come into effect in December 2014, may still offer a benchmark of savings to leverage.
- Customers might not take advantage of available energy efficiency features even if the media service provider or manufacturer sets energy-saving settings as defaults (e.g., customers may select higher-consuming settings). It is difficult for efficiency programs to monitor such behaviors and reliably determine the savings resulting from program efforts.
- It may not be within consumers’ power to opt for energy-efficient STB models or engage in energy-saving behaviors (turning devices off when not in use) despite program efforts to encourage them (through incentives or education).⁴⁸ In some cases, media service providers can offset the efficiency of an STB unit through increases in consumption that are enabled through software updates.
 - **Recommendation:** Addressing STBs through end-user incentives may be inappropriate. If program efforts address STBs through incentives for the purchase, sale, or deployment of energy-efficient models, program designers might benefit from requiring rigorous energy efficiency requirements above ENERGY STAR V4.0 criteria.

5.4 Personal Computers

- **Estimated PC Savings.** The energy-saving measures that the team examined for PCs could increase PC UEC efficiency by 12% to 80%. Two measures that could be implemented in the near term stood out as the highest-saving measures. Optimizing power management settings for the installed base of desktop PCs could possibly result in savings of 144 kWh/year among installed desktop PCs. If successfully implemented, it could have the technical potential to save 43.4 GWh/year in Connecticut as a whole.
 - **Recommendation:** The EEB may wish to explore using campaigns to educate consumers on optimizing power management and/or use direct installation efforts, perhaps as part of a home energy audit visit for another program.

⁴⁷ Most, but not all, of the media service providers in Connecticut were signatories, such as Cablevision Systems Corp., Comcast Cable Communications, LLC., Charter Communications, Inc, and Cox Communications, Inc. Other smaller media service providers in Connecticut, such as MetroCast, were not signatories.

⁴⁸ Additionally, the team speculates that the addition of higher efficiency units does not ensure that less efficient older units will be removed from the grid (for example, after purchasing an ENERGY STAR unit, an end-user may simply move their older, less efficient unit to a secondary TV within the home).

- Selecting models labeled by ENERGY STAR showed great promise. For example, ENERGY STAR desktop PC models offered 77 kWh/year in savings over standard desktop PC models.
 - **Recommendation:** Consider offering incentives to end-users, retailers, and distributors for ENERGY STAR models (or models percentages greater in efficiency than ENERGY STAR).

PC Market Dynamics. Some market dynamics may indicate that addressing PCs is not prudent in terms of claimable savings and market barriers.

- First, laptop PC models are becoming increasingly efficient, possibly resulting in limited program claimable savings.
- Second, increases in cloud computing may reduce home PC energy consumption by shifting power requirements to data centers, thus making end-user incentive programs obsolete.
- Laptop PC sales are increasing as desktop PC sales decline. As such, targeting desktop PCs may quickly become irrelevant and result in low participation rates.
 - **Recommendation:** Despite sizable UEC and household-level savings, the EEB might consider that these factors among others can present barriers to claiming sizable program savings and achieving adequate participation rates.

5.5 Network Equipment

Estimated Network Equipment Savings. Immediate program-relevant measures, like replacing the installed base with equipment that is as efficient as the top 25% of current equipment, have the potential to generate notable savings (34%). Despite the fact that the UEC savings for these network equipment measures are fairly small, ranging from 3 kWh/year to 20 kWh/year, homes with network equipment often have more than one device—typically, a modem and router configured together. As such, greater savings opportunities are likely present. California has proposed standards, to be ruled on in 2015, that could potentially increase the efficiency of network equipment overall.

- **Recommendation:** The Companies may wish to investigate the cost-effectiveness of and market barriers and opportunities for implementing some near-term programmatic strategies to address network equipment such as equipment recycling opportunities, offering incentives based on labels, and offering recognition programs directed at end-users, retailers, and distributors. More research on common configurations, household ownership and usage patterns, and the role of media providers would be helpful for gaining further insight into the savings opportunities at the household level and in the state as a whole.

Additionally, further research on network equipment’s market trends would be particularly useful—if the EEB wishes to explore the possibility of addressing network equipment they should remain abreast of the timing of the release of next generation equipment and potential passage of energy efficiency standards in California.

5.6 Game Consoles

Estimated Game Console Savings. Two measures to increase the efficiency of game consoles that could be addressed in the near term through consumer education campaigns stood out as offering the greatest savings.

- Disabling connected standby could potentially generate savings of 100 kWh/year in Xbox UEC and 55 kWh/year in PS4 UEC.
- If APD were enabled and set to turn off after one hour, it could possibly achieve 89 kWh/year in savings for Xbox and 50 kWh/year for PS4.

Game Console Market Barriers. Because there are few game console models, consumers have limited choice to select higher efficiency models and programs have fewer models to promote. Even if one manufacturer increases the efficiency of its only model, program efforts to incentivize the purchase of energy-efficient models will result in easy free ridership. Moreover, customers have gained interest in game console models that happen to be more energy-efficient, again opening the door to free ridership. Further, California has proposed standards, to be ruled on in 2015, that would also increase the efficiency of game consoles overall.

- **Recommendations:** Program designs should not include incentives for the purchase and sale of energy-efficient game console models. Consider encouraging energy-saving behaviors for game consoles through consumer education campaigns.

5.7 Advanced Power Strips

Some program administrators found that APSs can be effectively implemented through direct installation where installers can ensure that the units are properly set up to maximize savings opportunities. One study demonstrated that a very sophisticated category of APSs—Tier 2 APS—could reduce household home entertainment energy consumption by 48% to 53%, representing savings of 346 kWh/year, on average. Savings from APSs in general are expected to diminish as the efficiency of other devices improves, however. Claiming the savings associated

with APSs can also be challenging because user behavior continues to play a large part in their effectiveness.

- **Recommendations:** The Companies may wish to investigate the cost-effectiveness of and market barriers and opportunities for reducing the energy consumption of consumer electronics as a whole through incentivizing APSs. Part of this investigation could include an assessment of the ways that other APS programs have successfully included the measure to ensure that user behavior does not hinder savings.

Appendix A Acronyms

Table 11: Acronyms

Acronym	Term
APD	Auto-Power Down
ABC	Automatic Brightness Control
DOE	Department of Energy
GWh	Gigawatt hour
kWh	Kilowatt hour
NRDC	Natural Resources Defense Council
NYSERDA	New York State Energy Research and Development Authority
NEEP	Northeast Energy Efficiency Partnerships
NEEA	Northwest Energy Efficiency Alliance
PC	Personal Computer
PS4	PlayStation 4
RPP	Retail Plug-Load Portfolio
STB	Set-Top Box
TV	Television
TWh	Terawatt hour
UEC	Unit Energy Consumption
Xbox	Xbox One

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