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Response to Invitation to Participate - Set Top Boxes

Additional submitted attachment is included below.

Set-top Boxes

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

Response to the California Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking
Set-top Boxes
17-AAER-11

June 16, 2017

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1. Summary

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® – sponsored this effort (herein referred to as the CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. The information presented herein is a response to the Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking for Set-top Boxes (STBs).

In response to a previous Energy Commission Invitation to Participate, the CASE Team docketed extensive information on STBs (Docket# 12-AAER-2A) and ask the Energy Commission to review the information docketed. The 2013 CASE Team response is also included, in its entirety, in Appendix A of this report. Some of the information in that response, such as product descriptions and operational modes, is still relevant while other information, such as energy consumption, may be out of date. In this current response, the CASE Team provides updated information for those sections of the 2013 report that are no longer relevant.

Given the expiration in 2018 of a commitment by industry to improve the energy efficiency of STBs, the CASE Team supports this effort by the Energy Commission to gather data. We encourage the eventual development of a roadmap for STBs based on the information the Energy Commission receives. The STB market is unique, fast-moving, and complex, so the CASE Team looks forward to the engagement and contributions of pay television industry throughout this process.

2. Overview

2.1 Description

The information included in this response outline the characteristics of the STB market that will be helpful in developing a roadmap for this product category. In response to a previous Energy Commission Invitation to Participate (Docket# 12-AAER-2A), the 2013 CASE Team docketed extensive information on STBs. This 2013 CASE Team response is also included, in its entirety, in Appendix A of this report as a reference.

3. Background

3.1 Regulatory Background

3.1.1 Federal Regulatory Background

There are currently no federal mandatory efficiency standards for STBs in effect. In June 2011, the United States (U.S.) Department of Energy (DOE) published a proposal to determine coverage of STBs and effectually establish mandatory efficiency standards (U.S. DOE, 2011). However, a voluntary agreement (VA), between STB equipment manufacturers, service providers (cable, satellite, and internal protocol [IP]), and energy efficiency advocates, that specified energy efficiency requirements was established in December 2012 and later expanded in 2013. Following this VA announcement, in December 2013, DOE withdrew the proposed determination, suspending the rulemaking for STBs (U.S. DOE, 2013).

The U.S. Federal Communications Commission was considering a rule to require pay-TV providers to make video programming available directly to the makers of third-party devices and software, essentially eliminating the need for consumers to rent cable boxes. That rule has been delayed indefinitely and is no longer being considered under the current Administration.

3.1.2 California Regulatory Background

There are currently no state mandatory efficiency standards for STBs in effect. Since DOE never published a final coverage determination, STBs are not considered a covered product by DOE and, therefore, not federally-preempted.

3.1.1 International Regulatory Background

The CASE Team previously provided information on the regulations for STBs in the European Union, which include mandatory power mode requirements and additional voluntary requirements (CA IOUs, 2013).

3.2 Utility and Other Incentive Programs

There are no energy utility programs in California that offer incentives for STBs.

3.3 Model Codes and Voluntary Standards

The VA, previously referenced, will be expiring January 1, 2018. In addition, the U.S. Environmental Protection Agency (EPA) has included STBs in the ENERGY STAR® program since the first specification was first introduced in 2000 (U.S. EPA, 2003). The latest ENERGY STAR specification, Version 5.1, was finalized on May 13, 2016, and outlines efficiency requirements, test method, and service provider requirements. The Version 5.1 ENERGY STAR specification has

been effective since January 1, 2017, for all STB products except thin clients (U.S. EPA, 2016). Requirements for thin clients will take effect on January 1, 2018.

4. Product Characteristics

The Energy Commission requested information on a number of topics regarding product definitions and scope.

4.1 Description

STBs are devices that receive video and other signals, process and store them, and deliver them to televisions for watching. Set-top boxes have become more sophisticated over time and include the following product types (see also Table 1): cable, satellite, cable digital transport adapter (DTA), over-the-top (OTT) IP, multichannel video programming distributor (MVPD) IP, and thin client. Unlike most other electronic devices designed for use in homes, many set-top boxes are bought and owned by pay television service providers, such as cable, satellite, or telephone companies, and leased to end-users as part of their service agreement. Updated definitions for STBs and operation modes are outlined in detail in Section 1 of the Version 5.1 ENERGY STAR specification that was finalized last year (U.S. EPA, 2016).The CASE Team believe these Version 5.1 ENERGY STAR definitions cover the current STB forms and functions and should be used in the STB roadmap.

Table 1. STB Product Types

Product Type	Definition from ENERGY STAR
STB	A device with the primary purpose of receiving digital television services from a coaxial, hybrid fiber coaxial, or fiber-to-the-home distribution system, from satellites, or encapsulated in IP packets from managed IP distribution networks; decrypting or descrambling these signals; and decoding/decompressing for delivery to residential consumer displays and/or recording devices, and/or one or more other Set-Top Boxes, including Thin Clients, in a residential multi-room architecture.
Cable	A STB that can receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system with Conditional Access (CA) or a STB capable of receiving cable service after installation of a CableCARD or other type of Conditional Access system.
Satellite	A STB that can receive and decode video content as delivered from a MVPD satellite network.
DTA	A minimally configured Cable STB that can receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system.
OTT IP	A STB that can receive television/video signals encapsulated in IP packets that cannot receive signals from a MVPD as defined in Title 47 U.S. Code § 522.
MVPD IP	A STB that can receive television/video signals encapsulated in IP packets that can receive signals from a MVPD.
Thin Client	A STB that can receive content over a Home Network Interface from another STB, but is unable to interface directly to the MVPD network.

4.2 Metrics

The Version 5.1 ENERGY STAR specification establishes efficiency requirements using a typical energy consumption (TEC) calculation that results in a kilowatt-hour per year (kWh/yr) metric. The TEC maximum, or limit, is a base TEC limit with additional allowances depending on the STB type and functionality. Table 2 lists the functionalities and the additional power allowances permitted in the Version 5.1 ENERGY STAR specification. These adders and allowances were determined by EPA and stakeholders during the Version 5.1 development process using data made available through the VA. Descriptions of each of these functions are outlined in the Version 5.1 ENERGY STAR specification. STB functions have changed over time and some functions that previously received additional energy allowances in previous versions, such as high-definition (HD), no longer receive allowances. The CASE Team feels this list of functions is a comprehensive list of energy consuming features employed by current STBs. In addition to STB product types, other equipment such as

Table 2. STB Functions with Additional Power Allowances

Additional Functionality	Additional Allowance Provided by ENERGY STAR (kWh/yr)
CableCARD	15
CableCARD – Max One Additional	15
DVR[1]	35
DOCSIS 2	25
DOCSIS 3.0 (May be also applied to DOCSIS 3.1 devices)	45
High Efficiency Video Processing	10
High Efficiency Video Processing for Thin Clients (HEVP-TC)	10
Home Network Interface	15
MIMO[2] Wi-Fi HNI 802.11n Low Power (< 200 milliwatts conducted output power) Base (Initial 2x2 Streams)	9
MIMO 802.11ac Low Power Base (initial 2x2 Streams)	18
MIMO Wi-Fi Low Power – Each Additional Stream Beyond 2x2	3
MIMO 802.11n High Power (≥ 200 milliwatts conducted output power) Base (Initial 2x2 Streams)	11
MIMO 802.11ac High Power Base (initial 2x2 Streams)	22
MIMO Wi-Fi High Power – Each Additional Stream Beyond 2x2	4
Multi-room	21
Multi-stream – Cable/Satellite	18
Multi-stream – IP	18
Transcoding	13
Transcoding – Additional	5

[1] Digital video recorder

[2] MIMO: Multi-input Multi-output

Additional Functionality	Additional Allowance Provided by ENERGY STAR (kWh/yr)
Ultra High Definition Resolution	5
Access Point	8
Router	15
Telephony	4

Source: (U.S. EPA, 2016).

The TEC calculation includes the following operational modes: on-mode, sleep-mode (including, deep sleep-mode), and scheduled sleep-mode. These operational modes and their relationships with one another are outlined in Figure 1 below. Other requirements for some STBs are also outlined in the Version 5.1 ENERGY STAR specification, such as the time and frequency of maintenance activities, time and default setting of auto power down (APD), and automatic scheduled sleep settings.

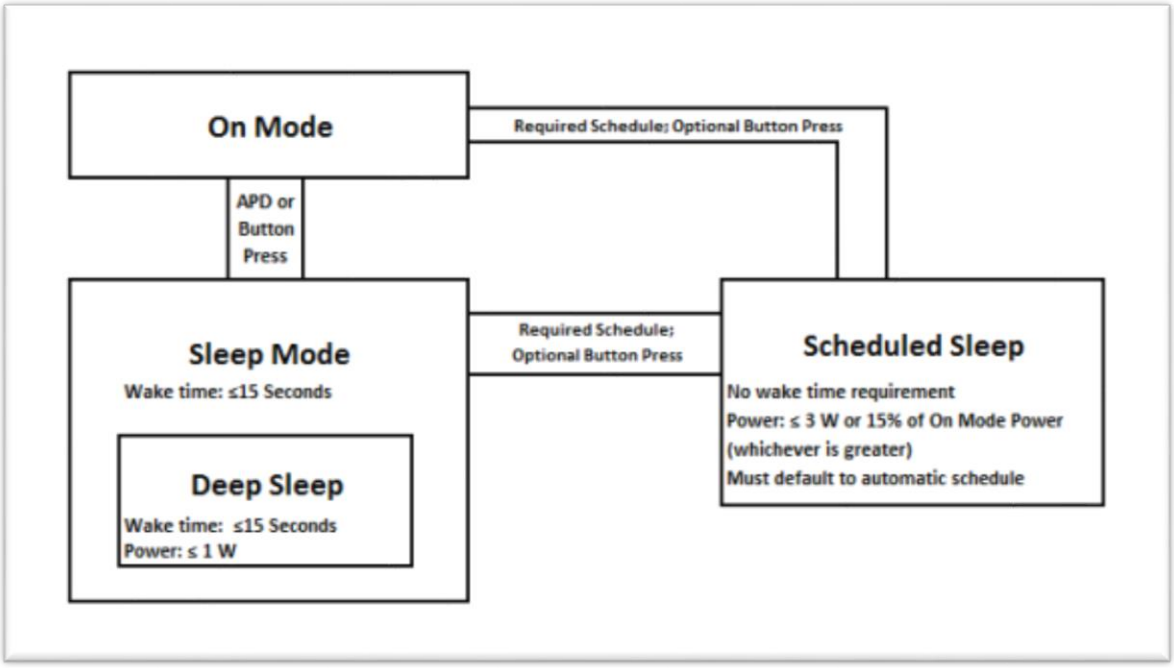


Figure 1. STB Operational Modes

Source: (U.S. EPA, 2016).

5. Market Characteristics

The Energy Commission requested information on a number of topics regarding installed base and market characteristics.

5.1 Stock

In response to the Energy Commission's requests on equipment stock, the CASE Team is not aware of existing market data on the STB stock specifically for California. Various studies have examined STB stock, by product type, in the U.S. Further analysis of these U.S. stock numbers could be conducted to estimate the existing stock in California. The U.S. stock estimates, with sources and applicable notes, are listed in Table 3. Some of these studies have information on stock of premise equipment, such as modems and gateways.

Table 3. STB U.S. Stock Studies

Study Title (Author)	Total U.S. Stock, million (units)	Relevant Year of Stock Estimate	Additional Notes
2015 Annual Report: Voluntary Agreement for Ingoing Improvement to Energy Efficiency of Set-Top Boxes (D+R International)	227	2015	DVR, non-DVR, thin client, DTA
Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities (U.S. DOE)	327	2015	
Analysis and Representation of Miscellaneous Electric Loads in NEMS[3] (Navigant Consulting)	233	2015	Additional stock projections for 2020, 2030, and 2040
Energy Consumption of Consumer Electronics in U.S. Homes in 2013 (Fraunhofer)	361	2013	Shipments by product type

Sources: (U.S. Energy Information Administration, 2017) (U.S. DOE, 2015) (D+R International, 2016) (Urban, Shmakova, & Roth, 2014 (Revised in 2015)).

5.2 Shipments

The Navigant Consulting study on the stock of STBs, referenced in Table 3 above, also includes future projections of stock. There are also several market reports that are available for sale with information on current and project shipments of STBs, including reports from S&P Global Market Intelligence,[4] Grand View Research,[5] and IHS Markit.[6] One of these studies projects significant growth in U.S. shipments through 2024.

5.3 Other Market Information

Cloud DVR and local storage services are growing given service provider product lines. Smaller and faster STB products are also trending upwards (refer to Figure 2).

[3] NEMS: National Energy Modeling System

[4] S&P Global. "Global Set-top Box Market Continues to Defy Predictions of its Demise." December 8, 2016. https://marketintelligence.spglobal.com/our-thinking/newsroom/global-set-top-box-market-continues-to-defy-predictions-of-its-demise

[5] Grand View Research. "Set Top Box (STB) Market Analysis." October 2016. http://www.grandviewresearch.com/industry-analysis/the-global-set-top-box-market

[6] IHS Markit. "Set-Top Box Intelligence Service." https://technology.ihs.com/Services/424122/Set-Top%20Box%20Intelligence%20Service/Analysis?f=261:135237

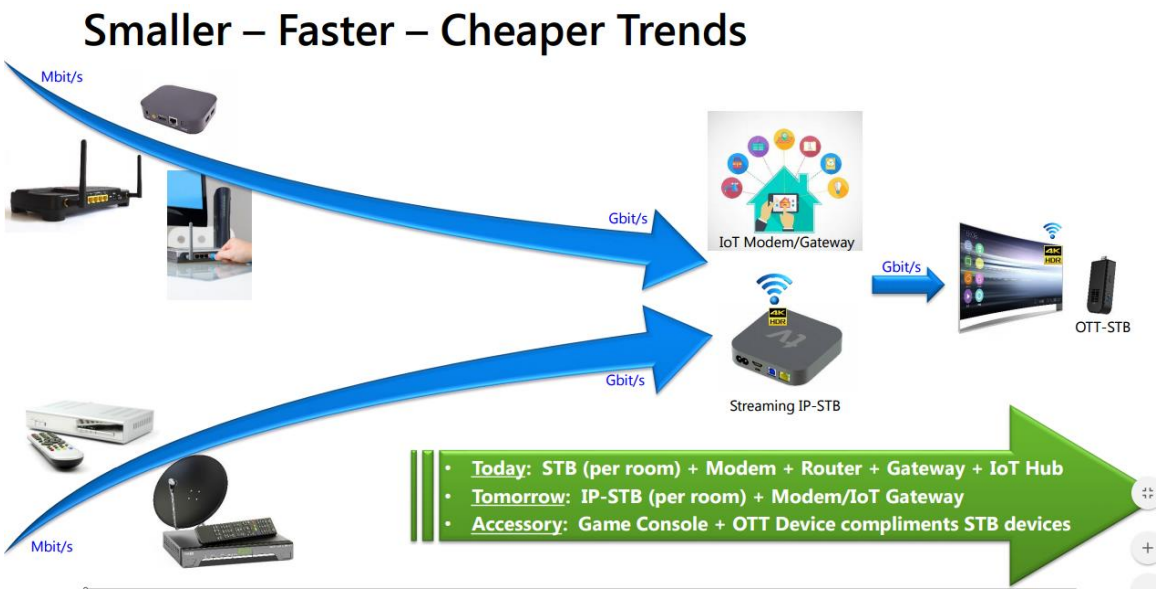


Figure 2. STB Market Trends

Source: (Tran, 2017).

6. Test Methods

The Energy Commission requested information on the test procedure.

6.1 Current Test Methods

An updated test method for STBs is outlined in detail in the Version 5.1 ENERGY STAR specification that was finalized last year (U.S. EPA, 2016). This test procedure aligns with the test setup and instrumentation in Section 7 of the Consumer Technology Association (CTA) standard, CTA-2043, "Set-top Box (STB) Power Measurement", Revised August 2013. At this time, the CASE Team believes the ENERGY STAR test procedure is adequate for consideration in the roadmap. Further study of how STB functions are enabled (or disabled) during setup and on mode operation should be considered to ensure the outputs of the test procedure reasonably reflect real world settings.

7. Energy Usage

The Energy Commission requested information on a number of topics regarding test data and lifetime.

7.1 Data Sources

The CASE Team recommends using the ENERGY STAR certified products list and VA datasets, which cover a majority of the market, as sources of test data. The last published VA report was for 2015 products, so product data published in the upcoming 2016 report would better reflect the current market. CASE Team is not aware of other publically available data sources; however, some

outreach should be conducted to understand the energy consumption of products that do not meet the VA or the ENERGY STAR levels to get an understanding of entire market.

7.2 Duty Cycle

The Energy Commission asked stakeholders about best available estimates of STB duty cycle. In 2016, the CA IOUs proposed new rulesets (or "algorithms") to use in the Title 24 residential compliance software to estimate annual energy use of plug loads and lighting in residential buildings during the 2016 code change cycle for California's Building Energy Efficiency Standards. The 2016 CASE Report developed by the California Utilities Statewide Team referenced duty cycle data from a DOE rulemaking to estimate the annual energy consumption (AEC) of some STBs, shown in Figure 3 (California Utilities Statewide Codes and Standards Team, 2016). DOE's duty cycle assumptions were derived from 2011 metering data that binned daily usage into on the three modes: on, multi-stream, and sleep. The CEC should consider these duty cycles estimates for the relevant STB product types. Additionally, the D+R Report includes TEC reported by STB product type, but not the assumed duty cycles, provided by service providers. Further outreach to the service providers could be conducted to obtain duty cycle information.

Operational Mode	Cable without DVR [47]	Cable with DVR	Satellite without DVR	Satellite with DVR
On	12.4	12.9	12.7	11.5
Multi-stream	0	1.8	0	3.8
Sleep	11.6	9.3	11.3	8.7

Figure 3. Duty Cycle Estimates

Source: (California Utilities Statewide Codes and Standards Team, 2016).

7.3 Lifetime

The 2013 CASE Team previously provided information on an estimated mean product lifetime for STBs of five to seven years based on a 2013 DOE analysis (CA IOUs, 2013). The CASE Team is not aware of other sources of data on STB lifetimes. Under the VA, this information is not collected. One alternative method the Energy Commission could use to estimate useful lifetime is how often a consumer changes video subscriptions since it is likely the consumer will update their STB equipment at that time. We encourage the Energy Commission to work closely with service providers and STB manufacturers to better understand the useful lifetimes of STBs by product type and subscription trends. A better understanding of useful lifetime will also help inform how the roadmap can address the existing STB stock, on which the Energy Commission also requested information.

7.4 Per Unit Energy Use

The VA outlines two tiers of requirements with regard to energy use and the service providers procurement of STBs. Specifically, at least 90 percent of STBs purchased after December 31, 2013 shall meet the efficiency standards established for Version 3.0 ENERGY STAR specification, described in the VA as Tier 1. After December 31, 2016, more stringent efficiency levels, designated as Tier 2, took effect that were similar to the Version 4.1 ENERGY STAR specification. The procurement commitment under Tier 2 is also 90 percent. Table 4 below outlines the base

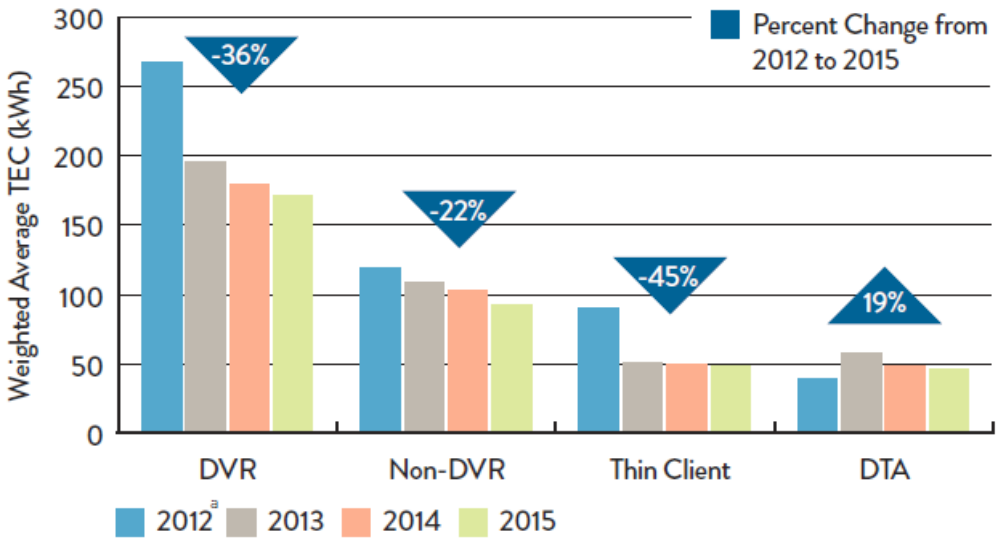
allowances without functional allowances across the different versions of the ENERGY STAR specification and the effective dates.

Table 4. STB Base Functionality Allowances in ENERGY STAR Versions

STB Base Functionality	ENERGY STAR Version 3 Allowance (kWh/yr): Tier 1 VA	ENERGY STAR Version 4.1 Allowance (kWh/yr): Tier 2 VA	Current ENERGY STAR - Version 5.1 Allowance (kWh/yr)
Cable	60	60	50
Satellite	70	65	50
Cable DTA	35	40	37
IP	50	-	-
Terrestrial	22	18	-
Thin-client	35	30	7
MVPD IP	-	65	40
OTT IP	-	10	7

Source: CASE Team analysis.

The procurement of energy efficient set-top boxes under the VA has resulted in an average decrease of energy consumption as shown in Figure 4.



[a] 2012 data represents the baseline estimated per unit energy consumption. It was developed using data from the service providers and energy efficiency advocates.
Note: Data used to create this chart is available in Table 6.

Figure 4. Weighted Total Energy Consumption Average of STBs

Source: (D+R International, 2016)

7.5 Energy Saving Features

The Energy Commission asked stakeholders about energy savings features for STBs. The VA outlines a variety of commitments to features that can reduce a STB's overall energy consumption, including deployment of light sleep, automatic power down, whole-home systems, cloud-based recording, next generation power management, among others (D+R International, 2016). There have been examples of successes in meeting these commitments for some service providers, but more energy savings opportunities remain, especially since VA commitments will end in 2018.

8. Conclusions

While significant efficiency gains have been made with the adoption of the Tier 1 and 2 levels specified in the VA, there are still significant energy savings opportunities for STBs as reflected by the Version 5.1 ENERGY STAR specification. For instance, according to EPA, products that meet the Version 5.1 ENERGY STAR specification will offer more than 30 percent or **21 kWh** in annual savings beyond conventional products. With an existing stock in the range of 227 to 361 million units, per Table 3, the potential stock turnover energy savings is **4.8 to 7.6 TWh annually**. Given this savings potential and the VA is scheduled to end in 2018, the CASE Team encourages the Energy Commission to pursue a roadmap for STBs.

9. References

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U.S. EPA. (2016). ENERGY STAR Program Requirements for Set-top Boxes. *Eligibity Criteria*.
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Appendix A: CA IOU 2013 Response

(See following pages)

Set-top Boxes and Small Network Equipment

Response to California Energy Commission
2013 Pre-Rulemaking Appliance Efficiency
Invitation to Participate

Docket Number: 12-AAER-2A; Consumer Electronics

May 9, 2013

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY

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SAN DIEGO GAS AND ELECTRIC

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This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

Summary

The U.S. policy landscape for set-top boxes is dynamic, including federal Department of Energy rulemakings and the finalization of the ENERGY STAR® Version 4.1 specification; however, we see this as an opportune time for California to explore efficiency opportunities for set-top boxes. There are large variations in energy consumption between set-top box models that offer similar capabilities and DOE's recently released engineering analysis shows that there are many cost-effective choices for improved components. Furthermore, European service providers are experimenting with scheduled and quick-wake deep sleep, technologies that could pave the way for more efficient pay-television delivery in the U.S.

In our response for set-top boxes below, we include several data submissions and recommendations for CEC consideration, including information on product scope, functions and modes of operations, energy saving technologies, market characteristics, and market competition for efficient products. We recommend that CEC follow EPA's lead by including headless gateways in the scope for a set-top box rule. Furthermore, CEC should follow Europe's lead by including adders for emerging technologies such as 3D television and ultra high definition television as well as gateway functions such as voice, data routing, or Wi-Fi access. The most recent energy consumption data for set-top boxes comes from the ENERGY STAR qualified products list and the DOE NODA. We also provide key information on market characteristics and hope to see more specific market data for California in industry's ITP responses.

Similarly, small network equipment, a category that has received little policy focus until recently, presents a significant savings opportunity given the power level variation between similar products. In our response for small network equipment below, we include several data submissions and recommendations for CEC consideration, including information on product scope, functions and modes of operations, energy saving technologies, market characteristics, and market competition for efficient products. The EPA has crafted a final draft test procedure and is well on its way to finalizing its Version 1.0 ENERGY STAR specification. Energy efficient technologies are available in the market for zero to little incremental cost, but stock penetration is low. We do not have detailed data about sales penetration of efficient network gear, but market actors state that technologies like Energy Efficient Ethernet will become ubiquitous in the coming years. There are early efforts to improve the efficiency of Wi-Fi, the most common type of local area networking in U.S. homes. We hope to learn more about Wi-Fi efficiency from industry through this process. We also provide useful market data and market characteristics for this group of products. The chief sources of power level data come from the ENERGY STAT data set, which includes data points from an NRDC study of residential network equipment that is in progress.

The information below provides direct response to the California Energy Commission's (CEC) Invitation to Participate (ITP) for the 2013 Appliance Efficiency Pre-Rulemaking, regarding Set Top Boxes and Small Network Equipment, including reference to several primary sources, some of which are attached separately (see References for more details). This document includes all of the questions asked in the ITP, even for those with no response.

Table *of* Contents

1 Basic Information

1.1 Product Definition and Scope

Set-top boxes

We recommend that California consider the definitions and scope defined in the ENERGY STAR® Product Specification for Set-top Boxes Eligibility Criteria Draft 1 Version 4.1 (herein referred to as the ENERGY STAR Set-top Boxes Specification) with the exception terrestrial set-top boxes. We favor exclusion of terrestrial set-top boxes given the fact that a) the market has contracted significantly for these devices, which were developed to enable people with analog televisions to watch digital broadcast channels during the transition to all-digital broadcast, and b) a federal rebate program for efficient digital converter boxes resulted in widespread sale and adoption of efficient devices. We agree with EPA's inclusion of headless gateways in abovementioned document. Per our comments about the DOE set-top box test procedure NOPR (see Appendix A), we would prefer a set-top box definition that did not limit set-top boxes to devices with direct video output. However, we feel that the EPA's definition and scope is sufficient and aligns with the DOE NOPR.

Small network equipment

We recommend aligning with ENERGY STAR Product Specification for Small Network Equipment Eligibility Criteria Draft 2 Version 1.0 on definition and scope. "Small network equipment is network equipment that is intended to serve users in either small networks or a subset of a large network. It is designed for stationary operation outside of standard equipment racks, and contains 11 or fewer wired physical network ports" (EPA 2012a).

1.2 Set-top box types, thin client, router, modem?

Set-top boxes

We recommend that California considers the set-top box definitions in the ENERGY STAR Set-top Box Specification (EPA 2013a).

> **Cable:** A STB or Displayless Video Gateway whose primary function is to receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system with Conditional Access (CA) or a STB capable of receiving cable service after installation of a CableCARD or other type of Conditional Access system.
>
> **Satellite:** A STB or Displayless Video Gateway that receives and decodes video content as delivered from a Service Provider satellite network and that is not Cable.
>
> **Cable Digital Transport Adapter (DTA):** A minimally-configured STB whose primary function is to receive television signals from a broadband, hybrid fiber/coaxial, or community cable distribution system.
>
> **Internet Protocol (IP):** A STB or Displayless Video Gateway whose primary function is to receive television/video signals encapsulated in IP packets and that is not Cable, Satellite, or Cable DTA.

i) Over-the-top (OTT) Internet Protocol (IP): An IP STB that does not receive signals from a Multichannel Video Programming Distributor (MVPD).
ii) Service Provider Internet Protocol (IP): An IP STB that receives signals from a MVPD.

Terrestrial: A STB whose primary function is to receive television signals over the air (OTA) or via community cable distribution system without Conditional Access (CA) and that is not Cable, Satellite, Cable DTA, or IP.

Thin-client / Remote: A STB that can receive content over an HNI from another STB, but is unable to interface directly to the Service Provider network.

Small network equipment
We recommend that California consider the small network equipment device types defined in the ENERGY STAR Product Specification for Small Network Equipment Eligibility Criteria Draft 2 Version 1.0.

1.3 Existing Test Procedures

Set-top boxes
We recommend that California considers the test procedure used by EPA in the ENERGY STAR Product Specification for Set-top Boxes Eligibility Criteria Draft 1 Version 4.1. This test procedure consists of the proposed DOE test procedure for set-top boxes plus an additional test procedure for headless gateways based on CEA 2043.[1] Neither ENERGY STAR nor DOE test procedures are finalized, but we don't believe that timing should hinder forward progress on the Title 20 pre-rulemaking. The EPA has stated its intent to finalize v4.1 in summer 2013 based on the DOE test procedure NOPR independent of the timeline for a final DOE rule.

Small network equipment
We believe that ENERGY STAR has developed the best small network equipment test method and recommend aligning with the Final Draft, Rev. November-2012.

1.4 Sources of Test Data

Set-top boxes
The most current source of set-top box test data is the ENERGY STAR Qualified Products List (QPL) (EPA 2013b). Other important test data sources include DOE's Notice of Data Availability (NODA) (DOE 2013) and the Natural Resources Defense Council study of set-top boxes (NRDC 2011).

Small network equipment
ENERGY STAR has published a masked data set for small network equipment (EPA 2012b) and plans to publish an updated data set based on its recent request for additional information from

[1] DOE has published a notice of proposed rulemaking for a test procedure for set-top boxes. 78 FR 5075 (January 23, 2013).

manufacturers. NRDC has also recently collected data on small network equipment and plans to publish its findings and data in the near future.

1.5 Existing Standards and Standards under Development

(Note: we take this to mean efficiency standards.)

Set-top boxes
In the U.S. there are currently no state or federal standards in effect. DOE is considering the development of a federal standard for set-top boxes and has published an initial analysis that estimates the potential impacts of an energy conservation standard for set-top boxes. 78 FR 14717 (March 7, 2013).

Small network equipment
In the U.S. there are currently no state or federal standards in effect. ENERGY STAR is developing a voluntary specification.

1.6 Product Lifetime

Set-top boxes
The best publically available source of information about product lifetime is captured in DOE's NODA (DOE 2013), which we have reproduced below (Table 1).

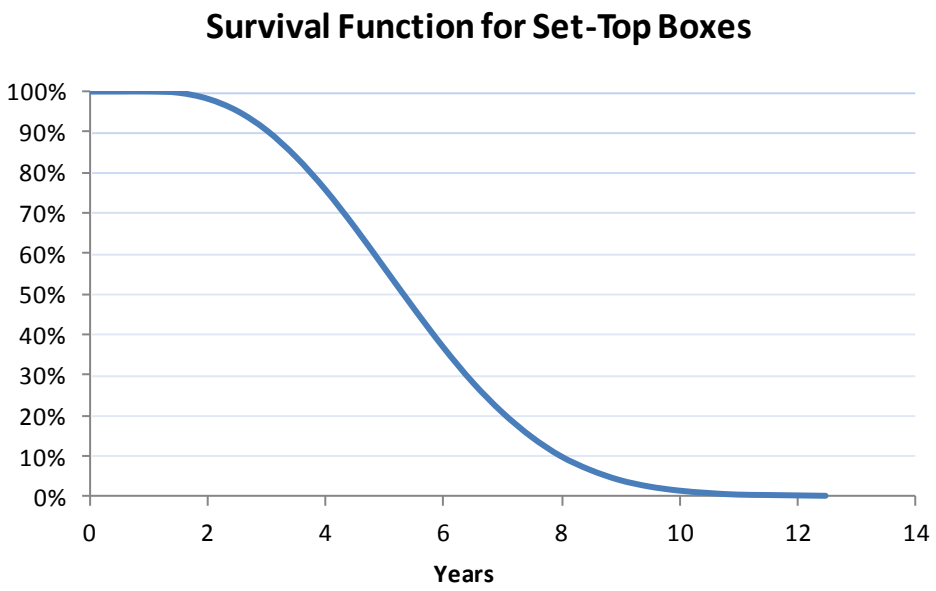
STB lifetime was estimated based on expert opinion. The consensus among 5 technical experts was that the mean STB lifetime was between 5-7 years, and the maximum STB lifetime was approximately 11 years. DOE modeled the distribution of STB product lifetimes as a cumulative Weibull distribution, with a mean STB lifetime of 5-6 years, a minimum lifetime of 1 year, and a maximum lifetime of 12 years (Figure 1).

Table 1. Product lifetime from DOE NODA

Age	% retiring	% surviving
0.0	0.0%	100.0%
0.5	0.0%	100.0%
1.0	0.0%	100.0%
1.5	0.3%	99.7%
2.0	1.5%	98.2%
2.5	3.0%	95.2%
3.0	4.8%	90.4%
3.5	6.6%	83.8%
4.0	8.1%	75.7%
4.5	9.3%	66.4%
5.0	10.0%	56.4%
5.5	10.0%	46.4%
6.0	9.6%	36.8%
6.5	8.7%	28.1%
7.0	7.4%	20.7%
7.5	6.1%	14.6%
8.0	4.8%	9.8%
8.5	3.4%	6.4%
9.0	2.5%	3.9%
9.5	1.6%	2.3%
10.0	1.0%	1.3%
10.5	0.6%	0.7%
11.0	0.4%	0.3%
11.5	0.1%	0.2%
12.0	0.1%	0.1%
12.5	0.1%	0.0%
Sum	100%	
wt. avg. Life =	5.69	

Source: DOE (2013)

Figure 1. Survival function for set-top boxes from DOE NODA



Source: DOE (2013)

Small network equipment

All small network equipment product categories are estimated to have a 5 years design life based on Infonetics (2012).

1.7 Product Development Trends

Set-top boxes

Unicast video content whether free (e.g. YouTube) or subscription-based (e.g. Netflix) continues to grow in popularity. This will affect the product design of and duty cycles for a variety of devices including Blu-ray players, game consoles, smart phones, tablets, set-top boxes, smart televisions, over-the-top (OTT) set-top boxes (e.g. AppleTV) and the network equipment that distributes this content within the home.

The pay-television industry's ongoing shift to multi-room, client-server set-top box deployments will enhance the consumer viewing experience by enabling consumers to program one DVR and later enjoy the recorded content on any television or supported display device within the home. Multi-room architectures will deliver a better consumer experience than a multi-DVR deployment for less energy. Satellite service providers are adopting a thin-client approach, while cable operators appear to be adopting an approach where hybrid clients can receive broadcast content from the service provider headend or recorded content from the in-home DVR server. The energy trade-off between these two approaches is complex and requires further study.

Transcoding pay-television broadcast and locally stored content for distribution throughout the home and over the internet will require higher processing power for server set-top boxes that support this function.

We have heard reports of European product development trends focused on deep sleep to include scheduled sleep deployments at Sky Deutschland and the development of a satellite receiver box with a low power, quick wake deep sleep mode.

Small network equipment
The market continues to evolve to faster, higher-power mechanisms for delivering content to the home (e.g. DOCSIS 3.0, VDSL, Fiber to the Home) and faster means for sharing content within the home (e.g. MoCA 2.0, 802.11ac). Manufacturers have introduced products that adhere to the Energy Efficient Ethernet (EEE) standard, IEEE 802.3az, with full adoption of this technology forecasted for 2-3 years from now.[2] Finally, as with set-top boxes and other consumer electronics devices, there is a trend towards integration of broadband, VOIP and local area networking capabilities into gateway devices. This integration has the potential to save energy, but it also presents challenges to policy makers in terms of adding complexity to test methods and efficiency metrics.

2 Operations, Functions, and Modes

2.1 What are defined modes of operation for set-top boxes? Are there methods for measuring each of these states?

Set-top boxes
Fundamentally, set-top boxes have three operational modes, On, Sleep, and Off as defined in draft CEA 2043, the text of which we will not reproduce here in recognition of the fact that CEA has not publicly released the draft document. Few if any of today's set-top boxes have an Off mode, and power levels can vary based on use or activity for either On or Sleep modes.

CEA 2043 and the proposed DOE test procedure provide ways to measure power levels in each of these states. As noted in the IOU comments about the DOE test procedure NOPR (Appendix A), there are gaps in these methods. For example, the lack of a means to measure power in scheduled sleep provides a disincentive for pay-television set-top box market actors to develop a scheduled deep sleep state. Makers of efficient OTT set-top boxes achieve lower power sleep states with quick resume, so scheduled deep sleep is not needed.

There are currently design constraints having to do with reestablishing a secure connection with headend equipment and downloading program guide content that result in long wake times for deep (i.e., lower power) sleep states. There are two possible solutions to this problem. One is to reduce the wake time associated with deep sleep. The other is to identify other, more creative ways to put the box into deep sleep without compromising the user experience; scheduled sleep has the potential to do this.

Small network equipment
Network equipment has three operating modes, On, Sleep, and mechanical Off. Devices in On mode are being actively used to do transfer information for the consumer. Devices in sleep mode

[2] According to one network equipment manufacturer.

(a.k.a., network standby or idle) maintain their connection to the internet and other connected devices but do not actively transfer content for the user. From the perspective of most users, small network devices are continuously on and available to transfer data. The ENERGY STAR test method for small network equipment requires manufacturers to measure the power of these devices with very low data rate to simulate the typical operating environment for small network devices. The intent is to capture the power level of each device in network standby; however, EPA requires a data rate greater than zero megabits per second in order mitigate the risk of gaming.

2.2 What is the most consumptive state, which is the lowest consumptive state (other than a mechanical off)?

Set-top boxes

On is the most consumptive state. Sleep is the least consumptive state. Most, if not all, set-top boxes do not have an off state.

Small network equipment

On is the most consumptive state. Sleep is less consumptive.

2.3 How frequently are products in each of these states?

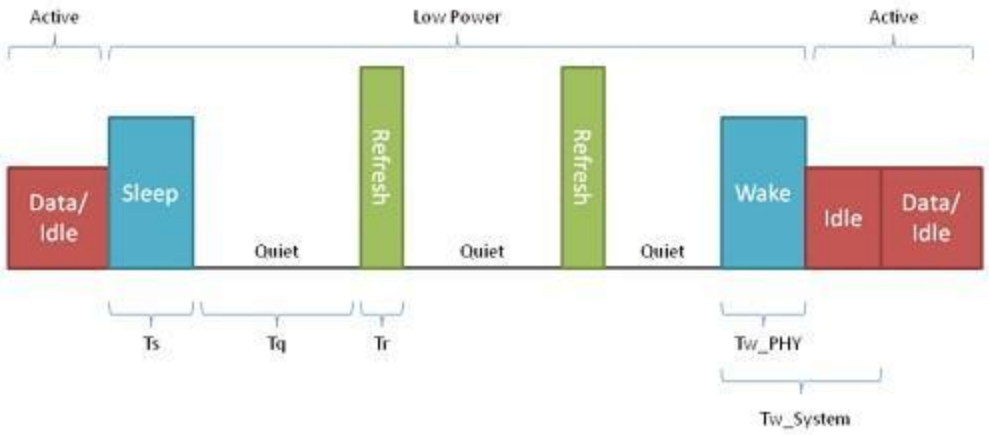
Set-top boxes

Set-top box duty cycles depend on the device type, product design and user interaction. The EPA team that developed the ENERGY STAR duty cycle performed a broadly-accepted evaluation of the best available data. DOE proposed to adopt the ENERGY STAR duty cycle but has asked for feedback on different set of duty cycle assumptions as well.

Small network equipment

Small network equipment spends the vast majority of its time in sleep mode or network standby. From a technical perspective, there is little difference in device behavior between network standby and active with low data rate. Inefficient devices will be fully powered in both standby and active modes, and efficient devices like those with energy efficient Ethernet (EEE) will briefly send information followed by intervals of Low Power Idle, measured in milliseconds (Figure 2).

Figure 2. Low power idle diagram where t_q is measured in milliseconds and t_r, t_w and t_s in microseconds



Source: Connecting Edge (2013)

2.4 How well does energy consumption scale with the utilization of hardware such as processors by processing load and networking hardware by data rate/volume, number of clients etc?

Set-top boxes

Historically, set-top boxes have done a poor job of scaling power levels to use. A standard pay-television set-top box draws nearly the same power when in sleep state as it does when the user is watching or recording a show. In the last year, however, the cable industry began to improve designs, powering down the hard drives and other components of recent model set-top boxes. This resulted in a sleep mode power decrease from On mode of about 7 watts compared to the 1-2 watt decrease from On mode we see in set-top boxes without hard drive power-down. Recently offered multi-room servers have greater potential to power scale by powering-down unused tuners and network interface ports.

According to DOE's NODA, there are cost effective pathways to more effective power scaling than offered in today's set-top boxes. Figure 3 below plots On and Sleep mode power levels associated with DOE's Candidate Standard Level 3 for all DOE product classes except OTT.[3]

[3] Ecova analysis of DOE teardown and improved component analyses is within the engineering analysis workbook.

Figure 3. On and Sleep mode power levels associated with DOE's Candidate Standard Level 3 for all DOE product classes except OTT.

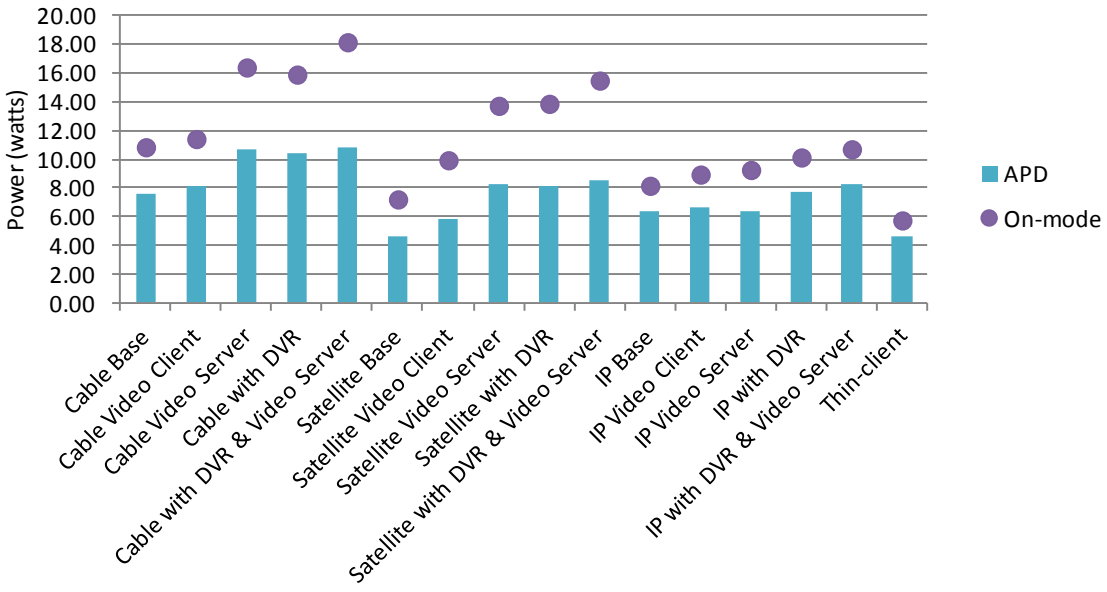
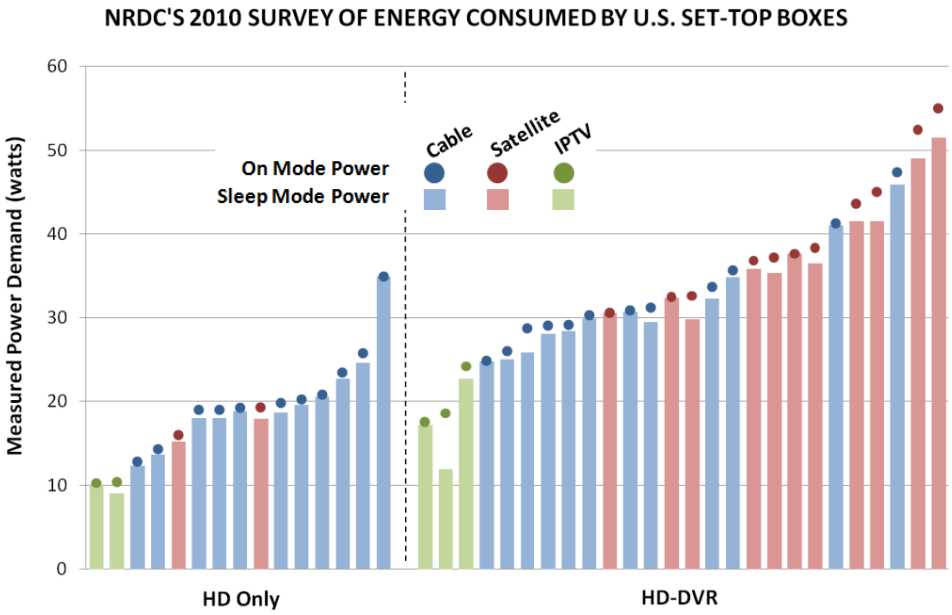


Figure 3 contrasts sharply with the data collected for NRDC (2011) shown below (Figure 4). This data reflects differences of 1-2 watts between On and Sleep mode power levels; whereas, the DOE analysis reflects power drops ranging from 1-8 watts.

Figure 4. Survey of U.S. set-top box power levels



Source: NRDC (2011)

Small network equipment

Devices with EEE effectively scale power to use. Most of today's devices power down Ethernet ports that are not in use. EEE devices go the extra step of enabling power scaling for active ports based on data transfer rate. EEE saves energy at both ends of the link (e.g. router and computer) but only if both ends of the link support EEE and have it enabled. Therefore, it is important to encourage or possibly require widespread adoption of EEE. We observe some degree of power scaling of Wi-Fi devices with use based on a limited number of data points, but further study is required.

2.5 What components and functions represent a fixed energy consumption while the product is on or in a sleep state?

Set-top boxes

The DOE NODA (DOE 2013) engineering analysis workbook provides a breakdown of component power use by mode by product class. For example, in Table 2 below, which shows tear-down analysis data for a cable DVR video server, one can see that most of the major subsystems, those highlighted in yellow, use the same power regardless of whether or not the set-top box is displaying content on a single, connected television (watch), in sleep mode, or sending content to multiple displays (multi-stream). Note that the power supply unit (PSU) produces less waste heat when other components power down because it operates at relatively constant efficiency within the range in question for this example. Other terms:

- SOC: system on chip
- RF: radio-frequency tuner
- HDD: hard disk drive
- HNI: home network interface (e.g. MoCA or Wi-Fi)

Table 2. Tear-down analysis data for a cable DVR video server

		Baseline
		Teardown
	Source	5
	MPC	$208.57
	Incremental Cost	$0.00
	AEC (kWh/yr)	277.9 kWh
	PWATCH	31.89 W
	PSLEEP	31.50 W
	PAPD	N/A
	PMULTISTREAM	31.89 W
Watch	PSU	4.78 W
	SOC	8.10 W
	RF	4.50 W
	HDD	6.00 W
	HNI	2.00 W
	Other	6.51 W
Sleep	PSU	4.73 W
	SOC	8.10 W
	RF	4.50 W
	HDD	6.00 W
	HNI	2.00 W
	Other	6.18 W
Multi-stream	PSU	4.78 W
	SOC	8.10 W
	RF	4.50 W
	HDD	6.00 W
	HNI	2.00 W
	Other	6.51 W

Source: DOE (2013)

Small network equipment

Small network devices have many fewer components than STBs on average. The California IOUs plan to perform limited tear down analysis of small network devices in order to answer this question. The results are not available in time for the May 9 ITP deadline but we plan to submit within the coming weeks or months. We also look forward to reviewing and comparing data provided by industry.

3 Energy Saving Technologies, Components, and Features

3.1 What power management features exist at both the system and subsystem levels?

Set-top boxes

Pay-television set-top box system level power management focuses primarily on auto power-down (APD), which has not yet achieved broad adoption according the April 8th, 2013 ENERGY STAR QPL. Of the 87 set-top boxes listed on the QPL, only 29 have APD. None of the pay-television set-top boxes in this group auto-power-down to deep sleep; four streaming media players from two vendors do.

We look forward to reviewing additional data submitted by industry for detailed information about component level power management (e.g. processor voltage and frequency scaling).

Small network equipment

Network equipment power management focuses primarily on:

- Powering down unused Ethernet ports
- Powering down ports and other system components to low power idle (LPI) between data packets when operating at less than the maximum supported data rate

Devices with EEE support these capabilities; however, it is important to note that there is an opportunity to automatically power down network devices during long periods of inactivity, such as the middle of the night. Furthermore, we have observed variation in power levels for devices with similar features and power management capabilities; we believe that this variation has to do with component level efficiency, not power management. We are planning to perform a teardown analysis to verify our observations.

3.2 How long does it take products to wake from various sleep modes? What contributes to this wake time?

Set-top boxes

Wake from light sleep takes as little as a second or two because few of the typical pay-television set-top box's components or functions are sleeping.

The 0.5 watt deep sleep mode offered in European set-top boxes typically uses a proxy chip that wakes the main components from an off state. Wake times from this state are comparable to power-up times for U.S. boxes when mains power is restored after being removed and can range from 1 to 7 minutes (including the time it takes to restore full program guide capability).

Small network equipment

It takes microseconds for EEE devices to wake from low power idle. Most small network equipment users would never notice the latency associated with EEE.

3.3 To what extent are energy efficient mobile networking technologies incorporated into STBs and network equipment?

Set-top boxes

Some OTT set-top boxes appear to have benefited from reuse of mobile system architecture and components. For example, AppleTV architecture is based on the iPhone. Some set-top boxes sold in Europe and Canada include low-power, 2.5 inch mobile hard drives. We look forward to seeing additional input from industry on this question.

Small network equipment
Since Wi-Fi is commonly used on mobile devices, Wi-Fi standards and technologies have been developed with battery life in mind.

3.4 What are the design practices and technologies incorporated into the most efficient products?

Set-top boxes
IP set-top boxes (IPTV and OTT) are not burdened by some of the legacy standards (e.g. DOCSIS and CableCARD) that serve as barriers to more efficient cable set-top box operation. We believe that the use of digital rights management (DRM) in OTT set-top boxes is one of the key factors enabling very low On and Sleep state power levels. DRM however, may not provide a sufficient level of security for the most valuable television content. This needs further study; more and more highly valuable content (e.g. Argo) are available via DRM-based services (e.g. Vudu) shortly after their first play in theaters, which evidences that content providers trust DRM content security.

Small network equipment
Certainly EEE is key to achieving high efficiency levels for small network equipment. We are still studying differences in Wi-Fi and broadband efficiency levels and look forward to industry input on these topics and other efficiency opportunities.

3.5 What are the costs associated with more efficient hardware such as energy efficient Ethernet technology?

Set-top boxes
The best incremental cost data available is captured in DOE's NODA engineering analysis. We return to the example of the cable DVR video server in the table below (Table 3), which records the results of DOE's tear down analysis, on the left and component-level analysis in the columns to the right. The peach-colored shaded cells flag where component changes have been made. The second data column represents an analysis of the energy consumption of the baseline model with an improved hard drive. The third data column represents the base case with improved hard drive and more efficient power supply and so on.

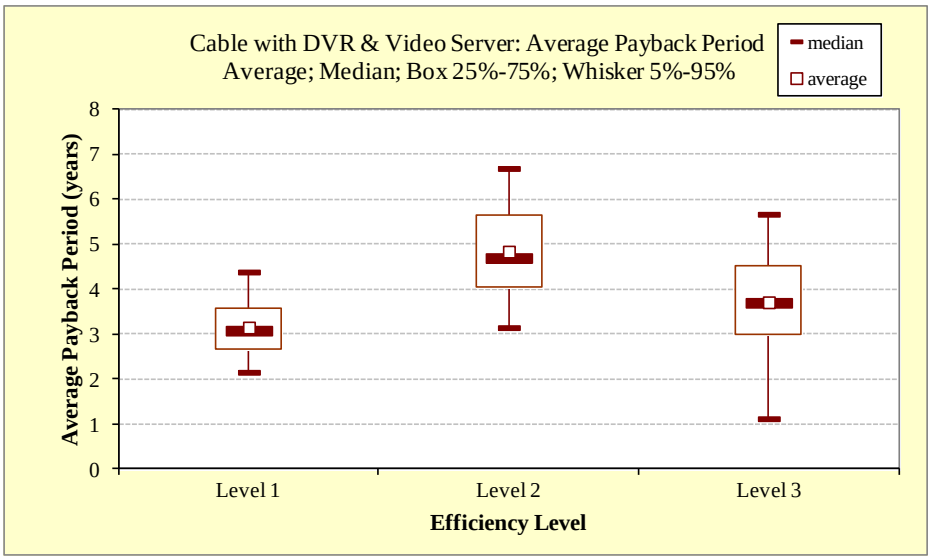
Table 3. Tear-down and component-level analysis of cable DVR video server

		Baseline				CSL 1		CSL 2			CSL 3
		Teardown	HDD	PSU_60W	RF	HNI	HDD	Cable_SOC	PSU_60W	SOC Power Scaling	HDD Power Scaling
	Source	5	Improved	Efficiency Level 3	Full-band Tuner	MoCA 2.0	Best Available	Improved	Efficiency Level 4		Best Available
	MPC	$208.57	$213.07	$214.65	$218.54	$222.74	$234.73	$240.22	$241.54	$241.54	$241.54
	Incremental Cost	$0.00	$4.50	$6.08	$9.97	$14.17	$26.16	$31.65	$32.97	$32.97	$32.97
	AEC (kWh/yr)	277.9 kWh	250.7 kWh	242.1 kWh	214.8 kWh	207.2 kWh	188.7 kWh	169.5 kWh	163.9 kWh	130.5 kWh	120.9 kWh
	PWATCH	31.89 W	28.89 W	27.91 W	24.79 W	23.09 W	20.98 W	18.79 W	18.17 W	18.17 W	18.17 W
	PSLEEP	31.50 W	28.50 W	27.53 W	24.41 W	22.71 W	20.61 W	18.41 W	17.81 W	12.41 W	10.87 W
	PAPD	N/A	28.50 W	27.53 W	24.41 W	22.71 W	20.61 W	18.41 W	17.81 W	12.41 W	10.87 W
	PMULTISTREAM	31.89 W	28.89 W	27.91 W	24.79 W	27.06 W	24.96 W	22.77 W	22.02 W	22.02 W	22.02 W
Watch	PSU	4.78 W	4.33 W	3.35 W	2.97 W	2.77 W	2.52 W	2.25 W	1.64 W	1.64 W	1.64 W
	SOC	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	6.17 W	6.17 W	6.17 W	6.17 W
	RF	4.50 W	4.50 W	4.50 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W
	HDD	6.00 W	3.45 W	3.45 W	3.45 W	3.45 W	1.60 W	1.60 W	1.60 W	1.60 W	1.60 W
	HNI	2.00 W	2.00 W	2.00 W	2.00 W	0.50 W	0.50 W	0.50 W	0.50 W	0.50 W	0.50 W
	Other	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W
Sleep	PSU	4.73 W	4.28 W	3.30 W	2.93 W	2.73 W	2.47 W	2.21 W	1.60 W	1.12 W	0.98 W
	SOC	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	6.17 W	6.17 W	1.26 W	1.26 W
	RF	4.50 W	4.50 W	4.50 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W
	HDD	6.00 W	3.45 W	3.45 W	3.45 W	3.45 W	1.60 W	1.60 W	1.60 W	1.60 W	0.20 W
	HNI	2.00 W	2.00 W	2.00 W	2.00 W	0.50 W	0.50 W	0.50 W	0.50 W	0.50 W	0.50 W
	Other	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W	6.18 W
Multi-stream	PSU	4.78 W	4.33 W	3.35 W	2.97 W	3.25 W	3.00 W	2.73 W	1.98 W	1.98 W	1.98 W
	SOC	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	8.10 W	6.17 W	6.17 W	6.17 W	6.17 W
	RF	4.50 W	4.50 W	4.50 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W	1.76 W
	HDD	6.00 W	3.45 W	3.45 W	3.45 W	3.45 W	1.60 W	1.60 W	1.60 W	1.60 W	1.60 W
	HNI	2.00 W	2.00 W	2.00 W	2.00 W	4.00 W	4.00 W	4.00 W	4.00 W	4.00 W	4.00 W
	Other	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W	6.51 W

Source: DOE (2013)

We plan to ask DOE several questions about this analysis in order to ensure that we understand it correctly. We would like to confirm that the pricing information is forward priced to 2019 or so. We would also like to understand why MoCA 2.0 would be considered an incremental cost given our understanding that industry plans to move to MoCA 2.0 because of its enhanced performance, not because of its energy efficiency benefits. We also wonder if the cost effectiveness of CSL 3 would improve if DOE skipped the best available hard drive (presumably solid state memory), which is expensive and offers little savings. DOE payback calculations show less than four years for CSL 3 for this set-top box type (Figure 5).

Figure 5. Payback calculations for cable DVR video server



Source: DOE (2013)

Small network equipment

The production cost of silicon that supports EEE is expected to have zero incremental cost according to industry actors. It takes up little chip real estate, which is typically the driver of chip cost. We are planning a tear down analysis of efficient devices with the goal of understanding component level efficiency opportunities and the incremental cost of each.

3.6 How well are hardware efficiency features utilized by system software?

Set-top boxes

We hear reports that hardware of most new set-top boxes supports APD and component-level power management capabilities. However, the proprietary software provided by many pay-television service providers does not take advantage of these energy-saving hardware features.

Small network equipment

Unlike the case for STBs, we believe that small network equipment software is typically developed by the manufacturer resulting in software support for all hardware features.

4 Market Characteristics

4.1 How many STBs, modems, and routers are sold to end-users each year in California? How many are currently in use? Commercial or residential?

Set-top boxes

We have procured data from a leading market analyst, SNL Kagan (2012), and are working on a data use arrangement in order to effectively share data during the rulemaking process.

Small network equipment

We estimate there to be approximately 5.5 million residential small network devices purchased by end-users in California in 2013.[4] Based on analysis of proprietary data in Infonetics (2012).

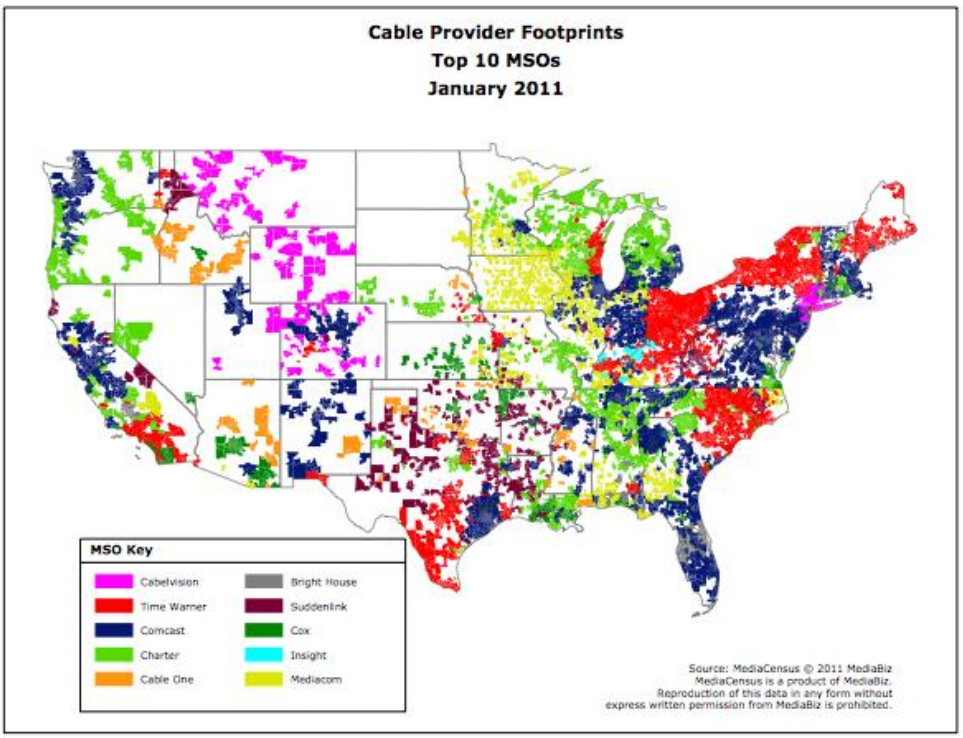
4.2 To what extent is the market uniform or different within the state, country, continent, and world?

Set-top boxes

Service providers tend to offer the same set-top box models nationwide in order to reduce the complexity of their systems. However, many service providers have grown through acquisition of smaller service providers and therefore may have a patchwork of headend equipment supporting a variety of compatible set-top boxes. Often, service providers pair set-top boxes produced by the one manufacturer with headend equipment from the same manufacturer because the manufacturer controls the conditional access security code.

There are regional differences in service provider market share. As shown below in the cable provider map (Figure 6), some service providers are stronger in certain regions than others.

Figure 6. Cable provider footprints, Top 10 MSOs, January 2011



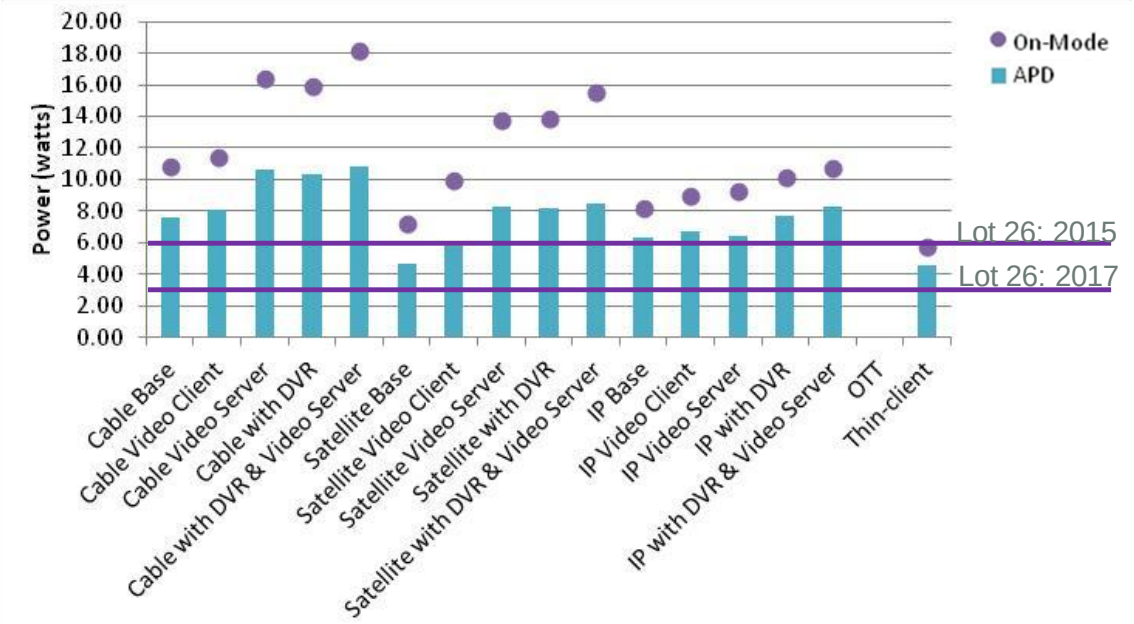
Source: TV by the Numbers (2011)

Europe tends to have lower power set-top boxes, greater innovation relative to quick-wake and scheduled deep sleep, and more stringent regulations. Figure 7 below shows how DOE's engineering analysis compares with the latest levels proposed for Europe's network standby

[4] This also includes estimates for commercial access points from Infonetics (2012).

regulation—Lot 26 (EC 2011)—which would apply to complex set-top boxes deployed in Europe. The dates shown are the latest proposed effective dates for the two power levels. It's important to note that DOE is not proposing to regulate set-top box power levels, but Europe is proposing to regulate network standby power levels for all networked products including complex set-top boxes. Pay-TV system technologies in Europe are different, so it is difficult to make direct comparisons. However, it is also important to stay technology neutral and to consider scenarios where U.S. service providers shift technologies to those that are proven to use less energy. In some cases, the investment required to make the shift will not be worth the return in terms of energy saved; however, it is important to perform this sort of analysis in support of a transparent process for identifying all cost effective savings.

Figure 7. A comparison of DOE On and APD power levels for CSL 3 in 2019 compared to European network standby standard levels for 2015 and 2017



Small network equipment

We understand that small network equipment has fewer technical differences between worldwide markets than is the case for set-top boxes. We look forward to more specific information from industry on this topic.

4.3 Is there a particular time of the year when new models are released?

No response.

4.4 What is the range of efficiency in the market for products with similar performance? Is the variance great?

Set-top boxes
In order to assess the range of efficiency levels, we look at how far above or below the ENERGY STAR TEC allowance the reported TEC of each set-top box falls. This method accounts for differences between high definition (HD) and standard definition (SD) set-top boxes, but it does not account for differences in hard drive size for example. Using this method we see a TEC range for satellite HD DVR server set-top boxes that spans from 160 to 240 kWh per year. And DOE NODA (DOE 2013) engineering analysis provides power levels for OTT set-top boxes that range from 6 to 68 kWh per year. These are just two examples of broad efficiency rages within a product class.

Small network equipment
Preliminary analysis of NRDC data suggests that there 20-30% variation in power level between efficient and inefficient small network devices with the same feature set.

4.5 How frequently are STBs, routers, and modems updated after initial release (firmware and hardware)?

Set-top boxes
We hear reports ranging from daily to monthly. Most reports are on the long end of that range.

Small network equipment
No response.

5 Market Competition for Efficiency Products

5.1 How many small businesses are involved in the manufacture, sale, or installation of these products?

Set-top boxes
The DOE test procedure NOPR includes a brief national small business impact assessment in section IV.B. Review Under the Regulator Flexibility Act. DOE has tentatively concluded that testing costs would not be significant enough to pose a substantial burden on small manufacturers. DOE also requested comment in test procedure NOPR section E.35. This DOE analysis provides useful context to California in assessing the statewide small business impact. From our discussions with satellite service providers, we have learned that some satellite service providers use independent installers to perform installs and maintenance.

Small network equipment
No response.

5.2 What are the current market drivers towards improving efficiency?

Set-top boxes
There are many natural market drivers. Lower power boxes can require less expensive cooling technology and can last longer because they run at lower temperature and have fewer active components (e.g. fans) that reduce mean time between failure. They can be quieter, a consideration that is important to many subscribers. Chip consolidation and die shrinks reduce cost

and energy consumption. These drivers have contributed greatly to the efficiency gains we have seen over the past decade. Although per-box energy consumption has not dramatically increased in the last decade, today's boxes are many times more capable than their predecessors. For example, a decade ago set-top boxes did not have HD or DVR capabilities, but still used about the same amount of energy as today's set-top boxes. However, we have seen relatively little innovation in power management over the past decade compared to, for instance, the level of innovation in mobile devices.

Small network equipment

Mobile device manufacturers select Wi-Fi components based on power levels. It also stands to reason that there would be natural market forces to motivate manufacturers to reduce the energy consumption of large network equipment. Internet service providers pay significant electric bills associated with operating their network infrastructure. These service providers have savvy procurement staff with tremendous buying power. The resulting innovations (EEE included) can be easily transferred to the small network equipment market.

5.3 What markets currently place requirements on the efficiency of products through regulations or procurement requirements?

Set-top boxes

Europe has several regulations related to set-top boxes. These are summarized below.

- EC 1275/2008 (1 / 0.5W stby) 2010 / 2013
  European Commission's (EC) 1 watt standby regulation (EC 2008), which is transitioning to 0.5W this year, applies to all energy using products, where appropriate. This rule is not considered appropriate for network equipment, for example, because in most cases network equipment must provide continuous service. Set-top box makers have chosen to comply with this requirement, rather than risking a legal battle over the "appropriateness" of the rule to set-top boxes, by including a deep sleep mode that can be activated by holding the power button down for 3-5 seconds. Most reports suggest that not many consumers use this feature because of 2-10 minute wake times.
- EC Network standby (6 / 3W stby) 2015 / 2017
  Europe has developed a network standby regulation to address products like network equipment that require persistent connectivity (EC 2011). The European Commission has specifically stated that complex set-top boxes are within scope of this requirement. The proposed draft was been notified to the WTO, which was scheduled to vote on it on March 23, 2013. We do not know the outcome of that vote.
- EC 107/2009 Simple Set-top Boxes 2009 / 2012
  Simple set-top boxes, defined as set-top boxes with no conditional access function, must meet the power levels specified below (effective 2012) with 3 hour auto power down (EC 2009b).

	Standby mode	Active mode
Simple STB	0,50 W	5,00 W
Allowance for display function in standby	+ 0,50 W	—
Allowance for hard disk	—	+ 6,00 W
Allowance for second tuner	—	+ 1,00 W
Allowance for decoding HD signals	—	+ 1,00 W

Source: EC (2009b)

- EU Code of Conduct for Digital TV Services 2010 / 2013
  Europe's Code of Conduct sets out the basic principles to be followed by all parties involved in digital TV services (EC 2013a). This aspirational labeling program is structured like ENERGY STAR, using TEC base levels with functional adders. Version 8 (EC 2009a) Tier 2 became effected Jan 1, 2013; however, Version 9 is reported to be planned for a mid-2013 effective date. Notes from fall, 2012 meetings (Moraillon 2012) suggest that Version 9 will add additional functionalities and introduce changes to better align with the Voluntary Industry Agreement and Network Standby regulation. New adders in consideration include High Efficiency Video, Full High definition, Ultra High Definition, 3DTV, Advanced Graphics,
  Multi Decode/Transcode, Multi display, Router, VOIP, and Smart Home Services.
- EU Voluntary Industry Agreement 2010 / 2013
  This industry agreement for complex set-top boxes is structured similar to ENERGY STAR with TEC base and functional adder levels (eceee 2013). Tier 2 takes effect on July 1, 2013. Industry is reported to be working on a version 4.0 that would take effect on July 1, 2013 to coincide with the Tier 2 effective date. The VIA includes adder levels for Full High Definition, Ultra High Definition, and 3DTV.

Small network equipment

Europe has several policy activities related to network equipment. These are summarized below.

- The EU network standby regulation referenced above applies to network equipment.
- EU Code of Conduct for Broadband Access Equipment 2011 / 2013
  The Broadband CoC has much broader scope than ENERGY STAR (EC 2013b, 2013c). It covers:

  Customer premises equipment

  Home gateways:
  • DSL CPEs (ADSL, ADSL2, ADSL2plus, VDSL2)
  • Cable CPEs (DOCSIS 2.0 and 3.0)
  • Optical CPEs (PON and PtP)
  • Ethernet router CPEs
  • Wireless CPEs (WiMAX, 3G and LTE)

Simple broadband access devices:
• DSL CPEs powered by USB
• Layer 2 ONTs

Home network infrastructure devices:
• Wi-Fi access points
• Small hubs and non-stackable Layer 2 switches
• Powerline adapters
• Alternative LAN technologies (HPNA, MoCA) adapters
• Optical LAN adapter

Other home network devices:
• ATA / VoIP gateway
• VoIP telephone
• Print server

Network equipment

• DSL Network equipment (example: ADSL, ADSL2, ADSL2plus, VDSL2)
• Combined DSL/Narrowband Network equipment (example: MSAN where POTS interface is combined with DSL BroadBand interface, etc.)
• Optical Line Terminations (OLT) for PON- and PtP-networks
• Wireless Broadband network equipment (example: Wi-Fi access points for Hotspot application, WiMAX Radio Base Station)
• Cable service provider equipment
• Powerline service provider equipment

5.4 How are consumers able to identify the most efficient products on the market?

Set-top boxes

Consumers can identify service providers that are ENERGY STAR partners at the ENERGY STAR web site. Consumers can also identify efficient set-top boxes on the ENERGY STAR website, but in many cases they will not be able to get the box that they want. For example, a service provider may list an efficient box on the QPL, but a subscriber may not be in a service territory where that box is offered for the reasons discussed in section 4.2 above. The power level information available in the QPL indicates that OTT set-top boxes use significantly less power than most pay-TV set-top boxes, and that IPTV set-top boxes generally use less power than cable or satellite set-top boxes. However, only the most educated of consumers will research, understand, and ultimately make an efficient purchase given this information.

Small network equipment

Knowledgeable consumers can look for 802.3az in the technical specs or can look for proprietary efficiency labels such as TrendNet's GREENnet label shown below.

As mentioned earlier ENERGY STAR is developing a voluntary labeling program for small network equipment that will clearly identify efficient devices for consumers.

5.5 What is the current market share of products that meet ENERGY STAR's STB specifications versions 2, 3, and 4 and latest small network equipment draft version 1.

Set-top boxes
We look forward to seeing input from industry.

Small network equipment
We look forward to seeing input from industry.

6 STB Specific Market Characteristics

6.1 How many STBs are purchased by service providers each year?

We have procured data from a leading market analyst, SNL Kagan (2012), and are working on a data use arrangement in order to effectively share data during the rulemaking process.

6.2 How many STBs are in service in California? What percentage of STBs have been in service for 1, 2, 3, 4, or 5+ years?

We have procured data from a leading market analyst, SNL Kagan (2012), and are working on a data use arrangement in order to effectively share data during the rulemaking process.

6.3 How do service providers determine how much to charge for a STB? How is this related to the discount rate provided along with the use of a cable card?

We look forward to hearing from service providers on this question. New rules went into effect on August 8, 2011, that clarified and expanded rights for owners of CableCARD-ready devices (FCC 2013). The FCC guide for these rules (FCC 2013) stipulate, "Your operator must give you a discount on any packages that include the price of a set-top box if you choose to use your own CableCARD-enabled device."

6.4 How are requests for more efficient set-top boxes resolved by service providers?

We understand that it may not be cost-effective for industry to replace many set-top box models with efficient models before the end of useful life. However, if one accounts for the retail cost of electricity saved by the more efficient set-top box, there may be situations where early retirement is cost-effective. We look forward to seeing specific data from industry on this point.

6.5 How do set-top box manufacturers collaborate with service providers during research and development (R&D)?

Our understanding is that major manufacturers (i.e., Motorola and Cisco) collaborate heavily on both set-top box and headend design with major cable service providers (i.e., Comcast and Time Warner). Echostar collaborates closely with Dish Networks, which is owned by the same parent company. DirecTV sources from a variety of manufacturers, who supply private-labeled boxes to DirecTV.

6.6 For STBs where constant connection is required, how do service providers handle customer implementation of energy saving technologies such as smart power strips?

We look forward to hearing from service providers.

7 Other

7.1 What types of operations prevent a STB and network equipment from entering a sleep state? What are some of the satellite specific barriers to sleep modes?

Set-top boxes

Most of today's set-top boxes can enter sleep state. The question is, what prevents them from going into lower power sleep states? The U.S. satellite service providers report that it will be difficult to power down components such as the hard drive because they keep program guide information up-to-date continuously. Essentially satellite providers plan to continue offering sleep states that draw about one watt less than On mode power levels. However, new cable set-top boxes are capable of powering down the hard drive and other components to achieve On to Sleep power drops of 7-8 watts. No U.S. service providers have offered set-top boxes with truly deep sleep, which ENERGY STAR defines as sleep with a power level less than equal to the greater of 3 watts or 15% of On mode power.

MoCA 2.0 fixes some of the power management issues associated with MoCA 1.0. We hope to learn more from industry about MoCA power scaling. DOCSIS has historically not enabled power scaling to data rate; however, DOCSIS 3.0 reportedly has a low power 1x1 mode that will enable lower power network standby for set-top boxes. CableCARD may present a barrier to effective processor shut down for cable set-top boxes.

Small network equipment

As noted clearly in Europe's network standby final report (EC 2011), network availability is the primary barrier to enabling lower power sleep modes. However, there may be opportunities to offer reduced power states accompanied by longer wake times during the middle of the night for example. Customers who required high network availability during these times could opt out.

7.2 What types of events cause a STB or network equipment to automatically awake from a sleep state?

Set-top boxes

Our understanding is that auto-wake events break down into three categories, wake to record pre-programmed shows, wake for a maintenance event, or wake to speculatively record or to otherwise push content onto a consumer's hard drive.

Small network equipment

Small network equipment does not sleep in the same sense that other product categories, like laptop computers sleep. The EEE standard enables Ethernet devices to power down their Ethernet ports and sometimes the processor during the millisecond gaps between packet transfers when not operating at full data rate. During periods of time when the consumer is not requesting any data transfer, network devices still exchange information in order to maintain the network followed by periods of low power idle.

7.3 What product development trends in the market may have an impact on power consumption or proper categorization of devices?

Set-top boxes
The emergence of gateways that support set-top box functionality will likely increase set-top box power draw but reduce total home energy consumption. Per our DOE test procedure NOPR comments, we believe that all gateways with set-top box functionality including headless gateways should be categorized as set-top boxes and that the gateway functions (e.g. VOIP, routing) should be on but not actively in use (i.e., in network standby). Furthermore, many device categories now support OTT video streaming to include smart phones, tablets, game consoles, televisions, and blu-ray players; this trend makes it difficult to clearly distinguish between set-top boxes and other device categories.

Small network equipment
Once again, the emergence of multifunction devices, including gateways, may blur distinctions between product categories.

7.4 What minimum functionalities are required to be maintained by networking protocols?

No response to this question for either set-top boxes or small network equipment.

7.5 What types of products are powered by network connections such as "power over Ethernet"?

Set-top boxes
We are unaware of any set-top boxes that are powered by network connections.

Small network equipment
The primary small network product type powered over Ethernet is the commercial access point, commonly used to provide Wi-Fi signals across large commercials areas such as airport terminals.

7.6 What are the consumption characteristics of Low-Noise Block (LNB) and Optical Terminal Network (ONT) devices?

Set-top boxes
ODUs powered by a household's set-top boxes via coax cable scale power with increasing numbers of active low noise block converters (LNBs) within the ODU. Each LNB within the ODU serves a distinct group of channels, so increasing the number of different channels tuned will increase the number of active LNBs until all LNBs are active. Limited observations of this type of ODU showed that a 5 LNB set-top box powered ODU drew about 1.25 watt when only one channel was tuned to a maximum of about 6.25 watts once all LNBs were active.

Small network equipment
Preliminary test results from an NRDC study of small network equipment suggest that ONTs draw constant power at 10 to 20 watts resulting in an annual energy consumption of 90 to 180 kWh/yr. In addition to providing Internet and phone service, some of these devices receive video

information for watching television. They do not, however, replace the set-top box at each television in the home. Like ODUs, subscribers often leave these devices connected to the exterior of the house even after they discontinue service. Consequently, the consumer could be paying up to $20 a year for wasted electricity.

7.7 Any other information relevant to this proceeding

Set-top boxes

Manufacturers determine the energy consumption of stand-alone DVRs and OTT set-top boxes; however, service providers play the largest role in determining the overall energy consumption of the set-top boxes that they deploy. Large service providers develop specifications and engage in design activities with set-top box manufacturers. They develop program guide application software that dictates whether or not power management features will be used. They also control the configuration of these boxes over time. Small service providers play less significant of a role, but they still select set-top box make and model and control power management configuration.

Small network equipment

Service providers deploy and lease some small network devices; this is more common for broadband access equipment. Local networking devices like Wi-Fi routers are typically sold in retail stores, but there are many exceptions to these trends. It appears that manufacturers are the key determinants of the energy consumption of retail products and that service providers may play an important role in determining the energy consumption of the equipment that they deploy. However, we would like to better understand industry input on this subject.

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Appendix A: General comments regarding DOE test procedure NOPR

Recommend not including the AEC equation in the test procedure

The proposed test method includes an annual energy consumption (AEC) equation and duty cycle, which would be required shortly after the test method is finalized across the spectrum of U.S. policy tools and could delay the introduction or update of policy tools that are either based on updated duty cycle information or are structured to reward duty cycle improvements. Policy tools that may be impacted include state standards, the EPA ENERGY STAR program, utility incentive programs, and industry voluntary agreements. As proposed, the DOE test method would provide a disincentive for market actors to develop innovative approaches to reducing set-top box energy consumption through duty cycle improvements. Such innovations may include the following: user-friendly ways to shorten auto-power-down times, schedule deep sleep during the middle of the night, reduce the number of shows recorded on DVRs by offering more unicast programming, offer long-term shut-down modes for set-top boxes in seasonal vacation homes, educate consumers about how their behavior impacts set-top box energy consumption, or automatically power down the set-top box just after the television powers down using existing power state sharing standards.[5]

We recognize, however, two advantages to including an AEC equation in the DOE test method; although, we believe the disadvantages stated above outweigh these advantages. First, establishing a standardized method for calculating set-top box AEC would reduce variation in how set-top box energy consumption is estimated and reported. On the other hand, to-date there has been little variation in reporting under existing test procedures that do not use an AEC; most market players and advocates have adopted the ENERGY STAR duty cycle as the de facto standard. Furthermore, the variation in reporting we have seen has been welcome.[6] Second and more importantly, if DOE does not include the AEC equation in the test method, then if DOE moves forward with rule making, it would presumably put the AEC equation in the set-top box regulation, thereby reducing DOE's adaptability to duty cycle improvements and related innovations. Given the five-year period that the Energy Policy and Conservation Act requires between a final set-top box rule and its effective date, the DOE would be able to react more quickly to needed duty cycle updates if the AEC equation were in the test method, which becomes fully effective 180 days after the final method is released. However, considering the advantages and disadvantages outlined above and given historic timeframes for DOE test method updates, the CA IOUs believe that the potential negative consequences of including an AEC equation in the DOE test method outweigh the advantages.

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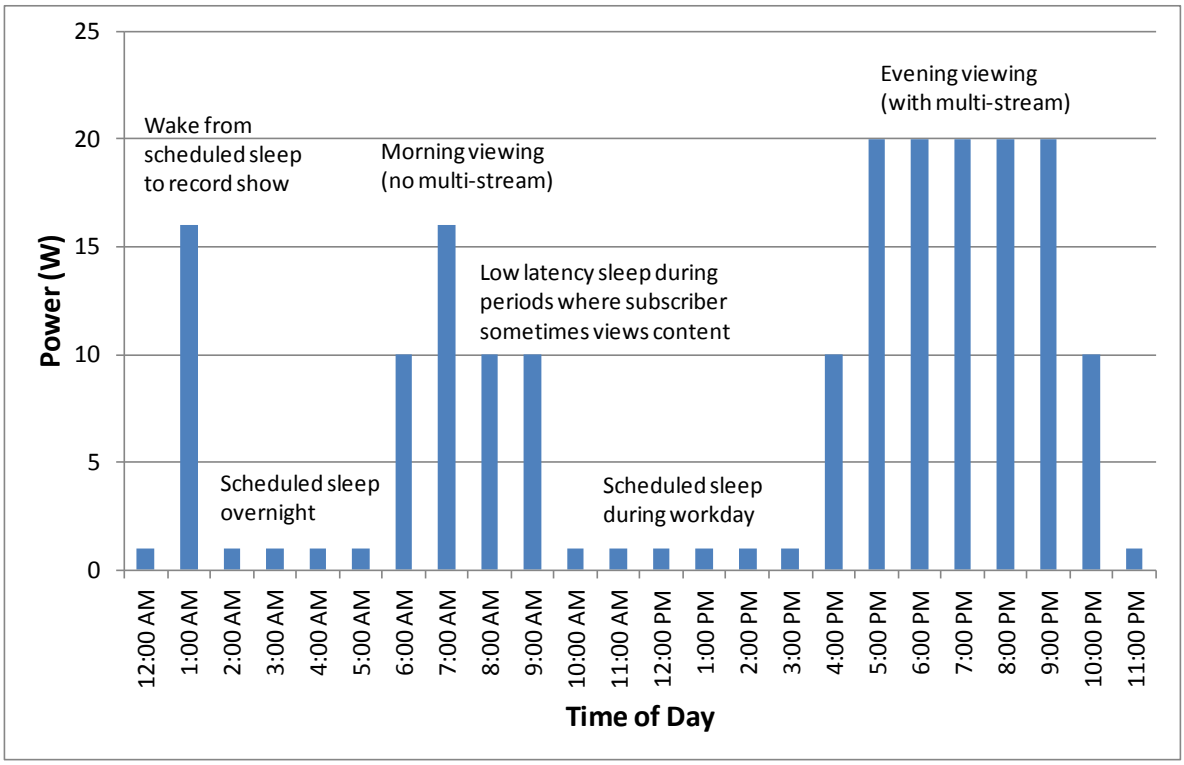
[5] e.g. HDMI consumer electronics control (CEC)

[6] CEA's 2010 survey of residential consumer electronics devices (Urban et al. 2011) provided useful duty cycle analysis; the fact that this study's energy calculations were based on duty cycle assumptions that were different from ENERGY STAR's did not lead to market confusion. Source: Urban, B., V. Tiefenbeck, & K. Roth. 2011. *Energy Consumption of Consumer Electronics in U.S. Homes in 2010.* Fraunhofer Center for Sustainable Energy Systems. Final Report to the Consumer Electronics Association.

Before proposing an alternative approach, we present an analysis of the potential benefits of encouraging deep sleep modes. Figure 8 below demonstrates the potential savings benefit of scheduled deep sleep mode for an efficient cable box of the future.[7] If this set-top box powers down to 1-watt scheduled sleep instead of 10-watt sleep during periods where the user rarely views TV, the user saves 36 percent of the energy used compared to a set-top box without deep sleep. If deep sleep is scheduled for only 4 hours per day, the set-top box still consumes 15 percent less energy.

Figure 8. Potential savings benefit of scheduled deep sleep mode for an efficient cable box of the future



For the reasons outlined above, we recommend that the DOE test procedure focus on measuring the power level and wake time associated with discrete sleep states. Defining sleep states in the face of rapid innovation is a difficult task, but there are precedents. For example, the computer industry has developed power management specification called the Advanced Configuration and Power Interface (ACPI) Specification that defines sleep states.[8] Given the long time required to develop

[7] We base modal power levels on recently released DOE Notice of Data Availability (NODA) information, which demonstrates the feasibility of achieving much lower power levels for cable DVRs with video streaming than exist today. The figure is based on power levels derived for such a set-top box at candidate standards level 3 (CSL3) with the addition of a hypothetical 1-watt scheduled sleep state. The figure assumes the DOE proposed duty cycle with the addition of the deep sleep state in lieu of light sleep.

[8] This specification, which is more than 900 pages in length, is available at http://www.acpi.info/spec.htm. To enable the reader to review quickly the basic sleep states of a PC, we include these definitions below:

such a power management specification, the CA IOUs recommend using the definitions of sleep states proposed in the test procedure NOPR with the addition of deep sleep, for which we would recommend using the definition developed by the EPA for the ENERGY STAR program. We recommend that DOE test method require the measurement of power levels and wake times for the following cases:

1. Sleep Manual
2. Sleep APD
3. Deep Sleep Manual
4. Deep Sleep Scheduled[9]

For Case 1 and 2 above, we recommend using the method currently proposed by DOE with the following additions:

- Disable any scheduled sleep states before testing.
- Run the test a second time to measure wake intervals at two randomly selected times during the test period.
    - For each of these two tests press the power button for < 1 second to wake the set-top box. Start the timer when the power button is released. Stop the timer when the program guide or other program navigation is fully populated and supports channel selection.
- In addition to reporting the average power per the current DOE proposal, report wake times and the power level just before pressing the power button for each wake test.[10]

For Case 3 and 4, we recommend the following steps:

S1 Sleeping State: The S1 sleeping state is a low wake-up latency sleeping state. In this state, no system context is lost (CPU or chip set) and hardware maintains all system context.

S2 Sleeping State: The S2 sleeping state is a low wake-up latency sleeping state. This state is similar to the S1 sleeping state except the CPU and system cache context is lost (the OS is responsible for maintaining the caches and CPU context). Control starts from the processor's reset vector after the wake-up event.

S3 Sleeping State: The S3 sleeping state is a low wake-up latency sleeping state where all system context is lost except system memory. CPU, cache, and chip set context are lost in this state. Hardware maintains memory context and restores some CPU and L2 configuration context. Control starts from the processor‘s reset vector after the wake-up event.

S4 Sleeping State: The S4 sleeping state is the lowest power, longest wake-up latency sleeping state supported by ACPI. In order to reduce power to a minimum, it is assumed that the hardware platform has powered off all devices. Platform context is maintained.

S5 Soft Off State: The S5 state is similar to the S4 state except the OS does not save any context nor enable any devices to wake the system. The system is in the —soft off state and requires a complete boot when awakened. Software uses a different state value to distinguish between the S5 state and the S4 state to allow for initial boot operations within the BIOS to distinguish whether or not the boot is going to wake from a saved memory image.

[9] DOE should also consider defining this case as *scheduled sleep* instead of *scheduled deep sleep* to allow for power management implementations where deep sleep is unachievable and scheduled light sleep would enable significant savings.

[10] These values would provide valuable information about how the tested set-top boxes operate. The intent of the CA IOUs would be to use the average power and average of the three wake times in developing a standards recommendation to the California Energy Commission (CEC).

Case 3

- Disable scheduled sleep if present
    - Put the set-top box into deep sleep state by pressing the power button on the remote or the set-top box for < 3 seconds or by pressing a button clearly labeled "Deep Sleep" on either the remote or the set-top box for < 1 second.

Case 4

- Enable scheduled deep sleep if present
- Allow the set-top box to enter scheduled deep sleep

Case 3 or 4

- Determine sleep mode power per the currently proposed APD test with the exception of the method for putting the set-top box to sleep
- Run the test a second time to measure wake intervals at two randomly selected times during the test period.
    - For each of these two tests press the power button for < 1 second to wake the set-top box. Start the timer when the power button is released. Stop the timer when the program guide or other program navigation is fully populated and supports channel selection.
- In addition to reporting the average power per the current DOE proposal, report wake times and the power level just before pressing the power button for each wake test.

This approach would enable more accurate energy calculations and provide an incentive for industry to develop scheduled sleep methods that could significantly reduce set-top box energy consumption. The approach does not include a test for *Deep Sleep APD* which could be useful in developing incentives for market actors to automatically power down to deep sleep boxes that have not been used for a number of days or weeks as might be the case in seasonal dwellings. We did not propose this test because we thought that the added test burden would outweigh the potential energy savings.

One final note about power level reporting: DOE should consider requiring that the test laboratory submit time-stamped data so that policymakers can resolve discrepancies between different test measurements of the same set-top box model. There are several factors inherent to set-top box testing that reduce the repeatability of test results, and review of time-stamped data would help resolve disputes and enable policymakers to evolve the test procedure and approaches to defining set-top box efficiency metrics.

Speculative recording

Speculative recording enables set-top boxes to monitor viewer habits and then automatically record shows that may be of interest to the viewer based on his or her viewing history. Speculative recording does not affect power levels, and we do not recommend that the DOE test method

include a test targeted at measuring the energy consumption of speculative recording given the complexity involved in establishing a viewing history before conducting the test.[11]

APD from service provider initiated wake events

In addition to measuring the power levels and wake times of discrete sleep states, the test procedure should measure the delay time for a set-top box to automatically resume sleep after waking for and completing the following activities: a) recording a pre-programmed show or b) performing a service provider initiated maintenance activity.

Testing with gateway functions in idle mode

The proposed test procedure stipulates that gateway set-top boxes—those with set-top box functions plus modem, router, or telephony capabilities—need to be tested with these additional features disabled. The IOUs are concerned that this will significantly underestimate energy impact of these devices. In order to capture the power draw of additional functions, we propose to test gateway set-top boxes with the added functionalities in idle mode (i.e. ready on moment's notice to support a phone call or high bandwidth data transfer). Specifically, we recommend using a simplified version of the ENERGY STAR Small Network Equipment draft test method to test these functions. We recommend conducting set-top box tests with networking features in idle mode (i.e. ready to respond but not actively transmitting data). Gateways are an emerging set-top box market segment, and it will be important to ensure that these integrated boxes use less power than the sum of the individual devices that would otherwise be needed to provide the same capabilities.

Inclusion of headless gateways and definition of video output

DOE excluded set-top boxes with no direct video connection to a display—also known as headless gateways—from the proposed test procedure. By doing so, DOE will miss regulating a rapidly growing and potentially important set-top box market segment. Therefore, we recommend the inclusion of headless gateways in the scope of the DOE test procedure per the test method articulated in CEA-2043 and referenced in the ENERGY STAR 4.1 draft specification. We understand the need to distinguish between networking and set-top box devices, and we propose to accomplish this by modifying the definition of set-top box as follows:

> *A device combining hardware components with software programming designed for the primary purpose of receiving television and related services from terrestrial, cable, satellite, broadband, or local networks, and providing video output. If a gateway device includes set-top box functionality, then it is a set-top box.*

This definition would include headless set-top box gateways but would exclude Integrated Access Devices that support voice and data.

Including low-noise block down converter power in set-top box power measurement

In the proposed test procedure, DOE includes low-noise block down convertor (LNB) power in the set-top box power measurement. The IOUs are concerned with this approach because it may

[11] We recommend that policymakers address the energy consumption of speculative recording as they define set-top box efficiency metrics.

create an incentive for manufacturers to shift to external power supplies, resulting in a less effective standard. Furthermore, a shift to external power supplies may result in a greater number of "stranded" power supplies that continue to draw power long after a service provider disconnects service. On the other hand, information about LNB power draw may enable policymakers to develop efficiency metrics that lead to reduced LNB energy consumption without causing an industry shift to LNBs powered by external power supplies. For these reasons, we recommend testing satellite set-top boxes with LNB power consumption per the DOE test method and without LNB power draw per the test method outlined in draft CEA-2043.

Testing emerging technologies

The IOUs believe that DOE should mitigate the risk of inhibiting innovation by structuring the test method to test all foreseeable technologies that would affect energy consumption (e.g. UHDTV, modem, router, etc.) per the conversation on this topic in the March 29th, 2013 ENERGY STAR set-top box 4.1 requirements review meeting held in Washington, D.C.. This would enable ENERGY STAR and other policymakers to provide AEC adders and DOE to provide other product classes to allow for the increased energy consumption of these emerging capabilities.