DOCKET
11-AAER-1
DATE SEP 30 2011
RECD. OCT 03 2011

Proposal Information Template for:
Set-Top Boxes and Small Network Equipment

Submitted to:
California Energy Commission
In consideration for the 2011 Rulemaking Proceeding on Appliance Efficiency Regulations,
Docket number 11-AAER-1

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Last Modified: September 30, 2011

Please note: all savings estimates and information in this document are preliminary and are based on data available to the authors at the time of the report. If the CEC moves forward with this topic, we anticipate updating our estimates and recommendations based upon additional input from stakeholders.

Proposal Information Template –Set-Top Boxes and Small Network Equipment

2011Appliance Efficiency Standards

Prepared for: Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison, Southern California Gas Company

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Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations, §§ 1601 – 1608) This report specifically covers set-top boxes and small network equipment.

Background

Set-top Boxes

Set-top boxes (STBs) are entertainment content delivery devices connected to a television or other display and are found in most California residences and many commercial spaces. Functionality can range from accessing standard definition (SD) cable channels, to high-definition (HD) content with digital video recording (DVR). STBs are distributed by cable, satellite, and IP-based content providers to their customers and are additionally used by consumers of terrestrial broadcast signals and internet video streaming services. Set-top box energy consumption levels depend on the service type (satellite, cable or IP), age of the box, and by the features included on the device. STBs can be as small as a paperback book or as large as a DVD/Blu-ray player. Over-the-top (OTT) devices are particularly efficient because they can stream video directly from the internet. Services such as Netflix and Hulu are examples of streaming services offered for OTT boxes that are typically purchased directly by consumers, as compared to other STB devices described below. OTT boxes are included in the IP category under ENERGY STAR specifications and to remain consistent, will be classified as such for our discussion and analysis.

Figure 1: Set-Top-Box Device Examples

Apple TV 2nd Generation
(IP/OTT)

Motorola DCT6412
(Comcast Cable HD-DVR)

Only a handful of manufacturers supply STBs to the major Pay-TV services providers, who are the largest purchasers of STBs in the United States. The service provider will typically lease or rent these to their subscribers, placing the provider, not the consumer, in control over what features manufacturers will include with their devices. Because the cost of energy consumed by a STB is paid for by the consumer, no expense associated with the operation of the STB is charged to the service provider. With no fiscal pressure to address power consumption, service providers tend to favor customer experience and feature availability as requested by their customers. This makes STBs a reasonable candidate for efficiency standards given that consumers have no choice about which device the pay TV service provider deploys, yet are directly responsible for the associated costs of operating the STBs. A few service providers are exploring new solutions for sharing recorded media over a residential network, reducing the number of full-featured STBs needed in a single home. These are referred to as multi-room solutions and while they do have the potential to reduce overall household energy consumption, the usage of the main device is likely to remain high. In California, we estimate that there are roughly 18 million STBs in homes, consuming roughly 3980 Gigawatt (GWh) annually.[1] Two-thirds of energy consumption occurs while the devices are not in use with minimal reduction during standby states (NRDC 2011).

Small Network Equipment

The term “networking equipment” is a very broad description that can include a large assortment of devices. For the purpose of this standard proposal, small network equipment (SNE) specifically refers to internet gateways, DSL or cable modems, and fiber optic terminals. Gateways consist of an integrated modem and router and will often include a phone adapter for “triple-play” type services. Fiber Optic Terminals are found outside of homes and are used to convert optical signals to digital.

[1] Subscriber numbers are from the California Cable and Telecommunications Association and the National Cable and Telecommunications Association. The value of 1.6 STBs per home is used throughout the paper and is based on the Sixth Northwest Conservation and Electric Power Plan and from discussions with industry stakeholders.

Figure 2: SNE Examples

From left to right: ONT device, cable modem, wireless router, and gateway

Networking devices require a constant network presence to be able to send and receive information in real time. Without energy-efficiency measures in place, the power draw of a device in standby is almost as much as a fully utilized device. As bandwidth increases and more devices join the home network, energy consumption presents a growing concern. Lawrence Berkeley National Laboratory (LBNL) experts estimate residential networking products in United States households will consume an estimated 7.9 TWh in 2011 (Lanzisera, Nordman, & Brown, 2010). These devices typically operate under 5 percent utilization, leaving much room for energy savings if they would scale power to functionality. From a consumer perspective, SNE is unique in that it requires limited interaction by the user. After setup, users typically place the equipment out of sight where it stays powered on, regardless of how often the consumer utilizes it. For this reason, savings potential is largely dependent on the protocols built into the device. Similar to most United States STBs, usage patterns are not a determinant of power consumption because the device is designed to stay on and there is little variance between power consumption when idle versus active. Unlike a STB, the end consumer can typically choose between competing networking devices in the retail market. The increase in selection allows manufacturers to compete based on energy efficiency and voluntary labeling approaches, such as ENERGY STAR. When products are in the retail market, consumers' preference and awareness can drive the market, increasing the array of products offered.

Overview

Description of Standards Proposal	**Set-top Boxes** We present two approaches for a STB energy efficiency standard in California: *TEC Approach* The standard would be based on the typical electricity consumption (TEC, kWh/year) for an individual device.[2] TEC is determined by device class with allowances for advanced features. Base TEC levels should be 60 kWh/yr for cable, 70 kWh/yr for satellite, and 50 kWh/yr for IP as defined by the ENERGY STAR 3.0 specification, which also specifies device classifications and test procedures we recommend for this standard. Allowances for additional features, definitions, and test procedures can be found through the link in Appendix B. *Modal Approach* The standard would set a power level requirement for different device modes. An example would be to require a maximum of 1 - 5 W power level when a STB is not in use. This paper specifically looks at savings relative to a 5 W standby requirement. **Small Network Equipment** We recommend that California adopt a test and list procedure for SNE following the ENERGY STAR test procedure on track to be finalized in 2012. The latest revision of these specifications can be found through the link in Appendix B. Test results on annual energy use for SNE on sale in California should be made available for consumers.
California Stock and Sales	**Set-top Boxes** There are currently about 18 million STBs in California. 11 million of those belong to cable subscribers, 6 million are satellite service, and 1 million are IP devices. 20% of these STBs turnover each year, resulting in sales of roughly 3.5 million to service providers by box manufacturers.[3] Consumers typically do not purchase the devices themselves, but are provided them for free or for rent as part of the service they purchase from providers. California pay-TV service providers are Bright House, Charter, Comcast, Cox, DirecTV, DISH Network, MediaCom, Northland, Suddenlink, Time Warner, and Wave Broadband. Key STB manufacturers include Pace, Motorola, LG, Samsung, Sony and others.[4]

[2] Typical Energy Consumption (TEC) is based on average device usage patterns modeled by the ENERGY STAR specification for a single device.
[3] 20% turnover assumes a 5yr average lifespan for devices. This is based on conversations between numerous industry stakeholders and Ecos.
[4] Stock and sales information made available by the California Cable and Telecommunications Association.

Energy Savings and Demand Reduction	**Set-top Boxes** STBs in California are estimated to consume 3,980 GWh/year with a peak demand of 478 MW.[5] *TEC Approach* From the proposed standard following the ENERGY STAR specification, first year savings are roughly 105 GWh, with savings after stock turnover of roughly 525 GWh. Peak demand reduction is estimated to be 63 MW. *Modal Approach* Requiring a STB to power down to 5 W for non-active states results in an estimated savings after stock turnover of 842 – 2,241 GWh and peak demand reduction of 101 – 268 MW depending on sales baseline and duty cycle assumptions. **Small Network Equipment** There are no direct savings associated with the proposed test and list approach for SNE; however, the information provided could result in product efficiency gains.

[5] Peak demand values calculated by multiplying GWh/yr by the kW/MWh ratio listed on p.13 of Brown, Richard E., and Jonathan G. Koomey. Electricity Use in California: Past Trends and Present Usage Patterns. Energy Policy (also LBNL-47992). vol. 31, no. 9. July. pp. 849-864.

Economic Analysis	**Set-top Boxes** *TEC Approach* Market actors report that most of today's STBs have the capability to meet ENERGY STAR 3.0 TEC levels if service providers use existing or develop new applications software that takes advantage of the energy-saving light sleep power management features designed into the STBs by the manufacturers. Service providers whose STB applications software lacks this capability might have to modify this code to achieve these savings, a relatively small R&D investment that would likely not affect subscription fees. Ecos estimates zero incremental STB cost in the timeframe of this regulation. *Modal Approach* The incremental unit cost and R&D effort required to meet a 5 W light sleep state power level are unknown. If the industry was unable to meet the power level with a light sleep mode, then deep sleep would be needed. STB manufacturers report a $2 incremental cost per unit to enable deep-sleep on STBs. Deep sleep implementation would also require significant research and development expense to update head-end and system-wide software capabilities. **Small Network Equipment** There is no expected impact to the California economy, revenue or jobs.
Non-Energy Benefits	**Set-top Boxes** This proposal will increase greenhouse gas reduction at the power generation source, helping California to meet its AB 32 goals (1990 levels by 2020).
Environmental Impacts	**Set-top Boxes** None anticipated. Regular lifecycle of boxes expected to generate the same amount of e-waste before and after standard compliance date.

Acceptance Issues	**Set-top Boxes** Service providers may resist the proposed standard. There is currently no expense to them associated with the electricity consumed by the STBs they deploy, so there is no direct financial motivation for them to work towards more efficient boxes. Their primary interest is delivering the best quality of service with the most features to their subscribers. *TEC Approach* By taking the TEC approach, CEC allows service providers flexibility to reduce either on-mode or sleep-mode energy consumption. Light sleep modes have little impact on the user experience. *Modal Approach* It may be possible to achieve a 5 W power limit with a light sleep state that wakes almost instantly. However, in the case where this cannot be done, deep sleep states have the potential to increase wake time to several minutes. This would result in consumer acceptance issues. However, service providers may be able to design their systems to improve usability by reducing wake times with cloud-based program guides and by offering partial functionality during the wake cycle. Service providers could also use Network Proxy capability to enable smart phone program recording requests during periods of deep sleep. **Small Network Equipment** Industry would probably not strongly oppose a test and list approach for SNE.
Federal Preemption or other Regulatory or Legislative Considerations	The U.S. Department of Energy has determined that set-top boxes and network equipment qualify as a covered product under Part A of Title III of the Energy Policy and Conservation Act (EPCA).[6] If DOE proceeds with rulemaking, federal regulation would not take effect for 5 or more years.

[6] http://www.gpo.gov/fdsys/pkg/FR-2011-06-15/pdf/2011-14825.pdf

Methodology and Modeling Used in the Development of the Proposal

Set-top Boxes

In developing STB energy savings estimates, separate calculations were performed for each of the proposed approaches. For increased accuracy, we segmented STBs into six categories: cable, cable DVR, satellite, satellite DVR, IPTV and IPTV DVR.

TEC Approach

For the TEC based approach, a feature-normalized kWh/year savings number was calculated for each of the above six categories by adding a) the average difference between compliant model allowed and reported TEC values and b) the average difference between non-compliant model allowed and reported TEC values. To calculate statewide savings, we multiplied these average savings figures by the estimated number of non-compliant STBs, by category, in California.[7]

We base sales volume for each category on a) publicly available household pay-TV subscription data, b) an Ecos market model assumption of 1.6 STBs per home, c) a market assumption based on interviews that average STB life is five years and therefore annual turnover is twenty percent of stock, d) high definition capability has achieved 100 percent penetration of STBs and e) that DVR penetration has reached approximately fifty percent of households.

For this calculation, we assume that the percentage of non-compliant models in the ENERGY STAR Qualified Product List, relative to ENERGY STAR version 3.0, equals the percentage of non-compliant STBs sold into the market for each of the six categories mentioned above. The statewide savings figure is sales weighted by category but not by model, a refinement that we would recommend if California moves forward with a CASE report. Ecos savings estimates represent the savings if the proposed regulation was put into effect today and sales volume was to remain constant. Ecos assumes that the efficiency levels of STBs sold to service providers today are represented by the models listed in the July, 2011 ENERGY STAR 2.0 qualified products list and that the duty cycle is 14 hours on and 10 hours sleep. Links to the ENERGY STAR 3.0 specification may be found in Appendix B.

Modal Approach

Ecos calculates a savings range for the model approach based on the following two sets of assumptions:

More conservative assumptions (low end of the savings range):

- Efficiency levels of STBs sold to service providers today are represented by the models listed in the July, 2011 ENERGY STAR 2.0 qualified products list. We call this the sales baseline.
- Duty cycle is the same as ENERGY STAR 2.0 (14 hours on and 10 hours standby).

Less conservative assumptions (high end of the savings range):

[7] See Appendix C for equation and example.

- Sales baseline is represented by the STBs tested in NRDC's 2010 study, which consist of models deployed in the 2008 to 2010 timeframe.
- Duty cycle is based on the assumption that subscribers do not wait for auto-power-down and instead power-down their STBs with the remote when not in use (7 hours on and 17 hours standby).

To calculate the savings associated with the proposed standby mode requirement Ecos calculated TEC values with a 5 W power level for standby and assumed 100 percent non-compliance. The difference between this compliant STB TEC and the sales baseline represents the potential savings. Average savings for each of the six STB classes were then multiplied by the estimated number of STBs for their respective class in California. The sum of these values equals the total estimated savings for the standby power limit.

Small Network Equipment

No modeling was conducted for SNE because there are no energy savings directly related to the actions proposed.

Data, Analysis, and Results

Set-top Boxes

The subscriber data retrieved from the California Cable and Telecommunications Association and state satellite providers' websites listed that there are currently 10.9 million cable subscribers, 6.1 million satellite subscribers, and 0.8 million IP subscribers or device owners. Using the Ecos model assumed value of 1.6 STBs per household and 1 household per subscriber, the annual energy consumption for all STBs in California was found to be roughly 3,980 GWh per year. See Figure 3.

Figure 3: Annual STB Gwh/year[8]

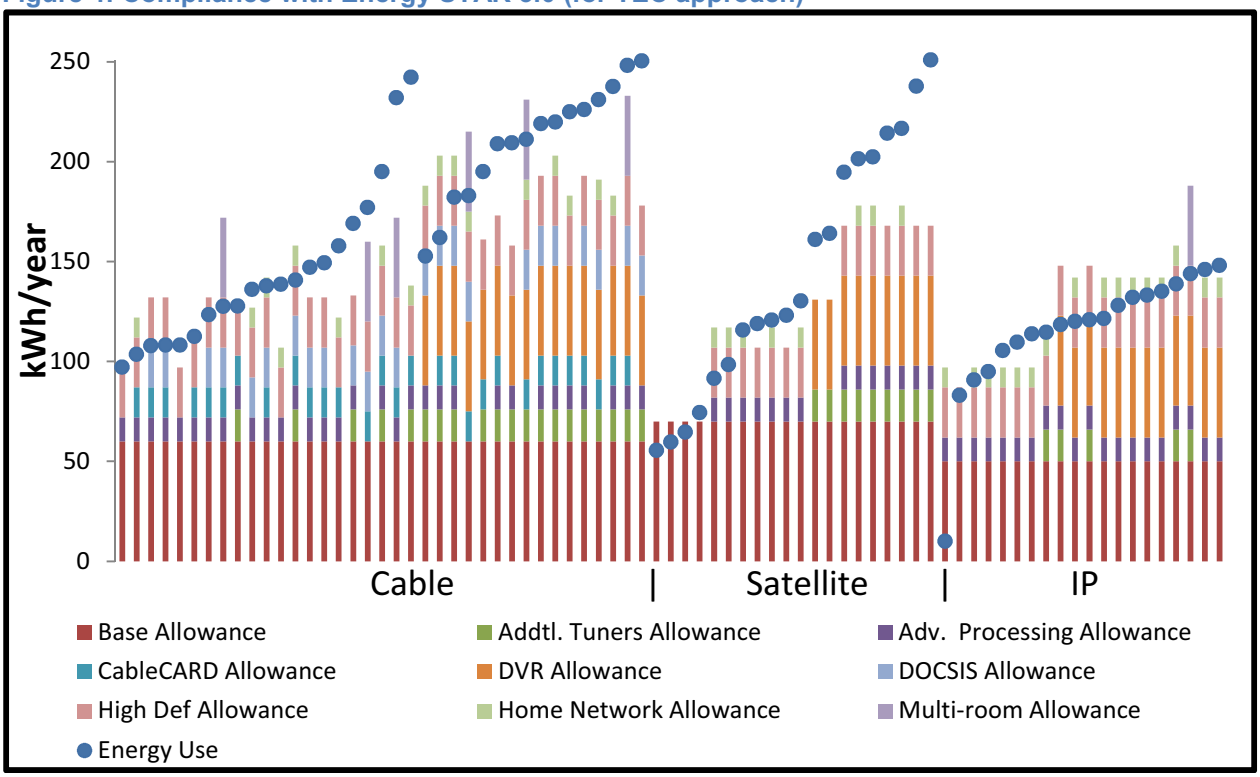
	STBs (millions)	Unit TEC Average (kWh/year)	Statewide Annual TEC (GWh/yr)
Cable	5.44	180	976
Cable DVR	5.44	270	1,463
IP	0.40	60	24
IP DVR	0.40	137	54
Satellite	3.04	147	447
Satellite DVR	3.04	333	1,014
TOTAL	**17.76**		**3,980**

TEC Approach

Figure 4 compares the 86 STBs, separated by class, and plots reported energy consumption (dots) against ENERGY STAR 3.0 allowances (stacked bars), for the TEC approach.

[8] Based on NRDC 2010 measured power levels

Figure 4: Compliance with Energy STAR 3.0 (for TEC approach)[9]



Total potential savings for implementing the proposed STB TEC standard relative to today's sales baseline is estimated at 105 GWh per year with annual savings after stock turnover of roughly 525 GWh. See Figure 5 below.

[9] Data from July 2011 ENERGY STAR QPL for Set-top boxes

Figure 5: Savings by Base Type and Total (for TEC Approach) [10]

	STBs (millions)	Average Unit Savings (kWh/year)	% Non-Qualified	Total CA First Year Savings (GWh/yr)	Total CA Savings After Stock Turnover (GWh)
Cable	5.44	37	58%	23	115
Cable DVR	5.44	66	64%	46	230
IP	0.40	14	57%	1	5
IP DVR	0.40	25	17%	0	0
Satellite	3.04	26	45%	7	35
Satellite DVR	3.04	45	100%	27	135
TOTAL	**17.76**		**64%**	**105**	**525**

Modal Approach

For a standard based on a 5 W max power requirement for standby mode, savings after stock turnover are estimated to be 842 – 2,241 GWh. Figure 6 illustrates savings per unit and total savings. If implemented today, most complex STBs in the market would not qualify.

Figure 6: Savings by Base Type and Total (for Modal Approach)

	STBs (millions)	Average Unit Savings (kWh/year)	Total CA First Year Savings (GWh/yr)	Total CA Savings After Stock Turnover (GWh)
Cable	5.44	40 - 95	43 - 104	214 - 518
Cable DVR	5.44	67 - 158	70 - 172	352 - 858
IP	0.40	21 - 22	1 - 2	8 - 9
IP DVR	0.40	29 - 59	2 - 5	12 - 24
Satellite	3.04	19 - 71	12 - 43	58 - 217
Satellite DVR	3.04	65 - 202	40 - 123	198 - 615
TOTAL	**17.76**		**168 – 448**	**842 – 2,241**

[10] Table based on subscriber numbers from the California Cable and Telecommunications Association. The remaining data is from Ecos' modeling and calculations.

Proposed Standards and Recommendations

Set-top Boxes

We recommend that California adopt one of the energy efficiency standard approaches presented in this paper. The TEC approach would require no incremental cost and less industry investment than a low-power (5 W) sleep mode power limit but would result in less energy saved.

TEC Approach

The standard would be based on the typical electricity consumption (TEC, kWh/year) for an individual device. TEC is determined by device class with allowances for advanced features. Pending additional stakeholder input on expected energy efficiency trending, the base and additional functionality TEC levels should be set at ENERGY STAR 3.0 levels, and the standard should adopt ENERGY STAR 3.0 device definitions and test procedure.

Modal Approach

The standard would set a power level requirement for sleep mode. Specifically, there would be a 1 – 5 W maximum power level required when devices are in a sleep state. The user could put the device into this state by pressing the power button on the remote control, and STBs would be set to auto-power-down after some period of inactivity by default with an option to opt out.

Small Network Equipment

We recommend that California adopt a test and list procedure for SNE following the ENERGY STAR test procedure on track to be finalized in 2012. See Appendix B for links to the ENERGY STAR SNE specification development web site.

Bibliography and Other Research

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References and Appendices

Appendix A: Definitions

Set-top box (STB)	An entertainment content delivery device connected to a television or other display that converts digital information into a video signal.
Small network equipment (SNE)	Consumer electronic devices that allow communication between devices or to the internet.
Digital Video Recorder (DVR)	A device that can capture and playback digital video.
IP	Internet protocol or STBs that receive information using the internet protocol set of rules for data transmission.
Over-the-top (OTT)	A device that can receive media to display on a display, without a cable provider. This is typically done by streaming video from the internet.
Multi-room	A device configuration featuring one, fully featured set-top box which is capable of streaming to other devices around the house.
DOCSIS	Data communications protocol for coaxial cable.
Home Network	The connection of multiple devices allowing communications within a home.
CableCARD	A special device add-on card that allows consumers to view and record digital video provided by a cable company.
Internet Gateways	An integrated modem and router. They will often include a phone adapter for “triple-play” type services.
Modems	A device used to connect to the internet.
Fiber Optic Terminals	A device used to convert optical signals to digital and usually found outside of a home at the point of connection to a fiber network.
Total Energy Consumption (TEC)	The amount of energy a device consumes in a year, based on a use-cycle model. Typically given in kWH/year or GWh/year.

Appendix B: ENERGY STAR 3.0 Set-top Box Specification and Small Networking Equipment Specification Draft 4

The STB specification and test procedure details can be found at:
http://www.energystar.gov/ia/partners/product_specs/program_reqs/STB_Final_Version_3_Specification_Manufacturer.pdf
The SNE specification and test procedure details can be found at:
http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/small_network_equip/SNE_Test_Method_Rev_4_Dataset.pdf

Appendix C: Example Savings Calculations for TEC Based Standard

$$(STBpass_{avg} - STBfailavg\ ) = STBsav$$
$$STBfail_{count}/(STBfail_{count} + STBpass_{count}) = STBfail_{\%}$$
$$STBsav + STBfail_{\%} + STBsales = STBsavings$$

$STBpass_{avg}$ = Average difference between TEC and ENERGY STAR spec value for passing devices
$STBfail_{avg}$ = Average difference between TEC and ENERGY STAR spec value for failing devices
$STBsav$ = kWh/yr savings for an individual device for a class of STBs
$STBfail_{count}$ = Number of STBs that don't meet ES spec
$STBpass_{count}$ = Number of STBs that meet ES spec
$STBfail_{\%}$ = Percentage of STBs that don't meet ES spec
$STBsales$ = Number of STBs sold in California
$STBsavings$ = Total kWh/yr savings for a class of STBs in California under proposed standard

Example: For cable boxes with DVR where 1,088,000 represents the number of cable DVR boxes sold in a year,

$$(30) - (-36) = 66\,kWh/yr$$
$$9/(9+5) = 64\%$$
$$66\,kWh/yr * 64\% * 1{,}088{,}000 = \ 46\,GWh/yr$$