STB Energy Conservation

Initiatives and Challenges

A Technical Paper prepared for the Society of Cable Telecommunications Engineers
By

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Overview

The power consumption of set-top boxes (STBs) has become a key focus of energy advocates and regulators over the past two years. The cable industry has responded with an initiative dedicated to improving the energy efficiency of consumer STBs. This paper presents an analysis of cable STB energy consumption, including the operational challenges of sleep modes and technology trends toward more energy efficient STBs. It also discusses the unprecedented Set-Top Box Energy Conservation Voluntary Agreement and the progress made toward the commitments of the agreement.

History

In the summer of 2011, the NRDC (Natural Resources Defense Council) published a report comparing the energy consumption of STBs in the home to that of a refrigerator[1]. Needless to say, this caught the attention of the regulators.

In September of same year, California Senator Dianne Feinstein issued a letter to the CEOs of the country's largest cable, satellite, and telco providers, calling for the phase-out of energy inefficient set-top boxes that consume "astronomical amounts of energy." Senator Feinstein urged the industry to distribute STBs with lower-power "sleep" modes when not in use[2].

But the reports of STB energy consumption were exaggerated, and STB energy consumption has improved over the years. Figure 1 illustrates how various cable devices have reduced their energy use while in the on mode from 2002 to 2011. This graph includes an average measurement for the refrigerator class, which has not made as substantial gains over the last decade.

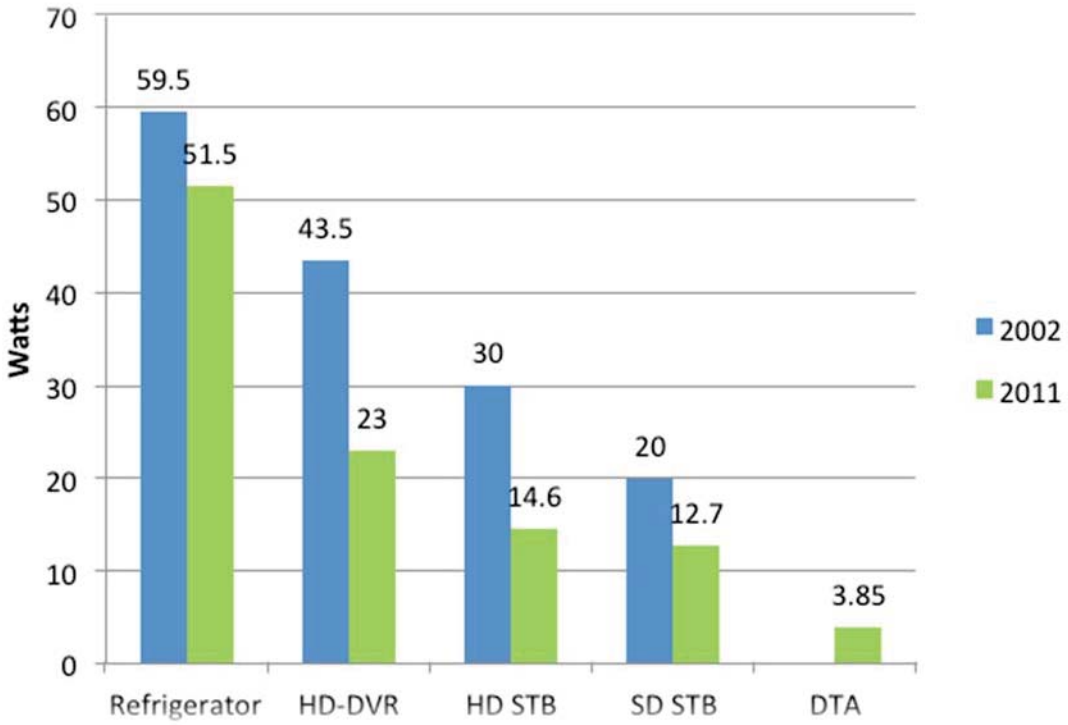

Figure 1 Historic Energy Reduction of Cable Devices Compared to a Refrigerator

Figure 2 shows the STB energy consumption trend over the last decade. This chart demonstrates how increased features and capabilities increases the power, but manufacturers have continued to make strides in reducing the overall energy consumption even for more full-featured devices.

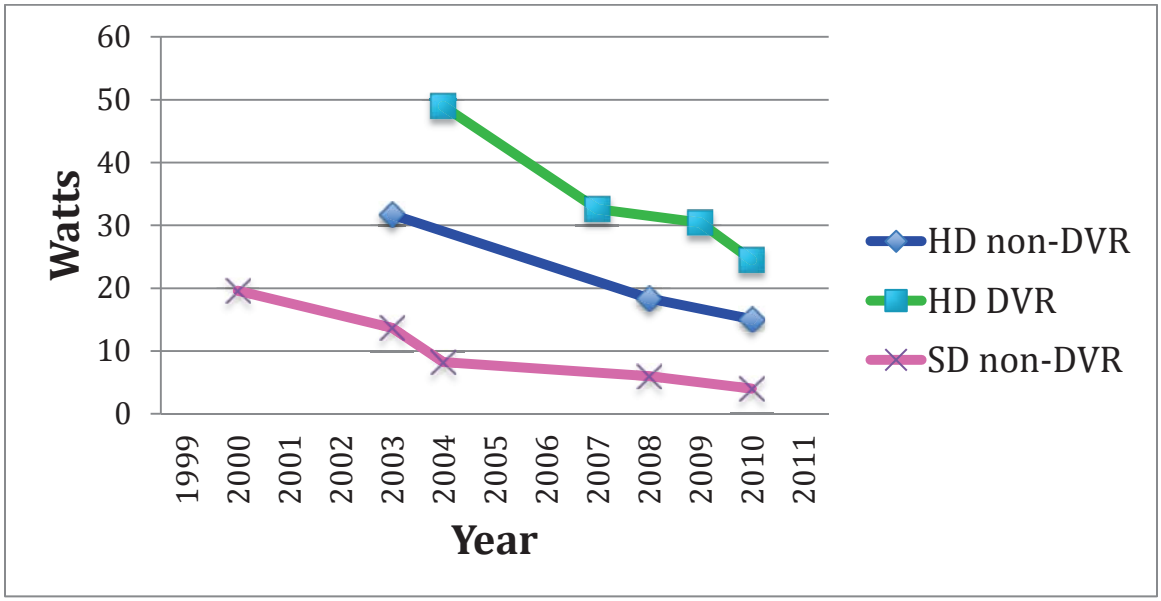

Figure 2 Power Consumption of STB Models

Energy consumption reduction in STBs benefits not only the consumer's wallet and the environment, but there are benefits to the service provider as well. Newer STBs consolidate functions into single SoCs (System on a Chip), which helps to reduce power and operating temperatures. Reducing the heat and component count generally increases reliability and longevity of the devices, which results in fewer trouble calls and truck rolls.

Enter the Regulators

Department of Energy

In addition to the publicity and political attention mentioned above, the federal regulators were also putting the spotlight on STBs. In June of 2011, the Department of Energy (DOE) started the process toward the regulation of energy consumption of STBs. The following table outlines the activities taken by DOE to date in this process[3].

Date	DOE Activity
June, 2011	Published a Notice of Proposed Determination indicating that STBs were products under consideration for regulation
December, 2011	Published RFI seeking information on topics related to STB test procedures and potential energy conservation standards for STBs
January, 2013	Issued a Notice of Proposed Rulemaking (NOPR) for a STB test procedure, which included the draft test procedure and solicitation for comments
February, 2013	Published a Notice of Data Availability, which presents an analysis of STB data to develop an energy conservation standard for set-top boxes

Note that as of July, 2013, the test procedure has not been finalized, and a specification has not been published.

California Energy Commission

The state of California is also considering its own regulation of STB energy consumption[4]. The California Energy Commission (CEC) started the process in March of 2012, first instituting a rulemaking proceeding to establish energy efficiency standards and test procedures for a number of products including STBs. Since then, the CEC issued an invitation to participate and requested proposals. However, in the case of cable STBs, the cable industry has argued that the federal Cable Act (amended in 1992) preempts states from adopting technical standards related to cable STBs. So it is not clear at this time how the cable STB industry will be impacted by the CEC activities.

Energy Star/U.S. Environmental Protection Agency (EPA)

Energy Star is a voluntary program supported by the EPA that establishes energy levels and specifications that initially can typically be met by about 25% of products in a particular space (at the time the specification is issued). Manufacturers can voluntarily sign up to be Energy Star partners, have their products certified, and include the Energy Star label on their products. Consumers are accustomed to the bright yellow EnergyGuide label (required by Energy Star) and may make purchasing decisions based on the available energy consumption information.

In the case of the STB product category, Energy Star has a current specification (version 3.0) against which nearly one hundred different STB models have been certified[5]. The EPA is working on a new, more stringent, version of the specification (version 4.1), which will likely be finalized during the latter half of 2013 and go into effect in late 2014.

But there are distinct differences between a refrigerator and a STB when it comes to a consumer purchasing decision. The STB is not an isolated piece of consumer equipment like a refrigerator, but rather part of a larger, "always on", complex distribution network. The STB is in nearly constant contact with the service provider network (cable head end, satellite, or fiber hub) to receive software updates, guide information, and other control signals. Together, the network and the STB provide the video service to the consumer, not the STB alone.

Consumers do not generally purchase STBs. The STB is most often provided by the service provider who is offering the video service, whether that be a cable operator, satellite operator, or a telco operator. The subscriber makes a choice of *type* of device based on their subscription – if they need just a basic Digital Transport Adapter (DTA), a bi-directional HD STB, or a bi-directional HD DVR STB. Newer deployments also offer a video "gateway" device with the capability to receive and record multiple channels, and play out the recordings to "client" STBs within the home. Yet all these device types are still provided by the service provider, and the consumer only makes a decision about the type of service. This is why the voluntary agreement is so important.

The Industry Voluntary Agreement

In December of 2012, the industry responded to these threats of regulation by coming together in unprecedented fashion to form the industry voluntary agreement to "continue improvements in the energy efficiency of STB used in the distribution of video signals"[6]. Fifteen companies signed the voluntary agreement, representing all major video service provider platforms and the largest manufacturers of STBs for these providers. The list of signatories is as follows:

Cable Operators

- Bright House Networks
- Cablevision
- Charter
- Comcast
- Cox
- Time Warner Cable

Satellite Providers

- DirecTV
- DISH Network

Telco Providers

- AT&T
- CenturyLink
- Verizon

Manufacturers

- Arris
- Cisco
- EchoStar Technologies
- Motorola Mobility (as of the signing of the VA)

The service provider signatories serve over 90 million households in the United States, representing over 90% of the paid television service industry. The service provider commitments include:

- Beginning in 2014, at least 90% of all new STBs purchased will meet or exceed Energy Star version 3 levels.
- Newly purchased STBs will have a light sleep capability that includes automatic power down (APD). The cable service providers also committed deploy light sleep on existing deployed STBs that are capable of supporting light sleep.
- Operators are accelerating the deployment of whole-home DVRs and client STBs, thus reducing the number of DVR devices within the home.

- To support transparency and accountability, the signatories will utilize an Independent Administrator to verify service provider reports, determine compliance, and audit when necessary.
    - Service providers will report on purchases on an annual basis.
    - Service providers will provide information on energy consumption of their devices to the public.
    - This includes supporting independent field verification of test results.
- The VA will be reviewed annually to determine additional energy efficiencies and other products that should be considered.

There are many benefits to a voluntary agreement approach versus a federal or state regulation. The energy savings from this voluntary agreement will far exceed regulation, because the VA takes effect in 2014, whereas a federal regulation would not go into effect for five (5) years from the date of issuance. As of the writing of this document in July 2013, the earliest a federal mandate would go into effect would be the second half of 2018! In addition, a regulation would only apply to new STBs purchased and deployed. The VA commits to retrofitting some of the STBs that have been deployed over the past years to have energy-saving modes with light sleep and APD. Based on average energy costs as of the end of 2012, it is estimated that the VA as published in December of 2012 will save U.S. consumers 1.5 Billion dollars annually. This also equates to a reduction of over four power plants in the U.S.[7]

A significant disadvantage to federal or state regulation is that such a mandate will stifle creativity and the ability to continue to innovate in the STB space. In some cases, the government regulation would essentially dictate product design so that products can remain compliant. The VA provides the opportunity to continue to explore new horizons in the video delivery space, while also addressing energy consumption in a flexible and ongoing manner. Some examples of recent STB innovations are whole-home DVR solutions, wide-band tuning to demodulate multiple streams simultaneously, networked DVR, and HTML guides that don't require lengthy guide data downloads to STBs. In addition STBs are morphing into multi-service gateways which provide video service, high-speed data service, and telephony all within one device. The consolidation of three devices into one provides additional energy savings. These multi-service gateways are platforms that could further be expanded to support additional services such as home security, health management, home automation and even home energy management, just to name a few. Although a gateway itself may require more energy than a typical STB, the whole-home architecture of the gateway plus client devices uses far less energy than multiple STBs at each video or data outlet.

STB Energy Modes and Challenges

One of the primary concerns raised by the scrutiny of older STBs is that the energy consumption did not change even when the subscriber pressed the "off" button on the device. This was before the deployment of "light sleep". Manufacturers and service providers are now exploring further energy saving sleep modes. However, there are reasons why a STB doesn't completely power off when the subscriber is not viewing television. This section provides an overview of a digital video network, in order to help the reader better understand the challenges associated with STB sleep modes. It also discusses a "light sleep" mode, which reduces energy consumption when the STB is not being used by the subscriber, and a new DOCSIS energy saving mode to conserve energy when data traffic is low.

Digital Video System Overview[8]

Figure 3 contains a high-level diagram of a digital cable system. It shows four major categories of devices which may be used to deliver service to cable customers' homes, with utilization varying by individual home.

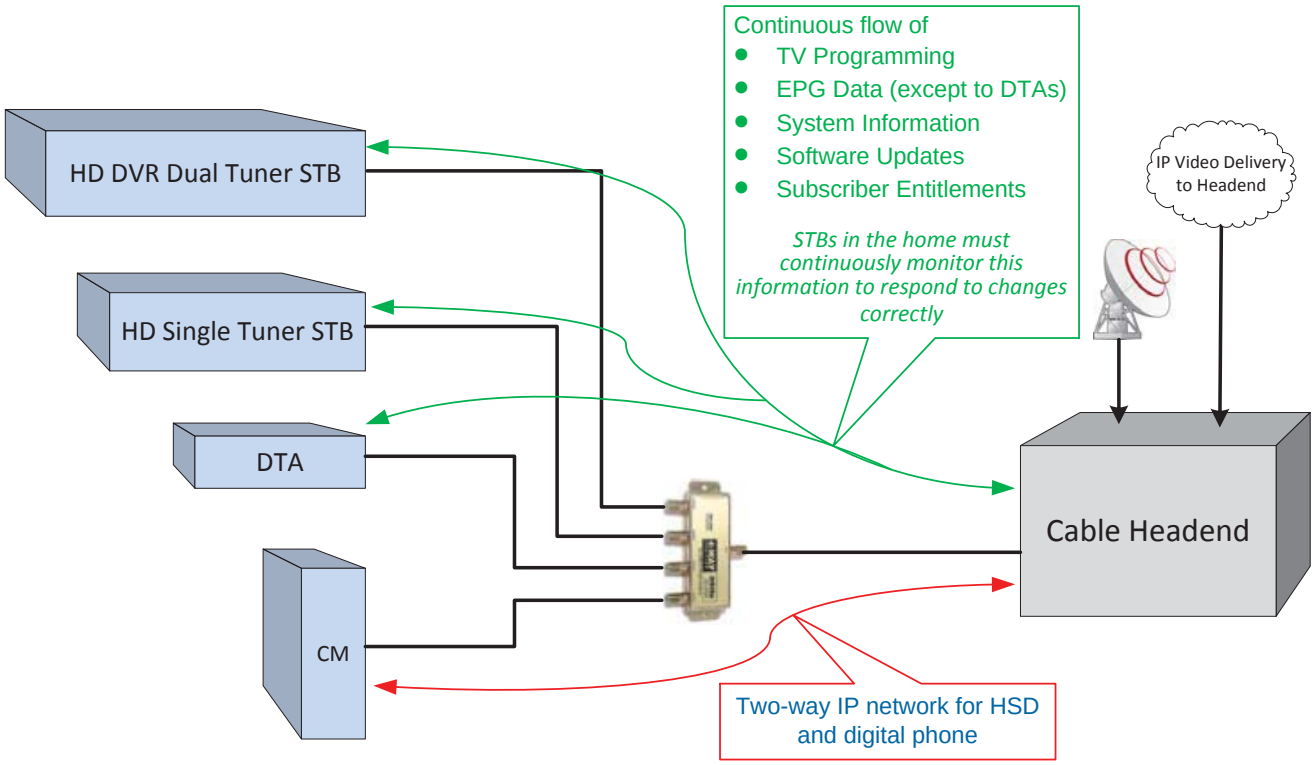

Figure 3 - High-Level Diagram of a Digital Cable System

On the right side of this diagram is the cable head end, which includes the signal origination for the cable system. It includes connectivity via satellite to broadcast digital cable channels, and Internet access via a point of presence on the Internet. The green lines indicate the flow of information over the cable system, primarily from the cable head end to the various set-top boxes. The red line shows the two-way communications channel for IP network connectivity supporting HSD and telephony services.

For this discussion we will focus on the green lines of communication, showing a continuous flow of data:

- Broadcast television programming – this is the transmission of the actual television signal to which the consumer may tune their set-top box to receive a particular channel, or in the case of VOD, the set-top is directed to the channel on which that particular consumer may watch and control their specific programming.
- Electronic Program Guide (EPG) data – this is the metadata describing the available cable television programs, including date and time of broadcast, a description of the program, the ratings for use in parental control, and additional descriptions of the format (SD vs. HD). This information is essential for the consumer to navigate to the desired programming and, in the case of a DVR, to schedule recordings of desired programs. EPG data is updated periodically as new programs and dates further out in the schedule are added or changed.
- System Information – this is the information that describes the cable network to the cable set-top, what channels appear at what frequencies, in what modulation, the number and type of programming multiplexes, and the program streams available in each multiplex. This information is updated periodically as cable operators manage their plant to maintain efficiencies and provide new services to subscribers.
- Software updates – these represent the software code for each type and model of set-top box running on the network. As a new set-top is brought on to the network, they must be able to access and download the latest version of software and configuration for that type and model. Software is updated periodically to implement new features and functions, fix reported bugs, and communicate properly with the network.
- Subscriber Entitlements – these are the cryptographic keys necessary for the set-top box to decrypt and display the channels to which the consumer has subscribed. Keys are updated periodically and during an unscheduled security refresh (e.g., to renew security in the event of a change in the subscription package) in order to assure that the set-top box retains the ability to decrypt content. These keys are securely stored in a tamper-resistant secure processor in the CableCARD, or embedded in the set-top itself in the case of an embedded security set-top box.
- Incident Response – cable operators proactively monitor their networks to determine whether there are outages that must be repaired. When there are a

number of such set-top boxes that do not answer a ping in a given service area, operators identify a significant plant issue and take action to remedy it.

With the exception of the broadcast television programming, all of this data is repeatedly transmitted periodically, with the length of the period depending on the type of data, to ensure that a set-top can perform the necessary functions to provide service to the consumer as rapidly as possible upon either a power cycle or being newly brought onto the network. In general, much of this data is provided over a two-way, out-of-band, communications channel based on one of three different standards that are incompatible with one another: two narrow communications channels based on SCTE 55-1 and SCTE 55-2, and DSG, which is based on the DOCSIS standard.

As mentioned earlier, unlike a typical consumer-purchased item such as a refrigerator, the cable STB is part of a larger complex system originating beyond the cable head end and operating in tight coordination with multiple systems in the cable operator's network. These distribution networks employ various network architectures, transmission protocols, conditional access security systems, out-of-band communications channels, operating system and processor instruction sets, and electronic program guide applications and guide metadata formats. Consequently, energy-saving modes of STB must not adversely affect the consumer experience or the cable system operations themselves.

Light Sleep

Light sleep is a reduced power mode that is being deployed on new STBs today, and even some older deployed STBs can be retrofitted with a software update to support a light sleep mode. It can vary across STB models, but typically light sleep entails, at a minimum, spinning down the hard disk drive, disabling video outputs, and turning off in-band QAM video tuners.

Light sleep, as defined today, does not impact network functionality, and recovery from light sleep is within an acceptable timeframe so as to not adversely impact the user experience.

The following functions are still fully supported even in light sleep mode:

- Scheduled Recordings – the STB will "wake up" and record a program if it was in light sleep mode when the scheduled time arrives
- Entitlement Updates – new encryption keys and entitlement management messages can be received by the STB
- EPG Updates – new programming information will be received by the STB, as well as program ratings associated with parental controls
- SI Updates – if the operator changes the channel lineup in the head end, such as the frequency or program number associated with a virtual channel, this information will not be received by the STB

- Software Updates – which typically occur during maintenance windows while most subscribers are not actively viewing video from a STB
- Remote control, front panel and remote device (cross platform) communication – a subscriber will still have the ability to set up a program to be recorded from their tablet, mobile phone, computer, etc.

DOCSIS 1x1 Mode

At the end of 2012, CableLabs and the DOCSIS Working Group came up with an innovative way to reduce energy consumption of DOCSIS 3.0 cable modems. The DOCSIS 3.0 specification includes the ability to provide expanded bandwidth in both the upstream and downstream direction by bonding separate DOCSIS channels together.[9] A typical DOCSIS 3.0 Cable Modem configuration that might be embedded in a STB (to support the DSG out of band communications and other IP-based services), is an 8x4 configuration, meaning 8 bonded downstream channels and 4 bonded upstream channels. When a cable modem or STB with an embedded cable modem is idle and not sending or receiving significant quantities of data, all of those channels are not necessary. The CM can drop down to just one upstream and one downstream channel and remain connected to the network. The CM uses a thresholding mechanism to decide when to go in and out of 1x1 Mode. Figure 4 illustrates an example of how the thresholding mechanism works.[10]

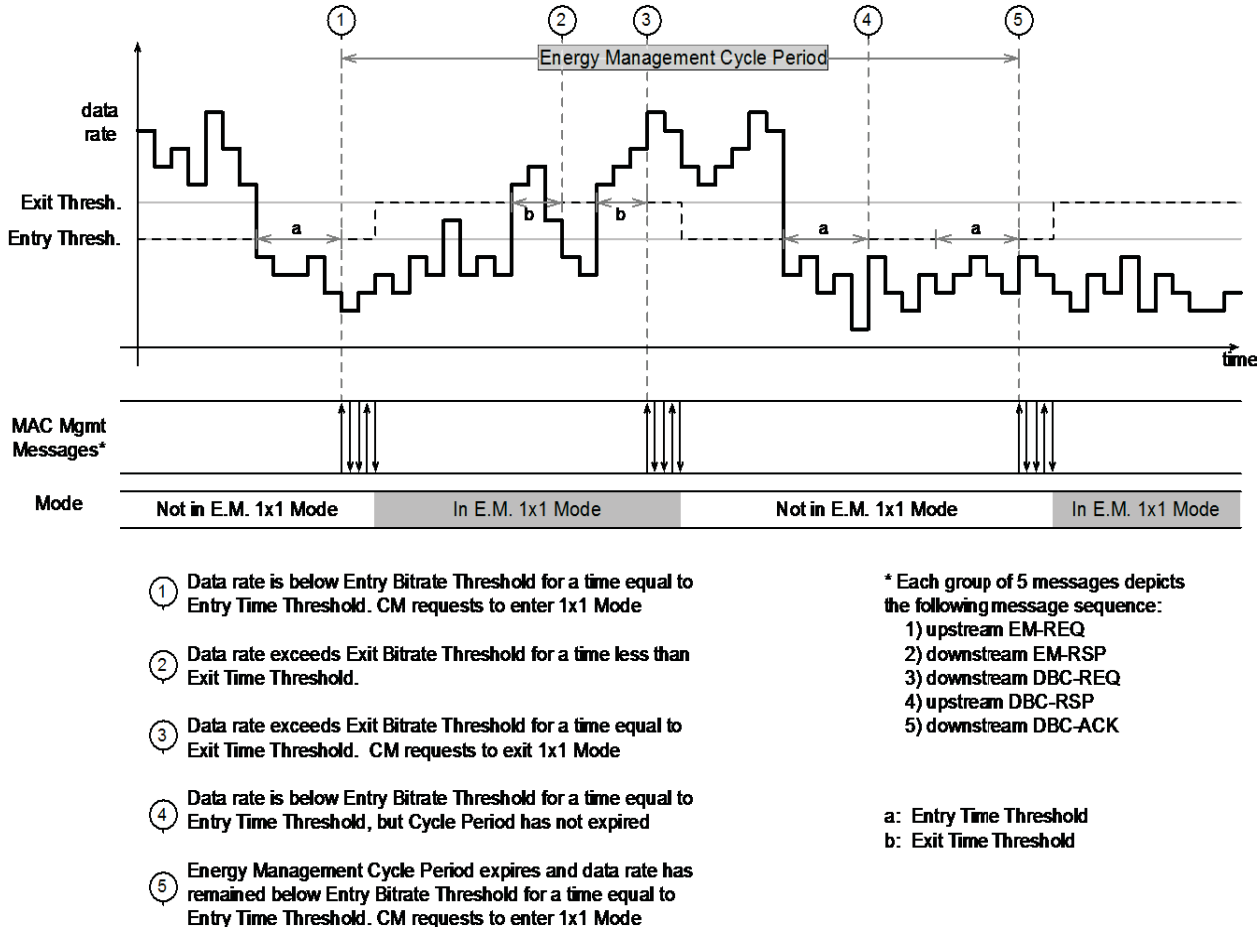

Figure 4 Example DOCSIS 3.0 1x1 Mode Energy Management Threshold Operation

DOCSIS 1x1 Mode is one step toward achieving greater energy savings in next generation STBs that have embedded cable modems. In addition, the next version of the DOCSIS protocol, DOCSIS 3.1, is currently in development at CableLabs. In the DOCSIS 3.1 working group, energy management and low power operation have been a key goal from the initial stages of specification design.

What's Next

Although there are challenges with legacy digital video networks and devices that may impact energy efficiencies, service providers and manufacturers are committed to exploring new and innovative ways to reduce energy consumption in consumer cable products. In the transition to all-digital, operators are providing low power Digital Transport Adapters (DTAs) for basic cable outlets, rather than higher-powered STBs. HD DTAs are also becoming readily available, operating at only 6 Watts. Next generation devices may consolidate features and functionality into one gateway device that can serve low power thin client devices in the home, or even consumer owned devices such as tablets and smart TVs. Operators are also exploring new architectures with the migration of DVR capability to the head end or "cloud", and creating more sophisticated guides using HTML with the program data maintained in the cloud. The voluntary agreement allows service providers to design and build innovative solutions, while addressing important energy consumption goals.

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Abbreviations and Acronyms

APD	Automatic Power Down
CC	CableCARD
CEC	California Energy Commission
CEO	Chief Executive Officer
CM	Cable Modem
CPE	Customer Premises Equipment
DBC-ACK	Dynamic Bonding Change-Acknowledgement (DOCSIS 3.0 Energy Management MAC Message)
DBC-REQ	Dynamic Bonding Change-Request (DOCSIS 3.0 Energy Management MAC Message)
DBC-RSP	Dynamic Bonding Change-Response (DOCSIS 3.0 Energy Management MAC Message)
DOCSIS	Data-Over-Cable Service Interface Specification
DOE	Department of Energy
DSG	DOCSIS Set-Top Gateway
DTA	Digital Transport Adapter
DVR	Digital Video Recorder
eCM	Embedded Cable Modem
EMM	Entitlement Management Message
EM-REQ	Energy Management-Request (DOCSIS 3.0 Energy Management MAC Message)
EM-RSP	Energy Management-Response (DOCSIS 3.0 Energy Management MAC Message)
EPA	Environmental Protection Agency
EPG	Electronic Program Guide
HD	High Definition
HDD	Hard Disk Drive
HDMI	High Definition Multimedia Interface
HDMI-CEC	High Definition Multimedia Interface-Consumer Electronics Control
HSD	High Speed Data

HTML	HyperText Markup Language
IP	Internet Protocol
NOPR	Notice of Proposed Rulemaking
NRDC	Natural Resources Defense Council
QAM	Quadrature Amplitude Modulation
SCTE	Society of Cable Telecommunications Engineers
SD	Standard Definition
SI	Service Information
SoC	System on a Chip
STB	Set-top Box
TV	Television
VA	Voluntary Agreement
VOD	Video-on-Demand