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**Access, Terminals, Transmission and Multiplexing (ATTM);
Energy Efficiency of Energy Related Products (ErPs) with regards to their Ecodesign Requirements;
Network Apparatus and Customer Premises Equipment relating to Cable Network Operator's Services**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

1 Scope

The present document summarizes the existing documents and standards on energy efficiency that impact cable devices.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European Code of Conduct on Energy Consumption of Broadband Equipment, Version 4, 10 February 2011.

NOTE: Available at http://re.jrc.ec.europa.eu/energyefficiency/pdf/CoC%20Brodband%20Equipment/Code%20of%20Conduct%20Broadband%20Equipment%20V4%20final%2010.2.2011.pdf.

[i.2] European Code of Conduct on Energy Consumption of External Power Supplies, Version 4, April 2009.

NOTE: Available at http://www.phihong.com/assets/pdf/Code_of_Conduct__EPS_Ver4__March_09.pdf.

[i.3] Commission Regulation (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment.

[i.4] Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies.

[i.5] Commission Regulation (EC) No 107/2009 of 4 February 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for simple set-top boxes.

[i.6] EuP Lot 26: Networked standby losses.

NOTE: Available at http://www.ecostandby.org/.

[i.7] Draft 1 Version 1.0 ENERGY STAR Small Network Equipment Specification - February 28, 2012.

NOTE: Available at http://www.energystar.gov/index.cfm?c=new_specs.small_network_equip.

[i.8] ETSI ES 202 874-1: "Access, Terminals, Transmission and Multiplexing (ATTM); External Common Power Supply for Customer Premises Network and Access Equipment; Part 1: Functional requirements".

NOTE: Available at ETSI Publications Download Area – Home.

[i.9] IEEE 802.11g: "IEEE Standard for Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher Data Rate Extension in the 2.4 GHz Band".

[i.10] IEEE 802.11n: "IEEE Standard for Local and Metropolitan Area Networks - Telecommunications and Information Ixchange between Systems -- Local and Metropolitan Area Networks - Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 5: Enhancements for Higher Throughput".

[i.11] Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.

[i.12] ENERGY STAR® Program Requirements for Single Voltage External Ac-Dc and Ac-Ac Power Supplies, Eligibility Criteria, Version 2.0.

[i.13] TR-069: "CPE WAN Management Protocol v1.1".

[i.14] ETSI TS 102 533: "Environmental Engineering (EE); Measurement Methods and limits for Energy Consumption in Broadband Telecommunication Networks Equipment".

NOTE: Available at ETSI Publications Download Area - Home.

[i.15] EuP Lot 18: Complex Set-Top Boxes.

NOTE: Available at http://www.eceee.org/Eco_design/products/complex_set_top_boxes.

[i.16] Voluntary Industry Agreement to Improve the Energy Consumption of Complex Set Top Boxes within the EU, Version 3.0.

NOTE: Available at http://www.difgroup.eu/uploads/DocsAndMediaManager/documents/Voluntary%20Industry%20Agreement%20CSTBs%20-%20V%203.0(2%2009%202011).pdf.

[i.17] ENERGY STAR® Program Requirements Product Specification for Set-Top Boxes, Eligibility Criteria, Version 3.0.

[i.18] ENERGY STAR® Program Requirements Product Specification for Set-Top Boxes, Eligibility Criteria, Version 4.0.

[i.19] Commission Regulation (EC) Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
APD	Auto Power Down
ARP	Address Resolution Protocol
CMTS	Cable Modem Termination System
CoC	Code of Conduct

CPE	Customer Premises Equipment
CPS	Common Power Supply
CSTB	Complex Set Top Box
DC	Direct Current
DECT	Digital Enhanced Cordless Telecommunications
DOCSIS	Data Over Cable Service Interface Specifications
DS	Downstream
EIRP	Equivalent Isotropically Radiated Power
EPON	Ethernet Passive Optical Network
EQAM	Edge Quadrature Amplitude Modulator
EU	European Union
FXO	Foreign eXchange Office
FXS	Foreign eXchange Station
GAP	Generic Access Profile
GPON	Gigabit Passive Optical Network
HFC	Hybrid Fibre-Coaxial
HPNA	Home Phoneline Networking Alliance
I-CMTS	Integrated CMTS
ISDN	Integrated Services Digital Network
LAN	Local Area Network
MAC	Media Access Control
M-CMTS	Modular CMTS
MIMO	Multiple Input Multiple Output
MoCA	Multimedia over Coax Alliance
OAM	Operations, Administration and Management
POF	Plastic Optical Fibre
QAM	Quadrature Amplitude Modulation
QVGA	Quarter Video Graphics Array
RF	Radio Frequency
SSTB	Simple Set Top Box
STB	Set Top Box
TEC	Typical Energy Consumption
TFT	Thin-Film Transistor
UDP	User Datagram Protocol
USB	Universal Serial Bus
VIA	Voluntary Industry Agreement
VG	Video Graphics

4 Ecodesign Organizations

This clause provides a lists of European and American organizations or standards efforts which participate in ecodesign. Some of the organizations or standards provide voluntary guidelines that stakeholders choose to support. Other organizations or standards provide government regulations with which stakeholders are to comply.

4.1 EU Codes of Conduct on Energy Consumption

The "Code of Conduct" documents are not regulations from the EU. The Code of Conduct documents provide guidelines that a company can voluntarily support. There is no certification involved, but audits to ensure compliance may occur at any time. There are a number of documents from the CoC which are relevant to the cable modem or gateway:

- Code of Conduct on Energy Consumption of Broadband Communication Equipment [i.1].
- Code of Conduct on Efficiency of External Power Supplies [i.2].

4.2 EU Ecodesign Requirements

The EU Ecodesign Requirements are regulations from the European commission and thus, are to be followed when applicable. There are a number of documents from the European Commission, but only the following documents are relevant to cable devices:

- Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment [i.3].
- Ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies [i.4].
- Ecodesign requirements for simple set-top boxes [i.5].
- Ecodesign preparatory studies Lot 26: Networked Standby Losses [i.6].
- Ecodesign preparatory studies Lot 18: Complex Set-Top Boxes [i.15].

4.3 ETSI

There is one standard within ETSI:

- ATTM External Power Supply Standard – ES 202 874-1 [i.8].

4.4 Energy Star

The United States Environmental Protection Agency uses the Energy Star label as a way to communicate that a product meets the strict energy efficiency guidelines. Energy star standards exist for many home electronic devices as well as for complex set-top boxes. The current Energy Star items that apply to cable devices are listed below:

- Program Requirements for Single Voltage External Ac-Dc and Ac-Ac Power Supplies [i.12].
- Draft 1 Version 1.0 ENERGY STAR Small Network Equipment Specification - February 28, 2012 [i.7].
- ENERGY STAR® Program Requirements Product Specifications for Set-Top Boxes [i.17] and [i.18].

4.5 Voluntary Industry Agreement on Energy Consumption

The "Voluntary Industry Agreement to Improve the Energy Consumption of Complex Set Top Boxes within the EU" [i.16] document is not a regulation from the EU, but a response to the EU regulatory discussions. The Voluntary Industry Agreement (VIA) is an industry initiative to provide guidelines that a company can voluntarily support. There is no certification involved, but audits to ensure compliance may occur at any time. The VIA has many signatories from service providers, equipment manufacturers, software providers, conditional access providers and component manufacturers.

5 Ecodesign References

5.1 Ecodesign references on Broadband Communication Equipment

5.1.1 CoC on Energy Consumption of Broadband Communication Equipment Version 4

The CoC for broadband communication equipment applies to cable devices.

5.1.1.1 Customer Premises Equipment

5.1.1.1.1 Broadband Code of Conduct Targets

The CoC for broadband communication equipment defines power consumption targets measured at the AC mains input. A home gateway is "a generic term which encompasses all kinds of access interfaces", including a DOCSIS cable modem.

The Broadband Code of Conduct defines the low-power state of a DOCSIS gateway as the DOCSIS WAN port in an idle state, the LAN ports disconnected, and one FXS port with phone connected. The central functions of the DOCSIS gateway are "not processing user traffic" and the physical configurations of the WAN interface (the DOCSIS modem) is defined as the same as in the on-state. However, there is a note in the low-power definition that "the low power state configuration can be different than in on-state if this does not require a manual reconfiguration by the end user (e.g. in case of DOCSIS 3.0, the CPE could transition to a 1x1 configuration or in case of ADSL2+ to the L2 mode)". This provides the cable industry the option of defining a means of configuring the DOCSIS 3.0 modem into a 1x1 configuration when in a low-power mode in the future.

The Broadband Code of Conduct defines the on-state of a DOCSIS gateway per table 1 (which is copied directly from the Broadband Code of Conduct). The DOCSIS targets in table 2 have been defined for the "low power" and "on-state". (Table 2 is also copied directly from the Broadband Code of Conduct.) The power allowances for LAN interfaces and additional functionality are shown in table 3 in the "low power" and the "on-state".

The description for a DOCSIS WAN interface includes a minimum subset of parameters -- the downstream modulation, upstream modulation, and upstream symbol rate. The parameters which are not defined are expected to occur within the range defined by the DOCSIS specifications. Specifically, the upstream transmit power levels are to be within the DOCSIS required levels, between 8 dBmV and 58 dBmV for DOCSIS 2.0 and between 17 dBmV and 61 dBmV for DOCSIS 3.0. The descriptions of the "on-state" include the traffic rate (of 500 byte UDP packets) to be forwarded through the DOCSIS HFC (WAN interface).

The Broadband Code of Conduct provides a power allowance to DOCSIS 3.0 modems for each additional four downstream channels that the modem is capable of supporting -- the "DOCSIS 3.0 additional power allowance for each additional 4 downstream channels". This allowance is based on the number of downstream channels that the modem is capable of supporting, not on the number of downstream channels with which the modem is configured to operate. For example, a modem that is registered in a configuration with eight downstream channels and four upstream channels, but is capable of supporting sixteen downstream channels, applies the four-downstream channel allowance three times (because of capability of twelve additional channels) for both the low power mode and the on-state. Note that the Broadband Code of Conduct does not provide an allowance for additional upstream channels that the modem is capable of supporting since the DOCSIS 3.0 specifications do not currently cover operation with more than four upstream channels.

Table 1: Definition of the on-state for home gateways

Port/component	On-state
Central functions (processor and memory: routing, firewall, OAM (e.g. TR-069 [i.13]), user interface).	Processing the user traffic present on the WAN and LAN interfaces.
WAN port	Single WAN: Active (link established and passing user traffic). In case of dual WAN interface, for backup or alternative purposes, only one of the two ports will be in the above described state, while the second will be disconnected, but able to be manually or automatically activated in case of need. In case of dual WAN interface for simultaneous operation, both ports will be in the above described state.
DOCSIS 2.0	Active with a downstream channel with a modulation type of 256 QAM and an upstream channel with a modulation type of 64 QAM and a symbol rate of 5,12 Ms/s and passing user traffic: 10 Mbit/s downstream, 2 Mbit/s upstream.
DOCSIS 3.0	Active with an NxM configuration with N downstream channels with a modulation type of 256 QAM and M upstream channels with a modulation type of 64 QAM and a symbol rate of 5,12 Ms/s. Modem is passing user traffic: 20 Mbit/s downstream, 5 Mbit/s upstream. Basic configuration: • The basic NxM configuration is a 4x4 configuration. Additional power allowance for each additional 4 downstream channels: • The NxM configuration is an Nx4 configuration where N is the maximum number of downstream channels supported by the modem. (Testing may be restricted by the number of channels supported by the plant.).

Table 2: Power values for home gateway central functions plus WAN interface

Home gateway central functions plus WAN interface	Tier 2011-2012: 1.1.2011 - 31.12.2012		Tier 2013-2014: 1.1.2013 - 31.12.2014	
	Low-Power-State (W)	On-State (W)	Low-Power-State (W)	On-State (W)
DOCSIS 2.0	3,7	4,6	3,7	4,6
DOCSIS 3.0 basic configuration	6,2	7,1	4,2	6,2
DOCSIS 3.0 additional power allowance for each additional 4 downstream channels	2,2	2,8	2,0	2,5

Table 3: Power values for home gateway LAN interfaces and additional functionality

Home gateway LAN interfaces and additional functionality	Tier 2011-2012: 1.1.2011 - 31.12.2012		Tier 2013-2014: 1.1.2013 - 31.12.2014	
	Low-Power-State (W)	On-State (W)	Low-Power-State (W)	On-State (W)
1 Fast Ethernet port	0,3	0,4	0,2	0,4
1 Gigabit Ethernet port	0,3	0,9	0,2	0,6
Wi-Fi interface single band IEEE 802.11g [i.9] or 11a/h radio with up to 23 dBm EIRP	0,7	2,0	0,7	1,5
Wi-Fi interface single band IEEE 802.11g [i.9] or 11a/h radio with up to 30 dBm EIRP	0,7	2,5	0,7	2,5
Wi-Fi interface single band IEEE 802.11n [i.10] radio with up to 23 dBm EIRP	1,0	2,5	0,8	2,0
Wi-Fi interface single band IEEE 802.11n [i.10] radio with up to 30 dBm EIRP	1,0	3,0	0,8	3,0
Additional allowance per RF chain above a 2x2 MIMO configuration (e.g. for 3x3 and 4x4)	0,1	0,4	0,1	0,3
Alternative LAN technologies (HPNA, POF…)	2,0	2,5	1,5	2,0
MoCA	2,0	2,5	1,8	2,2
Powerline - High speed for broadband home networking (less than or equal to 50 MHz bandwidth)	2,5	3,0	2,0	2,7
Powerline - High speed for broadband home networking (greater than 50 MHz bandwidth)	2,5	4,7	2,5	4,5
PowerLine - Low speed for smart metering and appliances control	0,9	2,0	0,8	1,5
FXS	0,5	1,5	0,3	1,2
ISDN S0	0,2	0,4	0,2	0,4
FXO	0,4	0,9	0,2	0,9
Emergency fall-back to analog telephone	0,8	0,8	0,6	0,6
DECT GAP	0,75	1,65	0,5	1,0
DECT Cat-iq	0,75	2,0	0,5	1,2
DECT charging station for DECT handset in slow/trickle charge	0,4	0	0,4	0
USB – no load connected	0,25	0,25	0,1	0,1
Built-in back-up battery	0,2	0,2	0,1	0,1
Bluetooth	0,2	0,3	0,1	0,3
Zigbee (or other low power wireless technologies)	0,15	0,15	0,15	0,15
Femto cell (Home use, RF power ≤10 mW)	7,0	8,0	6,0	7,0
Femto cell (Home use, RF power 10 mW-50 mW)	11,0	12,0	9,0	10,0
RF modulator (TV overlay for fiber network)	3,5	3,5	3,2	3,2
Embedded handsfree system	0,5	0,5	0,5	0,5
Additional Colour Display (typically found in VoIP devices) TFT QVGA and VG	0,5	1,0	0,5	1,0

5.1.1.1.2 Response to Current Broadband Code of Conduct Targets

The power numbers specified by the Broadband Code of Conduct for CM products were based on estimates of future developments. The numbers for the Tier 2011-2012 have proven to be attainable. However, as more complex and integrated products are being developed for deployments in the Tier 2013-2014, as an industry, we are finding that the limits for the Tier 2011-2012 need to be extended in order to allow for products to evolve to more energy efficient solutions.

As a result, ETSI ATTM AT3 proposes that the following set of numbers be used as guidelines for limits on CM products. These numbers represent ranges of real-world numbers calculated from deployed CM equipment and from CM equipment currently under development for the future. We believe that these numbers create more realistic goals for the industry as it moves into a more energy-efficient future.

Table 4: Power values for home gateway central functions plus WAN interface

Home gateway central functions plus WAN interface	Tier 2011-2013: 1.1.2011 - 31.12.2013		Tier 2014-2016: 1.1.2014 - 31.12.2016	
	Low-Power-State (W)	On-State (W)	Low-Power-State (W)	On-State (W)
DOCSIS 2.0	3,7	4,6	3,7	4,6
DOCSIS 3.0 basic configuration	6,2	7,1	4,2	6,2
DOCSIS 3.0 additional power allowance for each additional 4 downstream channels	2,2	2,8	2,0	2,5

5.1.1.2 CMTS Equipment

The CoC for broadband communication equipment defines power consumption targets on a per port basis for Network equipment.

5.1.1.2.1 Broadband Code of Conduct Targets

Table 5, copied directly from the Broadband Code of Conduct, defines the power consumption targets on a per downstream channel (or QAM) basis. The Broadband Code of Conduct measures the power values for CMTS equipment at the "A" interface as described in the standard TS 102 533 [i.14] or at the AC input, in case of directly mains powered systems". For a directly mains powered CMTS, the power consumption targets in table 5 are increased by ten percent.

Table 5: Cable Network Equipment

Equipment	Tier 2011 (01.01.2011) (W)	Tier 2012-2013 (01.01.2012) (W)
I-CMTS $\leq$ 32 DS (downstream) ports	65	35
I-CMTS > 32 DS ports	50	30
M-CMTS $\leq$ 280 DS ports	30	30
M-CMTS > 280 DS ports	25	25

NOTE: M-CMTS values include the CMTS and the EQAM (Edge Quadrature Amplitude Modulator).

Additionally, the CMTS equipment is given an additional allowance for its uplink interface. The below text from clause C.2.5 of the Broadband Code of Conduct describes this allowance.

The additional allowance for the uplink interface is:

- *4,5 W per equipment for each Point to Point 1 000 Mbit/s interface.*
- *9,0 W per equipment for each Point to Point 10 Gbit/s interface.*
- *6,0 W per equipment for each Point to Multipoint (GPON) interface.*
- *5,0 W per equipment for each Point to Multipoint (1G-EPON) interface.*
- *7,5 W per equipment for each Point to Multipoint (10/1G-EPON) interface.*
- *9,0 W per equipment for each Point to Multipoint (10/10G-EPON) interface.*

5.1.1.2.2 Response to Current Broadband Code of Conduct Targets

The power per channel numbers specified by the Broadband Code of Conduct for CMTS products are much higher than the power per channel numbers found in typical CMTS products - both for existing products of today and for planned products of the future. In addition, the differences in power levels originally proposed for I-CMTS and M-CMTS products does not accurately reflect the differences in power levels associated with actual product deployments. Field experiences have shown that the two types of deployments (M-CMTS and I-CMTS) actually consume similar power levels, with slightly more power required for the addition of optical links in M-CMTS environments.

As a result, ETSI ATTM AT3 proposes that the following set of numbers be used as guidelines for future power per channel limits on CMTS products. These numbers represent ranges of real-world numbers calculated from deployed CMTS equipment and from CMTS equipment currently under development for the future. We believe that these numbers create more challenging and more realistic goals for the industry as it moves into a more energy-efficient future.

Table 6: Cable network equipment

Equipment	Tier 2011 (01.01.2011) (W/Channel)	Tier 2012-2013 (01.01.2012) (W/Channel)	Tier 2014-2015 (01.01.2014) (W/Channel)
CMTS Power per Downstream Channel	16,0	6,0	4,0
Allowance for each M-CMTS Ethernet Point-to-Point 10 Gbit/interface between M-CMTS core and EQAM	8,0	8,0	8,0

NOTE: The term CMTS indicates both the I-CMTS and the M-CMTS. Additionally, the CMTS values applied to the M-CMTS include the CMTS and the EQAM (Edge Quadrature Amplitude Modulator).

The above values are nominal at 25 C for a fully equipped chassis at its maximum configuration. Sparing features are not assumed. The above values are for fully equipped systems with maximum configurations. The assumed configuration includes a ratio of two Upstream Service Groups paired with one Downstream Service Group. In the definition of Tier 2011, it is assumed that the ratio of number of channels in an Upstream Service Group to number of channels in a Downstream Service Group is 1:2. In the definition of Tier 2012-2013, it is assumed that the ratio of number of channels in an Upstream Service Group to number of channels in a Downstream Service Group is 1:4.

5.1.2 Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment

This regulation [i.3] is applicable to electrical and electronic household and office equipment and thus includes DOCSIS devices.

Article 2 of this regulation provides definitions for three different modes – Active Mode, Standby Mode, and Off Mode.

1) Off mode:
"'off mode' means a condition in which the equipment is connected to the mains power source and is not providing any function; the following shall also be considered as off mode:

- conditions providing only an indication of off-mode condition;
- conditions providing only functionalities intended to ensure electromagnetic compatibility pursuant to Directive 2004/108/EC [i.11] of the European Parliament and of the Council."

2) Standby mode:
"'standby mode(s)' means a condition where the equipment is connected to the mains power source, depends on energy input from the main power source to work as intended and provides ***only*** *the following functions, which may persist for an indefinite time:*

- reactivation function, or reactivation function and only an indication of enabled reactivation function; and/or
- information or status display;

'reactivation function' means a function facilitating the activation of other modes, including active mode, by remote switch, including remote control, internal sensor, timer to a condition providing additional functions, including the main function."

3) Active Mode:
"'active mode(s)' means a condition in which the equipment is connected to the mains power source and at least one of the main function(s) providing the intended service of the equipment has been activated."

Equipment that falls under the scope of this regulation is expected to provide an off mode and/or a standby mode. From annex II, "*Equipment shall, except where this is inappropriate for the intended use, provide off mode and/or standby mode, and/or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source"*.

The power consumption allowed in off mode and standby mode from Annex II of the regulation is detailed in table 7.

Table 7: Power Consumption in Off Mode and Standby Mode

Mode	1.1.2010 – 31.12.2012	1.1.2013 and beyond
Off and standby without display	1 W	0,5 W
Standby with display	2 W	1 W

Notably, the regulation allows an exception for cases in which an off or standby mode is inappropriate for the intended use of the equipment. The off mode is not expected to be used in a device with an embedded DOCSIS modem and as such may or may not be considered appropriate for the intended use. Standby mode is not applicable to a device with an embedded DOCSIS modem. The rationale for the appropriateness of the above modes is described in clause 6 of the present document, Operation Modes.

Additionally, the regulation provides that equipment can alternatively support "another condition" which does not exceed the power consumption limits in the above table.

Finally, the regulation allows that during the first term (from 1 year until 4 years after the regulation came into force), equipment is allowed to support manual switching into standby/off, but in the second term, it is required that the equipment support an automatic transition into standby mode, off mode, or another condition that does not exceed the applicable power consumption requirements. Automatic transition to off mode is likely to be inappropriate for the intended use of a device with an embedded DOCSIS modem.

5.1.3 Ecodesign reference on networked standby

The European Commission has funded studies on environmental policy for the European Union. Lot 26: Networked Standby Losses, Ecodesign preparatory studies on networked standby provides the following high-level definition of networked standby mode:

Networked standby mode *means a condition during which the equipment is directly or indirectly connected to the mains power source and provides the following functions:*

1) *Reactivation via network; this function means analyzing the incoming signals on one or more communication paths external to the equipment in order to initiate the reactivation of the equipment.*

2) *Network integrity communication; this function applies additionally for more complex network types and means maintaining the external communication paths.*

3) *Reactivation, information and status display; this means that standby functions according to EC 1275/2008 [*i.3*] may also be provided during networked standby mode.*

Lot 26 was completed on 24 June 2011. The recommendations of Lot 26 are being considered for inclusion in a draft amendment to the Regulation 1275/2008 [i.3].

Currently, the DOCSIS specifications have no allowance for such functionality. DOCSIS specifications are being extended to support features that are intended to address the need for Networked Standby.

5.2 Ecodesign references on Power Supplies

For cable modems powered by an external power supply, these references are relevant for cable devices. These references are provided for informational purposes because of the relevance for cable devices.

5.2.1 CoC on Efficiency of External Power Supplies

The CoC on efficiency of external power supplies provides guidelines "to minimise energy consumption of external power supplies". The present document provides power efficiency targets under "no-load" and "load" conditions. This CoC document defines on-mode efficiency as the "simple arithmetic average of efficiency measurements made at 25 %, 50 %, 75 %, and 100 % of full rated output current".

Specifically, this CoC requires less than 0,3 watts consumption for a "no load" condition per table 8 and the consumption targets in table 9 for active mode.

Table 8: No-load Power Consumption

Rated Output Power (P_{no})	No-load power consumption From 1.1.2009
0,3 W < P_{no} ≤ 50 W	0,3 W
50 W < P_{no} ≤ 250 W	0,5 W

Table 9: Energy-Efficiency Criteria for Active Mode

Rated Output Power (P_{no})	Minimum Four Point Average Efficiency in Active Mode From 1.1.2009
0 W < P_{no} ≤ 1 W	≥ 0,48 × P_{no} + 0,140
1 W < P_{no} ≤ 49 W	≥ 0,0626 × ln(P_{no}) + 0,622
49 W < P_{no} ≤ 250 W	≥ 0,870

5.2.2 Ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies

This regulation [i.4] supersedes the CoC on Efficiency of External Power Supplies. Annex I of this regulation mandates the no-load power consumption and the average active efficiency for AC/DC external power supplies. The no-load power consumption is not to exceed 0,3 watts. The average efficiency levels are provided in table 10.

Table 10: Limits on Average Active Efficiency of AC/DC External Power Supplies

Rated output power	Average active efficiency
P_0 ≤ 1,0 W	0,480 × P_0 + 0,140
1,0 W < P_0 ≤ 51,0 W	0,063 × ln(P_0) + 0,622
P_0 > 51,0 W	0,870

5.2.3 ETSI ATTM External Power Supply Standards

ETSI TC ATTM has developed a series of standards and technical specifications aimed at defining common external power supplies (CPS) suitable for customer premises network and access equipment. ES 202 874-1 [i.8] provides the overall requirements for power supplies in the series, while subtending technical specifications are intended to define specific requirements for an application.

In regards to energy efficiency, ES 202 874 [i.8] requires that CPS comply with EC Regulation No. 278/2009 [i.4].

5.3 Ecodesign references on Set-Top Boxes

Since cable modems may include an embedded set-top box, these references are relevant for cable devices which contain an embedded set-top box.

- Ecodesign preparatory studies Lot 18: Complex Set-Top Boxes [i.15].
- Voluntary Industry Agreement to improve the energy consumption of Complex Set Top Boxes within the EU, version 3.0 [i.16].
- Ecodesign requirements for simple set-top boxes [i.5].
- Energy Star Program Requirements Product Specification for Set-Top Boxes [i.17] and [i.18].

5.3.1 Ecodesign preparatory studies Lot 18: Complex Set-Top Boxes

The European Commission has funded studies on environmental policy for the European Union. Lot 18: Complex Set-Top Boxes provides the following high-level definition of Complex Set-Top Boxes:

Complex STBs are STBs which allow conditional access. *A set-top box is a stand-alone device, using an integral or dedicated external power supply, for the reception of Standard Definition (SD) or High Definition (HD) digital broadcasting services via IP, cable, satellite and/or terrestrial transmission and their conversion to analogue RF and/or line signals and/or with a digital output signal.*

STBs might have additional features, such as:

- return path/integrated modem/internet access,
- multiple tuners (for picture-in-picture or to serve several end-devices),
- connectivity with external devices (video recorders, PC, digital cameras, external hard disks or memory etc.),
- recording with internal mass storage media, and
- entitlements.

Digital receivers with recording function based on removable media in a standard library format (DVD, VHS tape, "Blu-ray" disc etc.) are excluded from the scope of this study, but complex STBs with players for removable media are included.

Lot 18 was completed in December 2008. The recommendations of Lot 18 were considered for inclusion in an amendment to the Regulation 107/2009. However, the stakeholders responded to the recommendations of Lot 18 by working together to create a voluntary agreement described in more detail in the next clause. With this vendor agreement, the recommendations of Lot 18 were never adopted as a Regulation.

5.3.2 Voluntary Industry Agreement to improve the energy consumption of Complex Set Top Boxes within the EU

The Voluntary Industry Agreement (VIA) to improve the energy consumption of Complex Set Top Boxes within the EU evolved from a large group of stakeholders responding to Lot 18. The stakeholders suggested that a voluntary agreement was preferable because (per http://www.eceee.org/Eco_design/products/complex_set_top_boxes/):

- *The energy use of these devises is impacted by the way they are operated by the service providers.*
- *The function of these devices are quickly evolving, which requires a flexible approach in setting requirements.*

According to Regulation 2006/32/EC [i.19], "The energy services, energy efficiency improvement programmes and other energy efficiency improvement measures put into effect to reach the energy savings target may be supported and/or implemented through voluntary agreements between stakeholders and public sector bodies appointed by the Member States". The web page, http://www.eceee.org/Eco_design/process/Voluntary_Agreements/), elaborates on voluntary agreements as an alternative for implementing measures under the Ecodesign Directive. With regards to the Complex Set Top Box, "the impact assessment showed that the proposed voluntary agreement meets the criteria set out in the Ecodesign Directive and that it offers similar energy savings to those that could be obtained from a possible regulation".

The VIA defines two tiers – tier one is effective until 30 June 2013 and tier two becomes effective on 1 July 2013. Both versions contain an allowance for base functionality of Cable Set Top boxes. The allowance for base functionality for tier one is 45 kWh/year. The allowance for base functionality for tier two is 40 kWh/year. There is an additional allowance for DOCSIS functionality under both tiers. In tier one, the DOCSIS functionality allowance of 70 kWh/year equates to 8 watts continuous. In tier two, the DOCSIS functionality allowance of 50 kWh/year equates to 5,7 watts continuous. Under both tiers, the DOCSIS 3.0 functionality allowance is defined per four bonded RF channels.

There are two operational modes defined for a Complex Set Top Box (CSTB), On and Standby. On mode is defined as "Operational mode in which the CSTB is at least actively performing its base functionality". Standby mode is defined as "Operational mode in which the CSTB has less energy consumption, capability, and responsiveness than in the "On" mode" and can be triggered by user notification or by auto power down.

For CSTBes that do not support an Auto Power Down (APD) feature, the annual energy consumption is calculated per the following equation:

$$kWh_{Base} = 0{,}365 \times (T_{On} \times P_{On} + T_{Standby} \times P_{Standby})$$

P_{on} and $P_{Standby}$ are the power levels in watts of the on and standby modes. T_{on} and $T_{Standby}$ are the times in hours of the on and standby modes; the value of T_{on} is 9 hours and $T_{Standby}$ is 15 hours.

For CSTBes that support an APD feature, the annual energy consumption is calculated per the following equation:

$$kWh_{Base} = 0{,}365 \times (T_{On} \times P_{On} + T_{Standby} \times P_{Standby} + T_{APD} \times P_{APD})$$

P_{on}, $P_{Standby}$. and P_{APD} are the power levels in watts of the on, standby, and APD modes. T_{on}, $T_{Standby}$, and T_{APD} are the times in hours of the on, standby, and APD modes; the value of T_{on} is 4,5 hours, $T_{Standby}$ is 15 hours, and T_{APD} is 4,5 hours.

5.3.3 Ecodesign requirements for simple set-top boxes

This regulation applies to simple set-top boxes. A simple set-top box (SSTB) is a set-top box that has no conditional access function or recording function.

This regulation defines two modes of operation - active mode and standby mode.

- *"'Active mode(s)' means a condition in which the equipment is connected to the mains power source and at least one of the main function(s) providing the intended service of the equipment has been activated".*
- *"Standby mode(s)' means a condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides only the following functions, which may persist for an indefinite time:*

  a) reactivation function, or reactivation function and only an indication of enabled reactivation function; and/or

  b) information or status display".

The regulation provides the requirements in table 11 for simple STBs.

Table 11: Ecodesign Requirements for SSTBs

	4.2.2009 – 4.2.2012		Beginning 4.2.2012	
	Standby Mode	**Active Mode**	**Standby Mode**	**Active Mode**
Simple STB	1,00 W	5,00 W	0,50 W	5,00 W
Allowance for decoding HD signals	N/A	+ 3,00 W	N/A	+ 1,00 W

5.3.4 ENERGY STAR® Requirements for Set-Top Boxes

The ENERGY STAR® Program has requirements defined by versions 3 and 4 which address different timeframes. The values in version 3 of the Set-Top requirements document became effective on 1 September 2011. The values in version 4 of the set-top requirements document will become effective on 1 July 2013. Both versions contain an allowance for base functionality of Cable Set-Top boxes. The allowance for base functionality in version 3 is 60 kWh/year. The allowance for base functionality in version 3 is 45 kWh/year. Both versions contain an allowance for DOCSIS functionality. The DOCSIS allowance in version 3 is 20 kWh/year which equates to 2,3 watts continuous. The DOCSIS allowance in version 4 is 15 kWh/year which equates to 1,7 watts continuous.

There are three operational modes defined by ENERGY STAR®, On, Sleep, and Deep Sleep. The definitions for the modes are as follows:

- On mode: "Where the product is connected to a mains power source, has been activated and may be providing one or more primary functions. The common terms "active", "in-use" and "normal operation" also describe this mode".
- Sleep mode: "Where the product is connected to a mains power source, is not providing a primary function, and offers one or more of the following user oriented or protective functions which may persist for an indefinite time:
  i. to facilitate the activation of other modes (including activation or deactivation of On mode) by remote switch (including remote control), internal sensor, timer;
  ii. continuous function: information or status displays including clocks;
  iii. continuous function: sensor-based functions".
- Deep Sleep mode: "A power state within Sleep Mode characterized by reduced power consumption and increased time required to return to full On Mode functionality".

ENERGY STAR® defines the Typical Energy Consumption (TEC) requirements. The Combined TEC ($TEC_{COMBINED}$) is calculated per the equation below.

$$TEC_{COMBINED} = TEC_{PRIMARY} + TEC_{PLAY/RECORD}$$

$$TEC_{PRIMARY} = 0{,}365 \times [(T_{TV} \times P_{TV}) + (T_{SLEEP} \times P_{SLEEP}) + (T_{APD} \times P_{APD}) + (T_{DEEP\_SLEEP} \times P_{DEEP\_SLEEP})]$$

$$TEC_{PLAY/REC} = 0{,}365 \times [((P_{PLAYBACK} - P_{TV}) \times H_{PLAYBACK}) + ((P_{RECORD} - P_{TV}) \times H_{RECORD})]$$

- T_{TV} is the time coefficient for On Mode;
- P_{TV} is the measured power in On Mode (W);
- T_{SLEEP} is the time coefficient for Sleep Mode;
- P_{SLEEP} is the measured power in Sleep Mode (W);
- T_{APD} is the time coefficient for APD;
- P_{APD} is the measured power after APD (W);
- T_{DEEP_SLEEP} is the time coefficient for Deep Sleep State;

- P_{DEEP_SLEEP} is the measured power in Deep Sleep State (W);
- T_{TV} is the time coefficient for On Mode;
- P_{TV} is the measured power in On Mode (W);
- T_{SLEEP} is the time coefficient for Sleep Mode;
- P_{SLEEP} is the measured power in Sleep Mode (W);
- T_{APD} is the time coefficient for APD;
- P_{APD} is the measured power after APD (W);
- T_{DEEP_SLEEP} is the time coefficient for Deep Sleep State;
- P_{DEEP_SLEEP} is the measured power in Deep Sleep State (W).

The Maximum TEC requirement (TEC_{MAX}) is calculated per the equation below:

$$TEC_{MAX} = TEC_{BASE\_MAX} + \sum_{i-1}^{n} TEC_{ADDL\_i}$$

- TEC_{BASE_MAX} is the Base Type TEC Allowance (kWh);
- TEC_{ADDL_i} is each applicable Additional Functionality TEC Allowance.

The Combined TEC is required to be less than or equal to the Maximum TEC Requirement.

6 Operation Modes

The EU directive on requirements for standby and off mode electrical and electronic household and office equipment [i.3] provides three modes of operation - off mode, standby mode, and active mode. Additionally, there have been prepatory studies on a networked standby mode.

6.1 Off Mode

Off mode is not expected to be used in DOCSIS modems for a number of reasons. First of all, an off mode would result in operational issues due to the length of time that would be required to restore service upon reapplication of power. Cable modems can take on the order of 30 seconds to several minutes to fully come online from a cold boot. Secondly, it is increasingly common that the cable modem either acts as a gateway router for home networked devices or is connected to a home router that provides this service. In the former case, powering off the cable modem would shut down the entire home network. In both cases, the cable modem is generally not located in close proximity to the end devices (e.g. wifi laptops, game consoles, connected televisions, smart phones, tablet devices), so it is exceedingly inconvenient for the user to power it up prior to using one of the end devices. Thirdly, many CMTS implementations track a modem that power cycles frequently as a "flap"; if many flaps are reported by a CMTS, it will take additional effort by the operator to determine whether these flaps are due to a customer powering off a modem or due to other issues whereby the operator needs to take corrective or maintenance action. Finally, there are an increasing number of devices and services that rely on a persistent Internet connection for their operation; these include VoIP telephony services, security systems, home power monitoring systems (smart meters), home automation systems, weather consoles, software updaters, remote backup services, etc.

Subsequently, an off-mode is unlikely to be utilized with any regularity in a cable modem. For the small number of users for which the above factors either don't apply or yield an acceptable trade off, simply unplugging the cable modem or connecting it to a switchable power strip provides a workable (and arguably better) solution.

That said, each cable modem vendor may choose to comply with this directive differently. Some vendors may choose to include a power switch in their device in order to meet this directive. Other vendors may simply consider that off mode is inappropriate for the intended use of a device containing an embedded DOCSIS modem.

6.2 Standby Mode

Standby mode is not applicable to cable modems.

Standby mode does not apply to a device with an embedded DOCSIS modem because standby mode is considered inappropriate for the intended use of the device. An embedded DOCSIS modem requires network connectivity all the time since traffic exists when no end user is present (i.e. ARPs or other background traffic that is necessary for the DOCSIS modem to bridge).

The DOCSIS modem is not an endpoint device, but a data networking device intermediary along the path to the end devices. The existing DOCSIS standards do not support a standby mode or reactivation function from any standby mode.

6.3 Active Mode

The DOCSIS 3.0 standard introduces flexibility in terms of the number of upstream and downstream channels implemented in a cable modem. Furthermore, the DOCSIS 3.0 standard requires cable modems to support operation using a subset of transmitters and receivers active. Both of these factors affect the power consumption of the device.

6.3.1 On mode

The DOCSIS 3.0 standard requires support for a minimum of four upstream and four downstream channels. As such, operation with four upstream channels and four downstream channels constitutes an "on-state" for a DOCSIS 3.0 cable modem.

6.3.2 Low power mode

Operation with a single upstream channel and a single downstream channel is the lowest power configuration for a DOCSIS 3.0 cable modem and could therefore be considered to be the "low-power" mode for the device.

There are a number of issues to consider in defining this mode. While the DOCSIS 3.0 specifications provide flexibility in the upstream and downstream channel configurations, the specifications have no defined mechanism for dynamically invoking the modem to operate in such a mode. There is a question as to the means of invoking such a mode as well as which device would be responsible for placing the modem in a low power mode, the modem, the head end, or a network management entity.

The DOCSIS 3.0 specifications have a provision for a battery mode (used in the US) in which the modem sends a MAC Management Message to the head end upon a loss of power. Once the head end receives the MAC Management Messages, it should initiate a transaction that reconfigures the transmitters and receivers such that the modem operates with a single transmitter and receiver. This provision could be extended to additionally cover a "low power" state.

Defining such a mode would require changes in DOCSIS specifications, the modem, the head end, and potentially the network management system.

6.4 Networked standby

The intent of networked standby mode is that the modem goes into a mode of very low energy consumption when there is no traffic to be transmitted while still being able to transition to an active mode upon the detection of traffic on any connected interface. However, this mode is problematic because traffic needs to be forwarded in order for the wake-up message to make it to its final destination. The modem would also need awareness as to the state of the devices on its network, whether these devices were "sleeping", in order to make forwarding decisions.

In order to achieve significant energy savings in this mode, technology is required to progress significantly to make the remote activation via the network signal possible.

Annex A: Bibliography

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- ETSI EN 302 878: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems".
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