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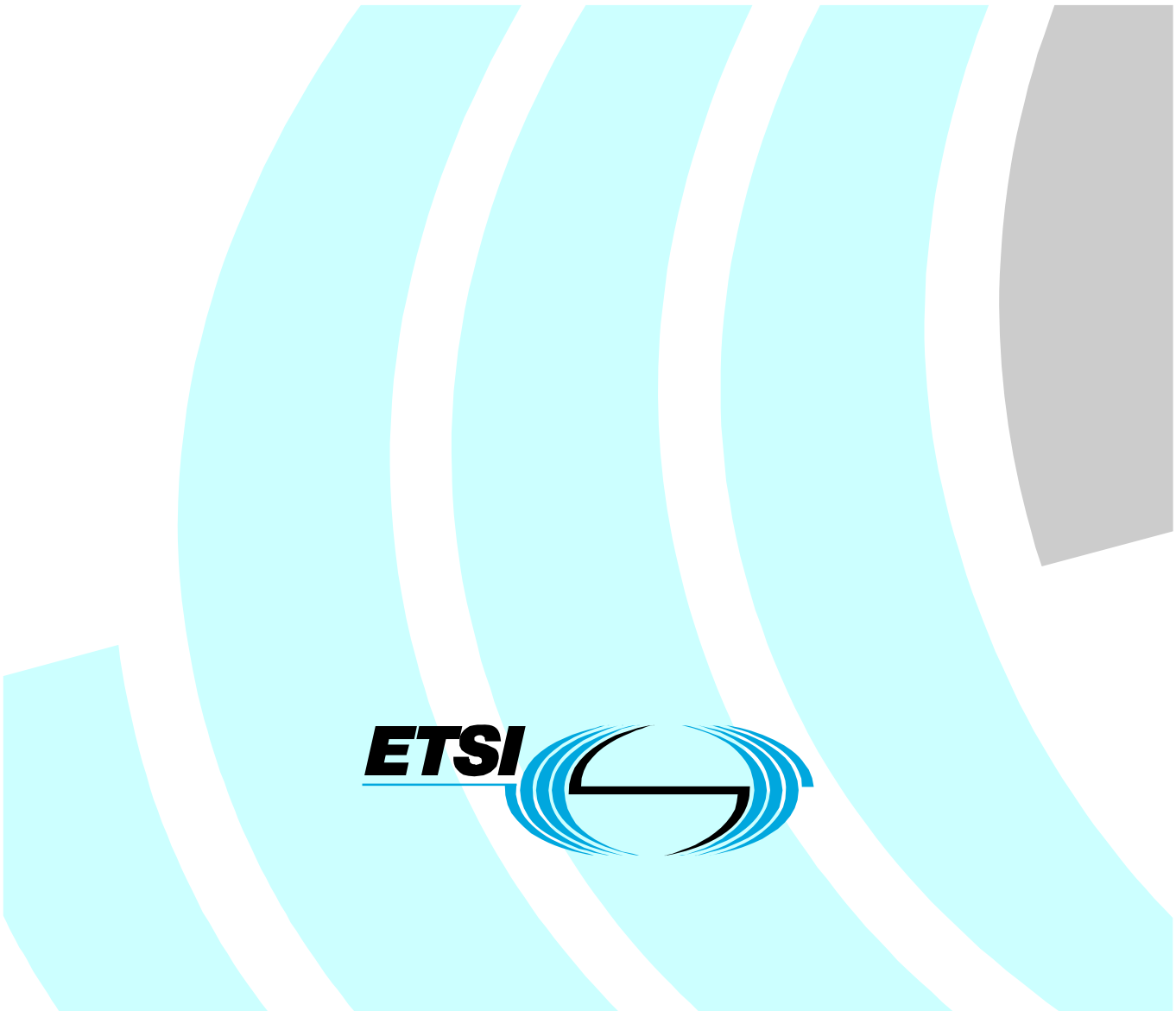
Technical Report

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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Contents

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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.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

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, 10th February 2011.

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

[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] ENERGY STAR Small Network Equipment.

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".

[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] DTS/EE-00018: "Environmental Engineering (EE); EE Eco Environmental Product Standards Metrics and target value for Energy consumption of End-user Broadband equipment (CPE)".

[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".

[i.15] EuP Lot 18: Complex Settop Boxes.

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

3 Abbreviations

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

AC	Alternating Current
ARP	Address Resolution Protocol
CMTS	Cable Modem Termination System
CoC	Code of Conduct
CoC	Code of Conduct
CPE	Customer Premises Equipment
CPS	Common Power Supply
DC	Direct Current
DECT	Digital Enhanced Cordless Telecommunication
DOCSIS	Data Over Cable Service Interface Specifications
DS	Downstream
EIRP	Equivalent Isotropically Radiated Power
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
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
POF	Plastic Optical Fibre
QAM	Quadrature Amplitude Modulation
QVGA	Quarter Video Graphics Array
RF	Radio Frequency
TFT	Thin-Film Transistor
USB	Universal Serial Bus
VG	Video Graphics

VoIP	Voice over IP
WAN	Wide Area Network

4 Applicable references

4.1 Existing ecodesign guidelines or requirements

4.1.1 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].

4.1.2 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 Settop Boxes [i.15].

4.1.3 ETSI

There are several standards and work items currently in progress within ETSI.

- DTS/EE-00018 [i.12] - Draft document entitled Environmental Engineering (EE): Measurement methods and limits for energy consumption of End-user Broadband Equipment (CPE).
- ATTM External Power Supply Standard - ES 202 874-1 [i.8].

4.1.4 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.7].
- In-progress topic of requirements for small network equipment [i.7].

4.2 Ecodesign references on Broadband Communication Equipment

4.2.1 CoC on Energy Consumption of Broadband Communication Equipment Version 4

The CoC for broadband communication equipment applies to cable devices.

4.2.1.1 Customer Premises Equipment

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 1x1configuration 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 twice (because of capability of eight 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, etc.)	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 to 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

4.2.1.2 CMTS Equipment

The CoC for broadband communication equipment defines power consumption targets on a per port basis for Network equipment. Table 4, 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 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 4 are increased by 10 %.

Table 4: Cable Network Equipment

Equipment	Tier 2011 (01.01.2011) (W)	Tier 2012-2013 (01.01.2012) (W)
I-CMTS ≤ 32 DS (downstream) ports	65	35
I-CMTS > 32 DS ports	50	30
M-CMTS ≤ 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.

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 5: Cable network equipment

Equipment	Tier 2011 (01.01.2011) (W/Channel)	Tier 2012-2013 (01.01.2012) (W/Channel)
CMTS Power per Downstream Channel	16,0	6,0
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).		

An additional allowance for the M-CMTS Ethernet Point-to-Point 10 Gbit/sec interfaces between M-CMTS Cores and EdgeQAMs is:

- 8 W for each Point-to-Point 10 Gbit/s interface used in connecting between MAC Cores and EdgeQAMs.

The above values are nominal at 25C 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.

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

This directive is applicable to electrical and electronic household and office equipment and thus includes DOCSIS devices.

Article 2 of this directive 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 standard is detailed in table 6.

Table 6: Power Consumption in Off Mode and Standby Mode

Mode	1 year after the regulation comes into force (1.1.2010)	4 years after the regulation comes into force (1.1.2013)
Off and standby without display	1 W	0,5 W
Standby with display	2 W	1 W

The off and active modes are applicable to a device with an embedded DOCSIS modem, but that standby mode is not applicable. The rationale for the applicability of the above modes is described in Operation Modes.

4.3 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:
  - 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.
  - Network integrity communication; this function applies additionally for more complex network types and means maintaining the external communication paths.
  - 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.

The EU has not yet established exact definitions and power consumption targets for networked standby mode. It is expected that a regulation will come into force at some point. However, none of these functions are present in existing gateway equipment. Additionally, the DOCSIS specifications have no allowance for such functionality.

4.4 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.

4.4.1 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 W consumption for a "no load" condition per table 7 and the consumption targets in table 8 for active mode.

Table 7: 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 8: 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

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

This regulation EC 278/2009 [i.4] supercedes 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 W. The average efficiency levels are provided in table 9.

Table 9: Limits on Average Active Efficiency of AC/DC External Power Supplies

Rated output power	Average active efficiency
$P_0 \leq 1,0$ W	$0,480 \cdot P_0 + 0,140$
$1,0 \text{ W} < P_0 \leq 51,0$ W	$0,063 \cdot \ln(P_0) + 0,622$
$P_0 > 51,0$ W	0,870

4.4.3 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 202 874-1 [i.8] requires that CPS comply with EC Regulation No. 278/2009 [i.4].

4.5 Ecodesign references on Settop Boxes

Since cable modems may include an embedded settop box, these references are relevant for cable devices which contain an embedded settop box. These references are listed for informational purposes:

- Ecodesign requirements for simple set-top boxes.
- Ecodesign preparatory studies Lot 18: Complex Settop Boxes.

4.6 Ecodesign references on energy consumption measurement

4.6.1 ETSI Draft document - Environmental Engineering (EE): Measurement methods and limits for energy consumption of End-user Broadband Equipment (CPE)

There is currently a work item, DTS/EE-00018 [i.12], to define measurement methods for energy consumption of CPE devices that may apply to cable devices.

5 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.

5.1 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 do not apply or yield an acceptable tradeoff, 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.

5.2 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.

5.3 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.

5.3.1 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.

5.3.2 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 headend, and potentially the network management system.

5.4 Networked standby

The intent of networked standby mode is that the modem go 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 needs to progress significantly to make the remote activation via the network signal possible.

Annex A: Bibliography

- Home Gateway Initiative HGI-RD009-R3: "Requirements for an energy efficient home gateway".
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NOTE: Available at http://www.cablelabs.com/specifications/CM-TR-MHA-V02-081209.pdf.

History

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