ISSN 1831-9424

European Commission

Code of Conduct on Energy Consumption of Broadband Equipment

Version 9.0

Lejeune, A., Bertoldi, P.

2024

Joint Research Centre

EUR 31875 EN

Contact information

Name: Bertoldi Paolo
Address: JRC, 21027 Ispra (VA), Italia, TP 450
Email: paolo.bertoldi@ec.europa.eu
Tel.: +39-0332 78 9299

EU Science Hub
https://joint-research-centre.ec.europa.eu

JRC136991
EUR 31875 EN

PDF ISBN 978-92-68-13294-4 ISSN 1831-9424 doi:10.2760/985625 KJ-NA-31-875-EN-N

Luxembourg: Publications Office of the European Union, 2024

How to cite this report: European Commission, Joint Research Centre, Lejeune, A. and Bertoldi, P., *Code of Conduct on Energy Consumption of Broadband Equipment*, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/985625, JRC136991.

Contents

Abstract

With the strong growth of the internet the energy consumption of data transmission has dramatically increased.

The potential new electrical load represented by this equipment needs to be addressed by EU energy and environmental policies. It is important that the electrical efficiency of broadband equipment is maximised, without reducing the provided service.

The Code of Conduct sets out the basic principles to be followed by all parties involved in broadband equipment, operating in the European Community, in respect of energy efficient equipment.

The Code of Conduct sets the (maximum) electricity consumption for broadband equipment sold in the EU and manufactured or procured by participating companies.

To help all parties to address the issue of energy efficiency whilst avoiding competitive pressures to raise energy consumption of equipment all service providers, network operators, equipment and component manufacturers are invited to sign this Code of Conduct.

Due to fast technological development the technical specification of the broadband equipment have to be regularly updated. The present document, version 9.0, is valid for 2024 and following years.

Acknowledgements

The authors would like to thank all the members of the Code of Conduct on Energy Consumption of Broadband Equipment Technical Workshop Group.

1 Introduction

Expectations are that broadband equipment will contribute considerably to the electricity consumption of households in European Community in the near future. Depending on the penetration level, the specifications of the equipment and the requirements of the service provider, a total European consumption of at least 50 TWh per year was estimated for the year 2015 for broadband equipment. With the general principles and actions resulting from the implementation of this Code of Conduct the (maximum) electricity consumption could be slightly reduced or kept constant compared to a business as usual scenario with growing usage and penetration of broadband equipment in the EU.[1]

The potential new electrical load represented by this equipment needs to be addressed by EU energy and environmental policies. It is important that the electrical efficiency of broadband equipment is maximised.

To help all parties to address the issue of energy efficiency whilst avoiding competitive pressures to raise energy consumption of equipment all service providers, network operators, equipment and component manufacturers are invited to sign this Code of Conduct.

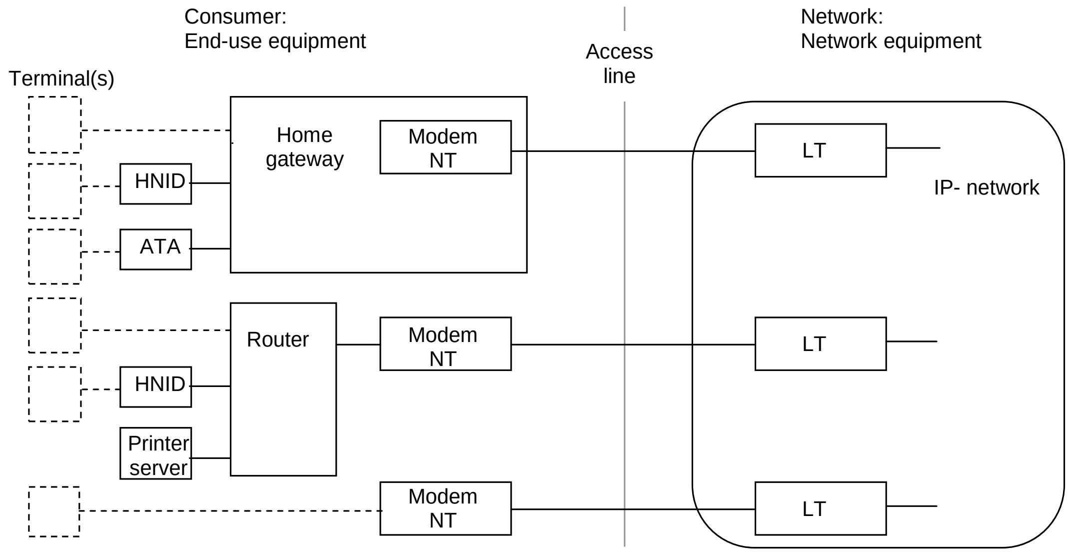
This Code of Conduct sets out the basic principles to be followed by all parties involved in broadband equipment, operating in the European Community, in respect of energy efficient equipment.

[1] The article by Ward Van Heddeghem, Sofie Lambert, Bart Lannoo, Didier Colle, Mario Pickavet, Piet Demeester, "Trends in worldwide ICT electricity consumption from 2007 to 2012" [25], estimated a global consumption of communication networks in 2012 of 334 TWh. As the EU total electricity consumption is 14.3% of global energy consumption, by adopting this proportion the EU consumption of communication networks in 2012 is estimated to 47 TWh. This is a conservative estimate as the ICT consumption in the EU is representing a large share of total electricity consumption compared to other regions.

2 Equipment covered

This Code of Conduct covers equipment for broadband services both on the customer side as listed in Table 1, and on the network side as listed in Table 2. Note that not all the equipment listed in these tables may yet have a complete set of associated power targets. Any such missing values may be added to future versions of the Code of Conduct, as may any additional technologies that become significant in the Broadband space. Figure 1 below gives examples of home gateway/modem configurations with the boundary between customer premises and network equipment that this Code of Conduct takes into account. This Code of Conduct covers also the equipment for Small Office Home Office (SOHO) applications. Terminals like PCs or TVs are not covered by this Code of Conduct.

Figure 1: Examples of configurations



Source: JRC

Broadband access equipment is defined by its incorporation of a transmission technology capable of providing more than 2048 kbit/s (ITU-T Rec I.113 [1]) full-rate capacity in at least one direction.
When equipment is in the ready state, it needs to be able to provide services with the same quality as in the on-state, or to be able transition to the on-state to deliver the service without introducing a significant additional delay from the user perspective. This requirement holds regardless of whether the service is initiated from the WAN-side, or the LAN-side.
In this Code of Conduct these categories of equipment will subsequently be referred to as “customer premises equipment” (CPE) and “network equipment” or “broadband equipment” in general.

Table 1: CPE covered

Type of CPE
Home gateways: • DSL CPEs (ADSL, ADSL2, ADSL2plus, VDSL2, VDSL2 with G.993.5 Vectoring support) and G.fast • DOCSIS Cable CPEs • Optical CPEs (PON and PtP) • Ethernet router CPEs • Wireless CPEs Simple broadband access devices: • Layer 2 ONUs Home network infrastructure devices: • Wi-Fi access points including repeaters • Small hubs and Layer 2 switches • Powerline adapters • Alternative LAN technologies (HPNA and MoCA) adapters • Optical LAN adapter Other home network devices: • ATA / VoIP gateway • VoIP telephone (standalone standard desktop phone)

Source: JRC, 2024

The following equipment is excluded from this version of the Code of Conduct:

- Terminals like PCs and TVs
- Set-top boxes for digital TV services; complex set-top boxes are covered by the Code of Conduct for digital TV Service Systems [2].
- Special purpose devices, like conference phones, video phones, or appliances that contain other main functionalities besides the VoIP function
- Video gateways providing conditional access "termination", characterized by their capability to receive select and descramble multiple digital video streams to be rerouted on a home network or/and locally decoded to output audio video content. Video gateways equipped with embedded audio/ video decoding and outputting capability are commonly called "headed" video gateways.
- Enterprise CPE products, intended as those equipment that include one or both of the following characteristics and are typically intended to be used in high end applications and users:
    - o Works only with other dedicated proprietary controlling device/server.

- Is modular (i.e., allowing non-standardized, proprietary LAN, or WAN interfaces to be inserted in the equipment).

If a product includes functions or interfaces that are not represented in this CoC, the product may either be considered out of scope (i.e. without making any statement regarding meeting or not meeting the CoC requirements), or may be evaluated on meeting the energy levels of the CoC as if the missing function or interface was not present in the product when calculating the total allowance.

To provide a path for innovation, at the time of its report, the signatory should notify the other parties and propose an initial allowance for the new function or interface and the parties will then make best efforts to study and set an appropriate allowance in the next revision of the CoC.

Table 2: Network equipment covered

Type of network equipment covered
• DSL network equipment (e.g., ADSL, ADSL2, ADSL2plus, VDSL2 and G.fast) • Combined DSL/Narrowband network equipment (e.g., MSAN where POTS interface is combined with DSL Broadband interface) • Optical Line Terminations (OLT) for PON- and PtP-networks • Wireless Broadband network equipment (e.g., Wi-Fi access points for Hotspot application and Radio Access Network Equipment) • Cable service provider equipment (e.g. CCAP, CMTS and Edge-QAM)

Source: JRC, 2024

3 Aim

To reduce energy consumption of broadband communication equipment without hampering the fast technological developments and the service provided.

4 Commitment

Signatories of this Code of Conduct agree to make all reasonable efforts to:

a) Abide by the General Principles contained in Chapter 7.

b) Achieve the power consumption targets set out in Chapter 9, for at least 90% (by number[2]) of the new-model of broadband equipment in each category (Section 9.1.1 to 9.1.4 and 9.2.1 to 9.2.5) covered by this Code of Conduct that are introduced to the market after the indicated dates. For an equipment vendor, “new-model” means equipment that is first placed on the market[3] during a given year (note that a simple production optimisation or bug-fix would not necessarily constitute a new-model). For a network operator, "new-model" means equipment of a particular type and specification being procured for the first time in a given year. For the subsequent manufacture or purchase/installation of the same equipment, the Code of Conduct values pertaining to the original year of introduction/purchase apply. To take into account the time network operators need to select new equipment and introduce it into their networks, network operators are entitled to specify the Tier of the Code of Conduct that applied at the date on which the operator formally initiated the procurement process for this equipment (e.g. the date on which the Invitation to Tender for that equipment was issued). If this approach is employed, the operator shall formally notify the supplier of the relevant date and Tier.

c) Provide end-users with information about power consumption of CPE (CPE-on-state, CPE-ready-state) and about switching off CPE in the user manual, on the Internet, the packaging, and/or at the point of sales.

d) Co-operate with the European Commission and Member State authorities in an annual review of the scope of the Code of Conduct and the power consumption targets for future years.

e) Co-operate with the European Commission and Member States in monitoring the effectiveness of this Code of Conduct through the reporting form that is available on the homepage of the EU Standby Initiative [3].

f) Ensure that procurement specifications for broadband equipment are compliant with this Code of Conduct.

Each version of the Code of Conduct, once published, is a standalone document that supersedes all previous versions, and neither refers to nor depends on such versions. When a new version of the Code of Conduct comes into force, it is assumed that companies/organizations who have already signed the Code of Conduct will remain signatories for the new version. However any company/organization may withdraw its signature from the Code of Conduct with no penalty.

---

[2] For CPE, ‘by number’ means ’by number of units placed on the market’. For network equipment ’by number’ means ‘by number of ports placed on the market’, so as to allow for equipment with very different numbers of ports.

[3] "A product is placed on the market when it is made available for the first time on the Union market." [26]

5 Monitoring

Signatories agree to provide information on the power consumption of their equipment which is covered by the Code of Conduct to the European Commission on annual basis. This should be provided by the end of each March for the previous calendar year. Where a signatory first signs part way through a calendar year, then reporting for that first year should be done from the date of signing, not the beginning of that calendar year.

The anonymous results will be discussed at least once a year by the signatories, the European Commission, Member States, and their representatives in order to:

a) Evaluate the level of compliance and the effectiveness of this Code of Conduct in achieving its aims.

b) Evaluate current and future developments that influence energy consumption, (i.e., Integrated Circuit development, etc.) with a view to agreeing actions and/or amendments to the Code of Conduct.

c) Set targets for future time periods.

6 Reporting

The presentation of the results provided to the Commission will be in the form of the reporting sheet available on the homepage of the EU Standby Initiative [3].

For CPE equipment and Network Equipment separately, the total percentage of all compliant and non-compliant equipment (new and/or old) procured by operators or placed on the market by vendors during the reporting year must be declared. For old equipment, compliance is based on the version of the code of conduct used when the product was first reported.

7 General Principles

Signatories of this Code of Conduct should endeavour to make all reasonable efforts to ensure that:

7.1 For broadband equipment in general

1. Broadband equipment should be designed to meet the Code of Conduct power consumption targets. However, power management must not unduly impact the user experience, disturb the network, or contravene the applicable standards.
2. Operational and control systems are specified under the assumption that hardware has power management built in, where applicable, i.e., depending on the functionality required of the unit, the hardware will automatically switch to the state with the lowest possible power consumption.
3. Signatories will endeavour to assist in the improvement of the existing low-power standards, and the development of new ones as appropriate.

7.2 For CPE

1. Any external power supplies used for CPE shall be in accordance with the EU Code of Conduct for External Power Supplies [4]. Power consumption of the external power supply shall be included in the power measurement.
2. CPE shall be designed under the assumption that the equipment may be physically disconnected from the mains or switched off manually by the customer, from time to time, at their own discretion.
3. Power delivered to other external equipment (e.g., over USB, PoE or to a reversed powered G.fast DPU port) shall not be included in the power consumption assessment of a CPE. This other equipment shall be disconnected for the power consumption measurement, except when this is in contradiction with the operation of the product. However, target values are specified for some specific USB devices, as a reference for USB manufacturers, and to be considered separately from the evaluation of the power budget (and related consumption objectives) of the CPEs they can be connected to.

7.3 For network equipment

1. Broadband network equipment should be designed to fulfil the environmental specifications of Class 3.1 for indoor use according to the ETSI Standard EN 300019-1-3 [5], and where appropriate the more extended environmental conditions than Class 3.1 for use at outdoor sites. At remote sites the outdoor cabinet including the Broadband network equipment shall fulfil Class 4.1 according to the ETSI Standard EN 300019-1-4 [6]. Broadband network equipment in the outdoor cabinet should be designed taking in account the characteristics of the cabinet and the outdoor environmental condition; e.g., in case of free cooling cabinet it should be considered that the equipment inside the cabinet could operate (for short time periods) at temperature up to 60° C. If cooling is necessary, it should be preferably cooled

with fresh air (fan driven, no refrigeration). The Coefficient of Performance of new site cooling systems, defined as the ratio of the effective required cooling power to the energy needed for the cooling system, should be higher than 10.

8 Definition of operation states

8.1 Definitions of CPE operation states

8.1.1 Introduction to updated CPE states as of CoC v9.0

The Code of Conduct originally defined its CPE operation states in 2006. Since then many things have changed. Not in the least, the home network has become much more essential for consumers in their daily life, and is expected to always be available. In addition, data consumption increased gradually over time, and technology is now capable of scaling its power consumption with workload better. This prompted a re-assessment of the way allowances are specified as well as the test methodology, to make sure they are sufficiently representative of real life but also easy to execute. This re-assessment prompted two changes to the CoC, described below.

8.1.1.1 Central functions and simplification of interface tables

The main change in v9.0 is to decouple the central functions from the WAN/uplink interface allowance and it is largely an administrative change. In previous versions, many tables were presented with allowances, some of which were overlapping (e.g. Ethernet ports specified for use as ‘Central functions plus WAN’, ‘additional backup WAN’, ‘additional simultaneous WAN’, and ‘LAN’, as well as allowances for certain ‘simple broadband access devices’ using Ethernet interfaces). Since implementations typically do not warrant different allowances for different logical use of a particular interface technology, this simplifies the preparation, maintenance and application of the tables.

Thus, the ‘central functions’ have been decoupled from the (WAN/uplink) interface technology. Central functions are rated depending on the throughput of the device (which typically determines the internal overhead for such ‘central functions’) and include such things as network processing, memory, LEDs, etc. See Table 10 and associated text for a more complete definition.

Furthermore, the tables now define allowances for ‘connected’ and ‘disconnected’ interfaces. These can be used respectively for the new ready-state (see below) as well as the existing on-state, depending on whether the interface is connected or not during testing.

Finally, it should be mentioned that the new table structure also covers allowances for ‘simple broadband access devices’, so there is no longer a separate table definition for these devices.

For backup WAN interfaces, in the new specification, one can simply take the allowance for ‘connected’ interface (if it’s a simultaneous WAN) or for ‘disconnected’ interface (if it is a regular backup WAN).

8.1.1.2 Replacement of CPE idle-state by a new ready-state

In addition to the interface simplification, it was found that the existing idle-state for home gateways is not sufficiently representative of typical home use (given that the home network is expected to be always available, and many connected devices are not switched off at night).

In order to address this situation, a new ready-state is defined, which is more representative of typical home use. The EU Code of Conduct ready state is based on with the CTA-2049-A specification [28]. At the same time, the existing idle-state is obsoleted and no longer specified in the Code of Conduct.

The existing on-state defined in ETSI EN 301 575 [29] for CPEs remains for tier 2024 and beyond, which also allows for the comparisons to previous versions of this Code of Conduct.

It can also be noted that at the time of preparation of this Code of Conduct v9.0, the ETSI EN 301 575 [29] is in the process of being updated to include and reflect the ready state as used in this Code of Conduct. With this in mind, ETSI EN 301 575 [29] can be referred to from the Code of Conduct in the future (in the same manner as ETSI EN 303 215 [15] is referred to already for the Network Equipment).

8.1.1.3 Guidance on applying CTA-2049-A for the ready-state

This Code of Conduct defines ready state based on the idle state in ANSI CTA-2049-A [28] with some modifications as mentioned above. This section provides guidance on its implementation, to ensure that the method can be applied consistently and that evolving technical considerations are taken into account.

For the avoidance of doubt, information in this section does not apply to testing the 'on-state', but only the 'ready-state'.

8.1.1.3.1 UUT configuration and traffic clarification

CTA-2049-A requires the UUT to be tested in the default 'as shipped' configuration (section 7.1 A). This starting point is slightly modified by this CoC to use the default 'as deployed' configuration. This allows for situations where (for example) operators deploy CPE devices that undergo an initial (remote) configuration upon deployment. The word 'default' is retained to ensure that configurations are not further modified, since most end-users will also not change configuration of CPE equipment beyond this initial (remote) configuration by the operator. Thus, using default 'as deployed' gives the best approximation of actual field-usage. While this does mean that configurations (and therefore resulting power consumption) may vary between deployments, it is understood that most such configurations will perform relatively close in power consumption given the definition of the measurement method (with interfaces specifically connected and other functionality 'largely idle'). It also enables operators to ask for consistent power consumption information for their deployment scenarios, using the CoC methodology.

CTA-2049-A further states that the configuration shall only be modified if required to be able to run the test. One specific aspect that this applies to are the interfaces. The test requires interfaces that are 'connected' to be connected in such a way that they can actually pass traffic (section 7.3).

While no traffic generator is required, the assumption is that there is always some amount of service-related traffic between any of the WAN interfaces and any of the LAN interfaces, wired or wireless, that client devices and servers send across the network (for example to keep alive a connection, or to check for updates, etc.) and indeed the connected interfaces must be configured in such a way that traffic can actually pass through the device for its regular functionality (e.g. as bridge or router). It is insufficient if connected ports are only in link-up state, but not configured to be able to pass traffic through the UUT.

If desired (though not required), it is possible to verify the readiness to pass user traffic by (for example) issuing a 'ping' command from LAN to WAN side of the network and ensuring a response is indeed received.

8.1.1.3.2 Type of interfaces

In CTA-2049-A, section 7.3, it states that half (rounded up) of the LAN-side interfaces of each type shall be connected. For the avoidance of doubt, the Code of Conduct considers interfaces with separate allowances in tables 10 through 13 to be different types. This includes Ethernet interfaces of different speeds. Thus, if a device has a 1Gbps, a 2.5Gbps and 2x 10Gbps LAN Ethernet interfaces, the 1Gbps interface, the 2.5Gbps interface and one of the 10Gbps interfaces must be connected, and the remaining 10Gbps interface is left unconnected.

The cable length used during testing of Ethernet interfaces is adjusted from 1-2m in CTA-2049-A to be 10m, to make it consistent with how the On state is being tested by the Code of Conduct. It should be noted that there is no known impact on power consumption between using 1m, 2m or 10m.

8.1.1.3.3 Wireless interfaces

a) 802.11-**based (excluding 802.11ah 'HaLow')**

With respect to channel selection, CTA-2049-A (section 7.3.3) says "A supported channel shall be selected and maintained for the duration of testing". Since allowed output power can vary depending on channel, and allowances may be different for devices supporting different output power, a channel with the highest supported output power shall be selected.

With respect to 'using the highest data rate option', the test must be conducted in such a way that nothing prevents this highest data rate from being used. It is acknowledged there may be power saving options that can dynamically change parameters such as channel width or bands in a real deployment. The intent is therefore to configure the UUT at the 'highest data rate option', understanding that this may be dynamically (and automatically, without user interaction) be changed during the test.

To further clarify, as part of 'nothing prevents', and additionally to ensure testing is repeatable and comparable, no interference shall be present, either from neighbouring access points, or from signals that might trigger DFS transitions. While the test does not require a specific method to achieve this, it is suggested that shielded boxes or anechoic chambers can ensure it. Alternatively, in a relatively clean radio-frequency (RF) environment, it may be possible to verify through logging that no such events happen during the test execution.

b) Non 802.11-based (e.g. 802.15.4, DECT-**ULE, etc. and including 802.11ah 'HaLow')**

As indicated by CTA-2049-A and above, these interfaces shall be in default 'as deployed' configuration during test (with no clients connected). With respect to allowances, any such interfaces that are disabled receive zero allowance, while interfaces that are enabled (but with no clients connected) receive the 'disconnected interface' allowance specified for that interface.

8.1.1.3.4 Backup WAN interfaces

CTA-2049-A specifies the test process for products that offer multiple WAN interfaces, but it only allows for a non-simultaneous backup scenario, and it requires only a single scenario to be tested (based on WAN interface precedence), though optionally additional scenarios can also be tested.

Testing according to this Code of Conduct for products offering a simultaneous backup WAN interface can be done simply by using the corresponding allowances for ‘connected’ interfaces for both WAN interfaces. Note that the allowance for ‘central functions’ should be added only once.

Additionally, for products offering a non-simultaneous backup WAN interface, both scenarios should be tested: once with the main interface active and the backup interface not active (using the ‘connected’ allowance for the main interface and the ‘disconnected’ allowance for the backup interface); and once with the backup interface active and the main interface not active (using the reverse allowances). Under this Code of Conduct, total allowances in both scenarios must be met.

Note that reporting should be done only once per product, using the scenario with the main interface active. Selection of which interface is the main interface and which is the backup interface is determined by the ‘as deployed’ condition requirement (see 8.1.1.3.1).

8.1.2 Off-state

In the off-state, the device is not providing any functionality. This state is defined by EU 2023/826 [8].

8.1.3 Ready-state

In the Ready-state, the device is connected to the mains power source and powered on, with all necessary main functions providing the intended service being activated. In Ready-state, the device is ready to provide the intended services without any reconfiguration or manual intervention, i.e. the CPE is not passing any user traffic but is ready to.

Table 3: Definition of the Ready-state for home gateways

Port / component	Ready-state
Central functions (processor and memory: routing, firewall, OAM (e.g., TR-069), user interface)	Not processing user traffic.
WAN interface	Single WAN interface: Connected and synchronized at the highest speed supported, with no user traffic present but ready to pass it. Multiple WAN interfaces (for backup or alternative purposes): Only one WAN interface is connected and synchronized at the highest speed supported, with no user traffic present but ready to pass it; all other WAN interfaces are disconnected. Multiple WAN interfaces (for simultaneous operation): Only one WAN interface is connected and synchronized at the highest speed supported, with no user traffic present but ready to pass it; all other WAN interfaces are disconnected.

Port / component	Ready-state
	In ready state can enter a low power mode without requiring a manual reconfiguration by the end user (e.g., in case of DOCSIS 3.0 and 3.1, the CPE automatically transitions into DOCSIS EM 1x1 mode, assuming a CMTS with DOCSIS EM 1x1 mode is available configuration)
LAN Ethernet ports	Half of LAN Ethernet ports (rounded up) of each individual Ethernet type are active, established at the highest speed supported by the interface, cable length is 10 m. No user traffic present but ready to pass it. Ethernet interfaces operating on the same physical transmission technology (copper or fibre), at the same highest attainable speed, in the same mode (duplex operation, aggregation, etc.) and according to the same definitions in IEEE Std 802.3 are considered the same Ethernet type. The remaining LAN Ethernet ports are not connected (or no Ethernet link) but with Ethernet link detection active.
Wi-Fi interface	During ready state testing, a single Wi-Fi client is associated with the UUT. The client must have the ability to operate with the UUT at the highest data rate capability (highest band, highest channel width) without manual reconfiguration. This does not prevent the UUT to implement power saving options that can dynamically change parameters such as channel width or available bands. The Wi-Fi client is associated and from 1 m to 5 m away from Access Point in the same room, avoiding interference in the same band. No user traffic present but ready to pass it.
Alternative LAN technologies (e.g. HPNA, MoCA, Powerline, POF)	Half of LAN ports (rounded up) of each individual type are connected, established at the highest speed supported by the interface. No user traffic present but ready to pass it.
FXS	No FXS ports connected to phone or other load, but able to detect a connection.
FXO	No active call, incoming call detection enabled.
DECT interface	No active call, incoming call detection enabled.
DECT charging station for DECT handset	No active call, incoming call detection enabled.
Backup battery	Battery is fully charged (trickle charging).
USB	No devices connected, detection of USB devices active.

Port / component	Ready-state
AI Processor	Not expected to perform any calculation and remains in its lowest power state.
Other home-network interfaces (such as PLC, Bluetooth, Zigbee, NB-IoT)	Inactive, but ready to detect activity or pass user traffic.
G.fin interfaces [30]	G.fin (MFU) & G.fin (SFU) are connected at the highest speed supported, with no user traffic present but ready to pass it.

Source: JRC, 2024

When activity is detected on a component, the appropriate components transition to the on-state. The transition time should be less than 1 second wherever possible in order to not adversely impact the customer experience. The detection of the Ethernet link may take more than 1 second, but must stay below 3 seconds. This longer transition time can be tolerated in this case because it requires some user interaction to bring up the link (e.g., connect a device or boot a PC).

Note that because only those components required to support the activated service go into their on-state, for a complete device (as opposed to a functional component) there will in fact be a range of power states. At any given time, the CPE should consume the minimum power commensurate with its current level of activity (with the appropriate hysteresis).

Table 4: This table is intentionally left blank

Table 5: This table is intentionally left blank.

Table 6: This table is intentionally left blank

8.1.4 On-state

In the On-state, the device is connected to the mains power source and powered on, with all the main function(s) providing the intended service being in their individual On-states (activated) as defined in Table 7.

For the interfaces carrying user traffic the minimal throughput that needs to be considered is indicated as well in Table 7. As this is the minimal traffic load to be applied to a certain interface, some interfaces can carry more traffic in order to accommodate all minimal traffic loads. This excess traffic should be carried on Ethernet LAN port(s).

Customer-side Ethernet ports present on CPEs are responsible of non-negligible energy consumption. Energy Efficient Ethernet (EEE) as defined in IEEE Std 802.3-2022 SECTION SIX [10] defines power saving mechanisms for wired, customer-side Ethernet ports. It is then required that copper Ethernet (IEEE 802.3 [10]) interfaces in the CPE comply with EEE and requires that such function be activated by default during deployment. During testing, the measurement equipment connected to EEE capable ports must also support EEE.

Transitions between the Ready-state and on-state must occur without manual reconfiguration of the device, i.e., they must happen automatically.

Table 7: Definition of the on-state for home gateways

Port / component	On-state
Central functions (processor and memory: routing, firewall, OAM, user interface)	Processing the user traffic present on the device.
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 On-state described above for a Single WAN, while the second will be disconnected or not active, but able to be manually or automatically activated in case of need. In case of dual WAN interface for simultaneous operation, both ports shall be in the On-state described above for a Single WAN.
ADSL2plus [18][19]	Line is configured as per TR-100 [12], Table 8-3. Select a valid ADSL2plus specific test profile, configured in rate adaptive mode. Use a test loop of 1250m. The DSL line is active (in showtime) and passing user traffic: 1 Mbit/s downstream, 1 Mbit/s upstream.
VDSL2 (8, 12a, 17a) [17]	Line is configured as per TR-114 [13], Table 9 (Specific Line Settings). Select a valid VDSL2 profile line combination, for the governing profile bandwidth (namely 8, 12, or 17 MHz), configured in rate adaptive mode. Use a test loop of 300 m for the 8 MHz profile and 150 m for each of the 12 and 17 MHz profiles. The DSL line is active (in showtime) and passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.
VDSL2 (35b)	Line is configured as per Broadband Forum Recommendation Amendment 2 to TR-114 Issue 3 [21]. VDSL2 Band Profile shall be: Profile 35b, using the Annex Q (998ADE35-M2x-M) PSD mask, configured in rate adaptive mode. Use a test loop of 100m. The DSL line is active (in showtime) and passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream

Port / component	On-state
G.fast 106a, 106b, 106c [22]	Line is configured as per the following settings: • Mds=28, Mus=7, Mf=36. • 106a, 106b or 106c MHz profile, operating in the 2MHz – 106MHz frequency band • test loop of 50m. The line is active (in showtime) and passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.
G.fast 212a, 212c	Line is configured as per the following settings: • Mds=28, Mus=7, Mf=36. • 212a or 212c MHz profile, operating in the 2MHz – 212MHz frequency band • test loop of 50m. The line is active (in showtime) and passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.
Fast Ethernet WAN	Link established at 100 Mbit/s and passing user traffic: concurrent 1 Mbit/s downstream and 1 Mbit/s upstream sent in bursts of 25 back-to-back 500 bytes Ethernet Frames (CRC included). These rate, size and traffic shape are selected to ensure that the Ethernet Interface can activate EEE Low-Power Idle (LPI) mode during testing (i.e., the interface will return to LPI mode between each burst).
Gigabit Ethernet WAN (1G through 10G)	Link established at the highest speed supported by the interface and passing user traffic: concurrent 10 Mbit/s downstream and 10 Mbit/s upstream sent in bursts of 250 back-to-back 500 bytes Ethernet Frames (CRC included). These rate, size and traffic shape are selected to ensure that the Ethernet Interface can activate EEE Low-Power Idle (LPI) mode during testing (i.e., the interface will return to LPI mode between each burst).
Fibre PtP Ethernet WAN (all speeds)	Link established at highest supported speed and passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.
PON (all types such as GPON, EPON, XG-PON1, etc.)	Passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.

Port / component	On-state
DOCSIS 3.0	4 downstream channels with a modulation type of 256 QAM. 4 upstream channels with a modulation type of 64 QAM, a symbol rate of 5,12 Ms/s, and a transmit level of 45 dBmV per channel. Modem is passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream. The Basic configuration represents a modem that supports 4 downstream and 4 upstream channels. An additional power allowance is provided for each additional 4 downstream channels supported by the modem.
DOCSIS 3.1	Note: Requires a high-split plant configuration and CM using a diplexer with a 204MHz cutoff. Downstream: 2 OFDM downstream channels: 4K FFT, 190MHz BW, 4096QAM, RxPower 0dBmV, CF 600/800MHz 24 SC-QAM downstream channels: 8MHz BW, 256QAM, RxPower 0dBmV, CF 300-438MHz Upstream: 2 OFDMA upstream channels: 2K FFT, 48 MHz BW, 1024QAM, TxPower 45dBmV, CF 100/150MHz 8 SC-QAM upstream channels: 6.4MHz, 64QAM, TxPower 45dBmV, CF 8.2-53MHz Modem is passing user traffic: 10 Mbit/s downstream, 10 Mbit/s upstream.
4G	Passing user traffic: 1 Mbit/s downstream, 200 kbit/s upstream.
5G	Passing user traffic: 1 Mbit/s downstream, 200 kbit/s upstream.
LAN Fast Ethernet ports	All ports active, link established at 100 Mbit/s, cable length is 10m as defined in ETSI EN 301575 and passing user traffic: concurrent 1 Mbit/s downstream and 1 Mbit/s upstream per port sent in bursts of 25 back-to-back 500 bytes Ethernet Frames (CRC included). These rate, size and traffic shape are selected to ensure that the Ethernet Interface can activate EEE Low-Power Idle (LPI) mode during testing (i.e., the interface will return to LPI mode between each burst).

Port / component	On-state
LAN Gigabit Ethernet ports (1G through 10G)	All ports active, link established at the highest speed supported by the interface, cable length is 10m as defined in ETSI EN 301575 and passing user traffic: concurrent 10 Mbit/s downstream and 10 Mbit/s upstream per port sent in bursts of 250 back-to-back 500 bytes Ethernet Frames (CRC included). These rate, size and traffic shape are selected to ensure that the Ethernet Interface can activate EEE Low-Power Idle (LPI) mode during testing (i.e., the interface will return to LPI mode between each burst).
Wi-Fi 802.11g or 11a	Beacon on, 1 Wi-Fi client associated and 1-5m away from AP in the same room, avoid interference in the same band, with user traffic: concurrent 1 Mbit/s downstream and 1 Mbit/s upstream.
Wi-Fi 802.11n, 11ac, 11ax or 11be	Beacon on, 1 Wi-Fi client associated and 1-5m away from AP in the same room, avoid interference in the same band, with user traffic: concurrent 10 Mbit/s downstream and 10 Mbit/s upstream.
Alternative LAN technologies (e.g., HPNA, MoCA, Powerline, POF)	MoCA, Powerline, HPNA, or POF capability is activated, with user traffic: concurrent 10 Mbit/s downstream and 10 Mbit/s upstream per interface.
FXS	1 phone connected (200 Ohm / loop current of 20 mA / 5m max cable length), off hook, 1 active call. Remaining FXS ports: no phone or other load connected, but able to detect a connection (for those FXS ports, the Ready targets apply).
FXO	1 active call.
DECT interface	1 active call.
DECT charging station for DECT handset	DECT handset not on cradle, no charging.
Backup battery	Battery is fully charged (trickle charging).
USB	No USB device connected, detection of USB devices active.
Low speed power line	Active
Bluetooth	Active, with traffic: 10 kbit/s.
Zigbee	Active, with traffic: 10 kbit/s.
Narrowband-IoT [27]	Active
AI Processor	During On state testing, the AI processor remains unused but ready
G.fin interfaces [30]	G.fin (MFU) & G.fin (SFU) are connected at the highest speed supported and passing user traffic: concurrent 10 Mbit/s downstream and 10 Mbit/s upstream per port

Source: JRC, 2024

Table 8: Definition of the on-state for simple broadband access devices (modems and NTs)

Port / component	On-state
WAN port	Active (link established and passing user traffic with the traffic load defined in Table 7 for a given WAN interface type).
LAN port	Active (link established and passing the same amount of user traffic as defined for the WAN port).

Source: JRC, 2024

For the on-state of Home Network Infrastructure Devices (HNID) the same definitions as listed in Table 7 apply.

Table 9: Definition of the on-state for other home networking devices

Port / component	On-state
Ethernet port	Port active (user traffic transmission to support the functionality of the device as described in the rows below, cable length is 10m as defined in ETSI EN 301575).
VoIP/telephony	1 active call.
Print server	Print job active.

Source: JRC, 2024

8.2 Definitions of network operation states

For Wired Broadband-Network-technologies the following states are differentiated:

- Network (e.g., DSL)-stand-by state: This state has the largest power reduction capability and there is no transmission of data possible. It is essential for this state that the device has the capability to respond to an activation request, leading to a direct state change. E.g., a transition to the network-full-load state may happen if data has to be transmitted from either side.
- Network (e.g., DSL)-low-load state: This state allows a limited power reduction capability and a limited data transmission is allowed. It is entered automatically from the network-full-load state after the data transmission during a certain time is lower than a predefined limit. If more than the limited data has to be transmitted from either side, the network-full-load state is entered automatically. The network-low-load state may comprise multiple sub-states with history dependent state-transition rules.

- Network (e.g., DSL)-full-load state: This is the state in which a maximal allowed data transmission is possible. The maximum is defined by the physical properties of the line and the settings of the operator.

For wireless network equipment, the following states are defined in ETSI TS 202 706-1 [9] and summarized here:

- Low-load-state: The state where 10% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.
- Medium-load-state: The state where 30% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.
- Busy-hour-load-state: The state where 50% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.

9 Power levels: targets and time schedule

9.1 CPE

CPEs covered by this Code of Conduct (home gateways, home network infrastructure devices and other home network devices) should meet the following maximum power consumption targets in the on-state and in the ready-state as defined in section 8.2. In the off-state, these CPEs must meet the requirements of the Code of Conduct for External Power Supplies [4].

The CPEs should apply all possible energy saving actions, minimizing the overall power consumption whenever possible (e.g., when all or some of its functions are not operating).

The power levels defined in this document for all states are mean values based on sufficiently long measurement periods. For ready-state, as defined in section 8.2. For on-state at least 10 minutes during which the equipment remains continuously in that same state (measurements should only start when the equipment is stable in this state for at least 60 seconds). Power is measured at the 230V AC input.

9.1.1 Home Gateways

The home gateway[4] is composed of several components, namely a processor plus memory, one or more WAN interfaces and several LAN interfaces. Depending on the purpose of a given home gateway, different components may be included. The power consumption targets for each type of home gateway are calculated by summing the values of its individual components. The home gateway as a whole has to meet the summed targets for its various modes of operation and activity. Component power consumption values are used to compute the overall home gateway target for a given configuration and mode of operation, but are not themselves normative.

The home gateway must meet the power targets for ready-state and for on-state as defined in section 8.2. Depending on the actual state of the individual components, several intermediate power consumption levels for the home gateway exist.

The values per component for the ready-state and the on-state are given in the following tables.

If an interface is able to work in different modes it must establish a link with the highest possible capability and the targets have to be chosen accordingly. This for example applies to VDSL2, Wi-Fi 802.11n interfaces or Gigabit Ethernet LAN ports. I.e., for a Gigabit Ethernet interface, a Gigabit Ethernet capable device must be connected for measurement purposes and the Gigabit Ethernet target applies. The targets are defined taking into account that certain interfaces may have this capability of falling back from a higher capability to a lower one. If a lower capability device is connected, the power consumption should be lower and ideally reach the target of this lower

[4] A home gateway is used here as a generic term which encompasses all kinds of access interfaces (e.g. DSL, cable, fibre, etc.)

capability technology, i.e., if a Fast Ethernet device is connected to a Gigabit Ethernet LAN port. Measurements in such lower capability configuration are not to be reported.

In cases where an interface is a removable module (e.g. Small Form-factor Pluggable (SFP) devices), vendors providing a CPE but no removable module must test the CPE without the module and report results, while vendors providing a CPE with removable modules and operators must test with the removable module present and with the allowances associated with it. If different types of modules are to be used by a single product, each type must meet the allocated budget but only the highest measurement is to be reported. Additional rules described below also apply in the case where the module is used in dual or backup WAN configurations.

In case of dual WAN, with reference to the definition of states, the calculation of targets for the ready state are described and clarified in 8.1.1.3.4, while for the on state, this will be performed on the basis of the following rules:

In case of dual WAN interface for backup or alternative purposes, the backup or alternative interface will be activated when the main interface loses connectivity. Additional allowances for the backup interfaces are found in Table 10a. Although only one WAN interface is active at any time, the calculation of the total budget must not take into account which interface is in the Ready state and which is active during testing and must be calculated only once. This total budget must be met under the below two conditions (and only the highest value for the Ready-State and the highest value for the On-state must be reported):

- The first one, corresponding to the situation when the main WAN interface is active and the backup or alternative interface is disconnected or not active
- The second one, corresponding to the situation when the backup is activated and the main interface is disconnected or not active

In case of dual WAN interface for simultaneous operation, additional allowances for the additional interfaces are found in Table 10b. The targets must be met under a test condition where both WAN interfaces are simultaneously connected and active in On mode.

Table 10 defines a base allowance for a CPE central functions, listed as separate range groups. Each range is defined using throughput, which is the maximum speed that can be achieved on the WAN/uplink interface. The speed of a WAN/uplink interface is defined as the maximum of its upload and download speed, but not the sum. Devices that have one or more backup WAN interfaces must determine the central function range by using the speed of the fastest interface supporting WAN/uplink functionality. Devices that support simultaneous (aggregated) WAN interfaces must take the aggregated speed of the WAN/uplink interfaces to determine the central function range. A CPE can only include one entry from Table 10 in the calculation of its power allowance.

Table 10: Power values for CPE central functions

CPE central functions	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Range A (Throughput < 1 Gbps)	1,2	1,4	1,2	1,4
Range B (1 ≤ Throughput ≤ 2.5 Gbps)	2,0	2,2	2,0	2,2
Range C (2.5 < Throughput ≤ 10 Gbps)	2,2	2,4	2,2	2,4
Range D (10 < Throughput ≤ 50 Gbps)	6,5	8,0	tbd	tbd

Source: JRC, 2024

Table 10a: Power values for the CPE Connected Interface

CPE Connected interface	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
ADSL2plus (Range A)	0,8	0,8	0,7	0,7
VDSL2 (8, 12a, 17a) | Note 10a.2 (Range A)	1,8	1,8	1,7	1,7
VDSL2 (35b) | Note 10a.2 (Range B)	1,8	1,8	1,7	1,8
G.fast (106a, 106b, 106c) (Range B)	1,5	1,6	1,5	1,6
G.fast (212a, 212c) (Range B)	2,4	2,5	2,3	2,4
Fast Ethernet (Range A)	0,2	0,2	0,2	0,2
Gigabit Ethernet (Range B)	0,3	0,3	0,3	0,3
2.5 Gigabit Ethernet (Range B)	1,6	1,6	1,6	1,6
5 Gigabit Ethernet (Range C)	2,1	2,1	2,0	2,0
10-Gigabit Ethernet (Range C)	2,5	2,5	2,3	2,3
Fibre PtP Fast Ethernet (Range A)	1,2	1,6	1,2	1,6
Fibre PtP Gigabit Ethernet (Range B)	1,4	1,8	1,4	1,8
Fibre PtP 10-Gigabit Ethernet (Range C)	2,4	2,4	tbd	tbd
GPON (Range B)	0,7	0,7	0,7	0,7
1G-EPON (Range B)	0,7	0,7	0,7	0,7
10/1G-EPON (Range C)	0,9	1,4	0,9	1,4
10/10G-EPON (Range C)	1,2	2,1	1,2	2,0
10/2.5 XG-PON1 (Range C)	0,9	1,8	0,9	1,7
10/2.5 NG-PON2 (Range C)	0,9	1,8	0,9	1,7
10/10 XGS-PON (Range C)	1,2	2,1	1,2	2,0
10/10 NG-PON2 (Range C)	1,2	2,6	1,2	2,2
50G/25G 50GPON (Range D)	3,0	3,5	tbd	tbd
50G/50G 50GPON (Range D)	3,5	4,0	tbd	tbd
DOCSIS 3.0 basic configuration (Range B)	3,0	3,3	2,9	3,2
DOCSIS 3.0 additional power allowance for each additional 4 downstream channels	1,2	1,8	1,2	1,8

CPE Connected interface	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
DOCSIS 3.1 (Range B)	6,5	9,7	6,2	9,5
4G (Range A)	1,8	2,2	1,8	2,2
5G (FR1) (Range A)	2,0	4,2	tbd	tbd
5G (FR2) (Range A)	tbd	tbd	tbd	tbd

Source: JRC, 2024

Notes:

(10a.1) The above consumption targets for all PON ONUs in Table 10 assume the use of optics that meet the PR-30 or PRX-30 power budgets (IEEE 802.3) or ITU-T G.984.2/G.987.2 [14] Class B/B+ power budgets, whichever is applicable.

(10a.2) VDSL2 allowances include Home Gateways supporting G.993.5 (Vectoring) [16].

Table 10b: Power values for CPE Disconnected interface

CPE Disconnected interface	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
ADSL2plus	0,3	0,3	0,3	0,3
VDSL2 (8, 12a, 17a) | Note 10a.2	0,4	0,4	0,4	0,4
VDSL2(35b) | Note 10a.2	0,4	0,4	0,4	0,4
G.fast (106a, 106b, 106c)	0,4	0,4	0,4	0,4
G.fast (212a, 212c)	0,4	0,4	0,4	0,4
Fast Ethernet	0,2	0,2	0,2	0,2
Gigabit Ethernet	0,2	0,2	0,2	0,2
2.5 Gigabit Ethernet	0,6	0,6	0,5	0,5
5 Gigabit Ethernet	0,8	0,8	0,8	0,8
10-Gigabit Ethernet	1,2	1,2	1,2	1,2
Fibre PtP Fast Ethernet	1,2	1,2	1,2	1,2
Fibre PtP Gigabit Ethernet	1,3	1,4	1,3	1,4
Fibre PtP 10-Gigabit Ethernet	2,4	2,4	tbd	tbd
4G	0,4	0,4	0,4	0,4
5G (FR1) (Tier A)	1,0	1,0	tbd	tbd
5G (FR2) (Tier A)	tbd	tbd	tbd	tbd

Source: JRC, 2024

Table 11: Power values for CPE additional functionality

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Central Processor Unit (CPU) for every 5k DMIPS above 15k DMIPs	0,1	0,2	0,1	0,1
Network Processor	0,3	0,4	0,3	0,4
AI Processor	0,3	0,5	0,2	0,5
G.fin MFU 2.5G/2.5G	2,5	3,0	tbd	tbd
G.fin MFU 10G/10G	3,0	4,5	tbd	tbd
G.fin SFU 2.5G/2.5G	2,5	3,0	tbd	tbd
G.fin SFU 10G/10G	3,0	4,5	tbd	tbd
Wi-Fi interface, IEEE 802.11g with up to 20 dBm EIRP or 11a/h radio with up to 23 dBm EIRP | Note 11.1	0,7	1,0	0,7	1,0
Wi-Fi interface, IEEE 802.11a/h radio with up to 30 dBm EIRP | Note 11.1	0,7	1,8	0,7	1,8
Wi-Fi interface, IEEE 802.11n radio at 2,4 GHz with up to 20 dBm total EIRP (up to 2x2) or at 5,0 GHz with up to 23 dBm total EIRP (up to 2x2) | Note 11.1	0,7	1,4	0,7	1,4
Wi-Fi interface, IEEE 802.11n radio at 5 GHz with up to 30 dBm total EIRP (up to 2x2) | Note 11.1	0,7	1,6	0,7	1,6
Wi-Fi, IEEE 802.11ac 2x2 radio at 2,4 GHz (20 MHz channel BW) with up to 17 dBm EIRP per chain (20 dBm EIRP total for 2x2) | Note 11.1	0,9	1,8	0,9	1,8
Wi-Fi, IEEE 802.11ac 2x2 radio at 2,4 GHz (40 MHz channel BW) with up to 17 dBm EIRP per chain (20 dBm EIRP total for 2x2) | Note 11.1	1,4	1,9	1,4	1,9
Wi-Fi, IEEE 802.11ac 2x2 radio at 5 GHz (20, 40, 80 MHz BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	1,6	1,9	1,6	1,9
Wi-Fi, IEEE 802.11ac 2x2 radio at 5 GHz (20, 40, 80 MHz BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	1,8	2,1	1,8	2,1

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Wi-Fi, IEEE 802.11ac 2x2 radio at 5 GHz (160 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,2	2,5	2,2	2,5
Wi-Fi, IEEE 802.11ac 2x2 radio at 5 GHz (160 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,9	3,1	2,9	3,1
Wi-Fi, IEEE 802.11ax 2x2 radio at 2,4 GHz (20 MHz channel BW) with up to 17 dBm EIRP per chain (20 dBm EIRP total for 2x2) | Note 11.1	1,6	1,9	1,5	1,8
Wi-Fi, IEEE 802.11ax 2x2 radio at 2,4 GHz (40 MHz channel BW) with up to 17 dBm EIRP per chain (20 dBm EIRP total for 2x2) | Note 11.1	1,9	2,2	1,7	2,0
Wi-Fi, IEEE 802.11ax 2x2 radio at 5 GHz (20, 40, 80 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	1,7	2,1	1,6	1,9
Wi-Fi, IEEE 802.11ax 2x2 radio at 5 GHz (20, 40, 80 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,3	2,4	1,9	2,1
Wi-Fi, IEEE 802.11ax 2x2 radio at 5 GHz (160 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,0	2,4	1,8	2,1
Wi-Fi, IEEE 802.11ax 2x2 radio at 5 GHz (160 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,6	2,9	2,2	2,5
Wi-Fi, IEEE 802.11ax 2x2 radio at 6 GHz (160 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,0	2,3	1,8	2,1
Wi-Fi, IEEE 802.11ax 2x2 radio at 6 GHz (160 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,5	2,8	2,2	2,5
Wi-Fi, IEEE 802.11ax 2x2 radio at 6 GHz (320 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,3	2,6	2,3	2,5

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Wi-Fi, IEEE 802.11ax 2x2 radio at 6 GHz (320 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,8	3,1	2,6	2,9
Wi-Fi, IEEE 802.11be 2x2 radio at 2.4 GHz (40 MHz channel BW) with up to 17 dBm EIRP per chain (20 dBm EIRP total for 2x2) | Note 11.1	2,6	2,9	2,3	2,6
Wi-Fi, IEEE 802.11be 2x2 radio at 5 GHz (20, 40, 80 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,1	2,5	2,0	2,4
Wi-Fi, IEEE 802.11be 2x2 radio at 5 GHz (20, 40, 80 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	2,5	2,9	2,3	2,6
Wi-Fi, IEEE 802.11be 2x2 radio at 5 GHz (160 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,6	3,0	2,3	2,7
Wi-Fi, IEEE 802.11be 2x2 radio at 5 GHz (160 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	3,0	3,3	2,6	2,9
Wi-Fi, IEEE 802.11be 2x2 radio at 6 GHz (160 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	2,6	2,9	2,4	2,7
Wi-Fi, IEEE 802.11be 2x2 radio at 6 GHz (160 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	3,0	3,3	2,7	3,0
Wi-Fi, IEEE 802.11be 2x2 radio at 6 GHz (320 MHz channel BW) with up to 20 dBm EIRP per chain (23 dBm EIRP total for 2x2) | Note 11.1	3,2	3,6	2,9	3,2
Wi-Fi, IEEE 802.11be 2x2 radio at 6 GHz (320 MHz channel BW) with up to 27 dBm EIRP per chain (30 dBm EIRP total for 2x2) | Note 11.1	3,7	4,0	3,3	3,6
Additional allowance per 802.11n RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 20 dBm EIRP per chain	0,1	0,2	0,1	0,2

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Additional allowance per 802.11n RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 27 dBm EIRP per chain	0,1	0,3	0,1	0,3
Additional allowance per 802.11ac RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 20 dBm EIRP per chain	0,3	0,5	0,3	0,5
Additional allowance per 802.11ac RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 27 dBm EIRP per chain	0,3	0,5	0,3	0,5
Additional allowance per 802.11ax RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 20 dBm EIRP per chain	0,3	0,5	0,3	0,5
Additional allowance per 802.11ax RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 27 dBm EIRP per chain	0,4	0,6	0,4	0,6
Additional allowance per 802.11be RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 20 dBm EIRP per chain	0,3	0,5	0,3	0,5
Additional allowance per 802.11be RF chain above a 2x2 MIMO configuration (e.g., for 3x3 and 4x4) with up to 27 dBm EIRP per chain	0,4	0,6	0,4	0,6
HPNA	1,5	2,0	1,5	2,0
MoCA 1.1	1,5	2,0	1,5	2,0
MoCA 2.0 (single channel)	1,5	2,0	1,5	2,0
Powerline - High speed for broadband home networking (up to 30MHz bandwidth)	1,2	1,6	1,2	1,6
Powerline - High speed for broadband home networking (up to 68 MHz bandwidth)	1,5	2,4	1,5	2,4
Powerline - High speed for broadband home networking (up to 86 MHz bandwidth)	3,4	3,8	3,3	3,7
High speed Powerline adapters (2xN up to 86 MHz bandwidth)	3,8	4,8	3,7	4,7

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Powerline - Low speed for smart metering and appliances control (Green Phy)	0,5	1,2	0,5	1,2
FXS (First interface)	0,2	0,8	0,2	0,8
FXS (Additional interface)	0,2	0,2	0,2	0,2
FXO	0,2	0,6	0,2	0,6
Emergency fall-back to analog telephone per FXS	0,1	0,2	0,1	0,2
DECT GAP	0,5	0,7	0,5	0,7
DECT Cat-iq	0,5	0,7	0,5	0,7
DECT ULE	0,1	0,2	0,1	0,2
DECT charging station for DECT handset in slow/trickle charge	0,4	n.a.	0,4	n.a.
USB 2.0 | Note 11.3	0,1	0,1	0,1	0,1
USB 3.0 | Note 11.3	0,1	0,1	0,1	0,1
USB 3.1 / USB 3.2 Gen 1 | Note 11.3	0,1	0,1	0,1	0,1
USB 3.2 Gen 2 | Note 11.3	0,2	0,2	0,2	0,2
SATA – no load connected	0,2	0,2	0,2	0,2
HDMI	0,2	0,2	0,2	0,2
Built-in back-up battery	0,1	0,1	0,1	0,1
Bluetooth	0,1	0,2	0,1	0,2
ZigBee	0,1	0,1	0,1	0,1
Z-Wave	0,1	0,1	0,1	0,1
Narrowband-IoT	0,1	0,1	0,1	0,1
IEC 14543-310 ("EnOcean")	0,1	0,1	0,1	0,1
Near Field Communication (NFC)	0,2	0,2	0,2	0,2
Integrated Storage (Flash e.g. eMMC, SSD or SD Card)	0,1	0,1	0,1	0,1
PCIe 1.0 / 2.0 / 3.0 (Connected) | Note 11.2	0,2	0,2	0,2	0,2
PCIe 1.0 / 2.0 / 3.0, for each additional lane (e.g. x2)	0,1	0,1	0,1	0,1

CPE additional functionality	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
PCIe 4.0 (Connected) | Note 11.2	0,3	0,3	0,3	0,3
PCIe 4.0, for each additional lane (e.g. x2)	0,2	0,2	0,2	0,2
RF modulator (TV overlay for fibre network)	1,9	2,6	1,9	2,6
Embedded hands-free system	0,3	0,5	0,3	0,5
Additional Colour Display with Display size defined by area A in (dm2); (typically found in VoIP devices)				
A ≤ 0,10	0,5	0,5	0,5	0,5
0,10 < A ≤ 0,30		0,8		0,8
0,30 < A ≤ 0,50		1,1		1,1
0,50 < A ≤ 0,70		1,4		1,4
0,70 < A ≤ 1,00		1,7		1,7
1,00 < A ≤ 1,40		2,0		2,0
1,40 < A ≤ 1,80		2,2		2,2
1,80 < A ≤ 2,20		2,4		2,4
2,20 < A ≤ 2,80		2,8		2,8

Source: JRC, 2024

Notes:

(11.1) For simultaneous dual-band operation the allowances for the individual radios can be summed up.

(11.2) PCIe allowance is only counted once for an internal bus with 2 interfaces (one interface on the SoC and one interface on the PCIe device), but it is counted multiple times if there are multiple PCIe devices in the product.

(11.3) The indicated allowance is either for an unconnected externally accessible USB interface, or for an internally connected USB interface. Also see section 9.1.2.

Table 12: This table is intentionally left blank

9.1.2 USB dongles

For a home gateway with USB ports additional functionality originally not built into the device can also be provided via USB dongles. The power consumption of USB dongles is measured at the DC 5V USB interface.

For a home gateway with an internal USB device, the power budget shall include the value of the USB device defined in Table 13 multiplied by a factor of (1/0.84) plus the USB value for the interface defined in Table 11 (also see note (11.3)).

Please note that the USB devices are considered as not equipped with additional chipsets implementing applications or complex software stacks that will drastically change the power values.

Table 13: Power values for USB dongles

USB powered peripherals and dongles	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
3G/4G	0,4	1,3	0,4	1,3
5G (FR1)	0,5	2,4	0,5	2,4
5G (FR2)	tbd	tbd	tbd	tbd
DECT	0,2	0,4	0,2	0,4
DECT GAP	0,2	1,0	0,2	1,0
DECT Cat-iq	0,2	0,4	0,2	0,4
DECT ULE	0,1	0,2	0,1	0,2
Wi-Fi interface single IEEE 802.11b/g or 1x1 IEEE 802.11n radio | Note 13.1	0,5	1,5	0,5	1,5
Bluetooth	0,1	0,2	0,1	0,2
ZigBee	0,1	0,2	0,1	0,2
Z-Wave	0,1	0,2	0,1	0,2
IEC 14543-310 ("EnOcean")	0,1	0,2	0,1	0,2

Source: JRC, 2024

Notes:

(13.1) For Wi-Fi USB dongles with more than 1 RF chain, an allowance for additional RF chains as defined in Table 11 can be added.

9.1.3 Home Network Infrastructure Devices

Table 14: Power targets for Home Network Infrastructure Devices (HNID)

Power targets for Home Network Infrastructure Devices	Tier 2024		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
Ethernet optical LAN adapters (fibre converter or POF adapter) up to 200 Mbit/s	1,2	1,2	1,2	1,2
MoCA LAN adapters	2,9	2,9	2,9	2,9
DECT ULE LAN adapters	0,2	0,2	0,2	0,2
ZigBee LAN adapters	0,2	0,2	0,2	0,2
Z-Wave LAN adapters	0,2	0,2	0,2	0,2
IEC 14543-310 (“EnOcean”) LAN adapters	0,2	0,2	0,2	0,2
High speed Powerline adapters (up to 30 MHz bandwidth)	2,3	2,9	2,3	2,9
High speed Powerline adapters (up to 68 MHz bandwidth)	2,5	3,4	2,5	3,4
High speed Powerline adapters (up to 86 MHz bandwidth)	3,7	3,8	3,6	3,7
High speed Powerline adapters (2xN up to 86 MHz bandwidth)	4,3	4,8	4,2	4,7
Powerline – low speed for smart metering and appliance control (Green Phy)	1,9	2,9	1,9	2,9
HPNA LAN adapter	3,1	3,5	3,1	3,5
Small hubs and non-managed 4 port Layer 2 Fast Ethernet switches without CPU (no VPN or VoIP)	1,3	1,8	1,3	1,8
Small hubs and non-managed 4 port Layer 2 Gigabit Ethernet switches without CPU (no VPN or VoIP)	1,4	2,5	1,4	2,5

Source: JRC, 2024

An HNID is typically a relatively simple device, where 1 Ethernet LAN port is already considered to be part of the initial configuration. Ethernet switches with 4 ports are considered to be part of the initial configuration. If an HNID has more than 4 Ethernet ports, additional allowances for those Ethernet ports can be added as defined in Table 11.

For more complex HNIDs, the same allowances for additional functionality apply as for home gateways (see Table 11). A function used for control or monitoring such as smart plugs, smart sensor and remote controllable light devices are considered equivalent to an HNID.

9.1.4 Other Home Network Devices

Table 15: Power targets for other home network devices

Power targets for Home Network Devices	Tier 2024:		Tier 2025:	
	Ready-State (W)	*On-State (W)*	*Ready-State (W)*	*On-State (W)*
ATA / VoIP gateway	1,3	1,7	1,3	1,7
VoIP telephone	2,4	2,9	2,4	2,9
VoIP telephone including Gigabit Ethernet Switching Function	3,3	3,4	3,3	3,4

Source: JRC, 2024

Some types of other home network devices require additional functionality; in that case the same allowances for additional functionality apply as for home gateways (see Table 11).

9.2 Network equipment

9.2.1 Broadband DSL and G.fast network equipment

The following targets are power consumption targets per port.

a) All power values of the DSL network equipment in line with 9.2.1 (except G.fast), 9.2.2 and 9.2.3 are measured at the power interface port interface as described in the standard ETSI EN 303 215 [15] or at the AC input, in case of directly mains powered systems. For directly mains (AC) powered DSL, optical and wireless systems, the power limits stated in Table 16 through Table 26 (except Table 16b, Table 17a and Table 18) are increased by 10%. In case of integrated remote or reverse (AC or DC) powered systems, the power limits stated are increased by 15%.

b) Power measurements of the G.fast equipment shall be performed on fully equipped, maximum configured DPUs (100% of activated ports). The power consumption numbers specified in Table 16b, Table 17a and Table 18 assume no extra allowance for <=128 lines and no extra allowance for vectoring. Depending on the different types of powering, the power limits specified in Table 16b, Table 17a and Table 18 should be increased by additional allowances defined in Table 16c.

c) For multi-profile boards, the power consumption limits do not apply to boards profile not optimized under energy efficiency point of view. Equipment makers shall specify what the optimized profile for the given board under test is at which the power consumption target limit apply. For instance, a board optimized for VDSL2 8b can support other profiles (e.g., 12a, 17a, 30a) but might have suboptimal performance at such additional profiles in terms of power consumption.

d) For boards which have additional functions (e.g., channel bonding) in addition to the bare DSL functionality, such boards are to be used in normal DSL mode of operation with any additional functions disabled. Optionally, a measurement with these functions enabled can be described/requested. If such additional functions cannot be fully disabled, manufacturers will declare what the extra power budget due to the added functionality is. Such an extra budget will not be considered in the per port power consumption computation.

e) In Table 16a, "vectored VDSL2" refers to a DSLAM that supports vectoring per ITU-T G.993.5 [16] on all its lines and operates with one or multiple vectored groups. Each line is included in one vectored group. The term "vectored group" is defined in ITU-T G.993.5. The DSLAM is configured for VDSL2 operation according to ETSI EN 303 215 [15] with upstream and downstream vectoring enabled on all its lines. For the configured profile, the DSLAM operates on all its lines at its maximum supported transmit power and over the widest frequency bands over which it supports vectoring. The DSLAM operates at its maximum cancellation capabilities in terms of number of cancelled disturbers and of SNR improvement gained with cancellation.

Table 16: DSL Broadband ports – full-load state (with service traffic on the lines as specified in Table 7)

Power targets for DSL-full-load-state	Tier 2024 (W)	Tier 2025 (W)
VDSL2 (profile 8b) transmission power 19,8 dBm	1,1	1,1
VDSL2 (profile 12a and 17a) transmission power 14,5 dBm	1,0	1,0
VDSL2-LR (profile 8b, 12a and 17a) transmission power 20,5 dBm	1,2	1,2
VDSL2 (profile 35b) transmission power 17 dBm	1,3	1,3
VDSL2-LR (profile 35b) transmission power 20,5 dBm	1,3	1,3
VDSL2 (profile 35b) based on G.fast capable transceiver 17 dBm (Note 16.0)	2,0	2,0

Source: JRC, 2024

Notes:

The above values apply to fully equipped, maximum configuration DSLAMs with more than 128 ports. For equipment up to 128 ports (and with maximum configuration) 0,15 W per line may be added to the above values, with a minimum value of 5 W for the whole DSLAM.

Table 16a: DSL Broadband ports – full-load state for Vectoring capable VDSL2 equipment

Equipment	Tier 2024 (W)	Tier 2025 (W)
Vectored VDSL2 (profile 8b, 12a and 17a) without crosstalk cancelling among boards, including VDSL2-LR	+0,05	+0,05
Vectored VDSL2 (profile 8b, 12a and 17a) with crosstalk cancelling among boards for up to 128 ports, including VDSL2-LR	+0,15	+0,15
Vectored VDSL2 (profile 8b, 12a and 17a) with crosstalk cancelling among boards for more than 128 ports, including VDSL2-LR	+0,4	+0,4
Vectored VDSL2 (profile 35b) without crosstalk cancelling among boards, including VDSL2-LR	+0,1	+0,1
Vectored VDSL2 (profile 35b) with crosstalk cancelling among boards for up to 128 ports, including VDSL2-LR	+0,3	+0,3
Vectored VDSL2 (profile 35b) with crosstalk cancelling among boards for more than 128 ports, including VDSL2-LR	+0,6	+0,6

Source: JRC, 2024

Note: Consumption limits are expressed as an additional allowance in [W/port] to be applied to the corresponding consumption target for non-vectoring capable VDSL2 equipment (see Table 16).

Table 16b: G.fast broadband ports – full-load-state (with service traffic on the lines as specified in Table 7)

Power targets for G.fast full-load-state	Tier 2024 (W)	Tier 2025 (W)
Profile 106a and 106c		
G.fast single line DPU	4,3	4,3
G.fast small multiline DPU, 1-4 lines	3,0	3,0
G.fast small multiline DPU, 5-16 lines	2,4	2,4
G.fast large multiline DPU, 17-48 lines	2,4	2,4
G.fast very large multiline DPU, 49-128 lines	2,5	2,5
Profile 106b		
G.fast single line DPU	4,6	4,6
G.fast small multiline DPU, 1-4 lines	3,3	3,3
G.fast small multiline DPU, 5-16 lines	2,7	2,7
G.fast large multiline DPU, 17-48 lines	2,7	2,7
G.fast very large multiline DPU, 49-128 lines	2,4	2,4
Profile 212a and 212c		
G.fast single line DPU	5,8	5,8
G.fast small multiline DPU, 1-4 lines	5,7	5,7
G.fast small multiline DPU, 5-16 lines	4,0	4,0
G.fast large multiline DPU, 17-48 lines	3,7	3,7
G.fast very large multiline DPU, 49-128 lines	3,5	3,5

Source: JRC, 2024

Notes: The above values in Table 16b apply to fully equipped, maximum configuration DPUs within each category (single line, small, large or very large multiline). These numbers assume no extra allowance for <=128 lines and no extra allowance for vectoring.

Table 16c: Allowances for different types of powering of DPU

Power type	Tier 2024	Tier 2025
Local Power from AC mains source	10%	10%
Forward Power from a Network Node	15%	15%
Reverse Power from the CPE	15%	15%

Source: JRC, 2024

Table 17: Broadband ports – DSL-low-power-state

Power targets for DSL-low-power-state	Tier 2024 (W)	Tier 2025 (W)
VDSL2 L2.1 low power state (transport of VoIP (POTS level) and keep alive data) compared to full-load-state target per Table 16 and 16a	-25%[i]	-25%[i]
VDSL2 L2.2 low power state (transport of "keep alive" data at times when there is no user activity) compared to full-load-state target per Table 16 and 16a	-50%[i]	-50%[i]
Note: Values marked [i] provide an indication for the power consumption.		

Source: JRC, 2024

Notes:

The DSL-low-power-state should allow transport of VoIP (POTS data) and keep-alive data at different levels of power saving and quality of service. VDSL2 low power mode (LPMode) is defined in Annex E of ITU-T G.998.4 [20] as the optional operation functionality. Therefore, is applicable only to VDSL2 systems that support low power state. CO-MIB configuration parameters related to LPMode are defined in Table E.1 [20].

Table 17a: Broadband ports – G.fast low-power-state

Power targets for G.fast low-power-state	Tier 2024 (W)	Tier 2025 (W)
L2.1 low power with mains powering (L2.1N)	N/A	N/A
L2.1 low power with battery powering (L2.1B)	N/A	N/A
L2.2 low power state (L2.2)	N/A	N/A

Source: JRC, 2024

Notes:

L2.1 low power state (with two sub-states: L2.1N and L2.1B) allows substantial reduction in power consumption and is primarily intended for support of VoIP, while other services are unused. L2.2 low power state is intended for keep-alive applications during multi-hour battery backup and it implements significant reduction of power consumption (resulting in extremely reduced data rate and loss of QoS).

Table 18: Broadband ports – DSL and G.fast standby-state

Power targets for standby-state	Tier 2024 (W)	Tier 2025 (W)
VDSL2 (Note 18.1)	0,5	0,5
G.fast for DPUs up to 16 ports (Note 18.1)	N/A	N/A

Source: JRC, 2024

Notes:

(18.1) DSL-standby-state corresponds to the L3-Idle state as defined in ITU-T Rec G.993. 2 [17]. G.fast-standby-state corresponds to the L3-Idle state as defined in ITU-T Rec G.9701 [22]. Stand-by targets do not apply to the Vectoring capable VDSL2 or Vectoring capable G.fast.

The above values for DSL-low-power and -standby-states are for fully equipped, maximum configuration DSLAMs with more than 128 ports. For equipment up to 128 ports (and with maximum configuration) 0,15W per line may be added to the above values for the whole DSLAM, with a minimum value of 5W.

The above G.fast values apply to fully equipped, maximum configuration DPUs within each category (single line, small, large or very large multiline). These numbers assume no extra allowance for <=128 lines and no extra allowance for vectoring.

To minimize cost, dimensions, and power consumption, the network equipment contains chips that control multiple DSL lines (4-8-16) each. If special care is not taken, a single line in DSL-full-load-state could result in a chip fully operational on the other lines also (in low-power or standby states), resulting in an unnecessary waste of energy. The network systems (and their basic components) shall therefore be designed in order to tackle this issue, maximizing the energy savings also in mixed environments with lines in different power states, being this the typical situation found in the network.

MELT-stand-by state is defined as the state in which the Metallic Line Testing entity (MELT) is in IDLE mode, i.e., inactive, connected in parallel to the broadband port on the DSLAM and provisioned for line testing. MELT standby targets are additional allowances on top of the power consumption targets defined for each of DSL operating states.

Table 18a: Broadband ports – MELT-stand-by state

Power targets for MELT-standby state	Tier 2024 (mW)	Tier 2025 (mW)
VDSL2	+30	+30

Source: JRC, 2024

An additional allowance for each uplink interface (applicable for all power states: full-load, low-power and standby) is defined below:

Table 18b: Uplink Interfaces

Uplink Interfaces	Tier 2024 (W)	Tier 2025 (W)
PtP 1000Mbit/s (Energy Efficient Ethernet)	1,8	1,8
PtP 10Gbit/s (Energy Efficient Ethernet)	5,5	5,5
PtP 25Gbit/s (Energy Efficient Ethernet)	12,5	12,5
PtP 100Gbit/s (Energy Efficient Ethernet)	40,0	22,5
PON (GPON) (2.5G/1G)	3,3	2,9
XG-PON1 (10G/2.5G)	4,3	4,0
XGS-PON (10G/10G)	8,3	8,0
NG-PON2 (40G/10G)	10,5	10,0
PON (1G-EPON)	1,8	1,8
PON (10G/1G-EPON)	4,2	3,8
PON (10G/10G-EPON)	5,2	5,0

Source: JRC, 2024

9.2.2 Combined DSL/Narrowband network equipment

Combined DSL/Narrowband network equipment is covered in the Code of Conduct on Energy Consumption of Broadband Equipment Version 6.

Table 19: Table deleted

9.2.3 Optical Line Terminations (OLT) for PON and PtP networks

Table 20: Optical Line Terminations for PON ports

	<= 32 PON ports		> 32 PON ports	
Power targets for Optical Line Terminations for PON ports	Tier 2024 (W)	Tier 2025 (W)	Tier 2024 (W)	Tier 2025 (W)
GPON (2.5G/1G)				
OLT (GPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	4,5	4,5	4,0	4,0
OLT (GPON, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	5,0	5,0	4,5	4,5
Additional per port allowance for GPON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for GPON OLT implementing telemetry	1,0	1,0	1,0	1,0

XG-PON1 (10G/2.5G) | Note 20.1				
OLT (XG-PON1 10G/2.5G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	8,5	7,5	6,0	5,5
OLT (XG-PON1 10G/2.5G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	9,5	8,5	7,0	6,5
Additional per port allowance for XG-PON1 OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements.	2,0	2,0	2,0	2,0
Additional per port allowance for XG-PON1 OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for XG-PON1 OLT implementing telemetry	1,0	1,0	1,0	1,0

XGS-PON (10G/10G)				
OLT (XGS-PON 10G/10G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	9,0	8,0	6,5	6,0
OLT (XGS-PON 10G/10G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	10,0	9,0	7,5	7,0
Additional per port allowance for XGS-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for XGS-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for XGS-PON OLT implementing telemetry	1,0	1,0	1,0	1,0

25GS-PON (25G/25G)				
OLT (25GS-PON 25G/25G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	18,0	17,0	17,0	15,0
OLT (25GS-PON 25G/25G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	20,0	19,0	19,0	17,0
Additional per port allowance for 25GS-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for 25GS-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for 25GS-PON OLT implementing telemetry	1,0	1,0	1,0	1,0

XG-PON+GPON Multi-PON (10G/2.5G+2.5G/1.25G) | Note 20.1				
OLT (XG-PON+GPON Multi-PON 10G/2.5G+2.5G/1.25G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	9,0	8,0	7,0	6,5
OLT (XG-PON+GPON Multi-PON 10G/2.5G+2.5G/1.25G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	10,0	9,0	8,0	7,5
Additional per port allowance for XG-PON+GPON Multi-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for XG-PON+GPON Multi-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for XG-PON+GPON Multi-PON OLT implementing telemetry	1,0	1,0	1,0	1,0

XGS-PON+GPON Multi-PON (10G/10G+2.5G/1.25G) | Note 20.1				
OLT (XGS-PON+GPON Multi-PON 10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	9,5	8,5	7,5	7,0
OLT (XGS-PON+GPON Multi-PON 10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	10,5	9,5	8,5	8,0
Additional per port allowance for XGS-PON+GPON Multi-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for XGS-PON+GPON Multi-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for XGS-PON+GPON Multi-PON OLT implementing telemetry	1,0	1,0	1,0	1,0

50G-PON+XGS-PON+GPON Multi-PON (50G/25G+10G/10G+2.5G/1.25G)				
OLT (50G-PON+XGS-PON+GPON Multi-PON 50G/25G+10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	34,0	34,0	30,0	30,0
OLT (50G-PON+XGS-PON+GPON Multi-PON 50G/25G+10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	37,0	37,0	33,0	33,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure.	3,0	3,0	3,0	3,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing telemetry.	1,0	1,0	1,0	1,0

50G-PON+XGS-PON+GPON Multi-PON (50G/50G+10G/10G+2.5G/1.25G)				
OLT (50G-PON+XGS-PON+GPON Multi-PON 50G/50G+10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	36,0	36,0	33,0	33,0
OLT (50G-PON+XGS-PON+GPON Multi-PON 50G/50G+10G/10G+2.5G/1.25G, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	39,0	39,0	36,0	36,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure.	3,0	3,0	3,0	3,0
Additional per port allowance for 50G-PON+XGS-PON+GPON Multi-PON OLT implementing telemetry.	1,0	1,0	1,0	1,0

NG-PON2 (10G/2.5G per Lambda)				
OLT (NG-PON2 10G/2.5G per lambda, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	10,0	10,0	7,7	7,7
OLT (NG-PON2 10G/2.5G per lambda, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	11,0	11,0	9,6	9,6
Additional per port allowance for NG-PON2 (10G/2.5G per Lambda) OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for NG-PON2 (10G/2.5G per Lambda) OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for NG-PON2 (10G/2.5G per Lambda) OLT implementing telemetry	1,0	1,0	1,0	1,0

NG-PON2 (10G/10G per Lambda)				
OLT (NG-PON2 10G/10G per lambda, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	12,0	12,0	9,5	9,5
OLT (NG-PON2 10G/10G per lambda, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping, policing)	13,0	13,0	11,5	11,5
Additional per port allowance for NG-PON2 (10G/10G per Lambda) OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for NG-PON2 (10G/10G per Lambda) OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for NG-PON2 (10G/10G per Lambda) OLT implementing telemetry	1,0	1,0	1,0	1,0

EPON (1G/1G)				
OLT (1G-EPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	4,5	4,5	4,0	4,0
OLT (1G-EPON, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	5,0	5,0	4,5	4,5
Additional per port allowance for EPON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for EPON OLT implementing telemetry	1,0	1,0	1,0	1,0

10G/1G EPON | Note 20.1				
OLT (10/1G-EPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	8,0	7,0	7,5	6,5
OLT (10/1G-EPON, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionality such as QoS, shaping and policing)	9,0	8,0	8,5	7,5
Additional per port allowance for 10/1G EPON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for 10/1G EPON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for 10/1G EPON OLT implementing telemetry	1,0	1,0	1,0	1,0

10G/10G EPON | Note 20.1				
OLT (10/10G-EPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	10,0	8,5	8,0	7,0
OLT (10/10G-EPON, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, and IP QoS, or more advanced Layer 2 functionalities such as QoS, shaping and policing)	11,0	9,5	9,0	8,0
Additional per port allowance for 10G/10G EPON OLT implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0	2,0	2,0
Additional per port allowance for 10/10G EPON OLT implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5	1,5	1,5
Additional per port allowance for 10/10G EPON OLT implementing telemetry	1,0	1,0	1,0	1,0

Source: JRC, 2024

Notes:

(20.1) The state of maturity of this technology is such that power targets can only apply to OLTs with the fibre technology implemented in ASIC. Signatories must report the power consumptions values of any OLT equipment that they manufacture or deploy, so that the state of development of this technology can be taken into account when revising these targets in the future. For OLTs with the fibre technology not implemented in ASIC, such report will not be included in the assessment of whether or not the 90% target has been achieved.

(20.2) Additional per port allowance implementing network slicing: The Network Slicing feature enabling strict separation of resource of the different slices requires more energy since a set of new functions are added in the hardware including per slice DBA scheduling, increased buffers for fulfilling a variety of SLAs, low latency support on the packet path, increased number of tables and increased table size, and more complex scheduling for priority and low delay.

(20.3) Additional per port allowance implementing fine-granular telemetry: Fine granular telemetry requires more energy since the granularity in terms of number of counters is increased and the frequency to read-out the counters is increased, with that also the amount of data to be transported is higher and uses more energy. That results in larger chipsets and more computation on a per user and service level.

Table 21: Optical Line Terminations for PtP ports

Power targets for Optical Line Terminations for PtP ports	Tier 2024 (W)	Tier 2025 (W)
PtP 1000Mbps		
OLT (PtP up to 1000 Mbit/s, up to 100 ports, fully equipped with maximum configuration)	2,5	2,2
OLT (PtP up to 1000 Mbit/s, from 100 and 300 ports, fully equipped with maximum configuration)	2,4	2,0
OLT (PtP up to 1000 Mbit/s, with more than 300 ports, fully equipped with maximum configuration)	1,7	1,6
Additional per port allowance, implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	0,3	0,3
Additional per port allowance, implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	0,5	0,5
Additional per port allowance, implementing telemetry	0,2	0,2
PtP 10Gbps		
OLT (PtP at 10 Gbit/s, up to 16 ports, fully equipped with maximum configuration)	15	11
OLT (PtP at 10 Gbit/s, from 16 to 48 ports, fully equipped with maximum configuration)	11	8
OLT (PtP at 10 Gbit/s, with more than 48 ports, fully equipped with maximum configuration)	7	7
Additional per port allowance, implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	1,0	1,0
Additional per port allowance, implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	1,5	1,5
Additional per port allowance, implementing telemetry	0,5	0,5

Power targets for Optical Line Terminations for PtP ports	Tier 2024 (W)	Tier 2025 (W)
PtP 25Gbps		
OLT (PtP at 25 Gbit/s, up to 16 ports, fully equipped with maximum configuration)	25	18
OLT (PtP at 25 Gbit/s, from 16 to 32 ports, fully equipped with maximum configuration)	21	15
OLT (PtP at 25 Gbit/s, with more than 32 ports, fully equipped with maximum configuration)	18	12
Additional per port allowance, implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	2,0	2,0
Additional per port allowance, implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure	2,5	2,5
Additional per port allowance, implementing telemetry	0,5	0,5
PtP 100Gbps		
OLT (PtP at 100 Gbit/s, up to 8 ports, fully equipped with maximum configuration)	55	50
OLT (PtP at 100 Gbit/s, from 8 to 16 ports, fully equipped with maximum configuration)	50	45
OLT (PtP at 100 Gbit/s, with more than 16 ports, fully equipped with maximum configuration)	45	40
Additional per port allowance , implementing Layer 3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	4,0	3,0
Additional per port allowance, implementing network slicing, allows multiple logical networks to be created on top of a common shared physical infrastructure.	4,0	3,0
Additional per port allowance, implementing telemetry.	1,0	1,0

Source: JRC, 2024

The above values are for fully equipped with maximum configuration OLTs.

An additional allowance for each uplink interface is available from Table 18b:

The above consumption for GPON, XG-PON1 and EPON OLT is per port whatever the number of ONU connected to it is. The above consumption for GPON OLT is with Class B+ (ITU-T G.984.2 amd1) optical modules.

The above consumption for PtP OLT is per user port. The optical budget for the OLT P2P interfaces shall be in line with IEEE 802.3, Clause 58 for the 100BASE-LX10 and 100BASE-BX10 interfaces and IEEE 802.3, Clause 59 for the 1000BASE-LX10 and 1000BASE-BX10 interfaces. The PtP 10 Gbit/s limits are applicable only to PtP links operating at 10 Gbit/s, fully equipped with maximum configuration that directly connect to CPE associated with broadband distribution for residential customers and SOHO.

The above power consumption for EPON OLT is per port and with PRX30 class for 10G/1G-EPON OLT, PR30 class for 10G/10G-EPON and PR30 class for 1G-EPON [11].

9.2.4 Wireless Broadband network equipment

Table 22: Wi-Fi network equipment
(This table is out-of-date and will be updated in the next version of this document)

Power targets for Wi-Fi network equipment	Tier 2024 (W)	Tier 2025 (W)
Wi-Fi access points (Hotspot application) 802.11b/g/n or 802.11/b/g/a – ON state and Active Standby | Note 22.1	8	8

Source: JRC, 2024

Notes:

(22.1) The On-state is defined with no traffic on the Wi-Fi port. Therefore there is no difference in power consumption between the On-state and the Low-load-state (Active Standby) for this equipment.

Table 23: Table deleted

The assessment of power consumption for radio base stations for different RATs is based on the measurement method specified in ETSI ES 202 706-1 [9]

The following load definitions for low, medium and busy-hour traffic are based on the load definitions specified in ETSI ES 202 706-1 [9].

Definition of low load level for RAN Radio Base Station

Equipment	Low load
Radio Base Station GSM/WCDMA/LTE/NR	The state where 10% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.

Definition of medium load level for RAN Radio Base Station

Equipment	Medium load
Radio Base Station GSM/WCDMA/LTE/NR	The state where 30% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.

Definition of busy-hour load level for RAN Radio Base Station

Equipment	Busy-hour load
Radio Base Station GSM/WCDMA/LTE/NR	The state where 50% of the total base station radio resources are occupied. In GSM, it is in the form of occupied time slots. In WCDMA, it is in the form of occupied frequency band. In LTE and NR, it is in the form of occupied physical resource block.

As it has become more energy efficient to decommission GSM/EDGE RAT for their frequency bands to be used instead with 4G/5G RAT, the power consumption values in Table 24 will not be updated further and are frozen on Tier 2023 level but remain applicable at any future time.

Table 24: GSM/EDGE network equipment

Power targets for GSM/EDGE network equipment	Tier 2022 (W)	Tier 2023 (W)
	0,9/1,8/1,9 GHz	0,9/1,8/1,9 GHz
80W <= Nominal output power of Radio Unit <= 200W		
GSM/EDGE Radio Base Station – Busy-hour-load-state	855	855
GSM/EDGE Radio Base Station – Medium-load-state	700	700
GSM/EDGE Radio Base Station – Low-load-state	585	585
200W < Nominal output power of Radio Unit <= 500W		
GSM/EDGE Radio Base Station – Busy-hour-load-state	960	960
GSM/EDGE Radio Base Station – Medium-load-state	780	780
GSM/EDGE Radio Base Station – Low-load-state	655	655

Source: JRC, 2023

Configuration of GSM/EDGE Radio Base Station:

1) Three sectors, four carriers per sector (S444). Nominal output power of Radio Unit: see table above.

2) Output power: 20W at antenna interface for each carrier (4 × 20W for each sector).

As it has become more energy efficient to decommission WCDMA/HSDPA RAT for their frequency bands to be used instead with 4G/5G RAT, the power consumption values in Table 25 will not be updated further and are frozen on Tier 2023 level.

Table 25: WCDMA/HSDPA network equipment

Power targets for WCDMA/HSDPA network equipment	Tier 2022 (W)	Tier 2023 (W)
	2,1 GHz	2,1 GHz
Nominal output power of Radio Unit <= 80W		
WCDMA/HSDPA Radio Base Station – Busy-hour-load-state	650	650
WCDMA/HSDPA Radio Base Station – Medium-load-state	540	540
WCDMA/HSDPA Radio Base Station – Low-load-state	455	455
80W < Nominal output power of Radio Unit <= 200W		
WCDMA/HSDPA Radio Base Station – Busy-hour-load-state	715	715
WCDMA/HSDPA Radio Base Station – Medium-load-state	595	595
WCDMA/HSDPA Radio Base Station – Low-load-state	500	500
200W < Nominal output power of Radio Unit <= 500W		
WCDMA/HSDPA Radio Base Station – Busy-hour-load-state	800	800
WCDMA/HSDPA Radio Base Station – Medium-load-state	665	665
WCDMA/HSDPA Radio Base Station – Low-load-state	560	560

Source: JRC, 2023

Configuration of WCDMA/HSDPA Radio Base Station:

1) Three sectors, two carriers per sector (S222). Nominal output power of Radio Unit: see above table.
2) Output power: 20W at antenna interface for each radio cell (20W+ 20W for each sector).

Table 26: Wireless broadband network equipment – LTE

Power targets for LTE wireless broadband network equipment, per activated band	Tier 2024 (W)	Tier 2025 (W)
	0,7/0,8/0,9/1,8/2,1/2,6 GHz	0,7/0,8/0,9/1,8/2,1/2,6 GHz
Nominal output power of Radio Unit <= 80W		
LTE Radio Base Station – Busy-hour-load-state	640	640
LTE Radio Base Station – Medium-load-state	535	535
LTE Radio Base Station – Low-load-state	460	460
80W < Nominal output power of Radio Unit <= 200W		
LTE Radio Base Station – Busy-hour-load-state	700	700
LTE Radio Base Station – Medium-load-state	585	585
LTE Radio Base Station – Low-load-state	505	505
200W < Nominal output power of Radio Unit <= 500W		
LTE Radio Base Station – Busy-hour-load-state	790	790
LTE Radio Base Station – Medium-load-state	660	660
LTE Radio Base Station – Low-load-state	565	565

Source: JRC, 2024

Configuration of LTE Radio Base Station:

1) 3 sectors, 10 MHz bandwidth channel 2 × 2MIMO per band. Nominal output power of Radio Unit: see table above.
2) Output power: 40W (20W × 2) per band at antenna interface for each sector.

Table 27: Wireless broadband network equipment – NR

Power targets for NR wireless broadband network equipment	Tier 2024 (W)	Tier 2025 (W)
	3,4 – 3,8 GHz	3,4 – 3,8 GHz
IBW <= 200 MHz		
Nominal output power of Radio Unit <= 200W		
NR Radio Base Station – Busy-hour-load-state	3300	3300
NR Radio Base Station – Medium-load-state	2700	2700
NR Radio Base Station – Low-load-state	2100	2100
200W < Nominal output power of Radio Unit <= 500W		
NR Radio Base Station – Busy-hour-load-state	4200	4200
NR Radio Base Station – Medium-load-state	3000	3000
NR Radio Base Station – Low-load-state	2100	2100
IBW > 200 MHz		
Nominal output power of Radio Unit <= 200W		
NR Radio Base Station – Busy-hour-load-state	3500	3500
NR Radio Base Station – Medium-load-state	3000	3000
NR Radio Base Station – Low-load-state	2500	2500
200W < Nominal output power of Radio Unit <= 500W		
NR Radio Base Station – Busy-hour-load-state	4400	4400
NR Radio Base Station – Medium-load-state	3300	3300
NR Radio Base Station – Low-load-state	2500	2500

Source: JRC, 2024

Configuration of NR Radio Base Station:

1) 3 sectors, 100 MHz OBW bandwidth channel, 64T mMIMO. Nominal output power of Radio Unit: see table above.

2) Output power: 200W at antenna interface for each sector.

Notes:

a) Instantaneous BandWidth (IBW) refers to the bandwidth in which all frequency components can be simultaneously analysed, defined by the frequency boundaries of the operating band(s).

b) Occupied BandWidth (OBW) refers to the bandwidth occupied by the base station when operated, defined by the sum of the active bandwidths of the band allocation(s) operated.

9.2.5 Cable Network Equipment

Cable network system vendors developed the Converged Cable Access Platform (CCAP) a number of years ago which incorporates multiple headend functionalities into a single piece of equipment. Suitable power metrics and targets for this equipment are now included in the Code of Conduct replacing I-CMTS and M-CMTS equipment going forward.

Most current CCAP installations are located in the headend in a single chassis and are referred to as Integrated CCAP (I-CCAP). There has been recent strong interest in Distributed CCAP Architectures (DCA) where some or all of the CCAP functionality is pushed to a remote location including the outside plant in the field.

The first DCA system from CableLabs to be included in the Code of Conduct is the Remote PHY (R-PHY) system that consists of a R-PHY device (RPD) located either in a node or shelf product; and a CCAP core chassis or server located in the headend or data center. The RPD performs the DOCSIS PHY layer processing while the CCAP core handles the DOCSIS MAC and upper layer CCAP protocols. The RPD plus CCAP core are functionally equivalent to I-CCAP. Some additional Ethernet aggregation switching may be needed in a DCA system.

The CableLabs Flexible MAC Architecture (FMA) working group is in the process of defining several other variants of DCA including interfaces for various Remote MAC-PHY (R-MACPHY) systems. Much new product development is happening in this area. The first DCA system from FMA to be included in the Code of Conduct is the R-MACPHY system that consists of a R-MACPHY device (RMD) located either in a node or shelf product; along with some core functions located in the headend or data center. The RMD performs the DOCSIS MAC and PHY layer processing. Additional processing may still be necessary in the headend or data center to provide full CCAP functionality. This may include routers, Ethernet switches, MAC manager and a video processing core. These collectively will be referred to as RMD core components.

9.2.5.1 CCAP Power Consumption Metrics

The two metrics below are to be used to evaluate the power consumption characteristics of CCAP equipment, both I-CCAP and DCA system implementations. It is important to note that evaluation and consideration of both metrics is required in order to ensure a comprehensive understanding of these characteristics.

9.2.5.1.1 CCAP Power Consumption per Service Group

The *CCAP power consumption per Service Group* shall be determined with the metric specified in [24] – section 8.2.1.

9.2.5.1.2 CCAP Power Consumption per Throughput

The CCAP power consumption per Throughput shall be determined as specified in [24]– section 8.2.2. This is the power per combined DSSG + USSGs throughput across all composite SGs.

9.2.5.1.3 I-CCAP Power Consumption – Configuration

The configuration and test procedures specified in [24] – sections 10.1, 10.2, 10.3, 10.5, and 10.8 (and their subsections) shall be applied in the evaluation of the I-CCAP and DCA power consumption metrics. The general testing standards and configuration specified in [23] shall also be applied. Note that configuration includes redundancy if supported by the I-CCAP equipment under test per [24]

9.2.5.2 I-CCAP Power Consumption – Allowances

Table 28: I-CCAP Power Consumption per Service Group

Power targets for I-CCAP equipment	Scenario C (2024) 1 DSSG, 1-2 USSGs per composite SG (Watts / SG)	Scenario C (2025) 1 DSSG, 1-2 USSGs per composite SG (Watts / SG)
I-CCAP Power per SG: 1x2	95	90
I-CCAP Power per SG: 1x1	72	65

Source: JRC, 2024

Table 29: I-CCAP Power Consumption per Throughput

Power targets for I-CCAP equipment	Scenario C (2024) 1 DSSG, 1-2 USSGs per composite SG (Watts / Gbps)	Scenario C (2025) 1 DSSG, 1-2 USSGs per composite SG (Watts / Gbps)
I-CCAP Power per Throughput: 1x2	24	18
I-CCAP Power per Throughput: 1x1	24	18

Source: JRC, 2024

9.2.5.3 DCA Power Consumption – Allowances

Table 30: DCA Power Consumption per composite SG

Power targets for DCA equipment	Scenario C (2024) 1 DSSG, 1-2 USSGs per composite SG (Watts / SG)	Scenario C (2025) 1 DSSG, 1-2 USSGs per composite SG (Watts / SG)
RPD Module Power per SG: 1x2	64	64
RPD Module Power per SG: 1x1	58	58

CCAP Core: 1x2	32	32
CCAP Core: 1x1	32	32
RMD Module Power per SG: 1x2	72	72
RMD Module Power per SG: 1x1	64	64

Source: JRC, 2024

Table 31: DCA Power Consumption per Throughput

Power targets for DCA equipment	Scenario C (2024) 1 DSSG, 1-2 USSGs per composite SG (Watts / Gbps)	Scenario C (2025) 1 DSSG, 1-2 USSGs per composite SG (Watts / Gbps)
RPD Power per Throughput: 1x2	8	8
RPD Power per Throughput: 1x1	8	8
CCAP Core Power per Throughput: 1x2	9	9
CCAP Core Power per Throughput: 1x1	9	9
RMD Power per Throughput: 1x2	10	10
RMD Power per Throughput: 1x1	10	10

Source: JRC, 2024

9.2.5.4 Other Cable Network Equipment

Allowances for older legacy cable network equipment such as I-CMTS, M-CMTS and Edge QAM devices are specified in the earlier version of Code of Conduct V6.

10 Example Home Gateway Power Consumption Targets

The home gateway power consumption targets are computed from the components according to the configuration (profile) of the home gateway. Some example profiles are provided below. Home gateways having these exact configurations must meet these power targets, and by using this approach it is possible to create the targets that must be met for a home gateway of arbitrary functionality.

10.1 GPON Home Gateway

GPON home gateway with 4 Gigabit Ethernet LAN ports, a single 4x4 radio IEEE 802.11ax Wi-Fi interface and 2 USB 3.0 ports:

- in ready-state: 2 Ethernet LAN ports connected and 2 disconnected, 1 Wi-Fi client associated
- in on-state: all Ethernet LAN ports active, traffic on Wi-Fi

Table 32: GPON Home Gateway Example

Function	2024		2025	
	Ready	On	Ready	On
Central functions	2,0	2,2	2,0	2,2
GPON WAN interface (connected)	0,7	0,7	0,7	0,7
Connected Gigabit Ethernet LAN connected	2 x 0,3 = 0,6	4 x 0,3 = 1,2	2 x 0,3 = 0,6	4 x 0,3 = 1,2
Disconnected Gigabit Eth. LAN ports	2 x 0,2 = 0,4	n/a	2 x 0,2 = 0,4	n/a
Single radio IEEE 802.11ax 2x2 Wi-Fi interface 2.4 GHz 40 MHz channel (17 dBm EIRP per chain)	1,9	2,2	1,7	2,0
Wi-Fi Extra radios 2x2	0,3 x 2 = 0,6	0,5 x 2 = 1,0	0,3 x 2 = 0,6	0,5 x 2 = 1,0
USB 3.0 ports	2 x 0,1 = 0,2	2 x 0,1 = 0,2	2 x 0,1 = 0,2	2 x 0,1 = 0,2
Total equipment	6,4 W	7,5 W	6,2 W	7,3 W

Source: JRC, 2024

10.2 XGS-PON Home Gateway

XGS-PON home gateway with 4 Gigabit Ethernet LAN ports, a single 10 Gigabit Ethernet LAN, 2 USB 3,1 ports:

- in ready-state: 2 Ethernet LAN ports connected and 2 disconnected, one 10 Gigabit Ethernet connected
- in on-state: all Ethernet LAN ports active

Table 33: XGS-PON Home Gateway Example

Function	2024		2025	
	Ready	On	Ready	On
Central functions	2,2	2,4	2,2	2,4
XGS-PON WAN	1,2	2,1	1,2	2,0
Connected Gigabit Ethernet LAN connected	2 x 0,3 = 0,6	4 x 0,3 = 1,2	2 x 0,3 = 0,6	4 x 0,3 = 1,2
Disconnected Gigabit Eth. LAN ports	2 x 0,2 = 0,4	n/a	2 x 0,2 = 0,4	n/a
One 10 Gigabit Ethernet LAN connected	2,5	2,5	2,3	2,3
USB 3.1 ports	2 x 0,1 = 0,2	2 x 0,1 = 0,2	2 x 0,1 = 0,2	2 x 0,1 = 0,2
Total equipment	7,1 W	8,4 W	6,9 W	8,1 W

Source: JRC, 2024

10.3 Gigabit Ethernet router with 4 Gigabit Ethernet LAN ports

Fast Ethernet router with 1 WAN and 4 LAN Ethernet ports:

Table 34: Ethernet router with 4 Fast Ethernet LAN ports Example

Function	2024		2025	
	Ready	On	Ready	On
Central functions	2,0	2,2	2,0	2,2
Connected Gigabit Ethernet (WAN port)	0,3	0,3	0,3	0,3
Connected Gigabit Ethernet (LAN ports)	2 x 0,3 = 0,6	4 x 0,3 = 1,2	2 x 0,3 = 0,6	4 x 0,3 = 1,2
Disconnected Gigabit Ethernet (LAN ports)	2 x 0,2 = 0,4	n/a	2 x 0,2 = 0,4	n/a
Total equipment	3,3 W	3,7 W	3,3 W	3,7 W

Source: JRC, 2024

10.4 Cable DOCSIS 3.0 CPE

DOCSIS 3.0 CPE in 32x4 configuration with 1 Gigabit Ethernet LAN port:

Table 35: Cable DOCSIS 3.0 CPE Example

Function	2024		2025	
	Ready	On	Ready	On
Central functions	2,0	2,2	2,0	2,2
DOCSIS 3.0 basic configuration WAN interface	3,0	3,3	2,9	3,2
1 DOCSIS 3.0 Additional power allowance for the additional 28 downstream channels	7 x 1,2 = 8,4	7 x 1,8 = 12,6	7 x 1,2 = 8,4	7 x 1,8 = 12,6
Connected Gigabit Ethernet LAN port	0,3	0,3	0,3	0,3
Total equipment	13,7 W	18,4 W	13,6 W	18,3 W

Source: JRC, 2024

10.5 Complex HNID – Wi-Fi Access Point

Dual-band 4x4 11ac access point with 4 Gigabit Ethernet LAN ports:

Table 36: Complex HNID Example

Function	2024		2025	
	Ready	On	Ready	On
Central functions	2,0	2,2	2,0	2,2
Wi-Fi single band IEEE 802.11ac radio (17 dBm), 2,4 GHz 2x2 MIMO	1,4	1,9	1,4	1,9
Extra 11ac chains 2x2	2 x 0,3 = 0,6	2 x 0,5 = 1,0	2 x 0,3 = 0,6	2 x 0,5 = 1,0
Wi-Fi single band IEEE 802.11ac radio Wi-Fi interface (27 dBm), 5 GHz 2x2 MIMO	1,8	2,1	1,8	2,1
Extra 11ac chains 2x2	2 x 0,3 = 0,6	2 x 0,5 = 1,0	2 x 0,3 = 0,6	2 x 0,5 = 1,0
Connected Gigabit Ethernet LAN ports	2 x 0,3 = 0,6	4 x 0,3 = 1,2	2 x 0,3 = 0,6	4 x 0,3 = 1,2
Disconnected Gigabit Ethernet LAN ports	2 x 0,2 = 0,4	n/a	2 x 0,2 = 0,4	n/a
Total equipment	7,4 W	9,4 W	7,4 W	9,4 W

Source: JRC, 2024

11 Reporting Form

See Reporting Sheet on the homepage of the EU Standby Initiative [3].

The reporting spreadsheet should be filled in on the basis of equipment capability, in particular the actual number of ports on cards or chassis should be entered, regardless of any design or regulatory constraints which may result in the suboptimal use of those cards.

For Network Operators, the tier to be used for compliance purposes should be that pertaining to the year when equipment of a given type was ordered for the first time.

12 Test methods

12.1 Customer premises equipment

Customer premises equipment with an external power supply shall be measured 230V AC input in all states (when existing) as they are described in section 8.1. At the time of preparation of this Code of Conduct v9.0, ETSI is in the process of updating EN 301 575 [29] in order to provide a European standardised specification for the measurement of the power consumption in different states, including those used in this Code of Conduct.

12.2 Network equipment

The values given in section 0 are indicating the averaged power consumption per port for a fully equipped system as delivered by the manufacturer.

Systems powered by DC voltage shall comply with the standard ETSI EN 300 132-2 [7].

The method of power measurement of equipment in line with point 9.2.19.2.1, 9.2.2 and 9.2.39.2.3 shall comply with the Technical Specification ETSI EN 303 215 [15]. The method of power measurement for equipment in line with point 9.2.4 shall comply with the Technical Specification ETSI ES 202 706-1 v1.7.1 [9].

In case of systems powered directly by AC mains voltage, the power consumption will have to be measured at the AC input. For AC mains powered systems, the power limits stated in Table 16 through Table 26 are increased by 10%. In case of integrated remote or reverse powered systems, the power limits stated are increased by 15% for remote and reverse powered systems.

The power limits have to be fulfilled for the system operating at ambient temperature (25 ± 2° C). Fans, if present in network equipment in line with points 9.2.1 and 9.2.2, have to be set at maximum speed.

Note: for both Customer premises and network equipment the xDSL test conditions under which energy consumption is measured should be representative of the scenario(s) under which network equipment or CPE is to be deployed (e.g., selection of band plan for VDSL2).The Broadband Forum and ETSI EE provide xDSL test plans, which may be used prior to the general availability of a unified test methodology which is fully compatible with the Code of Conduct.

In the spirit of industry harmonization, ETSI EE and the Broadband Forum will collaborate on the review/definition of the Broadband Energy efficiency measurement methods standards and test plans for xDSL CPE and network equipment published by ETSI with the aim of making joint recommendations for the next revision of the Code of Conduct.

13 Evolution of power saving for broadband equipment

The volume of deployed broadband equipment is increasing dramatically and so does its combined power consumption. Due to low customer aggregation ratios (typically, one CPE per customer), such equipment is typically idle most of the time (but “ready to serve” its function), most of the time exchanging data only to maintain its network status. It is therefore evident that such equipment can be optimized in terms of its power consumption and activity profiles. Examples of such techniques include dynamic adaptation (e.g., performance scaling), smart standby (e.g., through proxying network presence and virtualization of functions) and energy aware management. The following list gives an overview of some of available optimization techniques.

- Energy Efficient Ethernet (EEE) as defined in IEEE Std 802.3-2012 SECTION SIX – wired copper Ethernet interfaces on CPEs have the ability to operate at a data rate lower than their nominal data rate, reducing power consumption of the interface as a whole. Different port-type-specific signalling mechanisms are used in EEE, including Low Power Idle. To take the full advantage of the EEE potential, both link peers must support EEE.
- Network Proxying defined by the ECMA task group under the work programme of TC38-TG4 - Proxying Support for Sleep Modes. The work is focused on providing support for the Network Proxy function for various types of broadband equipment, including VoIP phones. A proxy in this context is an entity that maintains network presence for a sleeping higher-power broadband device. A VoIP phone remains idle most of the time. VoIP phones cannot be put into a full standby mode, since they are required to maintain network presence through persistent data connectivity. Through proxying, another entity within the broadband network can assure such persistent data connectivity on behalf of a VoIP phone and wake it up when required. In this way, a device can enter a full standby mode, without any adverse effects on associated communication protocols.
- Energy aware management IETF EMAN. Provides a framework for Energy Management for devices within or connected to communication networks, and components thereof. It defines an Energy Management Domain as a set of Energy Objects, for which each Energy Object is identified, classified and given context. Energy Objects can be monitored and/or controlled with respect to Power, Power State, Energy, Demand, Power Quality, and battery. https://datatracker.ietf.org/wg/eman/
- Energy aware management within ETSI - The Green Abstraction Layer (GAL) is an architectural interface/middleware that intends to give a flexible access to the power management capabilities of the future energy aware Broadband nodes to effectively exploit the capability of adapting their energy consumption with respect to the function (typically the traffic) variations. The GAL aims at synthetizing and at correctly exposing power management capabilities and corresponding consumption variation.
- Various parts of the 802.11 standards offer power saving methods that may be optional in the standard. While these may not have a large impact on AP-type devices, they can have a material impact in the overall network by allowing client devices to sleep longer and more efficiently.

Implementing those functions in broadband equipment enhances its capabilities for power saving.

14 Signing form

Code of Conduct
On Energy Consumption of Broadband Equipment

SIGNING FORM

The organisation/company/

……………………………………………………………………………………

signs the Code of Conduct on Energy Consumption of Broadband Equipment and commits itself to abide to the principles described **in point 3 "Commitment" for the equipment it** produces, buys, installs or specifies.

The organisation, through regular upgrade reports, will keep the European Commission informed on the implementation of the Code of Conduct of Broadband Equipment.

For the organisation

Director or person authorised to sign:

Name:	…………………………………………………
Managerial Function:	…………………………………………………
Address:	…………………………………………………
Tel. / Fax:	…………………………………………………
Email:	…………………………………………………
Date:	…………………………………………………

Signature ………………………………………………………

Please send the signed form to:

Paolo Bertoldi
European Commission - DG JRC
TP 450
I-21027 Ispra (VA)
Tel. +39 0332 78 9299
Fax +39 0332 78 9992
E-mail: paolo.bertoldi@ec.europa.eu

15 Copy of ANSI/CTA-2049-A

The new ready state for CPE is based on ANSI/CTA-2049-A [28], which is developed by a standard organisation that is not recognised in Europe. Work is being done to incorporate the concepts of ANSI/CTA-2049-A used in this CoC in a European standard such as EN 301 575 Measurement method for energy consumption of Customer Premises Equipment (CPE) [29]. In the interim, a copy of ANSI/CTA-2049-A is provided in the next pages to ensure appropriate referencing and availability.

Consumer Technology Association

ANSI/CTA Standard

Determination of Small Network Equipment Energy Consumption

ANSI/CTA-2049-A

December 2020

Consumer Technology Association

NOTICE

Consumer Technology Association (CTA)™ Standards, Bulletins and other technical publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards, Bulletins and other technical publications shall not in any respect preclude any member or nonmember of the Consumer Technology Association from manufacturing or selling products not conforming to such Standards, Bulletins or other technical publications, nor shall the existence of such Standards, Bulletins and other technical publications preclude their voluntary use by those other than Consumer Technology Association members, whether the standard is to be used either domestically or internationally.

Standards, Bulletins and other technical publications are adopted by the Consumer Technology Association in accordance with the American National Standards Institute (ANSI) patent policy. By such action, the Consumer Technology Association does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the Standard, Bulletin or other technical publication.

This document does not purport to address all safety problems associated with its use or all applicable regulatory requirements. It is the responsibility of the user of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before its use.

(Formulated under the cognizance of the CTA **R7 Consumer Electronics Networking Committee**.)

Published by
©CONSUMER TECHNOLOGY ASSOCIATION 2020
Technology & Standards Department
www.cta.tech

FOREWORD

This standard was developed by the Consumer Electronics Association under the auspices of the R7 Home Networks Committee.

(This page intentionally left blank.)

CONTENTS

FIGURES

TABLES

Determination of Small Network Equipment Energy Consumption

1 SCOPE

This standard defines procedures for measuring Small Network Equipment (SNE) energy consumption while in an idle state. It defines the interfaces that shall be active and connected for this test procedure, and is written with the intent of addressing current and future devices that qualify as a SNE device. This document does not define how an SNE device is placed into an idle state.

2 OVERVIEW

This document covers the configuration of three aspects in order to conduct the testing; the SNE device, test environment and the Test Client(s). A Small Network Equipment device could be any device including, but not limited to, the following WAN and LAN interfaces:

- DOCSIS Cable Modem
- DSL Modem
- Optical Network Termination (ONT) Device
- Ethernet
- MoCA
- Wi-Fi (IEEE 802.11)

It is important to define the test environment to ensure that the SNE devices are being tested similarly. The Test Client(s) ensure that the correct interfaces are connected to provide a basis for testing parity among all SNE devices regardless of the size and complexity of these devices.

3 REFERENCES

3.1 Normative References

The following standards contain provisions that, through reference in this text, constitute normative provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed here.

3.1.1 Normative Reference List

1. IEC 62301, Ed. 2.0, *Household electrical appliances – Measurement of standby power,* January 2011, https://webstore.iec.ch/publication/6789

2. IEEE 802.3-2018, *IEEE Standard for Ethernet,* August 31, 2018, https://standards.ieee.org/ ANSI/TIA-568.2 Revision D, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*, September 2018, http://www.tiaonline.org/standards
3. ANSI/TIA-568.4 Revision D, *Broadband Coaxial Cabling and Components Standard*, June 27, 2017, http://www.tiaonline.org/standards

3.2 Informative References

The following references contain provisions that, through reference in this text, constitute informative provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

3.2.1 Informative Reference List

1. ENERGY STAR *Test Method for Small Network Equipment Final Test Method Rev., November 2013,* http://www.energystar.gov/sites/default/files/specs//SmallNetworkEquipment_V1_ENERGYSTAR_ProgramRequirements_Nov2013_0.pdf
2. ATIS-0600015.03.2013, *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products,* https://www.atis.org/docstore/default.aspx
3. C872-14, *Power Consumption of Small Network Equipment (SNE),* http://shop.csa.ca/en/canada/energy-efficiency/c872-14/invt/27036782014
4. L.1310, *Energy Efficiency Metrics and Measurement Methods for Telecommunication Equipment*, http://www.itu.int/rec/T-REC-L.1310-201408-P/en

4 COMPLIANCE NOTATION

CTA defines the following compliance terms for use in its documents:

shall	This word indicates specific provisions that are to be followed strictly (no deviation is permitted).
shall not	This phrase indicates specific provisions that are absolutely prohibited.
should	This word indicates that a certain course of action is preferred but not necessarily required.
should not	This phrase means a certain possibility or course of action is undesirable but not prohibited.

may This phrase indicates that a certain course of action is optional.

5 DEFINITIONS, SYMBOLS AND ABBREVIATIONS

5.1 Definitions

Active State: A device is powered on and transmitting data

Bluetooth: Bluetooth is a short-range wireless technology used to create Personal Area Networks among devices, and with other nearby devices.

Idle Interface: An interface is configured and active, and capable of passing traffic.

Idle State: A device is powered on and ready to pass traffic, but no user-generated traffic is initiated during the test.

LTE: Long Term Evolution technology is a standard for wireless communication of high-speed data for mobile phones

Test Client: The Test Client is the device connected to the UUT.

ZigBee: ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15 standard.

Z-Wave: Z-Wave is a wireless communications protocol designed for home automation, specifically for remote control applications in residential and light commercial environments. The technology uses a low-power RF radio embedded or retrofitted into electronic devices and systems, such as lighting, access controls, entertainment systems and household appliances.

5.2 Symbols and Abbreviations

AC Alternating Current
ACL Access Control List
ANSI American National Standards Institute
AP Access Point
dB Decibels
DHCP Dynamic Host Configuration Protocol
DOCSIS Data Over Cable Service Interface Specification
DSL Digital Subscriber Line
EIA Electronic Industries Alliance
EPS External Power Supply
eSATA External Serial Advanced Technology Attachment

HPNA Home Phoneline Networking Alliance
IAD Integrated Access Device
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers
IMIX Internet Traffic Mix
IPsec Internet Protocol Security
ISP Internet Service Provider
L2TP Layer 2 Tunneling Protocol
LAN Local Area Network
LLDP Link Layer Discovery Protocol
MAC Media Access Control
MIMO Multiple-Input/Multiple-Output
MoCA Multimedia over Coax Alliance
MTU Maximum Transmission Unit
NAT Network Address Translation
ONT Optical Network Terminal
PoE Power over Ethernet
PON Passive Optical Network
POTS Plain Old Telephone Service
PPPoX Point-to-Point Protocol over X
RF Radio Frequency
SD card Secure Digital card
SNE Small Network Equipment
SSID Service Set Identifier
STA Wireless STAtion client
TIA Telecommunications Industry Association
TTL Time To Live
UDP User Datagram Protocol
USB Universal Serial Bus
UUT Unit Under Test
VoIP Voice over Internet Protocol

VPN Virtual Private Network
WAN Wide Area Network
WiFi Wireless Fidelity
WLAN Wireless Local Area Network
WPA WiFi Protected Access

6 TEST ENVIRONMENT

A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this procedure shall be in accordance with the requirements of IEC 62301, Ed. 2.0, "Household electrical appliances – Measurement of standby power", Section 4, "General Conditions for Measurements". In the event of conflicting requirements, the ANSI/CEA-2049 test method shall take precedence.

B) Input Power: Input power shall be as specified in Table 1. Testing shall only be required at the input power for the applicable market(s).

Table 1: Input Power Requirements

Market	Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion	Frequency	Frequency Tolerance
North America, Taiwan	115 Vac	+/- 1.0 %	2.0 %	60 Hz	+/- 1.0 %
Europe, Australia, New Zealand	230 Vac	+/- 1.0 %	2.0 %	50 Hz	+/- 1.0 %
Japan	100 Vac	+/- 1.0 %	2.0 %	50 Hz or 60 Hz	+/- 1.0 %

C) Ambient Temperature: Tests shall be carried out in a room where the air speed surrounding the unit under test (UUT) is <= 0.5 m/s, and the ambient temperature is maintained at 23 ± 5 °C throughout the test. There shall be no external cooling of the UUT such as by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be conditioned, rested, and tested on a thermally non-conductive surface. A readily available material such as Styrofoam will be sufficient.

D) Relative Humidity: Relative humidity shall be from 10% to 80%.

7 TEST CONFIGURATION

7.1 General

A) As-shipped Condition: Products must be tested in their default "as-shipped" configuration. For products that offer a choice of user-configurable options, all options shall be set to their default condition. Default settings shall not be modified, unless required to perform a test in this test method or if no default setting exists. Any features that require installation (e.g., battery, SFP module, antenna) or configuration prior to the UUT functioning (e.g., required setup before use as indicated in a reference manual) shall be recorded in the test report. If additional required settings are not defined, the setting type and option shall be recorded in the test report.

B) Test Procedure Order: All portions of this test method shall be followed in the order in which they are written.

C) Battery Operated Products: For products designed to operate using batteries either when not connected to the mains or during a power disruption, the battery shall be fully charged before the start of testing and shall be left in place for the test. To ensure the battery is fully charged, perform the following steps:

   a. For UUTs that have an indicator to show that the battery is fully charged, continue charging for at least an additional 5 hours after the indication is present.

   b. If there is no charge indicator, but the manufacturer's instructions provide a time estimate, continue charging for at least an additional 5 hours after the manufacturer's estimate.

   c. If there is no indicator and no time estimate in the instructions, but the charging current and rated charge capacity are stated on the UUT or instructions, calculate the test duration as the longer of 24 hours or:
   Duration (hours) = 1.4 * RatedChargeCapacity(Ah) / ChargeCurrent(A) + 5

   d. If none of the above methods are available, the charge duration shall be 24 hours.

D) Power Save Modes: If any power reduction features are supported by the UUT, such features may be enabled during testing in both the UUT and test equipment, provided that all enabled features are disclosed along with reported test results.

7.2 Supplied Power Configuration

This procedure only covers devices that can be powered by AC as-shipped. Power of the UUT shall be measured and tested between the AC power source and the UUT.

Note: The UUT can be powered in three ways: (a) using an internal power supply, (b) using a power adapter for standard DC (e.g., Power over Ethernet or USB), or (c) using a power adapter for non-standard DC (e.g., AC-DC wall adapter). Devices powered by standard DC and not shipped with a power adapter are not covered.

7.3 UUT Interface Configuration

The UUT will support some combination of interfaces, including WAN/uplink interfaces, wired LAN ports, wireless LAN interfaces, analog telephony interfaces, peripheral interfaces, etc. For testing, these interfaces shall be connected as described in this section and its subsections.

Overview of interface configuration

- WAN/uplink interface - single interface connected
- Wired LAN ports - for each LAN interface type, connect N/2 (rounded up) ports (where N is the number of ports of the type) to an active endpoint. The remaining N/2 (rounded down) ports are not connected.
- 802.11 wireless - single test client associated
- Peripheral interfaces (e.g., USB, eSATA, SD card, analog audio) - not connected
- POTS (telephony) ports - active but no handsets connected
- Other wireless interfaces (e.g., Bluetooth, Zigbee, Z-wave) in default as-shipped configuration, no client devices associated.

Connected interfaces shall be tested in a condition in which they are active and available to function in their normal, default and/or typical capacity of forwarding or otherwise processing network traffic. The tester shall verify that the UUT is capable of this function. The ability of an interface to pass IP traffic is sufficient to verify an interface is 'active and available'.

7.3.1 WAN/Uplink Interface Configuration

A) If the UUT offers more than one WAN connection option, the UUT shall be configured using the first available WAN connection presented in Table 2, from top to bottom. Only a single WAN port shall be connected.

   Note: For products with more than one WAN connection option, the tester may optionally choose to repeat testing for each WAN option separately. The reported results shall indicate which WAN interface was used.

B) The WAN connection shall be configured to operate at the highest supported link rate. A link that can dynamically change the speed through activity detection is acceptable.

   Note: When this test procedure is used to report product power on a particular network, the service provider may define and use a WAN interface configuration for typical installation.

Table 2: WAN/Uplink Priority

Connection Type	Media Type
DOCSIS (Cable)	Coax
PON	Fiber
DSL	Copper (Twisted Pair)
Ethernet (IEEE 802.3)	Copper (Twisted Pair)
Wi-Fi (IEEE 802.11)	Wireless
MoCA	Coax
Cellular (LTE, 5G)	Wireless
Other	Variable

7.3.2 Wired LAN Port UUT Configuration

Wired local area network (LAN) ports include Ethernet, HPNA, and MoCA.

For any wired LAN port connected for testing as required by this Test Method, the port shall be configured in full compliance with the relevant published or draft standard governing the technology (e.g., all features comply with IEEE 802.3).

The connected set of ports shall be contiguous, starting with the first (e.g., lowest numbered) port (e.g., a 5-port product would have ports 1-3 connected and ports 4 and 5 disconnected).

All wired LAN ports shall be configured for testing as follows:

A) Network Ports: All wired LAN ports shall be active and capable of transmitting data.

B) Port Connection Rate: All connected wired LAN ports shall be capable of achieving the maximum supported link rate for the duration of the test unless otherwise specified in this test procedure.

For Ethernet Interfaces, the following additional configuration applies:

A) Cabling: All Ethernet cables used for testing shall meet ANSI/EIA/TIA-568-C.2 Category 5e (Cat5e) specifications and shall be between 1 and 2 meters in length.

B) Efficient Networking Protocols:

   a. If the UUT supports IEEE 802.3az protocol, the Test Client must support IEEE 802.3az.

   b. If the UUT supports Link Layer Discovery Protocol (LLDP) for 802.3az, the Test Client must support LLDP for 802.3az.

C) Power over Ethernet:

   a. If the UUT can act as Power Sourcing Equipment (PSE) for Power over Ethernet (PoE), PoE PSE ports are considered a different LAN interface type from non-PoE PSE ports for purposes of port connectivity as defined in this section. (If UUT has a mix of PoE capable and non-PoE capable ports, then half of each type shall be connected.)

   b. If the UUT can act as Power Sourcing Equipment for Power over Ethernet, the Test Client must not act as a PoE Powered Device (PD), and thus must not draw power from the UUT.

For MoCA Interfaces, the following additional configuration applies:

A) Cabling: All cables used for testing shall meet ANSI/EIA/TIA-568-C.4 Coaxial Cable specifications and shall be between 1 and 2 meters in length.

B) Network Controller: The UUT shall be configured to be the network controller for the MoCA network.

7.3.3 Wireless UUT Configuration

For UUTs supporting single or multiple 802.11 wireless interfaces, only a single 802.11 client shall be associated to the UUT using the highest data rate option (802.11 version, band and channel width) supported by the UUT.

The UUT shall be tested with wireless network settings in their default as-shipped configuration. Default settings shall not be modified unless modification is necessary to complete this procedure, or if no default setting exists. Any features that require special configuration to achieve intended function (e.g., initial setup before use as indicated in a reference manual) shall be configured per the following requirements. If additional required settings are not listed below, the setting type and option shall be recorded in the test report.

If the UUT requires an access point controller for normal operation, an access point controller from the same manufacturer as the UUT shall be added to the network for testing. If the UUT is capable of full operation without an access point controller, it shall be tested without a controller on the test network.

If the UUT has multiple 802.11 wireless interfaces, and one of those interfaces is intended to function as a WAN/uplink network connection:

- The WAN/uplink connection shall be connected as intended for a typical installation.
- A single 802.11 client connection is required in addition to the WAN/uplink connection.

Wireless 802.11 LAN configuration:

A) SSID: As-shipped, or assigned a random value as required by the UUT (Note the UUT should be configured with the as-shipped or as-installed SSID configuration, and default SSIDs should not be removed nor should additional SSIDs be added during test, as this can change the power consumption of the device.)

B) Network Encryption: As-shipped, or 128-bit WPA2 as required by the UUT

C) Network Key: As-shipped, or assigned a random value as required by the UUT

D) Network Channel: A supported channel shall be selected and maintained for the duration of testing

E) Interference Mitigation: Interference robustness or other interference mitigation technology shall be as-shipped or set to "ON" if configuration required by UUT

F) Wireless Link Precedence:

   A UUT may support different wireless configurations. The most appropriate of the following options below shall be applied:

   a. *Single instantaneous frequency band support*: If the UUT supports a single wireless radio, the radio shall be configured to operate using the 802.11 version, band and channel bandwidth supporting the highest data rate for testing. Only one band shall be active during the test.

   b. *Simultaneous instantaneous frequency band support*: If the UUT supports multiple wireless radios concurrently, each radio shall be configured to operate using the 802.11 version and channel bandwidth supporting the highest data rate available. The test client shall be connected to the radio operating at the highest data rate available to the client.

   c. *Alternative wireless configurations*: If the device has a default as-installed wireless configuration not listed above, a configuration that represents the highest data rate shall be used. The configuration shall be recorded in the test report.

G) Single STA Association: The tester shall ensure that no extraneous devices become associated to the 802.11 interface(s). This can be accomplished in a variety of ways. For example:

   a. using a shielded enclosure;

   b. powering off or disabling all 802.11 enabled devices within range of the UUT;

   c. ensuring that the SSID is unique enough that any 802.11 devices in range of the UUT will not associate with the UUT; or

   d. specify only those clients allowed to associate with the UUT in the MAC ACL list.

7.4 Power Meter Connection:

A) Power Meter: Power meters shall possess the following attributes

a. Crest Factor: Capability to measure the current waveform without clipping.

i. The peak of the current waveform measured during Idle State shall determine the crest factor rating requirement and the appropriate current range setting

ii. The full-scale value of the selected current range multiplied by the crest factor for that range shall be at least 15% greater than the peak current

b. Bandwidth: Minimum bandwidth as determined by an analysis of current and voltage to determine the highest frequency component (harmonic) with a magnitude greater than 1% of the fundamental frequency under the test conditions.

c. Minimum Frequency Response: 3.0 kHz

d. Minimum Sampling Frequency: 60 Hz

e. Minimum Resolution:

i. 0.01 W for measurement values less than 10 W;

ii. 0.1 W for measurement values from 10 W to 100 W; and

iii. 1.0 W for measurement values greater than 100 W.

f. Measurement Accuracy:

i. Power measurements with a value greater than or equal to 0.5 W shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level

ii. Power measurements with a value less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level

B) Connect the power meter(s) to an ac voltage source set to the appropriate voltage and frequency for the test

C) Plug the UUT into the measurement power outlet on the power meter, as follows:

a. No other devices (e.g., power strips or UPS units) may be connected between the meter and the UUT;

b. If the UUT uses an EPS, the EPS is considered part of the UUT. Plug the EPS input into the measurement power outlet on the meter;

c. The power meter shall remain connected until all testing is complete.

D) Calculation of Average Power

For all tests in all power modes, the average power shall be calculated using one of the following two methods:

(a) Record the accumulated energy (E) in kilo-watt hours (kWh) consumed over the time period specified for each test (T). The average power is calculated as:

$P = E/T$

(b) Record the average power (P) by sampling the power at a rate of at least 1 sample per second and computing the arithmetic mean of all samples over the time period specified for each test (T).

The method used must be recorded by the tester.

7.5 Test Client Setup

The test procedure outlined in Section 9 requires the use of network tester equipment (the Test Client) capable of appropriately terminating the interfaces of the UUT. The Test Client may consist of several discrete pieces of test equipment used together to connect to the WAN/uplink, wired and wireless LAN interfaces. Because this test procedure is based on the UUT to be in an idle state and thus not required to pass traffic, any Test Clients need to simply establish link with the UUT.

7.6 Example UUT Configurations

A) Example 1: SNE device with WAN/Uplink Port(s) (e.g., Modem (DSL, Cable), Router or ONT or some Switches) Figure 1: Modem or ONT setup.

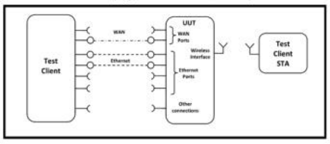


Figure 1: Modem or ONT Setup

a. Connect the UUT WAN port to the test client using the priority and link rate specified in Section 8.3.1.

b. Connect N/2 (rounded up) wired LAN port(s) (where N is the number of wired LAN ports) to the test client.

c. The remaining N/2 (rounded down) wired ports are not connected

d. If a wireless interface is included:

i. Associate a single STA with the wireless interface

B) Example 2: SNE device without WAN/Uplink Port(s) (e.g., simple Switch) Figure 2: Switch test setup.

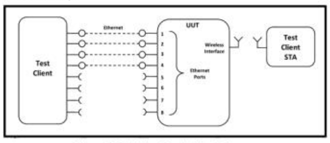


Figure 2: Switch or Router Test Setup

a. Connect exactly N/2 (rounded up) available ports (where N is the number of wired ports) to the test client and ensure that live links are maintained for the duration of testing on all connections.

b. The remaining N/2 (rounded down) wired connections are not connected.

c. If a wireless interface is included, associate a single STA with the wireless interface.

8 TEST PROCEDURE FOR ALL PRODUCTS

The following procedure shall be used for each test performed on the UUT while in an idle state:

A) Apply power to the UUT.

B) Wait a sufficient amount of time to allow the UUT to enter an idle state with stable energy consumption.

C) Measure the average power over a 10-minute period using the measurement method selected in Section 8.4.

D) Record the test measurement and any special setup conditions as required.

9 REPORTING

9.1 Reported UUT information and Functionality

The following characteristics are recommended for reporting using this procedure:

A) Manufacturer and model name;

B) Basic configuration information;

C) Powering options (e.g., direct ac, external ac-dc power supply);

D) Number and type of all wired data and network ports. Additional related details (e.g., Number of DOCSIS Channels Supported, Ethernet speed, 802.3az, LLDP for 802.3az) as required;

E) Number and type of wireless network support including supported bands, simultaneous band support and which band is associated with the test client, supported standards, and MIMO configuration. Additional details as required;

F) Additional wireless technologies supported (e.g., BlueTooth, ZigBee, ZWave) and configuration/state as-shipped;

G) Supported network traffic functions (e.g., firewall, VPN, VOIP functionality for POTS ports);

H) Any special equipment ratings (e.g., IEC 61850 / IEC61000 and IEEE1613, KEMA).

I) Any additional features and functionality that may impact idle power (e.g., mass storage options).

9.2 Reported Test Results

A) Voltage and frequency used in test;

B) Measured power level.

10 TEST CONFIGURATION REFERENCES

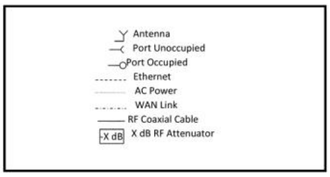


Figure 3: Legend for all Figures

Consumer Technology Association

Consumer Technology Association Document Improvement Proposal

If in the review or use of this document a potential change is made evident for safety, health or technical reasons, please email your reason/rationale for the recommended change to standards@CTA.tech.

Consumer Technology Association
Technology & Standards Department
1919 S Eads Street, Arlington, VA 22202
FAX: (703) 907-7693 standards@CTA.tech

Consumer Technology Association™

16 Conclusions

Expectations are that broadband equipment will contribute considerably to the electricity consumption of households in European Community in the near future. Depending on the penetration level, the specifications of the equipment and the requirements of the service provider, a total European consumption of at least 50 TWh per year was estimated for the year 2015 for broadband equipment, since then the consumption has grown steadily. With the general principles and actions resulting from the implementation of this Code of Conduct the (maximum) electricity consumption could be slightly reduced or kept constant compared to a business as usual scenario with growing usage and penetration of broadband equipment in the EU.

The potential new electrical load represented by this equipment needs to be addressed by EU energy and environmental policies. It is important that the electrical efficiency of broadband equipment is maximised.

To help all parties to address the issue of energy efficiency whilst avoiding competitive pressures to raise energy consumption of equipment all service providers, network operators, equipment and component manufacturers are invited to sign this Code of Conduct.

This Code of Conduct sets out the basic principles to be followed by all parties involved in broadband equipment, operating in the European Union, in respect of energy efficient equipment.

References

[1] ITU-T recommendation I.113,"Vocabulary of terms for broadband aspects of ISDN"

[2] Code of Conduct for Digital TV Services (version 9 – 01.07.2013), https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/code_of_conduct_digital_tv_service_systems_v9_final.pdf

[3] Reporting sheet CoC BB equipment, https://ec.europa.eu/jrc/en/energy-efficiency/code-conduct/broadband

[4] EU Code of Conduct for External Power Supplies (version 5 – 31.10.2013), https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/code_of_conduct_for_eps_version_5_-_final.pdf

[5] ETSI Standard EN 300019-1-3 European Standard, Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weather protected locations

[6] ETSI Standard EN 300019-1-4 European Standard, Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations

[7] ETSI EN 300 132-2 European Standard, Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc)

[8] COMMISSION REGULATION (EU) 2023/826 of 17 April 2023 laying down ecodesign requirements for off mode, standby mode, and networked standby energy consumption of electrical and electronic household and office equipment pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulations (EC) No 1275/2008 and (EC) No 107/2009

[9] ETSI ES 202 706-1, "Technical Specification, Environmental Engineering (EE), Energy Efficiency of Wireless Access Network Equipment"

[10] IEEE Std 802.3™-2022, IEEE Standard for Ethernet

[11] IEEE P802.3bk, draft D2.0, Draft Standard for Ethernet, Amendment 2: Physical Layer Specifications and Management Parameters for Extended Ether-net Passive Optical Networks

[12] Broadband Forum TR-100 Issue 2 (August 2012), ADSL2/ADSL2plus Performance Test Plan, http://www.broadband-forum.org/technical/download/TR-100_Issue-2.pdf

[13] Broadband Forum TR-114 Issue 2 (November 2012), VDSL2 Performance Test Plan, http://www.broadband-forum.org/technical/download/TR-114_Issue-2.pdf

[14] ITU-T Recommendation G.984, "Gigabit-capable passive optical networks (GPON): General characteristics"

[15] ETSI EN 303 215 V1.3.1, "ETSI Standard, Environmental Engineering (EE); Measurement Methods and Limits for Power Consumption in Broadband Telecommunication Networks Equipment"

[16] ITU-T Recommendation G.993.5 (2019), "Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers"

[17] ITU-T Recommendation G.993.2 (2019), "Very high speed digital subscriber line transceivers 2 (VDSL2)"

[18] ITU-T Recommendation G.992.3, “Asymmetric digital subscriber line transceivers 2 (ADSL2)”

[19] ITU-T Recommendation G.992.5, “Asymmetric digital subscriber line 2 transceivers (ADSL2)– Extended bandwidth ADSL2 (ADSL2plus)”

[20] ITU-T Recommendation G.998.4 (2018), “Improved impulse noise protection for DSL transceivers”

[21] Broadband Forum Amendment 2 to TR-114 Issue 3, VDSL2 Performance Test Plan.

[22] ITU-T Recommendation G.9701 (2019), “Fast Access to Subscriber Terminals (FAST) – Physical layer specification”

[23] SCTE 231 2019, “General Test Procedures for Evaluation of Energy Efficiency Metrics and in Support of Functional Density Metrics”

[24] SCTE 232 2019, “Key Performance Metrics: Energy Efficiency & Functional Density of CMTS, CCAP, and Time Server Equipment”

[25] Ward Van Heddeghem, Sofie Lambert, Bart Lannoo, Didier Colle, Mario Pickavet, Piet Demeester, "Trends in worldwide ICT electricity consumption from 2007 to 2012", in Computer Communications 50 (2014) 64–76

[26] COMMISSION NOTICE “The ‘Blue Guide’ on the implementation of EU products rules 2016 (2016/C 272/01), Official Journal of the European Union EN C 272/1”

[27] 3GPP TS 36.211: “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and Modulation”

[28] ANSI/CTA CTA-2049-A (2020): “Determination of Small Network Equipment Energy Consumption”; attached to this CoC for convenience, reproduced with permission”

[29] ETSI EN 301 575 v1.1.1 “European Standard, Environmental Engineering (EE); Measurement method for energy consumption of Customer Premises Equipment (CPE)”

[30] ITU-T Recommendation G.9941 (2024), “High speed fibre-based in-premises transceivers - physical layer specification”

List of abbreviations

1G-EPON	EPON operating at 1 Gbit/s downstream and 1Gbit/s upstream (IEEE 802.3)
10/1G-EPON	EPON operating at 10 Gbit/s downstream and 1Gbit/s upstream (IEEE 802.3)
10/10G-EPON	EPON operating at 10 Gbit/s downstream and 10Gbit/s upstream (IEEE 802.3)
ADSL	Asymmetric Digital Subscriber Line
ADSL2plus	Second generation ADSL with extended bandwidth
ATA	Analogue Terminal Adapter
CCAP	Converged Cable Access Platform
CoC	Code of Conduct
CPE	Customer Premises Equipment
CRC	Cyclic Redundancy Check
CTA	Consumer Technology Association
DCA	Distributed CCAP Architectures
DECT	Digital Enhanced Cordless Telecommunications
DFS	Dynamic Frequency Selection
DOCSIS	Data Over Cable Service Interface Specification
DPU	Distribution Point Unit
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DSSG	Downstream CMTS Service Group
EEE	Energy Efficient Ethernet
EIRP	Effective Isotropic Radiated Power
EPON	Ethernet Passive Optical Network, as specified by IEEE 802.3
ETSI	European Telecommunications Standards Institute
FFT	Fast Fourier Transform
FXO	Foreign eXchange Office
FXS	Foreign eXchange Station
GAP	Generic Access Profile
G.fast	ITU-T G series Fast Access to Subscriber Terminals
G.fin	ITU-T G series high-speed Fibre-based In-premises Network

GPON	Gigabit Passive Optical Network
GSM/EDGE	Global System for Mobile communication/Enhanced Datarate GSM Evolution
HDMI	High-Definition Multimedia Interface
HNID	Home Network Infrastructure Devices
HPNA	Home PNA Alliance
IEEE	Institute of Electrical and Electronics Engineers
I-CMTS	Integrated Cable Modem Termination System
IP	Internet Protocol
ITU	International Telecommunication Union
LAN	Local Area Network
LT	Line Termination
LTE	Long Term Evolution
M-CMTS	includes CMTS core and EQAM (Edge Quadrature Amplitude Modulator)
MELT	Metallic Line Testing Entity
MFU	G.fin Main FTTR Unit
MIMO	Multiple-Input and Multiple-Output
MoCA	Multimedia over Coax Alliance
MPLS	Multiprotocol Label Switching
MSAN	Multi-Service Access Node
NT	Network Termination
OAM	Operations, Administration and Maintenance
OFDM	Orthogonal Frequency-Division Multiplexing
OLT	Optical Line Termination
ONU	Optical Network Unit
POF	Plastic Optical Fibre
PtP	Point-to-Point Optical Network
PLC	PowerLine Communication
PoE	Power over Ethernet
PSD	Power Spectral Density
PON	Passive Optical Network

POTS	Plain Old Telephone Service
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RMD	Remote MAC-PHY Device
RPD	Remote PHY Device
SATA	Serial Advanced Technology Attachment
SC-QAM	Single- Carrier Quadrature Amplitude Modulation
SFU	G.fin Sub FTTR Unit
SNR	Signal to Noise Ratio
SOHO	Small Office, Home Office
ULE	Ultra Low Energy
USB	Universal Serial Bus
USSG	Upstream CMTS Service Group
UUT	Unit Under Test
VDSL2	Very High Speed Digital Subscriber Line 2nd generation
VoIP	Voice over IP
VPN	Virtual Private Network
WAN	Wide Area Network
WCDMA/HSDPA	Wideband Code Division Multiple Access/High Speed Packet Access
Wi-Fi	Wireless Fidelity; technology using IEEE 802.11 standards
XG-PON1	10-Gigabit passive optical network

List of figures

List of tables

Science for policy

The Joint Research Centre (JRC) provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society

EU Science Hub
joint-research-centre.ec.europa.eu

Publications Office
of the European Union