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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Informative values on the energy efficiency of telecommunication equipment

Recommendation ITU-T L.1340

ITU-T

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Informative values on the energy efficiency of telecommunication equipment

Summary

Recommendation ITU-T L.1340 provides informative values on the energy efficiency of different types of telecommunication network equipment and small networking equipment in use in both the fixed and mobile networks. These values are related to energy efficiency metrics, test procedures, methodologies and measurement profiles that have been defined in Recommendation ITU-T L.1310.

These informative values are intended to be a valued reference resource for those in the process of choosing the most energy-efficient technologies for network upgrade and deployment and, in so doing, reducing the carbon footprint of the Information and Communication Technology (ICT) sector.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Introduction

The growing demand for Internet connections from both governments and citizens is driving the rapid increase in worldwide deployment of broadband and ultra-broadband networks. Depending on the specific geographic, demographic and economic conditions, such networks can be either fixed (based on FTTx architectures and implementing technologies such as ADSL, ADSL2plus, VDSL2, GPON, GEPON, etc.) or mobile (based on HSPA, LTE, UMTS, etc.) (see Note).

The increasing deployment of broadband and ultra-broadband networks has a real impact on energy consumption and, in more general terms, on the carbon footprint. To address the critical issue of energy efficiency, it is essential that particular attention be given to the choice of specific technologies during the planning phase. An informed choice of available energy-efficient telecommunication equipment is fundamental to reducing energy consumption while guaranteeing the desired level of quality of service (QoS) and reliability.

Recommendation ITU-T L.1340 provides informative values on the energy efficiency of different types of telecommunication network equipment and small networking equipment used in both the fixed and mobile networks.

Such informative values are intended to provide a basic understanding of the energy efficiency performance of different equipment currently available and therefore serve as a useful resource in the upgrading and deployment of green broadband networks.

The informative values that are reported in this Recommendation are related to energy efficiency metrics, test procedures, methodologies and measurement profiles that have been defined in Recommendation ITU-T L.1310.

NOTE – See clause 4 for expanded meanings of abbreviations and acronyms.

Recommendation ITU-T L.1340

Informative values on the energy efficiency of telecommunication equipment

1 Scope

This Recommendation defines a set of informative values for telecommunication network equipment and small networking equipment used in the home and small enterprise locations.

The goal is to provide useful information to support a fast deployment of energy-efficient broadband and ultra-broadband networks.

Such informative values refer to the metrics, test procedures, methodologies and measurement profiles that have been defined in [ITU-T L.1310].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1310] Recommendation ITU-T L.1310 (2012), *Energy efficiency metrics and measurement methods for telecommunication equipment*.

[ATIS-0600015.02.2009] ATIS-06000 (2009), *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – Transport Requirements*.

[ATIS-0600015.03.2009] ATIS-06000 (2009), *Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products*.

[ETSI TS 102 706] ETSI TS 102 706 V1.2.1 (2011), *Environmental Engineering (EE) Measurement method for Energy Efficiency of Wireless Access Network Equipment*.

[ETSI ES 203 215] ETSI ES 203 215 V1.2.1 (2011), *Environmental Engineering (EE) Measurement Methods and Limits for Power Consumption in Broadband Telecommunication Networks Equipment*.

[IEEE 1904.1] IEEE standard 1904.1-2013, *Service Interoperability in Ethernet Passive Optical Networks (SIEPON)*.

[ISO 14040] ISO 14040:2006, *Environmental management − Life cycle assessment − Principles and framework*.

[ISO/IEC 17025] ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

Terms defined in [ITU-T L.1310]:

3.1.1 active mode: For small networking equipment, this is the operational mode where all ports (WAN and LAN) are connected, with at least one Wi-Fi connection, if a Wi-Fi function is available.

3.1.2 energy: "The capacity for doing work". In the telecommunication systems, where the primary source of energy is electricity, energy is measured in Joules.

3.1.3 energy efficiency metric: Ratio between the functional unit and the energy necessary to deliver the functional unit. The higher the value of the metric is, the higher the efficiency of the equipment is.

3.1.4 idle mode: For small networking equipment, this means the same as active mode, but with no user data traffic (it is not zero traffic, as service and protocol supporting traffic are present) being used, although it is ready to be used (U1 in routers part).

3.1.5 line rate/speed: For small network equipment, this is the maximum possible number of transmitted/received bits per second.

3.1.6 load-proportional metric: A metric which is related to equipment that operates under variable-load conditions, where the measured value of the functional unit can fluctuate based on user demand.

3.1.7 low power (sleep) mode: For small networking equipment, this means a state that happens after the device detects no user activity for a certain period of time and reduces energy consumption. For this state, no user-facing LAN ports are connected; the Wi-Fi is active but no clients are connected. The WAN port may be inactive. The device will reactivate on detecting a connection from a user port or device.

3.1.8 small networking device: A networking device with fixed hardware configuration, designed for home/domestic or small office use, with less than 12 ports. This device can have wireless functionality implemented. Wireless functionality is not considered a port.

3.1.9 throughput: For small network equipment, this is the maximum non-drop data rate between WAN and LAN port in ingress direction

3.1.10 functional unit (based on [ISO 14040]): A performance representation of the system under analysis. For example, for transport equipment, the functional unit is the amount of information transmitted, the distance over which it is transported and its rate in Gbit/s. Sometimes the term is used to indicate useful output or work.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
ADSL2plus	Asymmetric Digital Subscriber Line 2 transceiver extended bandwidth
BS	Base Station

BSC	Base Station Controller
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
DC	Direct Current
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
EDGE	Enhanced Data for GSM Evolution
EER	Energy Efficiency Rating
FTTx	Fibre To The x- where 'x' stands for the final location on the end-user side
G-EPON	Gigabit Ethernet Passive Optical Network
G-PON	Gigabit-capable Passive Optical Network
GSM	Global System for Mobile Communications
HSPA	High Speed Packet Access
ICT	Information and Communication Technology
IMIX	Internet MIX traffic
LAN	Local Area Network
LTE	Long Term Evolution
MPLS	Multi-Protocol Label Switching
MSAN	Multi Service Access Node
NNI	Network-Network Interface
OLT	Optical Line Termination
ONT	Optical Network Termination
OTN	Optical Transport Network
P2P	Point-to-Point
PF	Power Factor
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PSU	Power Supply Unit
PtP	Point-to-Point
RBS	Radio Base Station
RNC	Radio Network Controller
SIEPON	Service Interoperability in Ethernet Passive Optical Networks
TDM	Time Division Multiplex
UMTS	Universal Mobile Telecommunications Service
UNI	User Network Interface
UUT	Unit Under Test
VDSL2	Very high bit rate Digital Subscriber Line

WAN	Wide Access Network
WCDMA	Wideband Code Division Multiple Access
WDM	Wavelength Division Multiplexing
WiMAX	Worldwide Interoperability for Microwave Access

5 Conventions

Throughout this Recommendation, it is preferred to use the terms:

- "energy consumption" to describe the transformation of input energy into the functional unit and waste within telecommunication systems;
- "energy efficiency" to describe the ability of a telecommunication system to minimize energy waste, although the term "power efficiency" can be used to convey the same meaning.

For all practical purposes, it is assumed that telecommunication system devices act as single entities, with metrics estimating the total efficiency of input energy within the entire telecommunication device.

6 Digital subscriber line access multiplexer, multi-service access node and optical line termination equipment

6.1 Informative values for digital subscriber line access multiplexer (DSLAM), multi-service access code (MSAN) and optical line termination (OLT) equipment

This clause defines the informative values with respect to the energy efficiency metrics defined for the specific technologies used by DSLAM, MSAN and OLT equipment. More precisely, this clause covers the:

- DSLAM equipment and MSAN equipment implementing ADSL2plus, VDSL2 and POTS technologies
- OLT equipment implementing the gigabit passive optical network (GPON), gigabit Ethernet passive optical network (GEPON) and point-to-point (PtP) technologies.

For these equipment typologies, the most commonly used metric is the P_{port}, which considers the number of ports at a fixed load as a functional unit.

It is assumed that this metric refers to a fully equipped configuration taking into account the line cards with the same technology (e.g., all ADSL2plus cards, all VDSL2 line cards, all GPON cards, all POTS card, etc.). Moreover, such line cards must refer to the same profile or state.

Equipment with line cards working at different profiles or states shall be characterized by different metric values for each specific profile or state.

$$P_{port} = P_{EQ} / N_{ports} \quad \text{[W/port]} \tag{1}$$

where:

P_{EQ} is the power (in watts) of a fully equipped wireline network equipment with all its line cards working in a specific profile or state (e.g., all VDSL2 subscriber lines in L0 state, all ADSL2plus subscriber lines in L2 state). For DSL line cards that have additional functions (e.g., MELT, vectoring, test access and channel bonding, etc.), in addition to the bare DSL functionality the informative value for such boards refers to a normal DSL mode of operation with any additional functions being disabled.

N_{ports} is the maximum number of ports served by the broadband network equipment under test.

Tables 6-1, 6-2, 6-3 and 6-4 contain the informative values defined for the P_{port} metric. All values refer to 48 VDC powering.

Table 6-1 − Informative values for DSLAM/MSAN in L0 mode

Specific technology for DSLAM/MSAN (L0 mode)	Informative value in L0 for equipment with more than 96 ports (W/port)	Informative value in L0 for equipment with less than 96 ports (W/port)
ADSL2plus (including ADSL and ADSL2 and with transmission power of 19.8 dBm)	1.2	1.5
VDSL2 (profile 8b) transmission power 19.8 dBm	1.8	2.1
VDSL2 (profile 12a and 17a) transmission power 14.5 dBm	1.6	1.9
VDSL2 (profile 30a) transmission power 14.5 dBm	2.0	2.3
POTS (off-hook) (see Note)	2.0	2.3
NOTE – It is assumed that power consumed by the MSAN functionality which is common to both DSL and POTS is split appropriately across the two functions. For those boards, such as combo interface board and combo main control board, which integrate DSL and POTS functions, the informative values of these boards are assumed to be measured separately for each function, i.e., measure broadband with POTS disabled and vice versa.		

Table 6-2 − Informative values for DSLAM/MSAN in L2 mode

Specific technology for DSLAM/MSAN (L2 mode)	Informative value in L2 for equipment with more than 96 ports [W/port]	Informative value in L2 for equipment with less than 96 ports [W/port]
ADSL2plus (including ADSL and ADSL2)	0.8	1.1
VDSL2 (profile 8b, 12a, 17a and 30a)	1.2	1.5
POTS (on-hook)	0.5	0.8

Table 6-3 − Informative values for DSLAM/MSAN in L3 mode

Specific technology for DSLAM/MSAN (L3 mode)	Informative value in L3 for equipment with more than 96 ports [W/port]	Informative value in L3 for equipment with less than 96 ports [W/port]
ADSL2plus (including ADSL and ADSL2)	0.4	0.7
VDSL2 (profile 8b, 12a, 17a and 30a)	0.6	0.9

Table 6-4 − Informative values for OLT in L0 mode

Specific technology for OLT (L0 mode) (see Note)	Informative value for equipment with more than 32 ports [W/port]	Informative value for equipment with up to32 ports [W/port]
G-PON (2.5G/1G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	11	12
G-PON (2.5G/1G) implementing also functionalities at the IP layer such as routing, MPLS and IP QoS, or more advanced Layer 2 functionality (QoS, shaping, policing)	12	13
1G-EPON (1G/1G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	7	8
1G-EPON (1G/1G) implementing also functionalities at the IP layer such as routing, MPLS and IP QoS, or more advanced Layer 2 functionality (QoS, shaping, policing)	8	9
1G-EPON (1G/1G) without Layer 2/Layer 3 aggregation functionality with 16 ports	–	13.4
10G-EPON (10G/1G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	15	16
10G-EPON (10G/1G) implementing also functionalities at the IP layer such as routing, MPLS and IP QoS, or more advanced Layer 2 functionality (QoS, shaping, policing)	16	17
10G-EPON (10G/10G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	16	17
10G-EPON (10G/10G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	17	18
PtP (1G)	2.5	4.5
PtP (10G)	18	30
NOTE – The informative values for G-PON, 1G-EPON and 10G-EPON OLT are assumed to be per port whatever the number of ONU connected to it is. The values for G-PON OLT are with Class B+ (Appendix III to [b-ITU-T G.984.2]) optical modules. Informative values reported for 10G-EPON type applies to IEEE 1904.1 Package C compliant systems.		

Equipment test methodologies for MSAN, DSLAM and OLT equipment have been defined in [ITU-T L.1310].

7 Wireless access technologies

7.1 Informative values for wireless access technologies

This clause defines the informative values with respect to the energy efficiency metrics defined for the following radio access technologies: GSM/EDGE, WCDMA/HSDPA, WiMAX and LTE.

Establish informative value for wireless access technologies is not simple at current stage, as there are not enough measurement results available to establish informative values strictly related to the metrics defined in [ITU-T L.1310]. Therefore, Tables 7-1, 7-2, 7-3 and 7-4 just report power consumption values for radio base stations of different technologies that can represent a useful input for the future calculation of the informative values for the energy efficiency metrics defined in [ITU-T L.1310].

A wireless access network consists of more than one element: a radio base station (RBS), a controller, etc. An RBS is a network component that serves one or more sectors and has radio frequency (RF) interfaces to mobile stations through the air interface, and has metallic or optical interfaces to a wireless network infrastructure (BSC, RNC or a mobility management entity). Within this Recommendation, the RBS can be a base transceiver station (BTS) (for GSM/EDGE and cdma2000), a NodeB (for WCDMA/HSPA), an eNodeB (for LTE) or a base station (BS) (for WiMAX). The controller functionality within an RBS has interfaces to the core network or core network simulator.

In this Recommendation only the informative power consumption values for a radio base station have been taken into account, given that the RBS energy consumption is the dominant part of the total energy consumption of a wireless access network. Informative power consumption values for low-, medium- and high-load modes have been defined for the RBS usage profile. On the other hand, informative power consumption values for idle mode and maximum-load cases have been omitted intentionally for the following reasons:

- Idle mode is a state rarely used in a practical radio network. An RBS transmits as minimum pilot and broadcast channels.
- Maximum load is typically avoided by network design. It might occur during exceptional events a few times a year. If peak load is reached repeatedly, an operator will do a capacity upgrade.
- Testing of additional modes will increase complexity and testing time without providing significant additional information and with low impact on the average power consumption.

Equipment test methodologies and configuration for wireless access technologies have been defined in [ITU-T L.1310].

Table 7-1 − Informative values for GSM/EDGE network equipment

GSM/EDGE network equipment (see Note)	Informative value [W]
	0.9/1.8/1.9 GHz
GSM/EDGE radio base station (3 sectors) – full-load state	950
GSM/EDGE radio base station (3sectors) –medium-load state	750
GSM/EDGE radio base station (3sectors) – low-load state	600
NOTE – Three sectors, four carriers per sector (S444).	

Table 7-2 − Informative values for WCDMA/HSDPA network equipment

WCDMA/HSDPA network equipment (see Note)	Informative value [W]
	2.1 GHz
WCDMA/HSDPA radio base station (3 sectors) – full-load state	900
WCDMA/HSDPA radio base station (3 sectors) – medium-load state	780
WCDMA/HSDPA radio base station (3 sectors) – low-load state	690
NOTE – 3 sectors, 2.1 GHz, two carriers per sector (S222).	

Table 7-3 − Informative values for WiMAX network equipment

WiMAX network equipment (see Note)	Informative value [W]	
	2.5 GHz	**3.5 GHz**
WiMAX radio base station (3 sectors) – full-load state	640	610
WiMAX radio base station (3 sectors) – medium-load state	570	550
WiMAX radio base station (3 sectors) – low-load state	480	460
NOTE – 3 sectors, 2.5 GHz/3.5 GHz, 10 MHz bandwidth channel, 4 × 4 MIMO, 29:18 DL/UL sub-frame ratio.		

Table 7-4 − Informative values for WiMAX network equipment

LTE network equipment (see Note)	Informative value [W]
	2.6 GHz
LTE radio base station (3 sectors) – full-load state	1100
LTE radio base station (3 sectors) – medium-load state	950
LTE radio base station (3 sectors) – low-load state	750
NOTE – 3 sectors, 2.6 GHz, 20 MHz bandwidth channel 2 × 2 MIMO.	

8 Routers and Ethernet switches

This clause defines the informative values with respect to the energy efficiency metrics defined for routers and Ethernet switches.

8.1 Informative values for routers and Ethernet switches

This clause addresses informative values for equipment categorized as enterprise, service provider and branch office routers, and Ethernet switch equipment.

The metric defined for such types of equipment is the following:

$$EER = T_i \,/\, P_w \quad \text{[Mbit/s/W]} \tag{2}$$

where:

T_i is weighted throughput

P_w is weighted power (energy consumption rate).

$$T_i = a \times T_{u1} + b \times T_{u2} + c \times T_{u3} \tag{3}$$

$$P_w = a \times P_{u1} + b \times P_{u2} + c \times P_{u3} \tag{4}$$

where:

(a, b, c): relative weights for utilization levels, where $a + b + c = 1$, see Tables 8-1 and 8-3

(P_{u1}, P_{u2}, P_{u3}): power measured at respective utilization levels

(T_{u1}, T_{u2}, T_{u3}): throughput measured at respective utilization levels, see Tables 8-1 and 8-3.

Table 8-1 − Class definitions, energy efficiency rating (EER) calculation parameters and load profiles for routing equipment

Class	Representative utilization	Percentage of utilization for energy measurements, $u1$, $u2$, $u3$	Weight multipliers a, b, c	Traffic profile simple IMIX

Access router	1-3%	0; 10; 100	a = 0.1;
			b = 0.8;
			c = 0.1
				(IPv4)

Edge router	3-6%	0; 10; 100	a = 0.1;
			b = 0.8;
			c = 0.1
				IPv4/6/MPLS

Core router	20-30%	0; 30; 100	a = 0.1;
			b = 0.8;
			c = 0.1
				IPv4/6/MPLS

Due to the nature of the product in which the same functionality can be obtained using different configurations and considering that currently there is a huge variety of products and associated configurations, it is therefore not easy to define a unique value for each equipment type considering the classification adopted for such types. Moreover, for modular products, the permutations of hardware configurations are even higher.

For these reasons, the values reported in the following tables for routers and switches report informative ranges instead of specific values.

It is highlighted that, in order to make a real comparison between different products, the following process must be followed:

1. Select a group of functionally similar products based on expected use; for example, 48 GE port Layer 2 switch with 2 10GE uplink ports

   or

   24 GE ports Layer 3/4 POE-capable switch with 4 GE uplinks.
2. Perform proper testing or obtain test reports from vendors to obtain energy efficiency rating (EER) numbers.
3. Compare EER numbers. A product with the highest EER number, expressed in the same units, is the most energy efficient.

Tables 8-2 and 8-4 report examples of possible EER range for different classes of equipment.

Table 8-2 − Example of values for routing equipment

Class	Informative value [Mbit/s/W]
Access router	12~50
Edge router	35~100
Core router	50~300

Specific examples of EER from routers currently available in the market are reported in Appendix II.

Table 8-3 − Class definitions, EER calculation parameters and load profiles for Ethernet switching equipment

Class	Representative utilization	Percentage of utilization for energy measurements, $u1$, $u2$, $u3$	Weight multipliers a, b, c	Traffic profile simple IMIX, unicast
Access	1-3%	0; 10; 100	a = 0.1; b = 0.8; c = 0.1	Ethernet
High speed access	5-8%	0; 10; 100	a = 0.1; b = 0.8; c = 0.1	Ethernet
Distribution/ aggregation	10-15%	0;10;100	a = 0.1; b = 0.8; c = 0.1	Ethernet
Core	15-20%	0; 30; 100	a = 0.1; b = 0.8; c = 0.1	Ethernet
Data centre	12-18%	0; 30; 100	a = 0.1; b = 0.8; c = 0.1	Ethernet

Table 8-4 − Example of values for Ethernet switching equipment

Class	Informative value (Mbit/s/W)
Access	20~300
High speed access	20~300
Distribution/aggregation	20~200
Core	50~400
Data centre	50~400

Equipment test methodologies for routers and Ethernet switches have been defined in [ITU-T L.1310].

9 Energy efficiency metric for small networking devices

9.1 Informative values for small networking devices

The metric adopted for small networking devices intended for home/domestic or small office use is:

$$EER = \frac{0.35 \times Tidle + 0.5 \times Tlowpower + 0.15 \times T\mathrm{Maximum}}{0.35 \times P\,idle + 0.5 \times Plowpower + 0.15 \times P\mathrm{maximum}} \quad \text{(Mbit/s/W)} \tag{5}$$

For interfaces with throughput (T) sensitive to distance, this is defined as:

$$T = 0.5 \times \left(T_{20\%\text{ of max distance}} + T_{80\%\text{ of max distance}}\right) \tag{6}$$

Power shall be averaged over 5 minutes, taking measurements every 30 seconds. During idle power, IP ping shall be sent via the user interface. The informative values for small networking devices are reported in Table 9-1.

Table 9-1 − Informative values for small networking equipment

Class	Informative value [Mbit/s/W]
Small network equipment	5~50

Equipment test methodologies for small networking devices have been defined in [ITU-T L.1310].

Appendix I

Alternative informative values for wireline access technologies

(This appendix does not form an integral part of this Recommendation.)

This appendix reports an alternative metric available for wireline access technologies (including MSAN, DSLAM, GPON OLT and GEPON OLT).

EER: This metric considers the maximum output bit rate per line at different traffic states as a functional unit (variable load → traffic related metric).

$$EER_{avg} = T_{OSavg} \, / \, P_{avg} \quad \text{[Mbits/W]} \tag{I-1}$$

where:

T_{OSavg} output bit rate per subscriber line: is the weighted output bit rate for subscriber (in Mbit/s) of the broadband network equipment in possible (if implemented) different operational states (L0, L2, L3).

$$T_{OSavg} = a \times T_{OS1} + b \times T_{OS2} + c \times T_{OS3} \tag{I-2}$$

P_{avg} is the weighted energy consumption (in watts) per line of the broadband network equipment in possible (if implemented) different states

$$P_{avg} = a \times P_1 + b \times P_2 + c \times P_3 \quad \text{[W]} \tag{I-3}$$

where:

(a, b, c) are weight coefficients selected such as $(a + b + c) = 1$.

P_1, P_2, P_3 are power measurements (in watts) of fully equipped broadband network equipment, operating in different traffic conditions as defined below.

I.1 Informative values for DSLAM and MSAN network equipment

For DSLAM and MSAN network equipment, power is measured on a fixed loop length defined for any technology.

The parameter a, b and c values consider the traffic distribution during the day. These values are established considering the distribution of traffic contained in [ETSI ES 203 215].

P_1, P_2, P_3 are power measurements (in Watts) of fully equipped broadband network equipment, operating in L0, L2 and L3 states, respectively. The values, reported in Table I.1, depend on the energy mode available in the equipment.

Tables I.2 and I.3 report EER_{avg} informative values for DSLAM and MSAN with respectively more and less than 96 ports.

Table I.1 − Weight factor definition for DSLAM and MSAN

Power mode available	Weight multipliers a, b, c, d
L0, L2, L3	a = 0.15; b = 0.06; c = 0.79
L0, L2	a = 0.2; b = 0.8; c = 0
L0	a = 1; b = 0; c = 0

Table I.2 − EER_{avg} Informative values for DSLAM and MSAN with more than 96 ports

Specific technology for DSLAM/MSAN	EER informative value for equipment with L0, L1 and L2 with more than 96 ports [Mbits/W]	EER informative value for equipment with L0 and L2 with more than 96 ports [Mbits/W]	EER informative value for equipment with L0 with more than 96 ports [Mbits/W]
ADSL2plus (including ADSL and ADSL2 and with transmission power of 19.8 dBm)	5.5	4.6	16.7
VDSL2 (profile 8b) transmission power 19.8 dBm	7.4	6.1	22.2
VDSL2 (profile 12a and 17a) transmission power 14.5 dBm	11.5	9.4	37.5
VDSL2 (profile 30a) transmission power 14.5 dBm	14.2	11.8	40

Table I.3 − EER_{avg} Informative values for DSLAM and MSAN with less than 96 ports

Specific technology for DSLAM/MSAN	EER informative value for equipment with L0, L1 and L2 with less than 96 ports [Mbits/W]	EER informative value for equipment with L0 and L2 with more less 96 ports [Mbits/W]	EER informative value for equipment with L0 with less than 96 ports [Mbits/W]
ADSL2plus (including ADSL and ADSL2 and with transmission power of 19.8 dBm)	3.6	3.4	13.3
VDSL2 (profile 8b) transmission power 19.8 dBm	5.4	5.0	19.0
VDSL2 (profile 12a and 17a) transmission power 14.5 dBm	8.3	7.6	31.6
VDSL2 (profile 30a) transmission power 14.5 dBm	10.5	9.7	34.8

I.2 Informative values for OLT network equipment

For G-PON OLT equipment, the EER is an indicator of the amount of traffic transported for each watt of power in a fully equipped configuration.

Since the power of typical OLT gear is not directly related to optical fibre length, it is not necessary to define a reference optical fibre length.

$$EER = (\text{Bit rate per port}) / P_{port} \quad [\text{Mbits/W}] \tag{I-4}$$

where:

"Bit rate per port": is the downstream active data rate expressed in Gigabit/s

P_{port}: is the associated unit power consumption (in terms of watts) of the equipment.

Tables I.4 and I.5 report EER informative values for respectively G-PON OLT and 1G-EPON.

Table I.4 − EER informative values for G-PON OLT

Specific technology for OLT (see Note) (L0 mode)	EER informative value for equipment with more than 32 ports [Mbits/W]	EER informative value for equipment with up to 32 ports [Mbits/W]
G-PON (2.5G/1G) implementing standard Layer 2 (Ethernet) aggregation functionalities, including Multicast	230	210
G-PON (2.5G/1G) implementing also functionalities at the IP layer such as routing, MPLS and IP QoS, or more advanced Layer 2 functionality (QoS, shaping, policing)	210	190
NOTE – The informative values for G-PON OLT are assumed to be per port whatever the number of ONU connected to it is. The values for G-PON OLT are with Class B+ (Appendix III to [b-ITU-T G.984.2]) optical modules.		

For 1G-EPON OLT equipment, EER is an indicator of the amount of available port for each watt of power in a fully equipped configuration.

For OLT, use a value that divides average power consumption for the OLT (at full mounting), measured using DC input if the equipment power source is DC and AC input if the power source is AC, by the total number of lines (Total number of IF ports × number of PON branches).

$$EER = \text{total number of IF port/average power} \quad [\text{line/W}] \qquad \text{(I-5)}$$

where:

Average power: (power at 100% load + power at 50% load + power at 0% load)/3.

NOTE − It is possible to obtain a metric of the number of subscriber lines by multiplying the defined EER by the number of branches (e.g., 32).

Table I.5 − EER informative values for 1G-EPON OLT

Specific technology for OLT (see Note) (L0 mode)	EER informative value for equipment with more than 32 ports [line/W]	EER informative value for equipment with up to 32 ports [line/W]
1G-EPON (1G/1G) without Layer 2/Layer 3 aggregation functionality with 16 ports	To be defined	2.38
NOTE – The informative values for 1G-EPON OLT are assumed to be per port whatever the number of ONU connected to it is.		

Appendix II

Examples of calculation of EER for specific routers and switches

(This appendix does not form an integral part of this Recommendation.)

Tables II.1 and II.2 report examples of EER values for routers and switches currently available in the market.

Table II.1 – Examples of EER values for routers currently available in the market

Equipment	Class	T_{u1} (Gbit/s)	T_{u2} (Gbit/s)	T_{u3} (Gbit/s)	P_{u1} (W)	P_{u2} (W)	P_{u3} (W)	T_i (Gbit/s)	P_i (W)	EER (Mbits/W)
Equipment A	Core router	0	36	120	380	425	460	40.8	424	96.2
Equipment B	Core router	0	240	800	2250	2320	2530	272	2334	116.5
Equipment C	Access router	0	0.56	5.6	65.5	73.71	81.9	1	73.7	13.56

Table II.2 – Examples of EER values for switches currently available in the market

Layer 2 Switch 1RU Model description		Units	0%	10% NDR	30% NDR	100% NDR	Theoretical maximum/ power supply rating	EER Mbits/W
24 × 1000 Copper 4 × 1Gig SFP Non-POE	**Throughput**	Gbit/s	0	0.1499	N/A	1.5923	2 G	9.31
	Power	W	31.1162	30.6824	N/A	31.0571	60W	
48 × 1000 Copper 4 × 1Gig SFP Non-POE	**Throughput**	Gbit/s	0	0.1487	N/A	1.4899	2 G	5.50
	Power	W	49.1755	48.6903	N/A	48.8465	135W	
24 × 1000 Copper 4 × 1Gig SFP Non-POE	**Throughput**	Gbit/s	0	0.3205	N/A	3.2854	4 G	17.53
	Power	W	34.2528	33.6622	N/A	33.8337	60W	
48 × 1000 Copper 4 × 1Gig SFP Non-POE	**Throughput**	Gbit/s	0	0.3124	N/A	3.1265	4 G	11.26
	Power	W	50.895	49.857	N/A	50.03	135W	
48 × 1000 Copper 4 × 1Gig SFP Partial POE	**Throughput**	Gbit/s	0	0.3168	N/A	3.1254	4 G	8.86
	Power	W	64.514	63.3579	N/A	63.6261	525W	
24 × 1000 Copper 4 × 1Gig SFP Full POE	**Throughput**	Gbit/s	0	0.3123	N/A	3.1019	4 G	42.99
	Power	W	72.7463	72.0718	N/A	72.2093	915W	
24 × 1000 Copper 4 × 1Gig SFP Partial POE	**Throughput**	Gbit/s	0	0.3206	N/A	3.2061	4 G	7.74
	Power	W	51.6973	50.9736	N/A	51.1213	525W	
48 × 1000 Copper 2 × 10Gig SFP Non-POE	**Throughput**	Gbit/s	0	1.4565	N/A	14.6009	20 G	50.26
	Power	W	52.9248	51.9847	N/A	52.8041	135W	
24 × 1000 Copper 2 × 10Gig SFP Non-POE	**Throughput**	Gbit/s	0	1.54	N/A	15.366	20 G	74.64
	Power	W	37.1242	37	N/A	37.4518	60W	

Table II.2 – Examples of EER values for switches currently available in the market

Layer 2 Switch 1RU **Model description**		**Units**	**0%**	**10% NDR**	**30% NDR**	**100% NDR**	**Theoretical maximum/ power supply rating**	**EER** **Mbits/ W**
24 × 1000 Copper 2 × 10Gig SFP POE	**Throughput**	Gbit/s	0	1.5398	N/A	15.2835	20 G	51.47
	Power	W	53.3812	53.3489	N/A	54.2976	525W	
48 × 1000 Copper 2 × 10Gig SFP Full POE	**Throughput**	Gbit/s	0	1.4258	N/A	14.274	20 G	31.36
	Power	W	82.9217	81.7391	N/A	82.6494	915W	
48 × 1000 Copper 2 × 10Gig SFP Partial POE	**Throughput**	Gbit/s	0	1.4447	N/A	14.594	20 G	37.10
	Power	W	71.7667	70.5993	N/A	71.4371	525W	

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