



INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

# L.1310

(09/2020)

SERIES L: ENVIRONMENT AND ICTS, CLIMATE  
CHANGE, E-WASTE, ENERGY EFFICIENCY;  
CONSTRUCTION, INSTALLATION AND PROTECTION  
OF CABLES AND OTHER ELEMENTS OF OUTSIDE  
PLANT

---

## Energy efficiency metrics and measurement methods for telecommunication equipment

### **CAUTION !**

### ***PREPUBLISHED RECOMMENDATION***

This prepublication is an unedited version of a recently approved Recommendation. It will be replaced by the published version after editing. Therefore, there will be differences between this prepublication and the published version.

## FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

## NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

## INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU [had/had not] received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2020

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

## **Recommendation ITU-T L.1310**

### **Energy efficiency metrics and measurement methods for telecommunication equipment**

#### **Summary**

Recommendation ITU-T L.1310 contains the definition of energy efficiency metrics test procedures, methodologies and measurement profiles required to assess the energy efficiency of telecommunication equipment.

Energy efficiency metrics and measurement methods are defined for telecommunication network equipment and small networking equipment.

These metrics allow for the comparison of equipment within the same class, e.g., equipment using the same technologies.

The comparison of equipment in different classes is out of the scope of this Recommendation.

#### **Keywords**

Energy efficiency, methodology, metrics.

## Table of Contents

|       |                                                                      |    |
|-------|----------------------------------------------------------------------|----|
| 1     | Scope .....                                                          | 6  |
| 2     | References.....                                                      | 6  |
| 3     | Definitions .....                                                    | 7  |
| 3.1   | Terms defined elsewhere .....                                        | 7  |
| 3.2   | Terms defined in this Recommendation.....                            | 7  |
| 4     | Abbreviations and acronyms .....                                     | 7  |
| 5     | Conventions .....                                                    | 9  |
| 6     | Metrics definitions.....                                             | 9  |
| 6.1   | General .....                                                        | 9  |
| 6.2   | Energy efficiency hierarchy .....                                    | 9  |
| 6.2.1 | Energy efficiency at the network level.....                          | 9  |
| 6.2.2 | Energy efficiency at the equipment and system levels .....           | 10 |
| 6.2.3 | Energy efficiency at the component level .....                       | 10 |
| 6.3   | Load-proportional efficiency .....                                   | 10 |
| 6.4   | Metrics robustness .....                                             | 10 |
| 6.5   | Metrics and equipment modularity.....                                | 10 |
| 7     | General test methodology .....                                       | 11 |
| 7.1   | Environmental conditions.....                                        | 11 |
| 7.1.1 | Temperature .....                                                    | 11 |
| 7.1.2 | Humidity .....                                                       | 11 |
| 7.1.3 | Air pressure .....                                                   | 11 |
| 7.2   | Electrical conditions .....                                          | 11 |
| 7.2.1 | DC voltage .....                                                     | 11 |
| 7.2.2 | AC voltage and frequency.....                                        | 11 |
| 7.3   | Metrology requirements .....                                         | 11 |
| 8     | Reporting format.....                                                | 12 |
| 9     | DSLAM, MSAM GPON GEPON equipment.....                                | 12 |
| 9.1   | Metric for DSLAM, MSAM GPON GEPON equipment .....                    | 12 |
| 9.2   | Equipment test methodologies for broadband access technologies ..... | 13 |
| 9.2.1 | DSLAM and MSAN network equipment .....                               | 13 |
| 9.2.2 | GPON OLT network equipment .....                                     | 13 |
| 9.2.3 | GEPON OLT network equipment.....                                     | 13 |
| 10    | Wireless access technologies.....                                    | 13 |
| 10.1  | Metrics for wireless access technologies.....                        | 14 |

|            |                                                                                                                                               |    |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----|
| 10.1.1     | Metric for wireless access equipment power/energy consumption.....                                                                            | 14 |
| 10.1.2     | Metric for wireless access equipment RF energy efficiency .....                                                                               | 14 |
| 10.1.3     | Metric for wireless access equipment dynamic energy efficiency.....                                                                           | 15 |
| 10.2       | Tests methodologies for wireless access technologies.....                                                                                     | 15 |
| 10.2.1     | Test methodologies for wireless access equipment power<br>consumption and energy efficiency .....                                             | 15 |
| 10.2.2     | Test methodologies for wireless access equipment RF energy<br>efficiency.....                                                                 | 15 |
| 11         | Routers, Ethernet switches .....                                                                                                              | 16 |
| 11.1       | Metrics for routers and Ethernet switches .....                                                                                               | 16 |
| 11.2       | Tests methodologies for routers and packet switches (Ethernet, MPLS,<br>etc.).....                                                            | 17 |
| 12         | Energy efficiency metric for small networking devices .....                                                                                   | 17 |
| 12.1       | Metrics for small networking devices .....                                                                                                    | 17 |
| 12.2       | Test methodologies for small networking devices .....                                                                                         | 18 |
| 13         | WDM/TDM/OTN transport MUXes/switches.....                                                                                                     | 18 |
| 13.1       | Metrics for WDM/TDM/OTN transport MUXes/switches.....                                                                                         | 18 |
| 13.2       | Test methodologies for WDM/TDM/OTN transport MUXes/switches.....                                                                              | 19 |
| 14         | Converged packet optical equipment .....                                                                                                      | 19 |
| 14.1       | Metrics for converged packet optical equipment .....                                                                                          | 19 |
| 14.2       | Test methodologies for converged packet optical equipment .....                                                                               | 19 |
| 14.2.1     | Test methodologies for converged packet optical equipment with<br>packet signal and TDM signal functions.....                                 | 19 |
| 14.2.2     | Test methodologies for converged packet optical equipment with<br>packet signal, TDM signal and WDM signal functions.....                     | 19 |
| Annex A    | Metrics and measurement methodologies for converged packet optical<br>equipment with both packet signal and TDM signal functions .....        | 20 |
| A.1        | Equipment definition .....                                                                                                                    | 20 |
| A.2        | Energy efficiency metrics.....                                                                                                                | 22 |
| A.3        | Measurement methodology .....                                                                                                                 | 23 |
| Annex B    | Metrics and measurement methodologies for converged packet optical<br>equipment with packet signal, TDM signal and WDM signal functions ..... | 25 |
| B.1        | Equipment definition .....                                                                                                                    | 25 |
| B.2        | Energy efficiency metrics.....                                                                                                                | 25 |
| B.3        | Measurement methodology .....                                                                                                                 | 28 |
| Appendix I | Alternative metrics for wireline access technologies.....                                                                                     | 31 |
| I.1        | DSLAM and MSAN network equipment.....                                                                                                         | 31 |

|              |                                                             |    |
|--------------|-------------------------------------------------------------|----|
| I.2          | GPON OLT network equipment .....                            | 32 |
| I.3          | GEAPON OLT network equipment .....                          | 32 |
| Appendix II  | Alternative metrics for routers and switches .....          | 33 |
| II.1         | Routers and switches supporting sleep (standby) mode.....   | 33 |
| II.2         | Measurement methodology .....                               | 34 |
| II.3         | Routers and switches supporting explicit power states ..... | 34 |
| Bibliography | .....                                                       | 35 |

## Introduction

In general, energy efficiency is defined as the ratio of two different energy consumption values bearing the same functional unit (i.e., the ratio of useful work (energy) to total work (energy)). This definition is not easily applicable to a telecommunication system, as it does not consider the telecommunication performance of the equipment being measured.

Therefore, for the purposes of this Recommendation, energy efficiency will be defined as the relationship between the specific functional unit for a piece of equipment (i.e., the useful work of telecommunications) and the energy consumption of that equipment. For example, when transmission time and frequency bandwidth are fixed, a telecommunication system that can transport more data (in bits) with less energy (in joules) is considered to be more energy efficient.

For this reason, metrics that can evaluate the performance of a piece of equipment against its energy consumption are to be defined.

# Recommendation ITU-T L.1310

## Energy efficiency metrics and measurement methods for telecommunication equipment

### 1 Scope

This Recommendation specifies the principles and concepts of energy efficiency metrics and measurement methods for telecommunication network equipment.

This Recommendation also specifies the principles and concepts of energy efficiency metrics and measurement methods for small networking equipment used in the home and small enterprise locations.

### 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.

- |                        |                                                                                                                                                                                                                           |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [ATIS-0600015.02.2009] | ATIS-0600015.02.2009, <i>Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – Transport Requirements.</i>                                                                       |
| [ATIS-0600015.03.2013] | ATIS-0600015.03.2009, <i>Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products.</i>                                                       |
| [ETSI EN 303 215]      | ETSI EN 303 215 V1.3.1 (2015), <i>Environmental Engineering (EE) Measurement methods and limits for power consumption in Broadband telecommunication networks equipment.</i>                                              |
| [ETSI ES 202 706-1]    | ETSI ES 202 706-1 V1.5.0 (2016), <i>Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment; Part 1: Power Consumption - Static Measurement Method.</i> |
| [ETSI TS 102 706-2]    | ETSI TS 102 706-2 V1.5.1 (2018) <i>Environmental Engineering (EE) Metrics and Measurement Method for Energy Efficiency of Wireless Access Network Equipment Part 2; Energy Efficiency – dynamic measurement method</i>    |
| [ISO 14040]            | ISO 14040:2006, <i>Environmental management – Life cycle assessment – Principles and framework.</i>                                                                                                                       |
| [ISO/IEC 17025]        | ISO/IEC 17025:2005, <i>General requirements for the competence of testing and calibration laboratories.</i>                                                                                                               |

## 3 Definitions

### 3.1 Terms defined elsewhere

None.

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 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.

**3.2.2 energy:** "The capacity for doing work". In the telecommunication systems, where the primary source of energy is electricity, energy is measured in joules or Watt hours

**3.2.3 energy efficiency:** Useful output/energy consumption

**3.2.4 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.

**3.2.5 idle mode:** A network element 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 .

**3.2.6 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.

**3.2.7 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.

**3.2.8 useful output:** The useful work carried out by the equipment, e.g. delivered bits or output energy from a wireless equipment.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

|        |                                                                     |
|--------|---------------------------------------------------------------------|
| AC     | Alternating Current                                                 |
| ADSL2+ | Asymmetric Digital Subscriber Line 2 transceiver extended bandwidth |
| BSC    | Base Station Controller                                             |
| BTS    | Base Transceiver Station                                            |
| CDMA   | Code Division Multiple Access                                       |
| DC     | Direct Current                                                      |
| DSLAM  | Digital Subscriber Line Access Multiplexer                          |
| EDGE   | Enhanced Data for GSM Evolution                                     |
| EER    | Energy Efficiency Rating                                            |

|       |                                             |
|-------|---------------------------------------------|
| GEPON | Gigabit Ethernet Passive Optical Network    |
| GPON  | Gigabit Passive Optical Network             |
| GSM   | Global System for Mobile Communications     |
| HSPA  | High Speed Packet Access                    |
| IF    | Interface                                   |
| IMIX  | Internet MIX traffic                        |
| LAN   | Local Area Network                          |
| LTE   | Long Term Evolution                         |
| MAC   | Media Access Control                        |
| MPLS  | Multiprotocol Label Switching               |
| MSAN  | Multiservice Access Node                    |
| NNI   | Network-Network Interface                   |
| OADM  | Optical Add-Drop Multiplexer                |
| OC    | Optical Carrier                             |
| OLT   | Optical Line Termination                    |
| ONT   | Optical Network Termination                 |
| OTN   | Optical Transport Network                   |
| OTU   | Optical Transport Unit                      |
| OXC   | Optical Cross Connect                       |
| P2P   | Point-to-Point                              |
| PF    | Power Factor                                |
| PON   | Passive Optical Network                     |
| PONIF | Passive Optical Network Interface           |
| POTS  | Plain Old Telephone Service                 |
| PSU   | Power Supply Unit                           |
| RBS   | Radio Base Station                          |
| RF    | Radio Frequency                             |
| RFU   | Radio Frequency Unit                        |
| RNC   | Radio Network Controller                    |
| ROADM | Reconfigurable Optical Add-Drop Multiplexer |
| SDH   | Synchronous Digital Hierarchy               |
| SONET | Synchronous Optical Network                 |
| STM   | Synchronous Transport Module                |
| SW    | Switch                                      |
| TDM   | Time Division Multiplex                     |

|       |                                                 |
|-------|-------------------------------------------------|
| TEER  | Telecommunications Energy Efficiency Ratio      |
| UNI   | User Network Interface                          |
| VDSL2 | Very high bit rate Digital Subscriber Line      |
| WAN   | Wide Area Network                               |
| WCDMA | Wideband Code Division Multiple Access          |
| WDM   | Wavelength Division Multiplexing                |
| WiMAX | Worldwide Interoperability for Microwave Access |

## 5 Conventions

In this Recommendation, the term "energy consumption" is used to describe the transformation of input energy into the functional unit and waste within telecommunication systems.

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.

In this Recommendation, the term "energy efficiency" is used to describe the ability of a telecommunication system to minimize energy waste, although "power efficiency" could also have been used for the same purpose.

## 6 Metrics definitions

### 6.1 General

The energy efficiency metric is typically defined as the ratio between the functional unit and the energy necessary to deliver the functional unit; the higher the value of the metric, the greater the efficiency of the equipment.

The inverse metric, energy divided by functional unit, could be used as an alternative.

The following clauses contain detailed metric definitions and test methodologies for various telecommunication equipment.

The energy efficiency rating (EER) is a metric generally defined as a functional unit divided by the energy used. Various types of equipment have their own EER definitions

### 6.2 Energy efficiency hierarchy

An energy efficiency metric can be defined at the network level, the system level, the equipment level and the component level. In this Recommendation, only metrics at the system and equipment levels are considered as mandatory. Metrics at the component level are given as suggestions only and are not mandatory.

#### 6.2.1 Energy efficiency at the network level

Network level metrics are used to evaluate the energy efficiency of an entire network or part of it (e.g., the access network of an operator). They are normally used to evaluate a network for internal operator use or to satisfy an environmental assessment. For this Recommendation, the network level is considered a metric that will cover not only one single product but also a telecommunication network composed of different interworking equipment.

## **6.2.2 Energy efficiency at the equipment and system levels**

Equipment and system levels metrics are mostly used to compare telecommunication equipment of the same technology and similar configuration. They evaluate the overall energy efficiency performance at the equipment and system levels, which are considered as a "single box" or "single entity", from the measurement point of view.

## **6.2.3 Energy efficiency at the component level**

Component-level metrics can be used in the design, development and manufacture of energy efficient equipment. They regard equipment as an "open box" and evaluate the energy efficiency performance of its individual components. Measuring and understanding the energy efficiency or energy consumption of each component within the equipment helps to identify the bottlenecks and key components in a system with regard to energy saving. It should be kept in mind that these kinds of metrics may lead to sub-optimizations unless considered in the context of the overall equipment's energy efficiency.

## **6.3 Load-proportional efficiency**

There are classes of telecommunication equipment (e.g., time division multiplex (TDM) switches), where the functional unit is stationary and does not change through the active-use phase.

However, a vast number of telecommunication devices operate under variable-load conditions, where the measured value of a functional unit can fluctuate based on user demand.

Ideally, telecommunication devices should be able to reduce their energy consumption in proportion to the useful output produced. However, this goal presents different challenges and opportunities in recognizing and responding to low utilization periods.

In order to capture such capabilities, where available, this Recommendation defines the EER as a weighted, load-proportional metric.

## **6.4 Metrics robustness**

To allow reliable equipment comparisons based on metrics, the metric values should be obtained in strict accordance with ITU-T documentation and the referenced standardization documents.

Whenever the complete application of this Recommendation is not possible for technological reasons (e.g., new technologies may not be covered or may make measurement implementation difficult), manufacturers can use another metric that should be clearly documented.

## **6.5 Metrics and equipment modularity**

Telecommunication equipment is commonly available in both fixed and modular form factors. In the latter case, telecommunication equipment can be configured in various ways, which may affect its efficiency ratings. Throughout this Recommendation, the following approach to modularity is recommended:

- Metrics for modular telecommunication systems shall be obtained using the most common set-up and configurations. The metrics shall be reported along with the telecommunication equipment configuration used.
- Metrics for other telecommunication equipment configurations can be obtained by using metrics obtained from partial configurations. This methodology is described in the relevant measurement procedures. (For example, in [ATIS-0600015.02.2009] this is called the "modular method", and in [ETSI EN 303 215] it is called the "alternative method").