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Contents

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

The present document contains high level definition of energy efficiency, energy management requirement to increase the energy efficiency of ICT goods/networks/services.

Introduction

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5 and published respectively by ITU and ETSI as Recommendation ITU-T L.1315 [i.3] and ETSI Standard ETSI ES 203 475, which are technically equivalent.

1 Scope

The present document specifies terminology, principles and concepts for Energy efficiency and energy management.

The present document establishes common understanding on measurement methodology used to determine the energy efficiency of a good, service and network.

The present document is a framework for other ETSI standards and other Standard Development Organization SDO document for Energy efficiency thematic.

2 References

2.1 Normative references

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

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

Not applicable.

2.2 Informative references

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

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

[i.1] Recommendation ITU-T L.1310 (08/2014): "Energy efficiency metrics and measurement methods for telecommunication equipment".

[i.2] ISO 14040 (07/2006): "Environmental management -- Life cycle assessment -- Principles and framework".

[i.3] Recommendation ITU-T L.1315 (05/2017): "Standardization terms and trends in energy efficiency".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

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. (As defined in Recommendation ITU-T L.1310 [i.1]).

energy: "The capacity for doing work". In the telecommunication systems, where the primary source of energy is electricity, energy is measured in Joules. (As defined in Recommendation ITU-T L.1310 [i.1]).

functional unit: (Based on ISO 14040 [i.2]). A performance representation of the system under analysis. For example, for transport equipment, the functional unit is the amount of Data transmitted, the distance over which it is transported and its rate in Gbit/s. Sometimes the term is used to represent useful output or work. (As defined in Recommendation ITU-T L.1310 [i.1]).

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). (As defined in Recommendation ITU-T L.1310 [i.1]).

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. (As defined in Recommendation ITU-T L.1310 [i.1]).

small networking device: A networking device with fixed hardware configuration, designed for home/domestic or small office use, with less than 12 wired ports. This device can have wireless functionality implemented. (As defined in Recommendation ITU-T L.1310 [i.1]).

3.2 Symbols

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

η	Efficiency

3.3 Abbreviations

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

AC	Alternating Current
CRT	Cathode Ray Tube
EER	Energy Efficiency Rating
EUT	Equipment Under Test
ICT	Information and Communication Technology
LAN	Local Area Network
LCD	Liquid Cristal Display
LED	Light Emitting Diode
PUE	Power Usage Effectiveness (for datacentre)
SDO	Standard Development Organization
WAN	Wide Area Network

4 Energy Efficiency

4.1 General concept

Energy Efficiency is a widely used term with multiple meanings, one can hear "use stairs, be energy efficient" Energy efficient office or house or many others.

Since we are talking about electrical devices, efficiency definition could start from a generic definition for Energy Efficiency for energy converting devices:

$$\eta = Energy_{output} / Energy_{input} \quad (1)$$

"Energy Efficiency" that applies to any device that uses energy to do work: "Percentage of total energy input to a machine or equipment that is consumed in useful work and not wasted as useless heat." This could be expressed as follows:

$$\eta = \frac{Energyforusefullwork}{Totalusedenergy} \quad (2)$$

By definition, "Energy Efficiency" is always in the range from 0 to 1, or 0 to 100 % (if expressed as a percentage).

The goal of increasing energy efficiency is to realize solutions that will give the same or better functionality using less energy.

For IT equipment output energy does not represent useful output energy therefore, Energy, Energy Efficiency for IT equipment shows how much energy used to perform a Functional Unit (which is specific for the device or solution). EE increase is one of ways of managing and restraining the growth in energy consumption. Devices is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. For example, when a LED/LCD Display uses less energy than a traditional display based on Cathode Ray Tube (CRT) to reproduce the video, the display is considered to be more energy efficient.

The goal of energy efficiency increase is to provide solutions that will give more functionality using less energy.

Trivial solution for the maximum energy saving can be achieved simply by switching off the device, but that will eliminate the service delivered by the device as well and EE will be zero as a result.

This is the major reason to consider for an equipment the energy efficiency and not only the energy consumption; Energy Efficiency is not an absolute metric, this implies that if it is necessary to do a comparison between equipment it is possible only for equipment of the same type and with similar functionality.

Energy efficiency increase is important at all stages of the energy chain from generation to final consumption. Eventually the benefits of energy efficiency increase will outweigh the costs, for instance those involved in renovations.

Energy efficiency is not equal to energy conservation. Energy conservation is reducing or going without a service to save energy.

The Power Usage Effectiveness (PUE) concept used for data centre follows this formulation.

When the energy efficiency concept it is applied to the ICT world, it is not possible to make reference to output to power or energy and it is important to introduce the concept of a proxy for useful work, changing formula 1.

In this case, the energy efficiency rating of functionality shall be expressed as the ratio between the expected result normally called a proxy for Useful work (similar to Functional Unit) and the energy used to realize the that functionality.

The new formula will be:

$$EER = \frac{usefulwork}{Totalusedenergy} \quad (3)$$

This formula in this case is not a ratio between two values with same units but between two different characteristics so the indicator of efficiency realized will be not a pure number but a ratio of useful work and energy the measurement unit will be different depending on the useful work selected for the service/EUT e.g. bit/J in the case that the useful work is a throughput, measured in bit/s

To have an easy way to measure the efficiency, in the case of equipment without a big variation of energy consumption, it is preferable to measure the power of an equipment instead of the energy. In this case the power will be not an instantaneous power but a power averaged in a time period to eliminate the fluctuation of the instantaneous power measurement.

In this last case the energy efficiency it is expressed with the same terminology but using total power and not total energy in the numerator of the formula.

The energy efficiency indicator (EER) is a device metric defined as a Functional Unit divided by the power. Various types of equipment have their own EER definitions.

4.2 Energy efficiency hierarchy

4.2.0 Energy efficiency general definition

An energy efficiency metric can be defined at different level:

- the network/solution level,
- the equipment/system level,
- the component level.

Normally in standardization, only metrics at network equipment/system level are considered, defined and used to test/evaluate the energy efficiency of equipment/system; metrics at the component level are given as suggestions only and could be used as a tool to improve the efficiency of an equipment.

Metrics at the network level are under study.

4.2.1 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 an internal network of an operator use and to satisfy an environmental goals. For the present document, the network level EE is considered a metric that will cover not only one single product but all equipment used to build telecommunication network, composed of different interworking equipment.

4.2.2 Energy efficiency at the equipment/system level

Equipment/system level metrics are mostly used to compare telecommunication equipment of the same functionality and place in a network. They evaluate the overall energy efficiency performance at the equipment/system level, which is considered as a "single box" or "single entity", from the measurement and reporting point of view.

4.2.3 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 "hot spots" 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.

5 Useful work concept for ICT

Useful work is a general expression used to define the expected result that it is desired to be delivered by a device.

Considering that ICT devices are very complex, it is not simple to find a correct Functional Unit/ proxy for Useful work. Using the output energy of devices is not possible, because the equipment it is not designed only to send energy at its output ports but to realize other type of activities such as data switching/routing, area coverage, and data computation.

These activities are different from different type of equipment and as some of examples, could be the data throughput of a port or system, the computational capacity, the area coverage, the transmitting distance or a combination of above, depending on the equipment usage/application considered.

In the wired technologies that include, router, switch, transport, fixed access equipment the following concept can be utilized:

- Utilization:
  - **Port Utilization:** Port throughput expressed as percentage of theoretical maximum.
  - **System Utilization:** System throughput expressed as percentage of Maximum Demonstrated Throughput.
- Throughput:
  - **Port Throughput:** Rate of traffic (in bps) passing through a port on sustained basis in either direction, including minimally needed line overhead.
  - **System Throughput:** Sum of throughput on all system ports in the egress direction (bps). *Example*: Maximum throughput for 1 Gigabit Ethernet port is 1Gbps (measured in a specified topology).
  - **Line rate:** Indicates the actual speed with which the bits are sent onto the wire (or via wireless connection).

In wireless technologies it is necessary consider also:

- **Coverage area:** this is the geographical area in which mobile radio stations provide the service.
- **Path length:** in radio technologies another important factor to be considered is the radio link length. E.g. distance between the two radios stations of the radio link.

For facility equipment other factor are considered like the cooling capacity, energy output.

In case of the future EER application to a network/solution than some useful work shall be:

- Number of user.
- Service per user.
- Level of oversubscription.
- Total traffic to outside of the network.
- Combinations of the above.
- Facilities used energy.

6 Energy management

Energy management concept is covering not the efficiency of equipment but how the energy used by an equipment or a network, is managed or delivered from different available sources, as it is used, and how waste energy reused.

The energy management does not directly affect efficiency of equipment, network or services, however, it helps to realize a less impacting equipment, networks, services by utilizing and managing energy derived from less environment impacting sources such as renewable energy or reusing energy that would, without an adequate management, just energy waste e.g. energy derived from hot air/water in a cooling system, or by using external/internal to network management tools to shutdown/bring back in to network devices depending on network usage schedule.

7 Renewable energy sources

Energy sources from renewable source like solar, wind, hydroelectric etc. contribute to reduction of the environmental impact of an equipment/ network / service but they have no influence on the Energy Efficiency.

The energy consumption from renewable energy sources not connected with grid shall be included in the total ICT equipment/network energy consumption calculation.

It is clear that the increase of use of renewable energy source is an important factor to realize less environmental impacting solutions, Energy Efficiency is independent from energy sources.

8 Functioning status/mode and EE

Functioning status and utilization are another important factors to be considered during the EER measurements and calculation, as they have a big impact on the energy consumption of equipment.

In the case of EER for equipment having different utilization levels this different utilization need be considered during the calculations.

For equipment for which it is possible define a typical percentage of utilization for a defined period the EER can be only one number using weight factor for the energy consumption corresponding at different functioning status with the higher weight used for typical utilization, to reflect realistic usage.

Below an example of this concept from Recommendation ITU-T L.1310 [i.1].

$$EER = \frac{0{,}6 * Tidle + 0{,}3Tlowpower + 0{,}1 * TMaximun}{0{,}6Pidle + + \quad 0{,}3Plowpower + 0{,}1P\max imun} \qquad \text{(Mbit/s/W) (4)}$$

Weighting factors based on estimated time for use of EUT in each mode.

In this Formula:

- T*idle* is the throughput in idle mode in which the power is P*idle.*
- T*lowpower* is the throughput in low throughput mode in which the power is P*lowpower.*
- Tm*aximum* is the throughput in maximum throughput mode in which the power is P*maximum.*

It is noted that in reality formula (4) gives a ratio between throughput and power, considering this is an indication of energy efficiency. Technically energy is the integral of the power in a time window, so it is possible to consider measurements of energy efficiency as a ratio between throughput and power without any error. In this case the power is considered to be constant during the time integration window.

Functioning status are listed below.

- Idle mode

  Device not being used, but ready to pass traffic or return to full functionality in no time. It is in any case an active mode with expectation for a lower power.

- Low Power mode

  A state, that device enter after certain period of inactivity or idle mode, characterized with very lower power.

- Standby mode

  A condition where the device is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides **only** the following function, which may persist for an indefinite time: reactivation function or reactivation function and only an indication of enabled reactivation function, and/or information or status display.

- Networked Standby

  A condition in which the equipment is able to resume a function by way of a remotely initiated trigger via a network connection.

- Non Drop Rate

  It is the observed system throughput at which no packet drops are recorded.

- Full mesh traffic topology

  For EUT where all ports have identical roles, traffic with identical capacity streams between all ports shall be used, so each port in a system with N identical ports has N-1 traffic streams.

- Partial Uplink-Downlink Mesh topology

  For systems where EUT ports can be grouped into "network/uplink" and "access/downlink" sides, according to vendor discretion, traffic shall be run from every "network" side port to every "access" side port and vice versa, thus forming full mesh traffic between two groups. All streams originated from every port shall be the same capacity.

9 General measurement conditions

9.0 General

This clause gives general condition to measure the energy, power values and the useful work to define the concept of energy efficiency reported in previous clauses.

This clause describes normal environmental conditions for Energy efficiency test of ICT products. Some type of ICT devices intended to use in the abnormal conditions should be tested in the appropriate conditions reflecting intended use.

9.1 Environmental Consideration

9.1.1 Temperature

The equipment shall be evaluated at temperature of 25 °C ± 3 °C (77 ± 5 °F).

9.1.2 Humidity

The equipment shall be evaluated at a relative humidity of 30 % to 75 %.

9.1.3 Barometric Pressure

The equipment shall be evaluated at a barometric pressure between 1 060 and 812 mbar.

9.2 Voltage

9.2.1 DC Powered Equipment

The equipment powered by -48 V dc source shall be evaluated at a dc voltage of -53 V ± 2 V.

Equipment using nominal dc voltages other than -48 V dc shall be evaluated at ±4 % of the specified float voltage.

9.2.2 AC Powered Equipment

The equipment shall be evaluated with a source providing the following conditions:

- Total voltage Harmonic Distortion ≤ 3 % up to and including the 13th harmonic
- At either of the following:
  - Single phase, 120 Vac ± 5 %, 60 Hz ± 1 %
  - Single phase, 230 Vac ± 5 %, 50 or 60 Hz ± 1 %
  - Three phase, 208 Vac ± 5 %, 50 or 60 Hz ± 1 %
  - Unless otherwise specified in a supplemental standard to this General Requirement Standard, equipment using other nominal AC voltages shall be evaluated at ±5 % of the specified voltage and ±1 % of the specified frequency.

9.3 Power Source

DC power sources used to provide power to the equipment under test, shall be capable of providing a minimum of 1,5 times the power rating of the equipment under test.

9.4 Power Measurement Equipment

The measurement equipment used to measure voltage and current for the purposes of determining energy or power for the equipment under test shall have the following minimum characteristics:

- A minimum digitizing sample rate of 40 kHz.
- Input circuitry with a minimum bandwidth of 80 kHz.
- Ability to log and store data for the total measurement period.
- Overall measurement accuracy shall be within ±1 %.

Measurements may be performed with a variety of instruments. These range from voltage and current meters with data acquisition capability to power analysers capable of fully integrated measurement.

NOTE: Measurement equipment with higher digitizing rates and higher accuracy may be desirable to ensure accurate measurement when power spikes possible.

History

Document history			
V1.1.0	September 2017	Membership Approval Procedure	MV 20171031: 2017-09-01 to 2017-10-31