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दूरसंचार उत्पाद, उपकरण और नेटवर्क / सेवाएँ हेतु ऊर्जा खपत रेटिंग और ऊर्जा पासपोर्ट

Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/Services

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र
खुर्शीदलाल भवन, जनपथ, नई दिल्ली-110001, भारत
TELECOMMUNICATION ENGINEEING CENTRE
KHURSHIDLAL BHAWAN, JANPATH, NEW DELHI–110001, INDIA
www.tec.gov.in

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FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of TEC Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements & Standard document of TEC for Telecom Products and Services
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE)
- Field evaluation of Telecom Products and Systems
- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centers (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

ABSTRACT

This Energy Consumption Rating (ECR) standard delineates the test procedures and the measurement methodologies for ECR and energy passport certification for telecom products, equipment and networks or services. This standard will facilitate service providers and consumers in comprehensive evaluation of telecom products, equipment and networks or services with respect to energy planning and in adding energy efficiency to their purchase criteria.

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List of Figures

HISTORY SHEET

S. No.	Name of the Standard	No. of the Standard	Remarks
1	Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/ Services	TEC 74046:2020	First issue
2	Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/ Services	TEC 74046:2022	Second issue. This revision covers: (1) Standard referred in server is updated. (2) Testing procedure for NFV, Telecom Infrastructure Equipment added.
3	Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/ Services	TEC 74046:2022 (Rev 1.0)	Third issue. Standard referred in table-4 is updated to include gNodeB (NR) for static mode and a new table no 5A is inserted to include dynamic mode of gNodeB (NR).

REFERENCES

S. No.	Document No.	Title/Document Name
1.	ATIS-0600015.03.2009	Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products. Available: https://www.atis.org/docstore/product.aspx?id=25324
2.	ATIS-0600015.03.2013	Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products. Available: https://webstore.ansi.org/standards/atis/atis0600015032013
3.	ATIS-0600015.02.2016	Energy Efficiency for Telecommunication Equipment: Methodology for Measurement & Reporting – Transport & Optical Access Requirements. Available: https://www.atis.org/docstore/product.aspx?id=28263
4.	ETSI TS 102 706-2	Metrics and Measurement Method for Energy Efficiency of Wireless Access Network Equipment; Part 2: Energy Efficiency - dynamic measurement method. Available: https://www.etsi.org/deliver/etsi_ts/102700_102799/10270602/01.05.01_60/ts_10270602v010501p.pdf
5.	ETSI ES 201 554	Measurement method for Energy efficiency of Mobile Core network and Radio Access Control equipment. Available: https://www.etsi.org/deliver/etsi_es/201500_201599/201554/01.02.01_60/es_201554v010201p.pdf.
6.	ETSI ES 202 706-1	Metrics and measurement method for energy efficiency of wireless access network equipment; Part

		1: Power consumption - static measurement method. Available: https://www.etsi.org/deliver/etsi_es/202700_202799/20270601/01.06.01_60/es_20270601v010601p.pdf
7.	ETSI ES 203 539	Measurement method for energy efficiency of Network Functions Virtualisation (NFV) in laboratory environment. Available: https://www.etsi.org/deliver/etsi_es/203500_203599/203539/01.01.01_60/es_203539v010101p.pdf
8.	ETSI EN 303 215	Measurement methods and limits for power consumption in broadband telecommunication networks equipment. Available: https://www.etsi.org/deliver/etsi_en/303200_303299/303215/01.03.01_60/en_303215v010301p.pdf
9.	ETSI EN 303 470	Energy Efficiency measurement methodology and metrics for servers. Available: https://www.etsi.org/deliver/etsi_EN/303400_303499/303470/01.01.01_60/en_303470v010101p.pdf
10.	ETSI TS 103 786	Measurement method for energy efficiency of wireless access network equipment Dynamic energy performance measurement method of 5G Base Station (BS). https://www.etsi.org/deliver/etsi_ts/103700_103799/103786/01.01.01_60/ts_103786v010101p.pdf
11.	ISO/IEC 21836	Server energy effectiveness metric. Available: ISO/IEC 21836
12.	ITU-T L.1300	Best practices for green data centres. Available: https://www.itu.int/rec/T-REC-L.1300-201406-I/en
13.	ITU-T L.1310	Energy efficiency metrics and measurement methods for telecommunication equipment. Available: https://www.itu.int/rec/T-REC-L.1310/en
14.	ITU-T L.1320	Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres. Available: https://www.itu.int/rec/T-

		REC-L.1320-201403-I/en
15.	ITU-T L.1330	Energy efficiency measurement and metrics for telecommunication networks. Available: https://www.itu.int/rec/T-REC-L.1330/en.
16.	ITU-T L.1361	Measurement method for energy efficiency of network functions virtualization. Available: https://www.itu.int/rec/T-REC-L.1361-201811-I/en
17.	TRAI recommendation dated 12.04.2011	Recommendations on Approach towards Green Telecommunications. Available: https://trai.gov.in/sites/default/files/Green_Telecom-12.04.2011.pdf
18.	TRAI recommendation dated 23 10 2017	Recommendations on Approach towards Sustainable Telecommunications. Available: https://trai.gov.in/sites/default/files/Recommendation_Green_telecommunication_23102017.pdf.

Note: Unless otherwise explicitly stated, the latest approved issue of the standard/GR/IR, with all amendments in force, listed in references, on the issuance date of this GR/IR shall be applicable.

Abbreviations and acronyms

This Standard uses the following abbreviations and acronyms:

AC	Alternating Current
ADSL2+	Asymmetric Digital Subscriber Line 2 transceiver extended bandwidth
AIR	Authorized Indian representative
BEE	Bureau of Energy Efficiency
BSC	Base Station Controller
BS	Base Station
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CS	Circuit Switched
DC	Direct Current
DoT	Department of Telecommunications
DSLAM	Digital Subscriber Line Access Multiplexer
ECR	Energy Consumption Rating
ECR-VL	Energy Consumption Rating Variable Load
EDGE	Enhanced Data for GSM Evolution
EER	Energy Efficiency Rating
EIR	Equipment Identity Register
EP	Energy Passport
GEPON	Gigabit Ethernet Passive Optical Network
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GPON	Gigabit Passive Optical Network
GSM	Global System for Mobile Communications
HLR	Home Location Register
HSPA	High Speed Packet Access
IF	Interface
IP	Internet Protocol
ITU	International Telecommunication Union
LAN	Local Area Network
LTE	Long Term Evolution
MGW	Media Gate Way
MME	Mobility Management Entity

MNRE	Ministry of New and Renewable Energy
MSAN	Multiservice Access Node
MSC	Mobile Switching Centre
MSS	Mobile Switching center Server
MT	Mobile Terminated
MTCTE	Mandatory Testing & Certification of Telecom Equipment
eNodeB	LTE Base Transceiver Station
gNodeB	Base Station for 5G network
NNI	Network-Network Interface
NR	New Radio
OADM	Optical Add-Drop Multiplexer
OC	Optical Carrier
OEM	Original Equipment Manufacturer
OLT	Optical Line Termination
ONT	Optical Transport Network
PDN	Public Data Network
PDP	Packet Data Protocol
PGW	PDN Gateway
PtP	point-to-point
PF	Power Factor
PLMN	Public Land Mobile Network
PON	Passive Optical Network
PONIF	Passive Optical Network Interface
POTS	Plain Old Telephone Service
PPS	Packets Per Second
PSTN	Public Switched Telephone Network
PSU	Power Supply Unit
RBS	Radio Base Station
RNC	Radio Network Controller
SAU	Simultaneously Attached Users
SDH	Synchronous Digital Hierarchy
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SONET	Synchronous Optical Network
STM	Synchronous Transport Module
SW	Switch

TEC	Telecommunication Engineering Centre
TDM	Time Division Multiplex
TEER	Telecommunications Energy Efficiency Ratio
UNI	User Network Interface
VDSL2	Very high bit rate Digital Subscriber Line
VLR	Visitor Location Register
WCDMA	Wideband Code Division Multiple Access
WDM	Wavelength Division Multiplexing
WiMAX	Worldwide Interoperability for Microwave Access
WTO	World Trade Organization

1. Introduction:

The world’s increasing need for the computation, data storage, and communication is driving the rapid growth in telecommunication and enhancing the emissions associated with it. India has the second largest and fastest growing mobile telephone market in the world. Telecom network operation is most significant contributor of carbon emissions in the telecom industry. The greening of the telecom sector assumes significance not only for reduction of carbon emissions but for the need to effect economy in operations as well.

A necessary first step for greening the sector is to measure emission quanta from telecom devices and networks. After estimating the carbon footprint, the next step should be to put in place a robust carbon emission measurement system. Thus, specific standardization metrics for certifying telecom products and equipment to be deployed in the green telecom network are required to be specified.

Energy efficiency is an increasingly important requirement for all modern systems. In general, energy efficiency for telecom product is defined as the relationship between the specific functional unit of an 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 with less energy is considered to be more energy efficient.

For this reason, metric that can evaluate the performance of a telecom product, equipment and network or service against its energy consumption is called Energy Consumption Rating (ECR) and the same is required to be evaluated. This document is a step in that direction.

However, greening the telecom sector is an endeavour that would require active participation of all three sets of stakeholders – the government, the telecom industry and the citizenry.

2. Objective of Energy Consumption Rating & Energy Passport:

Aim of this standard is to delineate the test procedures and measurement methodologies for ECR and Energy Passport for various telecom products, equipment and network or services which will facilitate benchmarking for green passport certification. Green Passport certification is a step towards achieving broader objective of reduction in carbon emission intensity in telecommunication sector to meet the overall India’s target set out in Paris climate agreement 2015.

It is intended to help service providers and consumers in comprehensive evaluation of products, equipment and services for energy planning purposes in order to enable them to add energy efficiency to their purchase criteria so as to achieve required reduction in carbon footprint.

This Standard is intended to be used by telecommunication network operators, equipment manufacturers, suppliers, and test laboratories as a standard method for determining the energy consumption required to address a specific application. By comparing the ECR reports of multiple equipment that meet a common set of requirements, a telecommunications network operator can select equipment configuration that meets their energy consumption targets.

3. Scope:

The telecom network consists of three major components – the Access network, the Backhaul / aggregators and the Core Network. In the telecom network, the components that contribute to carbon emissions include the RAN (Radio Access Network upto 5G NR), fixed line network, fibre to the x (FTTx) networks in the access networks, their core, aggregators (backhauls) and the transmission systems in the central core network. In addition, power generation and power feeding equipment add to the above corban emission due to its own energy inefficiencies and losses.

The telecom access network could be broadly categories into four: first, landline which consists of copper distribution network and telephones; second, mobile which consists of access nodes (BTS, Node B, eNodeB, gNodeB), Controllers (BSC, RNC, CU etc.) and mobile phones; third, fixed (copper) broadband which consists of digital subscriber line access multiplexers (DSLAM), customer premise equipment (CPE) and splitters; and fourth, FTTx (optical) which consists of optical line termination equipment (OLT), optical network terminating equipment (ONT), optical distribution network (ODN), and passive / active splitters.

The other three vital blocks that add to the telecom network consist of core network (which includes exchanges (Local, Tandem, TAX), Mobile core (MSC, GGSN, SGSN, SMSC, IMS, EPC, NGC etc.), edge / core routers / NGN /soft switches / IP cores /all core items / data centers / all centralized sub systems / peripherals), aggregators or backhaul and transmission networks.

However, all the products, equipment and networks, as discussed above, are not covered in this standard. The present issue of standard covers the equipment and networks as per list given in succeeding para 3.1 and 3.2. Other equipment and services will be covered in subsequent issues, in due course of time.

3.1 Telecom Equipment:

The following telecom equipment has been covered in this standard.

i. DSLAM (Table-1)
ii. MSAN (Table-1)
iii. GPON OLT equipment (Table-2)
iv. GEPON OLT equipment (Table-3)
v. Wireless Access Technologies (Base Station upto 5G) (Table-4, Table-5, Table-5A)
vi. Servers (Table-6)
vii. Routers (Table-7)
viii. Ethernet Switches (Table-8)

ix. Small Networking Devices (intended for home/domestic or small office use)[1] (Table-9)

x. WDM/TDM/OTN Transport MUXes/Switches (Table-10)

xi. Converged packet optical equipment with packet signal and TDM signal (Table-11)

xii. Converged packet optical equipment with packet signal, TDM signal and WDM signal functions (Table-12)

xiii. Radio Network Controller (RNC) and Mobile core functions (GGSN, HLR, MGW, MME, MSC, SGSN and PGW/SGW) and equivalent functions in 4G (Table-13)

xiv. Virtualized Network Function (VNF) (Table-14)

3.2 Telecommunication Networks:

Under this category, operational telecommunication mobile network (Table- 15) and Network Functions Virtualization Infrastructure (NFVI) (Table-16) have been covered as of now; other type of networks such as fixed line telecommunication network, data centres etc. will be covered in subsequent issues.

3.3 Telecom Infrastructure:

Like telecommunication network, energy efficiency of telecom infrastructure can also be assessed at equipment level and network level:

3.3.1 Telecom Infrastructure Equipment:

The main energy-consuming telecom infrastructures are power feeding equipments and cooling equipments used in data centre or telecommunication facility. The energy efficiency of the telecom infrastructure equipment is expressed solely as the ratio of output energy (Watt-hours delivered) to input energy (Watt-hours consumed) unlike energy consumption rating (ECR) defined in this standard for telecom equipments which is the ratio of energy by throughput. The methodologies for energy efficiency are though applied at single infrastructure equipment

[1] 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. A tentative list of such devices is given in Table-9.

level but it will help telecom designers in planning and assessment of data centers, computer rooms, server rooms, TSP sites, telecom facility centre and similar spaces from energy consumption point of view.

These Standard covers:

i. Power feeding equipment:
    - AC power feeding equipment (AC UPS, DC/AC inverter); (Table-17)
    - DC power feeding equipment (AC/DC rectifier, DC/DC converter); (Table-18)
    - Renewable energy equipment (Photovoltaic (PV) panel, Wind turbine, Hydrogen fuel cell (FC) stack). (Table-19)

ii. Cooling equipment:
    - Air conditioner equipment; (Table-20)
    - Outdoor air-cooling equipment; (Table-21)
    - Heat exchanging cooling equipment.

3.3.2 Telecom Infrastructure site/centre/network:

Telecom infrastructure provider (IP) sites, TSP sites, telecom facility centre and data centres etc. are some of the examples where energy assessment can be done considering all the telecom infrastructure equipment installed at site as a single unit under normal operating condition over a fairly longer duration. The energy consumption by telecom infrastructure equipment is not the only attributor in the overall energy consumption of data centre or telecommunication facility. Other factors such as architecture and organization of the space and equipment to deliver the power or cooling to the systems, interoperability, management and response of these systems across the demand and operational range are also important. Hence consideration of best practices in all stages/factors helps in maximizing energy efficiency and minimizing environmental impact. Planner may refer ITU-T L.1300 for best practices for energy-efficient design, construction, operation and management of green data centres.

4. Terms and definitions:

The terms and definitions in this standard are primarily for the telecom equipment and telecom networks that are deployed to provide ICT services.

4.1 Energy Efficiency Hierarchy:

An energy efficiency metric can be defined at the network/service level, the equipment/system level and the component level. [1]

4.2 Energy Efficiency at the Network/Service 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). These are normally used to evaluate a network for internal operator use or to satisfy an environmental assessment. For this definition, the network level is considered a metric that will cover not only one single product, equipment but also a telecommunication network composed of different interworking equipment. [1]

4.3 Energy Efficiency at the Equipment/System Level:

Equipment/system level metrics are mostly used to compare telecommunication equipment of the same technology. 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 point of view [1].

4.4 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 [1].

4.5 Energy Efficiency Metric:

In general, energy efficiency metrics for telecom product is defined as the specific functional unit of an 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 with less energy is considered to be more energy efficient. Metric will evaluate the performance of a telecom equipment against its energy consumption. [1]

4.6 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 functional unit produced and in order to capture such capabilities, where available, this standard defines the ECR as a weighted, load-proportional metric. [1]

4.7 Energy Consumption Rating:

It is calculated as energy consumption normalized to effective throughput and defined by the formulae: ECR= (E / T), where E denotes the maximum energy consumption (in watts) and T denotes the effective system throughput (in bits per second).

In other words, it is assumed that the more energy-efficient product, equipment and network or service to be the one that can transport more data using the same energy budget. [2]

4.8 Energy Passport:

ECR of a product, equipment and network or service has very little value unless a comparison is drawn among the equals. By comparing the ECR reports of multiple equipment that meet a common set of requirements, a telecommunications network operator can select a product, equipment and network or service configuration that meets their energy consumption targets. Energy Passport is such a visual sign of compared result of ECR of same category of products, equipment and networks or services.

Comparing product metrics will allow the service providers to add energy efficiency to purchase criteria. [2]

4.9 Energy Passport classification:

Energy Passport classification will be used to signify relative position of product, equipment and network or services on energy consumption rating scale for certification and labelling purpose.

5. Methodology

5.1 Energy Consumption Rating determination methodology:

The following steps are required for determining ECR of telecom products, equipment and network or services.

Step A: Identifying common test methodology, equipment configuration and set-up.

Step B: Identifying common energy efficiency and/or performance measurement metrics

Step C: Identifying common scenario/states/mode associated with performance and characterizing energy efficiency and/or performance measurement metrics for such cases which are called variable-load metrics.

Step D: Expressing mathematical formula for weighted ECR by assigning prop- -ortionate weight coefficient to variable load metrics and calculating measured weighted ECR value.

Based on the above steps, ECR calculation methodology in respect of telecom equipment listed in 3.1 and telecom network listed in 3.2 are tabulated in annexure-1 and annexure-2 respectively.

5.2 Energy Passport determination and classification methodology:

Energy Passport determination (discovery of reference values)

Steps 1 to 3 are to be taken for determining energy passport reference values.

Step 1: Obtain weighted ECR values of each of samples in the given category of product/equipment/network/services as prescribed in 5. (Note: Number of samples required for calculating reference ECR

May be five or more which may be collected over a period of 6 months before proceeding to 5.2-step 2 in the beginning of this scheme.)

Step 2: Calculate mean and standard deviation of samples.

Mean= $\frac{(ECR_1+ECR_2+\cdots..+ECR_n)}{n}$

Standard Deviation= $\sqrt{\frac{\sum_{i=1}^{n}(ECR_i-mean)^2}{n-1}}$

Where ECR_1, ECR_2…ECR_i...ECR_n are weighted ECR values of samples.

Step 3: Finding reference ECR values; Ref_ECR_Val1= (mean-standard deviation) Ref_ECR_Val2= (mean)

Ref_ECR_Val3= (mean+standard deviation)

(Note: Validity of these reference values could be one year or as notified in the scheme. While calculating revised reference values, all active samples received preceding year will be considered.)

Step 4: Energy Passport classification:

(a) Class A or colour Green- if measured weighted ECR value is less than Ref_ECR_val1 (mean-standard deviation);

(b) Class B or colour Lime- if measured weighted ECR value is less than Ref_ECR_val2 (mean) but equal to or more than Ref_ECR_val1 (mean-standard deviation);

(c) Class C or colour Amber- if measured weighted ECR value is less than Ref_ECR_val3 (mean+standard deviation) but equal to or more than Ref_ECR_val2 (mean);

(d) Class D or colour RED- if measured weighted ECR value is equal or more than Ref_ECR_val3 (mean+standard deviation);

where Class A or colour Green signifies the most energy efficient followed by class B/ colour Lime, class C/ colour Amber and class D/ colour Red.

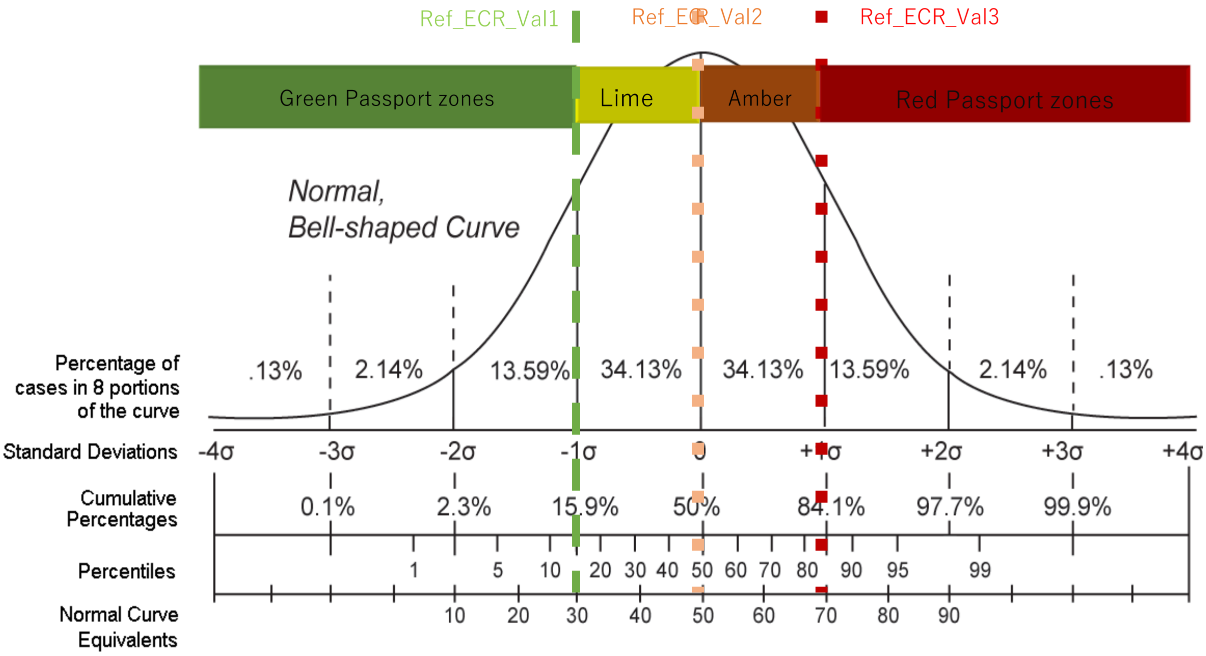

Figure 1 Graphical representation of Energy Passport zones

(Note: Considering Green Passport is an aspiration so top 16% devices having lowest power consumption vs throughput are considered for this label.)

6. Future Specification Revisions:

TEC reserves the right to revise the specification should technological and/or market changes affect its usefulness or its impact on the environment or due to any policy/ regulatory requirement.

ANNEXURE-1

(An integral part of the document)

Telecom Equipment Test procedures

Table - 1 DSLAM, MSAN (Multi-Service Application Node)

Equipment category	Telecom Equipment
Sub category	DSLAM, MSAN (Multi-Service Application Node)
Test Methodologies	ETSI EN 303 215
Equipment Configuration And Set-Up	ETSI EN 303 215
General Measurement Conditions	ITU-T L.1310
Metric	P_1 is power measurements (in Watts) of fully equipped broadband network equipment operating in L0 state. P_2 is power measurements (in Watts) of fully equipped broadband network equipment operating in L2 state. P_3 is power measurements (in Watts) of fully equipped broadband network equipment operating in L3 state. T_{OS1} output bit rate per subscriber line of the broadband network equipment operating in L0 state. T_{OS2} output bit rate per subscriber line of the broadband network equipment operating in L2 state. T_{OS3} output bit rate per subscriber line of the broadband network equipment operating in L3 state. Where, L0- full-power state in which the maximal allowed data transmission is possible L2- low-power state in which a limited power reduction capability and a limited data transmission is allowed L3-stand-by state in which the largest power reduction

<table>
<tr><td></td><td>capability and no transmission of data is possible
T_{OSavg} is the weighted output bit rate for the subscriber (in Mbit/s) of the broadband network equipment
P_{avg} is the weighted energy consumption (in Watts) per line of the broadband network equipment.</td></tr>
<tr><td>Modes</td><td>depending on the energy mode available in the equipment:
<table>
<tr><td>Power mode available</td><td>Weight multipliers a, b, c</td></tr>
<tr><td>L0, L2, L3</td><td>a=0.15, b=0.06, c=0.79</td></tr>
<tr><td>L0, L2</td><td>a=0.2, b=0.8, c=0</td></tr>
<tr><td>L0</td><td>a=1, b=0, c=0</td></tr>
</table></td></tr>
<tr><td>Weight coefficient</td><td>$T_{OSavg} = aT_{OS1} + bT_{OS2} + cT_{OS3}$
$P_{Avg} = aP_1+bP_2+cP_3$ [W]</td></tr>
<tr><td>Weighted ECR</td><td>$= P_{Avg}/T_{OSavg}$ [W/ Mbps]</td></tr>
<tr><td>Remark</td><td></td></tr>
</table>

Table - 2 GPON equipment

Equipment category	Telecom Equipment
Sub category	GPON equipment
Test Methodologies	ETSI EN 303 215
Equipment Configuration And Set-Up	ETSI EN 303 215
General Measurement Conditions	ITU-T L.1310
Metric	P_{EQ} is the power (in watts) of a fully equipped GPON-OLT equipment. Nports is the maximum number of ports served by the GPON-OLT equipment under test. T_{OS} is Bit rate per port is the downstream active data rate expressed in Gbit/s
Modes	One mode i.e. Full-load state
Weight coefficient	P_{port} power consumption per port (in W) of a fully equipped GPON-OLT equipment, Pport= PEQ /Nports[W/port] T_{OS} is the Bit rate per port in the downstream active data rate expressed in Gbit/s
Weighted ECR	$= P_{Port}/T_{OS}$ [W/Gbps]
Remark	

Table - 3 GEPON Equipment

Equipment category	Telecom Equipment
Sub category	GEPON equipment
Test Methodologies	ETSI EN 303 215
Equipment Configuration And Set-Up	ETSI EN 303 215
General Measurement Conditions	ITU-T L.1310
Metric	P_{100} is power consumption (in Watts) for the OLT at 100% load. P_{50} is power consumption (in Watts) for the OLT at 50% load. P_0 is power consumption (in Watts) for the OLT at 0% load. P_{avg} is the average power consumption (in Watts) N_{IF} is Total number of interface (IF) ports N_{PON} is number of PON branches T_L is total number of lines = N_{IF} x N_{PON}
Modes	Three modes for power metric (0%, 50%, 100% load)
Weight coefficient	$P_{Avg} = (P_{100} + P_{50} + P_0) / 3$
Weighted ECR	$= P_{Avg} / T_L$ [W/Line]
Remark	

Table - 4 Wireless Access Technologies (Static mode)

Equipment category	Telecom Equipment
Sub category	Wireless Access Technologies (depending on technology referred as BTS, Node B, eNodeB, gNodeB)
Test Methodologies	ETSI ES 202 706-1
Equipment Configuration And Set-Up	ETSI ES 202 706-1
General Measurement Conditions	ETSI ES 202 706-1
Metric	P_i -Measured Power Consumption (W) T_i -Measured time i - Modes
Modes	Three Modes: (i) Low load (ii) Medium term load, (iii) Busy-Hour load
Weight coefficient	$T_{low} = 6$, $T_{medium} = 10$, $T_{busy\text{-}hour} = 8$ $P_{Total} = \frac{\sum_{i=1}^{3} P_i * T_i}{\sum_{i=1}^{3} T_i}$
Weighted ECR	$= P_{Total}$ (W)
Remark	The technologies covered are- GSM, WCDMA, LTE, LTE-A and 5G BS(NR).

Table - 5 Wireless Access Technologies (Dynamic mode)

Equipment category	Telecom Equipment
Sub category	Wireless Access Technologies (eNodeB)
Test Methodologies	ETSI TS 102 706-2
Equipment Configuration And Set-Up	ETSI TS 102 706-2
General Measurement Conditions	ITU-T L.1310,
Metric	E_i : Measured Energy Consumption (Wh) T_i : Measured time DV_i : Measured data volume (bits) i : Modes
Modes	Modes: 3 (i) Low Power (ii) Medium Power, (iii) Busy-Hour
Weight coefficient	W_{low} =8, W_{medium} = 10, $W_{busy\text{-}hour}$ = 6 $DV_{Total} = \Sigma[(W_i*DV_i)/T_i]$ $E_{Total} = \Sigma[(W_i*E_i)/T_i]$
Weighted ECR	$= \frac{E_{Total}}{DV_{Total}} \frac{[Wh]}{bits}$
Remark	The technologies covered are- Long-Term Evolution (LTE) (Including LTE advanced (LTE-A).

Table - 5A Wireless Access Technologies (Dynamic mode)

Equipment category	Telecom Equipment
Sub category	Wireless Access Technologies (gNodeB)
Test Methodologies	ETSI TS 103 786
Equipment Configuration And Set-Up	ETSI TS 103 786
General Measurement Conditions	ETSI TS 103 786
Metric	E_i : Measured Energy Consumption (Wh) T_i : Measured time DV_i : Measured data volume (bits) i : Modes
Modes	Modes: 3 (i) Low Power (ii) Medium Power, (iii) Busy-Hour
Weight coefficient	W_{low} =6, W_{medium} = 10, $W_{busy-hour}$ = 8 $DV_{Total} = \Sigma[(W_i * DV_i)/T_i]$ $E_{Total} = \Sigma[(W_i * E_i)/T_i]$
Weighted ECR	$= \frac{E_{Total}}{DV_{Total}} \quad \left[\frac{Wh}{bits}\right]$
Remark	The technologies covered 5G New Radio (NR)).

Table - 6 Servers

Equipment category	Telecom Equipment
Sub category	Servers
Test Methodologies	ETSI EN 303 470 OR ISO/IEC 21836
Equipment Configuration And Set-Up	ETSI EN 303 470 OR ISO/IEC 21836
General Measurement Conditions	ETSI EN 303 470 OR ISO/IEC 21836
Metric	$Eff_{Compress}$ normalized interval efficiency of CPU $worklet_{Compress}$, Eff_{LU} normalized interval efficiency of CPU $worklet_{LU}$, Eff_{SOR} normalized interval efficiency of CPU $worklet_{SOR}$, Eff_{Crypto} normalized interval efficiency of CPU $worklet_{Crypto}$, Eff_{Sorts} normalized interval efficiency of CP $worklet_{Sort}$, Eff_{SHA256} normalized interval efficiency of CPU $worklet_{SHA256}$, and $Eff_{HybridSSJ}$ normalized interval efficiency of CPU $worklet_{Hybrid\ SSJ}$. Eff_{Flood3} normalized interval efficiency of Memory $worklet_{Flood3}$, $Eff_{Capacity3}$ normalized interval efficiency of Memory $worklet_{Capacity3}$. $Eff_{Sequential}$ normalized interval efficiency of Storage $worklet_{Sequential}$, Eff_{Random} normalized interval efficiency of Storage $worklet_{Random}$, Where $Eff_i = 1000*(Perf_i/P_i)$ $Perf_i$: Geometric mean of the normalized interval performance measurements. P_i: Geometric mean of the measured interval power values.

Modes	It is to be measured in 7 CPU, 2 Memory and 2 Storage worklets CPU worklets: Compress, LU, CryptoAES, SOR, Sort, SHA256; and Hybrid SSJ. Memory worklets: Flood3 and Capacity3.

	Storage worklets: Sequential and Random.
Weight coefficient	$Eff_{CPU} = (Eff_{Compress} * Eff_{LU} * Eff_{SOR} * Eff_{Crypto} * Eff_{Sorts} * Eff_{SHA256} * Eff_{HybridSSJ})^{1/7}$ $Eff_{Memory} = (Eff_{Flood3} * Eff_{Capacity3})^{1/2}$ $Eff_{Storage} = (Eff_{Sequential} * Eff_{Random})^{1/2}$ $Eff_{Server} = (Eff_{CPU})^{0.65} x(Eff_{Memory})^{0.3} x(Eff_{Storage})^{0.05}$
Weighted ECR	$= \frac{1}{Eff_{Server}}$ [W/bits]
Remark	The Server metrics of the present document are applicable to the following Server product categories: • Blade server • Multi-node server • Direct current server • Rack server • Pedestal or Tower server • Resilient server Note : To test/evaluate for ECR/EP, OEM declared product category and configuration from ETSI or ISO standard shall be referred.

Table - 7 Routers

Equipment category	Telecom Equipment
Sub category	Routers
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,
Metric	Ti is weighted throughput Pw_i is weighted power i Utilization level
Modes	3 modes based on three Utilization level i.e., 0%, 10%/30%, 100%.
Weight coefficient	$i_0/i_{100} = 0.1$, $i_{10}/i_{30} = 0.8$ $T_{Total} = (.1*T_0+.8*T_{10/30}+.1*T_{100})$ $Pw_{Total} = (.1*Pw_0+.8*Pw_{10/30}+.1*Pw_{100}))$
Weighted ECR	$= \frac{Pw_{Total}}{T_{Total}} \quad \left[\frac{W}{Mbps}\right]$
Remark	Access router, Edge router has 10% Utilization factor. Core router has 30% utilization factor. It is assumed that routers will be in i_0 or i_{100} state about 10% of time.

Table - 8 Ethernet Switches

Equipment category	Telecom Equipment
Sub category	Ethernet switches
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,
Metric	Ti is weighted throughput Pw_i is weighted power i is Utilization level
Modes	3 modes based on three Utilization level i.e., 0%, 10%/30%, 100%.
Weight coefficient	$i_0/i_{100} = 0.1$, $i_{10}/i_{30} = 0.8$ $T_{Total} = (.1*T_0+.8*T_{10/30}+.1*T_{100})$ $Pw_{Total} = (.1*Pw_0+.8*Pw_{10/30}+.1*Pw_{100}))$
Weighted ECR	$= \frac{Pw_{Total}}{T_{Total}} \quad \left[\frac{W}{Mbps}\right]$
Remark	(1) Access, (2) High speed access, (3) Distribution/ Aggregation switches has 10% Utilization factor (4) Core, (5) Data centre switches has 30% Utilization factor. For DUT with 40 GBs and higher speed ports it is permitted to use vertical "snake"/cascade topology and will be tested as per ITU- L.1310.

Table - 9 Small Networking Devices

Equipment category	Telecom Equipment
Sub category	Small Networking Devices
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,
Metric	T_{ij} is weighted throughput P_{ij} is weighted power i-Mode j-0.5(T $_{20\% \text{ of max distance}}$ +T $_{80\% \text{ of max distance}}$)-(Applicable to interfaces with throughput (T) sensitive to distance)
Modes	3 modes: idle mode, low power mode, Maximum load mode
Weight coefficient	W_{idle} = .35, $W_{low\ power}$ = .5, $W_{maximum}$ = .15 TTotal = (.35*T_{idle}+.5*$T_{low\ power}$+.15*$T_{maximum}$) PTotal = (.35*P_{idle}+.5*$P_{low\ power}$+.15*$P_{maximum}$)
Weighted ECR	$= \frac{Pw_{Total}}{T_{Total}} \quad \left[\frac{W}{Mbps}\right]$
Remark	Examples of small networking devices include, but are not limited to: ❖ 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 (WiMAX, 3G, and LTE) ❖ Simple broadband access devices: DSL CPEs powered by USB

	Layer 2ONUs ❖ Home network infrastructure devices: Wi-Fi access points Small hubs and non-stackable Layer 2 switches Power line adapters Alternative LAN technologies (HPNA and MoCA) adapters Optical LAN adapter ❖ Other home network devices: ATA / VoIP gateway VoIP telephone (standalone standard desktop phone)

Table - 10 WDM/TDM/OTN Transport MUXes/Switches

Equipment category	Telecom Equipment
Sub category	WDM/TDM/OTN Transport MUXes/Switches
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,
Metric	P_0 measured power consumption (W) at a 0% data traffic utilization P_{50} measured power consumption (W) at a 50% data traffic utilization P_{100} measured power consumption (W) at a 100% data traffic utilization $D_{100\text{-}i}$ 100% data rate (bps) at a given interface i n Total number of interfaces.
Modes	Three modes for power metric calculation i.e., 0%, 50%, 100% data traffic.

Weight coefficient	$P_{Total} = \frac{(P_0+P_{50}+P_{100})}{3}$ $D_{Total} = \sum_{i=1}^{n} D_{100-i}$
Weighted ECR	$= \frac{P_{Total}}{D_{Total}} \quad \left[\frac{W}{bps}\right]$
Remark	Examples of Transport category equipment include, but are not limited to: ❖ SONET/SDH ADMs, MSPP, and similar equipment. ❖ "OTN" (Optical Transport Network) equipment. ❖ Digital Cross Connect Systems (DCS). ❖ ROADM/WDM and similar equipment. ❖ Video transport equipment. ❖ Storage area networking equipment. ❖ Free space optics. ❖ Point-to-point wireless transport (e.g., Microwave).

Table - 11 Converged packet optical equipment with packet signal and TDM signal

Equipment category	Telecom Equipment
Sub category	Converged packet optical equipment with packet signal and TDM signal
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,

	B: maximum throughput (Gbps) of TDM functions (Port speed (Gbps) * number of ports * number of slots) Pidle: power consumption (W) of total equipment with no data throughput with minimum components and path configuration Pmax: power consumption (W) of total equipment during main signal transmission with maximum component configuration
Modes	2 modes for Throughput metric calculation 2 modes for Power consumption metric calculation
Weight coefficient	Maximum Throughput $D_i = \sqrt{(\frac{A^2 + B^2}{2})}$ Average Power Consumption $P_{Average} = \frac{P_{idle} + P_{max}}{2}$
Weighted ECR	$= \frac{P_{Average}}{D_i} \quad \left[\frac{W}{bps}\right]$
Remark	
Metric	A: maximum Throughput (Gbps) of Packet Functions (Port speed (Gbps) * number of ports * number of slots)

Table - 12 Converged packet optical equipment with packet signal, TDM signal and WDM signal functions

Equipment category	Telecom Equipment
Sub category	Converged packet optical equipment with packet signal, TDM signal and WDM signal functions
Test Methodologies	ITU-T L.1310,
Equipment Configuration And Set-Up	ITU-T L.1310,
General Measurement Conditions	ITU-T L.1310,
Metric	A: maximum throughput (Gbps) of packet functions
	(Port speed (Gbps) * number of ports * number of slots) B: maximum throughput of TDM function (Gbps) (Port speed (Gbps) * number of ports * number of slots) C: maximum throughput of WDM function (Gbps) (Port speed (Gbps) * number of ports * number of slots) α: add/drop rate of WDM function Pidle: power consumption (W) of total equipment with no data throughput with minimum components and path configuration Pmax: power consumption (W) of total equipment during main signal transmission with maximum component configuration (WDM part: full wave length, maximum frequency
Modes	3 modes for Throughput metric calculation 2 modes for Power consumption metric calculation
Weight coefficient	Maximum Throughput $D_i = \sqrt{(\frac{A^2 + B^2 + (C * \alpha)^2}{3})}$ Average Power Consumption $P_{idle} + P_{max}$

	$P_{Average} = \quad 2$
Weighted ECR	$= \frac{P_{Average}}{D_i} \quad \left[\frac{W}{bps}\right]$
Remark	

Table - 13 RNC and Mobile core functions (GGSN, HLR, MGW, MME, MSC, SGSN and PGW/SGW) or equivalent terminology in 4G

Equipment category	Telecom Equipment
Sub category	RNC and Mobile core functions (GGSN, HLR, MGW, MME, MSC, SGSN and PGW/SGW or equivalent terminology in 4G)
Test Methodologies	ETSI ES 201 554
Equipment Configuration And Set-Up	ETSI ES 201 554
General Measurement Conditions	ETSI ES 201 554
Metric	P_H – high Power Consumption during high capacity operation P_M – Medium Power Consumption during Medium capacity operation P_L – Low Power Consumption during Low capacity operation T_H - High capacity operation= 1.0x T_s T_M - Medium capacity operation= 0.7x T_s T_L - Low capacity operation= 0.1x T_s T_S - the maximum capacity according to the vendor's specification of the specific implementation of the function Pavg is average Power
Modes	Profile / Node / α / β / γ: Subscriber / HLR EIR, RNC / 0.1 / 0.4 / 0.5 Data / GGSN, SGSN, MME, PGW / 0.2 / 0.45 / 0.35 Voice / MGW MSC / 0.4 / 0.4 / 0.2
Weight coefficient	$\text{Pavg} = (\alpha \times P_L + \beta \times P_M + \gamma \times P_H)$ [W]
Weighted ECR	$= \frac{P_{avg}}{T_s}$ [W/Erlang or W/PPS or W/Subscribers or W/SAU]
Remark	The technologies covered are- GSM, UMTS, LTE and LTE-A

Modes:

Profile	Node	α	β	γ
Subscriber	HLR EIR, RNC	0.1	0.4	0.5
Data	GGSN, SGSN, MME, PGW	0.2	0.45	0.35
Voice	MGW MSC	0.4	0.4	0.2

Table - 14 Virtualized Network Function (VNF)

Equipment category	Telecom Equipment
Sub category	Virtualized Network Function (VNF)
Test Methodologies	ITU-T L.1361 OR ETSI ES 203 539
Equipment Configuration And Set-Up	ITU-T L.1361 OR ETSI ES 203 539
General Measurement Conditions	ITU-T L.1361 OR ETSI ES 203 539
Metric	U_i is the useful output of VNF under service capacity level *i*. Depending on the different types of VNFs, it can be throughput (e.g., bit per second (bps), packet per second (pps)) for a data plane VNF, or capacity (e.g., number of subscribers or sessions) for a control plane VNF. P_i is the power consumption of a NFVI platform introduced by a VNF deployed under service capacity level *i*.
Modes	*N* is the total number of service capacity levels w_i is the weight coefficient of level *i*.
Weight coefficient	$VNF\_EER_i = \frac{U_i}{P_i}$ $VNF\_EER = \sum_{i=1}^{n}(VNF\_EER_i \times w_i)$ VNF_EER_i is energy efficiency of a VNF under service capacity level *i*. VNF_EER is weighted energy efficiency of all service capacity levels.
Weighted ECR	$= \frac{1}{\text{VNF\_EER}} \quad [\frac{Wh}{bits}]$
Remark	The measurement method described in the present document is intended to be used to assess and compare the energy efficiency of same functional components

ANNEXURE-2

(An integral part of the document)

Telecommunication Networks

Table - 15 Operational Telecommunication Mobile Networks

Equipment Category	Telecom Network
Sub category	Operational Telecommunication Mobile Networks
Test Methodologies	ITU-T L.1330,
Equipment Configuration And Set-Up	ITU-T L.1330,
General Measurement Conditions	ITU-T L.1330,
Metric	EC_{MN} is mobile network energy consumption EC_{BS} refers to the base stations energy consumption in the MN under measurement EC_{BH} is the backhaul energy consumption providing connection to the BSs in the MN under measurement EC_{SI} is the site infrastructure (rectifier, battery losses, climate equipment, tower mount amplifier (TMA), tower illumination, etc.) energy consumption EC_{RC} is the control node(s), including all infrastructure of the RC site energy consumption $DV_{MN—PS}$ for packet switched services, DV_{MN--PS} is defined as data volume delivered by the equipment of the MN under investigation during the time frame T of the energy consumption assessment $DV_{MN—CS}$ for circuit switched services such as voice, DV_{MN-CS} is defined as the data volume delivered by the equipment of the MN under investigation during the time

	frame T of the energy consumption assessment.
Modes	2 modes for Throughput metric calculation 4 modes for Power consumption metric calculation
Weight coefficient	EC_{MN} mobile network energy consumption $EC_{MN} = \sum_i (\sum_k EC_{BS_{i.k}} + EC_{SI_i}) + \sum_j EC_{BH_j} + \sum_l EC_{RC_l}$ DV_{MN} Data volumes $DV_{MN} = DV_{MN-PS} + DV_{MN-CS}$
Weighted ECR	$= \frac{EC_{MN}}{DV_{MN}}$ [Wh/bit]
Remark	The mobile network consists of radio access parts namely radio base stations, backhauling systems, radio controllers and other infrastructure site equipment. The technologies covered are- GSM, UMTS, LTE and LTE-A.

Table - 16 Network Functions Virtualization Infrastructure (NFVI)

Equipment category	Telecom Network
Sub category	Network Functions Virtualization Infrastructure (NFVI)
Test Methodologies	ITU-T L.1361 OR ETSI ES 203 539
Equipment Configuration And Set-Up	ITU-T L.1361 OR ETSI ES 203 539
General Measurement Conditions	ITU-T L.1361 OR ETSI ES 203 539
Metric	$U_{i,j}$ is the useful output of VNF_j under service capacity level *i*. $P_{i,j}$ is the power consumption of a NFVI platform with VNF_j deployed under service capacity level *i*.
Modes	*j* is the total number of VNF deployed.
Weight coefficient	$NFVI\_EER_{VNFj} = \frac{U_{i,j}}{P_{i,j}}$

	NFVI_EER=$\sum_{j=1}^{n}(NFVI\_EER_j)$ NFVI _EER_j is energy efficiency of NFVI platform with VNFj deployed NFVI _EER is aggregation of all energy efficiency of NFVI platform with different VNF deployed.
Weighted ECR	$=\frac{1}{\text{NFVI\_EER}}$ $[\frac{Wh}{bits}]$
Remark	

ANNEXURE-3

(An integral part of the document)

Telecom Infrastructure Equipment

Table - 17 AC power feeding equipment (AC UPS, DC/AC inverter)

Equipment category	Telecom Infrastructure Equipment
Sub category	AC power feeding equipment (AC UPS, DC/AC inverter)
Test Methodologies	ITU-T L.1320,
Equipment Configuration And Set-Up	ITU-T L.1320,
General Measurement Conditions	ITU-T L.1320,
Metric	P_O is the active output power [W] P_i is the active input power [W]
Energy Efficiency	$= \frac{P_o}{P_i} \quad \left[\frac{W}{W}\right]$
Remark	

Table - 18 DC power equipment (AC/DC rectifier, DC/DC converter)

Equipment category	Telecom Infrastructure Equipment
Sub category	DC power equipment (AC/DC rectifier, DC/DC converter)
Test Methodologies	ITU-T L.1320,
Equipment Configuration And Set-Up	ITU-T L.1320,
General	ITU-T L.1320,

Measurement Conditions	
Metric	V_o is the output voltage [V] I_o is the output current [A] P_i is the input power [W]
Energy Efficiency	$= \frac{V_O \times I_O}{P_i} \quad \left[\frac{W}{W}\right]$
Remark	

Table - 19 Renewable energy equipment (Photovoltaic (PV) panel, Wind turbine energy, Hydrogen fuel cell (FC) stack)

Equipment category	Telecom Infrastructure Equipment
Sub category	Renewable energy equipment (Photovoltaic (PV) panel, Wind turbine energy, Hydrogen fuel cell (FC) stack)
Test Methodologies	ITU-T L.1320,
Equipment Configuration And Set-Up	ITU-T L.1320,
General Measurement Conditions	ITU-T L.1320,
Metric	V_o is the output voltage [V] I_o is the output current [A] P_i is the input power [W]
Energy Efficiency	$= \frac{V_O \times I_O}{P_i} \quad \left[\frac{W}{W}\right]$
Remark	• P_i is (Ir* S) for Photovoltaic (PV) panel, where Ir is irradiance and S is the squire of the PV arrays. • P_i is (1/(2* ρ*S*υ^2) for Wind turbine, where ρ is air density, S is wind wheel sweeping area and υ is wind

	speed. • P_i is (mH2* LHVH2) for Hydrogen fuel cell (FC) stack, where mH2 is the hydrogen flow rate [g/s] and LHVH2 is the hydrogen low heat value [J/g].

Table - 20 Cooling equipment (Air conditioner)

Equipment category	Telecom Infrastructure Equipment
Sub category	Cooling equipment (Air conditioner)
Test Methodologies	ITU-T L.1320,
Equipment Configuration And Set-Up	ITU-T L.1320,
General Measurement Conditions	ITU-T L.1320,
Metric	Qs is the sensible cooling capacity [W] QL is latent cooling capacity [W] P_i is the input power [W]
Energy Efficiency	$= \frac{Q_S+Q_L}{P_i} \left[\frac{W}{W}\right]$
Remark	• $QS = Cp \times \rho \times L \times \Delta T$, where Cp is specific heat of the air [J/kg°C], ρ is air density [kg/m3], L is the total room air volume [m3/s], ΔT is the temperature difference between inside and outside the room [°C]. • $QL = K \times \rho \times L \times (W1 - W2)$, where K is the latent heat of vaporization water [J /kg], ρ is air density [kg/m3], L is the total room air volume [m3/s], W1 is the initial water content of the air [kg/kg], W2 is the final water content of the air [kg/kg].

Table - 21 Cooling equipment (Outdoor air cooling equipment, Heat exchanging cooling equipment)

Equipment category	Telecom Infrastructure Equipment
Sub category	Cooling equipment (Outdoor air cooling equipment, Heat exchanging cooling equipment)
Test Methodologies	ITU-T L.1320,
Equipment Configuration And Set-Up	ITU-T L.1320,
General Measurement Conditions	ITU-T L.1320,
Metric	Qs is the sensible cooling capacity [W] P_i is the input power [W]
Energy Efficiency	$= \frac{Q_S}{P_i} \left[\frac{W}{W}\right]$
Remark	• $QS = Cp \times \rho \times L \times \Delta T$ for Outdoor air cooling equipment, where Cp is specific heat of the air [J/kg°C], ρ is air density [kg/m3], L is the total room air volume [m3/s], ΔT is the temperature difference between inside and outside the room [°C]. • $QS = Cp \times \rho \times L \times \Delta T \times \eta e$ for Heat exchanging cooling equipment, where Cp is specific heat of the air [J/kg°C], ρ is air density [kg/m3], L is the total room air volume [m3/s], ΔT is the temperature difference between inside and outside the room [°C] and η*e* is the efficiency of the core heat exchanger.

ANNEXURE- 4

(Not an integral part of the document)

Illustrations: ECR & EP measurement of GPON OLT equipment

1. **Assumptions**: 5 Samples of OLTs namely S1, S2, S3, S4 and S5 under test are of same configurations and are from five different vendors. Values given in table 18 are assumed for illustration. Actual OLT test may throw different values.

   Sampled GPON OLT under test are of following configuration:

   - Compliance with Recommendation ITU-T G.984
   - Downstream data-rate is 2.488 Gbps and upstream data-rate is 1.244 Gbps.
   - Configured with Class B+ (Recommendation ITU-T G.984.2) optical modules.
   - Each port of Line termination board is directly connected to one ONU with a 15 dB attenuator, but without splitter. The ONU will typically provide sufficient capacity to fully load the GPON interface with the OLT. It should be verified that the selected ONU is configured such that the upstream bandwidth can be filled by the ONU and that the downstream bandwidth coming from OLT can be fully processed.
   - Typical features: standard Layer-2 (Ethernet) aggregation functionalities, MAC address management, VLAN management, Multicast. For equipment with network layer functionalities, other features including static and dynamic routing protocols, MPLS, IP QoS. OLT (GPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast.

2. **Measurement Setup and test procedures:**

2.1. Setup the equipment under test as shown in the figure below.

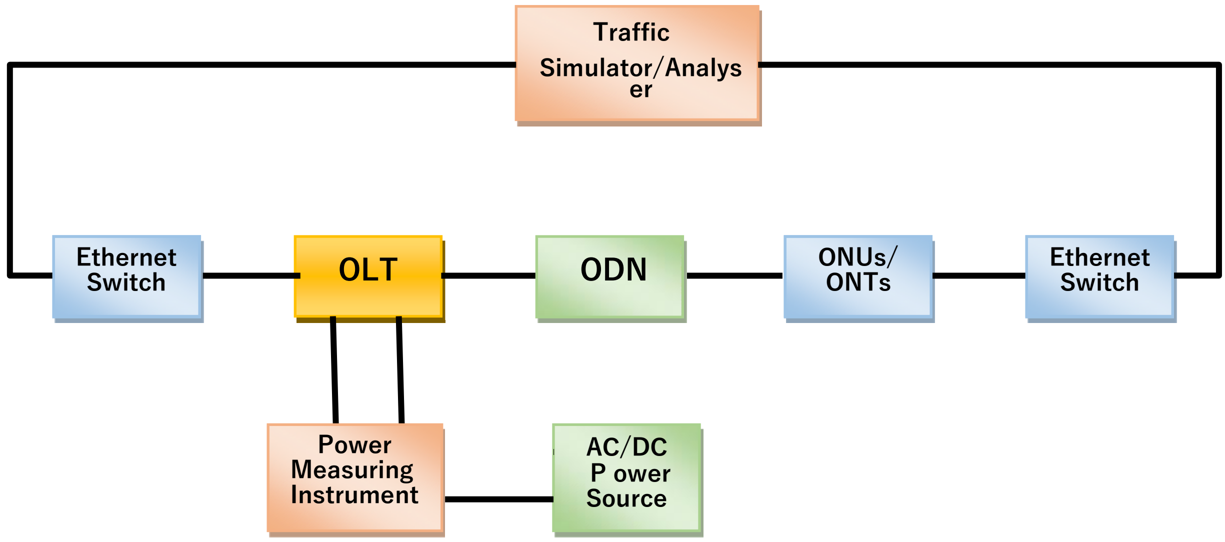

Figure 2 Measurement Setup

2.2. Instruments requirement for test:

Table A List of measurement instruments used to measure the power consumption, including calibration information

Instrument	**Make and Model**	**Calibration**
DC source		
Power meter		
ODN		
Traffic Analyzer/Simulator		
Ethernet Switch		
CPE (ONU/ONT) used for the measurement.		

2.3. Measurement of Environmental conditions during test:

Table B Environmental conditions during test

Environmental conditions	**Reference**	**Reading value**
Temperature	25±3ºC	
Relative Humidity	30% to 75%	

Air pressure	860 to 1060 hPa	
Electrical conditions		
Range of direct current (DC) voltage powering the equipment	−54 ±1.5 V	
Range of AC voltage and frequency powering the equipment	specified voltage ±5% and the specified frequency ±1%	

2.4. Reporting format of the measurements by Laboratories

The following details shall be included in the measurement report:

Table C Measurement report format

S.No.	Description	Details
	OEM	
	Product Name	
	Model No	
	Serial No	
	Year	
	System Configuration	
	Software/Firmware details	
	ECR value	
	Name of TEC Standard complied	

2.5. Measurement results:

Table D Measurement results

Metric	S1	S2	S3	S4	S5
P_{EQ} is the power (in watts) of a fully equipped GPON-OLT equipment	500	550	520	480	540
Nports is the maximum number of ports served by the GPON-OLT equipment under test	64	64	64	64	64
T_{OS} Active data rate per port in downstream in Gbit/s	2.488	2.488	2.488	2.488	2.488

2.6. **ECR and EP Calculation:** Value of ECR can be calculated as per the formula provided in table no.2 and as EP as per the formulae given in 5.2.

(i) Formula for weighted ECR for GPON is given in table 2

ECR= P_{port}/T_{ds} [W/ Gbps]

Where, Pport= P_{EQ} /Nports[W/port]

(ii) Measured weighted ECR:

Table E Measured weighted ECR

Samples	S1	S2	S3	S4	S5
ECR	3.140	3.454	3.265	3.014	3.391

(iii) Calculate mean and standard deviation of samples as per the formulae given in 5.2.

Mean= $\frac{(ECR_1+ECR_2+\cdots..+ECR_n)}{n}$=3.253

Standard Deviation= $\sqrt{\frac{\sum_{i=1}^{n}(ECR_i-mean)^2}{n-1}}$ = 0.179

Where ECR_1, ECR_2…ECR_n are weighted ECR values of samples.

(iv) Finding reference ECR values from samples passport designation;

Ref _ECR_Val1= (mean-standard deviation) =3.073

Ref _ECR_Val2= (mean)=3.253

Ref _ECR_Val3= (mean+standard deviation) =3.432

(v) Energy Passport for samples: (a) Class A or colour Green- if measured weighted ECR value is less than Ref_ECR_val1; (b) Class B or colour Lime- if measured weighted ECR value is less than Ref_ECR_val2 but equal to more than Ref_ECR_val1; (c) Class C or colour Amber- if measured weighted ECR value is less than Ref_ECR_val3 but equal to or more than Ref_ECR_val2; (d) Class D or colour RED- if measured weighted ECR value is equal or more than Ref_ECR_val3;

(vi) Designation of EP on the tested samples:

Samples>	S1	S2	S3	S4	S5
EP	Class B	Class D	Class C	Class A	Class C
	ECR=3.140	ECR=3.454	ECR=3.265	ECR=3.014	ECR=3.391

Table F Energy Passport Awarded

ANNEXURE-5

(Not an integral part of the document)

List of Equipment to be covered in future issues

The following Telecom Equipment, Telecom Networks and Telecom Services are left out in this document which may be added in future version of the document.

A. Category-Under Telecom Equipment

i. Radio Access Control Equipment-Base Station Controller (BSC)
ii. IMS core functions (BGCF, CSCF, HSS, IBCF, MRFC, MRFP, SLF and LRF)
iii. Any other new equipment not covered in this document

B. Under Telecommunication Networks

i. Telecommunication (TLC) fixed networks,
ii. Any other new network not covered in this document

C. Under Telecom Infrastructure at equipment level and network level

i. Battery
ii. Data Centers
iii. IP sites
iv. Telecom facility
v. Any other new equipment/site

END OF DOCUMENT