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Energy efficiency measurement and metrics for telecommunication networks

Recommendation ITU-T L.1330

ITU-T

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Energy efficiency measurement and metrics for telecommunication networks

Summary

Recommendation ITU-T L.1330 provides a set of metrics for the assessment of energy efficiency (EE) of telecommunication (TLC) mobile networks, together with proper measurement methods. Such metrics are of extremely high importance to operators, given that the optimization of the energy performance of a single piece of equipment does not guarantee the overall maximum energy efficiency of a complex network formed by several interconnected equipments. Hence, through the metrics reported in this Recommendation, a better comprehension of network energy efficiency will be gained, not only for "total" networks, but also for "partial" networks, definable through either geographic or demographic boundaries.

In a future step, energy efficiency of TLC fixed networks will be provided.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	2
3.1 Terms defined elsewhere	2
3.2 Terms defined in this Recommendation.....	2
4 Abbreviations and acronyms	3
5 Conventions	4
6 Network under test definition	5
6.1 Introduction	5
6.2 Test parameter categorization.....	6
6.3 Network classification	7
7 Metrics for energy efficiency assessment.....	9
7.1 Energy consumption metrics	9
7.2 Performance metrics	10
7.3 Mobile network energy efficiency metrics.....	10
8 Measurement of energy efficiency	11
8.1 Time duration of the measurement.....	11
8.2 Measurement procedures	11
9 Extrapolation for overall networks	14
9.1 Extrapolation method	15
9.2 Extrapolation reporting tables	16
10 Assessment report.....	18
10.1 Report of network area under test	18
10.2 Report of sites under test	20
10.3 Report of site measurement	21
11 Implementation guidelines.....	22
Appendix I – Implementation examples	23
Bibliography.....	29

Introduction

Recommendation ITU-T L.1330 provides a set of metrics for the assessment of energy efficiency (EE) of telecommunication (TLC) mobile networks, together with proper measurement methods. Such metrics are of extremely high importance to operators, given that the optimization of the energy performance of a single piece of equipment does not guarantee the overall maximum energy efficiency of a complex network formed by several interconnected equipments. Hence, through the metrics reported in this Recommendation, a better comprehension of network energy efficiency will be gained, not only for "total" networks, but also for "partial" networks, definable through either geographic or demographic boundaries.

This Recommendation 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.1330 and ETSI Standard ETSI ES 203 228, which are technically equivalent.

Recommendation ITU-T L.1330

Energy efficiency measurement and metrics for telecommunication networks

1 Scope

This Recommendation aims to define the topology and level of analysis necessary to assess the energy efficiency (EE) of mobile networks. Within the scope of this Recommendation are the radio access parts of the mobile network, namely: radio base stations, backhauling systems, radio controllers and other infrastructure radio site equipment. The technologies covered are: global system for mobile communications (GSM), universal mobile telecommunications communications (UMTS) and long-term evolution (LTE) (including LTE advanced (LTE-A)). In particular, this Recommendation defines metrics for mobile network energy efficiency and methods for assessing (and measuring) energy efficiency in operational networks. The purpose of this specification is to allow better comprehension of network energy efficiency.

This Recommendation deals with both homogeneous and heterogeneous "networks" and considers networks whose size and scale could be defined by topologic, geographic or demographic boundaries. For networks defined by topologic boundaries, a possible example of a network consists of a control node (whenever applicable), its supported access nodes, as well as its related network elements. Networks could also be defined by geographic boundaries, such as citywide, national or continental networks or by demographic boundaries, such as urban or rural networks.

This specification applies to the so-called "partial" networks where energy efficiency is measured in a standardized way. This specification extends the measurements in partial networks to wider so-called "total" network energy efficiency estimations (e.g., the network in a geographic area, the network in an entire country, the network of a mobile network operator (MNO)).

Terminal (end-user) equipment is outside the scope of this Recommendation and thus, is not considered in the energy efficiency measurement.

2 References

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

- | | |
|-------------------|---|
| [ITU-T L.1310] | Recommendation ITU-T L.1310 (2014), <i>Energy efficiency metrics and measurement methods for telecommunication equipment</i> . |
| [ETSI TS 123 203] | ETSI TS 123 203 V12.6.0 (2014), <i>Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Policy and charging control architecture (3GPP TS 23.203 version 12.6.0 Release 12)</i> . |
| [ETSI TS 125 104] | ETSI TS 125 104 V12.4.0 (2014), <i>Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 25.104)</i> . |
| [ETSI TS 132 405] | ETSI TS 132 405 V12.0.0 (2014), <i>Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Performance Management (PM)</i> ; |



Performance measurements; Universal Terrestrial Radio Access Network (UTRAN) (3GPP TS 32.405 version 12.0.0 Release 12).

- [ETSI TS 132 412] ETSI TS 132 412 V12.0.0 (2014), *Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Performance Management (PM) Integration Reference Point (IRP): Information Service (IS) (3GPP TS 32.412 version 12.0.0 Release 12).*
- [ETSI TS 132 425] ETSI TS 132 425 V12.0.0 (2014), *LTE; Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN) (3GPP TS 32.425 version 12.0.0 Release 12).*
- [ETSI TS 136 104] ETSI TS 136 104 V12.5.0 (2014), *LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104 version 12.5.0 Release 12).*
- [ETSI TS 136 314] ETSI TS 136 314 V12.0.0 (2014), *LTE; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Layer 2 – Measurements (3GPP TS 36.314 version 12.0.0 Release 12).*
- [ETSI TS 152 402] ETSI TS 152 402 V11.0.0 (2012), *Digital cellular telecommunications system (Phase 2+); Telecommunication management; Performance Management (PM); Performance measurements – GSM (3GPP TS 52.402 version 11.0.0 Release 11).*
- [ISO/IEC 17025] ISO/IEC 17025 (2005), *General requirements for the competence of testing and calibration laboratories.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 backhaul equipment: Equipment used to connect base stations (BSs) to the core network, or to other BSs (such as X2 in LTE).

3.2.2 base station (BS): A generic term used for a network component which serves one or more cells and interfaces the user terminal (through air interface) and a radio access network infrastructure.

3.2.3 distributed RBS: A radio BS (RBS) architecture which contains remote radio heads (RRHs) close to the antenna element and a central element connecting BS to network infrastructure.

3.2.4 energy: Capacity for doing work; having several forms that may be transformed from one to another, such as thermal (heat), mechanical (work), electrical or chemical, expressed in Joules. For the purpose of this Recommendation, energy will be expressed in Watt-hours (Wh) or kilo Watt-hours (kWh).

3.2.5 energy efficiency (EE): The relation between the useful output and energy/power consumption.

3.2.6 energy saving feature: A feature which contributes to decreasing energy consumption as compared to the case when the feature is not implemented.

3.2.7 integrated BS: A BS architecture in which all BS elements are located close to one another for example in one or two cabinets.

NOTE – The integrated BS architecture may include tower mount amplifier (TMA) close to antenna.

3.2.8 mobile network (MN): A set of equipment from the radio access network or subnetwork that are relevant for the assessment of energy efficiency.

3.2.9 mobile network coverage energy efficiency: The ratio between the area covered by the network in the mobile network under investigation and the energy consumption.

3.2.10 mobile network data energy efficiency: The ratio between the performance indicator based on data volume and the energy consumption when assessed during the same time frame.

3.2.11 mobile network energy consumption: The overall energy consumption of equipment included in the MN under investigation.

3.2.12 mobile network energy efficiency: The energy efficiency of a mobile network.

3.2.13 mobile network operator (MNO): An operator that manages one or more mobile networks.

3.2.14 mobile network operator penetration ratio: The percentage of traffic served by a mobile network operator in the area where it is active.

3.2.15 mobile network performance delivered: The performance indicator of the MN under investigation, defined as the data volume delivered by the mobile network under investigation during the time frame of the energy consumption assessment.

3.2.16 power: The rate at which energy is transmitted. Power is measured in units of Watts.

3.2.17 power consumption: The power consumed by a device needed to achieve an intended application performance.

3.2.18 radio access network: A telecommunication network in which the access to the network (connection between user terminal and network) is implemented without the use of wires and is part of GSM/EDGE radio access network (GERAN), UMTS terrestrial radio access network (UTRAN) or evolved UMTS terrestrial radio access network (E-UTRA) networks defined by 3rd Generation Partnership Project (3GPP).

3.2.19 telecommunication network: A network operated under a license granted by a national telecommunications authority, which provides telecommunications between network termination points (NTPs).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP	3rd Generation Partnership Project
BS	Base Station
BH	Backhaul
CoA	Coverage Area
CR	Coverage Ratio
CS	Circuit Switched
DCA	Designed Coverage Area
DP	Dominant Penetration
DU	Dense Urban
DV	Data Volume

ECA	Effective Coverage Area
EDGE	Enhanced Data rate GSM Evolution
EE	Energy Efficiency
FAO	Food and Agriculture Organization
GSM	Global System for Mobile communication
LTE	Long Term Evolution
MDT	Minimization of Drive Tests
MN	Mobile Network
MNO	Mobile Network Operator
MP	Minor Penetration
NDP	Non-Dominant Penetration
O&M	Operation and Maintenance
PS	Packet Switched
PSL	Packet Switched Large packets dominating
PSS	Packet Switched Small packets dominating
QoS	Quality of Service
RAB	Radio Access Bearer
RAN	Radio Access Network
RAT	Radio Access Technology
RC	Radio Controller
RRC	Radio Resource Control
RRH	Remote Radio Head
RU	Rural
SCH	Signalling Channel
SINR	Signal to Interference plus Noise Ratio
SU	Suburban
SW	Software
TCH	Traffic Channel
U	Urban
UE	User Equipment
UTRAN	UMTS Terrestrial Radio Access Network

5 Conventions

None.

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6 Network under test definition

6.1 Introduction

The mobile radio access network under investigation shall include all the equipment necessary to run a radio access network (RAN) or subnetwork. Equipment to be included in the mobile network (MN) under investigation follows:

- base stations (BSs) (see [ETSI TS 125 104], [ETSI TS 136 104]);
 - wide area BS;
 - medium range BS;
 - local area BS;
 - home BS.

NOTE – Home BSs (and WiFi access points) are not dealt with in this Recommendation version, but are being considered for a future version.

- site equipment (e.g., air conditioners, rectifiers/batteries, fixed network equipment);
- backhaul (BH) equipment required to interconnect the BS used in the assessment with the core network;
- radio controller (RC).

Power consumption and energy efficiency (EE) measurements of individual mobile network elements are described in several standards (e.g., [ITU-T L.1310] for radio base stations). This Recommendation however, describes energy consumption and MN energy efficiency measurements in operational networks.

As a complete and detailed energy consumption measurement of the entire network of a country or mobile network operator (MNO) is, in most cases, impossible or economically not viable, the total network is split into a small number of networks with limited size (i.e., "subnetworks").

These subnetworks are defined to represent some specific characteristics, for example:

- capacity limited networks representing urban (U) and dense urban (DU) networks;
- suburban (SU) networks with high requirements for coverage and capacity;
- rural (RU) networks, which are usually coverage limited.

The size and scale of the subnetworks are defined by topologic, geographic or demographic boundaries. For networks defined by topologic boundaries, a possible example of a network covered by this Recommendation consists of a radio controller (whenever applicable), its supported access nodes as well as the related network elements. Networks could be defined by geographic boundaries, such as citywide, national or continental networks or could be defined by demographic boundaries, such as urban or rural networks.

The subnetworks analysed might consist of macro-only base stations, heterogeneous networks or what is actually implemented in real networks.

The tests defined in this Recommendation for subnetworks provide the basis to estimate energy efficiency for large networks of one MNO or within an entire country, applying the extrapolation methods described in clause 9. The network under test definition is reported in Figure 1.

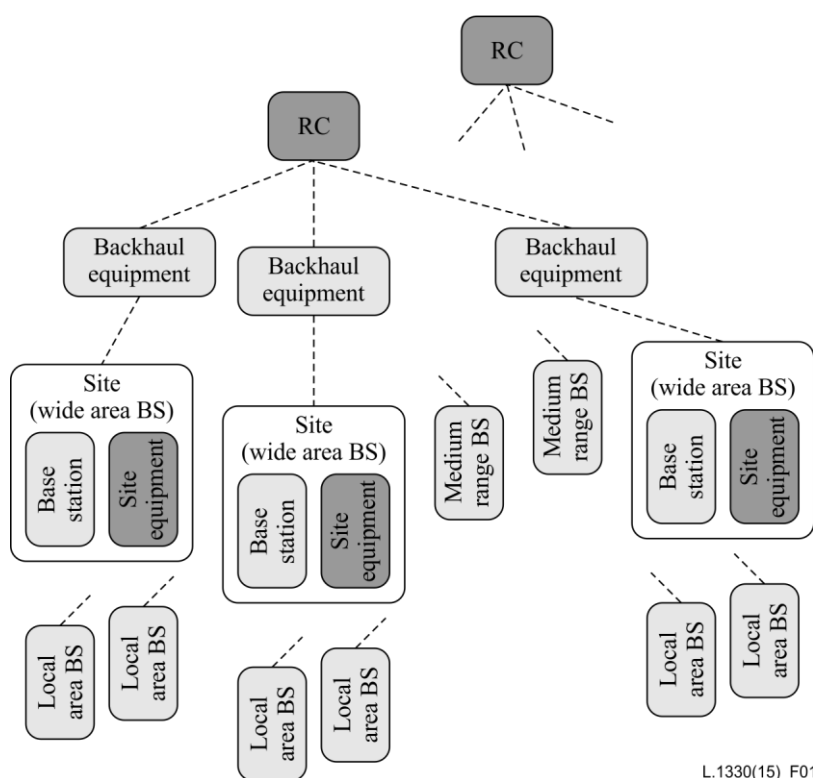


Figure 1 – Network under test definition

6.2 Test parameter categorization

Metrics used for the energy efficiency assessment of an MN require the definition and collection of a range of parameters and variables. These are separated into two categories:

- 1) parameters and variables required to calculate the network energy efficiency;
- 2) parameters needed to allow network energy efficiency evaluation.

The first category describes a set of network variables as described in clause 7 (i.e., energy consumption, delivered bits, coverage) to be used to calculate the energy efficiency.

The second category includes parameters that are not directly required in the energy efficiency calculation. These parameters describe the network characteristics, such as geographical conditions, population density, coverage area (CoA), targeted data rates, climate zones, etc., and are used to interpolate from the measured subnetwork to a larger network as described in clause 9. These parameters can be used to interpret variations in energy efficiency results of different networks. Table 1 reports the test parameter categorization.