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Metrics and Measurement Method for Energy Efficiency of Wireless Access Network Equipment;
Part 2: Energy Efficiency - dynamic measurement method

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Environmental Engineering (EE).

The present document is part 2 of a multi-part deliverable covering Metrics and Measurement Method for Energy Efficiency of Wireless Access Network Equipment, as identified below:

ETSI ES 202 706-1: "Power consumption - static measurement method";

ETSI TS 102 706-2: "Energy Efficiency - dynamic measurement method".

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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Introduction

Energy efficiency is one of the critical factors of the modern telecommunication systems which is about how much energy is going to be consumed for a certain delivered job from the network side while still having an acceptable performance. The energy consumption of the access network is the dominating part of the wireless telecom network energy consumption. Therefore, the core network and the service network are not considered in the present document. In a radio access network, the energy consumption of the Base Station is dominating (depending on technology often also referred to as BTS, NodeB, eNodeB, etc. and in the present document denoted as BS). The energy consumption of Radio Network Control nodes (RNC or BSC) are covered in ETSI ES 201 554 [i.6].

The present document defines the dynamic measurement method for evaluation of LTE BS energy efficiency:

- BS energy efficiency under dynamic load conditions: the BS capacity under dynamic traffic load provided within a defined coverage area and the corresponding energy consumption is measured for given reference configurations.

ETSI ES 202 706-1 [i.8] defines daily average power consumption of the base station, and ETSI TS 103 786 [i.9] defines energy efficiency measurement of the NR base station with dynamic load.

1 Scope

The present document covers the following radio access technology:

- LTE.

The methodology described in the present document is to measure base station dynamic energy efficiency. Within the present document, it is referred to as dynamic measurement.

The results based on dynamic measurements of the BS provide energy efficiency information for BS with dynamic load.

Energy consumption of the core network and the service network are not covered in the present document. The energy consumption of Radio Network Control nodes (RNC or BSC) are covered in ETSI ES 201 554 [i.6].

Energy consumption of user terminal (end-user) equipment is outside the scope of the present document, however, how a User Equipment (UE) affects a base station energy efficiency is an important factor and will be considered for further study.

The scope of the present document is not to set and define target values for the power consumption nor the energy efficiency of equipment and neither for regulatory nor type approval purpose.

The results should only be used to assess and compare the energy efficiency of base stations.

Wide Area Base Stations are covered in this version of the present document.

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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

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 necessary for the application of the present document.

[1] Void.

[2] ETSI EN 300 132-1: "Environmental Engineering (EE); Power supply interface at the input to Information and Communication Technology (ICT) equipment; Part 1: Alternating Current (AC)".

[3] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 2: -48 V Direct Current (DC)".

[4] ETSI TS 136 211: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (3GPP TS 36.211)".

[5] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".

[6] Void.

[7] ETSI EN 300 132-3: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 3: Up to 400 V Direct Current (DC)".

[8] 3GPP TS 36.101 (V18.3.0) (2023-09): "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 18)".

[9] ETSI TS 136 141: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing (3GPP TS 36.141)".

[10] Void.

[11] Void.

[12] IEC/ISO Guide 98-3: "Guide to the expression of uncertainty in measurement" (2008 or equivalent GUM:2008/JCGM 100:2008).

NOTE: Also available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf.

[13] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005)".

2.2 Informative 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 not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Void.

[i.2] Void.

[i.3] ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories".

[i.4] IEC 62018: "Power consumption of information technology equipment - Measurement methods".

NOTE: Equivalent to CENELEC EN 62018.

[i.5] Void.

[i.6] ETSI ES 201 554: "Environmental Engineering (EE); Measurement method for Energy efficiency of Mobile Core network and Radio Access Control equipment".

[i.7] ETSI ES 202 336-12: "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 12: ICT equipment power, energy and environmental parameters monitoring information model".

[i.8] ETSI ES 202 706-1: "Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment; Part 1: Power Consumption - Static Measurement Method".

[i.9] ETSI TS 103 786: "Environmental Engineering (EE); Measurement method for energy efficiency of wireless access network equipment; Dynamic energy performance measurement method of 5G Base Station (BS)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Base Station (BS): radio access network component which serves one or more radio cells and interfaces the user terminal (through air interface) and a wireless network infrastructure

BS test control unit: unit which can be used to control and manage BS locally in a lab

busy hour (load): period during which occurs the maximum total load in a given 24-hour period

distributed BS: BS architecture which contains remote radio heads (i.e. RRH) close to antenna element and a central element connecting BS to network infrastructure

efficiency: throughout the present document the term efficiency is used as the relation between the useful output (telecom service, etc.) and energy consumption of the BS

energy efficiency: Throughout the present document the term energy efficiency is used as the relation between the useful output (telecom service, etc.) and energy consumption of the BS. In more details, the ratio between the produced task or work and the consumed power for producing this task or work over a time period is called energy efficiency. The task or work could be anything and in telecommunication it can for example be the delivered bits to a User Equipment (UE). In this case the unit could be for example [Mbits / kWh] or [bits / kWh] or [Mbits / Joules]. Since the electricity bills for operators are normally presented in kWh and the work can be expressed as delivering Mbits to a user it would be more convenient to express the unit as [Mbits / kWh].

integrated BS: BS architecture in which all BS elements are located close to each other; for example, in one single cabinet

NOTE: The integrated BS architecture may include Tower Mount Amplifier (TMA) close to antenna.

low load: lowest generated traffic during the dynamic measurement period

medium load: medium load between the lowest and busy hour load generated during the dynamic measurement period

power saving feature: software/hardware feature in a BS which contributes to decrease power consumption

static measurement: power consumption measurement performed with different radio resource configurations with pre-defined and fixed load levels

NOTE: See ETSI ES 202 706-1 [i.8].

UE group: group of UEs whose path losses to the BS are identical

wide area base station: base station that is characterized by a Rated output Power (PRAT) greater than 38 dBm

NOTE: See ETSI TS 136 104 [5].

3.2 Symbols

Void.

3.3 Abbreviations

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

AC	Alternating Current
BH	Busy Hour
BS	Base Station
BSC	Base Station Controller

BSEE	Base Station Energy Efficiency
BTS	Base Transceiver Station
BW	Bandwidth
CCE	Control Channel Element
DC	Direct Current
DL	DownLink
DUT	Device Under Test
E2E	End to End
EPRE	Emitted Power per Resource Element
ERRH	Energy for Remote Radio Head
E-UTRA	Evolved Universal Terrestrial Radio Access Network
EVA	Extended Vehicular A model
FDD	Frequency-Division Duplexing
HSPA	High Speed Packet Access
HW	HardWare
kPa	kilo pascal
KPI	Key Performance Indicator
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
NIST	National Institute of Standards and Technology
NR	New Radio
PBCH	Packet Broadcast Control Channel
PCM	Pulse Code Modulation
PDCCH	Physical Downlink Control CHannel
PDSCH	Physical Downlink Shared CHannel
PRAT	Rated output power
PRB	Physical Resource Block
PSS	Primary Synchronizing Signal
PT	Probability Time
REG	Resource Element Group
RF	Radio Frequency
RNC	Radio Network Controller
RRH	Remote Radio Head
RS	Reference Signals
RX	Receiver
S/W	SoftWare
SDH	Synchronous Digital Hierarchy
SIMO	Single Input Multiple Output
SSS	Secondary Synchronizing Signal
SW	SoftWare
TCP	Transmission Control protocol
TM1	Transmission Mode 1
TMA	Tower Mount Amplifier
TX	Transmitter
UE	User Equipment
UL	UpLink
WT	Waiting Time

4 Assessment method

The assessment method is covering the BS equipment dynamic energy efficiency for which the present document defines reference BS equipment configurations and reference load levels to be used when measuring BS energy efficiency.

The assessment procedure contains the following tasks:

1) Identification of equipment under test:

   1.1 Identify BS basic parameters (Table A.1).

   1.2 List BS configuration (Annexes A and B).

1.3 List traffic load(s) for measurements (Annex C).

1.4 List of used power saving features and capacity enhancement features.

2) Energy efficiency measurement under dynamic load conditions, Measure BS equipment delivered task in terms of bits and the consumed energy under required conditions (see clause 6).

3) Collect and report the energy efficiency measurement results.

5 Reference configurations and Measurement requirements

5.1 Reference configurations

Reference configurations are defined for LTE in Annex B.

These configurations include integrated and distributed BS, mast head amplifiers, remote radio heads, RF feeder cables, number of carriers, number of sectors, power range per sector, frequency range, diversity, MIMO.

The BS shall be tested with its intended commercially available configuration at temperatures defined in clause 5.6. It shall be clearly reported in the measurement report if the BS cannot be operated without additional air-conditioning at the defined temperatures.

Appropriate transmission e.g. a transport function or other providing capacity corresponding to the BS capacity, shall be included in the BS configuration during testing. The configurations include:

1) UL diversity (this is a standard feature in all BS. Therefore, it is considered sufficient that the test is performed on the main RX antenna only. The diversity RX shall be active during the measurement without connection to the test signal).

2) DL diversity: Transmission mode 3 "Open loop spatial multiplexing" shall be according to ETSI TS 136 211 [4] (2×2 DL MIMO)).

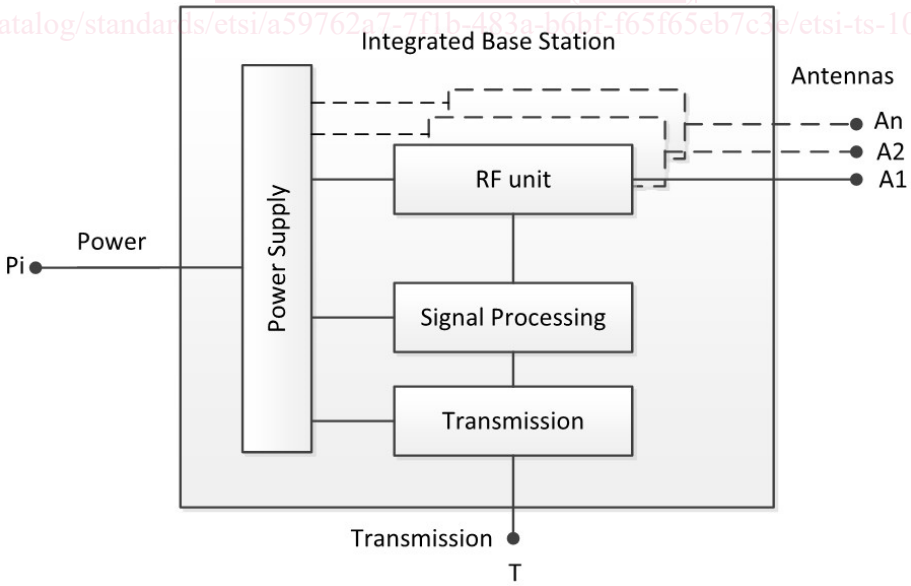

Figure 1: Integrated BS model