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**Environmental Engineering (EE);
Measurement method for energy efficiency
of wireless access network equipment;
Dynamic energy efficiency measurement method of
5G Base Station (BS)**

Reference
RTS/EE-EEPS74

Keywords
5G, base station, energy efficiency, KPI, NR

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
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Foreword

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

Modal verbs terminology

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Introduction

Increase of energy consumption and the related cost has been one of the key questions among the whole industry depending on energy and specially telecom operators whose energy consumption cost is one of the main contributors to their OPEX. Despite the increasing of the OPEX, the environmental aspect in terms of CO2 emission has been one of the most debated subjects within global warming discussions. Energy efficiency is one of the critical factors of the modern telecommunication systems.

In mobile telecom industry the energy consumption of the access network is the dominating part of a 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.

In context of 5G, one is often talking about three classes of use cases: enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC) and Ultra-Reliable and Low-Latency Communication (URLLC). eMBB corresponds to the evolution of today's mobile broadband services, enabling even larger data volumes and further enhanced user experience, higher end-user data rates while mMTC and URLLC correspond to services characterized by a massive number of devices and services with very low latency and extremely high reliability respectively.

The present document defines the dynamic measurement method for evaluating energy efficiency of 5G radio Base Stations with respect to the eMBB use case only. Dynamic measurement method for evaluating energy efficiency of 5G radio Base Stations with respect to mMTC and URLLC is subjected for further study and will be handled in future versions of the present document. Due to the dynamic nature of eMBB service it may be very difficult or impossible to show gains of some Base Station features that improve energy efficiency using static method ETSI ES 202 706-1 [i.6] alone. Compared to static method, the dynamic method strives to give more realistic estimates of Base Station's energy consumption and energy efficiency.

To evaluate BS energy efficiency under dynamic traffic load conditions, the BS capacity under dynamic traffic load provided within a defined coverage area and the corresponding energy consumption are measured for given reference configurations.

ETSI ES 202 706-1 [i.6] defines daily average power consumption of the base station (static method), and ETSI TS 102 706-2 [i.5] defines energy efficiency measurement of the LTE base station with dynamic load.

1 Scope

The present document covers the following radio access technology:

- 5G NR.

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.

The present document covers only the enhanced Mobile Broadband (eMBB) use case of 5G. Other use cases such as massive Machine-Type Communication (mMTC) and Ultra-Reliable and Low-Latency Communication (URLLC) will be the subject for future versions of the present document.

Energy consumption of terminal (end-user) equipment is outside the scope of the present document, however, how a User Equipment (UE) affects a Base Station energy performance 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 complete Base Stations.

Wide Area Base Stations are covered in the present document.

The present document only covers conducted testing, not Over The Air (OTA) testing. In other words, the present document is applicable to BS type 1-C and BS type 1-H (at TAB connectors).

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] 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)".

[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 300 132-3: "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)".

[4] ETSI TS 138 211: "5G; NR; Physical channels and modulation (3GPP TS 38.211)".

[5] ETSI TS 138 104: "5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104)".

[6] ETSI TS 138 141-1: "5G; NR; Base Station (BS) conformance testing Part 1: Conducted conformance testing (3GPP TS 38.141-1)".

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

[8] Void.

[9] Void.

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

[i.2] IEC 62018: "Power consumption of information technology equipment - Measurement methods".

NOTE: Equivalent to CENELEC EN 62018.

[i.3] Void.

[i.4] ETSI TR 138 901 (V17.0.0): "5G; Study on channel model for frequencies from 0.5 to 100 GHz (3GPP TR 38.901 version 17.0.0 Release 17)".

[i.5] ETSI TS 102 706-2: "Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment; Part 2: Energy efficiency - dynamic measurement method".

[i.6] 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.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".

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: relation between the useful output (telecom service, etc.) and energy consumption of the BS

energy efficiency: relation between the useful output (telecom service, etc.) and energy consumption of the BS

NOTE: 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: 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 (see ETSI ES 202 706-1 [i.6])

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

Wide Area Base Station: Base Station characterized by requirements derived from Macro Cell scenarios with a BS to UE minimum coupling loss equals to 70 dB and a rated output power (PRAT) above 38 dBm

NOTE: For example, for NR this PRAT is the mean power level per carrier according to ETSI TS 138 104 [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
BSEE	Base Station Energy Efficiency
DC	Direct Current
DL	DownLink
DUT	Device Under Test
eMBB	enhanced Mobile BroadBand
GUM	Guide to the expression of Uncertainty in Measurement
HW	HardWare
KPI	Key Performance Indicator
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
mMTC	massive Machine-Type Communications
NIST	National Institute of Standards and Technology
NR	New Radio
NSA	Non-StandAlone
OPEX	Operating Expense
OTA	Over The Air
PBCH	Packet Broadcast Control Channel
PCM	Pulse Code Modulation

PRAT	Power RATed
PRB	Physical Resource Block
PSS	Primary Synchronizing Signal
RF	Radio Frequency
RMSI	Remaining Minimum System Information
RRH	Remote Radio Head
RX	Receiver
SA	StandAlone
SDH	Synchronous Digital Hierarchy
SIB	System Information Block
SS	Synchronization Signals
SSB	Synchronization Signal Block
SSS	Secondary Synchronizing Signal
SW	SoftWare
TAB	Transceiver Array Boundary
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TMA	Tower Mount Amplifier
TX	Transmitter
UE	User Equipment
UL	UpLink
URLLC	Ultra-Reliable Low-Latency Communication

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 (Annex A).

   1.2 List BS configuration (Annex A and Annex 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 (Annex B).

5 Reference configurations and Measurement requirements

5.1 Reference configurations

The BS equipment is a network component which serves a number of user equipment within a specific coverage area over an air interface. A BS interfaces user equipment (through air interface) and a wireless network infrastructure.

Reference configurations are defined in Annex B.

These configurations cover 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: Rank 1, single layer transmission, (MU-MIMO).

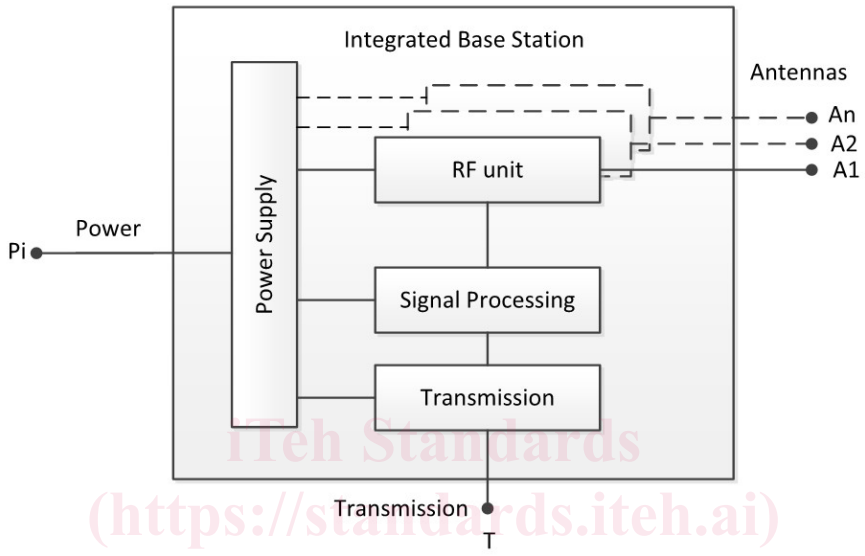

Figure 1: Integrated BS model (Example)

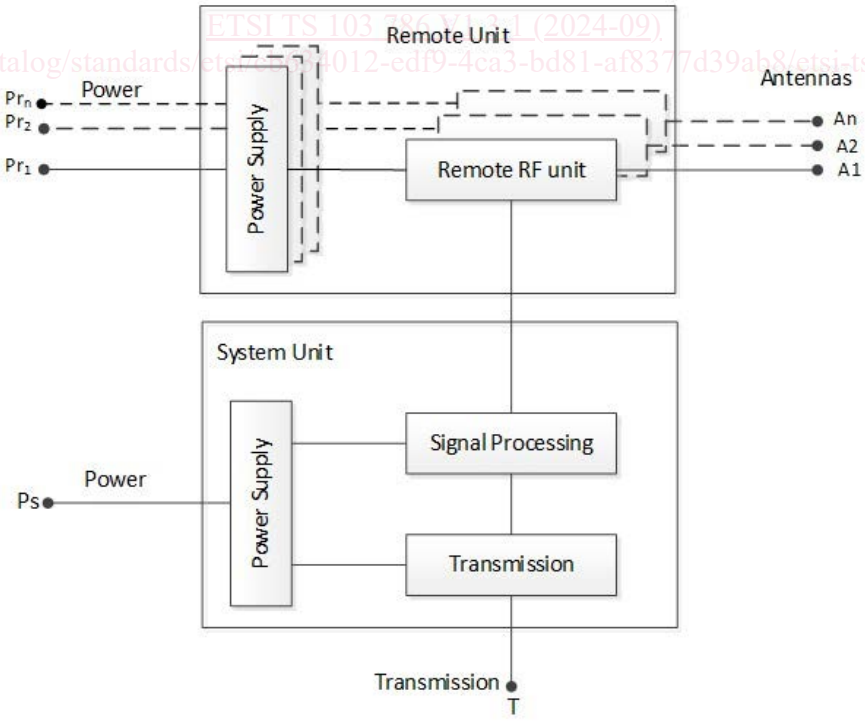

Figure 2: Distributed BS model (Example)