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Measurement method for
Energy efficiency of Mobile Core network and Radio Access Control equipment

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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 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**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 an increasingly important requirement for all modern systems. Governments, communication service providers, vendors, etc. do all agree that energy efficiency is a critical "piece" in the joint strive for a more sustainable society.

With the present document, the industry gets a jointly agreed definition of metrics and measurement methods that - over time - can serve as a platform to excel, measure, and report energy efficiency of the core networks of telecommunication systems. The present document provides robust and reproducible measurements for products used in core telecom networks.

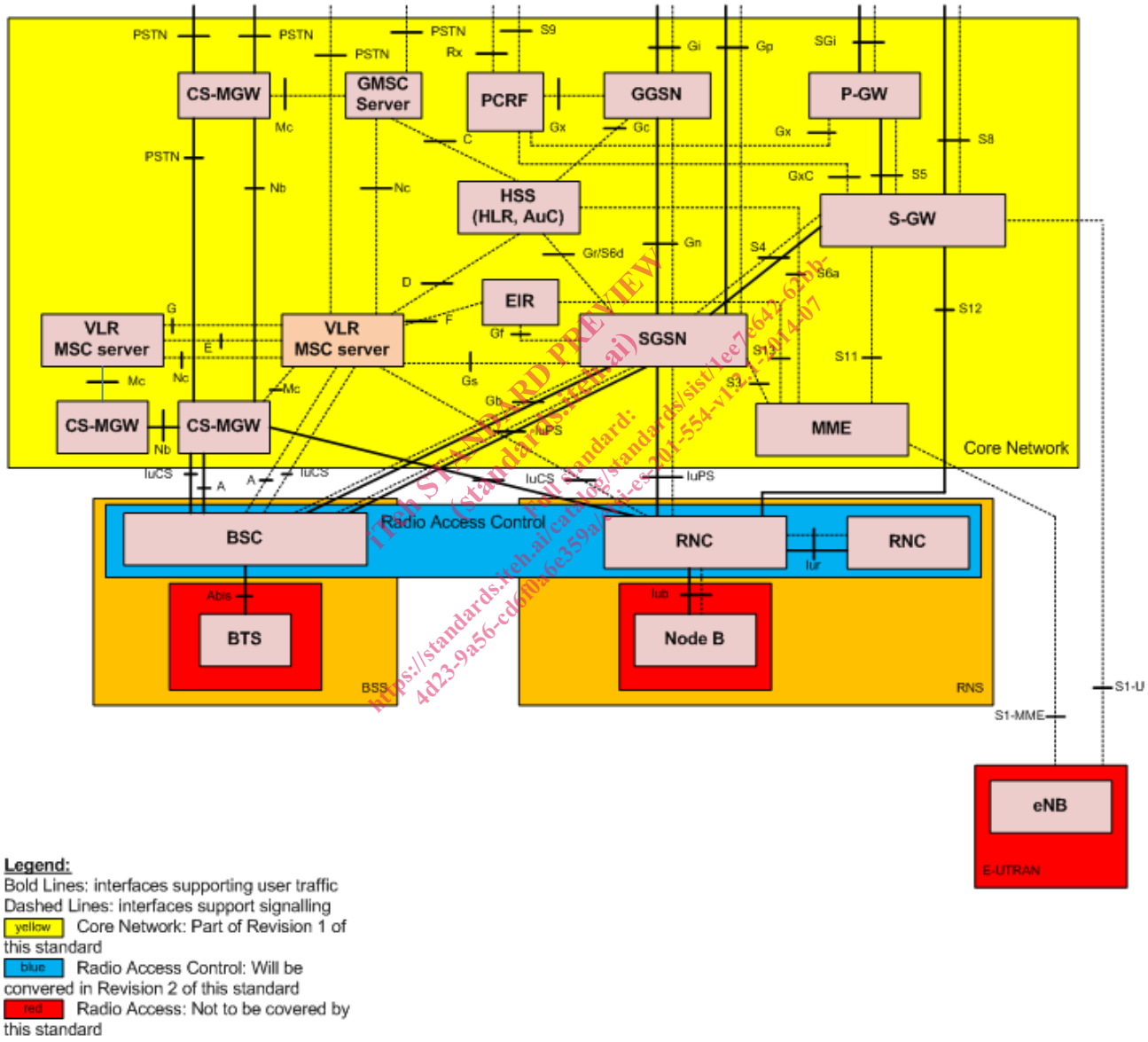
The present document defines energy efficiency metrics and measurement methods for mobile core equipment. In later revisions Base Station Controller (BSC) and IMS core will be added. Energy efficiency is defined as useful output normalized to energy consumption, and the assumption is that an energy efficient system handles more calls, subscribers, etc., with less energy. The present document promotes energy saving features as the traffic profile is a representation of the expected behaviour of the equipment in operation, i.e. the power consumption is measured at different load levels when processing traffic mimicking a typical usage of the equipment. The defined metrics can be used for comparing energy efficiency of different implementations (HW and SW) of the same function only. Energy efficiency of co-located functions can however not be compared using the methodology defined in the present document.

1 Scope

The present document defines metrics and measurement methods applicable for the following systems and nodes defined in TS 123 002 [i.3]:

- Mobile core functions (GGSN, HLR, MGW, MME, MSC, SGSN and PGW/SGW).
- Radio Access Controller (RNC).

Later revisions of the present document will include Base Station Controller (BSC) and IMS core functions (BGCF, CSCF, HSS, IBCF, MRFC, MRFP, SLF and LRF).



Legend:
Bold Lines: interfaces supporting user traffic
Dashed Lines: interfaces support signalling
yellow Core Network: Part of Revision 1 of this standard
blue Radio Access Control: Will be convered in Revision 2 of this standard
red Radio Access: Not to be covered by this standard

Figure 1: Illustrative view of the scope

2 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 reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://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.

2.1 Normative references

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 to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)".

2.2 Informative references

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] IEEE (05 June 2009): "Traffic Analysis for GSM Networks", Boulmalf, M. Abrache, J. Aouam, T. Harroud, H. Al Akhawayn Univ. in Ifrane, Ifrane.

[i.2] ISO/IEC 17025:2005: "General requirements for the competence of testing and calibration laboratories".

[i.3] ETSI TS 123 002 (V9.2.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Network architecture (3GPP TS 23.002 version 9.2.0 Release 9)".

[i.4] ETSI TR 121 905: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Vocabulary for 3GPP Specifications (3GPP TR 21.905)".

[i.5] Sandvine: "Fall 2010 Global Internet Phenomena Report".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

energy consumption: amount of consumed energy

NOTE: It is measured in Joule or kWh (where 1 kWh = 3,6 × 10^6 J) and corresponds to energy use.

energy efficiency: relation between the useful output and energy consumption

erlang: average number of concurrent calls carried by the circuits

function: logical representation of a network element defined by 3GPP

node: physical representation of one or more functions

power consumption: amount of consumed power

NOTE: It is measured in W and corresponds to the rate which energy is converted.

power saving feature: feature which contributes to decreasing power consumption compared to the case when the feature is not implemented

system under test: node being measured

test suite: complete sequence of measurements including low, medium, and high load levels as individual test steps

useful output: maximum capacity of the system under test which is depending on the different functions

NOTE 1: It is expressed as the number of Erlang (Erl), Packets/s (PPS), Subscribers (Sub), or Simultaneously Attached Users (SAU).

NOTE 2: It is expressed as maximum instantaneous traffic Erling (CS) and bits/s (PS).

3.2 Symbols

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

A Ampere

NOTE: SI unit of electric current.

h Hour

NOTE: SI unit of measurement of time.

J Joule

NOTE: SI unit of energy or work, J = W × s.

s Second

NOTE: SI unit of measurement of time.

V Volt

NOTE: SI unit for electric potential difference (voltage).

W Watt

NOTE: W = V × A.

3.3 Abbreviations

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

NOTE: Additional abbreviations may be found in TR 121 905 [i.4].

2G Second-Generation wireless telephone technology

EXAMPLE: GSM.

3G Third-Generation mobile telecommunications

EXAMPLE: WDCMA.

AC Alternating Current

NOTE: Bidirectional flow of electric charge.

AS Application Server
AUC AUthentication Centre

BGCF	Breakout Gateway Control Function
BICC	Bearer Independent Call Control
BSC	Base Station Controller
BTS	Base Transceiver Station
CS	Circuit Switched
CSCF	Call Session Control Function
DC	Direct Current

NOTE: Unidirectional flow of electric charge.

EIR	Equipment Identity Register
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
GUTI	Globally Unique Temporary Identity
HLR	Home Location Register
HO	HandOver
HSS	Home Subscriber Service
HW	HardWare
IBCF	Interconnect Border Control Function
IMEI	International Mobile Equipment Identity
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
ISUP	Integrated Services digital network User Part
LRF	Location Retrieval Function
LU	Location Update
MGW	Media GateWay
MHT	Mean Holding Time
MME	Mobility Management Entity
MO	Mobile Originated
MRFC	Media Resource Function Controller
MRFP	Media Resource Function Processor
MSC	Mobile Switching Centre
MSS	Mobile Switching centre Server
MT	Mobile Terminated
Node B	eq Base Transceiver Station
PDN	Public Data Network
PDP	Packet Data Protocol
PGW	PDN Gateway
PLMN	Public Land Mobile Network
POI	Point Of Interface
PPS	Packets Per Second
PSTN	Public Switched Telephone Network
RNC	Radio Network Controller
SAU	Simultaneously Attached Users
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SI	International System of units
SIP	Session Initiation Protocol
SLF	Subscriber Location Function
SMS	Short Message Service
SW	SoftWare
TDM	Time Division Multiplexing
USSD	Unstructured Supplementary Service Data
VLR	Visitor Location Register
WCDMA	Wideband Code Division Multiple Access

4 Definition of Power consumption and metrics for Core networks

4.1 Black box

The system under test is seen as a "black box", i.e. only the total power consumed by the device or shelf/shelves is/are measured and not different parts of the device or shelf/shelves. A "black box" can be viewed solely in terms of its input, output and transfer characteristics without any knowledge of its internal workings.

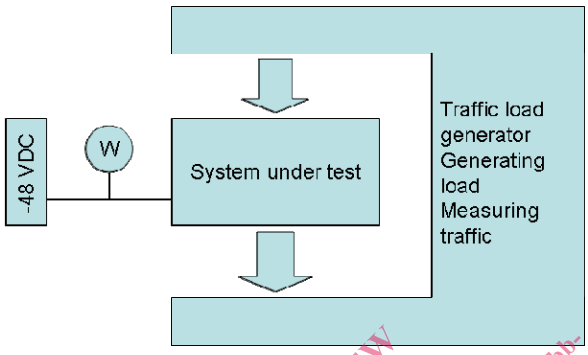


Figure 2: Measurement set-up of system under test

4.2 Site energy consumption

Energy consumption at site includes also climate units, losses, auxiliary equipment, etc. These aspects are not observed in the present document.

4.3 Power consumption

The defined traffic profile mimics the behaviour of a function in operation (i.e. with load level variations) and the resulting performance indicators constitutes of a weighted average of multiple measurements.

The load levels are defined as:

- Specification: T_S - the maximum capacity according to the vendor's specification of the specific implementation of the function
- High: $T_H = 1{,}0 \times T_S$
- Mid: $T_M = 0{,}7 \times T_S$
- Low : $T_L = 0{,}1 \times T_S$

As the present document defines metrics and measurements for a wide variety of implementations of functions - operating in control and/or user planes as well as circuit switched and/or packet switched domains - further details on the traffic models are specified per function in annexes A to G.

The power consumption levels associated with the above load levels are defined as:

- High: P_H = average power consumption [W] measured at T_H
- Mid: P_M = average power consumption [W] measured at T_M
- Low: P_L = average power consumption [W] measured at T_L

The average power consumption is defined as:

$$P_{avg} = \alpha \times P_L + \beta \times P_M + \gamma \times P_H \text{ [W]} \quad (1a)$$

Where α, β, and γ are weight coefficients selected such as $(\alpha + \beta + \gamma) = 1$.

The inclusion of power consumption at T_M, and T_L highlights the importance of Power saving features.

See annexes A to G for further details.

4.4 Shaping of weight coefficients

Although the functions included in the present document are heterogeneous in the sense that they operates in control and/or user planes as well in circuit switched and/or packet switched domains, it is possible to distinguish three normalized traffic profiles:

- Voice
- Data
- Subscriber

The weight coefficients for the normalized traffic profiles are derived by mapping the defined load levels (low, medium, and high) to the following analysis of live networks; IEEE (05 June 2009): "Traffic Analysis for GSM Networks" [i.1], Sandvine: "Fall 2010 Global Internet Phenomena Report" [i.5], respectively.

Table 1

Profiles	KPI (Key Performance Indicator)	P_{avg} weight coefficients		
		α	β	γ
Subscriber	Subscriber	0,1	0,4	0,5
Data	PPS or SAU	0,2	0,45	0,35
Voice	Erlang or Subscriber	0,4	0,4	0,2

The mapping of load levels to the analysis of live networks are illustrated in figures 3, 4 and 5, respectively.

Figure 3: Working states for voice centric function