GISFI TR GICT.107 V1.0.0 (2013-08)

Technical Report

Global ICT Standardisation Forum for India;

Technical Working Group GICT;

Metrics and Measurement Methods of Telecommunication Equipments: Radio Base Station

(Draft)

 

The present document has been developed within GISFI and may be further elaborated for the purposes of GISFI.

Keywords

GICT, Radio Base Station.

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# Foreword

This Technical Report has been produced by GISFI.

The contents of the present document are subject to continuing work within the Technical Working Group (TWG) and may change following formal TWG approval. Should the TWG modify the contents of the present document, it will be re-released by the TWG with an identifying change of release date and an increase in version number as follows:

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x the first digit:

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# Introduction

This clause is optional. If it exists, it is always the second unnumbered clause.

# 1 Scope

The present document surveys the global standards on metrics and measurement methods for energy efficiency of circuit switched cellular wireless equipments; specifically GSM radio base stations. There are several RBS deployment configurations that are supported within the applicable standards. This technical report provides a detailed comparison of the specifications on metrics, lab setup requirements, traffic generation, measurement methodology and report formats.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] ETSI TS 102 706 V1.2.1; (2011-10); Environmental Engineering (EE); Measurement Method for Energy Efficiency of Wireless Access Network Equipment

[2] ITU recommendation: L.1310; (2012-11); Energy efficiency metrics and measurement for telecommunication equipment.

[3] ATIS-0600015.06.2011; (2011-11): Energy efficiency for telecommunication equipment: Methodology for measurement and reporting of radio base station metrics

[4] ECR Initiative - Network and Telecom Equipment - Energy and Performance (Assessment Metrics, Test Procedure and Measurement Methodology), Draft 3.0.1, December 14, 2010

[5] ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories

[6] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005 Release 8)".

[7] ATIS-0600015-2009, Energy efficiency for telecommunication equipment: Methodology, Measurement and Reporting- general requirements.

[8] COAI, Presentation to the DoT Committee on Spectrum Allocation Criteria, Nov 2007. URL : www.coai.com/docs/Annexures1.PDF [Last accessed on 26-08-2013]

# 3 Definitions, symbols and abbreviations

##

## 3.1 Definitions

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

AMR Adaptive Multi Rate

ATIS Alliance for Telecommunications Industry Solutions

BCCH Broadcast Control Channel

BSC Base Station Controller

BTS Base transceiver station

CDMA Code division multiple access

COAI Cellular Operators Association of India

CS Circuit Switched

EDGE Enhanced Data Rates for GSM Evolution

ETSI European Telecommunications Standards Institute

EUT Equipment Under Test

FDD Frequency Division Duplexing

GPRS General Packet Radio Service

GSM Global System for Mobile Communications

ICT Information and Communication Technology

ITU International Telecommunication Union

LTE Long Term Evolution

RBS Radio Base Station

RF Radio Frequency

RNC Radio Network Controller

TEER Telecommunications Energy Efficiency Ratio

TRU Transceiver Unit

TRX Transceiver

TS Time Slot

UE User Equipment

UE User Equipment

UMTS Universal Mobile Telecommunications System

WCDMA Wideband Code Division Multiple Access

# 4 Equipment Category Description

A Radio Base Station (RBS) is telecommunication equipment that facilitates wireless communication between user equipment (UE) and a cellular wireless network such as those based on GSM, CDMA, 3G or LTE standards. A RBS serves one or more sectors and has radio frequency (RF) interfaces to UEs through the air interface, and has interfaces to a wireless network infrastructure (BSC, RNC or mobility management entity). The controller functionality within an RBS has interfaces to the core network. RBS may refer to a BTS (for GSM/EDGE and cdma2000), a NodeB (for WCDMA/HSPA), an eNodeB (for LTE) or a BS (for WiMAX).

This document provides a detailed comparison of standards from ETSI [1], ITU [2], ATIS [3] with a focus on GSM RBS equipment. Following is the scope of the three applicable global standards addressing energy efficiency of telecommunication equipments.

Table 1: Comparison of the equipments covered under the energy efficiency standards

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| The present version of the standard covers the following radio access technologies:1. GSM2. LTE3.WCDMA4. WiMAX | Wireless access technologies cover the following radio access technologies:1. GSM/EDGE2. WCDMA3. CDMA4. WiMAX5. LTE | Methodologies described in this standard are suitable for the following radio access technologies:1. LTE2. CDMA3. EV-DO4. UMTS5. GSM6. WiMAX |

# 5 Metric Definition

This section deals with the definition of energy efficiency metrics given by various global standards for GSM RBS equipment. In particular the ETSI [1], ITU [2] and ATIS [3] standards have been compared.

Table 2: Comparison of the metric definition for energy efficiency of RBS equipment

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| Definition:  Three level assessment method to be used to evaluate energy efficiency of wireless access networks. The three levels are:• RBS equipment average power consumption for which [1] defines reference RBS equipment configurations and reference load levels to be used when measuring RBS power consumption.• RBS site average power consumption which is based on measured RBS equipment power consumption and site level correction factors defined in the present document. • Network level performance indicators which are based on RBS site energy consumption as well as site coverage, site capacity.  | Definition:The metrics for radio base stations are defined in terms of coverage or in terms of traffic and are defined in ETSI TS 102 706[1].  | Definition: TEER is defined as $$TEER= \frac{Useful Work Done}{Power}$$Where “Useful Work” is the voice call throughput (Erlangs) or the data throughput (kbps) of the application layer and power is the input power (Watts) consumed by the RBS. TEER is measured over three coverage areas and at five traffic load levels. |
| Computation:Power consumption in static methodThe power consumption of integrated RBS equipment in static method is defined for three different load levels as follows* $P\_{BH} $ is the power consumption [W] with busy hour load
* $P\_{med} $ is the power consumption [W] with medium hour load
* $P\_{low} $ is the power consumption [W] with low load

The loads are defined for a given system. The model covers voice and/or data hour per hour.The average power consumption[W] of integrated RBS equipment in static method is defined as:$$P\_{equipment,static}=\frac{P\_{BH}t\_{BH}+ P\_{med}t\_{med}+P\_{low}t\_{low}}{t\_{BH}+ t\_{med}+ t\_{low} }$$Where,$t\_{BH}$ , $t\_{med}$ and $t\_{low}$ [hour] are duration of different load levelsDefinition of power consumption for distributed RBS in static method:The power consumption of distributed RBS equipment in static method is defined for three different load levels as following:* $P\_{BH,C}$ and $P\_{BH,RRH}$ are the power consumption[W] of central and remote parts of RBS with busy hour load.
* $P\_{med,C}$ and $P\_{med,RRH}$ are the power consumption [W] of central and remote parts of RBS with medium term load.
* $P\_{low,C}$ and $P\_{low,RRH}$ are the power consumption [W] of central and remote parts of RBS with low load.

The average power consumption [W] of distributed RBS equipment is defined as:$$P\_{equipment, static}= P\_{c,static}+ P\_{RRH,static} $$In which $P\_{c,static}$ and $P\_{RRH,static} $[W] are average power consumption of central and remote parts in static methods defined as :$$P\_{C,static}= \frac{P\_{BH,C}t\_{BH}+ P\_{med,C}t\_{med}+P\_{low,C}t\_{low}}{t\_{BH}+ t\_{med}+ t\_{low} }$$$$P\_{RRH,static}= \frac{P\_{BH,RRH}t\_{BH}+ P\_{med,RRH}t\_{med}+P\_{low,RRH}t\_{low}}{t\_{BH}+ t\_{med}+ t\_{low} }$$In which $t\_{BH}$, $t\_{med}$ and $t\_{low}$ [hour] are duration of different load levels. The average power consumption of distributed RBS equipment does not include the DC feeder loss for remote parts. | Not defined | Computation:$$TEER=c1\*\frac{T\_{Near(100)}}{\sum\_{i=1}^{M}b\_{i}P\_{Near(i)}}+c2\*\frac{T\_{Middle(100)}}{\sum\_{i=1}^{M}b\_{i}P\_{Middle(i)}}+ c3\*\frac{T\_{Cell\\_Edge(100)}}{\sum\_{i=1}^{M}b\_{i}P\_{Cell\\_Edge(i)}}$$c1,c2,c3 : Coefficient to represent subscriber percentage in near, middle and cell edge location respectively$T\_{Near(100)}$,$T\_{Middle(100)}$, $T\_{Cell\\_Edge(100)}$ : 100% throughput values for the three received signals measured in Erlang for voice technologies.$P\_{Near(i)}$, $P\_{Middle(i)}, P\_{Cell\\_Edge(i)}$ : The average power level in Watts at each load level *i* for each of the three test locations$b\_{i}$ The weighing factor for each load level*M* Number of load levels (5 for voice) |

From Table 2, it can be observed that the energy efficiency metric can be defined at the network level, the site level and the equipment level. Network level metrics are used to evaluate the energy efficiency of an entire network or part of it such as the access network of the operator. They are normally used to evaluate a network for internal operator use or to satisfy an environmental assessment. Equipment level metrics are mostly used for the comparison of telecommunication equipment of the same technology. They evaluate the overall energy efficiency performance at the equipment level which is considered as a single entity from a measurement point of view. Site level metrics are based on measured equipment power consumption and site level correction factors which may include non-ICT factors such as nature and source of the power supply, cooling equipments etc. These metrics may be used to compare different equipment at the site level. The ETSI specification defines site and network level energy efficiency metrics. The ATIS recommends equipment level energy efficiency metrics for RBS equipments.

# 6 Traffic Profile and Parameters

This section describes the traffic profile and system parameters used to generate the test load for RBS energy consumption measurements. In static load tests, the ETSI specification recommends method to simulate the three radio load conditions (high, medium and low) through predefined transmit power levels for the transceivers (TRXs) as per the RBS configurations. The ATIS specification on the other hand specifies the voice traffic source model and five variable load levels. It does not however define any particular methods to generate these loads as per the different RBS TRX configurations.

ITU [1]: Not defined

ETSI [2]: Model for GSM subscriber and busy hour traffic

CS voice traffic: 0.02 Erlangs/subscriber during Busy hour

Table 3: Busy hour traffic for GSM site

|  |  |
| --- | --- |
| Model for busy hour average traffic load [2] | Busy hour traffic |
| S222 | 18 Erlangs (3 x 6) |
| S444 | 51 Erlangs (3 x 17) |
| S888 | 123 Erlangs (3 x 41) |

Table 4: Load Model for GSM [2]

|  |  |  |  |
| --- | --- | --- | --- |
|  | Low Load | Medium load | Busy hour load |
| Load for 222 | BCCH: Fig. 1Other TRX: Idle | BCCH: Fig. 1Other TRX: idle | BCCH: Fig. 1Other TRX: 2 active TS per each sector at static power level. Other TS idle |
| Load for 444 | BCCH: Fig. 1Other TRX: Idle | BCCH: Fig. 1Other TRX 6 active TS per each sector at static power level. Other TS idle. | BCCH: Fig. 1Other TRX 12 active TS per each sector at static power level. Other TS idle. |
| Load for 888 | BCCH: Fig. 1Other TRX: Idle | BCCH: Fig. 1Other TRX 18 active TS per each sector at static power level. Other TS idle. | BCCH: Fig. 1Other TRX 36 active TS per each sector at static power level. Other TS idle. |
| Load level duration | 6 hours | 10 hours | 8 hours |

Static power level

Power

0

1

2

3

4

5

5

7

Pidle

Figure 1. Power level for BCCH TRX (All TS active) [2]

The Figure 1 and Tables 3 and 4 define the load model for GSM for three specific radio configurations (2-2-2, 4-4-4 and 8-8-8).

ATIS [3]: For GSM, the voice traffic model in the following Table 5 will be used.

Table 5: Voice traffic model for GSM

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Technology | Application | Min. QoS | Hold Time | AF (%) | Rate (kbps) | UL (kB) | DL (kB) |
| GSM | CS spec/AMR | - | 300 seconds | 50% time | 12.2 | 61 | 61 |

The voice traffic represents a normal speech call with an activity factor of 50% and usage as specified in the respective standard.

Table 6: Variable GSM traffic load levels and weighting factors

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Configuration | N1 | N2 | N3 | N4 | N5 |
| GSM load level | 100% | 75% | 50% | 25% | 0% |
| Weighting Factor (bj) | 0.10 | 0.15 | 0.20 | 0.40 | 0.15 |

For GSM, maximum RBS capacity is achieved when all available time slots are used for calls with a minimum of two time slots used for overhead. The Table 6 defines the GSM load levels and the corresponding weight factors to be used for computation of the ATIS energy efficiency metric.

# 7 General Requirements for Lab Setup

This section describes the general requirements for the laboratory setup including the environmental and the electrical requirements.

## 7.1 Environmental Requirements

Table 7 compares the environmental requirements for the measurements recommended by global standards. It is observed that the ITU and ATIS recommend ambient room temperature to be around 25° C, whereas the ETSI recommendation additionally specifies 40° C to be a requirement for energy consumption measurements.

Table 7: Comparison of environmental requirements for lab setup

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| Room Temperature: 25 °C and 40 °C (±2°C) | Ambient temperature:25°±3°C. | Temperature: 25 +/- 3 °C (77 +/- 5 °F) |
| Room Relative Humidity: 20 % to 85% | Relative humidity of 30% to 75% | Humidity: 30% to 75 % |
| Atmospheric pressure: 86 kPa to 106 kPa. | Site pressure between 860 to 1060 hPa. | Barometric Pressure: 1020 to 812 mbar |

## 7.2 Electrical Requirements

Table 8 provides a comparison of the electrical requirements recommended by the global standards for DC and AC powered equipments. The ATIS recommendations are found to be more stringent than the ETSI and ITU requirements for the power sources.

Table 8: Comparison of electrical requirements for lab setup

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| DC Powered Equipment: With a nominal voltage of -48 V DC according to TS EN 300 132-2, shall be tested with a test voltage of -54,5 V ±1,5 V. Equipment using voltage other than -48 V DC shall be tested at ±1 % of the nominal voltage. | DC Powered Equipment: The DC voltage powering the equipment shall be chosen in the range of - 55.5 to -52.5 V (54±1.5 V). | DC Powered Equipment: DC Voltage -53 V +/- 1V |
| AC Powered equipment: Equipment with a nominal voltage of 230 V shall be tested with a test voltage of 230 V ±5 % and at 50 Hz ±1 % of frequency. | AC powered equipment: The input to the equipment (all active feeds) should be the nominal specified voltage ±5% and the specified frequency ±1%. | AC powered equipment:Total harmonic distortion </=2% up to and including the 13th harmonic115 VAC +/- 1 %, 60 Hz +/- 1 %230 VAC +/- 1 %, 50 or 60 Hz +/- 1 % |

# 8 Test Procedure

This section provides a detailed comparison of the measurement conditions, equipment configurations and measurement procedure recommended for the computation of the energy efficiency metrics.

## 8.1 Measurement Condition

Table 9 compares the lab setup requirements before the measurements are commenced for the energy consumption of RBS equipments. Both the ETSI and ATIS standards require the RBS equipment to stabilize in the operating environment complying with the requirement outlined in the Section 7 for a minimum duration of one hour.

Table 9: Comparison of measurement conditions for lab setup

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| Stabilization:The power consumption measurements shall be performed when stable temperature conditions inside the equipment is reached. For this purpose the RBS shall be placed in the environmental conditions for minimum two hours with a minimum operation time of one hour before doing measurements. | Not Described | Stabilization:The equipment is to be powered and placed into the relevant operating mode.Allow the system to stabilize to the environment for at least one hour per ATIS 0600015.2009 [7] |

## 8.2 Equipment Configuration

In Table 10, a comparison of equipment configuration requirements for measurements as specified by ETSI and ATIS standards is provided. Apart from the RF transmit power and TRX configuration requirements; the other major difference amongst the applicable standards for static testing is with respect to the UE distribution. The ETSI specification does not consider spatial UE distribution model for static load tests for GSM whereas the ATIS standard defines the near, middle and cell edge UE requirements for the test setup. Figure 2 and Figure 3 depict the reference lab setup diagrams and specified by the ATIS and ETSI standards respectively.

Table 10: Comparison of equipment configuration for lab setup

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| Reference Configuration:• Number of sectors and carriers: 222 (2 carriers per sector, 3 sectors), 444, 888.• Power Input: -48 V DC, +24 V DC, 230 V AC.• Nominal TX power to be used for TS with user traffic.• RF output power level: Applicable range from 3 W to 100 W.The frequency band should be according to equipment specifications. Examples of frequencies for bands defined in TS 145 005 [6]

|  |  |  |
| --- | --- | --- |
| Band | Uplink (MHz) | Downlink (MHz) |
| 900 | 880 to 915 | 925 to 960 |
| 1800 | 1710 to 1785 | 1805 to 1880 |

 | Not Described | Reference Configuration:The GSM configurations shall have 3 sectors and 2 TRX per sector.For the purpose of this test, all systems shall be tested as FDD. The RF output power level shall be 20W per sector. Static receiver sensitivity (-102 dBm per 20 kHz)UE distribution determined by signal strengths

|  |  |  |
| --- | --- | --- |
| A1 (Near) | A2(Middle) | S3 (Cell Edge) |
| -60 dBm | -75 dBm | -90 dBm |

|  |  |  |
| --- | --- | --- |
| Band | Uplink (MHz) | Downlink (MHz) |
| 1900 M | 1850 – 1910 | 1930-1990 |
| 900 M | 890 – 915 | 935-960 |
| 1800 M | 1710 - 1785 | 1805-1880 |

 |

Power Analyzer Option

Traffic Generator

Core Network

Radio Base Station

Sector 1

Sector 2

Sector 3

Measuring RBS power consumption

AC or DC source

W

V

Power input

Sensor

RF power meter

Path loss Attenuator

N Calibration Attenuators

N UEs

Traffic Monitor

Ammeter / Voltmeter Option

A

Figure 2. ATIS reference configuration for static testing of GSM RBS

Power input

Alternatively

Radio Base Station

RBS Test control unit

RF power meter & load system

RF power meter & load system

RF power meter & load system

DC power supply

V

A

AC or DC power supply

RF output (RBS antenna connections)

Figure 3. ETSI configuration for static measurements

## 8.3 Measurement Procedure

A comparison of measurement procedures described in the ETSI, ITU and ATIS standards for GSM RBS equipment is provided in Table 11.

Table 11: Comparison of measurement procedures for computation of energy efficiency metric

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| In the static measurement, the RBS is powered either by a DC or AC power supply and operated by the RBS test control unit.This control unit provides the RBS with control signals and traffic data which are required to perform the static measurements. Each RF output (antenna) connector is terminated with a load with the capability to measure the RF output power. | For test methodologies, equipment configuration and set-up, the methodology reported in ETSI TS 102 706 [1] shall apply, with the modification of general measurement conditions presented in clause 7 of [2]. | Step 1:Prepare Measurement. Configure the RBS according to the appropriate reference configuration. Connect RBS according to the test setup.. Simulate UE positions by adjusting the attenuator setting for the Near position according to the appropriate technology. Allow the system to stabilize to the environment for at least one hour |
| The measurement equipment shall comply with following attributes:• Input power:- Resolution: ≤ 10 mA; ≤ 100 mV; ≤ 100 mW.- DC current: ±1,5 %.- DC voltage: ±1 %.- Wattmeter: ±1 %.- An available current crest factor of 5 or more.- The test instrument shall have a bandwidth of at least 1 kHz.- RF output power: ±0,4 dB. |  | Step 2: Measure the throughput and power for 100% power level. Determine the 100% traffic load according to the appropriate technology. For voice traffic, the vendor shall configure the system to the maximum Erlangs for the defined technology.. Generate 100% traffic load. Allow the system to operate under the maximum traffic conditions for 15 minutes. Confirm the system is still operating at 100% traffic load. Should any traffic throughput adjustments be necessary, make the adjustments and wait 15 minutes before proceeding.. Measure and record the total throughput and total radiated RF power for each sector, as well as the total input power of the RBS. This measurement should occur over a period of 5 minutes. The recorded throughput and RF power is the summation of the throughput and RF power for all antenna powers on all sectors and the input power is total input power consumed by the entire integrated RBS and the summation of the input power consumed by the common baseband unit plus all remote radio units for a distributed RBS. |
| The RF output powers as well as the corresponding power consumptions of the RBS shall be measured with respect tothe RF output power levels which are needed to fulfill the requirements from the reference networks as well as the trafficprofiles described in annexes D of [1].The RF output power signal and levels shall be generated according to the test models described in annexes D of [1].Stimulation shall be realized via the RBS controller interface.The test models as well as the system depended load levels are defined in annexes D [1]. |  | Step 3: Repeat the power measurement for all other (< 100%) load levels. Adjust traffic to X% of the 100% traffic measured in Step 2.Generate voice traffic load towards the cell.. Allow the system to operate under the maximum traffic conditions for 15 minutes. Confirm the system is still operating at X% traffic load. Should any traffic throughput adjustments be necessary, make the adjustments and wait 15 minutes before proceeding.. Measure and record the total radiated RF power for each sector, as well as the total input power of the RBS. The measurement should occur over a period of 5 minutes. Note that the input power and RF output power include all three sectors and common equipment. Record the throughput.. Collect the required measurements after allowing the EUT to stabilize at temperature. Parameters such as the radiated RF power and consumed power shall be measured. It is necessary to record the actual throughput for each load setting.. Repeat this step for all load levels defined for voice.Step 4: Repeat Steps 1 to 3 for Middle and Cell Edge attenuator settingsStep 5: Calculate TEER. Calculate the TEER using the data from Steps 2-4.. Include all measured and calculated values in the accompanying report. |

The ETSI specification considers variable load levels of the GSM RBS. However, it does not simulate either the presence of multiple UEs nor their relative distance from the RBS in case of the static load testing. The ATIS specification [3] takes into consideration both the variable load levels (five levels) and the relative distances of the UEs from the RBS (three levels).

# 9 Reporting Format

The Table 12 provides a brief comparison of the recommendations on the reporting format for energy efficiency metrics and measurement methods as per the ETIS, ITU and ATIS standards. The ETSI and ATIS standards recommend the guidelines on the test report and the parameters to be reported along with RBS specific configurations.

Table 12: Comparison of reporting formats

|  |  |  |
| --- | --- | --- |
| ETSI [1] | ITU [2] | ATIS [3] |
| The results of the assessments shall be reported accurately, clearly, unambiguously and objectively, and in accordance with any specific instructions in the required method(s).A list of reference parameters, measurement conditions, test results and derived calculation results which are to be reported is given in annex A of ETSI 102 706 [1].Further guidelines on the test report can be found in clause 5.10 of ISO/IEC 17025 [5]. | Not Defined | The test report shall contain complete information about the EUT, software version, EUT configuration information, hardware serial numbers, and test instruments’ models and serial numbers. The equipment class shall be included in the reporting description. The report would be based on the ATIS0600015-2009 [7] general requirements for measurement reports. |

# 10 Indian Requirements

## 10.1 Definition of energy efficiency of RBS

The general definition of energy efficiency metric by ITU [2] is: “Energy efficiency will be defined as the relationship between the specific functional unit for a piece of equipment (i.e., the useful work of telecommunications) and the energy consumption of that equipment.” This definition is generic and may be used as a guideline to determine the right metric for RBS.

The ETSI [1] specification does not define an energy efficiency metric for the RBS equipment. It defines site level and network level energy efficiency metrics that are dependent upon non-ICT components like air conditioning, source of electrical energy etc. Hence, they do not reflect the energy efficiency performance of the telecom equipment alone.

The ATIS [3] specification defines the energy efficiency of RBS equipment as the total useful work done per unit energy consumed by the equipment which is in agreement with the general definition of energy efficiency of telecommunication equipment.

## 10.2 RBS configurations

The Indian GSM deployment is heterogeneous and consists of various antenna profiles. Some of these listed by COAI [8] are given below:

Macro cell deployment

a. 1-1-1

b. 2-2-2

c. 4-4-4

d. 5-5-5

e. 6-6-6

f. 8-8-8

g. 10-10-10

In building Micro cell deployment

a. 2-0-0

b. 2-2-0

The ETSI specification [1] describes the 2-2-2, 4-4-4 and 8-8-8 configuration, whereas the ATIS specification [3] describes the 2-2-2 configuration alone. Indian deployment configurations must be further supported in the specifications. Further, comparison must be allowed among RBS equipment of the same configuration since the useful work done [Erlang traffic capacity] increases non-linearly with increase in TRUs (Transceiver Units).

## 10.3 Transmit power of the RBS

The ETSI specification [1] has considered energy efficiency measurements for RF output power levels of 3-100 W. Further the ATIS specification [3] suggests measurement at 20 W RF power per sector. While considering pico, micro RBS apart from the macro coverage equipments, appropriate transmit power levels should also be supported.

## 10.4 Computation of energy efficiency metric

The ETSI specification [1] takes care of variable load levels for the UEs connected to the GSM RBS. However, it does not simulate either the presence of multiple UEs nor their relative distance from the RBS in case of the static load testing. At the same time, the ATIS specification [3] takes into consideration both the variable load levels (five levels) and the relative distances of the UEs from the RBS (three levels).

It may be noted that in practice, the Indian GSM deployment is very heterogeneous and discrete levels of load and subscriber density w.r.t distance from RBS cannot accurately model the Indian scenario. The densities vary a lot from the urban scenario to the rural scenario as well as depend on network planning. From TEC data in [8], the dense urban deployment (2% of total Indian deployment) can have intersite distance of 100 meters with more than 100% of tele-penetration whereas the rural deployment (48% of total Indian deployment) can have intersite distance of 1130 meters with just 12% of tele-penetration. Thus, using pre-defined coefficients to model subscriber density in a cell area may lead to incorrect interpretation of results.

The COAI data [8] shows that the average utilization of city GSM deployment is close to 70% in India. However, due to unpredictable spread of traffic a small percent of cells in the cities encounter traffic overload and therefore call drops. In such conditions, the operator would upgrade the network capacity. Thus modelling either 0% or 100% traffic load states for measurement of energy efficiency is not recommended. The appropriate load levels for low, medium and high traffic conditions may be obtained from updated TRAI data or from operators.

## 10.5 Traffic models

Voice only traffic is considered in both the ATIS and ETSI specification. In practice a mix traffic model with voice and data simultaneous traffic is used in GSM/GPRS network with few TSs dedicated for data traffic. Such a model needs to be introduced for taking care of mix traffic scenario.

# 11 Conclusion

This technical report provides detailed comparative analysis of the applicable global standards for energy efficiency of GSM radio base station equipments. It is found that, currently only the ATIS standard [3] defines energy efficiency metric for the GSM RBS equipment. Further, India specific requirements have been outlined in the Section 10, that indicate that both ETSI and ATIS standard do not fully address the Indian GSM network requirements.

Annex <A>:
<Annex title>

Annexes are labelled A, B, C, etc. and are "informative"(3G TRs are informative documents by nature).

# A.1 Heading levels in an annex

Annex <1>:
Change history

It is usual to include an annex (usually the final annex of the document) for reports under TSG change control which details the change history of the report using a table as follows:

|  |
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| **Change history** |
| **Date** | **TSG #** | **TSG Doc.** | **CR** | **Rev** | **Subject/Comment** | **Old** | **New** |
| 2013-08 |  |  |  |  | TOC for TR on Energy Efficiency of RBS equipments. |  | 0.0.0 |
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