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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Energy efficiency metrics of a base station site

Recommendation ITU-T L.1350

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ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1350

Energy efficiency metrics of a base station site

Summary

Recommendation ITU-T L.1350 contains basic definitions of energy efficiency metrics, to evaluate the energy efficiency of a base station site including the energy consumption for:

- the telecom equipment inside the base station site e.g., backhaul and base station equipment;
- the entire infrastructure, including cooling systems, monitoring systems (for power consumption, equipment running status, environment parameters, etc.), fire protection and lighting systems for all the sites;
- energy losses due to AC/DC rectifiers, generator and cable losses.

The following energy factors will be considered for the evaluation:

- electric energy from a public grid;
- electric energy generated by generators such as diesel generators for emergency or normal operation purposes;
- renewable energy.

Measurement methodologies for the parameters considered in the metrics proposed are contained in other ITU-T Recommendations of the same series.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1350	2016-10-07	5	11.1002/1000/12883

Keywords

Energy efficiency, metric, radio site facilities.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Energy efficiency metrics of a base station site

1 Scope

This Recommendation specifies principles and concepts of energy efficiency metrics used to evaluate the energy efficiency of a base station site considering the energy consumption for:

- the telecom equipment inside the base station site e.g., backhaul and base station equipment;
- the entire infrastructure, including cooling systems, monitoring systems (for power consumption, equipment running status, environment parameters, etc.), fire protection and lighting systems for all the sites;
- energy losses due to AC/DC rectifiers, generators and cable losses.

This Recommendation shall not be used to evaluate the energy efficiency of equipment that are covered by other Recommendations such as [ITU-T L.1310] and [ITU-T L.1320].

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), *Energy efficiency metrics and measurement methods for telecommunication equipment*.

[ITU-T L.1320] Recommendation ITU-T L.1320 (2014), *Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres*.

[ITU-T L.1330] Recommendation ITU-T L.1330 (2015), *Energy efficiency measurement and metrics for telecommunication networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 active energy [b-IEC 60050-131]: Integral of the instantaneous power p over a time interval $[t_1, t_2]$

$$W = \int_{t1}^{t2} p \, \mathrm{d}t$$

Note that the coherent international system (SI) unit of active energy is the joule (J). Another unit is the Watt hour (Wh). The kilowatt-hour (kWh) is commonly used for billing consumers of electric energy and is therefore indicated on electric energy meters.

3.1.2 backhaul equipment [ITU-T L.1330]: Equipment used to connect base stations (BSs) to the core network, or to other BSs (such as X2 in LTE).

3.1.3 base station (BS) [ITU-T L.1330]: 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.

3.1.4 energy [ITU-T L.1330]: 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 kilowatt-hours (kWh).

3.1.5 mobile network operator (MNO) [ITU-T L.1330]: An operator that manages one or more mobile networks.

3.1.6 power [ITU-T L.1330]: The rate at which energy is transmitted. Power is measured in units of Watts.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 energy efficiency (EE): The relation between the useful output and energy consumption.

3.2.2 infrastructure (**facility)**: Equipment that supports the ICT equipment functionality providing energy, cooling and site ancillary activity, e.g., power delivery components and cooling system components.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BS Base Station

EE Energy Efficiency

GSM Global System for Mobile communication

ICT Information and Communications Technology

KPI Key Performance Indicator

LTE Long Term Evolution

MNO Mobile Network Operator

PUE Power Usage Effectiveness

SEE Site Energy Efficiency

UMTS Universal Mobile Telecommunications System

5 Conventions

This Recommendation uses the following conventions:

E_{CT} Base station telecommunications equipment energy consumption

E_{FE} Electrical energy locally generated

E_{GE} Electrical energy from a public grid

E_{TS} Total site electrical energy consumption

6 Base station site definition

The base station (BS) site is the mobile network physical site used to guarantee the coverage of a certain area providing the user accessibility to a radio mobile service.

The base station site can be classified in different ways depending on the location: urban or rural and on the technologies present in the site: global system for mobile communication (GSM), universal mobile telecommunications system (UMTS), etc.

A shared site is considered only as a single entity without allocating energy consumption to each operator/service present at the site.

The base station site under investigation shall include all the equipment necessary for the full functionality of a radio site.

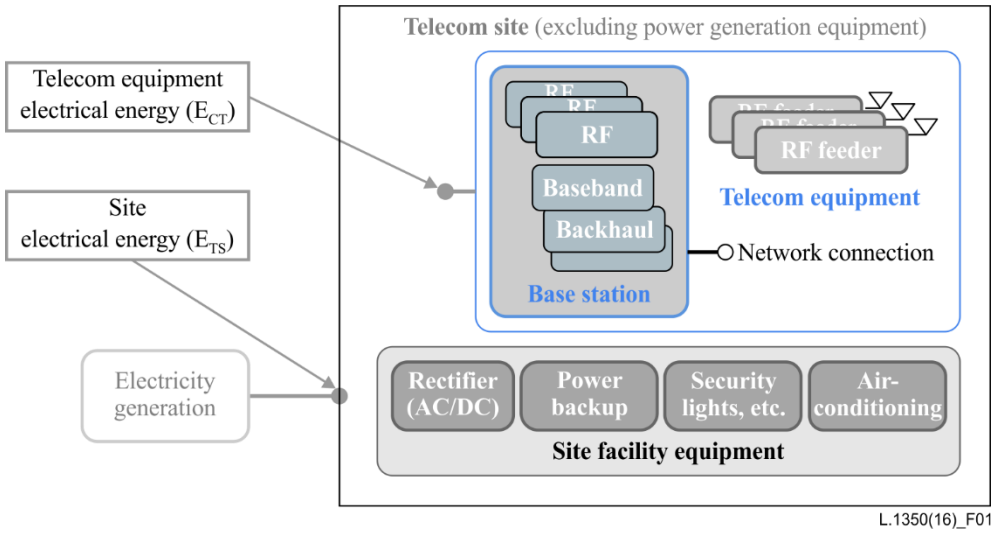

Figure 1 – Elements of a base station site example

Figure 1 shows an example of the equipment present in a base station site and includes telecom equipment and site facility equipment such as rectifiers, power backup, air conditioning and other site housekeeping equipment.

The radio base station site as described above includes no local electricity generation.

In some cases telecom sites may include local electricity generation:

– Electrical energy generated at the site by diesel or other types of generators.

– Locally produced electricity from renewable sources (solar, wind, etc.).

In order to operate the site, electricity has to be provided.

The energy needed to operate a telecom site is typically provided in the form of electricity by a utility organization.

A site can also be equipped with own electricity generation as shown in Figure 2.

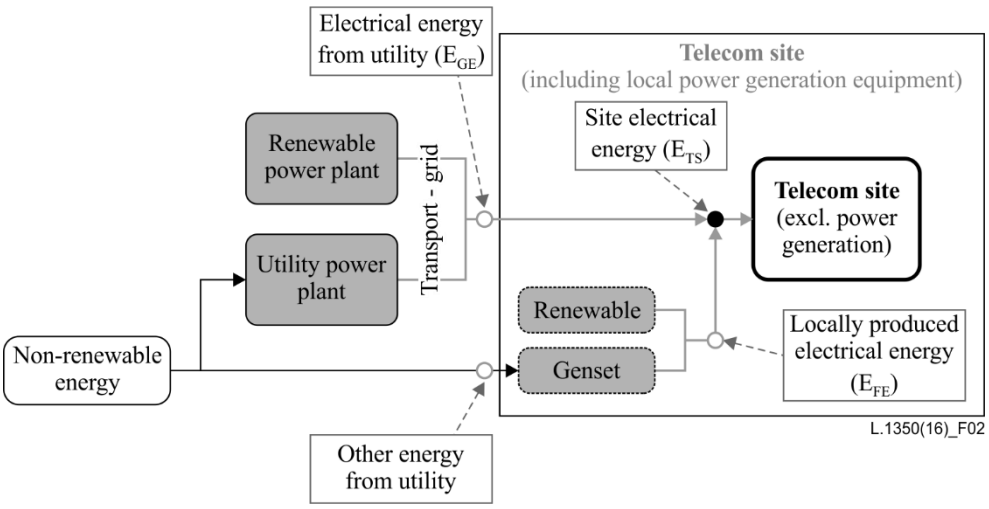

Figure 2 – Electricity generation for a telecom site

The base station site typically includes: base station equipment, backhaul equipment, cooling equipment such as air conditioning units, a rectifier system and renewable energy solutions such as solar, wind energy systems, etc.

The metrics developed in this Recommendation consider a base station site that normally includes the following types of equipment:

– Telecommunication equipment.

– Site equipment (e.g., air conditioners, rectifiers, batteries, safety and monitoring equipment).

This equipment can exist as separate items of equipment or can be integrated into one or more physical units depending on the solution and base station site type, e.g., an indoor or an outdoor site.

Power and energy efficiency metrics and measurements for individual site elements of base stations are described in several ITU-T Recommendations, such as [ITU-T L.1310] for radio base stations and [ITU-T L.1320] for power and cooling equipment.

This Recommendation instead describes metrics for base station site energy efficiency in operational states.

7 Energy efficiency metrics for base station sites

Energy efficiency has become an important issue for base station sites, where specific performance metrics, requirements and technologies to improve energy efficiency must be taken into consideration.

For site infrastructure, a simple metric used to verify the efficiency of base station site facilities is considered sufficient and has the advantage of being relatively simple to calculate as well as allowing remote measurements to be carried out.

Renewable energy usage is considered an important factor to reduce the effect of climate change. Consumption of more energy from renewable sources including local or dedicated grid power and the use of fuels with lower carbon contents are ways to reduce carbon emissions. Electricity from renewable energy sources shall be included in the total energy consumption on site.

The site energy efficiency (SEE) metric described in this Recommendation helps mobile network operators (MNOs) to assess important sustainability aspects on cell sites as well as helping them to compare results and determine opportunities to increase energy efficiency or reduce power consumption.

The total energy consumption of the base station site will include the grid electricity as well as local energy sources such as diesel generators or solar systems.

7.1 Base station site energy efficiency assessment

Clause 7.1.1 defines the metric proposed for a base station site energy efficiency assessment. Figure 3 shows a base station site diagram illustrating the energy measurement points considered in this Recommendation.

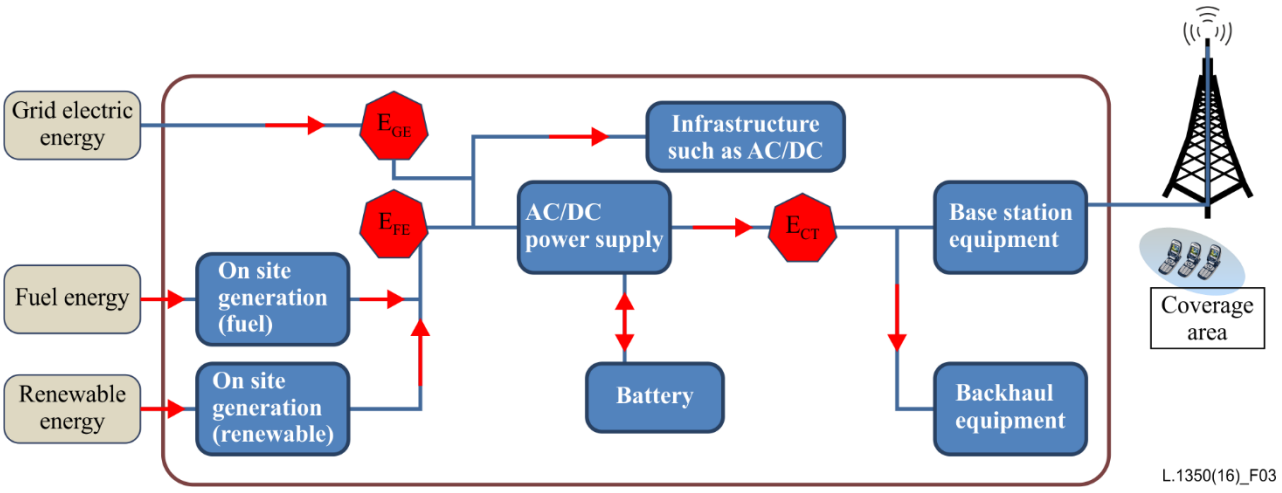

Figure 3 – An example of a radio base station site with energy flow and measurement points

Figure 3 does not take into account the fact that the power system is always a separate entity with respect to the telecom equipment, nor does it take into account the following configurations:

– the AC/DC conversion may be integrated into the telecom part and the air cooling unit may be not present, e.g., for a pole mounted base station site.

– The battery may be present if power backup is required.

– Multiple functions (telecom AC/DC conversion, battery and cooling) may be integrated in a single box as is typical for outdoor equipment.

– Functions may be realized as separate physical units.

7.1.1 Site energy efficiency metric definition

Site energy efficiency (SEE) represents the site efficiency of the measured site.

Site energy efficiency (SEE) is the ratio between the total energy consumption of telecommunication equipment and the total energy consumption on site:

$$SEE = \frac{E_{CT}}{E_{TS}} \times 100\%$$

NOTE – The definition proposed here is selected employing the same philosophy as the power usage effectiveness (PUE) indicator used in data centre technologies.

The total energy consumption of telecommunication equipment is indicated as E_{CT} in Figure 3. E_{CT} is the energy consumption of telecommunications equipment present in the base station site under consideration during the measurement time period.

E_{TS} is the sum of different input energy sources such as from a public grid, a diesel generator present on the site or from a different type of local generator or a renewable energy source, etc. E_{CT}, E_{GE} and E_{FE} are shown in Figures 2 and 3:

$$E_{TS} = E_{GE} + E_{FE}$$

Where:

E_{CT} is the energy consumption of telecommunications equipment present in the base station site under consideration during the measurement time period

E_{GE} is the input electric energy (in kWh) from the public grid during the measurement time period

E_{FE} is locally produced electrical energy (in kWh) generated by a genset or other type of local generator with a renewable energy source on the site during the measurement time period.

7.2 Use of the metric

The metric defined in this Recommendation can be used by telecommunication operators to check their installations for different purposes; some possible uses are outlined as follows:

- To verify the effect of implementing some action in a base station site by simply calculating using the metric before and after the action.
- To verify an analysis on different sites and find out which sites are more relevant to plan an intervention with a view to obtaining an improved value for the metric.
- To verify the metric values by using a monitoring system for radio site facilities to find out if there is a variation of the metric in the same site. A variation can be considered as an indication of degradation in performance of a base station site facilities component signalling the need for preventive maintenance.
- As an indicator for the selection of an integrated site power solution.

8 Data collection basic requirement

International standards shall be used to measure the data necessary for SEE calculation. In cases where international standards are not available, the data used for the assessment using the metric defined in this Recommendation shall be collected as defined in this clause.

8.1 Test instrument requirements

The testing equipment accuracy shall be in line with the requirements outlined in Table 1.

Table 1 – Testing equipment accuracy requirements

Item	Accuracy
Temperature	−0.5°C~+0.5°C
Humidity	−5.0%~+5.0%
Voltage	−1%~+1%
Current	−1%~+1%
Electric energy	Class 1
Weight	−1%~+1%
Volume	−1%~+1%
NOTE – Class 1 is for energy measurement accuracy and should refer to class 1 of [b-IEC 62053-21]. NOTE – The accuracy of voltage and current measurements are defined in [ITU-T L.1320].	

8.2 Observation period

Examples of factors that will influence the metrics for assessment of energy efficiency on cell sites include:

- The number of users covered by the cell site.
- Climate conditions such as the temperature and humidity of the site and target environmental requirements.

The metric of energy efficiency varies with seasonal and load variances. Increasing the minimum frequency of the measurement provides a larger and more accurate data set to analyse. Continuous real-time monitoring can be one option to manage the site efficiency so that historical trending and statistical analysis can be carried out.

Other benefits of continuous real-time monitoring include early detection of unexpected variations that could indicate systems issues. In cases where continuous real-time monitoring is not practical or economically justifiable, some form of repeatable, defined process should be in place to capture the metric value as often as possible for comparison purposes.

When reporting metric values, cell site owners should use the average SEE measured over a one-year period. For cell sites without real-time monitoring, the metric of energy efficiency should be collected in a repeatable fashion and the methodology documented for review.

8.3 Measurement of energy consumption

Measurement of E_{GE} should use kilowatt-hour (kWh) meters that report the active energy. E_{CT} can be the mathematical product of volts, amperes and the timeframe of the measurement duration as power delivery provides direct current (DC). The measurement point of the E_{CT} should be at the power feeding interface of the telecommunication equipment considering the energy losses of the cable.

The energy provided by a public grid can be measured by means of metering information provided by utility suppliers or by mobile network integrated measurement systems [b-ETSI ES 202 336-12]. The energy generated locally can be measured by the meters installed in site. Moreover, sensors can be used to measure site and equipment energy consumption.

The measurement point of energy consumption of E_{GE}, E_{CT} and E_{FE} should reference Figure 2 and Figure 3.

Bibliography

[b-ITU-T L.1340] Recommendation ITU-T L.1340 (2014), *Informative values on the energy efficiency of telecommunication equipment*.

[b-ITU-T L.1410] Recommendation ITU-T L.1410 (2014), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*.

[b-ETSI ES 202 336-12] ETSI ES 202 336-12 (2015), *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*.

[b-IEC 62053-21] IEC 62053-21:2003, *Electricity metering equipment (a.c.) –Particular requirements – Part 21: Static meters for active energy (classes 1 and 2).*

[b-IEC 60050-131] IEC 60050-131:2002, *International Electrotechnical Vocabulary – Part 131: Circuit theory*.

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