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Radio base station site best practices

ITU-T L-series Recommendations – Supplement 45

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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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Supplement 45 to ITU-T L-series Recommendations

Radio base station site best practices

Summary

Supplement 45 to ITU-T L-series Recommendations contains best practices for the realization of a radio base station (BS) site to improve its site energy efficiency (SEE) as specified in Recommendation ITU-T L.1350 and considering the measurement method reported in Recommendation ITU-T L.1351.

Supplement 45 to ITU-T L-series Recommendations contains cases of:

- radio BS site from indoor to outdoor – SEE improvement 64%;
- intelligent operation support system implementation;
- room modernization – SEE improvement 19%.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L Suppl. 45	2021-12-10	5	11.1002/1000/14883

Keywords

Best practices, radio site facilities, SEE.

* 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.

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1 Scope

This Supplement contains best practices for the realization of a radio base station (BS) site to improve its site energy efficiency (SEE).

The Supplement uses the specification of SEE in [b-ITU-T L.1350] and the methodology described in [ITU-T L.1351].

Descriptions of sites are reported with best practices implemented, with calculations of SEE.

2 References

[ITU-T L.1210] Recommendation ITU-T L.1210 (2019), *Sustainable power-feeding solutions for 5G networks.*

[ITU-T L.1351] Recommendation ITU-T L.1351 (2018), *Energy efficiency measurement methodology for base station sites*.

[ITU-T L.1382] Recommendation ITU-T L.1382 (2020), *Smart energy solution for telecommunication rooms*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following term defined elsewhere:

3.1.1 base station (BS) [b-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.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AC Alternating Current

BBU Base Band Unit

BS Base Station

DC Direct Current

DCDU Direct Current Distribution Unit

EER Energy Efficiency Ratio

O&M Operation and Maintenance

ODF Optical Distribution Frame

OPEX Operating Expenditure

OSS Operation Support System

PSU Power Supply Unit

PTN Packet Transport Network

RF Radio Frequency

SEE Site Energy Efficiency

5 Conventions

E_{CT} Base station telecommunications equipment energy consumption

E_{TS} Total site electrical energy consumption

6 Site energy efficiency specification

[b-ITU-T L.1350] specifies that the SEE is the ratio between the total energy consumption of telecommunication equipment and the total energy consumption of a site:

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

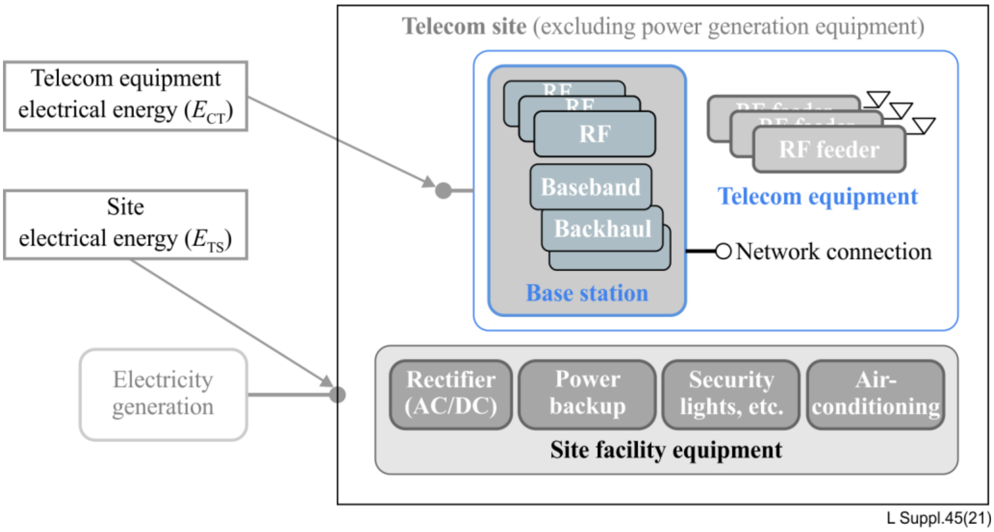
To calculate the SEE metric it is necessary to have the two quantities E_{CT} and E_{TS}.

E_{CT} is the energy consumption of telecommunication equipment present in the BS site under consideration during the measurement time period.

E_{CT} shall be measured as closely as possible to the input of the equipment, see Figure 1. For equipment powered by direct current (DC), the reference point should be the interface A specified in [b-ETSI EN 300 132-2].

E_{TS} is the sum of energies from different input sources such as a public grid, a diesel generator present on the site or other type of local generator, or a renewable source.

Figure 1 (from [ITU-T L.1351]) gives an example of the different equipment or functionality present in a BS site.



RF: radio frequency

Figure 1 – Generic base station site

7 Case 1 – Transformation from indoor to outdoor

This case reports the transformation of a BS site from an indoor room to an outdoor cabinet in accordance with [ITU-T L.1210].

The goal of the transformation is to minimize site energy consumption. Indoor sites use conventional air conditioners for cooling, which are energy intensive and incur high electricity costs. Replacing the equipment room with an outdoor cabinet with a more compact facilities solution and larger user space, and removing air conditioners can greatly reduce power consumption. In addition, the new system shall support −57 V DC output without adding an additional DC/DC system to reduce the cable loss for a remote active antenna unit (over 50 m away) as specified in [ITU-T L.1210].

In conventional outdoor solution deployment, a lead-acid battery string occupies 8 U (units of space) inside the cabinet, which cannot provide space for expanding batteries or equipment for 5G in the future. As a result, additional cabinets are required, which also increases construction work costs.

[ITU-T L.1382] for outdoor cabinet design uses the high-density lithium battery, which reduces the height by more than 60% compared with lead-acid batteries. Lithium batteries can easily be expanded to output 600 Ah while still providing 16 U of space for telecom equipment without requiring a new cabinet as shown in Figure 2.

Figure 2 – Comparison of space requested by storage battery between lead-acid and lithium battery technology

With the new solution deployed, all modernized equipment, including rectifier and battery, and equipment expansion, is contained within one cabinet without adding an additional one on the site.

The solution uses an outdoor integrated power system that consists of high-density power subracks and a lithium battery to replace the existing indoor air conditioner. An integrated DC air conditioner replaces indoor alternating current (AC) air conditioners running all the time to solve the problem of their high energy consumption.

Figure 3 shows a BS site before and after modernization.

Figure 3 – Site before and after modernization

The modernization lowers air conditioner heat loss because of a smaller exposed area and greater temperature adaptability of the lithium battery.

Table 1 lists the main technical data of the BS site before and after modernization.

Table 1 – Technical characteristics of base station site

Item	Footprint m^2	Ambient temperature °C	Room temperature °C	Heat leakage W	Equipment power consumption W	Air conditioner coefficient of performance	Air conditioner power consumption W
Before	3 × 4	45	25	3 000	2 508	1.5	3 672
After	0.75 × 0.75	45	35	210	2 497	2.1	1 289

For a 4 500 W site, the air conditioner heat loss is reduced by 64.9%. The annual energy consumption is cut by (3 672 − 1 289)/1 000 × 24 × 365, which equals 20 875 kWh. A reduction of 16 t of CO_2 emissions/site·year is estimated.

7.1 Conclusion

Results of SEE calculations are listed in the rightmost column of Table 2, in accordance with the requirements of [ITU-T L.1351].

The total energy consumption, E_{TS}, is the sum of equipment energy consumption, E_{CT}, plus power feeding losses considering the losses for energy conversion (before modernization 8% and after the modernization 4%), E_{PF}, plus the air conditioner energy consumption, E_{AC}.

$$E_{TS} = E_{CT} + E_{PF} + E_{AC}$$

Table 2 – Site energy efficiency calculations

Item	Equipment energy consumption (E_{CT}) Wh	Power feeding losses (E_{PF}) Wh	Air conditioner energy consumption (E_{AC}) Wh	Total energy of the site (E_{TS}) Wh	SEE
Before	60 192	4 815.36	88 128	153 135.36	39.30
After	59 928	2 397.12	30 936	93 261.12	64.26

As these best practices are in accordance with [ITU-T L.1210], the SEE increases by 63%, which reduces BS site energy consumption and contributes to a reduction in CO_2 emission if a site is powered by non-renewable sources.

8 Case 2 – Intelligent energy operation support system for energy saving

This is a case in which the energy management helps to reduce site power consumption and so increase the SEE.

Conventional site facility management only has dry contact alarms and no energy efficiency analysis. Operators cannot therefore identify and optimize low efficiency sites and devices. Many low efficiency sites and devices waste large quantities of energy. The efficiency of the power supply unit (PSU) module of 32% of sites of an operator in Indonesia is about 83%.

An intelligent operation support system (OSS) can analyse the site energy efficiency of a whole network. The energy consumption of telecommunication equipment (E_{CT}) and the total input energy consumption (E_{CT}) are visible. The intelligent OSS can calculate the SEE of every site. The intelligent OSS also has device level efficiency analysis such as that for the PSU module and diesel generator. After deploying an intelligent energy OSS, an operator in Indonesia identified low efficiency sites and devices. After identification of a low efficiency and fault-prone PSU module, it was replaced on 1 300 sites by one with 97% efficiency, saving 4 570 kWh/site·year in energy.

Invisible energy efficiency

Visible energy efficiency of all sites

Figure 4 – Energy management before and after deploying an intelligent operation support system

Table 3 – Energy saving through power supply unit modernization aiming at low efficiency sites

Item	PSU module efficiency %	Average energy consumption kWh/site·year	Reduction in energy consumption kWh/site·year
Before	83	31 663	4 570
After	97	27 093	

In addition, a conventional management solution does not have temperature and air conditioner management. Lots of air conditioners work at low temperature. As the temperature varies with time of day and season, an operation and maintenance (O&M) engineer does not know which air conditioner can be allowed to operate at higher temperatures. Air conditioners wastefully consume large quantities of energy. Among equipment rooms of an operator in Indonesia, 28% of air conditioners work at 20°C. The average energy consumption of air conditioners on one site is 19 560 kWh.

After deploying intelligent OSS and temperature sensors, an O&M engineer of an operator in Indonesia was able to obtain 24 h temperature reports of all equipment rooms in different seasons, enabling identification of which air conditioners increased the temperature. With an air conditioner controller, an O&M engineer was able also to increase the air conditioner temperature remotely, without a site visit. As environmental temperature varies according to season, an O&M engineer was able adjust the air conditioner temperature remotely to save energy. At the same time, real-time temperature monitoring ensured that the temperature of the equipment room did not exceed the upper limit temperature for devices. Through the use of an intelligent energy OSS, the operator increased the air conditioner temperature in 115 equipment rooms, saving an average 9 960 kWh/room·year in energy.

Table 4 – Energy saving through intelligent air conditioner management

Item	Temperature of air conditioner °C	Average energy consumption of air conditioner kWh/site·year	Reduction in energy consumption kWh/room·year
Before	20	19 560	9 960
After	28	9 600	

In conclusion, intelligent OSS is essential for energy saving. The first step in energy saving is to identify targets for increased energy efficiency thanks to detailed visibility of network efficiency conditions. Operators can then take measures to eliminate energy waste aimed at low efficiency sites and devices. In addition, air conditioning in an equipment room consumes large quantities of energy. Intelligent management of air conditioning can avoid operation at low temperatures to save energy. Remote management of air conditioning can also reduce the need for site visits.

9 Case 3 – Equipment room modernization

This case describes the simplified modernization of an old access equipment room to improve site SEE and reduce operating expenditure (OPEX).

According to the current situation of a carrier, a certain number of sites are expected to be deployed in a year, with a forecast increase in site-related OPEX of 20%. The goal is therefore to achieve SEE improvement and OPEX reduction by 10%.

The current BS site before reconstruction is composed of a total of 13 base band units (BBUs) and four transmission devices that are housed in eight cabinets, occupying about three-quarters of the equipment room footprint. Figure 5 shows a typical configuration before and after the modernization and Figure 6 reports a picture of the modernization of the site.

The power supply is 53.5 V/48 A, with five 50 Ah lithium batteries and a 300 Ah lead-acid battery (directly hybrid used). There are another four 1 U power subracks in use, which cannot measure the current. The power consumption is 80.4 kWh/day. For temperature control, one air-conditioner is used with cooling capacity of 7 500 W; electrical power of 2 286 W, energy efficiency ratio (EER): 3.28.

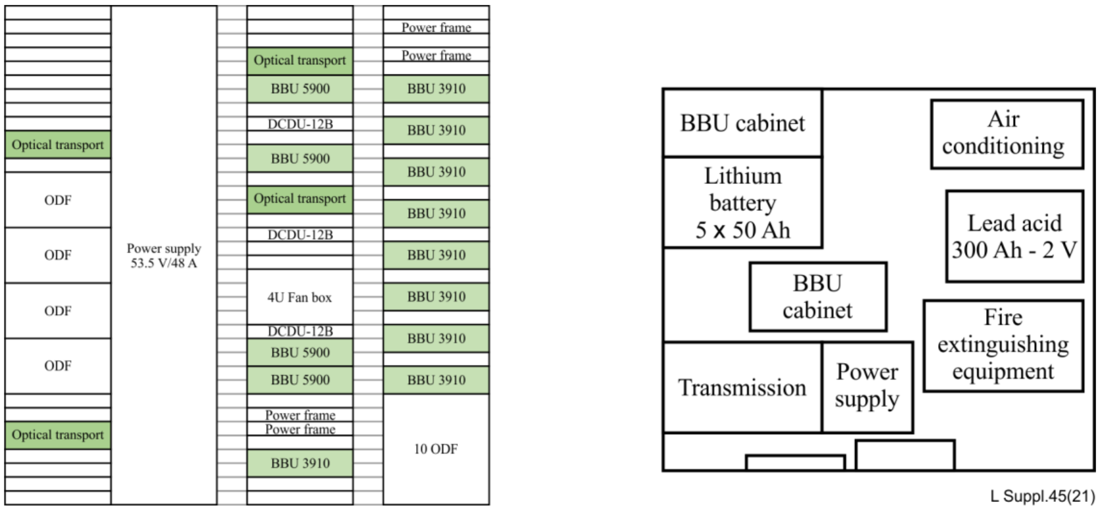


Figure 5 – Equipment room configuration before modernization

The existing equipment room on the live network cannot meet service expansion requirements, and has the following challenges. First, the equipment room space is insufficient, reconstruction is difficult and the project duration will be long. Furthermore, the power supply, battery, air conditioner and cabinet need reconstruction for service expansion. Second, there are insufficient power supply and backup capabilities. It is difficult to reconstruct the battery of the existing power system, and service expansion is required to add multiple AC and DC power supply and backup systems. Third, there are insufficient temperature control capability and high energy consumption. The air conditioner on the live network has insufficient cooling capabilities and is difficult to reconstruct. Conventional large-area open cooling always has low energy efficiency.

With the new solution deployed, all modernized equipment, including power supply, battery and temperature control, is contained within two cabinets to replace the conventional eight.

Figure 6 – Site transformation

The solution utilized an indoor power system, which integrates a high-density power supply, lithium batteries and a modular air conditioner. A single cabinet can meet the requirements for both temperature control and power supply. In addition, cooling efficiency is greatly improved compared to conventional room-level heat dissipation. By using in-cabinet enclosed cooling, air conditioners are deployed nearby, and devices can be directly blown, improving cooling efficiency. Besides, the system can interwork with the intelligent energy OSS to optimize temperature in real time and save energy. After modernization, the cooling temperature of the air conditioner is optimized at 35°C from 20°C. Table 5 lists the results of optimization. Table 6 reports the calculation of SEE; note that a reduction in active load was also made during the modernization.

Table 5 – Site modernization result

Item	**Volume** m^3	**Average air conditioner temperature** °C	**Air conditioner capacity/EER**	**Estimated annual energy consumption** kWh
Before	4.5*L**2.5*W**2.8*H*	20°C	7500/3.28	5 676.7
After	1*L**0.6*W**2.2*H**2 pieces/ cabinet	35°C	3500/3.2*2 piece s/cabinet	2 608.6

Table 6 – Site energy efficiency analysis

Item	**Equipment energy consumption (ECT)** Wh	**Total energy of the site (ETS)** kWh	**SEE**
Before	3 753.3	5 676.7	65.8
After	2 037.3	2 608.6	78.1

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

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