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SERIES L: ENVIRONMENT AND ICTS, CLIMATE
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CONSTRUCTION, INSTALLATION AND PROTECTION
OF CABLES AND OTHER ELEMENTS OF OUTSIDE
PLANT

Energy efficiency, smart energy and green data centres

Energy saving technologies and best practices for 5G radio access network (RAN) equipment

Recommendation ITU-T L.1390

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OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node elements (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	L.380–L.399
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449
E-WASTE AND CIRCULAR ECONOMY	L.1000–L.1199
POWER FEEDING AND ENERGY STORAGE	L.1200–L.1299
ENERGY EFFICIENCY, SMART ENERGY AND GREEN DATA CENTRES	L.1300–L.1399
ASSESSMENT METHODOLOGIES OF ICTS AND CO2 TRAJECTORIES	L.1400–L.1499
ADAPTATION TO CLIMATE CHANGE	L.1500–L.1599
CIRCULAR AND SUSTAINABLE CITIES AND COMMUNITIES	L.1600–L.1699
LOW COST SUSTAINABLE INFRASTRUCTURE	L.1700–L.1799

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Recommendation ITU-T L.1390

Energy saving technologies and best practices for 5G radio access network (RAN) equipment

Summary

The rapid development and commercialization of 5G radio communication technology is further accelerating 5G network construction. While it is an important enabler for the digitalization of other industries and thereby contributes to significant energy savings and emission reductions, it is also important to consider the energy consumption of the 5G network infrastructure itself.

Recommendation ITU-T L.1390 identifies energy saving potentials, describes energy saving principles and technologies for 5G RAN and related equipment, and provides best practice recommendations on when and how these technologies should be used and controlled, thereby reducing 5G RAN energy consumption, saving operational costs and making 5G RAN a green and high-efficiency network.

History

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Table of Contents

		Page
1	Scope	1
2	References.....	1
3	Definitions	1
	3.1 Terms defined elsewhere	1
	3.2 Terms defined in this Recommendation.....	1
4	Abbreviations and acronyms	2
5	Conventions	3
6	Overview of energy consumption of 5G	3
	6.1 Where is energy consumed?	3
	6.2 Baseline and variable power consumption	3
7	Energy saving design principles	4
	7.1 Dynamic scaling	4
	7.2 Shutdown capabilities.....	5
	7.3 Trade-offs	5
8	Energy saving technologies for 5G RAN	6
	8.1 Time-domain energy saving	6
	8.2 Spatial-domain energy saving	7
	8.3 Frequency-domain energy saving.....	7
	8.4 Power-domain energy saving	8
9	AI-based energy saving for 5G RAN	8
	9.1 AI technology	9
	9.2 Energy saving based on AI.....	9
	9.3 Architecture of AI-based energy saving.....	10
	Appendix I – Example of 5G power-domain energy saving practices – Beam optimization energy saving.....	11
	Appendix II – Example of 5G power-domain energy saving practice – Ultra-large-scale antenna array with beam pattern optimization.....	13
	Appendix III – Example of a 5G power-domain energy saving practice – High gain antenna-lens antenna	14
	Appendix IV – Example of energy saving practice based on AI – Service awareness energy saving for 4G/5G coordination	18
	Bibliography.....	21

Introduction

The rapid development and commercialization of 5G radio communication technology is further accelerating 5G network construction. While it is an important enabler for the digitalization of other industries and thereby contributes to significant energy savings and emission reductions [b-GeSI] [b-GSMA-1], it is also important to consider the energy consumption of the 5G network infrastructure itself. 5G will use wider bandwidths, more antennas and new frequency bands in order to boost the capacity of the mobile communication network and facilitate new use cases such as massive machine type communications (mMTC) and ultra-reliable low latency communications (uRLLC). Consequently, with the roll-out of 5G on top of existing network generations, network energy consumption will become an important operating cost for mobile network operators (MNOs).

Energy saving and emission reduction is not only the social responsibility of telecommunications operators but also inherent development needs of operators to continuously reduce electricity costs and improve market competitiveness. Hence, energy saving technologies and best practices for 5G RAN equipment are needed.

Recommendation ITU-T L.1390

Energy saving technologies and best practices for 5G radio access network (RAN) equipment

1 Scope

This Recommendation identifies energy saving potentials, describes energy saving principles and technologies for 5G RAN and related equipment, and provides best practice recommendations on when and how these technologies should be used and controlled to reduce 5G RAN energy consumption.

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 standalone document, the status of a Recommendation.

[ITU-T F.749.13] Recommendation ITU-T F.749.13 (2021), *Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence*.

[ISO/IEC 13273-1] ISO/IEC 13273-1:2015, *Energy efficiency and renewable energy sources – Common international terminology – Part 1: Energy efficiency*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 artificial intelligence (AI) [ITU-T F.749.13]: An interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning.

3.1.2 big data [b-Viktor]: A term that describes the large volume of data – both structured and unstructured – that inundates a business on a day-to-day basis. Big data can be analysed for insights that lead to better decisions and strategic business moves.

3.1.3 energy consumption [ISO/IEC 13273-1]: Quantity of energy applied.

3.1.4 energy efficiency [ISO/IEC 13273-1]: The ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy.

3.1.5 energy saving [ISO/IEC 13273-1]: Reduction of energy consumption following implementation of an energy performance improvement action.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G	2nd Generation of wireless networks
3G	3rd Generation of wireless networks
4G	4th Generation of wireless networks
5G	5th Generation of wireless networks
AAU	Active Antenna Unit
AI	Artificial Intelligence
ARIMA	Auto-Regressive Integrated Moving Average
BS	Base Station
CRS	Cell-specific Reference Signal
EIRP	Equivalent Isotropic Radiated Power
KPI	Key Performance Indicator
LSTM	Long Short-Term Memory
LTE	Long Term Evolution
MDT	Minimization of Drive Test
MIMO	Multiple Input Multiple Output
mMTC	massive Machine Type Communications
MNO	Mobile Network Operator
MR	Measurement Report
NR	New Radio
O&M	Operation and Management
OFDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PRB	Physical Resource Block
PM	Performance Measurement
RAN	Radio Access Network
RF	Radio Frequency
RRC	Radio Resource Control
RRU	Remote Radio Unit
RSRP	Reference Signal Received Power
SA	StandAlone
SINR	Signal to Interference plus Noise Ratio
TA	Timing Advance
UE	User Equipment
uRLLC	ultra-Reliable Low Latency Communications

5 Conventions

None.

6 Overview of energy consumption of 5G

6.1 Where is energy consumed?

To determine the potential for energy saving and emission reduction in a mobile network, it is necessary to understand the power consumption distribution in the network. In 2015, mobile networks worldwide consumed 90 TWh of electricity, a figure that is expected to grow to ~130 TWh in 2030 [b-ITU-T L.1470]. The majority of this is consumed by the radio access network (RAN), i.e., the base station (BS) sites.

In the RAN, the power consumption of a BS site is divided into two parts: the power consumption of the main equipment (BS) and the power consumption of auxiliary equipment (such as air conditioners). For an outdoor site, the power consumption of the site is mainly from the main equipment, while for indoor sites the auxiliary equipment can make up a significant part.

Main equipment (BS) power consumption can be divided into the following two types: compute power consumption, which refers to the power consumed by the baseband processing, including the power consumption of digital part processing, management and control, communication with the core network and other BSs; and transmission power consumption, which refers to the power consumed by the power amplifier (PA) and radio frequency (RF) parts.

The greater the output power of the BS, the larger the share of the BS power consumption that is transmission power consumption, and the larger the share of the transmission power consumption that is PA power consumption [b-Auer]. However, 5G introduces massive MIMO where the number of RF channels is increased significantly, which means that a larger share of the transmission power consumption comes from the other RF parts, even though the PA still is dominating. With lower output powers, the relative share of the compute power consumption is increasing, and so is the non-PA part of the transmission power consumption [b-Debaillie].

6.2 Baseline and variable power consumption

Power consumption at the site, BS or equipment level can be classified into baseline power consumption and variable power consumption. Simply put, the power consumption that does not vary with the load is called baseline power consumption, and the power consumption that is positively related to the load is called variable power consumption. For example, the power consumption of the PA varies with the load. However, when the load is zero, the power consumption of the PA is not zero because the PA power consumption can be divided into baseline power consumption and variable power consumption.

In general, we can approximate the power consumption model with a simple first-order linear model [b-Holtkamp]:

$$P = a \times T + b$$

where P represents the total power consumption, a represents the power consumption variation, T represents the traffic load, $a \times T$ represents the variable power consumption, and b represents the baseline power consumption.

The higher the percentage of variable power consumption, the stronger the dynamic capability of the equipment. In addition to the baseline power consumption b , the slope a of the curve is also important. The slope determines the magnitude of the variable power consumption change with the load. Therefore, the primary function shown in Figure 1 is not an ideal scenario. The concave curve of the origin is passed. For example, a quadratic curve $P = a \times T^2$ has better dynamic capability than a primary curve.