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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

Smart energy solution for telecommunication rooms

Recommendation ITU-T L.1382

ITU-T L-SERIES RECOMMENDATIONS

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.1382

Smart energy solution for telecommunication rooms

Summary

Recommendation ITU-T L.1382 specifies requirements for the power supply mode of the three-layer architecture of telecommunication rooms. Recommendation ITU-T L.1382 aims to drive future-oriented network deployment for the information and communication technology (ICT) industry, as well as maximizing energy efficiency, the use of renewable resources and social resources in the digital era, and reduce energy and resource consumption. while ensuring network performance and user experience. Innovative ICTs are used to promote network energy saving, emission reduction and circular economy development, as well as continuously driving all parties in the industry chain to jointly build green networks and low-carbon societies. In addition, Recommendation ITU-T L.1382 provides suggestions and requirements on the deployment of three types of telecommunication rooms, which can be used as a reference for operators to build the target network evolution strategies for telecommunication room power supply. Recommendation ITU-T L.1382 accelerates network deployment, reduces capital expenditure (CAPEX) and operating expenditure (OPEX), optimizes investment efficiency, and guides ICT industry transformation and optimization. The new networking architecture, new power supply technologies and specifications in Recommendation ITU-T L.1382 will also effectively promote the upgrade of industry technologies.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1382	2020-06-29	5	11.1002/1000/14306

Keywords

Lithium battery, power feeding, smart energy, telecommunication room.

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FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

NOTE

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Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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Introduction

With the increasing popularity of fifth generation (5G), a series of significant changes has taken place in telecommunication networks, including the addition of wireless frequency, fixed access, fibre-in and copper-out, all-optical fibre to the x (FTTx), with "x" being the home, the antenna, etc., telecommunication room capacity expansion and fixed-mobile convergence/information and communication technology (FMC/ICT) convergence. Site functions will also change from single telecommunication connections to comprehensive functions. Digitalization drives ICT infrastructure to become wider, faster and smarter.

In the 5G era, both wireless and fixed networks are facing upgrades. The wireless bandwidth will be increased from 1 Gbit/s or 2.5 Gbit/s to 10 Gbit/s or 25 G bit/s. The high 5G frequency band will cause the site density to be several times that of conventional 2G, 3G or 4G networks. A large number of new sites brings site acquisition difficulty, some operators will deploy base band units (BBUs) in the access and aggregation telecommunication room, increasing its power consumption.

The impact of the fixed network on the evolution of telecommunication rooms is more obvious. The home broadband bandwidth will be increased from 10 Mbit/s to 100 Mbit/s, the enterprise private line will be upgraded from a gigabit passive optical network (GPON) to a 10GPON, and the big video will be increased from 1 kbit/s or 2 kbit/s to 4 kbit/s or 8 kbit/s. The fixed network will enter the F5G era.

However, the running of the ICT infrastructure and its connected terminals also consumes huge amounts of energy and resources.

Recommendation ITU-T L.1382

Smart energy solution for telecommunication rooms

1 Scope

This Recommendation specifies a smart energy solution for telecommunication rooms. It provides design requirement for the power supply and backup systems for telecommunication rooms of the integrated access, aggregation and core types, based on the trend of fifth generation (5G), edge computing sinking and content delivery network (CDN) sinking.

2 Reference

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.1350] Recommendation ITU-T L.1350 (2016), *Energy efficiency metrics of a base station site*.

[IEC 60950-1] IEC 60950-1:2013, *Information technology equipment – Safety – Part 1: General requirements*.

[IEC 62368-1] IEC 62368-1:2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*.

[IEC 62619] IEC 62619:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 content delivery network sinking: A content delivery network (CDN) not centralized, but moved near to the end user.

3.2.2 fixed 5G network: An end-to-end (E2E) full-fibre network comprised of on-premise network, access network, transport network and Internet protocol (IP) network.

3.2.3 metropolitan area network (MAN): A medium-scale computer network with area larger than that covered by a local area network (LAN) and smaller than that covered by a wide area network (WAN). It interconnects multiple LAN networks in a geographic region of a city.

3.2.4 site energy efficiency (SEE): The ratio between the total energy consumption of telecommunication equipment and the total energy consumption of a site.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G	second Generation
3G	third Generation
4G	fourth Generation
5G	fifth Generation
AAU	Active Antenna Unit
AI	Artificial Intelligence
BBU	Base Band Unit
BMS	Battery Management System
CAPEX	Capital Expenditure
CDN	Content Delivery Network
CT	Communication Telecommunication
C-RAN	Cloud-Radio Access Network
E2E	End-to-End
F5G	Fixed 5G
FMC	Fixed-Mobile Convergence
FTTx	Fibre To The x
GPON	Gigabit Passive Optical Network
HVDC	High-Voltage Direct Current
ICT	Information and Communication Technology
IP	Internet Protocol
IT	Information Technology
LAN	Local Area Network
LFP	Lithium iron Phosphate
MAN	Metropolitan Access Network
O&M	Operation and Maintenance
OPEX	Operating Expenditure
PSU	Power Supply Unit
RF	Radio Frequency
SEE	Site Energy Efficiency
SOC	State Of Charge
SOH	State Of Health
WDM	Wavelength Division Multiplexer
WAN	Wide Area Network

5 Conventions

None.

6 Telecommunication room evolution

Fixed sites, especially the sites serving the new generation mobile service network, the so called fixed 5G network (F5G), are entering the all-optical era, which is driven by experience. In the all-optical era, all-round transformation is required. First, gigabit is no longer a new term. Gigabit broadband services have entered into commercial use in more than 50 countries and will become the mainstream bandwidth in the next decade. Second, fibre connections and 5G will be used in a variety of industries.

The all-round optical network transformation will trigger new technical trends in the telecommunication room, such as bearer network bandwidth upgrade and ICT convergence (core network cloudification, edge computing sinking, and CDN deployment or downstream sinking). This clause describes the requirements for the existing telecommunication room space, capacity and output mode of the existing power supply, capacity of existing batteries and through-current capability of existing cables.

Figure 1 shows evolutionary trends in the telecommunication room.

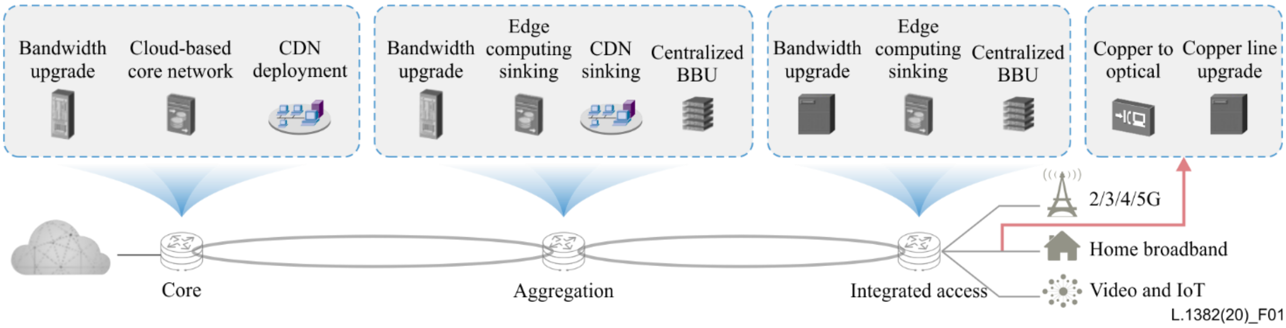


Figure 1 – Evolutionary trends in the telecommunication room

6.1 Telecommunication room classification

5G, home broadband and enterprise services bring bandwidth acceleration of 10 times on the user side of the access network and of 2 to 4 times on the upper-layer metropolitan access network (MAN) and backbone network. Based on the evolution of the future-oriented network and telecommunication room devices, telecommunication rooms can be classified into:

- integrated access telecommunication rooms;
- aggregation telecommunication rooms;
- core telecommunication rooms.

6.2 Telecommunication room evolution

The future evolution of three types of telecommunication rooms is mainly driven by the following trends:

– **integrated access telecommunication room**: bandwidth expansion, edge computing sinking, base band unit (BBU) convergence and evolution into a social telecommunication room;

– **aggregation telecommunication room**: bandwidth expansion, edge computing sinking, CDN sinking, BBU convergence and evolution into a social telecommunication room;

– **core telecommunication room**: bandwidth expansion, core network cloudification, CDN deployment.

6.2.1 Evolution of the integrated access telecommunication room

New communication telecommunication (CT) devices, e.g., a wavelength division multiplexer (WDM), router and wireless BBU, and information technology (IT) devices, e.g., edge servers and storage devices, will be added to the integrated access telecommunication room. The power consumption of the main equipment will increase by 40% to 60%. In addition, new IT devices added to the integrated access telecommunication room, will require AC and DC power supply.

6.2.2 Evolution of the aggregation telecommunication room

New CT devices, e.g., metro WDM devices, metro routing devices and wireless BBUs, and IT devices, e.g., servers and storage devices, will be added to the aggregation telecommunication room. The power consumption of the main devices will increase by 30% to 50%. In addition, the increasing number of IT devices will require AC and DC hybrid power supply.

6.2.3 Evolution of the core telecommunication room

The three trends listed in clause 6.2 will lead to the addition of CT devices, e.g., backbone routers and WDM devices, and IT devices, e.g., universal servers, CDN servers and storage devices, in core telecommunication rooms. The total power consumption of the main devices will increase by 10% to 30%. Furthermore, the addition of IT devices will increase the proportion of AC power supply consumption in the telecommunication room. In typical scenarios, the proportion of AC power supply consumed in the core telecommunication room will increase from about 10% to about 30%.

6.3 New trends in energy requirements of telecommunication rooms

The comprehensive upgrade of network bandwidth, accelerated ICT convergence and new cloud radio access network (C-RAN) networking modes bring great challenges to energy facilities in conventional telecommunication rooms, typically reflected in the following aspects.

1) High power consumption and need for air conditioning in conventional telecommunication rooms, as well as large potential for energy saving and emission reduction.
2) Telecommunication room construction involves multiple phases, e.g., site survey, approval, civil engineering, construction and decoration. The construction period is long and the investment is high, which does not favour quick service and economic capacity expansion.
3) ICT convergence requires separate AC and DC power systems. Conventional solutions require two independent power supplies, backup systems and cabling systems, which increases the maintenance workload.
4) Existing telecommunication rooms have insufficient power supply, battery, power cable and air conditioning capabilities. Conventional solutions not in line with the requirements of this Recommendation require a large amount of reconstruction, high investment and long development periods.
5) The failure rate of existing power systems is high, key spare parts are difficult to obtain, and the periodic manual inspection requires high investment and is low efficiency.

Appendix I contains a detailed description of these aspects.

6.4 Telecommunication rooms – General requirements

The evolution of telecommunication rooms requires solutions to the problems and difficulties described in clauses 6.2 and 6.3.

For this reason, the new-generation telecommunication room energy solution shall have the following features.

1) In the new deployment scenario, the space occupation should be simplified. In the reconstruction scenario, the reconstruction should be reduced, and the infrastructure not

expanded during capacity expansion. The solution should support ICT converged power supply.

2) The solution shall support remote intelligent management.

3) The system is end-to-end (E2E) efficient and supports green energy access. The following describes solutions respectively in the integrated access, aggregation, and core telecommunication rooms.

4) The system need not reduce the availability and reliability of actual solutions present in the telecommunications room.

6.4.1 Telecommunication rooms – Energy efficient requirement for integrated access and aggregation telecom equipment room

The new-generation equipment room energy solution should save energy. It is recommended that the rectifier efficiency be improved to 98% and the inverter efficiency be higher than 94% in the access equipment room scenario, balancing a large number of site investments and high efficiency requirements.

The detailed efficiency requirements are:

a) single phase rectifier: the maximum efficiency of the rectifier shall be 98% (±0.2%), and the operating efficiency shall be 97% at a load rate from 20% to 90%;

b) three-phase rectifier: the maximum efficiency of rectifiers shall be ≥ 96% and the operating efficiency shall be ≥ 95% at a load rate of 30% to 80%;

c) the maximum efficiency of the inverter module shall be no lower than 94%.

6.4.2 Power distribution energy saving solutions

The intelligent power system synergizes with the main equipment to implement intelligent dynamic voltage boosting and intelligent shutdown to save energy in power distribution.

Bus voltage boosting: the system bus voltage is boosted to 57 V to meet the power supply requirements of the 5G active antenna unit (AAU) after the power increased and reduce cable loss, and meet the requirements of the −48 V safety framework.

Dynamic voltage boosting: for the AAU power supply port, the output voltage can be dynamically adjusted based on factors such as the AAU efficiency curve and cable voltage drop loss to achieve the highest efficiency of the AAU power supply loop.

6.4.3 Green energy solutions

Energy saving and emission reduction have become basic social responsibilities of enterprises. The cost of green energy, e.g., derived from photovoltaic solar panels, is continuously reducing, and the cost-effectiveness increasingly high.

An intelligent power system is needed to support access to solar energy, the maximum efficiency of the solar energy access module is ≥ 98%.

A solar energy access module can be installed in the same slot as the rectifier module to implement on-demand configuration.

The intelligent power supply supports the staggered power consumption function. It intelligently adjusts the charging and discharging policies based on the battery state of charge/state of health (SOC/SOH) and peak/valley electricity price to implement staggered power consumption.

6.4.4 Site efficiency

6.4.4.1 Outdoor access and aggregation telecommunication rooms

The intelligent power system provides efficient power supply and temperature control to achieve high site efficiency. Outdoor deployment is preferred, with reference to SEE established in clause 7.1.1 of [ITU-T L.1350].

It is required that:

– an outdoor site with air-conditioner has an SEE > 80%;

– an outdoor site with heat exchanger has an SEE > 92%;

– a natural-cooling outdoor site has an SEE > 95%.

6.4.4.2 Indoor aggregation and core telecommunication rooms

Currently, the core telecommunication room and some aggregation telecommunication rooms are generally deployed indoors with a conventional air conditioner; in addition, the number and types of aggregation equipment and core equipment deployed in the two types of telecommunication rooms are well diversified. Therefore, it is not recommended that SEE be used to measure energy efficiency. In this scenario, it is recommended that the efficiency of the power supply system be used as the main indicator for energy efficiency evaluation. See clause 6.4.4.1.

6.5 Smart energy solution for integrated access telecommunication rooms

6.5.1 Efficient and green site

This clause describes the efficiency and green requirements for the realization of telecommunication rooms

1) Energy efficiency requirement: the energy efficiency requirement specified in clause 6.4.1 shall apply.

2) Power distribution energy saving solutions: the power distribution requirement specified in clause 6.4.2 shall apply.

3) Green energy solutions: the green energy solution requirement specified in clause 6.4.3 shall apply.

4) Site efficiency: the site efficiency requirement specified in clause 6.4.4 shall apply.

6.5.2 Simple deployment

6.5.2.1 Outdoor cabinet replaces room solution

The integrated access telecommunication room should be preferentially deployed in a cabinet-type solution to simplify the high investment and long-term problems caused by acquisition, approval, civil engineering, decoration and installation of the room-type building. In addition, the SEE at the site is improved.

The cabinet-type solution should integrate a high-density power supply, high-density smart lithium battery and space reserved for installing different types of ICT device. Select different environment management modules, e.g., those for harmful gas filtering and temperature and humidity control, based on the working environment requirements of the equipment.

The cabinet-type solution should support the capacity expansion by combining modular cabinets. The number and type of cabinets should be determined based on space requirements.

An example of the deployment is depicted in Figure 2.

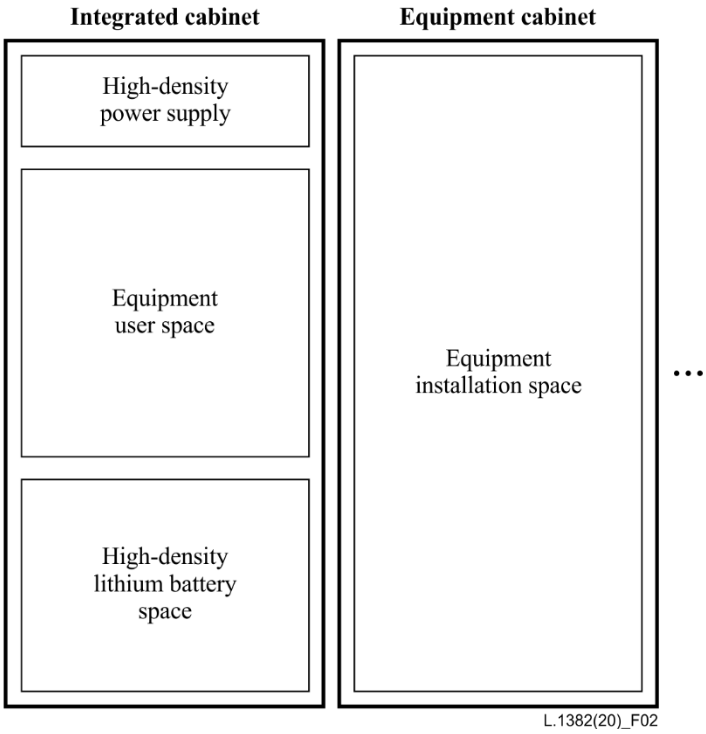


Figure 2 – Cabinet-type solution for integrated access telecommunication rooms

6.5.3 ICT converged power supply

In the future, IT devices, e.g., edge servers and storage devices, will be added to the integrated access telecommunication room, which will bring ICT converged power supply requirements. The new-generation telecommunication room energy solution uses only one power system to provide power supply, backup and distribution for CT and IT devices. No independent AC power system or AC cable tray is required. Figure 3 shows the recommended power supply architecture of the access telecommunication room.

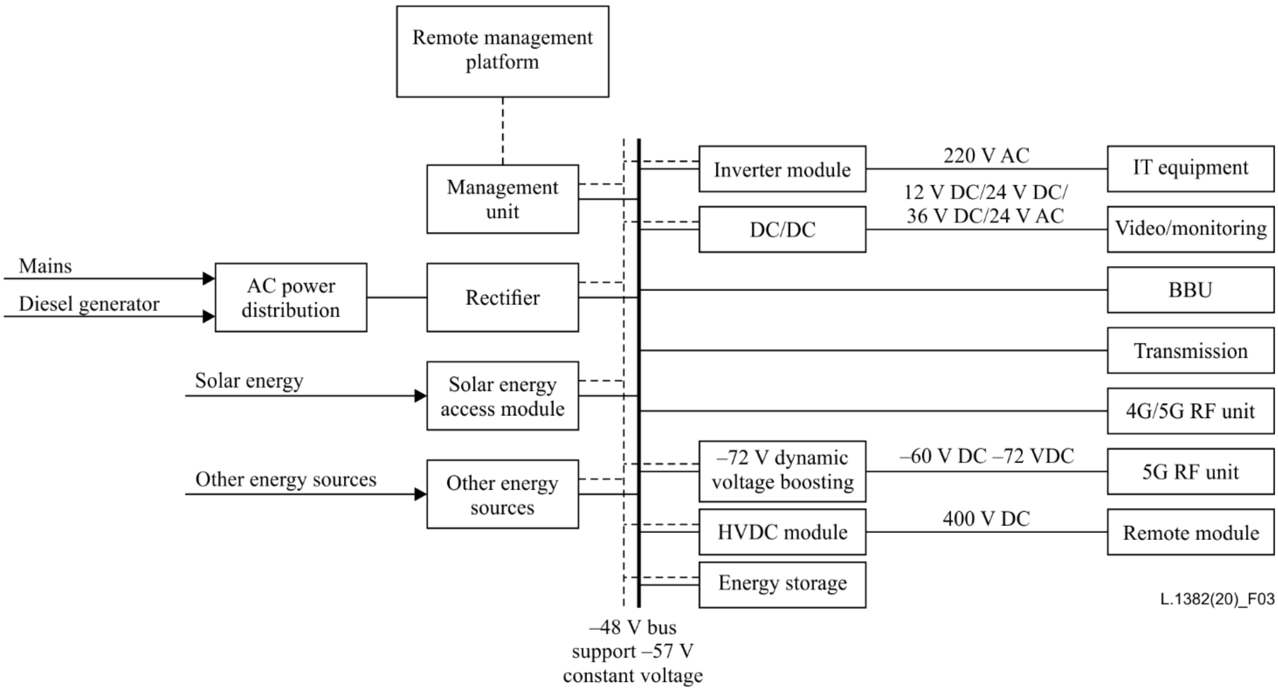


Figure 3 – Power supply architecture of access telecommunication rooms

HVDC: high-voltage direct current; RF: radio frequency

ICT converged power supply requires multiple input and multiple output, it should have the following specific features:

– multiple input: multiple AC inputs and solar energy inputs are supported;

– multiple output: 12/24/36/48/57/400 V DC and 24/220 V AC;

– modular architecture: multiple input and output modules can be configured in a modular manner, such as the AC input module, rectifier module, solar access module, inverter module, AC output module, and power distribution module;

– unified management: the site management unit schedules and controls site energy modules to achieve optimal energy efficiency – site management (operation and maintenance (O&M)) on the entire network is undertaken by the remote management platform.

6.5.4 Main specification of the intelligent power supply for access telecommunication rooms

Considering the trend of telecommunication rooms described in clauses 6.1 and 6.2 for the access telecommunication room the following requirements should apply.

a) Power station requirement: power density ≥ 7.2 kW/U (including power distribution), the minimum power provided by the power station should be ≥ 24 kW (450 A), possibility to expand in a simple way at higher power, e.g., 36 kW. U represents a unit rack height corresponding to 44.45 mm (1¾ inch) – a typical frame has height 19 inches.

b) Cooling requirement: the outdoor cabinet temperature control supports $N + 1$ redundancy heat dissipation, modular expansion and a maximum of 3 + 1 backup. The cooling capacity can reach 7.2 kW/cabinet. The overall heat transfer coefficient of the cabinet is less than 2.0 W/(m^2 K).

c) Inverter requirement: the inverter has a high power density of 6 kVA per 1U and supports modular expansion to 18 kVA.

d) Battery requirement: the lithium battery capacity is ≥ 100 Ah at 3U, and supports parallel uses without derating. The maximum discharge capability can be tested based on the backup time.

6.5.5 Comprehensive intelligence

The new-generation telecommunication room energy solution should support comprehensive intelligent management, including that of energy efficiency, reliable power supply, efficient O&M and assets, as well as implementing closed-loop management of energy efficiency visualization, analysis and optimization. The battery SOH and backup power are visible, and abnormal batteries can be identified, preventing the risk of telecommunication room power failure caused by insufficient battery backup power. Remote O&M can be used to locate and analyse faults, and remote battery testing and software upgrades can reduce manual site visits. Multiple intelligent anti-theft measures can be integrated by using technologies, such as digital anti-theft and artificial intelligence (AI) image analysis, to implement site security from physical anti-theft to digital anti-theft.

6.6 Smart energy solution recommendation for aggregation telecommunication rooms

6.6.1 Efficient and green site

This clause describes the efficiency and green requirements for the realization of aggregation telecommunication rooms:

• energy efficiency requirement: the energy efficiency requirement specified in clause 6.4.1 shall apply;

• power distribution energy saving solutions: the power distribution requirement specified in clause 6.4.2 shall apply;

- green energy solutions: the green energy solution requirement specified in clause 6.4.3 shall apply;
- site efficiency: the site efficiency requirement specified in clause 6.4.4 shall apply.

6.6.2 Simple deployment

6.6.2.1 Outdoor cabinet replaces room

The development of an outdoor aggregation telecommunication room can be realized with the same cabinets as the outdoor access telecommunication room, depicted in Figure 2, to accommodate more main equipment.

The cabinet-type telecommunication room should support capacity expansion by combining modular cabinets. The number and type of cabinets should be determined based on the space requirements.

6.6.3 High density and voltage boosting

High-density power supply unit (PSUs) and intelligent lithium battery solutions reduce the footprint of power by more than 50%. In reconstruction and capacity expansion scenarios, capacity expansion can be implemented without expanding the telecommunication room, while site acquisition could be simplified in new deployment scenarios.

In capacity expansion and reconstruction scenarios, cabling reconstruction is extremely difficult. The intelligent power system should be able to provide 57 V constant voltage output. Compared with the −48 V conventional power system, the transmission capability is improved by more than 35% without changing cables.

An example of a power system for aggregation telecommunication rooms is shown in Figure 4.

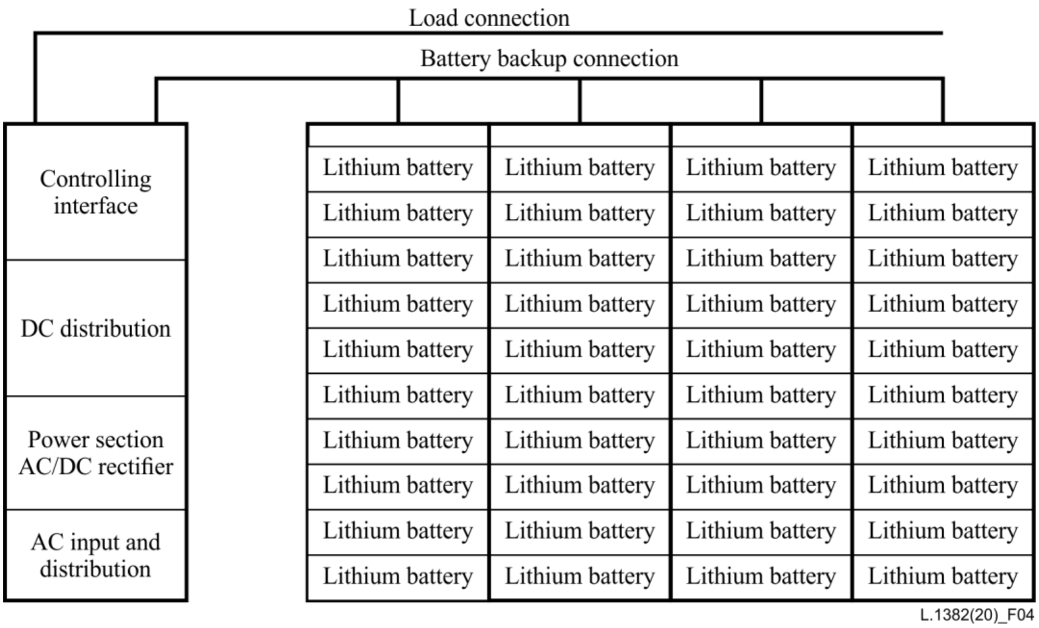
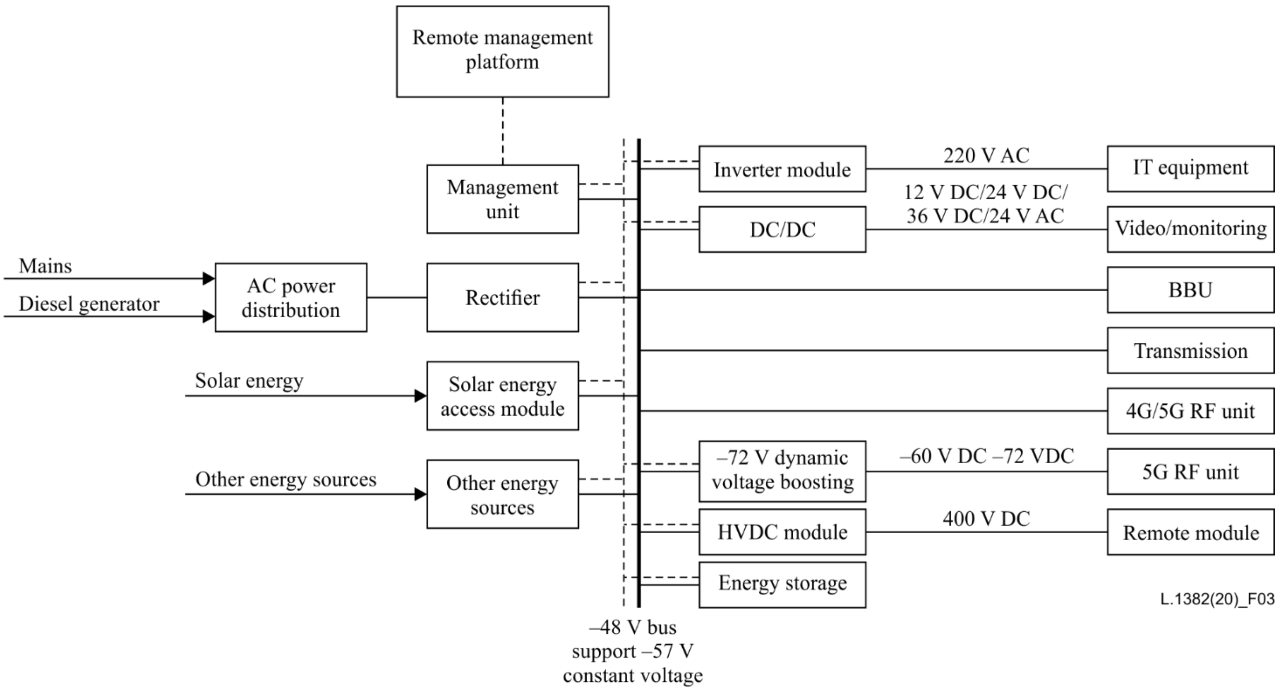


Figure 4 – Energy solution for indoor aggregation telecommunication rooms

6.6.4 ICT converged power supply

The requirements of clause 6.5.3 shall apply. A schematic diagram of the energy distribution for aggregation telecommunication rooms is shown in Figure 3.



6.6.5 Main specification recommendation of power supply solutions for aggregation telecommunication rooms

Considering the trend of telecommunication rooms described in clauses 6.1 and 6.2 for access telecommunication rooms the following requirements should apply:

a) For outdoor scenario deployment, the following requirements should apply.

   1) Power station requirement: power density ≥ 7.2 kW/U (including power distribution), the minimum power provide by the power station should be ≥ 24 kW (450 A), possibility to expand in a simple way at higher power, e.g., 36 kW.

   2) Cooling requirement: the outdoor cabinet temperature control supports $N + 1$ redundancy heat dissipation, modular expansion, and a maximum of 3 + 1 backup. The cooling capacity can reach 7.2 kW/cabinet. The overall heat transfer coefficient of the cabinet is less than 2.0 W/(m^2 K).

   3) Inverter requirement: the inverter has a high power density of 6 kVA/1U and supports modular expansion to 18 kVA.

b) For indoor scenario deployment, the following requirements should apply.

   1) Power station requirement: power density of rectifier cabinet ≥ 400 kW/m^2, and the capacity of single cabinet basic power supply should be ≥ 2 500 A.

   2) The maximum capacity of combined cabinets is 10 000 A.

   3) The inverter has a high power density of 6 kVA/1 U and supports modular expansion to 30 kVA.

   4) Power cabinet supports power cables up inlet up outlet and down inlet down outlet.

   5) Supports lithium battery with feature of 100% internal safety and self-extinguishing in external fire.

6.6.6 Comprehensive intelligence

The requirements of clause 6.5.5 shall apply.

6.7 Smart energy solution recommendation for core telecommunication rooms

6.7.1 Efficient and green site

This clause describes the efficiency and green requirements for the realization of core telecommunication rooms:

- energy efficiency requirement: the energy efficiency requirement specified in clause 6.4.1 shall apply;
- power distribution energy saving solutions: the power distribution requirement specified in clause 6.4.2 shall apply;
- green energy solutions: the green energy solution requirement specified in clause 6.4.3 shall apply;
- site efficiency: the site efficiency requirement specified in clause 6.4.4 shall apply.

6.7.2 Simple deployment

1) High density and voltage boosting

High-density PSUs and high-density intelligent lithium battery solutions reduce the footprint of power by more than 50%. In reconstruction scenarios, capacity expansion can be implemented without expanding the telecommunication room, while site development can be simplified in new deployment scenarios.

In capacity expansion and reconstruction scenarios, cabling reconstruction is extremely difficult. The intelligent power system should be able to provide 57 V constant voltage output. Compared with the −48 V conventional power system, the transmission capability is improved by more than 35% without changing cables.

An example of a power solution is shown in Figure 5.

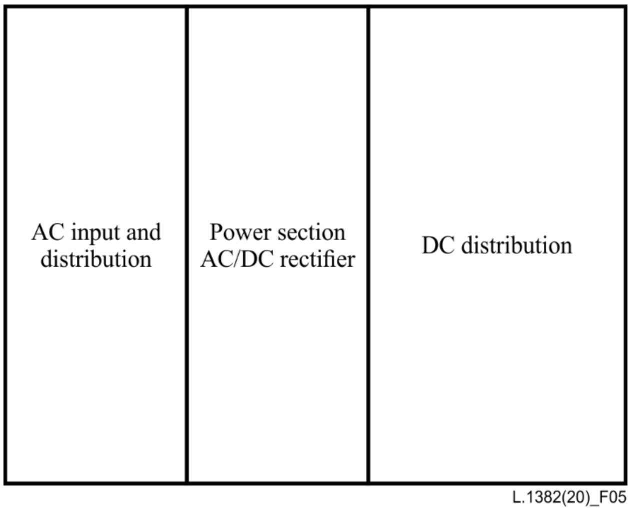


Figure 5 – Energy solution for core telecommunication room

2) ICT converged power supply

Capacity expansion and evolution of aggregation telecommunication rooms require new IT devices, e.g., servers and storage devices, which impose ICT converged power supply requirements. The new generation telecommunication room energy solution should avoid problems, e.g., telecommunication room construction and re-laying of AC cable trays, caused by conventional solutions. A unified power system can provide power supply and backup power for CT and IT devices, without the need to add an independent AC power system or re-lay AC cable trays. Figure 6 is a schematic diagram showing the recommended electrical distribution power supply architecture for an aggregation telecommunication room.

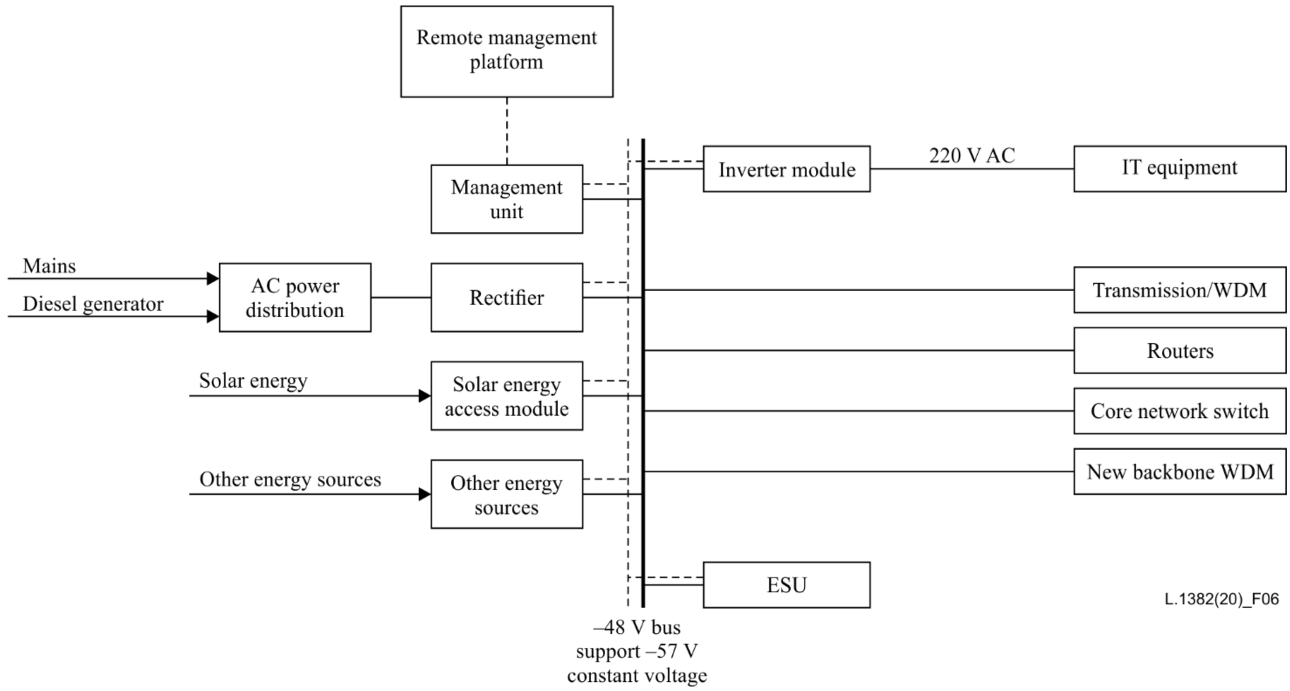


Figure 6 – Power supply architecture for a core telecommunication room

An ICT converged power supply requires multiple input and multiple output. There follow recommendations on specific features:

– multiple input: multiple AC inputs and solar energy inputs are supported;

– multiple output: 48/57 V DC and 220 V AC;

– modular architecture: multiple input and output modules can be configured in a modular manner, such as the AC input module, rectifier module, solar access module, inverter module, AC output module and power distribution module;

– unified management: the site management unit schedules and controls site energy modules to achieve optimal energy efficiency – sites on the entire network are managed by the remote management platform.

3) It is recommended that a split power supply be used in core telecommunication room with the following main specification recommendations.

a) The power system of a split-type telecommunication room consists of AC cabinets, rectifier cabinets and DC cabinets. Each cabinet occupies a 0.6 m × 0.6 m area and has a total power density > 140 kW/m^2.

b) The capacity of a single rectifier cabinet is ≥ 3 000 W and the capacity of combined rectifier cabinets is ≥ 20 000 A.

c) Power grid adaptability is strong, with a wide input voltage range: 260–530 V AC (cable voltage).

d) The inverter has a high power density of 6 kVA/1U and supports modular expansion to 30 kVA.

e) A lithium battery is supported with 100% internal safety and a self-extinguishing feature for external fire.

6.7.3 Comprehensive intelligence

The requirements of clause 6.5.5 shall apply.

6.8 Intelligent energy storage system for telecommunication rooms

6.8.1 Lithium battery use for telecommunication room power backup

After about 20 years of development, especially with the rapid application of electric vehicles in recent years, the cost of lithium batteries has decreased greatly. Compared with their lead-acid predecessors, lithium batteries have advantages such as long cycle, large rate, small size and light weight. Lithium batteries have replaced the lead-acid variety as the preferred energy storage for telecommunication operators.

[b-ITU-T L.1221] contains general considerations on lithium batteries.

6.8.2 Telecommunication room power backup intelligentization trend

The evolution from conventional lead-acid to intelligent lithium batteries should be used to increase the telecommunication room efficiency.

An AI algorithm and advanced power electronic conversion technologies are used to implement intelligent lithium batteries, including real-time monitoring of the SOC and SOH status, current equalization when multiple battery strings are connected in parallel, dynamic voltage boosting, application security in high or low temperature scenarios and intelligent antitheft.

To protect battery assets effectively, batteries shall be of a type that favours flexible expansion. For example, new and old batteries, batteries from different vendors, batteries of different capacities and batteries of different types shall be connected in parallel.

Smart battery application: from pure power backup to power backup plus possibility to cycle the battery backup solution. In the 5G era, conventional lead-acid batteries cannot meet the requirements of mains modernization, short-term power backup and high-density energy storage due to their weak cycle performance, high discharge rate and small discharge capacity. With excellent cycle and rate performance, intelligent lithium batteries reduce the need for mains modernization through intelligent peak shaving, reduction of operators' electricity fees through staggered power features and implementation of a refined configuration through high-rate discharge to cope with short-term power backup. Further discussion of these aspects is given in [b-ITU-T L.1210].

6.8.3 Lithium batteries in telecommunication rooms – Safety suggestions

When the battery experiences overtemperature, overvoltage or overcurrent, different types of heat release side effects occur, producing positive heat feedback, occur. As a result, there is no longer thermal control, the battery heats up and a large amount of combustible gas are generated, resulting in a burnt battery. In the telecommunication room scenario, the lithium battery, pack design, battery management system (BMS) and fire safety should be ensured by comprehensive safety design.

a) Lithium iron phosphate (LFP) has a stable crystalline structure and should be used as the lithium material in batteries to increase reliability, as well as reducing the risk of fire and explosion caused by internal or external battery damage; it is not recommended to use ternary cathode materials for lithium batteries.

b) The pack design meets the requirements of electrochemical cells and BMS mechanical fixing, ensuring that lithium batteries are secure and reliable during transportation and that they comply with international standards such as [b-UN 38.3], [IEC 60950-1], [IEC 62368-1] and [IEC 62619].

c) Battery pack design needs to consider both heat dissipation and insulation design, and to support accurate electrochemical cell temperature and voltage sampling. The electrochemical cell package should meet the requirements for clamping lithium batteries. The electrochemical cells should be connected using laser welding technology to ensure reliable connection and to minimize security risks. The electrochemical cell package and the shell should be insulated.

d) The intelligent BMS should support the following status detection functions: cell voltage, current, temperature and port reverse connection. An intelligent BMS can also determine exceptions, e.g., cell over- and undervoltage, charging and discharging overcurrent, high and low temperatures and cell faults. An intelligent BMS supports high-precision SOC/SOH calculation, intelligent voltage adjustment and current limiting, and software anti-theft.

e) A lithium battery needs to be configured with a built-in fire extinguishing module. When the cell heats up out of control, the fire extinguishing module can actively release an extinguishing agent through an overtemperature trigger signal, thereby preventing the lithium battery from catching fire.

6.8.4 Lithium battery in telecommunication room main specification recommendation

The lithium battery used in telecommunication should be designed considering the following.

a) The standard capacity of a single lithium battery string is 100 Ah at 3U (common lithium batteries) or 100 Ah at 3.6U (safe lithium batteries).

b) The maximum charge/discharge power is 100 A/100 A at 35°C.

c) Parallel use: A maximum of 16 strings can be connected in parallel in the telecommunication room access scenario, and a maximum of 120 strings can be connected in parallel in the aggregation telecommunication room or core telecommunication room. The discharge power of the lithium batteries used in parallel will not be derating. The maximum discharge capability is tested based on the backup time. The discharge capacity must be greater than 80% of the rated capacity.

d) The fire extinguishing system is integrated with the automatic fire extinguishing function.

e) The lithium battery supports flexible hybrid use (mixed use of lithium and lead acid battery) and reuse of existing lithium batteries.

f) The lithium battery supports SOC/SOH display.

g) Anti-theft function: When the battery is moved or tilted abnormally, the battery is locked and an alarm is generated. The communication unlock function can be enabled remotely on the management system to notify users of the location information.

Appendix I

Trends in telecommunication room evolution

(This appendix does not form an integral part of this Recommendation.)

I.1 Conventional power supply and high power consumption of air conditioner, unable to support green energy

The energy efficiency of conventional telecommunication rooms is generally low. The rectifier efficiency is generally between 80% and 92%, while that of new mainstream products in the industry can reach 98%. The potential for energy saving and reconstruction is large. Typical conventional telecommunication room power modernization (load 270 kW, efficiency improved from 88% to 98%) can save 250 000 kWh/year.

In addition, low efficiency of the power system causes high heat consumption. As a result, the cooling capacity and configuration of air conditioners in the telecommunication room are high. Conventional telecommunication rooms use lead-acid batteries for power backup. The normal operating temperature of lead-acid batteries ranges from 20°C to 25°C, while the operating temperature range of telecom equipment, power supply, diesel generator and air conditioner is wide. Lead-acid batteries become the key heat sensitive source. The actual operating temperature of the telecommunication room should be the same as that of lead-acid batteries; as a result, both the control configuration specifications and heat consumption are high. According to statistics, the power consumption of air conditioners in the telecommunications room accounts for 30% to 40% of the total AC input power consumption.

Third, conventional telecommunication room power supply system cannot support solar access. It cannot optimize the power supply structure and reduce the energy consumption cost by using solar energy, which cannot help operators effectively fulfil social responsibilities of energy saving and emission reduction.

According to the preceding analysis, energy conservation becomes an important requirement for telecommunication room energy modernization. Specific measures, which should be implemented, include improving power efficiency and reducing air conditioner power consumption in the telecommunication room.

I.2 Conventional telecommunication room construction mode requires high investment, long construction period, and a large number of social resources

In the past 30 years, wireless sites have experienced an evolutionary process of room-cabinet-pole sites. Development has led the main equipment towards high density and small-size. The requirements for site locations and accommodation environments have been continually lowered. Deployment has become simpler and faster, and the energy efficiency of sites overall has continuously improved. However, the evolution of the fixed network has been slow for many years. The telecommunication room still adopts the room-style construction mode, in which the process of site acquisition, negotiation, construction approval application, civil work, decoration, equipment installation, commissioning and acceptance are inevitable. The room occupies a large footprint, uses a lot of resources, such as land, engineering materials and electricityand the process to set it up requires a long time and high investment.

With the continuous development of telecommunication networks and energy technologies, cabinet sites have become an important means to cope with the preceding challenges. Compared with conventional telecommunication rooms, cabinet sites greatly save space, simplify negotiation, civil engineering, decoration and equipment installation, greatly reduce investment, shorten the deployment period and significantly improve energy efficiency of telecommunication rooms; social resources are greatly saved. Due to the preceding advantages, the new integrated access and convergence telecommunication room should be mainly deployed using cabinets. Considering the large number of devices in the core telecommunication room and large aggregation telecommunication room, as well as the limited capacity of the cabinet, the room site will be retained for a long time in the future.

Currently, the industry ecosystem that supports the evolution of telecommunication rooms from room to cabinet sites is gradually maturing. With the evolution of high-density and small-sized main devices, as well as the simplification of maintenance modes, the front-access maintenance mode has become mainstream. The requirements for accommodation and maintenance space have been continuously reduced. Centralized high-density accommodation of main devices has become a reality. Meanwhile, with the continuous development of the telecommunication energy industry, the power density of rectifier and batteries has increased by several times. The high-density modular design of components, e.g., power supplies, batteries, power distribution and temperature control, is making integrated power supply and backup, as well as accommodation a reality.

I.3 Reconstruction difficulties by separate AC and DC power supply systems

Conventional telecommunication rooms mainly use DC power supply. The proportion of AC power supply in core telecommunication rooms is generally lower than 10%. There are no IT devices or AC power supply systems in edge aggregation and integrated access telecommunication rooms. Core network cloudification, CDN deployment or sinking, and edge computing sinking are gradually increasing the proportion of AC power supply in conventional telecommunication rooms. In typical scenarios, the proportion of AC power supply in core or backbone telecommunication rooms has increased from 10% to 30%, and the proportion of AC power supply in aggregation and integrated access telecommunication rooms, has increased from 0% to 5%and 0% to 10%, respectively.

In the conventional solution, AC power supply and batteries need to be added, and AC cable trays need to be reconstructed. The newly added AC power supply system may result in insufficient space and bearing capacity. Therefore, the power supply room needs to be expanded. In addition, the laying of the AC cabling pipe support is inevitable during the engineering phases, e.g., drilling holes, reinforcement, installation and cable laying, which requires high investment and long period.

In addition, with the continuous expansion of service boundaries of major operators, the functions carried out by telecommunication rooms are gradually being diversified, and multi-mode power supply requirements, e.g., cameras and sensors, will be added. The power supply mode (48 V DC) of the existing telecommunication room is single, and the 12 V DC, 24 V DC, and 24 V AC voltage modes cannot be output. In conventional solutions, independent power or voltage adapters are required, which increases the installation space and footprint. As a result, simplified and fast service deployment cannot be supported.

To sum up, the new-generation telecommunication room energy solution should support ICT converged power supply, AC and DC output, continuous capacity expansion and evolution of the output voltage mode, as well as having a simplified engineering reconstruction.

I.4 Difficult capacity expansion of existing telecommunication room

The capacity expansion and reconstruction of a conventional telecommunication room usually involves a large amount of engineering work, including telecommunication room construction, cable tray capacity expansion, air conditioning and ventilation pipe modernization. The costs are high and the reconstruction period is long. In the investment for capacity expansion and reconstruction of conventional telecommunication rooms, the proportion of power supply and backup systems is only 30% to 40%, and the proportion of engineering work is 60% to 70%.

1) Power supply and battery capacity expansion requires new telecommunication rooms

The power consumption increase in telecommunication rooms imposes new requirements on the power supply and battery capacity. To solve the problem that the power supply capacity of the conventional telecommunication room is insufficient, the conventional solution is to expand and reconstruct the power system. Capacity expansion of the power system greatly increases the footprint and load-bearing capacity. A typical core telecommunication room capacity expansion scenario (average load: 55 kW before modernization; increased to 105 kW after modernization; backup time: 3 h; area: 120 m^2). After capacity expansion, two groups of 3 000 Ah lead-acid batteries and a 1 000 A power cabinet need to be added. The power room occupies an additional 10 m^2, and adds 9 t to the load to be borne. Nearly 50% of conventional telecommunication rooms have insufficient power room space and load-bearing capacity. Therefore, the power room needs to be expanded.

The expansion of the power supply room involves site survey, negotiation, approval, civil engineering, construction, and decoration. The construction period is long, and the investment is high, which cannot support a fast and cost-effective expansion. The capital expenditure (CAPEX) of the power room in a typical core telecommunication room exceeds US$500,000, and the time to market is 6 to 12 months. The power room leasing process also involves negotiation, approval, cable tray installation, air conditioning and air duct reconstruction, and decoration. The process is also faced with the problems of high investment and long project duration.

2) Cable expansion requires cable tray reconstruction

The increasing power consumption in telecommunication rooms results in insufficient through-current capability of existing cables. More power cables need to be configured with conventional 48 V power supply mode. In a typical core telecommunication room capacity expansion scenario (the power consumption of the main equipment increases by 50 kW), eight additional 240 mm^2 cables need to be configured. New power cables bring new requirements for space and load-bearing capacity. Conventional cable trays cannot meet the requirements. In most cases, cable trays need to be expanded and result in high investment and long project period.

3) Capacity expansion of air conditioners and air ducts

The power efficiency of conventional telecommunication rooms is generally low (80% to 92%), and the power heat emission is high, which causes high requirements for air conditioners. After the capacity of telecommunication rooms has been expanded, the heat emission of the power system increases, and the cooling capacity of the existing air conditioners and air ducts is insufficient. Capacity expansion and reconstruction bring problems in equipment procurement and engineering reconstruction.

To address the preceding problems of high investment and long-term reconstruction, simplification and less reliance on infrastructure modification become important requirements for telecommunication room energy future evolution. During capacity expansion and reconstruction of existing telecommunication rooms, if no additional telecommunication rooms, cables, cable trays, independent AC power supplies, air conditioners or ventilation pipes are required, this supports continuous capacity expansion and evolution of services in the telecommunication room after one-time deployment.

I.5 Difficult maintenance of conventional power systems in telecommunication room

More than half of existing power systems in the world have been running for more than 10 years and have a high fault rate. Figure I.1 shows the distribution of the fault rate of the power systems in telecommunication rooms with different periods of operation.

The average fault rate of power systems in telecommunication rooms in the last 10 to 15 years is 1.75%, while in the last 15 to 20 years it is over 10%.

Figure I.1 reports an estimation of power failure rate depending on power equipment age.

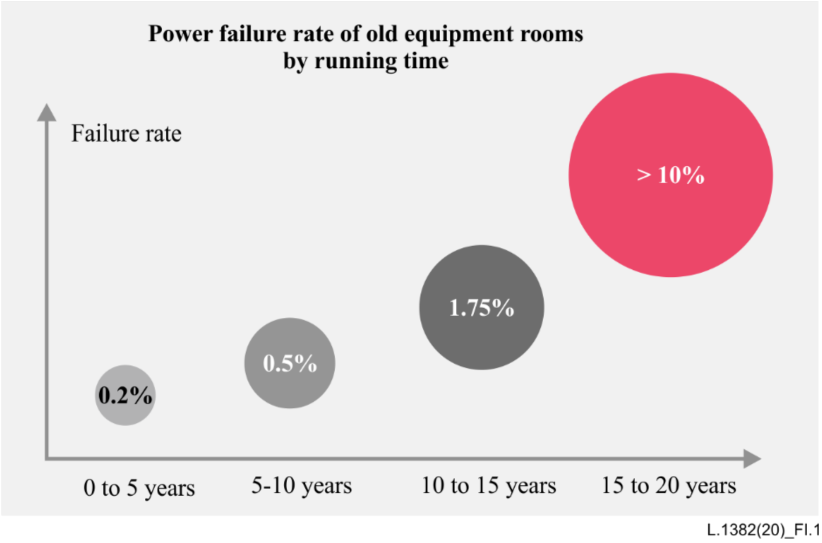


Figure I.1 – Power system failure rate by period of operation

In addition, most conventional telecommunication room power product models are no longer on the market, and some small- and medium-sized vendors have also exited the industry. As a result, some key spare parts are difficult to find, and even if they can be obtained, the price is high. In most scenarios, conventional power systems cannot support continuous service expansion. The conventional power system is one of the dumb components in telecommunication rooms and needs to be inspected periodically. In addition, the fault diagnosis efficiency is low and manual check is required. Regular maintenance, and charge and discharge tests, are required for conventional lead-acid batteries. All of these increase O&M costs. To solve the preceding problems, comprehensive intelligence has become one of the important requirements for telecommunication room energy. The main systems and components of the new telecommunication room energy solution should be remotely visible and manageable. Energy efficiency can be managed in a closed-loop manner through telecommunication room energy efficiency visualization, energy efficiency analysis and energy efficiency optimization. Precise and reliable power supply can be achieved through refined battery management. Intelligent O&M can be implemented by remote fault locating, remote battery test and remote software upgrade, reducing inefficient and ineffective telecommunication rooms.

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