International Telecommunication Union

# ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

# L.1325

(12/2016)

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

---

# Green ICT solutions for telecom network facilities

Recommendation ITU-T L.1325

ITU-T

International Telecommunication Union

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**



*For further details, please refer to the list of ITU-T Recommendations.*

# Recommendation ITU-T L.1325

## Green ICT solutions for telecom network facilities


### Summary

Recommendation ITU-T L.1325 has been developed to introduce highly-efficient infrastructure solutions, including highly-efficient power solutions, renewable energy solutions, air conditioning energy-saving solutions and free and economical cooling solutions.

Not every solution mentioned in this Recommendation is fit for everywhere. When operators choose the solution, it should be selected according to local situations.

With the development of information and communication technologies, and especially high power-density equipment, the energy consumption of communication industry is increasing. Therefore, we must pay attention to energy conservation, and protection of the environment. This Recommendation specifies Green ICT solutions for telecom network facilities.



### History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
|---|---|---|---|---|
| 1.0 | ITU-T L.1325 | 2016-12-14 | 5 | 11.1002/1000/13146 |

### Keywords

Energy efficiency, green solutions, ICT, telecom network.


* 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

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

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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.

## INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

## Table of Contents

# Recommendation ITU-T L.1325

## Green ICT solutions for telecom network facilities

## 1 Scope

This Recommendation specifies Green ICT solutions for telecom network facilities and aims to increase the energy efficiency of the whole telecom network and to reduce carbon emissions. ICT infrastructure can be defined as a repository for the telecom equipment, management system, power system and cooling system. It is designed for maximum energy efficiency and minimum environmental impact. The construction and operation of telecom network infrastructures includes advanced technologies and strategies. This Recommendation provides a set of rules to be referred to when undertaking improvement of existing telecom network infrastructure, or when planning, designing or constructing new ones.

## 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 L.1200] Recommendation ITU-T L.1200 (2012), *Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment.*

[ITU-T L.1201] Recommendation ITU-T L.1201 (2014), *Architecture of power feeding systems of up to 400 VDC.*

[ITU-T L.1204] Recommendation ITU-T L.1204 (2016), *Extended architecture of power feeding systems of up to 400 VDC.*

[ITU-T L.1300] Recommendation ITU-T L.1300 (2014), *Best practices for green data centres.*

[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.*

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 energy** [b-ISO 16818]: Capacity for doing work; having several forms that may be transformed from one to another, such as thermal (heat), mechanical (work), electrical or chemical, and is expressed in Joules. For the purpose of this Recommendation, energy will be expressed in Watt-hours (Wh) or kilowatt-hours (kWh).

**3.1.2 power** [b-ISO 16818]: Rate at which energy is transmitted.

## 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 infrastructure**: Equipment that supports the ICT equipment, e.g., power delivery components and cooling system components.

**3.2.2 ICT equipment**: Information and Communication Technology equipment (e.g., computing, storage, and network equipment) used in data centre.

**3.2.3 power feeding system**: Power source to which ICT equipment and facilities are intended to be connected, such as uninterruptible power supply (UPS) and backup generator, etc.

# 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

APF Active Power Filter

DC Direct Current

DG Diesel Generator

HVDC High Voltage Direct Current

PV Photovoltaic

UPS Uninterruptible Power Supply

# 5 Conventions

None.

# 6 General requirements of green solutions

Telecommunication safety and equipment life cycle are the two basic requirements in telecommunications systems. Therefore, any energy-saving activities should not affect the safety and life-cycle of the telecommunication equipment and its environment.

The applications of high efficiency solutions such as: high voltage direct current (HVDC), and high-efficiency air conditioning are encouraged.

Renewable energy systems such as: solar, wind turbine or fuel-cell are recommended if renewable energy resources are available, so as to reduce carbon emissions.

The application of free and economical cooling methods such as outdoor air cooling, heat exchangers and heat pipes are encouraged.

# 7 High efficiency power-feeding solutions

## 7.1 High-frequency switching rectifier sleeping mode solution

The high-frequency switching rectifier sleeping mode solution controls the number of active rectifiers in a power supply system by monitoring the load current to make the power supply system operate in the region around the maximum efficiency point.

This technology is suitable for modularized power supply systems with redundancy.

Reliability and safety of a power supply system should not be decreased while this function is enabled.

If the power module, controller or grid fails or if an equalization charge of battery is started, the system must stop this function. The sleeping function will be recovered when the system is restored and system is operating in floating charging mode.

The detailed information on principle and energy saving characteristics can be found in [b-Liu Yiheng].

## 7.2 HVDC power feeding solution

HVDC power feeding systems for telecommunication systems have an output voltage of up to 400 VDC. For the definition of this system refer to [ITU-T L.1200].

This solution can be used in telecom centres and data centres. Typical architectures are shown in Figure 1 to Figure 3 according to [ITU-T L.1201].

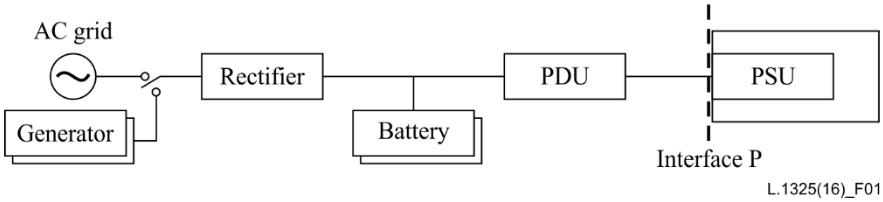


**Figure 1 – A power feeding system with backup solution including up to 400 VDC power feeding**

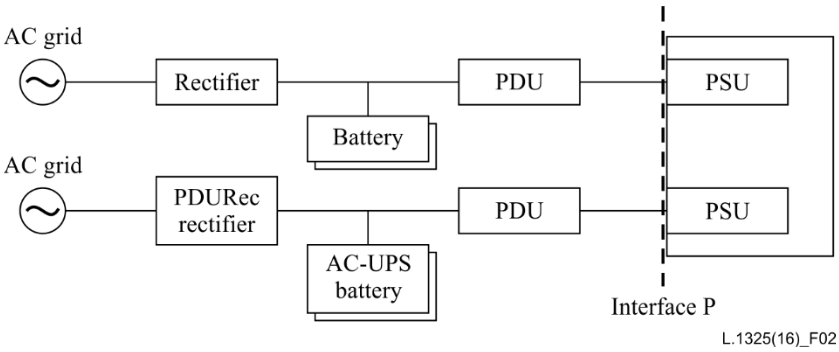


**Figure 2 – Dual AC supply system configuration for dual PSU ICT equipment**

## 7.3 Hybrid power feeding solution with up to 400 VDC and AC power feeding system

In this solution, priority is given to the use of the AC grid, which reduces the energy conversion section, and contributes to improving the system efficiency.

There are two kinds of operational modes, one is the AC grid priority connected to the load and the other is when the AC grid and the UPS are working together. The system structure is shown in Figure 3.

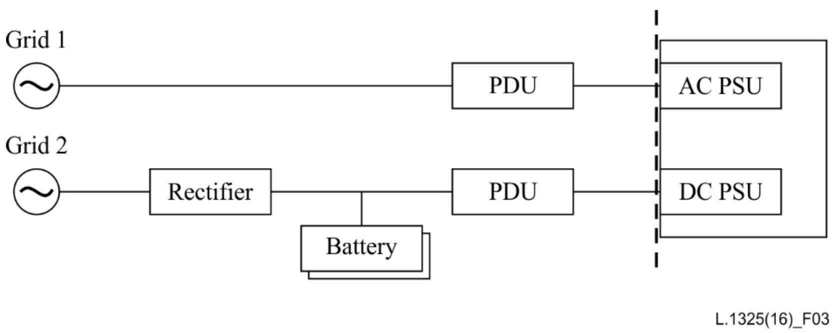


**Figure 3 – AC grid + HVDC power supply structure**

### 7.4 Parallel active power filter solution

Harmonic current elimination is a solution that can cancel high order harmonics in the power grid by active or passive technologies. Power quality can be improved and prevents users from disadvantages of excess harmonics.

The active power filter (APF) is more complicated and expensive than the passive power filter. However, it shows better control performance, smaller size, adaptive tracking and compensation of different harmonic components.

There are different types of APFs, therefore it is recommended that the parallel type of APF is used. For harmonics which come from UPS and HVDC systems, closed-loop, three-phase three-wire can be selected for both local and distributed elimination. For the harmonics which come from switched-mode power supplies and air conditioners, closed-loop, three-phase four-wire can be selected for both local and distributed elimination. For concentrated harmonics elimination on the low-voltage side of distribution transformer, closed-loop, three-phase four-wire is recommended.

Before this solution is applied, space for the active power filter should be reserved.

### 7.5 High temperature lead acid battery solution

High temperature lead acid battery technology improves upon the traditional shell structure, material, paste formula, separator and electrolyte etc. It can adapt to a wider temperature range and long-term work below 35°C.

This solution can improve the service life when working temperatures are high. This kind of battery is recommended if the temperature is normally in the range of 20°C to 35°C, and the permitted temperature range is between −20°C and +65°C. More detailed information can be found in [b-Dong Hong].

## 8 Renewable energy power supply solutions

This clause includes solar power solution, wind power solution and hydrogen fuel cell power supply solution.

### 8.1 Solar power solution

The structure of solar system solution applied to a telecommunication system is shown in Figures 4 and 5.

It needs batteries as energy storage devices and is mainly used in places not connected to the grid. It is widely distributed in these areas. It is highly reliable and easy to maintain.

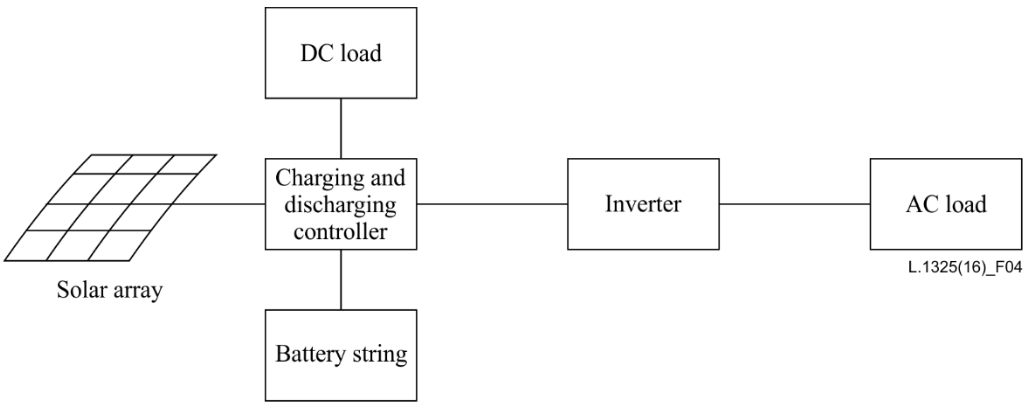


**Figure 4 – Off-grid solar power system**

The solar power system sometimes works together with a diesel generator (DG). The system structure is shown in Figure 5, which depicts a standby DG (or mains) powerline. When the photovoltaic (PV) panel arrays generate insufficient power or there is a lack of other backup power, the standby DG will start. It can be used either to power the AC load directly or to charge the battery through rectifiers.

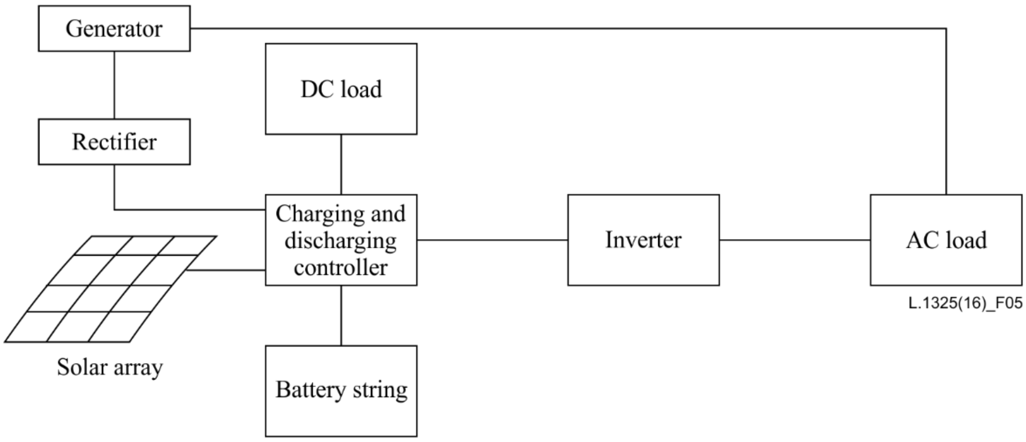


**Figure 5 – Solar and DG power system**

## 8.2 Wind power solution

An off-grid powering solution for telecommunication base stations based on using a wind generator is shown in Figure 6.

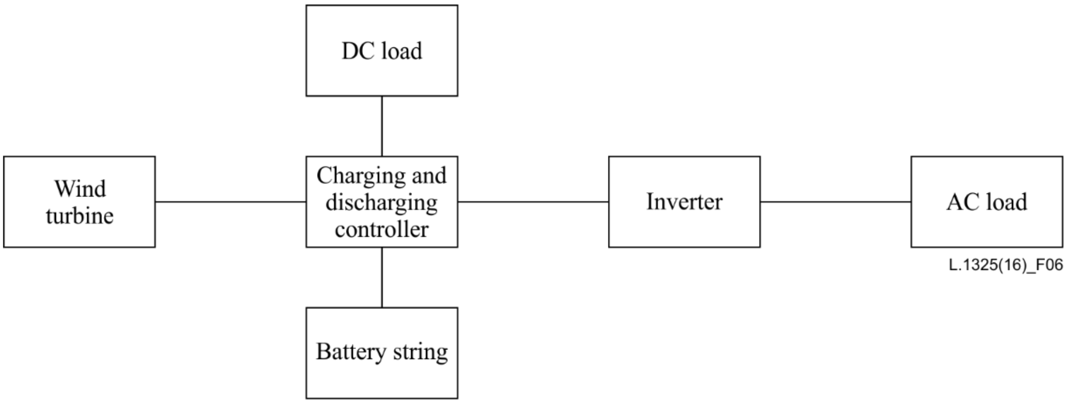


**Figure 6 – Off-grid wind power system structure**

Wind energy is converted to mechanical energy through a wind turbine, and rectifiers will supply DC power to loads, or via an inverter convert DC to AC output power for an AC load. Wind instability should be taken into account to achieve a balance between supply and load.

## 8.3 Fuel cell power solution

Hydrogen fuel cell systems used in communication base stations adopt a proton exchange membrane fuel cell system. They are quick starting, stable in power output and environmentally adaptable. Its structure is shown in Figure 7.

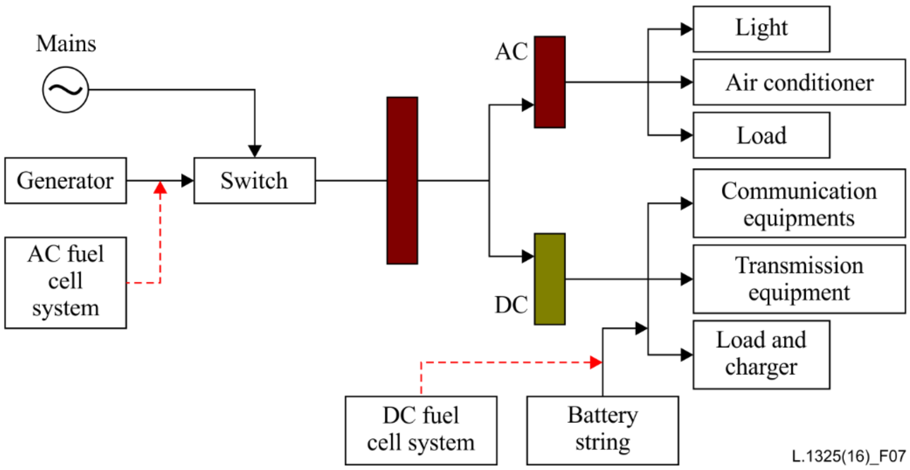


**Figure 7 – Hydrogen fuel cell-powered system DC power supply and AC power lines**

The hydrogen fuel cell has the following advantages when compared to the traditional power system.

1) High energy efficiency

   Normally, the fuel cell system has high energy conversion efficiency. Carbon dioxide emissions reduce by more than 40 per cent compared with fossil fuel alternatives, which is good for the environment.

2) Environmentally-friendly

   When the fuel cell uses pure hydrogen as fuel, the chemical reaction product is only water. Nitrogen oxides, carbon dioxide and other emissions are virtually eliminated and, as there are no moving parts in the fuel cell power supply system, noise output is quite low.

3) Flexibility

   System capacity is very flexible as cells may be connected in series or in parallel. It is therefore very convenient for expansion, according to customer demand.

## 9 Air conditioning power-saving solutions

A refrigerant pumping power-saving solution and adaptive control of an air conditioning power-saving solution are covered in this chapter.

### 9.1 Refrigerant pump power-saving solutions

This solution is used in seasons when there is a big difference between indoor and outdoor temperatures. If the outside temperature is low, the system uses the evaporator in the refrigeration system and the air-cooling condenser automatically switches to the refrigerant pump for refrigeration. Since the refrigerant pump consumption power is much lower than the compressor power consumption, the telecommunication room can be rapidly cooled to save energy.

### 9.2 Adaptive control of air conditioning power-saving solution

The adaptive control of air conditioning power-saving is a power-saving solution that uses a self-adaptive control method to automatically adjust the output air flow and temperature of the air conditioner, therefore several air conditioners can work simultaneously in a coordinated way.

The air-conditioner should be adaptively controlled according to different parts of the room, changes in temperature and humidity during day and night, different seasons, and different regions. The air conditioner can automatically adjust the working status and temperature to coordinate with other air conditioners. Using this solution, the compressor's working hours and the power consumption of the air conditioning system can be reduced. It can also automatically monitor temperature and humidity so that humidification and dehumidification is controlled.

### 9.3 Central air conditioning inverter solution

In cases where there is a chiller in the data centre's central air conditioning system, frequency control technology can be used to control chilled water pumps and cooling tower fans and provide chilled water to the cooling system. This will help achieve terminal side cooling according to demand. This system can save energy as the frequency is changed according to the load.

To apply this solution, the inverter capacity should match the load. It also should be noted that harmonic current will be produced from the inverter technology and the circuit will result in decreased power factor, increased noise, vibration of the system and increased waste heat. The detailed analysis on energy-saving characteristics can be found in the [b-inverter].

## 10 Free and economical cooling solutions

This clause includes an outdoor fresh-air cooling solution, a heat-exchange cooling solution and a heat pipe solution.

### 10.1 Outdoor fresh air cooling solution

An outdoor fresh-air cooling solution is an air conditioning system that uses a controlling unit to purify the air from outside and introduce it into the telecommunication room in order to expel the hot air. It uses no refrigeration, just the fresh air outside to reduce the indoor temperature. It can therefore reduce power consumption.

This solution can give very good energy-saving characteristics if used in cool seasons, and the relative humidity is lower than 90 per cent. It requires that outdoor air is clean and the humidity balanced.

### 10.2 Heat exchange cooling solution

Outdoor fresh air flows into the room through a controlling unit. This removes the hot air inside through the sensitive heat exchange core module. It works without any refrigeration components and reduces the air conditioning power consumption.

In this heat-exchange cooling solution, indoor and outdoor air is separated to avoid introducing air pollution, so that cleanliness can be fully guaranteed. Although sensitive heat exchange uses more power, it still has a power-saving effect as it is more efficient than an air conditioner. This solution can obtain very good energy saving characteristics if used in places where temperature gap between the outdoors and the room is more than 10°C.

### 10.3 Heat pipe solution

The heat pipe system consists of evaporators, condensers, fans and other components. The evaporator is filled with circulating refrigerant which is connected to the evaporator and condenser through the heat pipe. When fans start to drive hot air in the control room flows through the evaporator, the circulating refrigerant inside the evaporator transforms the coolant to gas which passes through the main air pipe then to the condenser. Gas in the condenser becomes liquid when the outdoor cool air passes through the condenser, then returns to the evaporator through the main liquid pipe. Thus heat transfer energy efficiency is much higher than traditional solutions.

The heat pipe system may work in parallel with the original air conditioning system in high temperature regions. The alternation between this system and a traditional air conditioner can offer mutual backup. An example of the heat pipe working in parallel with the original air conditioning system is given in [b-Heat Pipe]. Not only can it save energy, but it is also very effective in improving the safety and reliability of air conditioning equipment, and extending its life.

### 10.4 Wet film solution

When dry and hot air passes through a wet film, moisture and dust is absorbed, the air is cooled and filtered and the humidity controlled.

As the air passes through the wet film, the heat in the air is absorbed, in especial during seasons when outdoor temperatures are lower than indoor air. After being filtered by the water wall filter, the air from outdoors can be cooled down by between 4°C and 10°C, and it is purified. The cool air then flows into the room by the draught fan, reducing the room temperature quickly.

Energy consumption can be decreased by enthalpy humidification technology. To apply this solution, a water source is required. Moreover, antifreeze measures should be taken during cold seasons. In addition the wet film should be periodically cleaned and replaced.

### 10.5 Cooling tower free-cooling solution

When the outdoor temperature is lower than the set value, the water-cooling unit will close down and start the cooling tower in free-cooling mode to directly or indirectly cool the air conditioning system, thus saving energy.

The structure of cooling tower water side free cooling technology is shown in Figure 8. This includes an open type cooling tower heat exchanger mode and closed cooling tower direct cooling mode.

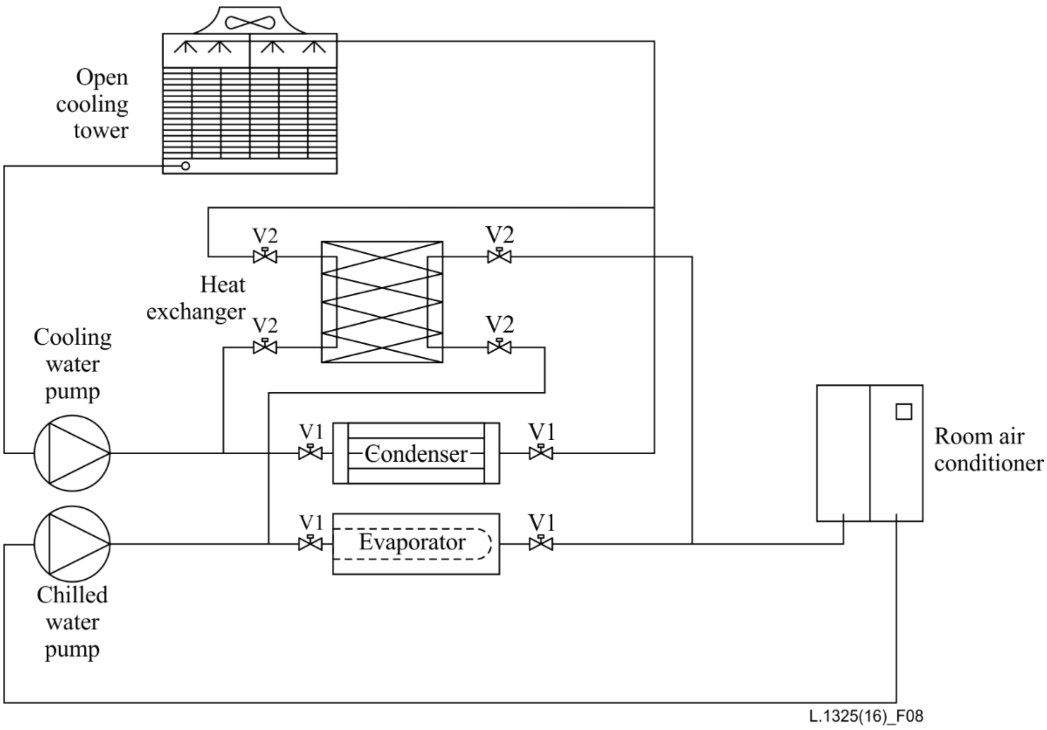


**Figure 8 – Open cooling tower cooling system**

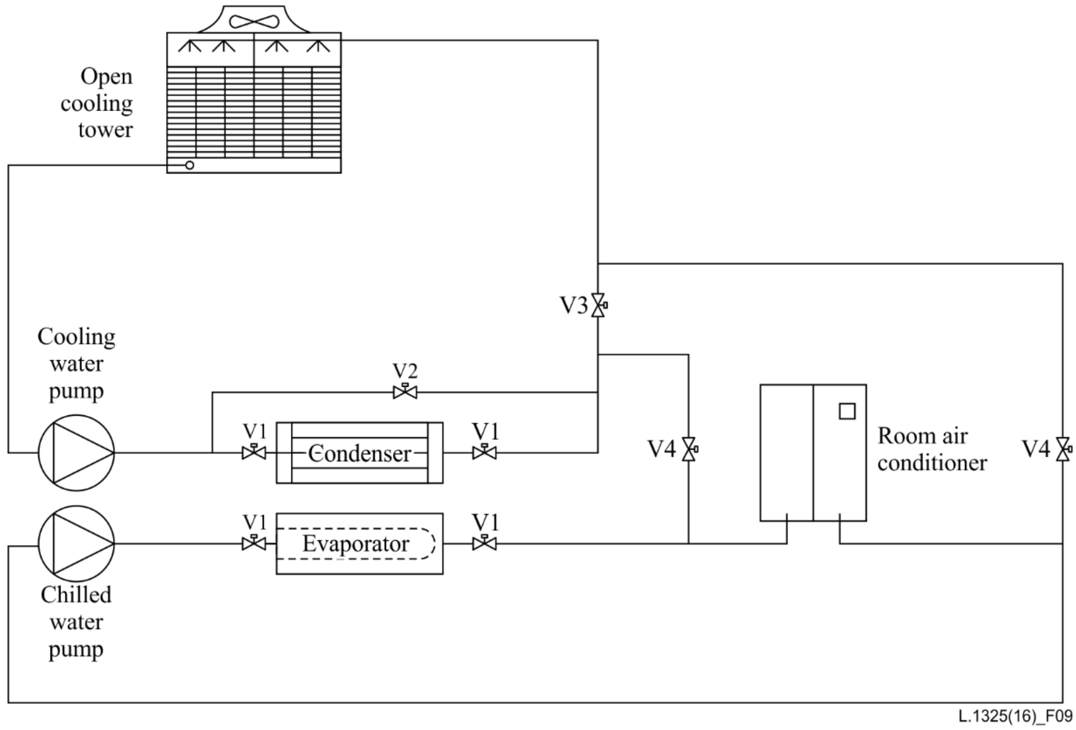


**Figure 9 – Closed cooling tower cooling system**

This system reduces the running time of the chiller and prolongs the service life of the water chiller. It also reduces the noise of the refrigeration room and does not affect the cleanliness of the ICT rooms. The detailed analysis on principle and application can be found in [b-Zhu Hongbo].

For this system, how much energy it saves depends on outside environmental conditions. This solution should be applied, taking into account the natural cooling capability of the telecommunication room or data centre. To apply this solution, there should be reliable technical measures to ensure the smooth transition between the two operating conditions of cold water chiller cooling and cooling tower natural cooling, and also anti-freeze technical measures.

# Bibliography


[b-CCSA YDB 071.2] Guide for energy saving technology of power supply for telecommunications and Room environment Part 2: application condition.

[b-Bauer] E.J. Bauer and P.H. Franklin (2006), Power system availability Bell Labs, *Framework for Availability Characterization by Analyzing Outrage Duration,* Bell Labs Technology Journal, 11(3), 36-46.

[b-Dong Hong] Dong Hong., Lai Shineng (2014), *Application and development of High Temperature Valve – regulated Sealed Lead – acid Battery*, Telecom Power Technology, Vol 32, P(4-8).

[b-Heat Pipe] Shi Wenxing., Han Linjun., Wang Baolong., Zhou Dehai., Li Xianting (2011), *Principle of combined air conditioner by heat pipe and vapor compression and its application analysis in high heat density space*, Refrigeration and Air-Conditioning, No. 1.

[b-inverter] K. H. Yang, M. L. Lee (1991) *Analysis of an inverter-driven air-conditioning system and its application in a hot and humid area, as referenced here* http://onlinelibrary.wiley.com/doi/10.1002/er.4440150503/abstract

[b-Liu] X. Liu and W. Wang (2010), Battery reliability Intelec, *VRLA Battery System Reliability and Proactive Maintenance,* Proc. of 32nd International Telecommunications Energy Conference (INTELEC 2010).

[b-Liu Yiheng] *Analysis on energy efficiency of High-Frequency Switching rectifier with sleeping mode function*.

[b-Qi Shuguang] Qi Shuguang, HouFuping, Jing Hui (2012), DC for telecom in China Intelec *Study and Application on High Voltage DC Power Feeding System for Telecommunications in China,* Proc. of 34th International Telecommunications Energy Conference (INTELEC 2012).

[b-Qi Shuguang] Qi Shuguang (2012), *Analysis on reliability and energy saving characteristics of new power feeding mode in telecommunications*, Modern Science & Technology of Telecommunications, Vol. 42, No. 10, P(6-11).

[b-Tier] W. Pitt Turner IV *et al.*, *Uptime Institute*, Tier Classifications Define Site Infrastructure Performance.

[b-Tsumura] T. Tsumura, T. Takeda and K. Hirose (2008), ICT power supply reliability Intelec (2008), *A Tool for Calculating Reliability of Power Supply for Information and Communication Technology Systems,* Proc. of 30th International Telecommunications Energy Conference (INTELEC 2008), pp. 14-18.

[b-Zhu Hongbo] Zhu Hongbo (2014), *Summary of design of centralized cold source air conditioning system in data center*, Telecommunication Network Technology, No. 10, October, P(15-26).

## SERIES OF ITU-T RECOMMENDATIONS

| | |
|---|---|
| Series A | Organization of the work of ITU-T |
| Series D | Tariff and accounting principles and international telecommunication/ICT economic and policy issues |
| Series E | Overall network operation, telephone service, service operation and human factors |
| Series F | Non-telephone telecommunication services |
| Series G | Transmission systems and media, digital systems and networks |
| Series H | Audiovisual and multimedia systems |
| Series I | Integrated services digital network |
| Series J | Cable networks and transmission of television, sound programme and other multimedia signals |
| Series K | Protection against interference |
| Series L | Environment and ICTs, climate change, e-waste, energy efficiency, construction, installation and protection of cables and other elements of outside plant |
| Series M | Telecommunication management, including telecommunication network management and network maintenance |
| Series N | Maintenance: international sound programme and television transmission circuits |
| Series O | Specifications of measuring equipment |
| Series P | Telephone transmission quality, telephone installations, local line networks |
| Series Q | Switching and signalling, and associated measurements and tests |
| Series R | Telegraph transmission |
| Series S | Telegraph services terminal equipment |
| Series T | Terminals for telematic services |
| Series U | Telegraph switching |
| Series V | Data communication over the telephone network |
| Series X | Data networks, open system communications and security |
| Series Y | Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities |
| Series Z | Languages and general software aspects for telecommunication systems |

Printed in Switzerland
Geneva, 2017