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PROTECTION OF CABLES AND OTHER ELEMENTS
OF OUTSIDE PLANT

Best practices for green data centres

Recommendation ITU-T L.1300

ITU-T



Recommendation ITU-T L.1300

Best practices for green data centres

Summary

Recommendation ITU-T L.1300 describes best practices aimed at reducing the negative impact of data centres on the climate. It is commonly recognized that data centres will have an ever-increasing impact on the environment in the future. The application of the best practices defined in this Recommendation can help owners and managers to build future data centres, or improve existing ones, to operate in an environmentally responsible manner. Such considerations will strongly contribute to a reduction in the impact of the information and communication technology (ICT) sector on climate change.

History

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FOREWORD

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

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

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

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Recommendation ITU-T L.1300

Best practices for green data centres

1 Scope

This Recommendation specifies best practices aimed at developing green data centres. A green data centre can be defined as a repository for the storage, management, and dissemination of data in which the mechanical, lighting, electrical and computer systems are designed for maximum energy efficiency and minimum environmental impact. The construction and operation of a green data centre includes advanced technologies and strategies. The Recommendation provides a set of rules to be referred to when undertaking improvement of existing data centres, or when planning, designing or constructing new ones.

The proposed best practices cover:

- data centre utilization, management and planning;
- ICT equipment and services;
- cooling;
- data centre power equipment;
- data centre building;
- monitoring.

The environmental impact of a data centre should be assessed in line with [ITU-T L.1400], [ITU-T L.1410] and [ITU-T L.1420].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1400]	Recommendation ITU-T L.1400 (2011), <i>Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies</i> .
[ITU-T L.1410]	Recommendation ITU-T L.1410 (2012), <i>Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services</i> .
[ITU-T L.1420]	Recommendation ITU-T L.1420 (2012), <i>Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations</i> .
[ETSI EN 300 019-1-3]	ETSI EN 300 019-1-3 V2.3.2 (2009), <i>Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weather protected locations</i> .

[ETSI TR 102 489]	ETSI TR 102 489 V1.2.1 (2010), <i>Environmental Engineering (EE); European telecommunications standard for equipment practice; Thermal Management Guidance for equipment and its deployment.</i>
[ISO/IEC 62040-3]	ISO/IEC 62040-3 Ed2.0 (2011), <i>Uninterruptible Power Systems (UPS) – Part 3: Method of specifying the performance and test requirements.</i>

3 Definitions

3.1 Term defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 power density: The energy consumption of ICT equipment per rack cabinet of floor area of a server room.

3.2.2 space efficiency: The ratio of floor area employed for ICT equipment in relation to the total floor area of the building.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AHU	Air Handling Unit
ATS	Automatic Transfer Switch
BC	Business Continuity
BIOS	Basic Input-Output System
BREEAM	Building Research Establishment Environmental Assessment Methodology
CFD	Computational Fluid Dynamics
COP	Coefficient Of Performance
CRAC	Computer Room Air Conditioner
DC	Data Centre
DCMI	Data Centre Manageability Interface
DX	Direct expansion
DR	Disaster Recovery
HVAC	Heating Ventilation and Air Conditioning
ICT	Information and Communication Technology
IGBT	Insulated-Gate Bipolar Transistor
IPMI	Intelligent Platform Management Interface
LEED	Leadership in Energy and Environmental Design
M&E	Maintenance and Engineering
OA	Outdoor Air
PDU	Power Distribution Unit

PSU	Power Supply Unit
PUE	Power Usage Effectiveness
RA	Return Air
REACH	Registration, Authorization and restriction of Chemical substances
RH	Relative Humidity
RoHS	Restrictions of Hazardous Substances
RT	Refrigerant Ton
SA	Supply Air
SMASH	Systems Management Architecture for Server Hardware
SNMP	Simple Network Management Protocol
Tri-Gen	Tri-Generation
UPS	Uninterruptible Power Supply
VFI	Voltage and Frequency Independent
WEEE	Waste Electrical and Electronic Equipment

5 Introduction to best practices for green data centres

In order to improve the energy efficiency of data centres, it is necessary to consider all stages from design through to construction. Even after the building of data centres is complete, they must continue to be managed and maintained to ensure efficient energy consumption.

This Recommendation describes best practices for energy-efficient construction, operation and management of green data centres that contain a number of essential components, including ICT equipment and services, cooling, power equipment, data centre building, etc.

The best practices discussed herein have been numbered for easy reference.

Best practices have been identified and divided into different clauses to cover the following different components of a data centre:

- planning, utilization and management;
- ICT equipment and services;
- cooling;
- data centre power equipment;
- other data centre equipment;
- data centre building;
- monitoring;
- design of network;
- cloud data centre;
- optimization of energy management of the whole data centre.

5.1 Role of best practices

This Recommendation is provided as a comprehensive guide to assist data centre operators in identifying and implementing measures to improve energy efficiency of their data centres.

The full list of best practices that are specified in this Recommendation can be of practical help for those who are pursuing green data centres.

5.2 Value of practices

Each practice has not been assigned a qualitative value to indicate the level of benefit to be expected from an action and the relative priorities that should be applied to it.

When there is a choice of practices, a preference should be given to the one having the least impact on the environment.

6 Planning, utilization and management of data centres

It is important to develop a holistic strategy and management approach to the data centre to support economic efficiency and environmental benefits.

6.1 Involvement of organizational groups

Effective communication between different departments working in the data centres is crucial to ensure efficiency and thereby avoid capacity and reliability issues.

To ensure effective communication, the following steps are proposed:

No.	Name	Description
6.1.1	Group involvement	Establish an "Approval Board" composed of representatives from different departments (e.g., software, ICT, power cooling and other facilities). Submit all important decisions for board approval to ensure that all possible impact has been fully understood and that an effective solution has been identified. For example, one of the decisions could be the definition of standard ICT hardware lists through considering the maintenance and engineering (M&E) implications of different types of hardware.

6.2 General policies

These policies apply to all aspects of the data centre and its operation.

No.	Name	Description
6.2.1	Consider the embedded energy in devices	Carry out an audit of existing equipment to ensure that optimal use is made of existing capability before making any new investment.
6.2.2	Mechanical and electrical equipment environmental operating ranges	Recommend the selection and deployment of mechanical and electrical equipment which does not itself require refrigeration. Note that this refers to mechanical compressors and heat pumps, any device which uses energy to raise the temperature of the rejected heat.
6.2.3	Lifecycle Analysis	Introduce a plan for lifecycle assessment (LCA) in accordance with [ITU-T L.1410].

6.3 Resilience level and provisioning

One of the most significant sources of inefficiency in a data centre is the over-provision of space, power or cooling, and the use of existing facilities operating at partial capacity. Monolithic design, as opposed to modular design, of facilities is also frequently an unnecessary capital expenditure.

No.	Name	Description
6.3.1	Build resilience to business requirements	Build or, in the case of a co-location customer, purchase only the level of resilience actually justified by business requirements and an impact analysis. Full backup (1+1) of infrastructure is frequently unnecessary and inappropriate. Resilience for a small portion of critical services can be obtained by using disaster recovery (DR)/business continuity (BC) sites.
6.3.2	Consider multiple levels of resilience	Build a single data centre to provide multiple levels of power and cooling resilience to different floor areas. Many co-location providers already deliver this, for example, as optional "grey" power feeds without uninterruptible power supply (UPS) or generator back up.
6.3.3	Design effective resilience	Utilize appropriate levels of resilience at the data centre ICT equipment, software and network levels to achieve the required service resilience. High resilience at the physical level is rarely an effective overall solution.
6.3.4	Lean provision of power and cooling for a maximum of 18 months of data floor capacity	Avoid unnecessary fixed losses as a result of the provision of excess power and cooling capacity in the data centre. Plan a data centre for modular (scalable) expansion and then build upon this capacity in a rolling programme of deployment. This design is more efficient, allows the technology "generation" of ICT equipment, and supports the match of M&E infrastructure, thereby improving both efficiency and the ability to respond to business requirements.
6.3.5	Design to maximize the partial load efficiency once provisioned	All areas of the data centre should be designed to maximize the efficiency of the facility under partial fill and variable ICT electrical load. This is in addition to one-off modular provisioning and considers the response of the infrastructure equipment to dynamic loads, e.g., variable frequency (or speed) drives for pumps and fan units.

7 ICT equipment and services

ICT equipment creates the demand for power and cooling in the data centre. Any reduction in power and cooling used by, or provisioned for ICT equipment will have magnified effects for the utility energy supply.

The purpose of environmental specifications of equipment, as outlined in the next clause, is to ensure that new equipment is capable of operating under the wider ranges of temperature and humidity, thus allowing the operator a greater flexibility in operating temperature and humidity.

7.1 Selection of new ICT equipment

Once ICT equipment is purchased and installed in the data centre, it is usually in use for several years, consuming power and creating heat. The appropriate selection of hardware and deployment methods can provide significant long-term savings.

No.	Name	Description
7.1.1	Multiple tender for ICT hardware – power	Include energy efficient performance of the ICT device as a high priority decision factor in the tender process e.g., through application or deployment of specific user metrics more closely aligned to the target environment, which may include service level or reliability components. The energy consumption of the device, at the expected utilization or applied workload, should be considered in addition to peak performance per watt figures.

No.	Name	Description
7.1.2	Multiple tender for ICT hardware – operating temperature and humidity range at equipment intake Low priority practices	Include the operating temperature and humidity ranges at the intake of new equipment as high priority decision factors in the tender process. The minimum range, at the air intake to servers, is 18°C-32°C and 5.5°C dew point up to 15°C dew point and 60% RH. This is defined in [b-ASHRAE TC 9.9].
7.1.3	Multiple tender for ICT hardware – extended operating temperature and humidity range High priority practices	Introduce a stronger requirement for new ICT equipment stipulating the need for them to withstand the air inlet temperature and relative humidity (RH) ranges of 5°C to 40°C and 5% to 80% RH, non-condensing respectively, and under exceptional conditions up to +45°C, as described in [ETSI EN 300 019-1-3] Class 3.1. All vendors should indicate the maximum allowable temperature and humidity for all equipment, to maximize the efficiency opportunities in refrigeration and free cooling. It should be noted that where equipment with differing environmental requirements are not segregated, the equipment with the more restrictive temperature range will influence the cooling conditions and corresponding energy consumption for all ICT equipment. From 40°C to 45°C intake temperature, it is acceptable for equipment to implement performance reduction mechanisms to continue delivering the intended service at a lower speed whilst preventing damage. These mechanisms should not reduce performance to below 80% of the nominal for that device. Where such performance reduction mechanisms are used, a clear description of the operating parameters and performance impact should be provided.
7.1.4	Environmental exclusions	Exclusions from the requirement for ICT equipment to meet the ETSI specification will be considered under the following specific conditions: – equipment that requires tighter environmental controls to meet the requirements of storage media such as tapes; – equipment that requires tighter environmental controls to meet long warranty durations (10+ years); – devices whose primary cooling method is not air (directly liquid cooled). These exclusions would require that equipment unable to meet best practice 7.1.3 should be deployed with separate airflow and cooling provision. This allows data centre cooling plants to be set up using equipment that has a less restrictive environmental range without compromising the eco-efficiency of the entire data centre.
7.1.5	Multiple tender for ICT hardware – compliance with green regulations	Tender processes for new ICT equipment that are compliant with green regulations, will be considered as high-priority decision factors. Environmental pollution can be reduced by selecting equipment that is compliant with green regulations of each region or country (e.g., restrictions of hazardous substances (RoHS), registration, authorization and restriction of chemical substances (REACH), and waste electrical and electronic equipment (WEEE)).

No.	Name	Description
7.1.6	Select equipment suitable for the data centre – power density	Select and deploy equipment according to the defined power density (per rack or square metre) of the data centre to avoid running the cooling system outside design parameters. Note that increasing power density may create cooling and airflow management problems, thereby reducing both capacity and efficiency. Power and cooling need to be considered as a capacity constraint in addition to a physical space constraint.
7.1.7	Select equipment suitable for the data centre – airflow direction	When selecting equipment for installation into racks, ensure that the airflow direction matches the airflow design for that area. This is commonly front-to-rear or front-to-top. If the equipment uses a different airflow direction to that defined for the area into which it is installed (such as right-to-left when the rack is intended to be front-to-back), then it should only be used with a correction mechanism such as ducts, or special racks that divert the airflow to the defined direction. Uncorrected equipment with non-standard airflow will compromise the airflow management of the data centre, and therefore restrict temperature set points. It is possible to mitigate this issue by segregating such equipment.
7.1.8	Select free-standing equipment suitable for the data centre – airflow direction	When selecting equipment which is free-standing, or supplied in custom racks, the airflow direction of the enclosures should match the airflow design in that area of the data centre. This is commonly front to rear or front to top. Specifically, the equipment should match the hot/cold aisle layout or containment scheme implemented in the facility. Uncorrected equipment with non-standard airflow will compromise the airflow management of the data centre and therefore restrict temperature set points. It is possible to mitigate this compromise by segregating such equipment. Suggestions on airflow management are present in an annex to this Recommendation and in [ETSI TR 102 489].
7.1.9	Enable power management features	Formally change the deployment process to include the enabling of power management features on ICT hardware as it is deployed. This includes basic input-output system (BIOS), operating system and driver settings.
7.1.10	Provision to the as-configured power	Provision of power and cooling only to the as-configured power draw capability of the equipment, and not the power supply unit (PSU) or nameplate rating. Note that this may require changes to provisioning if the ICT equipment is upgraded internally.
7.1.11	Energy efficiency compliant hardware	ICT equipment with energy efficiency labels, such as the Energy Star labelling programmes, should be used as a guide to server selection when and where available for that class of equipment. Operators who are able to determine the in use energy efficiency of hardware through more advanced or effective analysis, should select the most efficient equipment for their scenario.
7.1.12	Energy and temperature reporting hardware	Select equipment with power and inlet temperature reporting capabilities, preferably reporting energy used as a counter in addition to power as a gauge. Where applicable, industry standard reporting approaches should be used, such as intelligent platform management interface (IPMI), data centre manageability interface (DCMI) and systems management architecture for server hardware (SMASH).

No.	Name	Description
		To assist in the implementation of temperature and energy monitoring across a broad range of data centres, all devices with an IP interface should support simple network management protocol (SNMP) polling of inlet temperature and power draw. Note that event based SNMP traps and SNMP configuration are not required. The intent of this practice is to provide energy and environmental monitoring of the data centre through normal equipment churn.
7.1.13	Control of equipment energy use	Select equipment that provides mechanisms to allow the external control of its energy use. An example of this would be the ability to externally restrict a server's maximum energy use or trigger the shutdown of components, entire systems or sub-systems.
7.1.14	Operating temperature range – liquid cooled ICT equipment	These devices should be able to operate with supply coolant liquid temperatures equal to the air temperatures specified in best practice 7.1.3, i.e., from 10°C to 35°C (50°F to 95°F).
7.1.15	ICT equipment power against inlet temperature	When selecting new ICT equipment, require the vendor to supply at minimum, either the total system power or the cooling fan power for temperatures covering the full allowable inlet temperature range for the equipment under 100% load using a specified benchmark such as [b-SPECPower]. Data should be provided for 5°C or smaller steps of inlet temperature.

7.2 Selection of new telecom equipment

Once ICT equipment is purchased and installed in the data centre, it typically remains in use for several years, consuming power and creating heat. The appropriate selection of hardware and deployment methods can provide significant long-term savings.

No.	Name	Description
7.2.1	New equipment selection	Processes should be put in place to select new telecom equipment solutions that take into consideration the energy efficiency of the equipment and of the related infrastructure required for the correct operation of the telecom product.

7.3 Deployment of new ICT services

The service architecture, software and deployment of ICT services have an impact at least as great as that of the ICT hardware.

No.	Name	Description
7.3.1	Deploy using grid and virtualisation technologies	Processes should be put in place to require senior business approval for any new service that requires dedicated hardware and will not run on a resource-sharing platform. This applies to servers, storage and networking aspects of the service. This can improve available floor space, cost savings, rack utilization, ICT equipment utilization, and energy efficiency.
7.3.2	Reduce ICT hardware resilience level	Determine the business impact of service incidents for each deployed service and deploy only the level of hardware resilience actually justified.
7.3.3	Eliminate traditional 2N hardware clusters	Determine the business impact of short service incidents for each deployed service and replace traditional active/passive server hardware clusters with fast recovery approaches, such as restarting virtual machines elsewhere. (This does not refer to grid or high performance computer clusters.)

No.	Name	Description
7.3.4	Reduce hot/cold standby equipment	Determine the business impact of service incidents for each ICT service and deploy only the level of BC/DR standby ICT equipment and resilience that is actually justified by the business impact.
7.3.5	Select/develop efficient software	Make the energy use performance of the software a significant selection factor. Whilst forecasting and measurement tools and methods are still being developed, approximations can be used such as the (under-load) power draw of the hardware required to meet performance and availability targets. If outsourcing software development, then consider the energy use of the software in the bonus/penalty clauses of the contract.
7.3.6	Further development of software efficiency definitions	There is much research and development needed in the area of defining, measuring, comparing and communicating software energy efficiency. Suggested examples are: Software could be made resilient to delays associated with bringing off-line resources on-line, such as the delay of drive spin, which would not violate the service level requirements. Software should not gratuitously poll or carry out other unnecessary background "housekeeping" that prevents equipment from entering lower-power states; this includes monitoring software and agents.

7.4 Management of existing ICT equipment and services

It is common to focus on new services and equipment to be installed in the data centre, but there are also substantial opportunities to achieve energy and cost reductions from within the existing service and physical installation.

No.	Name	Description
7.4.1	Audit existing physical equipment and services	Audit the existing physical equipment and services to establish what equipment is in place and what service(s) it delivers. Consider the implementation of an ITIL type configuration management database and service catalogue.
7.4.2	Decommission unused ICT equipment/services	Completely decommission and remove the supporting hardware for unused ICT equipment/services.
7.4.3	Decommission low business value services	Identify services whose business value is low and does not justify the financial or environmental cost. Decommission or archive these services.
7.4.4	Shut down idle equipment	Servers, networking, and storage equipment that lie idle for a significant period of time, and cannot be virtualized and archived, should be shut down or put into a low power sleep mode. It may be necessary to validate the ability of legacy applications and hardware to survive these state changes without loss of function or reliability.
7.4.5	Virtualize and archive legacy services	Servers which cannot be decommissioned for compliance or other reasons, but which are not used on a regular basis, should be virtualized and then the disk images archived to a low-power media. These services can then be brought online when actually required.
7.4.6	Consolidation of existing services	Existing services that do not achieve high utilization of their hardware should be consolidated through the use of resource sharing technologies to improve the use of physical resources. This applies to servers, storage and networking devices.

No.	Name	Description
7.4.7	Control of system energy use	Consider resource management systems capable of analysing and optimizing where, when and how ICT workloads are executed, and their consequent energy use. This may include technologies that allow remote deployment or delayed execution of jobs, or the movement of jobs within the infrastructure, to enable shutdown of components, entire systems or sub-systems. The desired outcome is to provide the ability to limit localized heat output or to constrain system power draw to a fixed limit, at a data centre, row, rack or sub-DC level.
7.4.8	Audit of existing ICT environmental requirements	Identify the allowable intake temperature and humidity ranges for existing ICT equipment.

7.5 Data management

Storage is a major growth area in both cost and energy consumption within the data centre. It is generally recognized that a significant proportion of the data stored is either unnecessary or duplicated and does not require high performance access, and that this represents an organisational challenge. Some sectors have a particular issue due to very broad and non-specific data retention directions from governments or regulating bodies. Where there is little structure to the data storage, implementation of these regulations can cause large volumes of data that are not required by the regulations to be unnecessarily heavily protected and archived.

No.	Name	Description
7.5.1	Data management policy	Develop a data management policy to define which data should be kept, for how long and at what level of protection. Communicate the policy to users and enforce it. Particular care should be taken to understand the impact of any data retention requirements.
7.5.2	Separate user logical data storage areas by retention and protection policy	Provide users with multiple data storage areas that are clearly identified by their retention policy and level of data protection. Communicate this policy to users to enable them to store data in an area that matches the required levels of protection and retention. This is particularly valuable where strong retention requirements exist, as it allows data subject to those requirements to be separated at source, thereby presenting substantial opportunities for cost and energy savings. Where possible automate the application of these policies.
7.5.3	Separate physical data storage areas by protection and performance requirements	Create a tiered storage environment utilising multiple media types that deliver the required combinations of performance, capacity and resilience. Implement clear guidelines on usage of storage tiers, with defined SLAs for performance and availability. Consider a tiered charging model based on usage at each tier.
7.5.4	Select lower power storage devices	When selecting storage hardware, evaluate the energy efficiency in terms of the service delivered per watt between options. This may be deployment-specific and should include the achieved performance and storage volume per watt, as well as additional factors where appropriate, such as the achieved levels of data protection, performance availability and recovery capability required to meet the business service level requirements defined in the data management policy. Evaluate both the in-use power draw and the peak power of the storage device(s) as configured, both impact per device cost and energy consumption through provisioning.

No.	Name	Description
7.5.5	Reduce total data volume	Implement an effective data identification and management policy and process to reduce the total volume of data stored. Consider implementing "clean up days" where users delete unnecessary data from storage.
7.5.6	Reduce total storage volume	Implement the data management policy to reduce the number of copies of data, both logical and physical (mirrors). Implement storage subsystem space saving features, such as space efficient snapshots/copies or compression. Implement storage subsystem thin provisioning features where possible.
7.5.7	Further development of storage performance and efficiency definitions	Storage performance has multiple dimensions, including throughput and latency, not all of which can be measured at the storage layer. Capacity also has multiple dimensions, allocation and usage, not all of which can be measured at the storage layer. Technologies such as de-duplication, compression, snapshots, and thin provisioning also need to be accounted for in a consistent and informative manner.

8 Cooling

Cooling of the data centre is frequently the largest energy loss in the facility and as such represents a significant opportunity to improve efficiency.

8.1 Airflow design and management

The objective of airflow management is to minimize bypass air that returns to the computer room air conditioner (CRAC) units without performing its cooling function. The resultant recirculation and mixing of cool and hot air, increases the equipment intake temperatures. To compensate, CRAC unit air supply temperatures are frequently reduced, or airflow volumes are increased, which has an energy penalty. Addressing these issues will deliver more uniform equipment inlet temperatures and allow set points to be increased (with the associated energy savings), without the risk of equipment overheating. Implementation of air management actions alone does not result in energy saving – they are enablers which need to be tackled before set points can be raised.

No.	Name	Description
8.1.1	Design – contained hot or cold air	There are a number of design concepts which intend to contain and separate the cold air from the heated return air on the data floor: – hot aisle containment; – cold aisle containment; – contained rack supply, room return; – room supply, contained rack return, (including rack chimneys); – contained rack supply, contained rack return. This action is expected for air-cooled facilities over 1 kW per square meter power density. Note that the in-rack cooling options are only considered to be containment where the entire data floor area is cooled in rack, not in mixed environments where they return cooled air for remix with other airflow.

No.	Name	Description
8.1.2	Design – hot/cold aisle	As the power densities and airflow volumes of ICT equipment have increased, it has become necessary to ensure that equipment shares an airflow direction, within the rack, in adjacent racks and across aisles. The hot/cold aisle concept aligns equipment airflow to create aisles between racks that are fed cold air from which all of the equipment draws intake air in conjunction with hot aisles with no cold air feed, to which all equipment exhausts air.
8.1.3	Design – contained hot or cold air – retrofit	Where hot/cold aisle separation is already in use, but there is no containment of hot or cold air, it is possible to retrofit to provide basic separation.
8.1.4	Rack airflow management – blanking plates	Installation of blanking plates where there is no equipment to reduce cold air passing through gaps in the rack. This also reduces air heated by one device being ingested by another device, increasing intake temperature and reducing efficiency.
8.1.5	Rack airflow management – other openings	Installation of aperture brushes (draught excluders) or cover plates to cover all air leakage opportunities in each rack. This includes: – floor openings at the base of the rack; – gaps at the sides, top and bottom of the rack between equipment or mounting rails and the perimeter of the rack.
8.1.6	Rack airflow management – obstructions	The main cause of rack airflow obstruction is the cables behind racks. Unorganized cables may block hot airflow from ICT equipment and cause re-intake of the air by the rack front, further increasing the equipment inlet temperature. Therefore, cables behind racks should be organized to secure adequate amount of cold airflow.
8.1.7	Raised floor airflow management	Close all unwanted apertures in the raised floor. Review placement and opening factors of vented tiles. Maintain unbroken rows of cabinets to prevent bypass air – where necessary fill with empty fully blanked racks. Managing unbroken rows is especially important in hot and cold aisle environments. Any opening between the aisles will degrade the separation of hot and cold air.
8.1.8	Raised floor airflow management – obstructions	Review the placement and level of obstruction created by cabling, cable trays and other structures in the airflow paths to enable unobstructed airflow and prevent turbulence and increased resistance. The use of overhead cabling trays for signalling, for example, can substantially reduce the energy requirements for air movement.
8.1.9	Design – raised floor or suspended ceiling height	If, when designing a data centre, spaces are created by raising the floor level or suspending the ceiling, such air chambers are commonly used to feed cold air to equipment, or extract hot air from it. Where such voids are utilized, the increased spaces can significantly reduce fan loss in moving the air.
8.1.10	Design – return plenums	Consider the use of return dedicated ducts to return heated air from the ICT equipment to the air conditioning units.

No.	Name	Description
8.1.11	Design – perforated tiles	Mixed use of two or three perforated tiles with different aperture ratios is more advisable than using perforated tiles having the same aperture ratio in all spots of the computer room. In general, areas closer to CRAC units have higher air volume and static pressure, which enables provision of a sufficient amount of cold air to ICT equipment, even with perforated tiles having low aperture ratios. In the areas farther from CRAC units, provision of cold air can be controlled by using perforated tiles with high aperture ratios. It is recommended not to install perforated tiles in areas that are too close to CRAC units. In these areas, the fast airflow under the raised floor creates negative pressure on perforated tiles and causes Venturi reversal, in which the air above the raised floor is pulled down under. The Venturi reversal rather draws hot air to ICT equipment while causing a lack of cold air provision to the equipment.
8.1.12	Equipment segregation	Deploy groups of equipment with substantially different environmental requirements and/or equipment airflow direction in a separate area. Where the equipment has different environmental requirements, it is preferable to provide separate environmental controls. The objective of this practice is to address the issue of the data centre cooling plant settings being constrained by the ICT equipment with the most restrictive environmental range, or poor airflow control, as this compromises the efficiency of the entire data centre.
8.1.13	Disposition of high-heat equipment	As energy consumption and heat from blade servers or large equipment increase, disposition of such high-heat equipment often affects the efficiency of the entire computer room. It is appropriate to position high-heat equipment in places where most cold air is provided. – CRAC units are often installed facing each other in the computer room. In this situation, the air temperature is lowest in the centre of the room. Therefore, high-heat equipment should be installed in the centre of the computer room, rather than in places near CRAC units. – If it is uncertain which place receives the most amount of cold air, it is recommended to measure the temperature of each area and install the high-heat equipment in the place with the lowest temperature.
8.1.14	Provide adequate free area on rack doors	Solid doors can be replaced (where doors are necessary) with partially perforated doors to ensure adequate cooling airflow within the enclosed cabinet further increasing the equipment intake temperature.

No.	Name	Description
8.1.15	Separate from external environment	The more contact the computer room has with the outer environment (outside air and solar heat), the more it is exposed to influences on temperature and humidity, further decreasing the entire air conditioning efficiency. Therefore, blocking contacts with the outer environment is a significant factor that is directly related to reducing energy consumption. For separation from the external environment, the following activities are required: • designing a windowless room or sealing windows; • installing double doors or an automatic door; • restricting entry/exit of unnecessary persons; • blocking channels connected to the outside, such as an outlet, etc. To prevent temperature increase from solar heat in the computer room, it is necessary to deploy a windowless design or shield windows (by way of window shades, curtains, solar screen panels, etc.)

8.2 Cooling management

The data centre is not a static system and the cooling systems should be tuned in response to changes in the facility thermal load.

No.	Name	Description
8.2.1	Scalable or modular installation and use of cooling equipment	Cooling plants should be installed in a modular fashion allowing operators to shut down unnecessary equipment. This should then be part of the review at each cooling load change.
8.2.2	Shut down unnecessary cooling equipment	If the facility is not yet fully populated or space has been cleared through consolidation, non-variable plants, such as fixed speed fan CRAC units, can be turned off in the empty areas. Note that this should not be applied in cases where operating more plants at a lower load is more efficient, e.g., variable speed drive CRAC units.
8.2.3	Review of cooling before ICT equipment changes	The availability of cooling, including the placement and flow of vented tiles, should be reviewed before each ICT equipment change to optimize the use of cooling resources.
8.2.4	Review of cooling strategy	Periodically review ICT equipment and cooling deployment against strategy.
8.2.5	Review CRAC/air handling unit (AHU) settings	Ensure that CRAC/AHU units in occupied areas have an appropriate and consistent temperature, and relative humidity settings, to avoid units working against each other. For example, many CRAC/AHU units now have the option to connect their controls and run together when installed in the same area.
8.2.6	Dynamic control of building cooling	It is possible to implement control systems that take many factors into account, including cooling load, data floor air temperature and external air temperature, to optimize the cooling system (e.g., chilled water loop temperature) in real time.
8.2.7	Effective regular maintenance of cooling plant	Effective regular maintenance of the cooling system is essential to maintain the design operating efficiency of the data centre, e.g., belt tension, condenser coil fouling (water or air side), evaporator fouling, filter changes, etc.

No.	Name	Description
8.2.8	Evaporative cooling method and the spot cooling method	Evaporative cooling method and the spot cooling method were proposed as best practice for data centres, with high-density ICT devices (see Annex B).

8.3 Temperature and humidity settings

Facilities are often over-cooled, bringing about air temperatures (and hence chilled water temperatures, where used) that are colder than necessary and resulting in an energy penalty. Increasing the set range for humidity can substantially reduce humidifier loads. Reviewing and addressing air management issues is required before set points can be changed in order to avoid risk to operational continuity. Expert advice should be sought before changing the environmental range for the facility. An increase in chilled water temperature set points provides enhanced efficiency for free cooling economizers and a reduction in compressor energy consumption. Unnecessary humidifier loads, generated by water loop or evaporator temperatures below the working dew point causing dehumidification-humidification loops, should be eliminated through adjustment of the lower humidity set point.

The specification of wider operating humidity and temperature ranges for the data floor should be performed in conjunction with changes in ICT equipment procurement policy. Over time, narrow tolerance equipment will be naturally cycled out and replaced.

No.	Name	Description
8.3.1	Expanded ICT equipment inlet environmental conditions (temperature and humidity) High priority practices	Where appropriate and effective, the data centre can be designed and operated within the air inlet temperature and relative humidity ranges of 5°C to 40°C and 5% to 80% RH, non-condensing respectively, and under exceptional conditions up to +45°C as described in [ETSI EN 300 019-1-3], Class 3.1. It is necessary to consider that some ICT equipment may exhibit significant increases in fan energy consumption as intake temperature is increased (e.g., above 25°C). Validate that your ICT equipment will not consume more energy than is saved in the cooling system.
8.3.2	Review and, if possible, raise target ICT equipment intake air temperature Low priority practices	Data centres should be designed and operated at their highest efficiency within the current environmental range of 18°C to 32°C. This is defined by ASHRAE as allowable for class 1 data centres [b-ASHRAE TC 9.9]. Operations in this range enable energy savings by reducing or eliminating over-cooling. This range applies to legacy data centres with existing equipment. Note that other best practices for airflow management (containment, hot aisle/cold aisle, blanking plates, and sealing leaks) may need to be implemented at the same time to ensure successful operations.
8.3.3	Review and increase the working humidity range Low priority practices	Reduce the lower humidity set point(s) of the data centre within the range (5.5°C dew point) to eliminate loop dehumidification and re-humidification. Review and, if practical, increase the upper humidity set point(s) of the data floor within the current environmental range of 20°C dew point and 80% RH to decrease the humidity control loads within the facility.