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TECHNICAL SPECIFICATION

Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 2: ICT Sites: Implementation of energy and lifecycle management practices

Reference

RTS/ATTM-0250

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 2 of a multi-part deliverable, covering lifecycle resource management of broadband deployment as identified below:

ETSI EN 305 174-1: "Overview, common and generic aspects";

ETSI TS 105 174-2: "ICT Sites: Implementation of energy and lifecycle management practices";

ETSI TS 105 174-4: "Access Networks";

ETSI EN 305 174-5: "Customer network infrastructures";

ETSI TS 105 174-6: "Cable Access Networks";

ETSI TS 105 174-7: "Digital multiservice cities";

ETSI EN 305 174-8: " Implementation of WEEE practices for ICT equipment during maintenance and at end-of-life".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The increasing interaction between the different elements of the Information Communication Technology (ICT) sector (hardware, middleware, software and services) supports the concept of convergence in which:

- multi-service packages can be delivered over a common infrastructure;
- a variety of infrastructures is able to deliver these packages;
- a single multi-service-package may be delivered over different infrastructures.

As a result of this convergence, the development of new services, applications and content has resulted in:

- an increased demand for bandwidth, reliability, quality and performance, with a consequent increase in the demand for power which has implications for cost and, in some cases, availability;
- an associated continuous evolution of ICT equipment.

It is therefore important to consider the environmental viability of all network elements necessary to deliver the required services in terms of the management of their operational aspects i.e. energy management (including energy efficiency) and the management of the End-of-Life (EoL) of the ICT equipment.

NOTE: The term "environmental viability" is used while recognizing that well established treatments of "sustainability" feature three separate viability objectives (environmental, economic and social). For the purposes of the ETSI EN 305 174 series, only operational aspects of environmental viability are considered. A wider approach to environmental viability takes other factors into account including the use of raw materials and avoidance of hazardous substances in the construction of infrastructure or ICT equipment- these factors are not considered.

New technologies and infrastructure strategies are expected to enable operators to decrease the energy consumption, for a given level of service, of their existing and future infrastructures, thus decreasing their costs. This requires a common understanding among market participants that only standards can produce.

The ETSI EN 305 174 series specifies the general engineering of various broadband infrastructures to enable the most effective energy management (and management of other resources) and the appropriate measures for EoL treatment of ICT equipment. Certain of the standards may specify requirements for interoperability.

The ETSI TS 105 174 series provide further details of the implementation of specific parts of standards in the ETSI EN 305 174 series.

The present document specifies requirements for ICT sites within broadband deployment infrastructures.

The present document has been produced by ETSI Technical Committees Access, Terminals, Transmission and Multiplexing (ATTM) and Cable in close collaboration with CENELEC, via the Installations and Cabling Co-ordination Group (ICCG).

1 Scope

ETSI EN 305 174-2 [3] specifies a minimum set of required practices for energy management which are applicable to ICT sites of all sizes and business models. These are taken from a sub-set of those practices recommended by CLC/TR 50600-99-1 [1].

CLC/TR 50600-99-1 [1] also contains a much wider range of recommended practices which are applicable to specific designs of ICT site and may be applied to improve the energy management beyond the minimum requirements of ETSI EN 305 174-2 [3].

The present document:

- maps the practices of CLC/TR 50600-99-1 [1] to general application of ETSI EN 305 174-2 [3] and also to the specific design options which may apply in a given ICT site;
- details examples of the impact of such practices in relation to reductions in energy consumption or improvements in energy efficiency or management.

In addition, the present document addresses the end-of-life and maintenance aspects of WEEE (as in ETSI EN 305 174-8 [4] and ETSI TS 105 174-8 [5]).

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] CLC/TR 50600-99-1:2019: "Information technology - Data centre facilities and infrastructures - Part 99-1: Recommended practices for energy management".

[2] ETSI EN 305 174-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 1: Overview, common and generic aspects".

[3] ETSI EN 305 174-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 2: ICT sites".

[4] ETSI EN 305 174-8: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 8: Management of end of life of ICT equipment (ICT waste/end of life)".

[5] ETSI TS 105 174-8: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 8: Implementation of WEEE practices for ICT equipment during maintenance and at end-of-life".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] CLC/TR 50600-99-2:2019: "Information technology - Data centre facilities and infrastructures - Part 99-2: Recommended practices for environmental sustainability".

[i.2] CENELEC EN 50173 series: "Information technology - Generic cabling systems".

[i.3] CENELEC EN 50174-2: "Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings".

[i.4] CENELEC EN 50600-1: "Information technology - Data centre facilities and infrastructures - Part 1: General concepts".

[i.5] CENELEC EN 50600-2-1: "Information technology - Data centre facilities and infrastructures - Part 2-1: Building construction".

[i.6] CENELEC EN 50600-2-2:2019: "Information technology - Data centre facilities and infrastructures - Part 2-2: Power supply and distribution".

[i.7] CENELEC EN 50600-2-3:2019: "Information technology - Data centre facilities and infrastructures - Part 2-3: Environmental control".

[i.8] CENELEC EN 50600-2-4: "Information technology - Data centre facilities and infrastructures - Part 2-4: Telecommunications cabling infrastructure".

[i.9] CENELEC EN 50600-4-2: "Information technology - Data centre facilities and infrastructures - Part 4-2: Power Usage Effectiveness".

[i.10] CENELEC EN 50600-4-6: "Information technology - Data centre facilities and infrastructures - Part 4-6: Energy Reuse Factor".

[i.11] CENELEC EN 62040 series: "Uninterruptible power systems (UPS)".

[i.12] ETSI EN 300 019-1-3: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations".

[i.13] ETSI EN 300 132 series: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment".

[i.14] ETSI EN 300 132-3 series: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 3: Up to 400 V Direct Current (DC)".

[i.15] ETSI EN 300 132-3-1: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 1: Direct current source up to 400 V".

[i.16] ETSI EN 301 605: "Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment".

[i.17] ETSI EN 303 470: "Environmental Engineering (EE); Energy Efficiency measurement methodology and metrics for servers".

[i.18] ETSI EN 305 200-2-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 2: Specific requirements; Sub-part 1: ICT Sites".

[i.19] ETSI EN 305 200-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 1: General requirements".

[i.20] ETSI EN 305 200-3-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 3: ICT Sites; Sub-part 1: DCEM".

[i.21] ETSI ES 202 336-9: "Environmental Engineering (EE); Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks); Part 9: Alternative Power Systems".

[i.22] ETSI ES 202 336-12: "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 12: ICT equipment power, energy and environmental parameters monitoring information model".

[i.23] ETSI ES 203 199: "Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services".

[i.24] ETSI TR 102 489: "Environmental Engineering (EE); European telecommunications standard for equipment practice; Thermal management guidance for equipment and its deployment".

[i.25] ETSI TS 103 199: "Environmental Engineering [EE]; Life Cycle Assessment (LCA) of ICT equipment, networks and services; General methodology and common requirements".

[i.26] ETSI TS 105 200-3-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Implementation of Global KPIs; Part 3: ICT sites: Sub-part 1: DCEM".

[i.27] ISO 14040: "Environmental management. Life cycle assessment. Principles and framework".

[i.28] ISO 14044: "Environmental management. Life cycle assessment. Requirements and guidelines".

[i.29] ISO 14045: "Environmental management. Eco-efficiency assessment of product systems. Principles, requirements and guidelines".

[i.30] ISO 14511 series: "Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors".

[i.31] ISO 14644-1:2015: "Cleanrooms and associated controlled environments. Classification of air cleanliness by particle concentration".

[i.32] ISO 16890-1: "Air filters for general ventilation. Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)".

[i.33] ISO 50001: "Energy management systems. Requirements with guidance for use".

[i.34] ISO/IEC 20000 series: "Information technology - Service management".

[i.35] ISO/IEC 21836: "Information technology - Data centres - Server Energy Effectiveness Metric".

[i.36] Void.

[i.37] ISO/IEC 30134-6: "Information technology - Data centres - Key performance indicators: Part 6: Energy re-sue factor (ERF)".

[i.38] ISO/IEC TR 22237-50: "Information technology - Data centre facilities and infrastructures - Part 50: Earthquake risk and impact analysis".

[i.39] ISO/IEC TS 22237-2: "Information technology - Data centre facilities and infrastructures - Part 2: Building construction".

[i.40] ISO/IEC TS 22237-3: "Information technology - Data centre facilities and infrastructures - Part 3: Power distribution".

[i.41] ISO/IEC TS 22237-4: "Information technology - Data centre facilities and infrastructures - Part 4: Environmental control".

[i.42] CLC/TR 50600-99-1:2018: "Information technology - Data centre facilities and infrastructures - Part 99-1: Recommended practices for energy management".

[i.43] ASHRAE white paper 2011: "Gaseous and Particulate Contamination Guidelines for Data Centres".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 305 174-2 [3], CLC/TR 50600-99-1 [1], ETSI EN 305 174-8 [4], ETSI TS 105 174-8 [5] and the following apply:

absorption chiller: refrigeration unit that uses a heat source to provide the energy needed to drive a cooling process

microgrid: group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid

primary (power) supply: principal power supply that provides power to the ICT site under normal operating conditions

secondary (power) supply: power supply independent from, and that is continuously available to be used to provide power to the ICT site following the disruption of, the primary power supply

NOTE: A second feed to a separate transformer from the same grid is not a secondary supply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 305 174-2 [3], CLC/TR 50600-99-1 [1], ETSI EN 305 174-8 [4] and ETSI TS 105 174-8 [5] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 305 174-1 [2], ETSI EN 305 174-2 [3], CLC/TR 50600-99-1 [1], ETSI EN 305 174-8 [4], ETSI TS 105 174-8 [5] and the following apply:

AC	Alternative Current
BREEAM	Building Research Establishment Environmental Assessment Method
DC	Direct Current
EMAS	Eco-Management and Audit Scheme
HQE	Haute Qualité Environnementale
LCA	Life Cycle Assessment
MMR	Measurement, Monitoring and Reporting
UPS	Uninterruptible Power System

4 Applicability of the present document

4.1 Introduction to CLC/TR 50600-99-1

CLC/TR 50600-99-1 [1] was first published in 2016 as a "standards-based" equivalent to the Best Practices Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency V.7. At the time of initial publication of CLC/TR 50600-99-1 it was hoped that the European Commission Directorate General Joint Research Centre would abandon their Best Practices Guidelines in favour of CLC/TR 50600-99-1 which would have been jointly badged as a CLC and DG JRC document.

This did not occur and as a result each year, until 2019, CLC/TR 50600-99-1 has been updated in line with the changes to the Best Practices Guidelines.

However, in 2019 it was decided to discontinue the direct reference to the Best Practices Guidelines and only update CLC/TR 50600-99-1 when required.

This separation from the EU Code of Conduct on Data Centre Energy Efficiency and associated stability of CLC/TR 50600-99-1 means that direct reference to it from the present document is viable.

In addition, "environmental sustainability" practices contained within CLC/TR 50600-99-1:2018 [i.42] were transferred into CLC/TR 50600-99-2 [i.1] which clearly differentiates the practices as follows:

- CLC/TR 50600-99-1 dealing with energy management;
- CLC/TR 50600-99-2 dealing with environmental sustainability.

4.2 ICT sites

ETSI EN 305 174-2 [3] specifies requirements for resource management of ICT sites based on the practices of CLC/TR 50600-99-1 [1] which are applicable to ICT sites of all sizes and business models.

ETSI EN 305 174-1 [2] highlights that the concept of ICT sites was focussed on operator site (OS) and network data centre (NDC) facilities of broadband deployment.

The definition of "ICT site" within ETSI EN 305 174-1 [2] and ETSI EN 305 174-2 [3] is a site containing structures or group of structures dedicated to the accommodation, interconnection and operation of ITE and NTE together with all the facilities and infrastructures for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service availability.

However, it has to be highlighted that the wide range of buildings and other structures housing OS and NDC facilities makes it impossible to consider them to be ICT sites subject to all of the requirements and recommendations of the present document. There are many reasons for this including the fact that were designed to, and only do, accommodate NTE equipment (although they may be evolving to incorporate ITE). That legacy NTE may restrict the application of some of the practices of both ETSI EN 305 174-2 [3] and the present document.

4.3 Other Network Distribution Nodes (NDNs)

ETSI EN 305 174-1 [2] defines an NDN as a grouping of NTE equipment within the boundaries of an access network providing distribution of service from an operator site (OS). Structures historically identified as being NDNs and only housing NTE are now evolving to also contain ITE also and are therefore technically ICT sites according to the definition of ETSI EN 305 174-1 [2] and ETSI EN 305 174-2 [3].

The application of the practices of both ETSI EN 305 174-2 [3] and the present document may be applicable in specific cases but cannot be considered generally or universally applicable.

5 Mapping ETSI EN 305 174-2 to CLC/TR 50600-99-1

5.1 General

ETSI EN 305 174-2 [3] specifies the requirements, applicable to all ICT sites, addressing the general engineering for energy management and management of end-of-life procedures.

The energy management requirements are taken from specific recommendations of CLC/TR 50600-99-1 [1] are were selected because they are applicable to all sizes and types of ICT site. The following clauses describe these as:

- Clause 5.2 Power supply and distribution.
- Clause 5.3 Environmental control.
- Clause 5.4 ICT equipment and software.

5.2 Power supply and distribution

5.2.1 Design aspects

Table 1 shows the required energy management practices of ETSI EN 305 174-2 [3]. Further information can be obtained by reading the relevant reference in CLC/TR 50600-99-1 [1].

NOTE: Both CLC/TR 50600-99-1 [1] and ETSI EN 305 174-2 [3] state UPS incorrectly to be "uninterruptible power supply", the correct term is "uninterruptible power system": "UPS systems" is therefore an incorrect phrase but is used here because of the source material.

Table 1: ETSI EN 305 174-2 [3] requirements for power supply and distribution design

Practice	Reference within CLC/TR 50600-99-1 [1]
Electrical equipment, other than Uninterruptable Power Supply (UPS) batteries, shall be selected which does not require cooling in normal operation.	5.4.1
Power supply and distribution capacity in excess of that anticipated in the short term shall not be provisioned.	5.4.4 5.2.8
The above practice has to take into account that OSs are designed to have a longer life than NDC facilities and as a result this practice is modified as follows. "Taking into consideration works required for future expansion, the power supply and distribution capacity should not exceed the expected load anticipated in the short term".	
Where UPS systems are required, they shall be modular (scalable).	5.4.5 5.4.27
Static UPS systems shall be compliant with the EU Code of Conduct for AC Uninterruptible Power Systems.	5.4.30
The above practice has to take into account that OSs do not always contain a UPS, but a rectifier and a battery directly in parallel to the 48 VDC bars. "Where UPS systems are required, they shall be compliant with the EU Code of Conduct for AC Uninterruptible Power Systems".	
Mechanical and electrical equipment shall be selected to enable local metering/monitoring of temperature and incorporated within a system that allows for reporting of temperature trends over a period of time as well as instantaneous temperature readings.	5.4.35

5.2.2 Operational aspects

Table 2 shows the required energy management practices of ETSI EN 305 174-2 [3]. Further information can be obtained by reading the relevant reference in CLC/TR 50600-99-1 [1].

Table 2: ETSI EN 305 174-2 [3] requirements for power supply and distribution operation

Practice	Reference within CLC/TR 50600-99-1 [1]
Electrical equipment shall be subjected to regular maintenance to preserve or achieve a "like-new condition".	Extension of 5.1.16

5.3 Environmental control

5.3.1 Design aspects

Table 3 shows the required energy management practices of ETSI EN 305 174-2 [3]. Further information can be obtained by reading the relevant reference in CLC/TR 50600-99-1 [1].

Table 3: ETSI EN 305 174-2 [3] requirements for environmental control design

Practice	Reference within CLC/TR 50600-99-1 [1]
Mechanical equipment shall be selected which does not require cooling in normal operation.	5.4.1 5.4.18
Cooling capacity in excess of that anticipated in the short term shall not be provisioned.	5.4.26 6.1.15
The above practice has to take into account that OSs are designed to have a longer life than NDC facilities and as a result this practice is modified as follows. "Taking into consideration works required for future expansion, cooling capacity should not exceed the expected load anticipated in the short term".	
Cooling system infrastructures shall be designed to maximize its efficiency under partial load conditions (e.g. variable speed (or frequency) controls shall be used to optimize energy consumption during changing load conditions).	5.4.5 5.4.16 5.4.17 5.4.23 6.1.15 6.4.12
Cooling designs and solutions shall maximize the use of free cooling taking into consideration site constraints, local climatic conditions or applicable regulations.	5.4.18 5.4.22 6.4.2 6.4.3 6.4.4 6.4.5 6.4.6 6.4.7 6.4.8
Cooling units shall be sized such that they are capable of providing the maximum amount of free cooling to the ICT equipment at the temperature and humidity recommended by the ICT equipment manufacturer(s).	5.4.26
Designs shall incorporate appropriately controlled variable speed fans.	5.4.23 6.4.12
Electrically commutated motors shall be used (and retro-fitted where possible) which are significantly more energy efficient than traditional AC motors across a wide range of speeds.	5.4.17
Where required, humidity control shall be centralized at the ICT site supply computer room air handling (CRAH) unit. Computer Room Air Conditioner (CRAC) and CRAH units shall not be equipped with humidity control capability, or reheat capability, to reduce both capital and on-going maintenance costs.	5.4.25
Mechanical and electrical equipment shall be selected to enable local metering/monitoring of temperature and incorporated within a system that allows for reporting of temperature trends over a period of time as well as instantaneous temperature readings.	5.4.35
Where air cooling is used for ICT equipment: • ICT equipment shall be aligned in the computer room space(s) in a hot/cold aisle configuration.	5.2.16
The above practice has to take into account that some NTE in OS facilities is not designed to benefit from hot aisle/cold aisle or raised (access) floor designs as the equipment takes in cooling air and exhausts it from the same face (generally the front). As a result this practice is modified as follows.	

Practice	Reference within CLC/TR 50600-99-1 [1]
"Where air cooling is used, ICT equipment shall be arranged in cold/hot aisle configuration. Equipment which takes in cooling air and exhausts it from the same face shall instead use air deflectors to prevent mixing of cooling and exhaust air".	

5.3.2 Operational aspects

Table 4 shows the required energy management practices of ETSI EN 305 174-2 [3]. Further information can be obtained by reading the relevant reference in CLC/TR 50600-99-1 [1].

Table 4: ETSI EN 305 174-2 [3] requirements for environmental control operation

Practice	Reference within CLC/TR 50600-99-1 [1]
Mechanical equipment shall be subjected to regular maintenance to preserve or achieve a "like-new condition".	5.1.16
Allowable temperature and humidity ranges for existing installed ICT equipment shall be identified and: 1) the energy consumed by cooling systems shall be the minimum appropriate for these requirements (and not over-supplied); 2) ICT equipment with restrictive intake temperature ranges shall be either: i) be marked for replacement as soon as is practicable with equipment capable of a wider intake range; or ii) installed within groups of ICT, mechanical and electrical equipment with common environmental requirements.	5.4.26 5.1.8 5.4.10
ICT equipment with different airflow directions shall be installed in separate areas which have independent environmental controls.	5.1.13 5.4.6 5.2.18
The opportunity to optimize the refrigeration cycle set-points of mechanical refrigeration systems to minimize compressor energy consumption shall be regularly evaluated.	5.1.20
Where air cooling is used for ICT equipment: • blanking plates shall be installed in locations within cabinets/racks where there is no equipment.	5.1.10

5.4 ICT equipment and software

5.4.1 Design aspects

None

5.4.2 Operational aspects

Table 5 shows the required energy management practices of ETSI EN 305 174-2 [3]. Further information can be obtained by reading the relevant reference in CLC/TR 50600-99-1 [1].

Table 5: ETSI EN 305 174-2 [3] requirements for ICT equipment operation

Practice	Reference within CLC/TR 50600-99-1 [1]
An ITIL type Configuration Management Database and Service Catalogue shall be implemented in accordance with ISO/IEC 20000 series [i.34].	5.1.6
The above practice has to take into account that the range (number and size) of ICT sites may limit the practicality of this requirement. As a result this practice is modified as follows. "The network operator shall establish a framework defining the ICT sites for which for the application of an ITIL type Configuration Management Database and Service Catalogue shall be implemented in accordance with ISO/IEC 20000 series [i.34]".	
Energy efficiency performance shall be a high priority criterion when choosing new ICT equipment.	5.2.1

Practice	Reference within CLC/TR 50600-99-1 [1]
ICT equipment shall perform the required task with the lowest power consumption in the expected environmental conditions (see notes 1 and 2).	5.2.5
The above practice has to take into account that: • the energy consumption of NTE is addressed by the EU Code of Conduct for the energy consumption of broadband equipment; • the energy consumption of servers is addressed by key performance indicators specified in ETSI EN 303 470 [i.17] and ISO/IEC 21836 [i.35].	
Periodic reviews shall be undertaken to validate the consistency of deployment of ICT equipment with respect to the cooling design and identify and implement appropriate changes.	5.1.15
Software shall use the least energy to perform the required task whilst ensuring that the application fully meets the defined operational needs.	5.3.1
NOTE 1: The power consumption of the device in normal operating circumstances should be considered in addition to peak performance per Watt. NOTE 2: ENERGY STAR®, SERT™, SPECpower® or other appropriate performance metrics should be closely aligned to the target environment.	

5.5 Other practices of CLC/TR 50600-99-1

There are many other energy management practices contained within CLC/TR 50600-99-1 [1] which cannot be converted into requirements because they are not applicable to all sizes or types of ICT sites or are dependent upon the design and/or operation of the ICT site. These are described in:

- Clause 6 Construction.
- Clause 7 Power supply and distribution.
- Clause 8 Environmental control.
- Clause 9 ICT equipment and software.

6 Construction recommendations

6.1 General

ICT sites can be housed in buildings or other structures and the term structures is used hereafter as being a generic term.

The specification of a structure housing an ICT site is directly impacted by its location (see clause 6.2). The orientation of the structure together with the design and thermal insulation properties of walls, roofs and windows have a significant effect on the energy consumption associated with environmental control of the interior.

The European standard for the construction of structures housing data centres (which can be applied to some extent to other ICT sites) is CENELEC EN 50600-2-1 [i.5] which specifies requirements and recommendations for:

- site location and selection;
- layout (configuration);
- construction including relevant aspects of physical security and fire protection.

NOTE: CENELEC EN 50600-2-1 [i.5] is the basis for ISO/IEC TS 22237-2 [i.39].

This clause contains practices that are applicable to the design of new or refurbished ICT sites (clause 6.2) and the operation of existing ICT sites (clause 6.3).

National approaches exist for energy efficient buildings such as HQE (Haute Qualité Environnementale) for France, and BREEAM (Building Research Establishment Environmental Assessment Method) in United Kingdom.

6.2 Design practices

6.2.1 Location of ICT sites

6.2.1.1 Selection criteria

In addition to the applicable criteria identified in CENELEC EN 50600-2-1 [i.5], a qualitative analysis for the location of a new ICT site should review a number of factors grouped by theme with a weight attributed by the company such as those shown below. This type of analysis may be used to compare countries or sites as in shown in Table 6.

The practices indicated in Table 6 should be noted against the wider background of site selection for ICT sites which has, in some cases, to consider their proximity to end users.

Table 6: Example of theme-based analysis of ICT site selection

Example themes	Example factors	Example weighting
Telecommunications	Reliability and availability of network access Quality of connections, stability of data rate, latency Diversity of available technology offerings	25
Access to equipment and software vendors, and other suppliers	The level of support offered by suppliers should be compatible with the objectives in terms of quality and responsiveness The presence on site or nearby, stock parts, machinery parts and response personnel is important	25
Environment (see note 1)	Political stability Economic and financial stability The strategic aspect of the country	15
Risk of loss (see note 2)	Natural hazards such as weather disturbances (weather, earthquake, tsunami, etc.) Risk of human origin (sabotage, terrorism, simply human error, etc.) Technical risks (a bad operation of a critical technical feature, a failure element, wear of equipment, etc.)	12
Energy (see note 3)	Source availability (reliability, quick intervention) The ability to have separate power supplies and managed by different providers The existence of local, usable, renewable energy	10
Access to skilled personnel	The importance of local employment pool The availability of qualified IT personnel and engineers	5
Availability	Easy access by airlines from airports Easy access from other company sites	5
Quality of life	Quality of life for some expatriates	3
Confidentiality	Company is able to implement its policy of data security	0
NOTE 1: National or local legislation, regulation and constraints concerning industrial buildings influence the selection of location of new ICT site. However, facilities offered by local authorities such as tax reductions, subventions, green bonus also have an effect. NOTE 2: In case of free-water cooling, proximity of a river, lake, sea, or other source of cold water will be a main factor. In such a case, floods or Tsunamis risks have to be taken into account. ISO/IEC TR 22237-50 [i.38] provides general information of mitigation for earthquakes. NOTE 3: Solar or wind energy sources do not guarantee the continuity required for a data centre, but can represent a non-negligible part of energy when appropriate conditions are respected.		

6.2.1.2 Environment

Table 7 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

The practices indicated in Table 7 should be noted against the wider background of site selection for ICT sites which has, in some cases, to consider their proximity to end users.

Table 7: CLC/TR 50600-99-1 [1] practices addressing environmental aspects of ICT site selection

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Minimize solar heating (insolation), of the cooled areas of the data centre by: • providing shade or increasing the albedo (reflectivity) of the building through the use of light coloured roof and wall surfaces; • avoiding the use of external windows in data centre spaces.	5.4.40
Locate the data centre in areas of low ambient external temperature in order to maximize the potential of free and economized cooling technologies.	6.4.18
Locate the data centre in areas of low external humidity in order to maximize the potential of free and economized cooling technologies.	6.4.19

6.2.1.3 Power: sources of supply

The European standard for the power supply to structures housing data centres (which can be applied to other ICT sites) is CENELEC EN 50600-2-2 [i.6].

NOTE 1: CENELEC EN 50600-2-2 [i.6] is the basis for ISO/IEC TS 22237-3 [i.40] (in preparation as a future ISO/IEC 22237-3 in 2020).

A primary and secondary supply can be provided by the grid or by local renewable energy solutions. In addition, back-up supplies to maintain service from the ICT sites following disruption to primary or secondary supplies are considered. The requirements and recommendations of CENELEC EN 50600-2-2 [i.6] are linked to the Availability Classification of the ICT site. See Annex A for further information on the Availability Classification of CENELEC EN 50600-2-2 [i.6].

Table 8 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE 2: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

The practice indicated in Table 8 should be noted against the wider background of site selection for ICT sites which has, in some cases, to consider their proximity to end users.

Table 8: CLC/TR 50600-99-1 [1] practices addressing power source aspects of ICT site selection

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Locate the data centre close to power generating equipment as this can reduce transmission losses.	6.4.21

A local electrical power supply close to the user and distributed by a microgrid is preferred to a centralized power plant with a long-distance electricity transport grid. This local power supply can be an individual ICT site or a small collective energy power plant for a group of ICT sites (see Table 9 for examples). It can include energy sources or storage or cogeneration of heat and electricity using energy that is renewable or not. This may facilitate the opportunity to operate absorption chillers from power source waste heat.

Table 9: Types of local power sources

Energy source	Description	Non-exhaustive list of constraints
Water flow engine	Some small installations called micro hydro installed in the river can produce green electricity for the ICT site for without significant capital expenditure	Flow need to be guaranteed Permission to use the flow has to be obtained
Fuel cell energy	A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with an oxidizing agent like hydrogen or biogas	Adequate supply (transportation) of comparatively small hydrogen bottles has to be guaranteed
Solar power system	Using the heat and radiant light from the sun to produce electricity with photovoltaics, concentrated solar power, etc.	Energy storage (batteries) is required to stabilize supply
Wind power system	Using the airflows with wind turbines	Energy storage (batteries) is required to stabilize supply
External heat engine generator system	Biomass Geothermal energy	Logistics of supply Availability at desired location

6.2.1.4 Environmental control: sources of coolant

Table 10 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 10: CLC/TR 50600-99-1 [1] practices addressing coolant source aspects of ICT site selection

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Locate the data centre near a source of free ground source cooling such as a river or lake etc. subject to local environmental regulation.	6.4.20

The practice indicated in Table 10 should be noted against the wider background of site selection for ICT sites which has, in some cases, to consider their proximity to end users.

6.2.1.5 Reuse of energy

ICT sites can produce significant quantities of waste heat and there are some applications for reuse of this energy.

As ICT equipment utilization is increased, the exhaust temperature increases which will provide greater opportunity for waste heat to be re-used. Direct liquid cooled ICT equipment (see clause 8.1) provides a potential increase in the return temperature of coolant.

An Objective KPI (KPI_{REUSE}) is specified as part of the Global KPIs for energy management in ETSI EN 305 200-2-1 [i.18] and ETSI EN 305 200-3-1 [i.20].

Table 11 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

The practices indicated in Table 11 should be noted against the wider background of site selection for ICT sites which has, in some cases, to consider their proximity to end users.

Table 11: CLC/TR 50600-99-1 [1] practices addressing energy reuse aspects of ICT site selection

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Locate the data centre where there are opportunities available for the reuse of waste heat.	6.4.17
Consider the re-use of waste heat that would normally be rejected from the data centre site.	6.4.13
Consider, where the data centre heat is too low to reuse, the use of additional heat pumps to raise the temperature to a useful point for office heating or hot water supply within the data centre building.	6.4.14
Reduce or eliminate the electrical preheat loads for generators and fuel storage by using warm exhaust air from the data centre to maintain temperature in the areas housing generators, fuel storage tanks.	6.4.15
Consider referencing the Energy Reuse Factor (ERF) as defined by CENELEC EN 50600-4-6 [i.10] and ISO/IEC 30134-6 [i.37], respectively.	6.4.16

6.2.2 Structure and configuration of ICT sites

6.2.2.1 General

In order to maximize the overall energy efficiency, the internal structure and configuration of the ICT site should be analysed to ensure that the appropriate power and environmental control resources are applied in different areas.

A minimum set of identifiable spaces within ICT sites are:

- computer rooms (principally accommodating ITE);
- network telecommunications rooms (accommodating NTE);
- electrical spaces (accommodating UPS, batteries, etc.).

The demand of each of these, and any other, spaces should be assessed in term of their energy consumption and environmental control based upon their size and operating environmental conditions.

The increasing incorporation of ITE within core and access networks makes the boundaries of the computer room and network telecommunications room spaces more complex. However, the critical issue is the assessment of the environmental control requirements of the ICT equipment and grouping of equipment with common demands. This allows a clear determination of the requirements of the spaces and may justify localized cooling solutions (see clause 8.2.4).

Computer rooms also should be assessed in terms of the need for, and structural implications of, the constructions of raised (access) floors. The internal design process should also cover the impacts on the distribution of cooling air (or other coolant technology) created by the dimensions of, or the necessary utilities and services within, the spaces or the distribution pathways serving those spaces (including raised (access) floors, suspended ceilings or ducts).

NOTE 1: The planning and installation of telecommunications cabling in data centres (which can be applied to other ICT sites) is specified in CENELEC EN 50600-2-4 [i.8] and by reference to CENELEC EN 50174-2 [i.3].

Table 12 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE 2: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 12: CLC/TR 50600-99-1 [1] practices addressing ICT site structure and configuration

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Consider the computer room, electrical and mechanical spaces to be industrial spaces enabling the environmental conditions in those spaces to comply with local statutory requirement and law (Health and Safety, etc.) rather than be designed for human comfort. The computer room, electrical and mechanical spaces should be designed, built and operated with the single primary objective of delivering high availability ICT services reliably and efficiently rather than for seated human comfort. As such these spaces might only require the control of make-up air volumes and environmental conditions to pressurize the spaces in order avoid ingress of particles and contaminants. These areas should not contain desks or workstations.	5.1.5
The above practice has to take into account that such spaces can be fitted with controls to modify the environmental conditions for any periods of time that humans require access.	
Review the placement and level of obstruction created by cabling, cable management systems and other structures in the airflow pathways. Ensure that the under floor airflow pathways are as free of obstructions as possible. Consider the use of overhead cable management systems which might substantially reduce the level of obstruction.	5.1.12
Deploy low energy lighting systems in the data centre spaces.	5.4.33
Use pale/light colours on walls, floors fixtures and fittings including cabinets, etc. to reduce the amount of lighting required to illuminate a computer room and therefore the energy consumed for lighting.	5.4.34
Locate mechanical and electrical equipment (e.g. UPS units) which generates heat outside the cooled data centre spaces to reduce the loading on the data centre cooling system.	5.4.36
Ensure sufficient ceiling height to enable the use of efficient air cooling technologies such as raised floor, suspended ceiling, aisle containment or ducts in the data centre when air movement is used to cool the ICT equipment.	5.4.37
Ensure that the physical layout of the building does not obstruct or restrict the use of "Free Cooling" (either air-side or water-side), or other equipment with an economization/free cooling mode.	5.4.38
Locate cooling equipment, particularly dry or adiabatic coolers, in an area with free air movement. This equipment should ideally be located in a position on the site where the waste heat does not affect other buildings and create further demand for air conditioning.	5.4.39
Implement techniques to minimize losses associated with the movement of air.	6.1.14

6.2.2.2 Infrastructure supporting ICT equipment

The supporting infrastructure should:

- be designed for maximum agility, scalability and to enable sharing of infrastructure;
- adopt the most efficient hardware technologies proposed by the vendors (requiring vendors to prove the real efficiency of their technologies, and their impact on TCO;
- support various hosted ICT equipment assemblies that can globally reflect a combination of:
  - standard ICT cabinets, racks or standalone ICT equipment that meet the overall power density (kW/m²) requirements of the space;
  - high power ICT cabinets, racks or standalone ICT equipment within high power density spaces requiring specific cooling systems (e.g. in-row confinement, passive cold doors).

Table 13 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 13: CLC/TR 50600-99-1 [1] practices addressing ICT infrastructure

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Utilize floor layout and equipment deployment design concepts whose basic intent is to contain and separate the cold air from the heated return air in the computer room.	5.4.7
Design computer rooms to enable discrete areas with additional "close control" cooling equipment which can be offered to customers with extremely tight environmental control requirements. This allows a tighter SLA to be offered without compromising overall energy efficiency.	5.4.11

6.3 Operational practices

Table 14 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 14: CLC/TR 50600-99-1 [1] practices addressing ICT site operation

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Turn off lighting (preferably automatically) whenever areas of the building are unoccupied.	5.1.21

7 Power distribution recommendations

7.1 General

The European standard for the design of power distribution within structures housing data centres (which can be applied to other ICT sites) is CENELEC EN 50600-2-2 [i.6].

NOTE: CENELEC EN 50600-2-2 [i.6] is the basis for ISO/IEC TS 22237-3 [i.40] (in preparation as a future ISO/IEC 22237-3 in 2020).

This clause contains practices that are applicable to the design of new or refurbished ICT sites (clause 7.2) and the operation of existing ICT sites (clause 7.3). Example outcomes are presented in clause 7.4.

Actions to improvement the energy management of the power distribution system in an existing ICT site will require significant capital expenditure, except for actions such as the deployment specific software solutions.

Moreover, the actions on power distribution are not without risk for business continuity.

7.2 Design practices

7.2.1 Overview

Figure 1 shows an example of complex power distribution system within an ICT site from the primary distribution equipment to, and within, the NTE and ITE. Each component in the power distribution system has specified and measurable energy efficiency. Similar schematics can be considered for -48 VDC (see clause 7.2.3) and 380 VDC (see clause 7.2.5) power distribution.

The application of a short-term design (scalable) approach to the design of the power supply and distribution system is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.2.1).

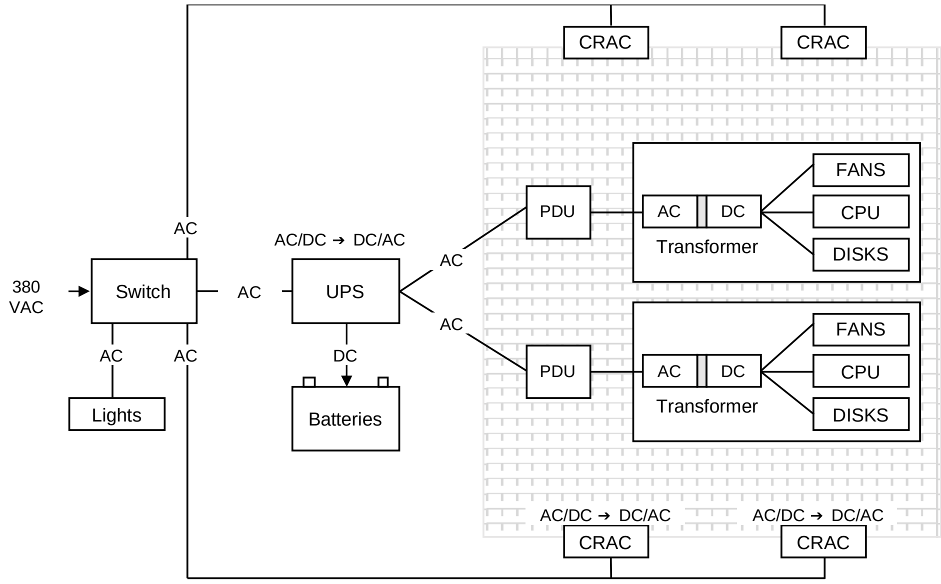

Figure 1: Example of complex power distribution on an ICT site

7.2.2 Uninterruptible power systems (UPS)

7.2.2.1 Efficiency

Table 15 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: Both CLC/TR 50600-99-1 [1] and ETSI EN 305 174-2 [3] state UPS incorrectly to be "uninterruptible power supply", the correct term is "uninterruptible power system": "UPS systems" is therefore an incorrect phrase but is used below because of the source material.

Table 15: CLC/TR 50600-99-1 [1] practices addressing UPS

Practice (information in any "Notes" of each practice is not shown)	**Reference within CLC/TR 50600-99-1 [1]**
Select high efficiency UPS systems. This Practice should be implemented with reference to CENELEC EN 62040 series [i.11].	5.4.28
Deploy UPS units in their most efficient operating modes where appropriate. Use of alternative UPS technologies such as rotary or direct current systems can be considered. The comparison and evaluation of the technologies should be based on latest and non-biased information about available products in the market. Some UPS systems can have technologies allowing energy optimization at partial load levels and these should be taken into account as appropriate for the application. This might also be particularly relevant for any UPS system feeding mechanical loads e.g. CRAC/CRAH fans.	5.4.29
Ensure that all electrical infrastructure remains energy efficient under variable ICT electrical loads as described in Practice 5.4.5.	5.4.32

The most common UPS technologies are "in-line" and "double-conversion" (see Figure 2). Other UPS technologies exist but are generally proprietary to specific vendors.

CENELEC EN 62040 [i.11] standards define the efficiency of a UPS as "the ratio of output power to input power under defined operating condition".

As shown in Figure 3:

- a UPS is generally more efficient when used at high load;

- "in-line" technology is more efficient than the double conversion as there is no conversion stage between input and output in the normal mode, but it typically needs an input filter (not shown) which contributes to some losses;
- an AC transformer (not shown in Figure 2) can be added in serial to change the neutral connection to earth from building distribution to equipment distribution (e.g. from TN or IT to TNS), bringing some additional losses. These transformers tend to be avoided if the grid supply is considered stable.

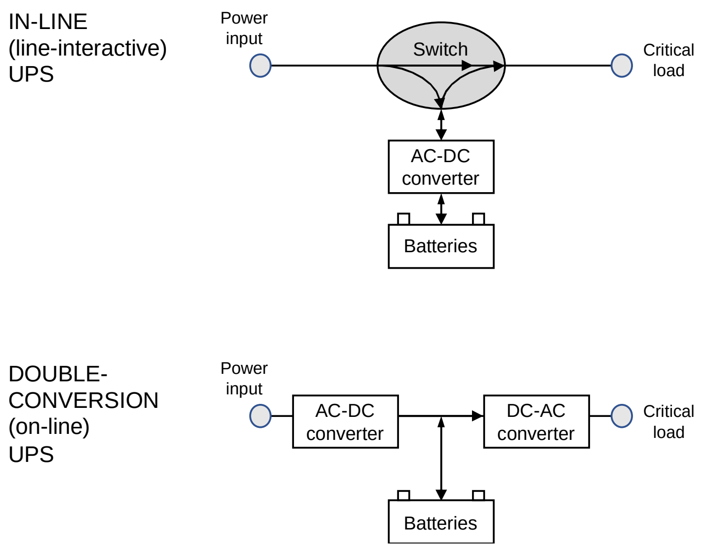

Figure 2: Multi-vendor AC UPS technologies

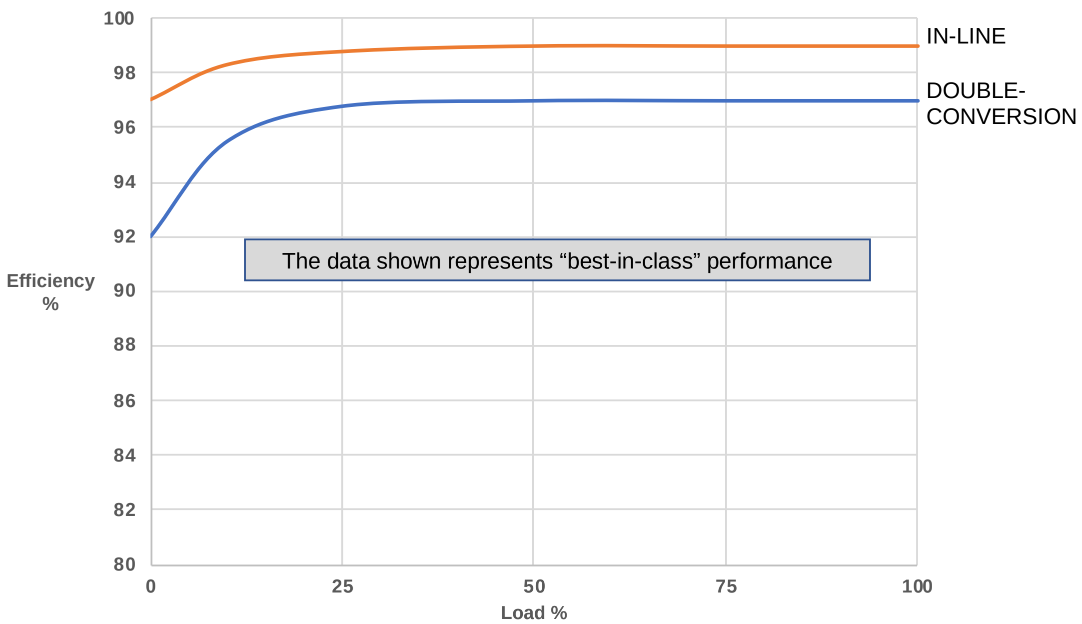

Figure 3: UPS efficiency

The data in Figure 3 is based on latest technology from a major UPS vendor which shows:

- "double-conversion" technology is the least efficient due to the two conversions stages (AC-DC and DC-AC);
- in general, UPS running in excess of 25 % load have good efficiency, but there is a dramatic decrease under 10 %;
- the most efficient technology is the "line-interactive" (with a 99 % efficiency) although AC filters and transformers can reduce this efficiency by 2 %.

7.2.2.2 Traditional UPS

In many legacy ICT sites:

- UPS use double-conversion technology;
- UPS are installed with the maximum capacity anticipated for the future needs which is often never realized.

In addition, redundancy requirements also promote the operation of UPS below their full capacity. ICT sites having a power distribution infrastructure of Availability Class 3 or 4 require two power distribution paths to be implemented meaning the load of an UPS is half of the critical load but the UPS needs full dimensioning should one distribution path fail. Also each modular UPS (see clause 7.2.2.3) can implement a spare module to take into consideration failure of one module.

For instance, considering 200 kW modules, a dual path configuration using a modular UPS with a redundant module on each path would need 5 modules on each path to power an 800 kW critical load, each branch being loaded at 40 %. It can be that the critical load might not be distributed evenly between paths, leading to a better load on one path and a worse one on the other.

This operation at low load could lead to increased energy waste if the load goes beyond 25 % for current state-of-the-art UPSs or any inflexion point from a given model.

In addition, each UPS chain should be able to recharge its own batteries. Further consideration would show that the peak input power is 1,5 to 2 times the UPS output power.

The higher heat dissipation associated with this inefficiency can require an active cooling system, which increases the energy consumption of the ICT site which requires "over-sizing" of the transformer and the front-end of the power distribution system.

7.2.2.3 Modular UPS

Modular UPS allow the capacity to be mapped to the demand thereby improving energy efficiency and reducing overall energy consumption.

Recently, vendors have begun to offer smaller modules (from 10 kVA to 50 kVA) to build "modular" UPS. The main advantage of the modular UPS approach is the ability to grow capacity taking account of real needs (with an initial sizing). These modules are "hot pluggable" and can be removed for exchange or maintenance. Modular systems are also generally designed to accept one more module than required for their rated capacity, making them "N+1 ready" at lower cost than large traditional UPS. In 1+1 system configuration this means 2(N+1).

Used correctly, a modular UPS runs at higher efficiency since they can be used close to maximum rated capacity (see Figure 4).

NOTE: For calculation of reliability and availability, environmental (thermal, vibration, etc.), stress levels and system architecture are considered. Small systems have strong advantages because being mass-produced, there are more feedback and improvements and less design errors.

Usually modular UPS exhibit greater reliability than big power unitary systems. The weakness may be the single bypass system as seen on Figure 4, which makes AC systems less reliable than DC systems. Synchronization and control between modules are also much more critical than in DC systems.

The application of the modular UPS concept is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.2.1).

7.2.2.4 UPS in combination

Both UPS types can be mixed, in either the same or in different zones of the data centre. Some use a traditional UPS as their main source, but use smaller, modular systems as the second source for their most critical hardware to give "1+1" redundancy without incurring that cost for the entire data centre.

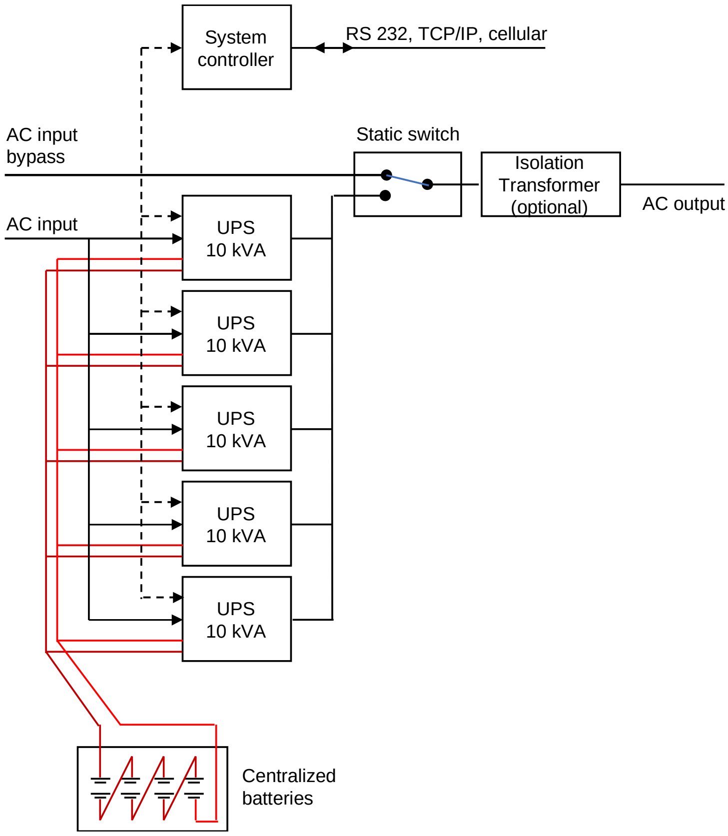

Figure 4: Example of modular in-line UPS technology

7.2.3 -48 VDC power solutions

To maximize energy performance, modular systems should be used where only the required number of modules should be activated (considering reliability requirements that may require addition of redundant modules).

7.2.4 High efficiency distribution and power equipment

This involves the installation of distribution and individual power equipment with improved energy efficiency specifications. Typical examples include:

- high-efficiency power distribution units (reduced length, better cable sizing, less losses in interconnection and protective devices, etc.);
- high-efficiency motors in fans and pumps (this can be obtained by using variable speed motor driver);
- AC or DC UPS that exhibit improved efficiency over the full range of load;
- rotary-based UPS units;
- correctly sized conversion to optimize efficiency;
- elimination of isolation transformers when possible with respect to safety rules and standards.

These solutions represent significant capital expenditure and a risk to business continuity.

Table 16 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 16: CLC/TR 50600-99-1 [1] practices addressing power distribution improvements

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Provision power and cooling only to the planned power draw of the IT equipment as-configured (based on the components actually installed), rather than the Power Supply Unit (PSU) size or nameplate rating.	5.2.8
Design the data centre to maximize the energy efficiency of the facility under partial fill/partial load and variable IT electrical and cooling loads. This is in addition to initial modular provisioning described in Practice 5.4.4 and should take into account the response of the infrastructure to dynamic loads e.g. appropriately controlled variable frequency (or speed) drive for pumps, fans and compressors.	5.4.5
Ensure that all electrical infrastructure remains energy efficient under variable ICT electrical loads as described in Practice 5.4.5.	5.4.32
Eliminate isolation transformers from distribution to ICT equipment.	5.4.31
Ensure that all electrical infrastructure remains energy efficient under variable ICT electrical loads as described in Practice 5.4.5.	5.4.32
Monitor the power factor of power supplied to the ICT, mechanical and electrical equipment within the data centre. Consider the use of power factor correction where appropriate.	6.1.18
Power factor correction is often a requirement placed on the ICT site owner by the "grid" operator. A low power factor (~ 0,9) can imply additional energy costs and in extreme cases may incur disconnection of supply.	6.1.18

7.2.5 Migrating to 400 VDC

7.2.5.1 General

The improvement of energy efficiency within the power distribution system by moving to 400 VDC is dependent on the type of ICT site. The issues differ between NDC sites (where equipment is generally currently supplied at 230 VAC, single phase in Europe) and OS (where the NTE is supplied at -48 VDC).

In both scenarios, changing the distribution policy (up to 400 VDC (ETSI EN 300 132-3-1 [i.15]) will have an impact on the equipment used.

For AC powered ICT sites, such a change represents a risk to business continuity can involve significant capital expenditure - particularly if the existing AC distribution system is maintained for some equipment.

For DC powered sites, the complexity of migration is reduced.

Reliability, availability and resilience are also important criteria, a significant saving in original cost with an energy bill and a very significant gain in maintenance contracts in the case of UPS.

7.2.5.2 400 VDC versus AC

The increase of service and of energy density of the ICT equipment has led to more equipment in the same existing premises and higher power consumption.

Therefore, the A3 power interface voltage ranges proposed in ETSI EN 300 132 series [i.13] have been defined with consideration to the:

- need to unify the power supply to all ICT equipment;
- reduction of the power losses and conductor cross-section area in the power distribution system;
- need to maintain a highly reliable power source for the NTE.

ETSI has published ETSI EN 300 132-3 series [i.14] concerning the requirements for the interface between ICT equipment and its power supply, and includes requirements relating to its stability and measurement.

The power feeding solutions for up to 400 VDC in ICT sites, using the 400 VDC power interface, are well adapted to renewable energy or distributed sources or new micro-grids, most of them being more complex in AC than in DC. The DC solution would allow great simplification by avoiding frequency synchronization and the removal of power factor correction circuitry in ICT equipment.

Many documents, studies, and standards suggest that direct DC can generate some savings from 5 % to 15 % depending on several conditions such as the generation of AC equipment and load of the site.

Technically, servers from main vendors could accept supply in the 400 VDC range and work on this continues.

7.2.5.3 Earthing and Bonding

ETSI has published ETSI EN 301 605 [i.16] on earthing and bonding of 400 VDC ICT equipment, in relation to safety, functional performance and EMC of HVDC. If all safety standards (IEC, ITU-T, ETSI) are complied with, 400 VDC is less dangerous than AC particularly the 3 phases with 660 VAC peak voltage.

NOTE: Energy operators should be trained to achieve the level of security required for the supply of up to 400 VDC but in many countries it is the same training as AC in terms of safety.

7.3 Operational practices

7.3.1 Measurement, monitoring and reporting

7.3.1.1 Measurement of energy efficiency of existing equipment

This involves the review of the existing power distribution equipment in terms of its energy efficiency enabling the measurement, monitoring and reporting (MMR) of relevant information. This may be undertaken without significant capital expenditure.

ETSI ES 202 336-9 [i.21] addresses monitoring and control of "alternative" local power supply systems (generally excluding diesel generators) for telecommunication equipment.

The selection of electrical equipment to enable MMR is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.2.1). However, it may be possible, based on the commonality of design and operation of groups of ICT sites, to derive information that is relevant at a global level. Mechanical and electrical equipment should be selected to enable local metering/monitoring of temperature and incorporated within a system that allows for reporting of temperature trends over a period of time as well as instantaneous temperature readings.

Table 17 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

ETSI ES 202 336-12 [i.22] should be used for measurements of power and energy consumption and environmental parameters of all the facilities of ICT technical environment.

Table 17: CLC/TR 50600-99-1 [1] practices addressing power distribution energy efficiency MMR

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Install metering equipment capable of measuring the total energy consumption of the spaces which comprise the data centre including all ICT, mechanical and electrical equipment.	5.1.22
Install metering equipment capable of measuring the total energy consumed by ICT equipment within the computer room space(s) to support the reporting of data as described in Practices 5.1.26 and 5.1.27.	5.1.23
Undertake manual measurements at regular intervals (ideally at peak load) and record the following: • energy consumption; • temperature and humidity (dry bulb temperature, relative humidity and dew point temperature).	5.1.26
Report periodically, as a minimum (via written or automated means), the following: • energy consumption; • Power Usage Effectiveness (PUE) in accordance with CENELEC EN 50600-4-2 [i.9] or Data Centre Infrastructure Efficiency (DCIE); • environmental ranges.	5.1.27
Select mechanical and electrical equipment with local metering/monitoring of energy usage and/or temperature as appropriate. Capabilities should allow for reporting cumulative periodic energy consumption (kWh), in addition to instantaneous power usage (kW). Temperature reporting should allow for visibility of temperature trends over a period of time as well as instantaneous temperature readings. To assist in the implementation of temperature and energy monitoring across a broad range of data centre infrastructure all monitoring devices installed should be able to use existing networks and operate on an Open Protocol basis. This interface protocol should enable all operators' existing monitoring platform to be able to retrieve data from the installed meters without the purchase of additional licenses from the equipment vendor.	5.4.35
Improve visibility and granularity of data centre infrastructure energy consumption.	5.4.41
Monitor and report on usage/energy consumption by devices power by ICT cabling. Cabling in accordance with CENELEC EN 50173 series [i.2] (and international equivalents) is increasingly being used to deliver power to devices both inside and outside the data centre. The advantage of this technology is that the same cable can be used for both network connectivity and power. Examples of this include telephony (voice) handsets, cameras, a variety of different environmental sensors even LED lights and lighting control.	6.1.2
Measure ICT power consumption at cabinet/rack level. Consider "per-port" monitoring using individual power strips.	6.1.19
Measure power consumption at device level. Improve granularity and reduce metering cost by using built in ICT equipment level metering of energy consumption.	6.1.22
Implement automated daily readings of energy usage and environmental conditions.	6.1.23
Implement automated hourly readings of ICT energy consumption.	6.1.24

7.3.1.2 Energy capacity management

This involves the use of electrical capacity management tools in order to deliver a more efficient usage of consumption. This requires significant capital expenditure for the monitoring equipment) and operating costs of installation and the software.

The implementation of electrical capacity management can generate some immediate reduction in terms of consumption, without any work on the power distribution components, and without any risks for business continuity.

7.3.2 Maintenance

The maintenance of power supply and distribution equipment is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.2.2).

7.4 Example outcomes

Table 18 shows the typical outcomes resulting from the implementation of energy management practices within the power distribution system.

Table 18: Typical outcomes resulting from energy management practices on power distribution

Description	Reference in the present document	Reference within CLC/TR 50600-99-1 [1]	Typical savings within the power distribution domain (%)	Typical savings overall (see note 1) (%)	Implementation timescale
Improved efficiency UPS units	7.2.2.2	5.4.28 5.4.32	10	1,5	Medium term
Modular UPS	7.2.2.3	5.4.27	10	1,5	Long term
Rotary-based UPS units		5.4.29	8	1,2	Medium term
High-efficiency power distribution units	7.2.4	-	5	0,8	Long term
Elimination of isolation transformers	7.2.4	5.4.31	See note 2	See note 2	Long term
Up to 400 VDC	7.2.5	-	7	1,1	Long term
NOTE 1: The overall saving shown assumes that ICT infrastructure initially constitutes 37 % of overall consumption of the ICT site. NOTE 2: Dependent on application.					

8 Environmental control recommendations

8.1 General

The European standard for the design of environmental control within structures housing data centres (which can be applied to other ICT sites) is CENELEC EN 50600-2-3 [i.7].

NOTE: CENELEC EN 50600-2-3 [i.7] is the basis for ISO/IEC TS 22237-4 [i.41] (in preparation as a future ISO/IEC 22237-4 in 2020).

This clause contains practices that are applicable to the design of new or refurbished ICT sites (clause 8.2) and the operation of existing ICT sites (clause 8.3). Example outcomes are presented in clause 8.4.

The practices included should be considered in conjunction with the information provided in ETSI TR 102 489 [i.24].

8.2 Design practices

8.2.1 Overview

The energy consumption related to environmental control of the spaces in an ICT site depends upon many factors including:

- the waste heat produced by the mechanical, power distribution and ICT equipment;

NOTE: ICT sites of higher Availability Class, containing redundant mechanical, power distribution and ICT infrastructures tend to produce increased quantities of waste heat.

- the operating temperature and humidity range specified by the different items of equipment;
- the external temperature and humidity range.

However, poor design of environmental control systems (clause 8.2) and unmanaged thermal patterns (clause 8.3) within the ICT site will also contribute to the energy consumption.

The application of a short term design (scalable) approach, which is energy efficient under partial load conditions to the design of the environmental control system, is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.3.1).

8.2.2 Overview

8.2.2.1 Thermal segregation

8.2.2.1.1 Basic "hot aisle - cold aisle" concepts

Cooling efficiency decreases if the hot air and cold air become mixed within an ICT space. The mixing can be avoided by the use of thermal segregation techniques.

Thermal segregation is achieved by creating areas within the ICT spaces that are designed as dedicated "hot aisles" and "cold aisles".

The application of the "hot aisle - cold aisle" concept is a requirement of ETSI EN 305 174-2 [3] for all ICT sites using air-cooling except where the design of the equipment prevents it (see clause 5.3.1).

As shown in Figure 5, rows of cabinets are created in which the front of the cabinets face each other across a "cold aisles" and the rears of cabinets face each other across a "hot aisles". Cold air is drawn in through the front of the cabinets via the "cold aisles" and expressed through the rear of the cabinets into the "hot aisles".

A low cost, simple and rapidly deployable solution to problems of mixing air employs plastic curtains hanging from the ceiling of the computer room acting as barriers to isolate hot areas from cold areas as shown in Figure 5. This approach has the advantage that there is no impact on the installed infrastructure associated with fire detection and suppression (sprinklers).

However, infrastructure design, installation and operational procedures are critical to maximizing the benefit of basic hot aisle and cold aisle solutions.

However, an improvement of the "hot aisle, cold aisle" concept is provided by placing covers over the cold aisles as shown in Figure 6.

This approach reduces the loss of cold air losses and is able to demonstrate a rapid reduction in energy usage.

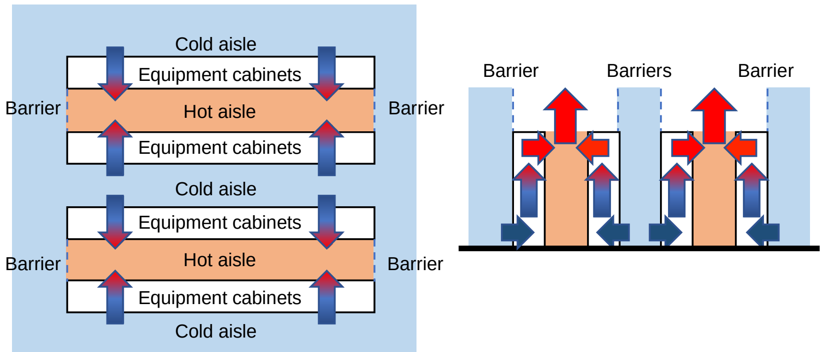

Figure 5: Hot aisle - cold aisle approach

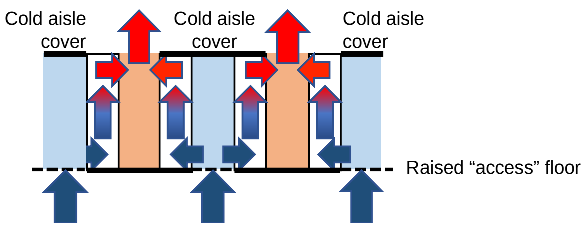

Figure 6: Hot aisle - cold aisle approach with improved containment

Table 19 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 19: CLC/TR 50600-99-1 [1] practices addressing "hot aisle - cold aisle" segregation

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Review placement and opening percentages of vented tiles to ensure appropriate airflow volume to ICT equipment and to reduce bypass air flow. Close unnecessary apertures in floors where the sub-floor space acts as an airflow pathway. Maintain unbroken rows of cabinets/racks to prevent re-circulated air and reinforce Hot/Cold aisle design with empty but fully blanked cabinets (or solid doors) rather than leaving gaps in aisles.	5.1.11
Align ICT equipment in the computer room space(s) in a hot/cold aisle configuration.	5.2.16
Ensure that ICT equipment shares an airflow direction, within the cabinet and in adjacent cabinets. Reinforce Hot/Cold aisle design with empty but fully blanked cabinets (or solid doors) rather than leaving gaps in aisles.	5.4.6
Install aperture brushes (draught excluders) or cover plates and panels to minimize all air leakage in each cabinet/rack and across raised floor areas when a raised floor is used as a cooling air supply plenum.	5.4.8
Implement containment techniques to separate hot and cold air. Consider the implications of these techniques for fire suppression and detection systems.	6.1.12
Consider the use of a return plenum(s) to return heated air from the ICT equipment directly to the air conditioning units.	6.1.13

8.2.2.1.2 "Pod" concepts

Vendors are predicting trends for ICT equipment with significantly increased energy consumption density (kW/m^2). This is an issue for many of legacy ICT sites that are not designed to provide such high levels of cooling.

If there are no restrictions on floor space, such as in an ICT site following consolidation initiatives, this problem can be solved by not filling the cabinets fully, and locating the cabinets such that maximum efficiency of cooling is maintained without having to change existing air flows. However, where the use of floor space has to be optimized there will be commercial pressure to fully load cabinets. For this case, very high density areas are the appropriate answer, but these areas have to be considered separately from other "traditional" ICT equipment areas and provided with their own energy and cooling needs.

The "pod" concept is supported by a number of vendors and extends the "hot aisle - cold aisle" concept by reducing the volume within the ICT site that is subject to environmental control. Pods are enclosed and secured areas containing a specific set of cabinets/racks which are provided with the required level of environmental control (as shown in Figure 7).

One of the advantages of such a solution is these areas can be installed outside computer room spaces.

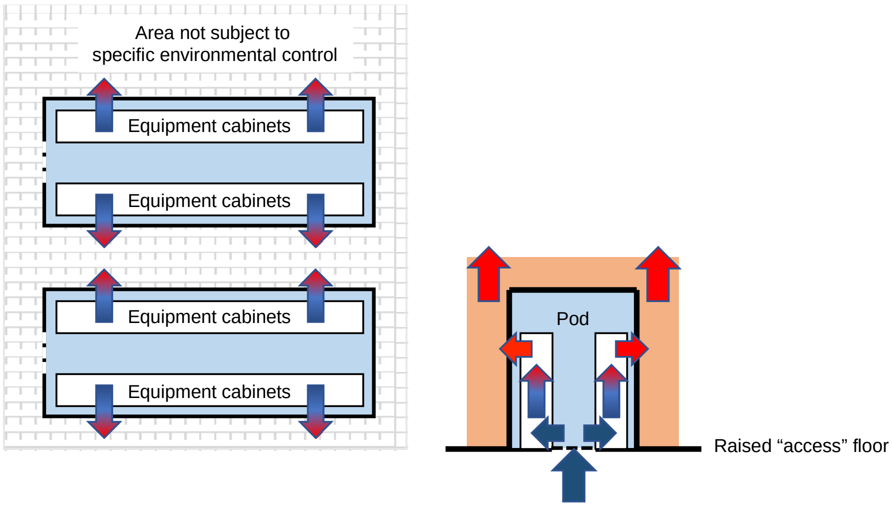

Figure 7: The "pod" concept

Table 20 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 20: CLC/TR 50600-99-1 [1] practices addressing "pod" concepts

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Install groups of ICT, mechanical and electrical equipment with substantially different environmental requirements and/or equipment airflow direction in separate areas which have independent environmental controls.	5.1.13
Implement containment techniques to separate hot and cold air. Consider the implications of these techniques for fire suppression and detection systems.	5.4.7
Install aperture brushes (draught excluders) or cover plates and panels to minimize all air leakage in each cabinet/rack and across raised floor areas when a raised floor is used as a cooling air supply plenum.	5.4.8
Provide separate areas for ICT equipment which: a) is compliant with the extended range of Practice 5.2.3; b) requires more restrictive temperature or humidity control as described in Practice 5.2.2. Examples are equipment which requires tighter environmental controls to: – maintain battery capacity and lifetime such as UPS; – meet archival criteria such as tape; – meet long warranty durations (10+ years). These areas should have separate environmental controls and might use separate cooling systems to facilitate optimization of the cooling efficiency of each zone. The objective of this Practice is to avoid the need to set the computer room cooling system for the equipment with the most restrictive environmental range and therefore compromising overall energy efficiency.	5.4.10
Design computer rooms to enable discrete areas with additional "close control" cooling equipment which can be offered to customers with extremely tight environmental control requirements. This allows a tighter SLA to be offered without compromising overall energy efficiency.	5.4.11
Segregate chilled water systems which are principally designed to provide an appropriate environment for equipment from those designed to provide human comfort. Where human comfort is necessary the use of heat pumps to provide either cooling or heating should be considered.	5.4.19

8.2.2.2 Airflow management in cabinets/racks

Any potential improvements in energy usage offered by the approaches detailed in clause 8.2.2.1 may be impacted by the failure of installers and maintainers to fit/re-fit "blanking panels" in the front and, where necessary, the rear of the racks within cabinets when equipment is not installed or has been removed - which creates significant losses of cold air coming into the rack and contributes to an inefficient management of cooling.

The application of blanking plates is a requirement of ETSI EN 305 174-2 [3] for all ICT sites using air-cooling (see clause 5.3.2).

This approach involves very little cost and is able to demonstrate a rapid reduction in energy usage.

Table 21 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 21: CLC/TR 50600-99-1 [1] practices addressing air flow management in cabinets/racks

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Install blanking plates in locations within cabinets/racks where there is no equipment.	5.1.10
Install aperture brushes (draught excluders) or cover plates and panels to minimize all air leakage in each cabinet/rack and across raised floor areas when a raised floor is used as a cooling air supply plenum.	5.4.8

8.2.3 "Free cooling"

8.2.3.1 General

The ICT site design, the set points and ranges of temperatures of the environmental control system should enable operation without refrigeration for a significant part of the year evaluated against a Typical Meteorological Year for the site.

The application of "free cooling" concept is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.3.1).

The selection of mechanical and electrical equipment that does not require cooling in normal operation is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.2.1 and clause 5.3.1).

If the opportunity exists and outdoor conditions permit, the re-introduction of air-side economizers (free cooling) or water-side economizers (cooling tower) approaches should be considered to reduce energy usage and improve the energy efficiency of the ICT site.

Free cooling uses external air or water temperature conditions for cooling rooms by introducing fresh air to the computer room equipment using traditional methods. There are two principle approaches to "free cooling":

- "free air-cooling": based on the air temperatures outside the building containing the ICT site;
- "free water-cooling": use of existing cold water sources, as sea, lake, river or other.

Most modern ICT equipment complies with ASHRAE A2 requirements meaning they it can operate within climatic margins of 10 °C to 35 °C and 20 % to 80 % relative humidity. However, all ASHRAE classes have a recommended climatic range of 18 °C to 27 °C and 5,5 °C dew point to 60 % relative humidity. It is considered that operation outside this recommended range can increase the energy consumption and/or shorten the lifetime of the ICT equipment.

If the suppliers of ICT equipment were to adopt the operational environmental specification applied to NTE (see ETSI EN 300 019-1-3 [i.12]) it would result in substantial increase in the time where free cooling could be applied and would generally increase the resulting saving.

NOTE: Optimum environmental control will be achieved by monitoring the environmental conditions and should take place as close as possible to the intake and exhaust at the rack level.

The effectiveness, and therefore the use, of free cooling are determined by two main climatic factors external to the ICT sites:

- mean air temperatures throughout the year (external temperatures should be 2 °C under the maximum temperature setting inside);
- mean relative humidity throughout the year (a mix of intern and extern air with some electrostatic protection should obviate the control of hygrometry).

The necessary amount of fresh air from outside is given by:

$$F = P/(C_P \times (T_i - T_o))$$

where:

F = Flow of external air [m$^{3/}$h]

P = heat load [W]

C_P = specific heat capacity = 0,34 [Wh/m^3.K]

T_i = indoor temperature [K]

T_o = outside temperature [K]

Total reduction in energy usage is directly linked to the external climatic conditions. The potential reduction is proportional to the total period during which the external environmental conditions matches the ideal combination.

Table 22 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 22: CLC/TR 50600-99-1 [1] practices addressing free cooling

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Investigate the installation of free cooling in all new builds and retrofits or upgrades of cooling systems.	5.4.22
Consider the installation of free cooling in all new builds and retrofits or upgrades of cooling systems.	6.4.2
Evaluate of alternative forms of cooling where available, practical to utilize and offer genuine energy efficiency.	6.4.9

8.2.3.2 Direct air free cooling

Use external air mixed with hot exhaust air to control supply air temperature and humidity to cool the facility.

This design tends to have the lowest difference between T_i and T_o and supply air and the ICT equipment is exposed to a large humidity and temperature range to allow direct air side economization to work effectively, see clause 8.4.3.1.

In many cases full mechanical cooling/refrigeration capacity is required as a backup to allow operation during periods of high airborne pollutant or if the external air is too hot. The achievable economizer hours are directly constrained by the chosen upper humidity and temperature limit. It should however be noted that many legacy OSs do not utilize mechanical cooling as they operate NTE with wider environmental ranges (see clause 8.2.3.1).

Table 23 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 23: CLC/TR 50600-99-1 [1] practices addressing direct air free cooling

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Cooling of the data centre by using external air. Mix exhaust air with incoming air during periods of low external temperature to ensure compliance with specified supply air temperature and environmental ranges. Special attention should be focused on external air quality monitoring and filtration in accordance with ISO 14644-1:2015 [i.31], Class 8 and reference to ISO 16890-1 [i.32] to determine filter efficiency. In many cases full mechanical cooling/refrigeration capacity is required as a backup to allow operation during periods of high airborne pollutant (e.g. external fires). Additional backup mechanical cooling might also be considered to ensure cooling at extreme ambient temperature and humidity conditions or for system redundancy. This design tends to have the lowest temperature difference between external temperature and ICT equipment supply air. The ICT equipment is likely to be exposed to a large humidity range to allow direct air free cooling/economization to work effectively. The achievable free cooling hours are directly constrained by the chosen upper humidity limit. The design dew point should ensure that condensation will not take place on components already within or brought in to the data centre.	6.4.3

8.2.3.3 Indirect air free cooling

Internal air is cooled using an air-to-air heat exchanger with the external air. When the outside air is not directly useable it is conditioned before cooling the internal air. A variation of this is a thermal wheel, quasi-indirect free cooling system.

This design of cooling system requires a minimal difference between T_i and T_o. The ICT equipment operating humidity range may be well controlled at negligible energy cost.

Table 24 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 24: CLC/TR 50600-99-1 [1] practices addressing free cooling

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Cooling using an air-to-air heat exchanger. This can be combined with an adiabatic function.	6.4.4

8.2.3.4 Indirect water free cooling

Chilled water is cooled by the external ambient conditions via a heat exchanger which is used between the condenser and chilled water circuits. This may be achieved by cooling towers or dry coolers; the dry coolers may have evaporative assistance through spray onto the coolers.

This design tends to have a higher difference between T_i and T_o restricting the economizer hours available and increasing energy overhead. The ICT equipment operating humidity range may be well controlled at negligible energy cost.

Table 25 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 25: CLC/TR 50600-99-1 [1] practices addressing indirect water free cooling

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Cooling using a water circuit and removal of heat by a free cooling coil. This can be achieved by dry coolers with or without adiabatic assistance.	6.4.5
Cooling using chilled water cooled by cooling towers or dry coolers. Dry coolers can also have an adiabatic function.	6.4.6
Cooling using chilled water produced by the free cooling chiller either through the free cooling coils in the chiller, if external temperatures are low, or with compressors at higher external temperatures.	6.4.7
Cooling using chilled water cooled via a plate heat exchanger to the condenser water circuit passing through dry/adiabatic coolers/cooling towers.	6.4.8

8.2.3.5 Absorption free cooling

This kind of economizer takes advantage of physical and chemical characteristics of absorption or adsorption processes. Thanks to this process the heat expelled by the ICT equipment is used to power the cooling system in place of electricity. The absorption free cooling system is not is common use.

8.2.3.6 Adiabatic cooling

This principle uses evaporation of water as a primary mechanism to cool either a chilled water loop or for latest technologies, directly cooling the inside air. This latest technology uses much less water than open cooling towers.

8.2.4 Direct cooling

8.2.4.1 Cooling-on-the-chip

This next generation technology aims to directly apply the cooling to the semiconductor packages within equipment such as servers. Hardware manufacturers are working on these technologies which are predicted to provide significant improvements in energy efficiency.

8.2.4.2 Liquid cooling

8.2.4.2.1 Direct water free cooling (Cooling-on-the-rack)

Chilled water is cooled by the external ambient air via a free cooling coil, it may be achieved by dry coolers or by evaporative assistance through spray onto the dry coolers.

This design tends to have a medium difference between T_i and T_o. The ICT equipment operating humidity range may be well controlled at negligible energy cost.

Some racks should be cooled directly by water system.

8.2.4.2.2 Liquid submersion cooling (oil cooling)

The system consists of a rack placed horizontally on the floor filled with coolant, a device for circulating and cooling the fluid up is installed to an external heat exchanger. The rack is based on a fluid recovery device, mainly composed of absorbent material (fluid can be: mineral oil, vegetal oil, natural/synthetic ester).

A number of servers have been provisioned, they were stripped from all their fans, paste between processors and their radiators were replaced with a thermal film and their disks were extracted. These transformations can be irreversible.

A high reduction of energy consumption and a huge increase of energy efficiency are expected from this device.

Table 26 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 26: CLC/TR 50600-99-1 [1] practices addressing liquid submersion cooling

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Operate direct liquid cooled devices with supply coolant liquid temperatures sufficient to meet manufacturers' minimum cooling requirements thus avoiding equipment damage or warranty violations.	6.2.3
Evaluate of alternative forms of cooling where available, practical to utilize and offer genuine energy efficiency.	6.4.9
Implement direct liquid cooling in part or all of some ICT equipment.	6.4.10

8.2.5 Enhancements of cooling systems

The following enhancements of cooling systems involve high capital and operational expenditure and represent a significant risk in terms of business continuity and quality of service during the implementation phase:

a) optimization of ICT sites airflow configuration;

b) installation of high-efficiency CRAC units;

c) sizing/re-sizing of cooling systems and the configuration of redundancy to maximize efficiency;

d) increasing the temperature difference between chilled water supply and return in order to allow a reduction in chilled water flow rates;

e) installation of high-efficiency variable-speed air-handler fans and chilled water pumps.

Table 27 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 27: CLC/TR 50600-99-1 [1] practices addressing cooling system enhancements

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Select chillers based upon their predicted or specified Coefficient of Performance (CoP) in accordance with the ISO 14511 series [i.30] throughout their likely working range. This is a key decision factor during procurement when mechanical refrigeration is to be installed.	5.4.15
Review and if practical increase the chilled water temperature set points to maximize the use of free cooling and reduce compressor energy consumption. Set points should be raised together with supply air flow set points to avoid reducing capacity. Review and if beneficial increase the chilled water temperature difference to reduce the water flow and thereby to reduce pump energy consumption. Where a DX system is used, review the evaporator temperatures.	5.1.19
Consider installing variable speed fans which are particularly effective where one or more of the following conditions apply: • a high level of redundancy in the cooling system; • low utilization of the facility; • highly variable ICT equipment load.	5.4.23
Select appropriately sized cooling units. Air volumes required by ICT equipment not only depend on the ICT load (kW) but also on the difference between the intake and exhaust temperatures of the ICT equipment, which will also vary with utilization. These factors should be considered together with predicted utilization and bypass to size the cooling units design flow rates. As the difference between the intake and exhaust temperatures of the ICT equipment for a given load condition is inversely proportional to airflow, any overestimate will result in undersized CRAC/CRAH air volumes and potential air management problems. Conversely any underestimation will result in excessive CRAC/CRAH air volumes, which will make part load operation inefficient and air bypass more likely.	5.4.26
Ensure sufficient ceiling height to enable the use of efficient air cooling technologies such as raised floor, suspended ceiling, aisle containment or ducts in the data centre when air movement is used to cool the ICT equipment.	5.4.37
Ensure that the physical layout of the building does not obstruct or restrict the use of "Free Cooling" (either air-side or water-side), or other equipment with an economization/free cooling mode.	5.4.38
Locate cooling equipment, particularly dry or adiabatic coolers, in an area with free air movement. This equipment should ideally be located in a position on the site where the waste heat does not affect other buildings and create further demand for air conditioning.	5.4.39
Implement techniques to minimize losses associated with the movement of air.	6.1.14
Consider operating CRAC/CRAH units with variable speed fans in parallel to reduce the electrical power necessary to achieve the required air movement. Electrical power is not linear with air flow. Care should be taken to understand any new failure modes or single points of failure that might be introduced by any additional control system.	6.4.11
Consider turning entire CRAC/CRAH units on and off where variable speed fans are not included to manage the overall airflow volumes.	6.4.12

8.3 Operational practices

8.3.1 General

Thermal measurement software tools can be employed to determine the thermal patterns within the ICT site without significant capital expenditure since the costs are restricted to the fees for the software and the operational expenditure for the installation and customization. This can include infra-red photographs of the spaces within the ICT site.

Some simple and low cost actions can be taken to avoid this which generate some non-negligible improvements in energy management.

8.3.2 Temperature and humidity settings

Increasing the temperature and adjusting humidity levels in ICT site spaces without violating vendors' specifications enables substantial reductions in energy usage associated with environmental control. The level of reduction depends upon some basic factors such as the size of the space and occupancy ratio.

The temperature and humidity in which the ICT equipment is operating, should be taken by an external sensor located at the air inlet as defined in ETSI EN 300 019-1-3 [i.12]. These standards define the environmental classification for NTE.

The CLC/TR 50600-99-1 [1] recommends consideration of changing the current temperature ranges applicable to ITE to approach or adopt the same as those for NTE.

Table 28 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 28: CLC/TR 50600-99-1 [1] practices addressing temperature and humidity settings

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Review and, if practical, increase the ICT equipment intake temperature to within the range of 10 °C to 35 °C in order to reduce energy consumption by reducing or eliminating unnecessary cooling. Some, particularly older, ICT equipment can exhibit significant increases in fan power consumption as intake temperature is increased. It should be confirmed that ICT equipment will not consume more energy than is saved in the cooling system.	5.1.17
Review and, if practical, reduce the lower relative humidity set-point of the computer room space(s) to -12 °C DP and 8 % rh to reduce the demand for humidification. Review and, if practical, increase the upper relative humidity set-point of the computer room space(s) to 27 °C DP and 80 % rh to decrease the dehumidification loads within the facility. Unnecessary humidifier loads generated by chilled water or evaporator temperatures below the computer room air dew point causing dehumidification should be eliminated through adjustment of the lower humidity set-point.	5.1.18
Review and if practical increase the chilled water temperature setpoints to maximize the use of free cooling and reduce compressor energy consumption. Set points should be raised together with supply air flow set points to avoid reducing capacity. Review and if beneficial increase the chilled water temperature difference to reduce the water flow and thereby to reduce pump energy consumption. Where a DX system is used, review the evaporator temperatures.	5.1.19
Evaluate the opportunity to optimize the refrigeration cycle set-points of mechanical refrigeration systems to minimize compressor energy consumption.	5.1.20
Minimize air re-circulation. Minimize air oversupply. Ensure that there is a slightly positive pressure (≤ 5 Pa) in the cold air stream with respect to the hot air stream.	5.4.12
Optimize the temperature and relative humidity settings of CRAC/CRAH units in occupied areas. For example, many CRAC/CRAH units now have the option to connect their controls and run together when installed in the same area to avoid units working against each other. Care should be taken to understand and avoid any potential new failure modes or single points of failure that might be introduced.	5.4.14
Ensure that cooling system set-points are defined by ICT equipment requirements. Segregate electrical and mechanical equipment requiring more restrictive temperature or humidity control ranges from ICT equipment.	5.4.20
Review chilled water systems configured with dual pumps (one active, one standby) for options to improve energy efficiency during operation.	5.4.21
Consider lowering the engine heater set-point of generators. Block heaters for the standby generators should be controlled to only operate when the temperature conditions warrant it. Manufacturers should be consulted to determine risk/reliability implications.	6.1.17
Where appropriate and effective, computer room space(s) should be designed and operated to provide: • intake temperature 10 °C - 40 °C; • humidity, -12 °C DP and 8 % rh to 27 °C DP and 85 % rh.	6.4.1

8.3.3 Environment control equipment

Table 29 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 29: CLC/TR 50600-99-1 [1] practices addressing environmental control equipment

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Employ regular maintenance of the cooling system in order to preserve or achieve a "like new condition".	5.1.16
Shut down unused, non-variable equipment where appropriate. If the facility is not yet fully populated or space has been cleared through consolidation, non-variable equipment such as fixed speed fan CRAC/CRAH units should be turned off in the empty areas. This should not be applied in cases where operating more equipment at lower load is more efficient, e.g. variable speed drive CRAC/CRAH units.	5.4.13
Control CRAC/CRAH units based on cold air supply temperature only to ensure an even supply air temperature independent of the load.	5.4.24
Consider implementing control systems that optimize the cooling system in real time.	6.1.16

8.3.4 Air flow in cabinets/racks

The application of blanking plates is a requirement of ETSI EN 305 174-2 [3] for all ICT sites using air-cooling (see clause 5.3.2).

Table 30 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 30: CLC/TR 50600-99-1 [1] practices addressing air flow in cabinets/racks

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Install blanking plates in locations within cabinets/racks where there is no equipment.	5.1.10
Install cabinets with either no doors (if security requirements are not compromised) or doors with at least 66 % perforated area where a hot/cold aisle configuration is implemented. Use solid doors only where the cooling system is specifically designed to incorporate them e.g. chimney cabinets which funnel hot air to an overhead plenum or water cooled cabinets with a heat exchanger inside the cabinet which circulate air within the cabinet. CENELEC EN 50174-2 [i.3] recommends a minimum of 66 % perforated area. 80 % is considered ideal by other experts in this field.	5.2.17
Install aperture brushes (draught excluders) or cover plates and panels to minimize all air leakage in each cabinet/rack and across raised floor areas when a raised floor is used as a cooling air supply plenum.	5.4.8
Replace solid doors (where doors are necessary and cooling airflow is necessary), with perforated doors to ensure adequate cooling airflow to ICT equipment.	5.4.9

8.3.5 Measurement, monitoring and reporting

8.3.5.1 Energy

This involves the review of the existing mechanical equipment in terms of its energy efficiency enabling the MMR of relevant information. This may be undertaken without significant capital expenditure.

The selection of mechanical equipment to enable MMR is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.3.1). However, it may be possible, based on the commonality of design and operation of groups of ICT sites, to derive information that is relevant at a global level.

Some periodic reports have to be written to manage the energy efficiency of the facility and these reports may be produced by an automated system.

Types of report include:

- energy use and environmental (temperature and humidity) data needs;
- energy consumption and environmental ranges;
- reporting of full/partial economizer, full refrigerant and compressor-based cooling hours.

Types of expected effects include:

- an automated energy and environmental reporting console to allow Mechanical and Electrical staff to monitor the energy use and efficiency of the facility provides enhanced capability;
- the intent being to report the amount of time and energy spent running on mechanical refrigerant and compressor-based cooling versus the use of air/water free cooling in order to reduce the amount of time spent on mechanical cooling during the year.

Table 31 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

Table 31: CLC/TR 50600-99-1 [1] practices addressing environmental control energy management MMR

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Install metering equipment capable of measuring the total energy consumption of the spaces which comprise the data centre including all ICT, mechanical and electrical equipment.	5.1.22
Install monitoring equipment at room level capable of indicating the supply air temperature and humidity for the ICT equipment.	5.1.24
Collect data from CRAC/CRAH units on supply and return (dependent upon operating mode) air temperature.	5.1.25
Undertake manual measurements at regular intervals (ideally at peak load) and record the following: • energy consumption; • temperature and humidity (dry bulb temperature, relative humidity and dew point temperature).	5.1.26
Report periodically, as a minimum (via written or automated means), the following: • energy consumption; • Power Usage Effectiveness (PUE) in accordance with CENELEC EN 50600-4-2 [i.9] or Data Centre Infrastructure Efficiency (DCIE); • environmental ranges.	5.1.27
Select mechanical and electrical equipment with local metering/monitoring of energy usage and/or temperature as appropriate. Capabilities should allow for reporting cumulative periodic energy consumption (kWh), in addition to instantaneous power usage (kW). Temperature reporting should allow for visibility of temperature trends over a period of time as well as instantaneous temperature readings. To assist in the implementation of temperature and energy monitoring across a broad range of data centre infrastructure all monitoring devices installed should be able to use existing networks and operate on an Open Protocol basis. This interface protocol should enable all operators' existing monitoring platform to be able to retrieve data from the installed meters without the purchase of additional licenses from the equipment vendor.	5.4.35
Improve visibility and granularity of data centre infrastructure energy consumption.	5.4.41
Implement collection and logging of full free cooling, partial free cooling and full refrigerant and compressor-based cooling hours throughout the year.	5.4.42
Implement reporting of full free cooling, partial free cooling and full refrigerant and compressor based cooling hours throughout the year. The site design, cooling system operational set-points and ICT equipment environmental control ranges should allow the data centre to operate without refrigeration for a significant part of the year with no refrigeration for the ICT equipment cooling load as evaluated against a typical meteorological year for the site.	5.4.43
Measure temperature at row or cabinet/rack level.	6.1.20

Practice **(information in any "Notes" of each practice is not shown)**	**Reference within CLC/TR 50600-99-1 [1]**
Measure intake and/or exhaust temperature at ICT equipment level. Improve granularity and reduce metering cost by using built in ICT equipment level metering of intake and/or exhaust air temperature as well as key internal component temperatures.	6.1.21
Implement automated daily readings of energy usage and environmental conditions.	6.1.23
Provide an automated energy and environmental reporting console. Report PUE (according to CENELEC EN 50600-4-2 [i.9]) or DCIE.	6.1.25
Provide an integrated energy and environmental reporting capability in the main ICT reporting console. Report PUE (according to CENELEC EN 50600-4-2 [i.9]) or DCIE and relate to ICT workload.	6.1.26

8.3.5.2 Air quality

Table 32 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 32: CLC/TR 50600-99-1 [1] practices addressing air quality MMR

Practice **(information in any "Notes" of each practice is not shown)**	**Reference within CLC/TR 50600-99-1 [1]**
Ensure that air quality is monitored and managed to ensure that critical equipment is not damaged by particulates or corrosive elements which might impact both IT equipment and cooling equipment in terms of performance, energy efficiency and reliability. This should inform the choice of filters used and the planned replacement schedule as well as the frequency of routine technical cleaning programme (including underfloor and ceiling void areas if applicable). Filter choices should be informed by ISO 16890-1 [i.32]. The ASHRAE white paper '2011 Gaseous and Particulate Contamination Guidelines for Data Centres' [i.43] recommends that data centre air quality is monitored and cleaned according to ISO 14644-1:2015 [i.31], Class 8. This can be achieved by routine technical cleaning and simple filtration using the following guidelines: • Continuously air filtering using MERV 8 filters. • Air entering a data centre being screened with MERV 11 or MERV 13 filters.	5.1.4 7.1.1

8.3.6 Maintenance

The maintenance of mechanical equipment is a requirement of ETSI EN 305 174-2 [3] for all ICT sites (see clause 5.3.2).

8.4 Example outcomes

8.4.1 General

Table 33 shows the typical outcomes resulting from the implementation of energy management practices within the power distribution system.

Table 33: Typical outcomes resulting from energy management practices on environmental control

Description	Reference in the present document	Reference within CLC/TR 50600-99-1 [1]	Typical savings within the environmental control domain (%)	Typical savings overall (see note 1) (%)	Implementation timescale
Improvement of cooling efficiency	8.2.2.1.1	5.2.14	30	11,1	Medium term
High density areas	8.2.2.1.2	5.2.18	25	9,3	Short term
Modification of temperature and humidity	8.3.2	5.1.17	40	14,8	Medium term
Direct air free cooling	8.2.3.1	6.4.3	30	7,4	Medium term
Indirect air free cooling	8.2.3.2	6.4.4	--	See note 2	Medium term
Direct water free cooling	8.2.3.3	NA	--	See note 2	Medium term
Sorption free cooling	8.2.3.5	NA	--	See note 2	Long term
Cooling-on-the-chip	8.2.4.1	5.4.2.9	--	See note 2	Long term
Indirect water free cooling	8.2.4.2.1	6.4.5	--	See note 2	Medium term
Liquid Submersion cooling (Oil cooling)	8.2.4.2.2	NA	40	14,8	Medium term
NOTE 1: The overall saving shown assumes that the environmental control systems initially constitutes 45 % of overall consumption of the ICT site. NOTE 2: Dependent on application.					

8.4.2 Free cooling

Reduction in energy consumption of the environmental control system can be calculated as:

$$R = W \times H \times F$$

where:

R = savings

W = fraction of energy consumption of ICT site used by environmental control system during periods without free cooling

H = fraction of hours of matching conditions per annum

F = fraction of environmental control system energy consumption inactive during periods of matching conditions

Table 34 shows an example of savings based on a "*W*" value of 37 % and an "*F*" value of 60 %. Figure 8 is a graphical representation of the information in the Table 34.

Table 34: Example of free cooling savings control

Total length of period with matching conditions (enabling free cooling) per annum		Environmental control system energy saved	Total energy saved ***R***
hours, [days]	***H* (%)**	***H* x *F* (%)**	***W* x *H* x *F* (%)**
1 000 [42]	11,42 %	4,22 %	2,53 %
2 000 [83]	22,83 %	8,45 %	5,07 %
3 000 [125]	34,25 %	12,67 %	7,60 %
4 000 [167]	45,66 %	16,89 %	10,13 %
5 000 [208]	57,08 %	21,12 %	12,67 %
6 000 [250]	68,49 %	25,34 %	15,20 %
7 000 [292]	79,91 %	29,57 %	17,74 %
8 000 [333]	91,32 %	33,79 %	20,27 %
8 760 [365]	100,00 %	37,00 %	22,20 %

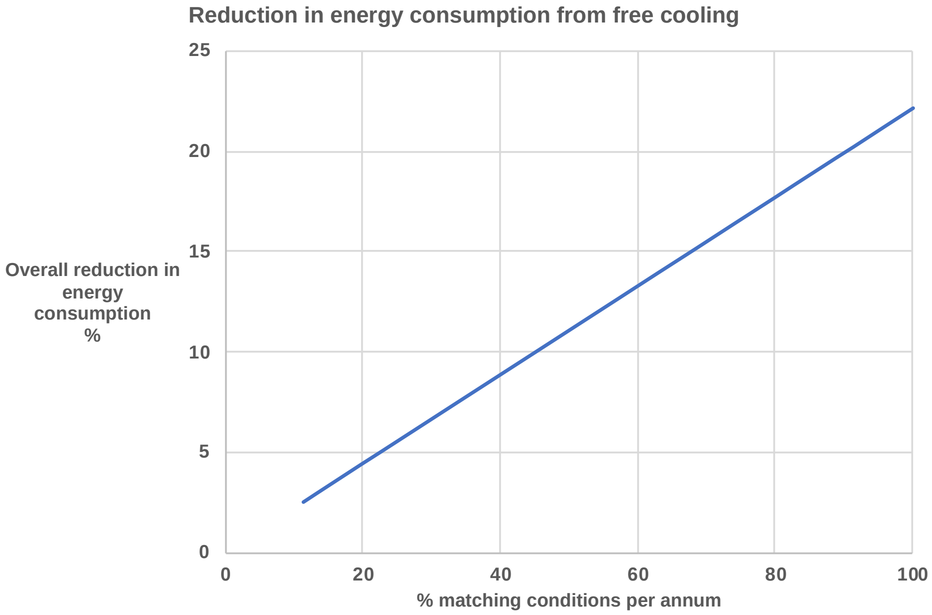

Figure 8: Graphical representation of Table 34

8.4.3 Temperature and humidity settings

8.4.3.1 Energy consumption

Experiments have been undertaken by some major telecommunications operators to determine the impact of increasing the average temperature in computer rooms without violating vendors' specifications.

Details of experiment are as detailed below:

- The experiment described below was undertaken in an ICT site using a telecommunications operators' data centre in Paris.
- The computer room space was underground comprising 1 000 m^2 and operating non-critical systems (development, backup, etc.) within which the heat dissipation was in the range 300 W/m^2 to 1 500 W/m^2. The information technology equipment comprised servers, disk arrays, robotics and networking equipment and exhibited operational temperature ranges from 18 °C to 28 °C / 30 °C (dependent on vendor specifications) which is more restrictive than the ETSI EN 300 019-1-3 [i.12] applied to NTE.
- The environmental control was provided by air cooling (recycling mode) from seven dry cooler units (80 kW per unit) and the energy consumption for air cooling was between 40 % and 60 % of the total energy consumption.
- Measurement instrumentation comprised 40 temperature and hygrometry sensors (measurement every 5 min) together with measurement of air cooling energy consumption.
- Step One was to modify the environmental conditions as shown in Table 35. This resulted in a reduction of the energy consumption of the environmental control system of 12 % without operational failure (since 2007).
- Step Two was to modify the environmental conditions as shown in Table 35. This resulted in a reduction of the energy consumption of the environmental control system of 20 % without operational failure (since 2007).

Table 35: Experimental temperature and humidity settings

Parameter	Initial settings	Step One	Step Two
Cooling unit start-up	20 °C to 24 °C	22 °C to 26 °C	24 °C to 28 °C
Dehumidifier start-up	50 % to 65 %	60 % to 75 %	60 % to 75 %
Humidifier start-up	45 % to 50 %	35 % to 40 %	30 % to 35 %
Winter/summer switching point	17 °C	19 °C	19 °C

8.4.3.2 Time to "system shut-down"

Many types of information technology equipment undergo automatic shut-down when temperatures exceed the vendors' maximum operating temperature specification (typically 30 °C or 32 °C). The available time to repair and/or restart cooling before automatic shut-down occurs is a major operational concern.

The time to system shut-down is defined as the interval between a total failure of the air conditioning system (with no redundancy) and the time at which the temperature in the room reaches a maximal functional limit. It depends upon a number of variables, the most important of which are:

- the area and volume of the space being cooled;
- the contents of the space;
- the operating temperature of the space;
- the quantity, type and of energy consumption of the equipment being cooled;
- the type, number and capacity of the CRAC units;
- environmental control system redundancy.

In circumstances where the total cooling demand of the equipment is very high the time to system shut-down can be short and is further reduced if the higher operating temperatures are applied.

Figure 9 shows the results of experimental work (based on computation and observation of real events) in a computer room space with the following characteristics:

- thermal load: 362 kW;
- computer room area: 1 080 m^2 (thermal load per unit area: 335 W/m^2);
- computer room volume: 3 240 m^3 (thermal load per unit volume: 112 W/m^3);
- cooling system: an air-conditioning system working in pure recycling mode (no free cooling). Seven dry cooler units (each with a cooling power of 80 kW) are used, associated with seven air treatment units. Cold air is blown through perforated tiles on the floor and the hot air outputs through the ceiling.

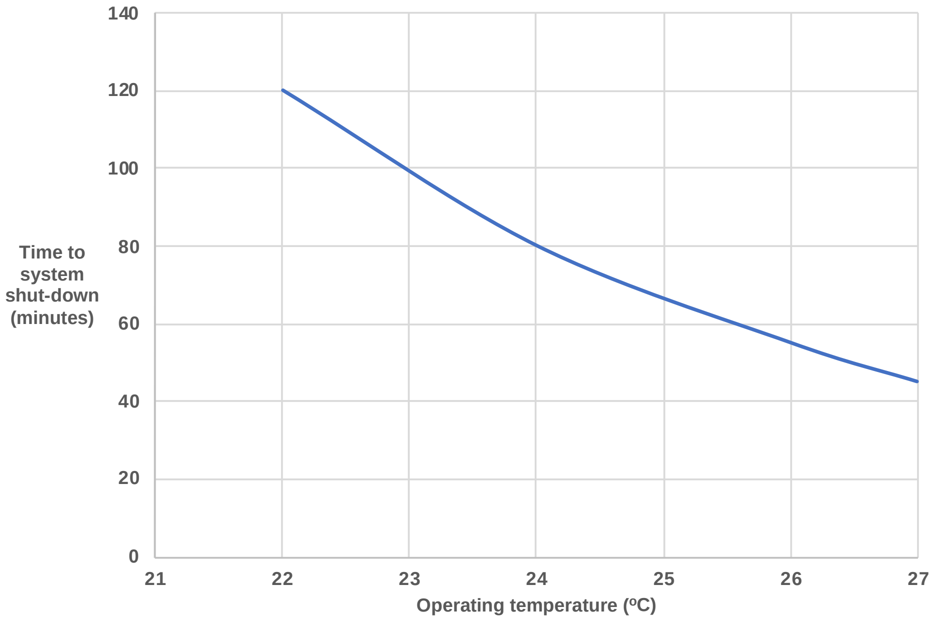

Figure 9: Example showing effect of operating temperature on "time to system shut-down"

Figure 9 clearly shows that increasing the operating temperature significantly reduces the time before system-shutdown.

This is an obvious concern for IT Managers and Operation Managers and may lead to this approach to energy usage reduction being ignored. However, a variety of approaches can be applied to provide lower, but significant, savings including:

- segregation of strategic "mission critical" business from other less critical activities and only apply increased operating temperature and humidity to those less critical areas;
- segregation of network NTE from the information technology equipment and only apply the increased temperature and humidity to the NTE.

NOTE: Such segregation would not be required and greater savings would be possible if ITE vendors change their operating specifications to those of NTE.

8.4.3.3 Restrictions on implementation

In an ICT site of Availability Class 4 in accordance with CENELEC EN 50600-1 [i.4] (see Annex A) , the risk posed by a cooling system failure is reduced by the presence of redundant environmental control systems and/or power distribution equipment. Any associated risks of operating the information technology and NTE are also minimized.

However, in ICT site meeting the requirements of lower Availability Class, those risks and their resultant impact on the business conducted from and by the ICT site need to be analysed.

9 ICT equipment and cabling infrastructure recommendations

9.1 General

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

This clause contains practices that are applicable to the design of new or refurbished ICT sites (clause 9.2) and the operation of existing ICT sites (clause 9.3). Example outcomes are presented in clause 9.4.

9.2 Design practices

9.2.1 Auditing the ICT estate

This involves an audit of the existing physical and logical estate.

Table 36 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 36: CLC/TR 50600-99-1 [1] practices addressing audits of ICT estate

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Identify the allowable intake temperature and humidity ranges for existing installed ICT equipment. Identify ICT equipment with restrictive intake temperature ranges so that it can be either: • marked for replacement as soon as is practicable with equipment capable of a wider intake range; or • moved and dealt with as per Practices "Equipment segregation" Practice 5.1.13 and "Separate environmental zones" Practice 5.4.10. The specification of wider operating humidity and temperature ranges for the computer room should be performed in conjunction with changes in ICT equipment procurement policy. Over time, ICT equipment with narrow environmental operating ranges should be replaced.	5.1.8

9.2.2 Obsolete ICT equipment

ICT equipment without any activity such as old servers, switches and routers should be identified, switched off and removed.

This typically represents a small percentage of the installed equipment (possibly 5 %) but decommissioning of this equipment provides an immediate reduction in energy consumption without any reduction in service levels.

NOTE: 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 (see clause 9.3.4.3).

Table 37 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 37: CLC/TR 50600-99-1 [1] practices addressing obsolete ICT equipment and services

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Decommission and remove any ICT equipment supporting unused services. Installed hardware should be regularly examined to ensure that it is still required and continues to support active services. In particular decommission and remove test and development platforms once no longer needed.	5.1.7
Develop a data management policy to define what data should be kept, for how long and at what level of protection taking care to understand the impact of any data retention requirements. Implement the policy by communication and enforcement by those responsible.	5.1.9
Restrict the deployment of redundant ICT equipment to the situations where the business need demands additional resilience. Redundant ICT equipment should only be implemented following a risk analysis to determine the business need for additional resilience i.e. where the risk and impact of loss of ICT services outweighs the potential savings in energy consumption and justifies the additional capital cost.	5.2.14
Restrict the deployment of standby ICT equipment to the situations where the business need demands additional resilience i.e. where the risk and impact of loss of ICT services on the business outweighs the potential savings in energy consumption and justifies the additional capital cost. "Cold standby" (switched "off") ICT equipment should be deployed in preference to "hot standby" (switched "on") ICT equipment provided that it can still meet the business requirements of the organization.	5.2.15
Identify services that have low business value or criticality and do not justify the financial or environmental overhead associated with continued operation. Decommission, archive or remove such services to locations offering lower energy consumption.	6.2.6
Shut down or put into a low power 'sleep' state servers, networking and storage equipment that is idle for significant time periods and cannot be virtualized. Consider complete removal of such ICT equipment. It will be necessary to validate the ability of legacy applications and hardware to survive these state changes without loss of function or reliability.	6.2.7

9.2.3 Selection of new ICT equipment

This involves the replacement of existing equipment from previous generations of technology with the most recent, more energy efficient ICT equipment.

NTE should consider products recognizing the EU Code of Conduct for energy consumption of broadband equipment.

For servers this may be through the application of ETSI EN 303 470 [i.17] which is based upon the SPECpower metric, or through application or deployment of specific user metrics more closely aligned to the target environment, which may include service level or reliability components.

New ICT equipment should be:

- selected considering the climatic range and its considered evolution;
- deployed meeting the design power density (per rack or m^2) of the ICT site to avoid running the cooling system outside design parameters;
- provisioned with high efficiency Power Supply Units (PSU) which are rated at 90 % power efficiency or better across the range of expected loads for the equipment to be installed.

Table 38 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

NOTE: The use of the term "data centre" below is considered to have wider application to the ICT sites of the present document.

The choice of server equipment should be directed by their ability to run virtualized operating systems. Blade server farms offer an excellent ratio of energy consumption/computing power in a limited space. High-end or mainframes are only necessary for unique and specific applications.

Table 38: CLC/TR 50600-99-1 [1] practices addressing selection of new ICT equipment

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Purchase ICT equipment which operates within the temperature and humidity range defined in Practice 5.2.3. Where this is not possible, purchase ICT equipment which operates within the intake temperature range 15 °C to 32 °C and -12 °C DP and 8 % rh to 27 °C DP and 80 % rh. ICT equipment with differing environmental requirements should be segregated within the computer room in order to minimize the size of the space requiring tighter environmental control. See Practice 5.4.10 and Practice 5.1.13.	5.2.2
Buy ICT equipment which operates within the temperature and humidity range defined in Practices 5.1.17 and 5.1.18 respectively. Procurement specifications should demand data from vendors regarding operating conditions for any model or range which restricts warranty to less than continuous operation within these temperature and humidity ranges. Directly liquid cooled ICT devices are addressed in Practice 6.2.3.	5.2.3
Observe the "per cabinet/rack" or "per square metre" power and cooling capacity limits of the computer room space(s). Exceeding these limits might create cooling and airflow management problems reducing the overall capacity and efficiency of the data centre. Power and cooling should be considered as capacity constraints in addition to physical space.	5.2.4
Use the Energy Star labelling programmes as a guide to select the most efficient ICT equipment where they are available for the class of equipment being reviewed. These include: • Energy Star specifications for servers. • Energy Star specifications for storage equipment. Those able to determine the in-use energy efficiency of ICT equipment through more advanced or effective analysis should do so.	5.2.9
Select ICT equipment that is capable of reporting energy consumption and inlet temperature. Where applicable, industry standard reporting approaches should be used e.g. IPMI, DCIM and SMASH. ICT equipment should have an IP interface and support one of the following: 1) SNMP polling of inlet temperature and energy consumption. Event-based SNMP traps and SNMP configuration are not required. 2) IPMI polling of inlet temperature and energy consumption. 3) An interface protocol which enables the operators' existing monitoring platform to retrieve inlet temperature and energy consumption.	5.2.10
Select ICT equipment containing high efficiency AC/DC power converters. These should be rated at 90 % power efficiency or better across the range of expected loads.	5.2.12
Select storage hardware based on an evaluation of the energy efficiency in terms of the service delivered per Watt. Evaluate the "in-use power draw" and the "peak power" of the storage device(s) as configured. Energy efficiency of storage devices can 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.	6.1.9
Include the operating temperature and humidity ranges at the air intake of new equipment as high priority decision factors in the tender process. Consider equipment which operates under a wider range of intake temperature and humidity than described in Practices 5.1.17 and 5.1.18 - such ranges include: • intake temperature 5 °C to 45 °C and -12 °C DP and 8 % rh to 27 °C DP and 90 % rh; • ETSI EN 300 019-1-3 [i.12] Class 3.1.	6.2.1

9.2.4 Installation of new ICT equipment

When installing ICT equipment into cabinets/racks ensure that the air flow direction matches the air flow design for that area. If the equipment uses a different air flow direction to that defined for the area into which it is installed it should only be used with a correction mechanism such as ducts, or special racks that divert the air flow to the defined direction.

Table 39 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 39: CLC/TR 50600-99-1 [1] practices addressing obsolete ICT equipment and services

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Select ICT equipment whose airflow direction matches the airflow design for the area in which it is to be operated. This is commonly front to rear or front to top. If the ICT equipment has a different airflow direction to the design of the area into which it is installed (such as right to left when the cabinet/rack is intended to be front to back), air diversion plates/ducts should be installed to change the airflow to match the design of the area.	5.2.6
Restrict the use of free standing ICT equipment or ICT equipment supplied in custom enclosures to areas where the airflow direction of the enclosures matches the airflow design in the area. 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.	5.2.11
Deploy groups of ICT equipment with substantially different environmental requirements and/or equipment airflow direction in separate areas. The environment and airflow should then be controlled separately to match the ICT equipment requirements in each area.	5.2.18

9.2.5 Software

Infrastructure management software brings some benefits in the way to manage the energy needs more efficiency, and have a clear view of the potential of power in a computer room, in a rack, in a server.

Make the energy use performance of the software a primary selection factor and a major factor of the development project. 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. This is an extension of existing capacity planning and benchmarking processes. Performance optimization should not be seen as a low impact area to reduce the project budget.

Suggested examples of measuring, comparing and communicating software energy efficiency 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 low-power states: this includes monitoring software and agents.

Table 40 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

9.3 Operational practices

9.3.1 Energy management

There are two separate rapid routes by which reductions of power consumption may be achieved by providing more efficient usage of existing resources within existing IT infrastructures without the need for changes to hardware. The routes are described as:

- power management (see clause 9.3.2);
- processing capacity management (see clause 9.3.3).

It may also be possible to reduce the energy consumption for environmental control but the level of savings is dependent upon the type of cooling employed. If it is not possible to dynamically adjust the cooling air-rate, any savings would be insignificant. However, if the cooling air-rate can be adjusted dynamically then the energy used to cool the servers can be reduced significantly.

Table 40: CLC/TR 50600-99-1 [1] practices addressing software

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Make energy performance optimization a high priority in the development process and develop software which uses the least energy to perform the required task whilst ensuring it meets the organizational needs.	5.3.2
Include the energy consumption required to operate software in the bonus/penalty clauses of the contract when outsourcing software development. Whilst forecasting and measurement tools and methods are still being developed, approximations can be used such as the (under load) energy consumption of the ICT equipment required to meet performance and availability targets. This is an extension of existing capacity planning and benchmarking processes. Performance optimization should not be seen as a low impact area to reduce the project budget.	6.3.1
Research and development is required in the area of defining, measuring, comparing and communicating software energy efficiency. Suggested examples of this are: • software could be made resilient to delays associated with bringing off-line resources online 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. This is a specialist area which is being examined in detailed by projects specializing in this field. A watching brief will be maintained and links established to any ongoing projects on the development of metrics and standards in this area, which this Technical Report can subsequently reference once published and use to underpin the expectations detailed in Practices 5.18.47 and 5.18.48.	7.2.2

9.3.2 Power management

9.3.2.1 Activation of basic power management features

This involves the activation of any power management features within existing equipment.

The application of dynamic allocation of equipment resources provides additional beneficial effects on power management.

Table 41 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 41: CLC/TR 50600-99-1 [1] practices addressing power management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Enable power management features on ICT equipment as it is deployed. This includes BIOS, operating system and driver settings. Ensure that this policy is documented in the ICT equipment deployment process.	5.2.7
Select ICT equipment which provides mechanisms to allow the external control of its energy use.	6.2.2
Consider the use of resource management systems capable of analysing and optimizing where, when and how ICT workloads are executed and their consequent energy use.	6.2.8

9.3.2.2 Activation of "sleep" mode

This involves the activation of sleep mode (that is not a system shut-down of the equipment) during periods without application activity during certain periods during days, weeks or months and can be applied to a variety of equipment.

It may even be possible to consider a full system shut-down of certain pieces of equipment.

These solutions are applicable to all servers that are not in continuous use (such as backup and development servers) and servers in Class 1 or 2. Typically, these servers or applications respect a schedule of the type shown in Figure 10.

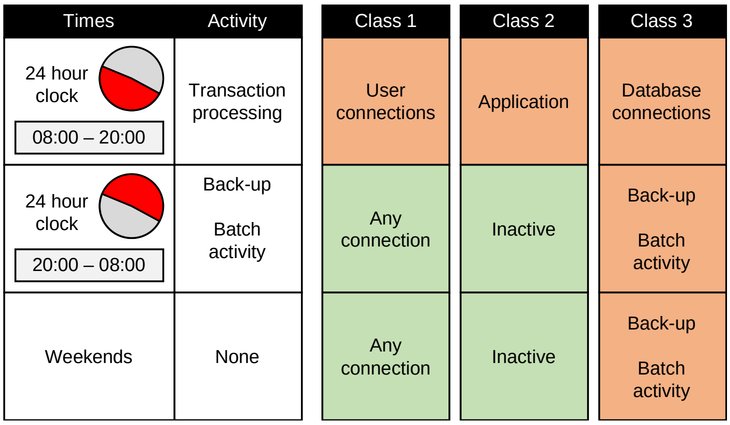

Figure 10: Server schedules

Table 42 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 42: CLC/TR 50600-99-1 [1] practices addressing environmental capacity management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Determine the business impact of short service incidents for each deployed service. Replace traditional active/passive server hardware clusters with fast recovery approaches such as restarting virtual machines elsewhere.	6.3.2

9.3.3 Capacity management

9.3.3.1 General

Capacity management is the ongoing, operational, process of estimation and allocation of space, environmental needs, computer hardware, software, and connection infrastructure resources to reflect the dynamic nature of ICT site users or interactions.

As shown in Figure 11, capacity management addresses the following questions:

- is the ICT site able to host new projects or support the growth of the activity?
- what is the capacity in terms of availability of space, energy and environmental control?
- what is the capacity in terms of storage, CPU, I/O, ports, etc.?

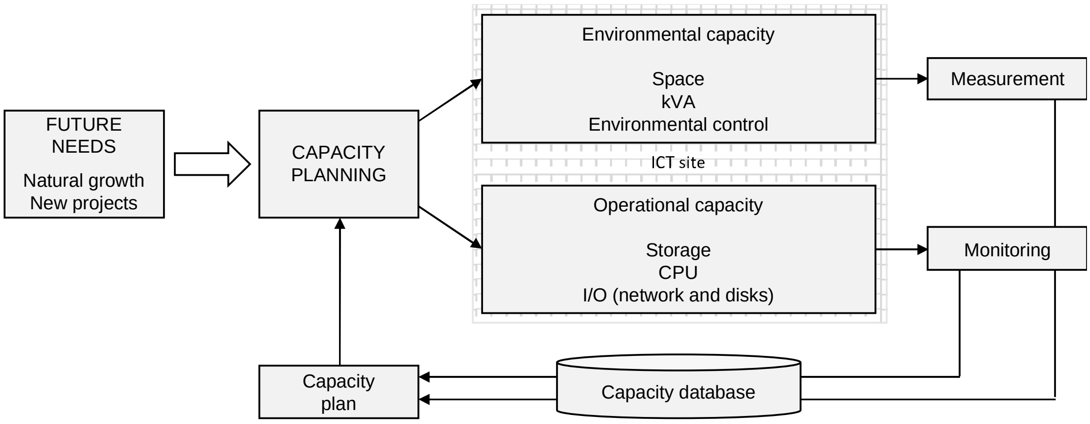

Figure 11: Capacity management

Capacity management provides an exhaustive view of the real needs in terms of computational power and/or environmental capabilities by continuous management, measurement and monitoring of the servers and application activities.

The objective of capacity management is to ensure that new capacity is added just in time to meet the anticipated need but not so early that resources go unused for a long period. Successful capacity management, using analytical modelling tools (responding to "what will happen if" scenarios) implements trade-offs between present and future needs that prove to be the most cost-efficient overall. The emergence of new technologies together with changes to business strategies and forecasts change require capacity management to be under continual review.

Effective capacity management supports the use of products that are modular, scalable and also stable and predictable in terms of support and upgrades over the life of the product.

Capacity management has the following objectives:

- prediction and anticipation of future needs of the business due to both natural growth and new projects;
- implementation of actions on IT or environment to provide adequate resources;
- adjustment of infrastructure usage to the real needs of the business and prevent waste due to over-sizing of applications;
- determination of equipment usage;
- preparation of consolidation initiatives (see clause 9.3.4).

9.3.3.2 Environmental capacity management

This requires the measurement and subsequent management of electrical, cooling and space needs. In many cases this information is obtained manually, directly by the ICT site personnel. However, the best method is to apply software solutions.

Table 43 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 43: CLC/TR 50600-99-1 [1] practices addressing environmental capacity management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Review the availability of cooling and means of delivery before any changes to ICT equipment in order to optimize the use of cooling resources.	5.1.14
Provision power and cooling only to the planned power draw of the IT equipment as-configured (based on the components actually installed), rather than the Power Supply Unit (PSU) size or nameplate rating.	5.2.8

9.3.3.3 Storage capacity management

This involves the use of shared data storage, active data compression and data de-duplication in order to maximize the utilization of storage capacity. The implementation of thin provisioning for storage, allowing the right disk-space is critical to the management of storage capacity.

Table 44 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 44: CLC/TR 50600-99-1 [1] practices addressing storage capacity management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Implement a policy defining storage areas by retention policy and level of data protection. Provide multiple data storage areas which are clearly identified by their retention policy and level of data protection. Store data in an area which matches the required levels of protection and retention. Automate the application of these policies where practicable.	6.1.7
Define the required combinations of data storage performance, capacity and resilience. Create a tiered storage environment utilizing multiple media types delivering the required combinations. 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 performance level.	6.1.8
Implement an effective data identification and management policy to reduce the total volume of data stored. Consider implementing 'clean up days' where unnecessary data are deleted from storage.	6.1.10
Apply the data management policy to reduce the number of logical and physical copies of data. Implement storage subsystem space-saving features. Implement storage subsystem "thin provisioning" features where possible.	6.1.11
Log and report storage capacity and utilization. This can be the proportion of the overall or grouped by service/location storage capacity and performance utilized. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative. The meaning of utilization can vary depending on what is considered available capacity (e.g. ports, raw vs. usable data storage) and what is considered used (e.g. allocation versus active usage). Ensure the definition used in these reports is clear and consistent. Mixed incentives are possible through the use of technologies such as de-duplication.	6.1.29

9.3.3.4 Server capacity management

This involves the use of existing equipment when additional server capacity is required. This approach is a step towards the consolidation initiatives of clauses 9.3.4 and 9.4.3.

Table 45 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 45: CLC/TR 50600-99-1 [1] practices addressing server capacity management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Log and report processor utilization.	6.1.27

9.3.3.5 Network capacity management

Table 46 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 46: CLC/TR 50600-99-1 [1] practices addressing network capacity management

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Log and report processor utilization.	6.1.28

9.3.3.6 On-demand scalability for on-line business

This requires the implementation of pre-packaged virtual environments, including all logical components necessary to run the application, and a "utility computing" tool to distribute them across the infrastructure taking account of, for example, the number of connections to the service. A critical aspect is that the automated system has to be able to remove the additional capacity as soon as the number of connection decreases. Virtualization is the main key for this, as each new server installed is a Virtual Machine.

9.3.4 Server consolidation

9.3.4.1 Consolidation of servers

The consolidation of processing within existing servers is the best way toward reduce energy costs for given level of service. The result of consolidation is a reduction in the number of servers which has a direct impact on the ICT infrastructure power requirements which has a corresponding effect on reductions in requirements for cooling and floor space.

There are two types of consolidation that are covered in this clause:

- physical consolidation (see clause 9.3.4.2);
- virtualization (see clause 9.3.4.3).

9.3.4.2 Virtualization

Virtualization allows running several servers on the same physical server. It is a pre-requisite for a shared infrastructure policy. It does not change the number of servers but reduces the number of supporting physical servers.

Although virtualization bring no gains on total cost of ownership of supporting the physical infrastructure, its impact on operational expenditure is huge by:

- reducing electricity consumption as servers are more used;
- reducing network complexity as a fewer links are required;
- reducing maintenance as servers are undifferentiated and so can be easily replaced by spares;
- offering better availability as VM on a failed physical server can be automatically re-instantiated.

Table 47 shows the references for the relevant practices of CLC/TR 50600-99-1 [1] which support this topic. Further information can be obtained by reading the relevant reference.

Table 47: CLC/TR 50600-99-1 [1] practices addressing virtualization

Practice (information in any "Notes" of each practice is not shown)	Reference within CLC/TR 50600-99-1 [1]
Deploy grid and virtualization technologies wherever possible to maximize the use of shared platforms. Obtain senior management approval prior to implementing any new ICT service that requires dedicated ICT equipment and which will not run on a resource sharing platform.	5.2.13
Virtualize and then archive disk images of servers or services that are not used on a regular basis, but cannot be decommissioned for compliance or other reasons, to media with lower energy consumption.	6.2.4
Consolidate, through the use of resource sharing technologies, existing services that do not achieve high utilization of their hardware.	6.2.5

9.3.4.3 Physical consolidation

Physical consolidation involves the gathering of stand-alone hardware within a physically more powerful container, as shown in Figure 12 and can be achieved without using virtualization if the server technology allows partitioning features.

A physical consolidation programme has the following effects:

- reduction in the number of physical components (servers, storage arrays, robotics);
- savings on floor space, maintenance costs, cooling and power;
- capital expenditure for new hardware.

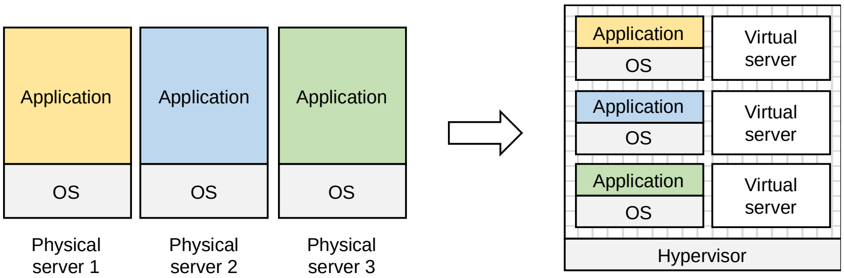

Figure 12: Physical consolidation and virtualization

9.3.5 Measurement, monitoring and reporting

Reporting the utilization of the ICT equipment is a key factor in optimizing the energy efficiency of the ICT sites. There are three different types of IT reporting; server, network and storage utilization:

- a basic level of internal reporting and logging of the processor utilization of the overall or grouped service/location IT server can be highly informative;
- the same analysis for the proportion of network capacity utilized can be expected;
- the proportion of storage capacity and performance utilized can be reported and used for IT optimization.

This is included in the relevant sub-clauses of clause 9.3.3.

9.4 Example outcomes

9.4.1 General

Table 48 shows the typical outcomes resulting from the implementation of energy management practices within the ICT equipment and associated cabling infrastructure.

Table 48: Typical outcomes resulting from energy management practices on ICT equipment

Description	Reference in the present document	Reference within CLC/TR 50600-99-1 [1]	Typical savings overall (see note 1) (%)	Implementation timescale
Removal of obsolete equipment	9.2.2	5.1.17	3,6	Short term
Select and develop efficient software	9.2.5	4.2.4 4.2.5	See note 2	Short term
Enablement of power management	9.3.2.1	5.2.7	4,5	Short term
Activation of sleep mode	9.3.2.2	6.2.7	13,5	Short term
Capacity management	9.3.3	5.4.4	3,6	Short term
Virtualization	9.3.4	5.2.13	18,0	Short term
NOTE 1: The overall saving shown assumes that ICT infrastructure initially constitutes 37 % of overall consumption of the ICT site. NOTE 2: Dependent on application.				

9.4.2 Power management

9.4.2.1 Activation of "sleep" mode

An active, last generation x86 mono or bi-processor, server has a typical mean consumption of 240 W. The same server in "sleep" mode has a typical consumption of 80 W and 0 W when switched-off.

In the experiment undertaken, 200 such servers were identified that could be put in sleep mode or switched off:

- during weekends and public holidays (e.g. 104 days plus 9 days);
- for 8 hours per day (for the remaining 252 days per year).

This suggests that 4 728 hours of operation (= 113 × 24 + 252 × 8 = 54 % per annum) would be impacted by sleep mode or switch-off.

The energy consumption reduction when sleep mode was activated for 54 % of the year would be:
(160 × 0,54)/240 = 36 %.

The energy consumption reduction when switched-off for 54 % of the year = 54 %.

For the 200 servers in the experiment this equates to approximately 150 000 kWh and 227 000 kWh respectively.

9.4.3 Server consolidation

9.4.3.1 Virtualization

Figure 13 provides a methodology to evaluate energy savings for a virtualized panel of servers. Other indirect savings could be also evaluated if the virtualization affects the cooling requirements in the computer room.

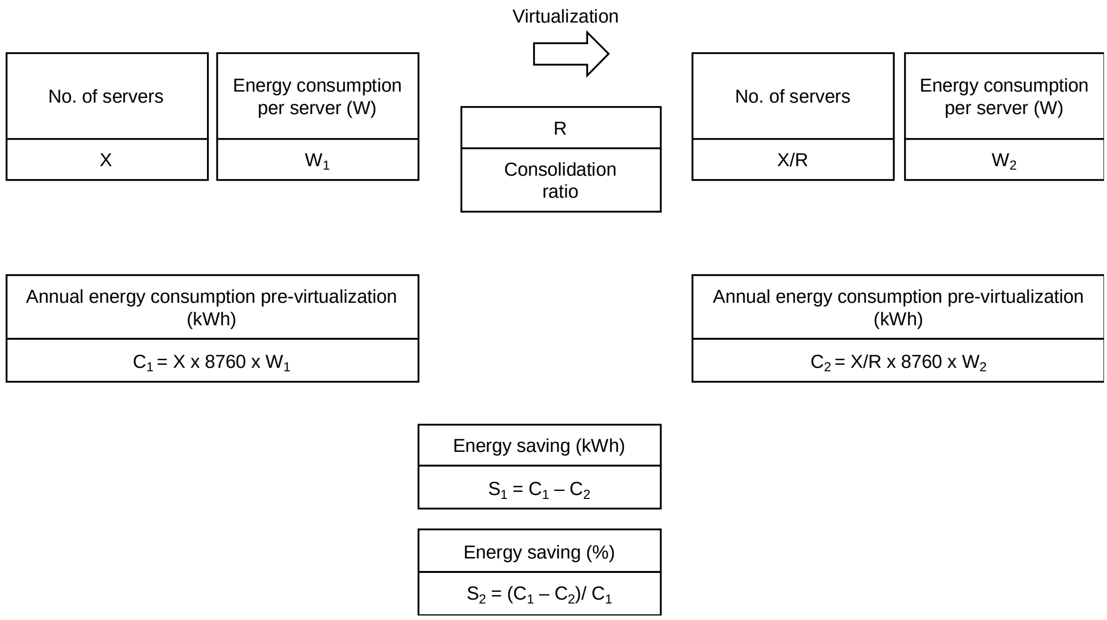

Figure 13: Energy savings from virtualization

An Objective KPI (KPI_{TE}) is specified as part of the Global KPIs for energy management in ETSI EN 305 200-2-1 [i.18] and ETSI EN 305 200-3-1 [i.20]. Since virtualization will decrease the energy consumption by ICT equipment, it will not improve (and may even have an adverse effect) on KPI_{TE} but it will reduce the overall energy consumption.

NOTE: Any savings will be ineffective unless the old servers are shut-down electrically.

Generally, mean values for energy savings using virtual environments are 40 % to 60 % of the energy consumed by the servers before virtualization. Under certain conditions, virtualization can deliver energy reductions of 80 % on a selected set of servers.

The following figures are provided by a major telecommunications organization that has launched a virtualization project on x86 servers under production.

In this example, the aim was to consolidate many physical servers of one multi-server application ($X = 170$, $W_1 = 290$ W) into new generation technology servers, associated with a virtualization tool. The legacy servers were 2 CPU Intel x86 "racked" servers from previous generation, containing one image of an operating system and one application instance. The new servers were Intel x86 4 CPU 2 core blade servers, racked.

The consolidation ratio (R) ≥ 12 (meaning that one new physical server contains at least 12 virtual servers) was achieved. The results are significant since in addition to applications subject to virtualization, the number of operating systems was also reduced.

A reduction, $S_{1,}$ of 384 932 kWh per annum was achieved representing a reduction in consumption, $S_{2,}$ of 89 %.

10 Mapping of ETSI EN 305 174-8 to CLC/TR 50600-99-2

10.1 ETSI EN 305 174-8 and ETSI TS 105 174-8

ETSI EN 305 174-8 [4] specifies requirements and recommendations for the ICT sector to contribute actively to the WEEE collection objectives as defined in the WEEE Directive.

ETSI TS 105 174-8 [5] support the requirements of ETSI EN 305 174-8 [4] by providing a framework for, and detailing, the necessary implementation procedures - and specifically extends the end-of-life aspects of ICT equipment to the treatment of components and sub-assemblies replaced during maintenance procedures.

10.2 Practices of CLC/TR 50600-99-2

Table 49 shows the references for practices within CLC/TR 50600-99-2 [i.1] that support the application of ETSI EN 305 174-8 [4] and ETSI TS 105 174-8 [5]. Further information can be obtained by reading the relevant reference.

Table 49: CLC/TR 50600-99-2 [i.1] practices addressing reduction of WEEE

Practice	Reference within CLC/TR 50600-99-2 [i.1]
Consider a maintenance strategy which maximizes the plant/system lifetime and repair rather than replacing where possible. This could involve leasing of plant.	8.2.2

In addition, there are environmental sustainability practices contained within CLC/TR 50600-99-2 [i.1] which could be converted into requirements because they are applicable to all sizes or types of ICT sites and which are independent upon the design and/or operation of the ICT site.

These practices relate to life cycle assessment (LCA), carbon footprint and "green procurement" and are shown in Table 50. Further information can be obtained by reading the relevant reference.

Table 50: CLC/TR 50600-99-2 [i.1] practices addressing reduction of environmental sustainability

Summary	Practice	Reference within CLC/TR 50600-99-2 [i.1]
Life Cycle Assessment	Implement a plan for life cycle assessment (LCA) in accordance with emerging EU guidelines and internationally standardized methodologies.	5.1
Review results from existing LCAs	Existing LCAs can provide insights into the highest areas of impact where the boundaries and assumptions are similar to those of a specific facility. In locations with a high renewable content in the grid, the embodied impacts become more significant. However for facilities using electricity with a high carbon intensity, actions to reduce the emissions associated with electricity consumption in use tend to have a higher impact.	5.2
Consider undertaking an LCA	This will provide information on the weighting of one area over another for the specific facility and help define which areas have the highest contribution towards environmental impact and therefore where actions should be focussed.	5.3
Environmental Management	Implement a plan for environmental management in accordance with emerging EU guidelines and internationally standardized methodologies. Consider appointing a cross functional Environmental Sustainability Manager to take responsibility for this initiative.	5.4

Summary	Practice	Reference within CLC/TR 50600-99-2 [i.1]
Monitor and report carbon footprint of in-use energy	Implementation of this action increases visibility of environmental impact and allows improvements to be tracked. The EU Eco-Management and Audit Scheme (EMAS) is possibly also relevant.	5.5
Green procurement	Include the relevant recommendations into procurement requirements. Additional information can be found in outputs from the EURECA (www.dceureca.eu) and EC JRC Data Centre Green Public Procurement (2018) projects.	5.6

There are other environmental sustainability practices contained within CLC/TR 50600-99-2 [i.1] which cannot be converted into requirements because they are not applicable to all sizes or types of ICT sites or are dependent upon the design and/or operation of the ICT site including those relating to source energy mix including the use of renewable or low carbon electricity.

NOTE: The Key Performance Indicators of ETSI EN 305 200-2-1 [i.18] and ETSI EN 305 200-3-1 [i.20] only take into account local generation of renewable energy or that generated in other premises under common ownership with the ICT site.

10.3 Eco-management and sustainability

10.3.1 Eco-design

Eco-design targets the reduction of environment impacts by savings of raw materials, energy consumption and transportation emissions in line with environmental sustainability objectives.

There are three elements of eco-design:

- eco-design for manufacturing with the use of minimal raw material quantities;
- eco-design for refurbishing and reuse;
- eco-design for end of life.

ISO 14045 [i.29] describes the recommendations, requirements and provides guidelines for the conduct of the assessment of eco-efficiency systems.

10.3.2 LCA

LCA is discussed in clause 10.2 and is standardized, in general, in ISO 14040 [i.27] and ISO 14044 [i.28] and which provide the basis of the following documents:

- ETSI TS 103 199 [i.25]: which establishes generic and specific requirements for LCA of ICT Equipment, Networks and Services and the document is valid for all types of Equipment which is/could be part of a Network.
- ETSI ES 203 199 [i.23]: which provides a methodology for evaluating the environmental impact of ICTs objectively and transparently.

10.3.3 Energy management

ISO 50001 [i.33] can be used to certify (in accordance with recognized certification schemes) an organization's policy and achievements in the area of energy management.

NOTE: It should be noted that ISO 50001 [i.33] certification focusses on continual improvements in the reduction, and improvements of efficiency of, energy consumption. Certification against the standard does not take account of renewable energy and energy re-use contributions which are the inherently important for the Global KPIs in ETSI EN 305 200-2-1 [i.18], ETSI EN 305 200-3-1 [i.20] and ETSI TS 105 200-3-1 [i.26].

Annex A (informative): ICT site Availability Classes

CENELEC EN 50600-1 [i.4] defines four Availability Classes for the critical infrastructures of data centres by separately specifying the requirements for:

- Power supply and power distribution by reference to CENELEC EN 50600-2-2 [i.6].
- Environmental control by reference to CENELEC EN 50600-2-3 [i.7].
- Telecommunications cabling infrastructure by reference to CENELEC EN 50600-2-4 [i.8].

These may be applied to the ICT sites of the present document.

These requirements are summarized in Table A.1.

Table A.1: Availability Classes and example implementations

	Availability Class 1	Availability Class 2	Availability Class 3	Availability Class 4
Power supply	Single path to primary distribution equipment - Single source	Single path to primary distribution equipment - Redundant sources	Multiple paths to primary distribution equipment - Redundant sources	Multiple paths to primary distribution equipment - Multiple sources
Power distribution	Single path	Single path with redundancy	Multiple paths - Concurrent repair/operate solution	Multiple paths - Fault tolerant except during maintenance
Environmental control	Single path	Single path with redundancy	Multiple paths - Concurrent repair/operate solution	Multiple paths - Fault tolerant except during maintenance
Telecommunications cabling	Single path - direct connections or fixed infrastructure with single access network connection	Single path - fixed infrastructure with multiple access network connections	Multiple paths - fixed infrastructure with diverse pathways with multiple access network connections	Multiple paths - fixed infrastructure with diverse pathways and redundant distribution zones and multiple access network connections

It has to be emphasized that the availability of one or more of the critical infrastructures listed above does not define the availability of the services provided by the ICT site since this is governed by the recovery time of the ICT equipment and associated software platforms and programmes operated in the ICT site.

These Availability Classifications are applicable to individual ICT sites. In some cases ICT sites configured across multiple locations can feature infrastructures of low Availability Class while maintaining the overall service availability objectives provided by the group of ICT sites. CENELEC EN 50600-1 [i.4] does not provide a mapping between the overall service availability of the multi-site group and that of the Availability Class of the infrastructures in any individual ICT site as this requires additional capabilities of the ICT services.

Annex B (informative): Historic issues in ICT sites

Clause 4.2 states that ICT sites comprise OS and NDC locations within the networks of broadband deployment.

Historically, NDCs have often migrated into existing OS which are typically located in buildings situated in urban areas. These buildings and their infrastructure were designed to accommodate NTE which had a power usage density several orders of magnitude lower than the modern ITE that has replaced it.

An unsatisfactory situation exists in legacy ICT sites where historical policies have created a situation where the rapid increase in the use of ITE, in the form of servers, has resulted in each application having its own dedicated physical server, sometimes as a result of running older operating systems not allowing virtualization features.

This lack of effective management of server capacity results in:

- low levels of CPU utilization with low energy efficiency;
- servers not being removed from service when they are no longer required.

The primary power supply to these locations was often not designed for the high levels of energy usage required by the technology now employed. Additionally, these existing buildings often have limited floor space that is difficult to increase due to commercial, building and planning constraints in urban areas; this, in turn, forces increased concentrations of processing capability. Legislative and environmental factors place severe constraints on the provision of the additional cooling equipment that becomes necessary.

The overall result of this is that many ICT sites operate at their limits in terms of energy consumption, environmental control and floor space utilization.

Modern building technology is capable of achieving far greater efficiency both in floor space utilization and energy usage; hence it is unlikely that the overall performance of legacy buildings could ever be made to approach that of purpose-built ICT sites. It is, therefore, probably necessary to consider these as separate cases when comparing energy performance.

However, as a general principle, all ICT sites are faced with rising energy costs and there continue to be concerns regarding its availability.

It is therefore increasingly necessary to employ new strategies and practices in the design and operation of ICT sites to improve energy efficiency by using:

- new generation ICT equipment with greater processing efficiency;
- better design and operation of environmental control.

Annex C (informative): The application of energy management metrics

ETSI EN 305 200-1 [i.19] establishes rules for the specification of metrics in the form of Global and Objective KPIs for energy management in networks of broadband deployment.

ETSI EN 305 200-2-1 [i.18], ETSI EN 305 200-3-1 [i.20] and ETSI TS 105 200-3-1 [i.26] define Global KPIs for ICT sites based on the following Objective KPIs:

- KPI_{EC}: total energy consumption;
- KPI_{TE}: task efficiency;
- KPI_{REN}: renewable energy generation;
- KPI_{REUSE}: reuse of waste energy produced by the environmental control system.

The CEN/CENELEC/ETSI Coordination Group on Green Data Centres produces free-of-charge documents which are updated annually to describe the general landscape of such standardization.

Annex D (informative): Bibliography

- ISO/IEC 30134-2: "Information technology - Data centres - Key performance indicators: Part 2: Power usage effectiveness (PUE)".
- Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency.

Annex E (informative): Change History

Date	Version	Information about changes
23/05/2019	V0.0.2	Changes made after initial circulation
25/06/2019	V0.0.3	Changes made after RoC of V0.0.2 but including more fundamental changes to address application of practices to all ICT sites
29/07/2019	V0.0.4	Stable draft

History

Document history		
V1.1.1	October 2009	Publication as ETSI TR 105 174-2-1 and ETSI TS 105 174-2-2
V1.2.1	January 2017	Publication
V1.1.1	February 2018	Publication as ETSI EN 305 174-2
V1.3.1	January 2020	Publication