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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

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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. Full details of the entire series can be found in part 1.

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).

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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. It is therefore important to maximize the energy efficiency of all the network elements necessary to deliver the required services.

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 present document is part 2 of a multi-part deliverable which has been produced by ETSI Technical Committee Access, Terminals and Transmission, Multiplexing (ATTM) in close collaboration with CENELEC via the Co-ordination Group on Installations and Cabling (CGIC). It offers a contribution to the required standardization process by establishing an initial basis for work on ICT general engineering, with active collaboration from a number of other ETSI and CENELEC Technical Bodies.

When complete, the multi-part deliverable will contain information that has been jointly evolved to present developments in installations and transmission implementation, and describing their progress towards energy efficiency in Next Generation Networks (NGN). In order to monitor the implementation and operation of energy efficient broadband deployment, the present document also discusses Data processing and Communication Energy Management (DCEM) for energy efficiency and focus on the possible consequences of standardization of installations, cabling techniques and equipment. In particular, the study will investigate possibilities and suggest solutions for development of processes for optimization in installation techniques and energy consumption.

1 Scope

The present document details measures which may be taken to improve the energy efficiency within ICT sites for broadband deployment. Clauses 2 and 3 contain references, definitions and abbreviations which relate to this part; similar information will be included in the corresponding clauses of the other parts, thus ensuring that each document can be used on a "stand-alone" basis.

Within the present document:

- clause 4 introduces ICT site concepts including those specifically related to network operators;
- clause 5 develops the concept of Data processing and Communication Energy Management (DCEM), introduced in ETSI GS OEU 001 [i.2];
- clause 6 details the approaches that may be employed to improve energy efficiency within the information technology infrastructure;
- clause 7 details the approaches that may be employed to improve energy efficiency within the communication technology infrastructure;
- clause 8 details the approaches that may be employed to improve energy efficiency within the environmental control systems;
- clause 9 details the approaches that may be employed to improve energy efficiency within the power distribution system;
- clause 10 details the approaches that may be employed to improve energy efficiency within the physical infrastructure;
- clause 11 provides a summary of energy efficiency approaches within ICT sites;
- annex A provides indications of the first order effect of applying the approaches outlined in clauses 6, 7 and 9;
- annex B contains the recommendations of the present document.

This will enable the proper implementation of services, applications and content on an energy efficient infrastructure, though it is not the goal of this multi-part deliverable to provide detailed standardized solutions for network architecture.

The present document focuses on energy efficiency. The CO_2 footprint is not taken in account to the present document but in the near future a regulation on CO_2 footprint will be will be created.

Two separate aspects of energy efficiency are considered as shown in figure 1:

- actions to improve energy efficiency in existing ICT sites in the short or medium term;
- actions to improve energy efficiency in new ICT sites, in medium or long term.

The domains under study are:

- in the Information Technology (IT) infrastructure: all aspects of the technical infrastructure in the ICT site, including servers, storage arrays, backup libraries and network equipment including routers, switches, etc.;
- in the IT operational strategy: all consolidation initiatives, such as virtualization, physical consolidations, usage of specific software and processes;
- in the technical environment: all aspects concerning energy usage, cooling and, more generally, all disciplines involved in the technical environment of the ICT site.

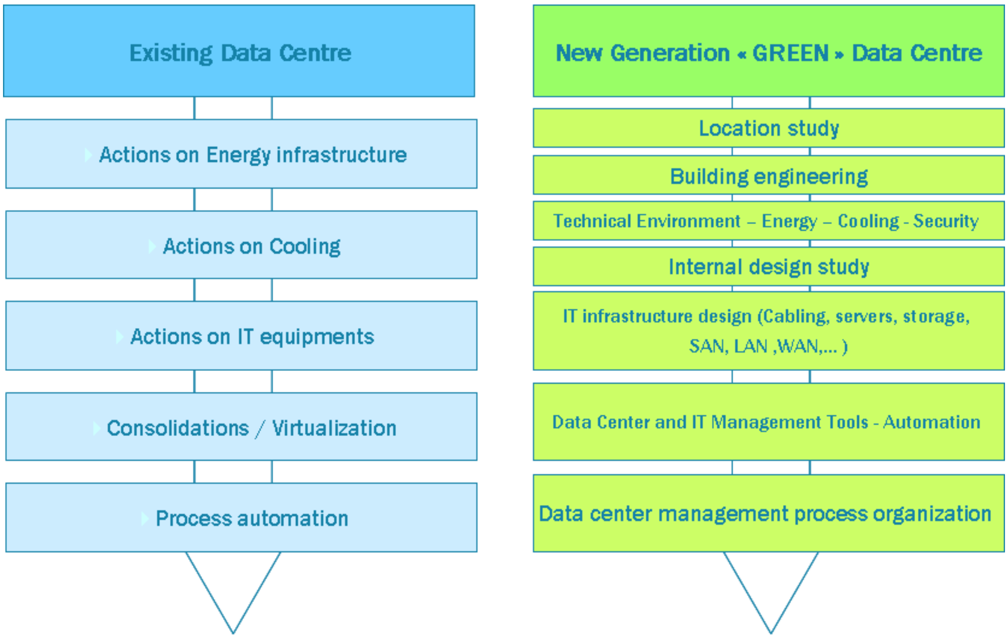

Figure 1: Aspects of data centres under consideration

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

[2] ISO 14045:2012: "Environmental management - Eco-efficiency assessment of product systems - Principles, requirements and guidelines".

[3] ISO 50001:2011: "Energy management systems - Requirements with guidance for use".

[4] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE).

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

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

[7] European Commission: "DG-JRC Code of Conduct on Data Centres Energy Efficiency".

[8] Recommendation ITU-T L.1300: "Best practices for green data centers".

[9] ETSI ES 205 200-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Global KPIs; Operational infrastructures; Part 1: General requirements".

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

[11] European Commission: "DG-JRC Code of Conduct on Energy Consumption of Broadband Equipment Version 5.0".

[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 weather protected locations".

[13] European commission: "DG JRC Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems (UPS)".

[14] 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".

[15] ETSI EN 300 132: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment".

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

[17] 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".

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

[19] ISO 14040: "Environmental management -- Life cycle assessment -- Principles and framework".

[20] ISO 14044: "Environmental management -- Life cycle assessment -- Requirements and guidelines".

[21] ETSI ES 203 237: "Environmental Engineering (EE);Green Abstraction Layer (GAL);Power management capabilities of the future energy telecommunication fixed network nodes".

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

[23] 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".

[24] ETSI EN 300 132-3: "Environmental Engineering (EE);Power supply interface at the input to telecommunications equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V".

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] ETSI TR 102 489: "Environmental Engineering (EE); European telecommunications standard for equipment practice; Thermal Management Guidance for equipment and its deployment".

[i.2] ETSI GS OEU 001: "Operational energy Efficiency for Users (OEU); Global KPI for ICT Sites".

[i.3] ETSI ES 205 200-3: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Global KPIs; Operational infrastructures; Part 3: Global KPIs for ICT sites".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

availability: time or period during the application or the service has to be operational

NOTE: Availability is one of the criticality criteria.

computer room: closed, secured and environmentally controlled room in which IT equipment is operating

criticality: level given to an application or service, linked to the impact for the enterprise in case of crash

NOTE: More the impact is strong, more the application or service is critical.

data centre: centralized repository for the storage, management, and dissemination of data and information organized around a particular body of knowledge or pertaining to a particular business

Data Centre Infrastructure Management (DCIM): set of automation tools for operations for managing and steering ICT site

data processing and communication energy management: overall performance of the operational infrastructures

disk array: cabinet containing physical disks

energy efficiency: search in existing DC, or for new future DC, of all tracks and actions allowing minimizing energy needs and costs

NOTE: Key drivers are Economic to decrease the energy bill by increasing the efficiency of all equipment and minimize power loss.

information technology equipment: equipment such as computers, servers, mainframes, calculators and all storage devices as arrays, libraries, tape robots together with routers and switches within the local area networks

IT equipment power: total power needed for operate servers, racks, disk arrays, libraries, network telecommunications equipment (such as routers and switches), equipment used for monitoring the data centre (PC, laptops, terminals and workstations) and network telecommunications-specific equipment (such as DSLAM and BTS)

green data centre: site that is energy efficient (consumption, energy re-use, renewable energy) and has a minimum carbon footprint

NOTE 1: Energy Efficiency is one way, to decrease CO_2 emissions, but it is not the only one.

NOTE 2: More "sustainable development" objective than economic, the key indicator is carbon footprint. Today, this concept is not still clearly defined, especially since data centres are not major producers of CO_2, but indirectly, due to their energy needs. If the source of power is becoming from renewable energies (hydraulic, solar, etc.) or nuclear (not so green for earth, but not producing CO_2) the carbon footprint of the data centre is low. But if energy is becoming from coal, or fuel the CO_2 emissions are high.

global KPI: KPI of an operational infrastructure which presents information from a number of separate objective KPIs

mainframe: high-performance computer used for large-scale computing purposes that require greater availability and security than a smaller-scale machine can offer

network telecommunications equipment: equipment providing direct connection to core and/or access networks including switches, DSLAM, BTS

objective KPI: KPI assessing one of the objectives of energy management or environmental viability of an operational infrastructure which may be subsequently used to define a global KPI

operator site: premises accommodating network telecommunications equipment providing direct connection to the core and access networks and which may also accommodate information technology equipment

physical server: box containing supplies for energy, mother board, central processing unit, memory, slots

server: computer program that provides services to other computer programs (and their users) in the same or other computers

technical KPI: KPI assessing the energy management or environmental viability of a component, sub-assembly, product or sub-system under a specified set of conditions

total computing load: total computing power in the data centre, that can be evaluated by taking vendors specifications of computational power of each model of server multiplied by the number of servers (transactions per minute is one measure of total computing power)

total facility power: total power used by all power delivery components (such as uninterruptible power supplies, switches, power distribution units, batteries and transformers), cooling system components (such as chillers, computer room air conditioning units, pumps, fans, engines) and the non-technical energy (such as building lighting)

utility computing: service provisioning model in which a service provider makes computing resources and infrastructure management available to the customer needs

NOTE: Like other types of "on-demand computing" (such as grid computing), the utility model seeks to maximize the efficient use of resources and/or minimize associated costs. This approach is becoming increasingly common in enterprise computing and is sometimes used for the consumer market as well, for internet service, web-site access, file sharing, and other applications.

Virtual Machine (VM): emulation of a physical server on a shared infrastructure

NOTE: Virtual machine embeds Operating System, specific software and applications.

virtual server: "piece" of physical server dedicated to run a "virtual machine

virtualization: software that separates applications from the physical hardware on which they run, allowing a "piece" of physical server to support one application, instead of requiring a full server

virtualization ratio: number of Virtual Machines per server

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI ES 205 200-3 [i.3] and the following apply:

AC	Alternative Current
AC/DC	Alternating Current/Direct Current
ADSL	Asynchronous Digital Subscriber Line
ATTM	Access Transmission Terminal and Multiplexing
BREEAM	Building Research Establishment Environmental Assessment Method
CGIC	Co-ordination Group on Installations and Cabling
CPU	Central Processing Unit
CRAC	Computer Room Air Conditioning
CRIP	Club des Responsables d'Infrastructure et de Production
DC	Data Centre
DCEM	Data processing Communication Energy Management
DCIM	Data Centre Infrastructure Management
DRP	Disaster Recovery Plan

FFS	For Further Study
GAL	Green Access Layer
HQE	Haute Qualité Energétique
HVDC	High Voltage Direct Current
ICT	Information Communication Technology
IEC	International Electrotechnical Commission
IS	Information Systems
ISP	Internet Service Provider
IT	Information Technology
ITIL	IT Information Library
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Analysis
M2M	Machine To Machine
MW	Megawatt
NGN	Next Generation Network
OS	Operating System
PCB	Printed Circuit Board
PDU	Power Distribution Unit
POD	Performance Optimized Datacentre
PUE	Power Usage Effectiveness
RTO	Recovery Time Objective
SAN	Storage Area Network
TCO	Total Cost of Ownership
TN	Terre Neutre

NOTE: Electricity: way Neutral & Protective are implemented.

TNS	Terre Neutre Séparés

NOTE: Electricity: Neutral & Protective using different wires.

TP	Transactional Processing
TV	TeleVision
UPS	Uninterruptible Power Supply
VAC	Volts Alternative Current
VDC	Volts Direct Current
VM	Virtual Machine
VOD	Video On Demand
VOIP	Voice Over IP

4 Overview of ICT sites

4.1 Types of ICT sites

There are a number of different types of ICT site:

- **a network data centre** has the primary purpose of the delivery and management of broadband services to the operator's customers. To enable their functionality, all network data centres shall be connected to at least one core network operator site. For reasons of network resilience, data centres will invariably be connected to more than one operator site and to several other data centres. Data Centres may serve core networks operated by several network operators, thus enabling traffic between customers of different network operators;

- **an enterprise data centre** has similar functions and connectivity functions and connectivity to that of a network data centre but has the primary purpose of the delivery and management of services to its employees and customers;

- **a co-location data centre** is one in which multiple customers locate their own network, server and storage equipment and have the ability to interconnect to a variety of telecommunications and other network service providers. The support infrastructure of the building (such as power distribution, security, environmental control and housekeeping services) is provided as a service by the data centre operator;
- **a co-hosting data centre** is one in which multiple customers are provided with access to network, server and storage equipment on which they operate their own services/applications and have the ability to interconnect to a variety of telecommunications and other network service providers. Both the information technology equipment and the support infrastructure of the building are provided as a service by the data centre operator;
- **an ICT nodes/Network operator site** is the network sub-system in the core network that enables the connectivity between network data centres and customer premises over which the required services can be delivered, using the access network. In turn, operator sites also enable indirect connectivity between customer premises. Operator sites will almost invariably each serve many thousands of customer connections. Each customer connection may be comprised of multiple communication paths and serve a variety of applications. **Servers and storage** are the core of ICT they centralized data storage or network communications resources and provide and organize access to these resources for other networks linked to it.

This clause will identify and explain the elements of the network sub-systems employed in broadband deployment.

4.2 Availability classes of ICT sites

4.2.1 Availability Class and criticality

Several levels of ICT sites have been defined, based on the criticality of the applications or the business processed which determine the global Recovery Time Objective (RTO). The lower the RTO, the more the ICT site has to be supported by the use of redundant equipment in both the technical environment and IT infrastructure domains.

A number of schemes defining the levels of ICT sites have been developed that are considered in the following clauses.

CENELEC EN 50600-1 [1] defines requirements for reliability and availability of ICT sites, including the associated redundant support infrastructures, based on four different qualitative " Availability Class" as shown in table 1.

Table 1: Availability Classes and example implementations (CENELEC EN 50600-1 [1])

	Availability Class 1	Availability Class 2	Availability Class 3	Availability Class 4
Availability of overall set of facilities and infrastructures	Low	Medium	High	Very high
Example for power distribution	Single-path (no redundancy of components)	Single-path (resilience provided by redundancy of components)	Multi-path (resilience provided by redundancy of systems)	Multi-path (fault tolerant even during maintenance)
Example for environmental control	No specific requirements	Single-path (no redundancy of components)	Single-path (resilience provided by redundancy of components)	Multi-path (resilience provided by redundancy of systems), allows maintenance during operation
Example for telecommunications cabling	Single-path using direct connections	Single-path using fixed infrastructure	Multi-path using fixed infrastructure	Multi-path using fixed infrastructure with diverse pathways

ICT sites should be designed with different areas which will not only provide energy efficiency but also minimize Capex and Opex, by considering:

- high density areas, treated separately from other areas, in small rooms;
- traditional computer rooms, with a kW/m² ratio;

- segregation of mission-critical from non-strategic business equipment;
- several environmental conditions regarding the redundancy of the equipment and/or the free/water cooling capabilities during the year.

This is shown schematically in figure 2.

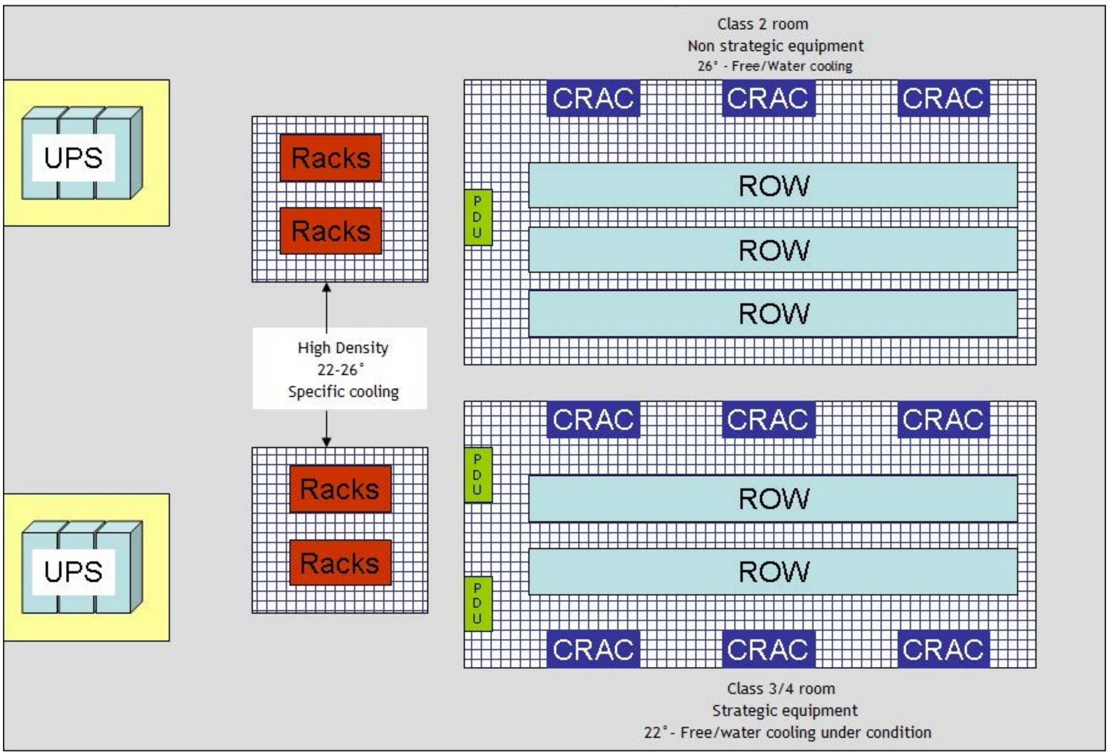

Figure 2: Environmental condition for different Classes

4.2.2 Resilience

Resilience determines the level of redundancy of energy or cooling equipments in an ICT site. Only the level of resilience and therefore availability currently justified by business requirements and impact analysis should be built, or purchased in the case of a collocation customer.

There are two trends for ICT site:

- A single level of resilience is available in the ICT site. Splitting the IT platform across multiple sites should increase resilience or availability for critical services.
- A single ICT site can provide multiple levels of power and cooling resilience to different floor areas.

Utilize appropriate levels of resilience at the ICT site, IT equipment, software and network levels to achieve the required service resilience and availability.

An ICT sites should be planning for modular expansion and then building out this capacity in a rolling program of deployments is more efficient and avoid excess power and cooling capacity. The design of all areas of the ICT site should maximize the achieved efficiency of the facility under partial fill and variable IT electrical load. This is in addition to one off modular provisioning and considers the response of the infrastructure to dynamic loads.

4.3 Issues faced by ICT sites

4.3.1 General

Clause 4.3 reviews the situation in existing ICT sites and the issues that all enterprises are facing now or will face in the near future.

There are several types of ICT site, from main strategic buildings, running enterprise, "mission critical" applications, for which maximum security and guarantee of service continuity is mandatory, to technical sites or computer rooms, for which the same level of integrity is not required This will have a direct and significant consequence on the energy costs, due to redundancy of the technical environmental and the IT infrastructure.

4.3.2 Current issues

4.3.2.1 Overview

The information in table 2 summarizes the results obtained from an internal benchmarking exercise undertaken by the enterprise members of Club des Responsables d'Infrastructure et de Production (CRIP).

NOTE: CRIP is a French organization representing major companies such as in the banking, telecommunications, insurance, car manufacturing and general industrial sectors.

Table 2: Average values of actual situation (CRIP source)

Aspect of ICT site design	**No. of servers**	
	100 to 200	**> 200**
Floor space for IT equipment (m^2)	139	2 405
Average total floor space of the data centre (m^2)	2 987	4 538
Average power consumption (W/m^2)	86	655
Autonomy following total failure of external electrical supply (days)	10	
	(% of those surveyed)	
Redundancy of electrical systems	67	94
Redundancy of cooling systems	91	91
Redundancy of telecommunications networks and rooms	58	90
Existence of local disaster recovery plan (DRP)	46	
Existence of campus mode DRP (dual sites within 10 km)	22	
Existence of metropolitan DRP (sites within 10 km to 100 km)	26	
Existence of continental DRP (sites separated by more than 100 km)	18	
Existence of effective DRP	51	
Supervision and control room backup	40	

4.3.2.2 Principle issues

An unsatisfactory situation exists in legacy ICT sites as a result of historical policies for the provision of servers, often with each application having its own dedicated physical server, sometimes as a result of running older operating systems not allowing virtualization features. As a result, these servers may have a Central Processing Unit (CPU) usage of only 10 % to 20 %, resulting in very low energy efficiency. One of the reasons for this has been the lack of effective management of server capacity, another consequence of which is that servers may not be removed from service when they are no longer required. The overall result of this is that many ICT sites are now at their limits in terms of energy, cooling and floor space.

Research surveying benchmarked significant enterprises indicates that the most significant concerns in existing ICT sites are:

- lack of energy;
- lack of cooling;
- absence of upgrade path due to new environmental legislation and other constraints;

- energy costs;
- new generation hardware, more efficient but creating areas with high energy density (from 0,7 kW/m^2 to 20 kW and potentially 40 kW per rack in 2014);
- low usage of servers, especially Windows and Linux (10 % to 20 %).

Nevertheless, unless improvement in energy efficiency are implemented it is clear that energy costs, as a proportion of the Total Cost of Ownership (TCO), which increase from a typical level of 10 % to 50 %, meaning that energy costs (Opex) will exceed annual IT Capex.

4.3.2.3 Operator data centres

Historically, network data centres have often migrated into existing operator sites which are typically located in urban areas. The primary power supply to these locations was often not designed for the high levels of energy usage required by the technology now employed.

These buildings and their infrastructure were designed to accommodate network telecommunications equipment which had a power usage density several orders of magnitude lower than the modern information technology equipment that has replaced it. 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 data centre complexes. It is, therefore, probably necessary to consider these as separate cases when comparing energy performance.

Additionally, these existing buildings often have a shortage of 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.

As energy costs continue to rise and concerns regarding its availability increase, it will become even more necessary to employ new generation hardware with greater processing efficiency.

These factors require new strategies and practices to be employed in the design and operation of data centres, particularly in relation to energy efficiency.

4.3.3 Evolution

4.3.3.1 Power and cooling demands of IT equipment

The technology road-maps of the main IT equipment (servers and/or storage) vendors road-maps show that predicted power consumption values (in terms of kW/m^2) are not aligned with the capabilities of the majority of computer rooms within ICT site facilities (both in terms of power provisioning and cooling capacity).

New technologies of servers (such as blades, chassis and Unix mainframes) have power requirements that exceed the capacity of computer rooms. Examples of such increases are from 0,5 kW/m^2 to 0,7 kW/m^2 to 4 kW/m^2 or 6 kW/m^2 in the two next years, and much more (10 kW/m^2) in the five next years.

Such increases make the concept of kW/m^2 as a design criterion irrelevant and introduce a new evaluation method based on kW into a rack, forcing designers to consider high density areas within ICT sites with the necessary electrical power and cooling systems. These areas may be specially configured areas within a traditional computer room (see figure 13 and figure 14) allowing the remaining space to accommodate low-density equipment such as robotics, backup libraries, network switches, etc.

The maximum density of a room is defined by the amount of calories to dispel to maintain some temperature and shall be calculated with this formula:

$$\mathbf{Q = C_P \times \Delta T \times F}$$

Where:

Q = the amount of calories dissipated [W]

$\mathbf{C_P}$ **=** specific heat capacity [Wh/m^{3}K]

ΔT = the temperature difference between the inlet and outlet of the device [K]

F = airflow driven [m^3/h]

4.3.3.2 Environmental impacts

Regulations frequently require a prolonged case-by-case study by authorities which can introduce significant delays to the planning process. These constraints make it very difficult if not impossible to implement projects for the expansion of an existing data centre in towns which would increase heat dissipation or have significant energy requirements.

In the near future the carbon footprint of ICT site will be introduced into a new European regulation.

4.4 The new context

4.4.1 Energy consumption and energy efficiency

The model "one application, one physical architecture", each with its own servers, storage, is becoming obsolete and is being replaced by a new model based on shared IT components and mutualisation of technical infrastructure. The ICT sites is now an industrial space, (see clause 10.4) with automation and industrialization and will become fully virtualized as described in clause 6.

New "energy efficient" equipment in all domains of IT, new cooling technologies (including solutions that only become practical as the power densities increase) and other solutions to manage power consumption more efficiently will all act to enable a reduction in energy costs for a given level of service. However, the greatest savings will only be obtained if other initiatives reflecting the "utility computing" concept are fully implemented (such as consolidation, automated provisioning of servers (network or storage) and recurrent operations).

The search for energy efficiency has to cover all disciplines and not only focus on the technical environment.

4.4.2 Factors impacting energy efficiency

The factors shown in table 3 contribute to poor energy efficiency and, consequently, high energy consumption.

Table 3: Principle factors leading to poor energy efficiency

Power distribution systems	Power distribution units and/or transformers operating well below their full load capacities.
	N+1 or 2N redundant designs, which result in underutilization of components.
	Decreased efficiency of Uninterruptible Power Supply (UPS) equipment when run at low loads.
Cooling systems	Air conditioners forced to consume extra power to drive air at high pressures over long distances.
	Pumps with flow rate automatically adjusted by valves (which reduces the pump efficiency).
	N+1 or 2N redundant designs, which result in underutilization of components.
Physical infrastructure	Under-floor "noodleware" that contribute to inefficiency by forcing cooling devices to work harder to accommodate existing load heat removal requirements, which can lead to temperature differences and high-heat load areas might receive inadequate cooling.
	Lack of internal computer room design.
IT infrastructure	Low usages of existing servers (10 % to 20 % CPU) especially in X86 world.
	Lack of capacity management process for technical environment and IT.
	Physical servers dedicated to applications.
	No consolidation, lack of sharing policy.
	Data redundancy, generating lot of storage capacity.
	IT equipment in active mode 24/24, 7/7 but only used at certain hours of the day and/or on certain days.
	Old generations of servers, with a low computing power/electrical consumption ratio.
	Lack of functional cartography, generating a lot of applications, data duplications, backups, and bit rate for exchanges, that contribute to dramatically increase the TCO (number of physical components, software fees, people, space floor, etc.) and energy consumption.

The actual situation is more generally the consequence of an important growth of the needs in term of IT equipment, due to the natural growth of the enterprises business and the creation of new services. Another factor increasing the IT load is that the functional cartography is very complex and generates a lot of applications.

Sometimes, the best way to make the maximum savings on energy is to decrease the number of applications and minimize data duplications.

4.5 Eco-management and sustainability

4.5.1 General

The Life Cycle Assessment goal is to measure the impact on the environment according to 11 criteria and the most important are: carbon dioxide equivalent gas emissions, energy, non-renewable resources and water consumption. The first step is to make an inventory with a first LCIA on the whole life cycle to see where are the impacts on the environment (manufacturing, use, transportation or end of life treatment) and therefore target the impacts on which company should act while respecting the continuity of the group strategy.

At the very beginning it is necessary to take into account the whole life of the product, from design to reuse, upgrading or recycling. When the critical phases are identified, the calculations can concern only these phases if one is sure not to transfer the impacts on another phase (reducing the CO_2 impact, but increasing impact on water).

4.5.2 Review of activities outside ETSI

Standards to be taken into account are:

- ISO 14045 [2] describes the recommendations, requirements and provides guidelines for the conduct of the assessment of eco-efficiency systems.
- ISO 50001 [3] guides organizations in the implementation of an energy management system that will allow them to make a better use.

4.5.3 Eco-design

Eco-design should be an important step for sustainability, because of its possibilities to efficiently reduce impacts on environment with savings of raw materials, energy consumption and transportation emissions. This term represents the will to create products in compliance with sustainability and environmental respect.

Three different types 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.

These involve a difficult balance between the group's strategy, the supply chain, the designers, the marketing and sustainability and corporate social responsibility.

4.5.4 Waste management

4.5.4.1 Waste Electrical and Electronic Equipment (WEEE)

The WEEE Directive known as 2002/96/EC [4] specifically requires:

- separate collection of WEEE, with a collection target of 4 kg/year/capita in 2006 for household waste and an obligation to take back old equipment free of charge when similar new household equipment is purchased;
- systematic treatment of specific components (such as PCB condensers, printed circuit boards) and of substances classified as dangerous (such as mercury, CFCs) to prevent pollution;

- reuse, recycling and recovery of collected WEEE with high recycling and recovery targets, with the reuse of whole devices being identified as the priority.

4.5.4.2 End-of-life

This part should not be neglected as the potential gains can be substantial. Waste management should be used for equipments, cooling and hardware of the ICT sites.

Two types of end of life shall be implemented:

- Reuse through a functional rehabilitation and aesthetic aimed at export or for a new rent for example;
- The recovery of raw materials like metals by recognized organizations.

4.5.5 LCA methodology

Following the ETSI methodology for LCA provides the quality that practitioners should strive to calculate the impacts on environment of ICT sites.

ETSI TS 103 199 [5] 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* including *end-user Equipment*.

Common ETSI ES 203 199 [6] provides a methodology for evaluating the environmental impact of ICTs objectively and transparently, and is based upon the life cycle assessment (LCA) methodology standardized by ISO (ISO 14040 [19] and ISO 14044 [20]).

5 Energy efficiency standards and metrics

5.1 Review of activities outside ETSI

5.1.1 EU Code of Conduct on Data Centres Energy Efficiency

The European Union Code of Conduct [7] provides the opportunity for operators of data centres to implement practices intended to reduce the energy consumption of their data centres. Details of the energy efficiency best practices [7] that are employed are detailed together with actual recorded energy consumption measured at specific points in the data centre.

5.1.2 Recommendation ITU

Recommendation ITU-T L.1300 [8] describes best practices aimed at reducing the negative impact of data centres on the climate. The application of the best practices defined in this Recommendation can help owners and managers to build future data centres, or improve existing ones, to operate in an environmentally responsible manner. Such considerations will strongly contribute to a reduction in the impact of the information and communication technology (ICT) sector on climate change.

5.2 Objective Key Performance Indicators

The Objective KPIs described in the documents of ETSI ES 205 200-1 [9] relate to specific elements of energy management for operational infrastructures under the control of operators as follows:

- energy consumption ($KPI_{EC)}$): the total consumption of energy by an operational infrastructure ;
- task efficiency (KPI_{TE}): a measure of the work done for a given amount of energy consumed (closer to former PUE);
- energy re-use ($KPI_{REUSE)}$): is the yearly energy reuse rate transfer or conversion of energy produced by the operational infrastructure to do other work;

- renewable energy (KPI_{REN}): is the yearly use rate of energy coming from dedicated generation systems using resources that are naturally replenished;

The set of Objective KPIs are used to define a Global KPI (KPI_{DCEM}) that allows benchmarking the energy management efficiency of ICT sites depending on their gauge.

5.3 Energy consumption in ICT sites

Of the total energy used in an ICT sites, the principal areas of consumption, shown schematically in figure 3, are:

- power distribution to information technology equipment and network telecommunications equipment in the computer room;
- environmental control (for example, cooling and humidity) applied to the computer room;
- lighting and equipment in offices associated with the data centre;
- lighting for the computer room.

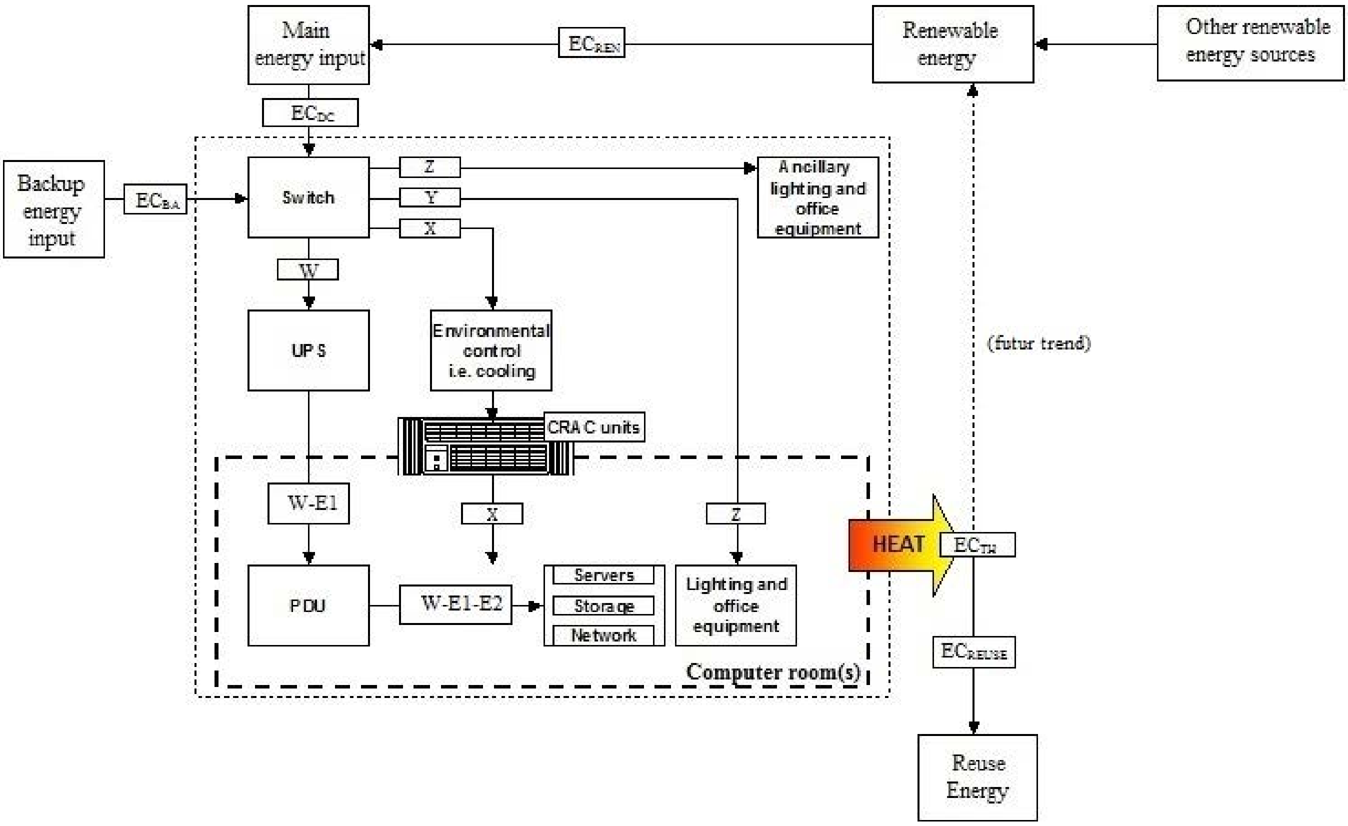

Figure 3: Schematic of energy consumption and wastage in ICT sites

With reference to figure 3:

- the proportion of the energy delivered to the information technology equipment is EC_{HE} = W - E1 - E2 where:

W = energy consumption at the input to the UPS;

E_1 = energy wasted within/by of the UPS;

E_2 = energy wasted within/by of the PDU;

- the energy consumed by the entire ICT site EC_{DC} = W + X + Y + Z;
- the energy consumed by the environmental control equipment X;

- the energy consumed by building facilities Y+Z;
- the energy reuse for external uses EC_{REUSE};
- the renewable energy use in the main energy input EC_{REN}.

With reference to figure 3 and ETSI ES 205-200-1 [9]:

$$KPI_{EC} = EC_{DC}$$

$$KPI_{TE} = \frac{EC_{DC}}{EC_{HE}}$$

5.4 Energy Efficiency Key Performance Indicators (KPIs)

5.4.1 Data processing and Communication Energy Management (DCEM)

5.4.1.1 Global KPI (KPI_{DCEM}) using the Objective KPIs

The Global operational KPI reflects the overall performance of the operational infrastructures against wider energy management targets.

KPI_{DCEM} is composed of two values, DC_G and DC_P, where:

- DC_G defines the energy consumption gauge of the DC;
- DC_P defines the performance of the DC for the relevant gauge.

Table 4: Default Gauges (DC_G)

DC_G	KPI_{EC} range
XXS	$KPI_{EC} \leq 0{,}04$ GWh
XS	0,04 GWh < $KPI_{EC} \leq 0{,}2$ GWh
S	0,2 GWh < $KPI_{EC} \leq 1$ GWh
M	1 GWh < $KPI_{EC} \leq 5$ GWh
L	5 GWh < $KPI_{EC} \leq 25$ GWh
XL	25 GWh < $KPI_{EC} \leq 100$ GWh
XXL	$KPI_{EC} > 100$ GWh

Table 5: Default Classes of DC_P

DC commissioning date	**since 2005 (see note)**		**before 2005 (see note)**	
	DC_P		DC_P	
Class	≥	<	≥	<
A		0,70		1,00
B	0,70	1,00	1,00	1,40
C	1,00	1,30	1,40	1,70
D	1,30	1,50	1,70	1,90
E	1,50	1,70	1,90	2,10
F	1,70	1,90	2,10	2,30
G	1,90	2,10	2,30	2,50
H	2,10	2,40	2,50	2,70
I	2,40		2,70	
NOTE: Year of Kyoto Protocol entering into force.				

The following formula applies to the calculation of DC_P for all the gauges:

$$DC_P = KPI_{TE} \times (1 - W_{REUSE} \times KPI_{REUSE}) \times (1 - W_{REN} \times KPI_{REN})$$

Where:

W_{REUSE} = Mitigation factor for KPI_{REUSE} (the value may vary depending on the gauge (ffs) within the range 0 to 1, the default value is 0,5).

W_{REN} = Mitigation factor for KPI_{REN} (the value may vary depending on the gauge (ffs) within the range 0 to 1, the default value is 0,5).

The Global KPI_{DCEM} is presented as a combination of the two values, DC_G and DC_P, in the following form: Gauge (see table 1), Class (see table 2), e.g. M, C.

All measurement points and processes of all KPI(s) for ICT sites are described in ETSI GS OEU 001 [i.2].

All KPI(s) should be applied to all ICT sites, of all sizes, include IT room in building and applied to all states of ICT sites, from initial to end of life.

5.4.1.2 Global KPI (KPIDCEM) using the Objective KPIs for a group of ICT sites

The set of Objective KPIs as defined in clause 5.2 are used to define a Global KPI (KPI_{DCEM}) for a group of ICT sites. That allows benchmarking the energy management efficiency of a group of ICT sites depending on its gauge.

DC_{EM} is composed of two values: Energy consumption Gauge and Class. The Gauge depends on the global energy consumption by all the ICT sites in the group and the Class is a weighted average of all ICT classes.

Note: DC_P is not used in the calculation of classes for group of ICT sites.

For a Group of ICT sites: $KPI_{ECG} = \sum_{i=1}^{n} KPI_{EC}(i)$ = KPI_{EC} for ICT site i.

For groups of ICT sites, gauges are not used. The actual consumption KPI_{ECG} is reported in combination with the group class.

KPI_{ECG} is the total consumption of energy by the group of ICT sites as defined in clause 4.3.2.

The default number of DC_{GG} gauges is 7 as shown in table 6 can be adapted by the user of the KPI_{DCEM}.

Table 6: Default Gauges (DC_{GG})

DC_{GG}	KPI_{ECG} range
XXS	$KPI_{EC} \leq$ 0,4 GWh
XS	0,4 GWh < $KPI_{EC} \leq$ 2 GWh
S	2 GWh < $KPI_{EC} \leq$ 10 GWh
M	10 GWh < $KPI_{EC} \leq$ 50 GWh
L	50 GWh < $KPI_{EC} \leq$ 250 GWh
XL	250 GWh < $KPI_{EC} \leq$ 1 000 GWh
XXL	KPIEC > 1 000 GWh

The class associated with a group of ICT sites is a weighted average of all ICT sites classes and the DC_p is the same as the table 5.

$$NumClassG = \frac{\sum_{i=1}^{n} NumClass\ (i) * KPI_{EC}(i)}{\sum_{i=1}^{n} KPI_{EC}(i)}$$

Where NumClass = class number, A=1…I=9.

5.4.1.3 Relationship between KPI(s)

At the most basic level, individual components or sub-assemblies can be designed to have improved task efficiency such components or sub-assemblies may be inherently more efficient in the way in which they use energy under specific operating conditions but are essentially unable to manage that consumption.

More complex products may contain hardware and/or software which automatically reduce energy consumption under specific operating conditions by putting certain functions into "idle" states if not required. This is distinctly different than that of a single task component or sub-assembly detailed above.

Technical KPIs can be applied to both of the above by assessing energy consumption for a number of specific operating conditions and also across a combination of such operating conditions. Assuming those operating conditions reflect the probable operating environment for the component, sub-assembly or product, a customer may make valued judgements in relation to the appropriateness of the technical KPI.

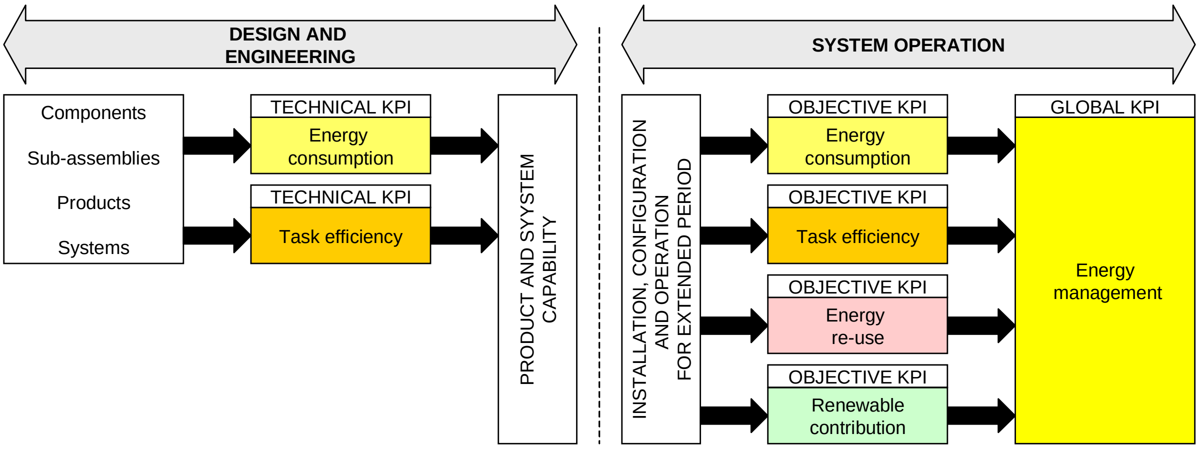

Figure 4: The relationship of energy-related Technical, Objective and Global KPIs

Operational Global and Objective KPIs are fundamentally different to the Technical KPIs applied to products and systems at the design and engineering stages. The former are used to monitor and drive user behaviour whereas the latter are substantial indications of potential operational performance.

It is therefore important to support, but differentiate, the role of the Technical KPIs from the Objective and Global operational KPIs.

5.4.1.4 KPI_{DCEM} for ICT sites

An ICT site under construction can be designed to have a specified KPI_{TE} and following construction the actual KPI_{TE} can be monitored against the design value. However, it should be recognized that any reduction of W (by means of improvement of the information technology or network telecommunications equipment or its usage, and by reduction of waste in the power distribution system, E_1 or E_2) without an equivalent reduction in the primary energy consumption parameters, X, Y and Z, will lead to worse energy efficiency.

As described in clause 10, the selection of ICT site location, building engineering strategies and system selection can substantially reduce the energy consumption required for environmental control. As described in clause 9, effective planning of pathways and spaces in accordance with CENELEC EN 50600-1 [1] and the ICT site specific aspects of CENELEC EN 50600-2-3 [10] can maximize the energy efficiency of environmental control systems.

As described in clause 6, internal design studies can influence the usage of equipment (servers, storage and networking). In addition, appropriate management tools used in conjunction with effective process organization and automation can significantly reduce the overall energy consumption of the information technology equipment.

The introduction of high efficiency power distribution components as described in clause 9 can reduce the value of W.

There is little opportunity within existing buildings to reduce energy consumption by modifications to building structures or to make substantial changes to the environmental control systems without incurring significant costs and operational disruption.

Small improvements may be achieved by limited changes to environmental control systems and general improvements in energy efficiency, in power distribution components and ancillary areas thereby reducing the values of E_1, E_2 and W in figure 4.

Procurement of more energy efficient IT equipment and consolidation/virtualization/process automation initiatives represents the only realistic solution for a reduction in energy consumption in existing buildings for a given level of services.

However, these actions without an equivalent reduction in the primary energy consumption parameters, X, Y and Z as efficiency rather than recognizing a reduction in energy usage.

5.4.1.5 Data collection

The production of the KPIs in clause 5.3 requires the collection and aggregation of a wide range of data as shown in table 6.

Table 7: Data required for the production of consolidation KPIs

Vendors characteristics of all equipment in the data centre	Vendor
	Model, type
	Number of CPU , cores
	Computational power
	Electrical consumption (idle, full load)
	Heat dissipation
	Weight,
	Size
Inventory database from all equipment of the data centre	Per data centre
	Per computer room
	Per business process
	Per application
Database containing measurement values during business activities and during periods of non-activity	
Electrical consumption	Per data centre
	Per computer room
	Per business process
	Per application
	Per end-user
Computational needs	Per computer room
	Per business process
	Per application
	Per user
Cooling needs	Per computer room
	Per business process
	Per application
	Per user

6 Increasing the energy efficiency of IT infrastructures

6.1 General

Indications of the impact of some of the actions in this domain of energy efficiency are shown in annex A.

6.2 Energy efficiency solutions

6.2.1 Obsolete equipment

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 involves an audit of the existing physical and logical estate and then the identification, turning-off and removal of all equipment without any activity such as old servers, modems and routers. 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.

Servers which cannot be decommissioned for compliance or other reasons but which are not used on a regular basis should be virtualised and then the disk images archived to a low power media.

6.2.2 Replacement equipment

This involves the replacement of existing equipment from previous generations of technology with the most recent, more energy efficient IT equipment. This may be through the use of SPECPower or similar metrics or through application or deployment of specific user metrics more closely aligned to the target environment, which may include service level or reliability components.

Select and deploy equipment at the design power density (per rack or m^2) of the ICT site to avoid running the cooling system outside design parameters. Select IT equipment containing high efficiency AC/DC power converters. These should be rated at 90 % power efficiency or better across the range of loads expected for the equipment to be installed.

When selecting equipment for installation into 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.

The choice of server equipment should be directed by their ability to run virtualized operating systems. Blade server farms offer an excellent ratio of power consumption / computing power in a limited space. High-end or mainframes are and, for the foreseeable future, will be necessary for the processing of large databases.

6.2.3 Select and develop efficient 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 lower-power states, this includes monitoring software and agents.

6.2.4 Power and capacity management

6.2.4.1 General

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 6.2.4.2);
- processing capacity management (see clause 6.2.4.3).

6.2.4.2 Power management

6.2.4.2.1 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.

6.2.4.2.2 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 table 8.

Table 8: Server schedules

Times	Activity	Class 1	Class 2	Class 3
08:00 to 20:00	TP	User connections	Application	Database connections
20:00 to 08:00	Backup/batches	Any connection	Inactive	Backup/batch activity
Week-ends	None	Any connection	Inactive	Backup/batch activity

An example of the potential savings is shown below.

EXAMPLE:

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 turned off. In table 9, 200 such servers were identified that could be turned-off or put in sleep mode:

- for 8 hours per day;
- during weekends and public holidays.

Table 9 shows that the potential energy savings from activating sleep-mode would be 31 % and from shut-down would be 46 %.

Table 9: Example saving calculation

Times		Activity
No. of week-ends per year	W	52
No. of public holidays per year	P	9
No. of working week-days	D = 365-2W-P	252
Total energy-reduction hours	R = 8D + 24(2W+P)	4 730
Total energy consumption (without action)	8 760 x 240 W Per server	420 480 kWh
Energy reduction with sleep mode	160(8 760-R) per server	128 960 kWh (30,7 %)
Energy reduction with shutdown	240(8 760-R) per server	193 440 kWh (46 %)

Figure 5: Void

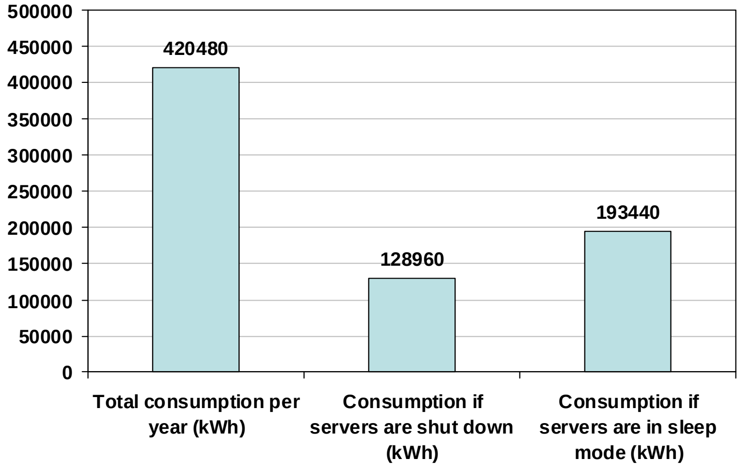

Figure 6: Example savings schematic

6.2.4.2.3 Reduction of energy consumption of environmental control equipment

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 could be reduced by up to 50 %.

6.2.4.3 Capacity management

6.2.4.3.1 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 4, capacity management addresses the following:

- Is the ICT site able to host new applications, services or support the growth of the activity?
- What is the capacity in terms of energy, space and cooling?
- What is the capacity in terms of storage, CPU, memory, I/O, ports, etc.?

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 6.2.4).

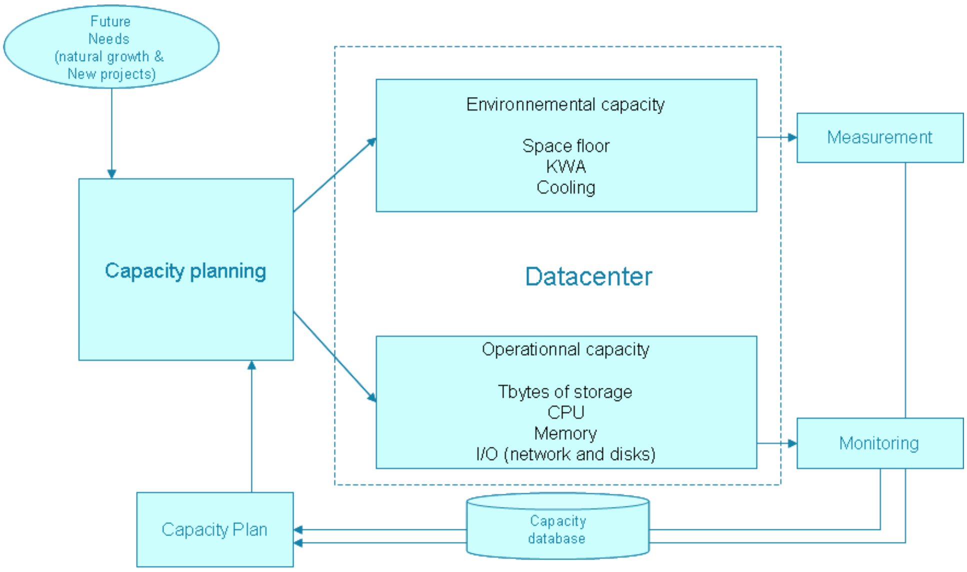

Figure 7: Capacity management

6.2.4.3.2 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.

6.2.4.3.3 Storage

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.

6.2.4.3.4 Servers

This involves the use of existing equipment when additional server capacity is required. This approach is a step towards the consolidation initiatives of clause 6.2.4.

6.2.4.3.5 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 (that is one new server provisioned all the 200 connections). 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.

6.2.5 Consolidation initiatives

6.2.5.1 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 IT 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;
- virtualization;

6.2.5.2 Physical consolidation

6.2.5.2.1 The process

Physical consolidation involves the gathering of stand-alone hardware within a physically more powerful container, as shown in figure 8 and can be achieved without using virtualization if the server technology allows partitioning features.

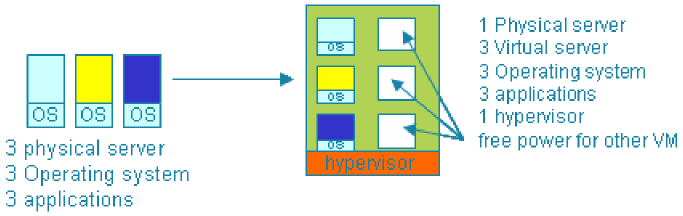

Figure 8: Physical consolidation - Virtualization

6.2.5.2.2 The effects

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;
- Capex for new hardware.

6.2.5.3 Virtualization

6.2.5.3.1 The process

Virtualization is a method of physical consolidation and has to be implemented made on new generation servers and is a pre-requisite for a shared infrastructure policy.

Physical consolidation has no effect on the number of "logical" servers (that is reducing the number of hardware has no effect on the number of Operating System (OS) images and on software licences).

The effect on the global IT TCO is not significant.

6.2.5.3.2 The effects

Under certain conditions, virtualization can deliver energy reductions of 80 % on a selected set of servers.

6.2.5.3.3 Reduction of energy consumption of IT infrastructure

Table 10 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. In majority of cases, virtualization will not have a positive effect on the KPI_{TE} of the ICT site, but it contributes to a reduction in total energy consumption.

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

Table 10: Virtualization savings profile

Number of servers to virtualize	X
Mean energy consumption per server (watt)	W1
Total consumption in Watt (X × W1)	C1
New server number (number of blades or boxes)	X / R
Average consumption per VM (including storage)	W2
Virtualization ratio	R
New consumption (X × W2)	C2
Savings on energy (watt) : C1-C2	S1
Savings on energy % (S1 / C1)	S2

The following figures are provided by a major telecommunications organization that has launched a virtualization project on X86 servers under production. The results are significant, since in addition to virtualization, was also applied, by reducing the number of operating systems. Generally, mean values for energy savings using virtual environments are 40 % to 60 % of the energy consumed by the servers before virtualization.

In this example, the aim was to consolidate many physical servers of one multi-server application (170) 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. A consolidation ratio of 12 (meaning that one new physical server contains at least 12 virtual servers) was achieved. Figure 9 shows the savings in electrical consumption that resulted.

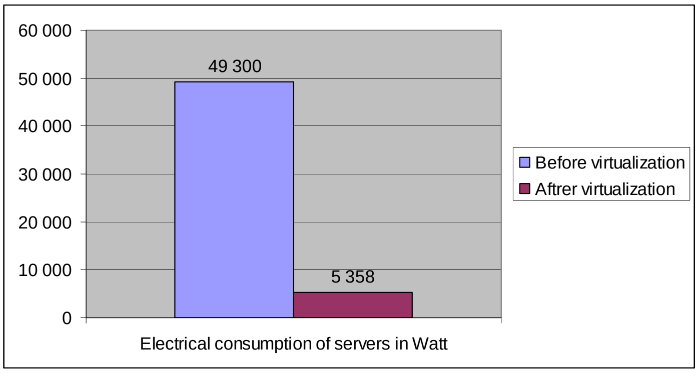

Figure 9: Electrical savings with virtualization

6.3 IT Reporting

Reporting the utilization of the IT 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.

7 Increasing the energy efficiency of the communication equipment

7.1 Review of activities outside ETSI

7.1.1 Code of Conduct on Energy Consumption of Broadband Equipment

The European Union Code of Conduct [11] sets out the basic principles to be followed by all parties involved in broadband equipment, operating in the European Community, in respect of energy efficient equipment.

7.2 Standard to be taken into account

ETSI ES 203 237 [21] describes the Green Abstraction Layer (GAL), which defines a novel way for managing and monitoring energy and performance profiles of device hardware. The Green Abstraction Layer (GAL) is an architectural interface/middleware that will give flexible access to the power management capabilities of future energy-aware telecommunication fixed network nodes. The standard defines the GAL design interface with the purpose of effectively exploiting the capability of adapting the energy consumption of the network nodes with respect to the load variations.

8 Reducing the energy demand of environmental control systems

8.1 General

This clause describes the approaches that may be employed to reduce the energy demand of environmental control systems within the ICT site which typically represents 35 % to 40 % of total energy consumption in an Availability Class 3 ICT site.

Some of the approaches are applicable to legacy ICT sites while other is more likely to be applied in new ICT sites. Further details are provided in clause 10.

The present document adds to the information provided in ETSI TR 102 489 [i.1].

European standard from CENELEC EN 50600-2-3 [10] addresses environmental control within data centres based upon the criteria and classifications for "availability", "security" and "energy efficiency enablement".

Indications of the impact of some of the actions in this domain of energy efficiency are shown in annex A.

8.2 Energy reduction solutions

8.2.1 Measurement of thermal behaviour

In order to enable reductions in energy usage it is important to determine the thermal patterns within the ICT site by using available thermal measurement software tools. These may be deployed without significant Capex since the costs are restricted to the fees for the software and the Opex for the installation and customization.

8.2.2 Improvement of cooling efficiency

8.2.2.1 Zonal approaches to thermal isolation

8.2.2.1.1 General

The actual design in most of legacy ICT site is that the Computer Room Air Conditioning (CRAC) units force cold air under a raised floor, into the cabinets, and draw up hot air coming from the top of the cabinets. However, if the hot air and cold air become mixed, bad aeraulic management results producing hot spots within the computer room. This can be shown by taking infra-red photographs of the room. Some simple and low cost actions can be taken to avoid this which generate some non-negligible savings on cooling and have a positive effect on the KPI_{TE}.

8.2.2.1.2 Hot aisle and cold aisle segregation

This approach creates areas within the ICT site that are designed as dedicated "hot aisles" and "cold aisles". Rows of cabinets are created in which the front of the cabinets face each other (cold aisles) and in the adjacent row, the rear of cabinets face each other (hot aisles). This segregation is shown in figure 10.

Cold air is drawn in through the front of the cabinets (cold aisles) and expressed through the rear of the cabinets into the hot aisles.

Infrastructure design, installation and operational procedures are critical to maximizing the benefit of basic hot aisle and cold aisle solutions (see clause 10).

8.2.2.1.3 Cold aisle covers

An improvement of the "hot aisle, cold aisle" concept is provided by placing covers over the cold aisles as shown in figure 11. This approach reduces the loss of cold air losses and is able to demonstrate a rapid reduction in energy usage.

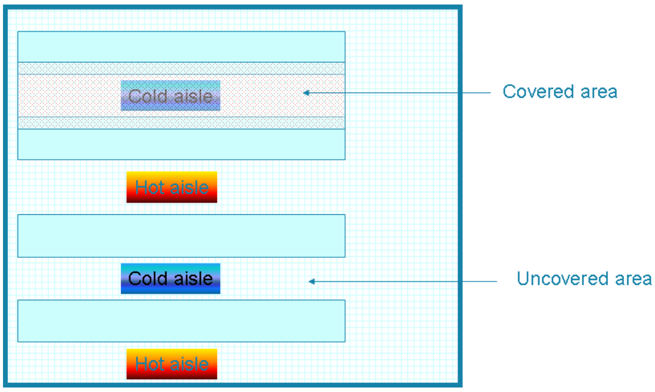

Figure 10: "Segregation of hot aisles and cold aisles

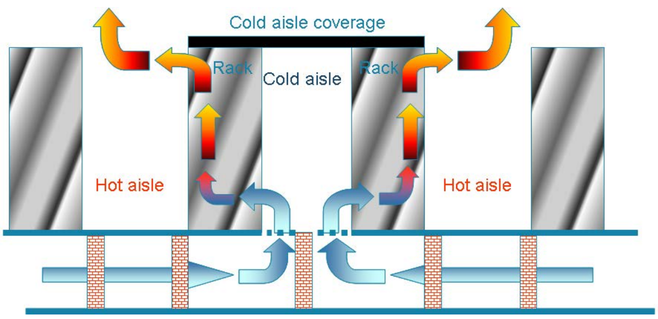

Figure 11: Cold aisle covers

8.2.2.1.4 Segregation using curtains

A low cost, simple and rapidly deployable solution to problems of air-flow employs plastic curtains hanging from the ceiling of the computer room to isolate hot areas from cold areas as shown in figure 12. This approach has the advantage that there is no impact on the installed infrastructure associated with fire detection and suppression (sprinklers).

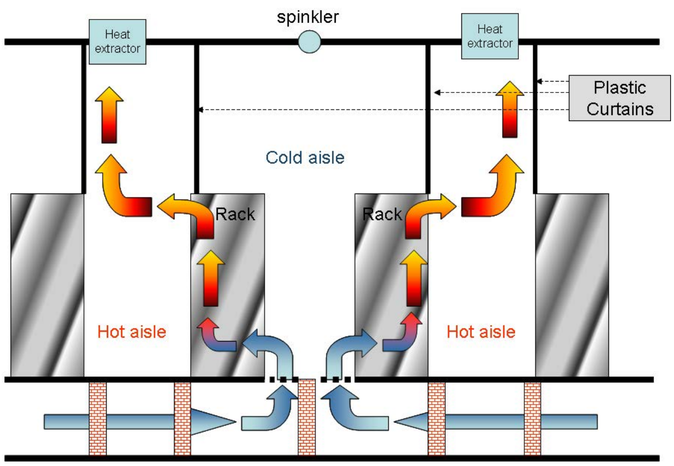

Figure 12: Segregation of hot/cold aisles using curtains

8.2.2.1.5 High density areas

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

As an example, how could a computer room built with an average ratio of 0,7 kW/m^2 be adapted to new generation racks of blade servers, for which it is necessary to cool 20 kW over a 1 m^2 area.

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" IT 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 data centre 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 13 and figure 14).

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

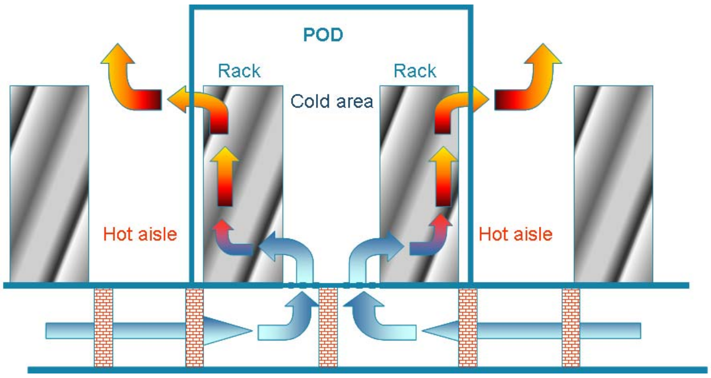

Figure 13: The "pod" concept

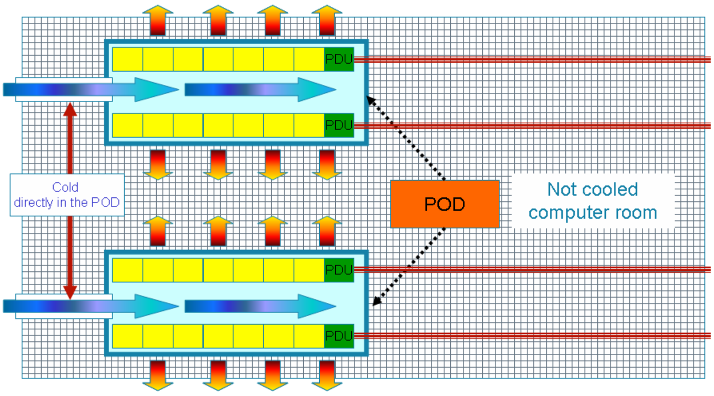

Figure 14: Pods within a computer room

8.2.2.2 Reduction of thermal waste 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 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 as indicated in figure 15.

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

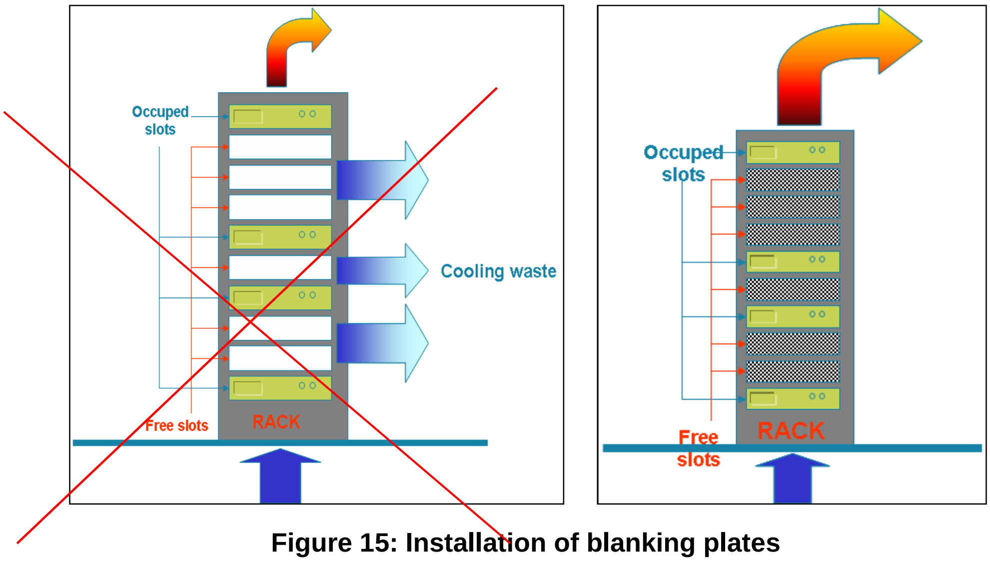

Figure 15: Installation of blanking plates

8.2.3 Modification of temperature and humidity

8.2.3.1 General

Increasing the temperature and adjusting humidity levels in computer rooms 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 room and occupancy ratio.

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

The European Code of Conduct [7] requests vendors to consider changing the current temperature ranges applicable to information technology equipment to approach or adopt the same as those for network telecommunications equipments defined in ETSI EN 300 019-1-3 [12].

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.

8.2.3.2 Results of experimentation

The experiment described below was undertaken in a telecommunications operators data centre in Paris.

Details of experiment:

- The underground data centre comprised a 1 000 m^2 computer room 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 [12] applied to network telecommunications equipment.
- The computer room cooling 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.
- The first change in environmental conditions is defined in table 10a. This resulted in reducing the energy consumption by 12 % without operational failure since 2007. This is shown in figure 16.

Table 10a: Step 1 changes in environmental conditions

	Previous settings	New settings
Cooling unit start-up	20 °C to 24 °C	22 °C to 26 °C
Dehumidifier start-up	50 % to 65 %	60 % to 75 %
Humidifier start-up	45 % to 50 %	35 % to 40 %
Winter/summer switching point	17 °C	19 °C

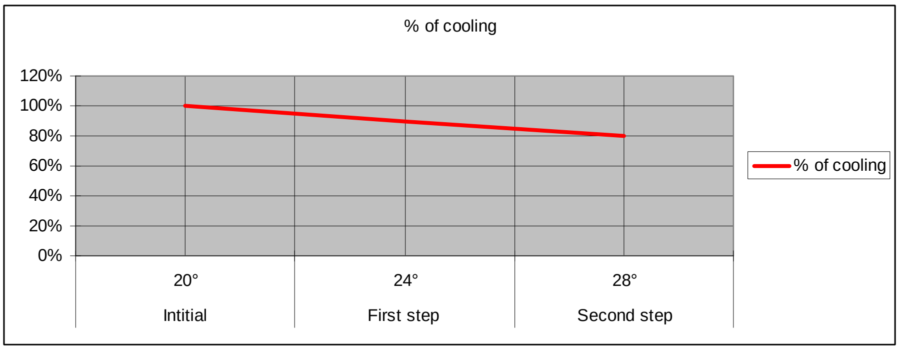

Figure 16: Computer room temperature and subsequent savings in energy usage

- The second change in environmental conditions is defined in table 11. This resulted in reducing the energy consumption by 20 % without operational failure since 2007. This is also shown in figure 16.

Table 11: Step 2 changes in environmental conditions

	Previous settings	First step	New settings (2)
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

8.2.3.3 Time before "system-shutdown"

Many types of information technology equipment undergo automatic shutdown 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 repair 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/room being cooled;
- the contents of the space/room;
- the quantity and type of information technology equipment (racks, servers, etc.) and the global electrical consumption;
- the type, number and capacity of the CRAC units;
- air conditioning system redundancy;
- the operating temperature of the room.

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

Figure 17 shows the results of experimental work (based on computation and observation of real events) in a computer room 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.

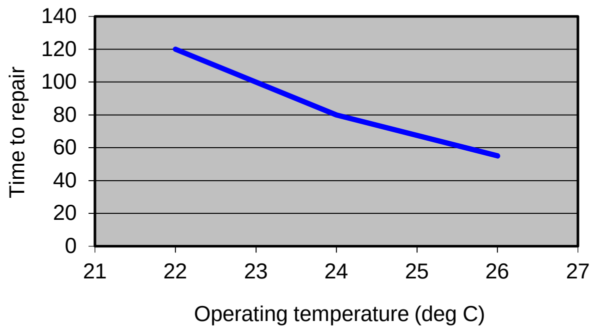

Figure 17: Example showing effect of operating temperature on "time to repair"

Figure 17 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 telecommunications equipment from the information technology equipment and only apply the increased temperature and humidity to the network telecommunications equipment.

NOTE: Such segregation would not be required and greater savings would be possible if information technology equipment vendors change their operating specifications to those of network telecommunications equipment as requested by the European Code of Conduct [7].

8.2.3.4 Restrictions on implementation

In an Availability 4 ICT site, 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 network telecommunications equipment 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.

8.2.4 Alternative cooling mechanisms

8.2.4.1 Free cooling

8.2.4.1.0 Generalities

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.

The ideal climatic combination at the intake and exhaust of the equipment lies in the range 22 °C to 26 °C and 20 % to 80 % relative humidity with a maximum dew point at 21 °C, and maximum rate of change 5 °C/h without irregular deviations in either parameter. If the suppliers of information technology equipment were to adopt the operational environmental specification applied to network telecommunications equipment (see ETSI EN 300 019-1-3 [12]) the period of time that free cooling could be applied and the resulting saving (see table 12) would generally increase.

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 site premises:

- 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).

To calculate the necessary amount of fresh air from outside to extract calories in the computer room, it is required to know the heat load of the room, the ideal temperature inside the room and the temperature at the outside, and the heat capacity of air.

The formula is:

$$\mathbf{F = P / (C_p \times (Ti - To))}$$

Where:

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

P = heat load [W]

$\mathbf{C_p}$ = Specific heat capacity = 0,34 [Wh/m^3.K]

Ti = indoor temperature [K]

To = 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 12 provides a methodology to evaluate energy savings for the use of free cooling.

Table 13 and figure 18 show the result for a series of examples using this methodology.

Table 12: Free cooling savings profile

Total energy consumption of environmental control system	W
Total number of hours per year	8 760
Number of hours of matching conditions during year	H
Energy consumption fraction of environmental control system made inactive during periods of matching conditions	F
% of potential free cooling per year	P
Savings	R
% of potential free cooling	P = (H/8760)
Savings on cooling	R = P x W x F

Table 13: Example of free cooling savings

No of hours of potential free cooling (hours[days]/year)	% of free cooling per year (H/8760)	Cooling load savings (P x W)	Total energy savings (R)
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 %

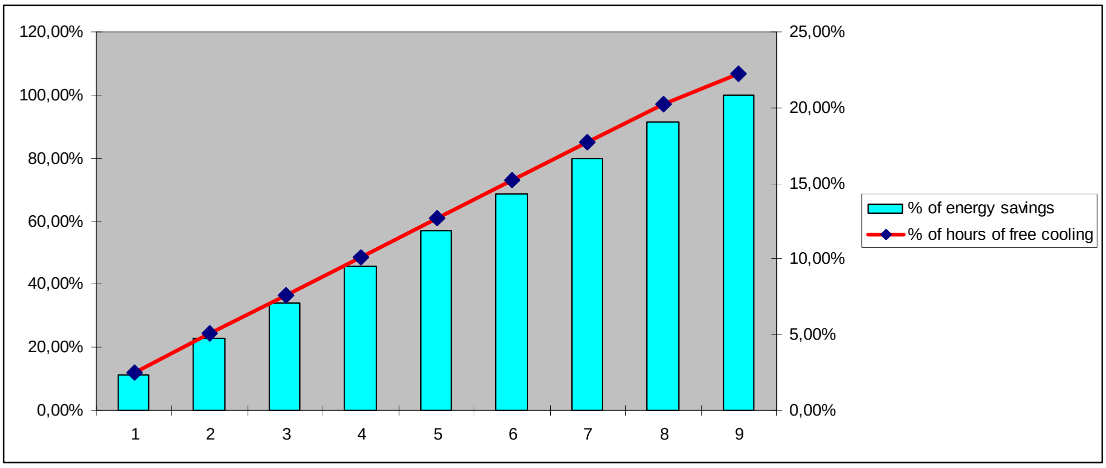

Figure 18: Free cooling savings

8.2.4.1.1 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 temperature difference between external temperature and IT supply air and the IT equipment is exposed to a large humidity and temperature range to allow direct air side economisation to work effectively, see clause 8.2.3.2.

In many cases full mechanical cooling/refrigeration capacity is required as a backup to allow operation during periods of high airborne pollutant or external air too hot. The achievable economiser hours are directly constrained by the chosen upper humidity and temperature limit.

8.2.4.1.2 Indirect air free cooling

This installation opened the air loop, an air to air heat exchanger between external air and intern hot air to remove heat to the atmosphere. A variation of this is a thermal wheel, quasi-indirect free cooling system.

This design tends to have a low temperature difference between external temperature and IT supply air. In this type of design, the operating IT equipment humidity range may be well controlled at negligible energy cost.

8.2.4.1.3 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 temperature difference between external temperature and IT supply air. As above the operating IT equipment humidity range may be well controlled at negligible energy cost.

Some racks should be cooled directly by water system.

8.2.4.1.4 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 temperature difference between external temperature and IT supply air restricting the economiser hours available and increasing energy overhead. As mentioned above the operating IT equipment humidity range may be well controlled at negligible energy cost.

8.2.4.1.5 Sorption 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 IT equipment is used to power the cooling system in place of electricity. The Sorption free cooling system is used rather rarely.

8.2.4.2 Emerging technology (auto cooled chassis or chip-level cooling)

8.2.4.2.1 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.

8.2.4.2.2 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).

Some provision shall be done, the servers 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.

8.2.5 Enhancements of cooling systems

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

a) installation of high-efficiency variable-speed air-handler fans and chilled water pumps;

b) optimization of ICT sites airflow configuration;

c) installation of high-efficiency CRAC units;

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

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

8.2.6 Energy Use and Environmental Reporting

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.

Type of report:

- Energy use and environmental (temperature and humidity) data needs.
- Energy consumption and environmental ranges.
- Reporting of full/partial economiser, full refrigerant and compressor based cooling hours.

Type of expected effects:

- 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.

The site design, cooling system operational set points and IT equipment environmental control ranges should allow the ICT site to operate without refrigeration for a significant part of the year with no refrigeration for the IT cooling load as evaluated against a Typical Meteorological Year for the site.

9 Improvement of energy efficiency of power distribution systems

9.1 Review of activities outside ETSI

9.1.1 EU Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems

The European Union Code of Conduct [13] sets out the basic principles to be followed by all parties involved in Uninterruptible Power Systems, operating in the European Community in respect of energy efficient equipment. The energy losses caused by UPS are not to be neglected by EU energy and environmental policies. It is important that the electrical efficiency of UPS is maximized in a large range of power load because it accounts a lot in the carbon footprint and the primary energy resources used to produce electricity of ICT site.

This optimization can be applied to DC UPS.

9.1.2 CENELEC EN 50600-2-2

CENELEC EN 50600-2-2 [22] addresses power supplies to, and power distribution within, data centres based upon the criteria and classifications for "availability", "physical security" and "energy efficiency enablement".

9.2 General

This clause describes the approaches that may be employed to increase the energy efficiency of the power distribution systems within the ICT site. Some of the approaches are applicable to legacy ICT sites while others are more likely to be applied in new ICT sites.

Figure 19 shows the power distribution systems within the ICT site from the main electrical arrival to, and within, the network telecommunications and information technology equipment. Each component in the power distribution system has specified and measurable energy efficiency.

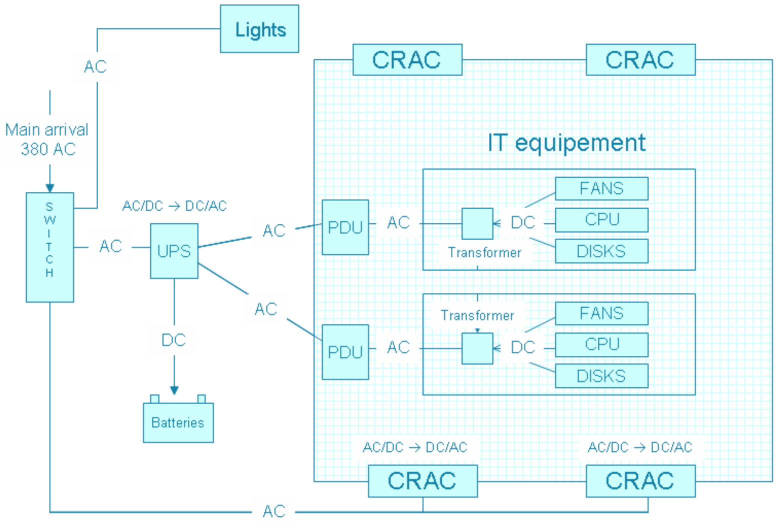

Figure 19: Power distribution system

Actions to increase the efficiency of the power distribution system in an existing ICT site will require significant Capex investments, except for actions such as the deployment specific software solutions for energy management. Moreover the actions on power distribution are not without risk for business continuity. Indications of the impact of some of the actions in this domain of energy efficiency are shown in annex A.

9.3 Uninterruptible Power Supplies (UPS)

9.3.1 Efficiency

The most popular UPS technologies including "line interactive "or "double conversion" (see figure 20). UPS technologies are recognized but may be proprietary technology from specific vendors.

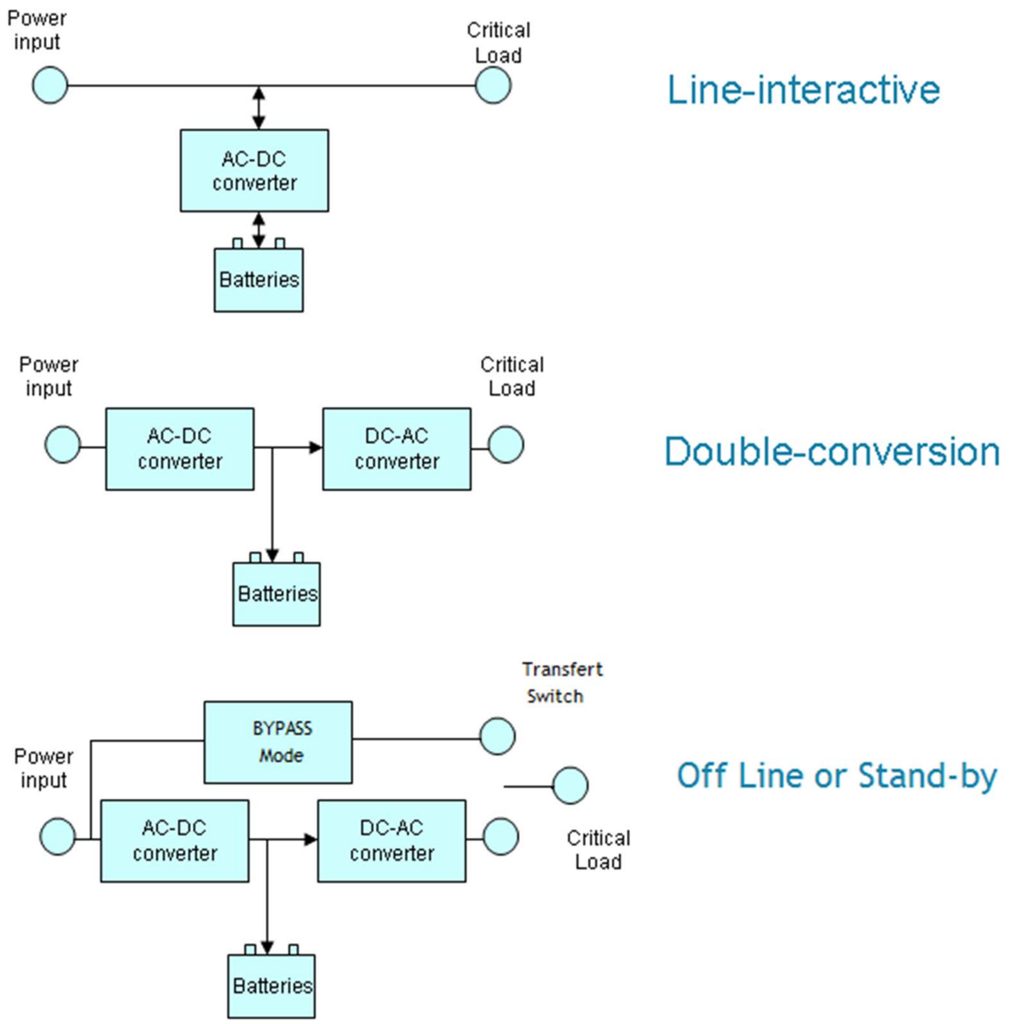

Figure 20: Multi-vendor AC UPS technologies

IEC standards define the efficiency of a UPS as "the ratio of output power to input power under defined operating condition".

As shown in figure 21:

- a UPS is generally more efficient when used at high load;
- line-interactive technology is more efficient than the double conversion due to no conversion stage between input and output in the normal mode, but it needs a strong AC line input filter adding some % of losses (not represented);
- in general an AC transformer (not represented) is added in serial to change the neutral connexion to earth from building distribution to equipment distribution (e.g. from TN or IT to TNS), bringing some additional losses.

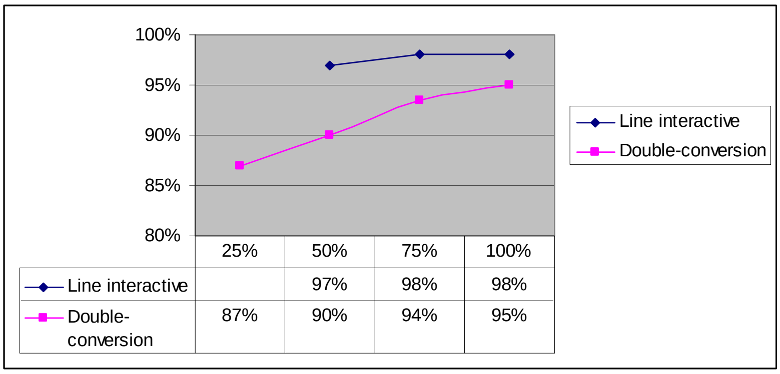

Figure 21: UPS efficiency

However, the data in figure 21 is based on an average of specified performance values taken from main UPS vendors and was reported in a report from Ecos Consulting-Epri Solutions. The efficiency of the different technologies varies significantly. For example:

- at 50 % load, the most efficient technology is the "line-interactive" (with a 98 % efficiency); AC filters and transformers can reduce of 2 % this efficiency;
- "double-conversion" technology is the least efficient;
- in general, UPS running in excess of 50 % load have good efficiency, but there is a dramatic decrease under 40 % (see figure 22).

In many legacy ICT sites, UPS systems are installed with the maximum capacity anticipated for the future needs. It is not uncommon for this capacity to never be fully used. In addition, redundancy requirements also promote the operation of UPS systems below their full capacity.

In the case of 1+1 redundant configuration the installation is consisting in 2 independent power chains with same or different UPS technology. In practice one chain has N UPS units synchronized and connected in parallel (independent of the UPS technology on line or interactive or offline) so the power system is more precisely a 2N configuration. One chain only shall be able to power the entire load at its peak power which means some over sizing of the UPS. In general a N+1 configuration is used to accept peak power and one inverter fault, so the system is in 2(N+1) e.g. a UPS of 2x(2+1) units of 800 kVA for a 1,6 MW load.

Consequently every 1+1 mode operates at less than maximum efficiency (i.e. at 20 % to 35 % load) which corresponds to 10 % to 15 % losses. In addition, each UPS chain shall be able to recharge its own battery, so further consideration would show that the maximum input power is between 1,5 to 2 time the output power of the UPS.

Finally the high heat dissipation may require an active cooling system, which is adding a lot of power consumption at the site level, and transformer the front AC power distribution is oversized.

Modular UPS systems (see clause 9.3.2) allow the capacity to be mapped to the demand thereby improving energy efficiency and reducing cooling system energy consumption.

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.

9.3.2 Modular UPS

In legacy ICT sites, UPS commonly use double conversion technology, as shown in figure 20. This means two conversions stages (AC/DC and DC-AC), generating consequent losses of energy.

Recently, vendors have begun to offer smaller modules (from 10 kVA to 50 kVA) to build "modular" UPS systems. 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 system. In 1+1 system configuration this means 2(N+1) as in clause 9.3.1.

Used correctly, modular UPS systems run at higher efficiency since they can be used close to maximum rated capacity (see figure 22).

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 there is a better reliability on modular UPS systems compared to big power unitary systems The weakness may be the single bypass system as seen on figure 16, which makes it less reliable than a DC system. Synchronization and control between modules is also much more critical than in DC.

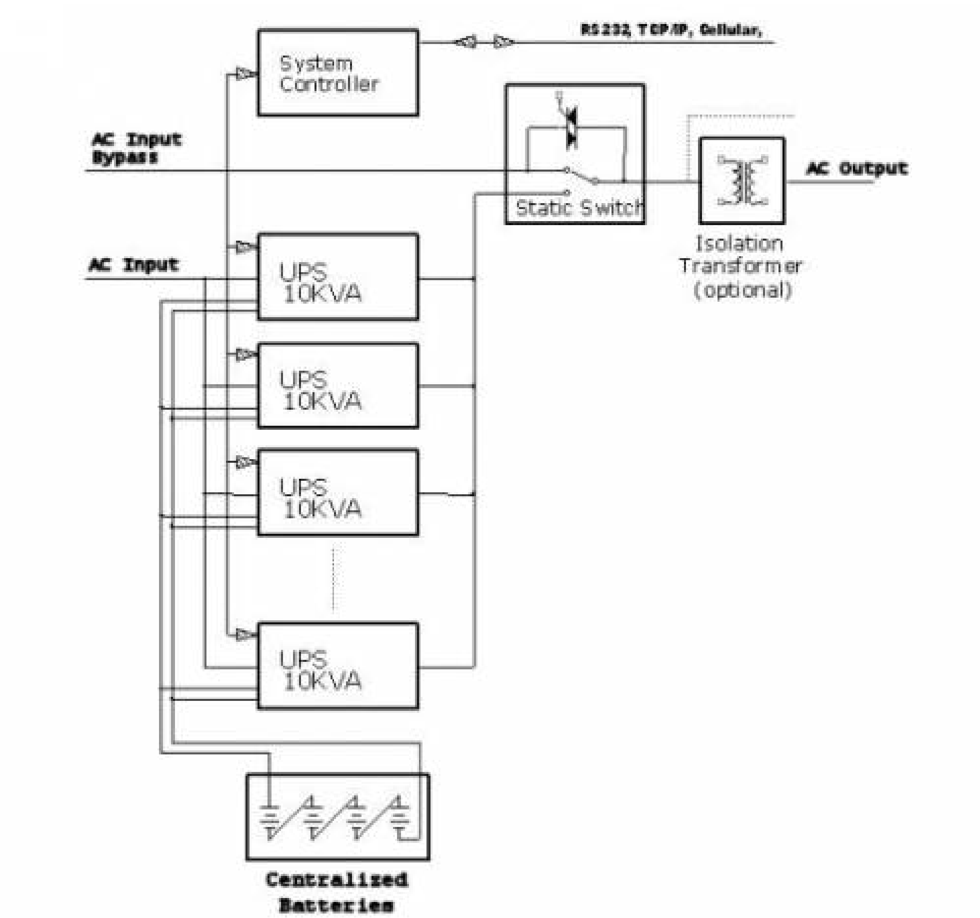

Figure 22: Example of modular line interactive UPS technology

9.4 Energy efficiency improvement solutions

9.4.1 Measurement of energy efficiency of existing equipment

This involves the review of the existing power distribution equipment within the chain in terms of its energy efficiency. This may be undertaken without significant Capex.

ETSI ES 202 336-12 [14] should be used for measurements of power and energy consumption and environmental parameters of all the facilities of ICT technical environment.

9.4.2 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 Capex (for the monitoring equipment) and Opex (installation and 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.

9.4.3 Review of policy

9.4.3.1 General

The implementation of improvements in energy efficiency by changing the distribution policy (such as AC or up to 400 VDC (ETSI EN 300 132-3-1 [23]) have an impact on the equipment used and can represent significant Capex and a risk to business continuity. Such changes cannot be recommended in existing ICT sites.

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

9.4.3.2 Up to 400 VDC versus AC

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

The telecom equipment are commonly powered in 48 VDC and the servers in AC e.g. 3 phases 400 VAC distribution and 230 VAC single phase at 50 Hz in Europe.

Therefore, the A3 power interface voltage ranges proposed in ETSI EN 300 132 series [15] have been defined with consideration to the:

- Need to unify the power supply to all telecommunications and datacom (ICT) Equipment.
- Reduction of the power losses as well as copper cross-section area in the power distribution wires.
- Need to maintain a highly reliable power source for telecommunications and datacom

ETSI has published ETSI EN 300 132-3 [24] concerning the requirements for the interface between telecommunications and datacom (ICT) equipment and its power supply, and includes requirements relating to its stability and measurement.

The up to 400 VDC power feeding solution for ICT sites and other building using the up to 400 VDC power interface, are well adapted to renewable energy or distributed sources or new micro-grids (see clause 10.2.3), most of them being more complex in AC than in DC. The DC would allow great simplification by avoiding frequency synchronization.

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

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

9.4.3.3 Earthing and Bonding

ETSI has published ETSI EN 301 605 [16] about earthing and bonding of 400 VDC data and telecom (ICT) equipment, in relation to safety, functional performance and EMC of HVDC, if all safety standards (IEC, ITU-T, ETSI) are complied, up to 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 up to 400 VDC but in many countries it is the same training as AC in term of safety.

9.4.4 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 system 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 Capex and a risk to business continuity.

9.4.5 Backup power

The use of on-site generated energy (more often with fuel generator sets) as back-up to the main electrical power source does not improve energy efficiency. It is intended to be deployed in crisis situations where the aim is to get back to normal operation as quickly as possible.

Note that backup power infrastructures should be designed to provide 100 % of the energy needs for a specified period (e.g. 72 hours minimum).

10 Infrastructure requirements to optimize energy efficiency

10.1 Location

The selection of a location is primarily affected by access to vendors, manufacturers and publishers, telecom, environment and risk.

Qualitative analysis for the location of a new ICT site reviews a number of factors considered as important and grouped by theme with a weight attributed by the company. These elements are used to compare countries or sites together.

The following topics are part of what these studies deal in practice.

Qualitative assessments:

Telecom:

- Reliability and availability of network access.
- Quality connections, stability of flow rate, low latency.
- Diversity of technology offerings practiced.

Access to vendors, manufacturers and publishers:

- 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.

Environment:

- Political stability.
- Economic and financial stability.
- The strategic aspect of the country.

Risk of loss:

- 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.).

Energy:

- Source availability (reliability, quick intervention).
- The ability to have separate power supplies and managed by different actors.
- The existence of renewable energy close by and usable.

Access to skilled personnel:

- The importance of local employment pool.
- The availability of qualified IT personnel, engineers.

Availability:

- Easy access by airlines from airports.
- Easy access from other company sites.
- Quality of life for some expatriates.

Confidentiality to ensure that the company can implement its policy of data security.

The themes are therefore of variable importance and shall be weighed (table 14).

Table 14: Overall weighting of themes for the importance of location from CRIP

The nine themes	Weight
Telecom	25
Access to vendors, manufacturers and publishers	25
Environment (note 1)	15
No risk of loss (note 2)	12
Energy (note 3)	10
Access to skilled personnel	5
Availability	5
Quality of life	3
Confidentiality	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. 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.	

10.2 Energy sources

10.2.1 Main energy

In case of availability of a class 4 ICT site, two separate sources of energy, coming from two remote plants or two different sources of energy are required and this dramatically limits the range of potential locations around the world that can support such ICT sites.

Locating the ICT site close to the power generating plant can reduce transmission losses and provide the opportunity to operate sorption chillers from power source waste heat.

10.2.2 Backup energy

Backup energy has to be dimensioned to cover 100 % of ICT sites needs for a determined period and provision has to be made using "on site" sources with generators or other renewable energy solutions.

10.2.3 Alternative power energy

A local electrical power source where energy is produced close to the user and distributed by a micro grid by opposition to a centralized power plant with a long distance electricity transport grid. This local power source can be an individual user power system or a small collective energy power plant for a group of customers. It can include energy sources or storage or cogeneration of heat and electricity using any primary energy renewable or not.

ETSI ES 202 336-9 [17] addresses to monitoring and control of alternative power supply systems for telecommunication equipment, these renewable energy is mainly non-fossil fuel converted into electricity.

The main alternatives energies are:

- Water flow engine.

Some small installations called micro hydro installed in the river can produce green electricity for the ICT site for low Capex:

- 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:

- Solar power system.

Using the heat and radiant light from the sun to produce electricity with photovoltaics, concentrated solar power, etc.:

- Wind power system.

Using the airflows with wind turbines:

- External heat engine generator system, biomass, geothermal energy.

10.2.4 Reuse heat

ICT sites produce significant quantities of waste heat, there are some applications for reuse of this energy. As IT equipment utilization is increased, the exhaust temperature increase which will provide greater opportunity for waste heat to be re-used.

Directly liquid cooled IT equipment is likely to provide a further improvement in the return temperature of coolant, see clause 8.2.4.2.2.

- Low grade heating to industrial space or to other targets such as adjacent office space fresh air will come directly from heat rejected from the IT room.

- A temperature too low for external use should be raised with additional heat pumps to a useful point.

- Reduce or eliminate the electrical preheat loads for generators and fuel storage by using warm exhaust air from the data floor to maintain the temperature in the areas housing generators and fuel storage tanks.

10.3 Building conception

The specification of a building housing an ICT site is directly impacted by its location (see clause 10.1). The orientation of the building together with the thermal insulation properties of the building walls, roof, windows, have a significant effect on the power demands associated with environmental control of the building interior.

The European standard for energy efficient buildings is CENELEC EN 50600-1 [1] and it specifies requirements and recommendations for the following: location and site selection, building construction, building configuration, fire protection and quality construction measures.

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

10.4 Internal design

The ICT site technical areas and plant rooms should be considered as an industrial space, designed built and operated with the single primary objective of delivering high availability IT services reliably and efficiently. ICT sites only require the control make up air volumes and environmental conditions according to sensible warehouse or industrial levels rather than for seated human comfort.

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 information technology equipment).
- Network telecommunications rooms (accommodating network telecommunications equipment).
- Technical rooms (accommodating UPS, batteries, etc.).

Each of these, and any other, spaces shall be assessed in term of their demands for electrical power and cooling based upon their size and operating environmental conditions. Computer rooms also should be assessed in terms of the need for, and structural implications of, the constructions of raised floors.

The internal design process should also cover the impact on cooling system introduced by the necessary utilities and services in the spaces, ceiling should be sufficient height to not obstruct the use of efficient air cooling technologies such as raised floor, suspended ceiling or ducts in the ICT site. To support this activity, the design, the planning and installation of the cabling is specified in CENELEC EN 50600-2-4 [18] Telecommunications Cabling Infrastructure.

Low energy lighting systems should be used in the ICT site and lights should be turned off, preferably automatically whenever areas of the building are unoccupied.

10.5 IT infrastructure

The IT infrastructure of an ICT sites has to:

- be designed for maximum agility, scalability, and a common shared architecture;
- 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.

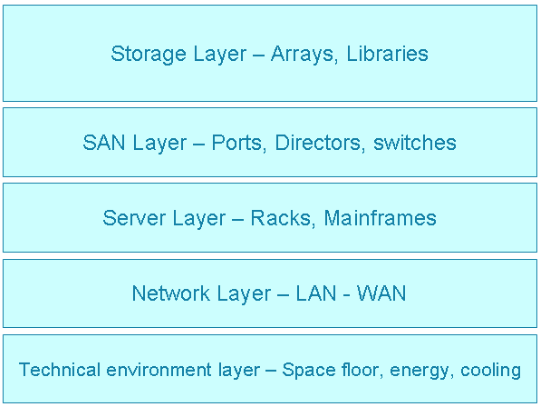

Figure 23: IT infrastructure layers

Independent of the Availability Class level, an ICT site will comprise a combination of:

- A rack-based architecture using very powerful serves will need high-density areas using, as a minimum, covered cold aisles with raised floors (as described in clause 8.2.2.1.3) or pods (as described in clause 8.2.2.1.5) in perhaps otherwise uncooled rooms and which are exhausted outside the building. This means the size of the computer room is not a main criterion, but the greatest concern is to carry the right resources to the right place. For these areas, the most appropriate indicator is the formula in which the maximal density area is linked to the maximal temperature.

- Legacy servers or Unix mainframes, which have the same problems as racks, consuming a lot of energy in a small area, and with an important heat dissipation.

- Other kinds of equipment such as robotics, storage, network telecommunications equipment, or non-racked servers that may be accommodated in traditional computer rooms, for which the right ratio is the kW/m^2.

11 Energy efficiency within ICT sites

11.1 General

This clause details the discipline that requires consideration during the design, installation and operation of an ICT site in order to maximize savings on energy usage and reducing its "Carbon Footprint".

Many of the solutions detailed in clauses 6, 7, 8 and 9 are applicable during the design of a new ICT site. However, it is clear that the design and operation of the most energy efficient ICT sites require a multi-disciplinary approach with each discipline contributing in its own domain to make energy usage more efficient - rather than one specific initiative concerning a single domain.

Every aspect of the ICT site requires detailed consideration, ranging from its urbanization via the consolidation actions employed to the tools and processes adopted to monitor the operational aspects of the ICT site.

11.2 Multi-disciplinary approach

11.2.1 Urbanization

11.2.1.1 General

Urbanization applied to the IT, improves the organization continuously, through virtuous processes, to ensure that the operational level does not degrade over time. It provides greater efficiency and agility of the IT, to reduce Opex through the resources in place, it is a process of rationalization and optimization and therefore modernization and transformation. Urbanizing an ICT site should be based on different flows present to optimize Capex and Opex and based on an overhaul of the global architecture of the IT, itself focused on strategic and business priorities of the company.

11.2.1.2 Processes

Urbanization should be acted on three ICT site's main elements.

The core business services (hardware and software):

- Data Centre Infrastructure Management (see clause 11.2.2).

Useful surfaces (m^2):

- Should respect the maximum densities defined for the room (see clause 8.2.2.1.5).
- It is possible to define several zones of different densities for a same room.

Utilities associated to the ICT site (cooling, power utilities, fire protection):

- The temperature should be homogeneous in the entire IT room for maximized air conditioning.
- In case of connection of new air conditioning equipment, the hydraulic and ventilation balancing should be redesigned.
- Cooling solution should be adapted to the power density of the equipment (table 15).
- Strictly separate hot and cold air flows (clause 8.2.2.1).
- It is essential to respect the settings of temperature set point cabinets CRAC.

Urbanization acts indirectly on energy efficiency, because it affects the utilities distribution and optimizes the site.

Table 15: Cooling solution adapted to the power density of hosted equipment

Type of cooling	Power density
Raised floor cooling	< 5 kW / bay
Hot and cold aisles containment	> 2 kW / bay
High raised floor cooling and free-cooling	< 15 kW/bay
Cabinets cooling air conditioning	5 kW to 20 kW / bay
Core server cooling or cold door	> 20 kW / bay

During its design, an ICT site had some characteristics such as its storage, its resilience, its performance. These characteristics tend to be deteriorated as and extent of its operations. Bad deployment can reduce the resilience and decrease the overall efficiency of IT room and therefore his ability.

There are two ways to improve these characteristics:

- Find the original level by a recovery plan or re-urbanization.
- Adding capacity or infrastructure optimization.

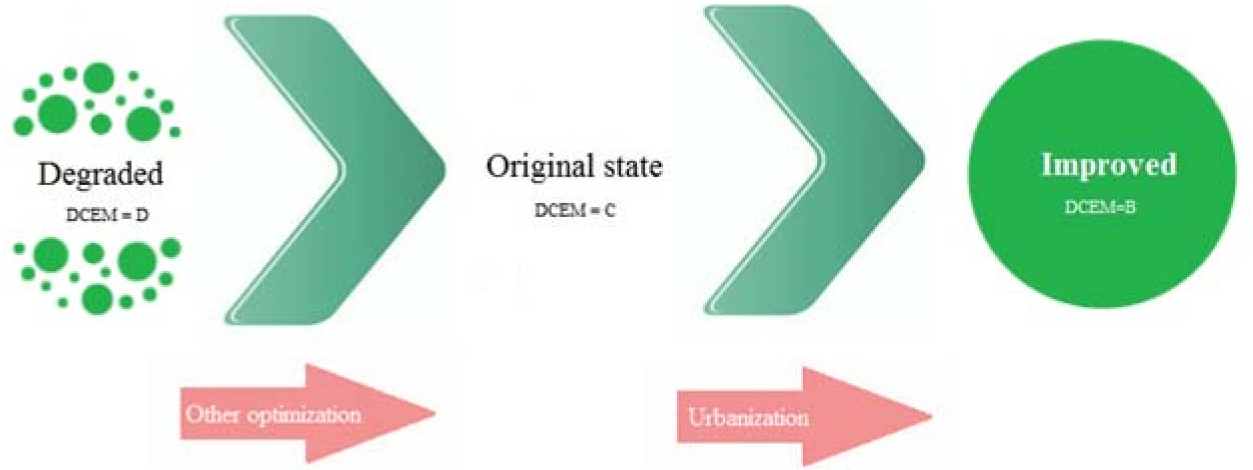

Figure 24: The way to improve eco-efficiency of an ICT site

11.2.2 Data Centre Infrastructure Management

11.2.2.1 General

DCIM (Data Processing and Communication Infrastructure Management) is a set of automation tools for operations for managing and steering ICT site. Its modern design, its referencing for the entire site, its interaction with IT, and workflow management, makes it the ideal tool but it is difficult to implement. DCIM is primarily a basis referential, it needs to be used globally to manage an existing ICT site, and have to be initialized and updated regularly. This reference structure requires technical teams to change their internal processes to integrate this new tool.

11.2.2.2 Processes

11.2.2.2.0 Overview

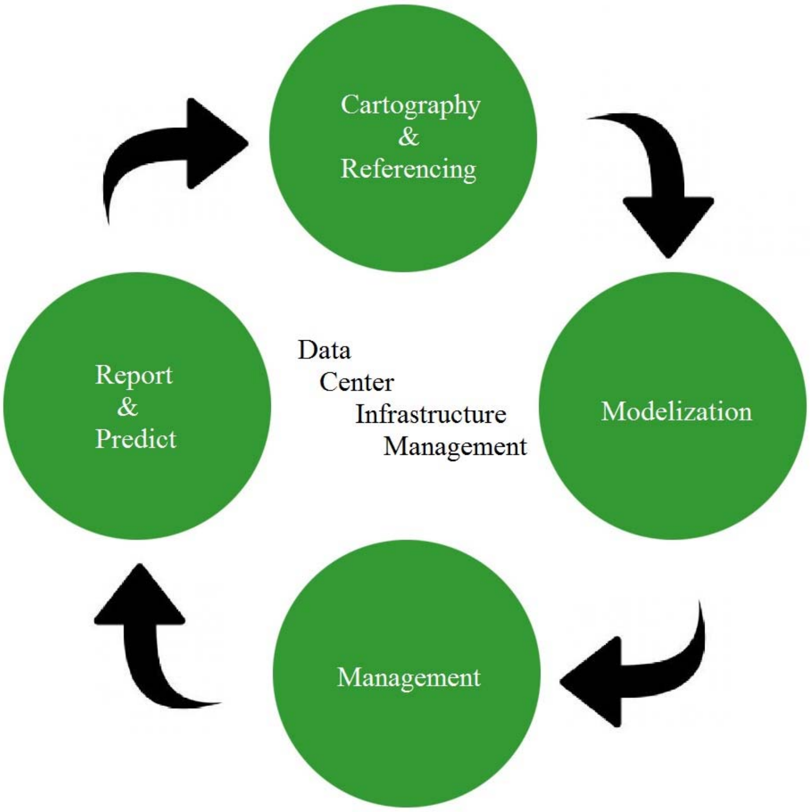

Figure 25: Data Centre Infrastructure Management processes

11.2.2.2.1 Cartography and Referencing

This tool allows to map ICT site in 2-3D, based on existing plans representing buildings, rooms, cable trays and other fluids. The granularity of information permitted the description of a building geolocation up to the characteristics of raised floor rooms. A catalogue of information related to equipment (manufacturer information) provides good management of IT equipment like the ITIL.

The ITIL (IT Information Library) best practices are key for a good management of the IT.

Involved ITIL process in energy efficiency:

- Asset management to know what is existing in the IT;
- Capacity Management (see clause 11.2.2.2.3.1) measures what exists and how it is used and sizes more precisely application needs;
- Service Level Management to provide the right level of services for an application.

Effective mapping allows efficient and accurate modelling of the room; this is the basis of DCIM and shall be really accurate to make the tool performant.

11.2.2.2.2 Modelization

Modelling the site from different data sources (catalogues) to visualize the relationships between all objects in the ICT site. The second tool allows the identification of deficiencies and environmental problems associated with the operation of the site management of all assets (IT Infrastructure) and life cycles.

All equipment and connections shall have a full description in modelization, examples of catalogues.

Electrical distribution:

- Cabinets Management 400 V, 220 V and 48 V (sources, circuit breakers, etc.).
- Definition of energy workshops (rectifiers, batteries, etc.).
- Description of the power supply chain.

Air conditioning:

- Dry cooler.
- Air treatment unit.
- Temperature sensor.

Protection:

- Central control.
- Detectors.
- Gas cylinders extinction.

Cabling infrastructure:

The entire ICT site cabling infrastructure should be modelled and especially optical or digital distribution (location, rail management. etc.) and the connection points in the bay.

An assistant to the wiring should be suggested to the user for optimal wiring suggestions between two elements based.

11.2.2.2.3 Management

11.2.2.2.3.1 Capacity management

With its proactive analysis, DCIM allows for easy management capabilities of ICT site. Taking into account the various planned developments, it provides:

- display meter of site "KPI_{TE}";
- monitor power consumption "KPI_{EC}" at different levels: equipment, bay, area, etc.;
- track the occupancy rates of physical space: building, room, bay, etc.;
- a capability monitoring points of electrical power and network;
- reservation implementation with corresponding impact on the work unit (Multi occupation);
- intelligent capacity planning;
- indicates the stocks status of the equipment at a time T and presents a projection of stocks at a later date depending on the planned deployments.

11.2.2.2.3.2 Management of equipment deployment

The DCIM tool used to manage the ICT site and the whole present ecosystem. Thus, any object instantiated shall be easily editable and include a certain level of control and helps to change.

To facilitate the installation of new equipment, DCIM should be able to simulate and plan the deployment of new equipment. This should include:

- Interface with project management tools.

- A comprehensive analysis of the stock to witness the placement of equipment (availability of space and connections necessary, geolocation compared to hot spots, etc.).
- Resource reservation of the entire project (area in a room, space, rack equipment, connections, etc.).

11.2.2.2.4 Report and Predict

The DCIM eliminates the information black hole that makes change so risky. With a high level of referencing the site is well known, mapped, modelled and managed, and reporting serves to update the site's data base, making some prediction to new deployment and have an idea of the Life Cycle Analysis (see clause 4.5).

Example of reports:

- Automated reports on equipment, performance and capacity.
- Real-time collection of data equipment and measuring tools (sensor, power, cooling, etc.) of ICT site and building.
- Analysis of data collected and reporting.

Example of prediction:

- Better capacity planning and management.
- Accurate lifespan prediction.

Annex A (informative): Indications of the effect of energy efficiency actions

Table A.1 provides indications of reduction of energy consumption using some the actions detailed in clauses 6, 7, 8, 9, 10 and 11.

The reductions shown are first order effects only, they do not show associated changes in one domain resulting from an action in another domain.

Table A.1: Indicative reductions in energy consumption

Actions		**Typical savings (%)**		**Nature of action**
Description	**Clause references**	**Within the domain**	**Overall**	
Domain: IT infrastructures				
Removal of obsolete equipment	6.2.1, 6.2.2	8	3,6 (see note 1)	Short term
Select and develop efficient software	6.2.3	--	D.o.A (see note 2)	Short term
Enablement of power management	6.2.4.2.1	10	4,5 (see note 1)	Short term
Activation of sleep mode	6.2.4.2.2	30	13,5 (see note 1)	Short term
Capacity management	6.2.4.3	8	3,6 (see note 1)	Short term
Virtualization	6.2.5.3	40	18,0 (see note 1)	Short term
Domain: Communications infrastructures				
FFS	FFS	FFS	FFS	FFS
Domain: Environmental control systems				
Improvement of cooling efficiency	8.2.2.1.2 8.2.2.1.3 8.2.2.1.4	30	11,1 (see note 2)	Medium term
High density areas	8.2.2.1.5	25	9,3 (see note 3)	Medium term
Modification of temperature and humidity	8.2.3	40	14,8 (see note 3)	Short term
Direct air free cooling	8.2.4.1.1	30	7,4 (see note 3)	Medium term
Indirect air free cooling	8.2.4.1.2	--	D.o.A (see note 2)	Medium term
Direct water free cooling	8.2.4.1.3	--	D.o.A (see note 2)	Medium term
Indirect water free cooling	8.2.4.1.4	--	D.o.A (see note 2)	Medium term
Sorption free cooling	8.2.4.1.5	--	D.o.A (see note 2)	Medium term
Cooling-on-the-chip	8.2.4.2.1	--	D.o.A (see note 2)	Long term
Liquid Submersion cooling (Oil cooling)	8.2.4.2.2	40	14,8 (see note 3)	Long term
Domain: Power distribution systems				
Modular UPS	9.3.2	10	1,5 (see note 4)	Long term
Up to 400 VDC	9.4.3.2	7	1,1 (see note 4)	Long term
High-efficiency power distribution units	9.4.4	5	0,8 (see note 4)	Long term
High-efficiency motors in fans and pumps	9.4.4	2	0,3 (see note 4)	Medium term
Improved efficiency UPS units	9.4.4	10	1,5 (see note 4)	Medium term
Rotary-based UPS units	9.4.4	8	1,2 (see note 4)	Medium term
Elimination of isolation transformers	9.4.4	--	D.o.A (see note 2)	Long term
Domain: Infrastructure requirements				
Location	10.1	--	D.o.A (see note 2)	Long term
Building conception	10.3	--	D.o.A (see note 2)	Long term
Internal Design	10.4	--	D.o.A (see note 2)	Long term
IT infrastructure	10.5	--	D.o.A (see note 2)	Long term
Domain: Energy efficiency within ICT sites				
Urbanization	11.2.1	--	D.o.A (see note 2)	Long term
DCIM	11.2.2	--	D.o.A (see note 2)	Long term
NOTE 1: The overall saving shown assumes that IT infrastructure initially constitutes 37 % of overall energy consumption. NOTE 2: D.o.A: Depend of the Application, the technology is so dependent on the scope that it is impossible to quantify the typical savings. NOTE 3: The overall saving shown assumes that environmental control systems initially constitute 45 % of overall energy consumption. NOTE 4: The overall saving shown assumes that power distribution systems initially constitute 15 % of overall energy consumption.				

Annex B (informative): Indications and recommendations

B.1 Indications

B.1.1 Class and costs

The capital expenditure (Capex) and operational expenditure (Opex) of new ICT sites increase with the class level.

Variability of costs depending on the class considered are:

- the cost of construction, equipment and maintenance increases according to class;
- power density (kW / m²) also increases, as well as the associated cooling needs;
- the proportion of area occupied by the technical elements (and therefore not used by servers) is higher when the class is higher;
- Finally, construction delays are longer for Class 4 site than for a Class 1.

Capex, which includes building, design, facilities (such as energy, cooling and fire detection) shows the most significant increase between Class 2 and Class 3 due to the creation of a fully redundant, concurrently maintainable facility including the power and cooling infrastructure.

B.1.2 Improvement of services

Improvement of services, especially in the telecommunications and Internet Service Provider (ISP) world, need huge computing power, linked to the natural growth of their activities or global consolidation initiatives. Additionally, new services (VOD, VOIP, TV ADSL, etc.), electronic exchanges with customers (B2C), suppliers or partners (B2B) and between machines (M2M) will impose new constraints in terms of connectivity, availability, security and random workload absorption.

An overall approach has to be taken to IT in the ICT sites, enabling sharing policies and being able to respond immediately to application needs, with the required level of service, in a cost effective manner.

B.2 Recommendations

B.2.1 Existing ICT sites

B.2.1.1 General

There are three mains approaches concerning energy management in an existing data centre:

- reduction of DCEM (increase efficiency);
- reduction of energy consumption KPI_{EC} (cost effective);
- optimum usage of existing resources (environment and/or technical).

For each of approaches some specific actions should be initiated. It should be noted that some actions will have positive effects via multiple approaches.

B.2.1.2 Reduction of KPI_{TE}

In addition to conforming to clause 11.1, it is recommended that equipment and processes be established to enable measurement of the electrical consumption at different points to determine KPI_{TE} (i.e. to determine the comparative values of clause 5.4.1).

All actions related to reducing power consumption of cooling systems infrastructures (chillers, fans, engines, pumps) and increasing the energy efficiency of the power distribution system (UPS, PDU, Transformers), will have a positive effect on the KPI_{TE}. It should be noted that most of these actions are costly, and represent a risk for business continuity.

B.2.1.3 Reduction of KPI_{EC}

In addition to conforming to clause 5.3, it should be noted that actions to reduce the energy consumption of the information technology equipment (such as power management, capacity management and consolidation initiatives) will have a positive effect on energy consumption and energy costs, but could have a negative effect on KPI_{TE}. These actions can be balanced by the actions in computer rooms such as aisle segregation, higher operating temperatures and free cooling.

B.2.1.4 Optimum usage of existing resources

In addition to conforming to clause 11.1, actions should be undertaken to optimize the usage of existing resources including capacity management, virtualization and logical consolidations in order to increase computational load of servers.

B.2.1.5 High density areas

High-density areas should not be created that would impact air-flow and the effective cooling of existing areas. In enterprise data centres, it is recommended not to load racks fully and to balance the use high- and low-density equipments in rows.

B.2.1.6 IT Infrastructure

B.2.1.6.1 Architecture and policy

Policy should be focused on shared components of the IT infrastructure.

The architecture should be based on blade farms for X86 servers, and partitionable high-end Unix servers or traditional mainframes for large database processing. For storage, a common shared infrastructure should be built on SAN architecture.

B.2.1.6.2 Automation and capacity management

All operation processes should be automated using specific tools including:

- supervision;
- backup;
- high-availability - disaster recovery;
- inventory - asset management;
- scheduling;
- monitoring (measurement);
- capacity management;
- utility computing.

History

Document history		
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V1.2.1	January 2017	Publication