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Abstract

The Information and Communication Technology (ICT) sector including data centres generates up to 2% of the global CO_2 emissions and data centres are estimated to have the fastest growing carbon footprint from across the whole ICT sector, mainly due to new business such as the cloud computing and the rapid growth of the use of Internet services. The European Code of Conduct for Data Centre Energy Efficiency programme is a voluntary initiative created in 2008 in response to the increasing energy consumption in data centres and the need to reduce the related environmental, economic and energy supply security impacts. Companies participating on the Code of Conduct have to adopt best practices for energy management in data centres. The present report supplement to the Code of Conduct and present the updated (year 2018) version of the Best Practices. This report is provided as an education and reference document as part of the Code of Conduct to assist data centre operators in identifying and implementing measures to improve the energy efficiency of their data centres. A broad group of expert reviewers from operators, vendors, consultants, academics, professional and national bodies have contributed to and reviewed the Best Practices. This report provides a full list of the identified and recognised data centre energy efficiency best practices within the Code of Conduct. Customers or suppliers of IT services may also find it useful to request or provide a list of Code of Conduct Practices implemented in a data centre to assist in procurement of services that meet their environmental or sustainability standards.

1 Document Information

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2 Introduction

This document is a companion to the EU Code of Conduct on Data Centre Energy Efficiency and provides the full list of identified Best Practices for data centre operators as referenced in the Code of Conduct Participant and Endorser Guidelines documents.

2.1 Role of Best Practices

This Best Practice supplement to the Code of Conduct is provided as an education and reference document as part of the Code of Conduct to assist data centre operators in identifying and implementing measures to improve the energy efficiency of their data centres. A broad group of expert reviewers from operators, vendors, consultants, academics, professional and national bodies have contributed to and reviewed the Best Practices.

This Best Practice supplement is a full list of the identified and recognised data centre energy efficiency best practices within the Code of Conduct. The best practice list provides a common terminology and frame of reference for describing an energy efficiency practice, to assist Participants and Endorsers in avoiding doubt or confusion over terminology. Customers or suppliers of IT services may also find it useful to request or provide a list of Code of Conduct Practices implemented in a data centre to assist in procurement of services that meet their environmental or sustainability standards.

2.2 Expected Minimum Practices

To help ensure that Participants to the Code of Conduct are recognised as having committed to a useful and substantial level of energy saving effort, a subset of the Best Practices are identified in this document as being the expected minimum level of energy saving activity for Participant status.

The less disruptive or intrusive of the Practices are identified as being applied to the existing data centre and IT equipment, retrospectively where necessary. It is accepted that a number of the Practices identified as expected are inappropriate or present an unnecessary burden when applied to an existing running data centre. These Practices are identified as being expected either, when new IT equipment or software is sourced and deployed, or during a retrofit of the facility. These Practices provide substantial benefits and are intended to achieve efficiency improvements through the natural churn of equipment and facilities.

All expected Practices should be applied to any data centre constructed from 2011 onwards, specifically all Practices marked as “Entire data centre”, “New software”, “New IT equipment” and “New build or retrofit” which are within the applicants control.

Practices are marked in the expected column as;

Category	Description
Entire Data Centre	Expected to be applied to all existing IT, Mechanical and Electrical equipment within the data centre
New Software	Expected during any new software install or upgrade
New IT Equipment	Expected for new or replacement IT equipment
New build or retrofit	Expected for any data centre built or undergoing a significant refit of the M&E equipment from 2011 onwards
Optional Practices	Practices without a background colour are optional for Participants

Note that existing IT equipment moved from another data centre is not expected to comply with the New IT Equipment or New Software Practices. New or replacement IT equipment excludes the direct replacement of failed hardware with like for like as part of normal operations. New software install or upgrade refers to major upgrades of software and not the application of service packs and patches in normal management and use.

Retrofit is intended to describe major disruptive works in the data centre which present the opportunity at little incremental cost to implement these additional Practices. Examples of retrofit would be (a) when the power to the data floor is shut off and the IT equipment and cabinets removed it is expected that Practice **5.1.1** Contained hot or cold aisle would be implemented (b) if the CRAC / CRAH units are being upgraded or replaced it is expected that Practice **5.5.1** Variable speed fans would be implemented as part of this change.

2.3 Application and Assessment

The Best Practices form part of the application and assessment for Participant status. This process is described in the Participant and Endorser Guidelines documents.

2.4 Value of Practices

Each Practice has been assigned a qualitative value to indicate the level of benefit to be expected from an action and the relative priorities that should be applied to them. These values are from 1 to 5 with 5 indicating the maximum value. These values are not intended to be totalled or aggregated to provide an overall 'operator score' and should not be mistaken for quantitative. This would require large scale data on the effects of each Practice or technology which is not yet available as well as a complex system of scoring representing the combinational increase or reduction of individual Practice values within that specific facility.

2.5 Applicability of Expected Practices

It is understood that not all operators will be able to implement all of the expected Practices in their facilities due to physical, logistical, planning or other constraints. In these instances an explanation of why the expected action is not applicable or practical should be provided in the "Reason why this Practice cannot be implemented in this data centre" column in the reporting form, alternative best practices from the Code of Conduct or other sources may be identified as direct replacements if they result in similar energy savings.

2.6 Type of Participant

Each Participant should identify the type of operator that best describes their activity within the data centre for which they are completing the form on the "Data Centre Information" tab as;

Table 2.-1 Types of Participants

Type	Description
Operator	Operates the entire data centre from the physical building through to the consumption of the IT services delivered.
Colocation provider	Operates the data centre for the primary purpose of selling space, power and cooling capacity to customers who will install and manage their own IT hardware and services.
Colocation customer	Owns and manages IT equipment located in a data centre in which they purchase managed space, power and cooling capacity.
Managed service provider (MSP)	Owns and manages the data centre space, power, cooling, IT equipment and some level of software for the purpose of delivering IT services to customers. This would include traditional IT outsourcing.
Managed service provider in colocation space	A managed service provider which purchases space, power or cooling in a data centre in order to provide services to third parties.

The type of operator serves two purposes, first it assists the secretariat in the assessment of an application and second it will be included in the listing for data centres which achieve Participant status on the Code of Conduct website.

2.7 Participants who do not control the entire data centre

It is understood that not all operators are responsible for all aspects of the IT environment defined within the Best Practices. This is not a barrier to Participant status but the operator should sign as a Participant and act as an Endorser for those Practices outside of their control.

The following sections are included to provide guidance to operators with partial control of the data centre on which practices they are expected to implement and which they are expected to Endorse.

It is suggested that you download the application form, select your type of operator and then your areas of responsibility whilst reading this document to understand how this categorisation guides practice implementation.

2.7.1 Guidance to operators with partial control of the data centre

The Best Practice tab of the reporting form provides guidance for each of the minimum expected Practices on whether these are considered to apply to each of these example types of operator, in which cases responsibility is to be shared and how that may be implemented. This may be found in the columns labelled "Guidance to operators with partial control of the data centre".

2.7.2 Areas of Responsibility

Operators' areas of responsibility are defined as;

Table 2-1 Areas of responsibility

Area	Description
Physical building	The building including security, location and maintenance.
Mechanical and electrical plant	The selection, installation, configuration, maintenance and management of the mechanical and electrical plant.
Data floor	The installation, configuration, maintenance and management of the main data floor where IT equipment is installed. This includes the floor (raised in some cases), positioning of CRAC / CRAH units and basic layout of cabling systems (under floor or overhead).
Cabinets	The installation, configuration, maintenance and management of the cabinets into which rack-mount IT equipment is installed.
IT equipment	The selection, installation, configuration, maintenance and management of the physical IT equipment.
Operating System / Virtualisation	The selection, installation, configuration, maintenance and management of the Operating System and virtualisation (both client and hypervisor) software installed on the IT equipment. This includes monitoring clients, hardware management agents etc.
Software	The selection, installation, configuration, maintenance and management of the application software installed on the IT equipment.
Business Practices	The determination and communication of the business requirements for the data centre including the importance of systems, reliability availability and maintainability specifications and data management processes.

An example of Participant responsibility would be a collocation provider who does not control the IT equipment should actively endorse the Practices relating to IT equipment to their customers. This might include the provision of services to assist customers in adopting those Practices. Equally an IT operator using collocation should request their collocation provider to implement the Practices relating to the facility.

Note that these boundaries of responsibility do not apply within organisations. An applicant is considered to control an area if a parent, subsidiary or group company owns or controls the area. For example, if another division of the same group of companies operates a colocation (Colo), facility within which the applicant operates equipment as a service provider this is considered to be a managed service provider with responsibility for the physical building, mechanical and electrical plant, data floor and cabinets, not a managed service provider in collocation space (Colo).

2.7.3 Implement or Endorse

Each operator should determine which of the Practices apply to them based on their areas of responsibility. The table below provides an overview for common types of Participant;

Table 2-3 Areas of responsibility for common applicant types

	Operator	Colo provider	Colo customer	MSP in Colo	MSP
Physical building	Implement	Implement	Endorse	Endorse	Implement
Mechanical & electrical plant	Implement	Implement	Endorse	Endorse	Implement
Data floor and air flow	Implement	Implement & Endorse	Implement & Endorse	Implement	Implement
Cabinets and cabinet air flow	Implement	Implement & Endorse	Implement & Endorse	Implement	Implement
IT equipment	Implement	Endorse	Implement	Implement	Implement
Operating System & Virtualisation	Implement	Endorse	Implement	Implement	Implement
Software	Implement	Endorse	Implement	Implement & Endorse	Implement & Endorse
Business Practices	Implement	Endorse	Implement	Endorse	Endorse

There are many instances where the responsibility for a Practice will need to be shared between supplier and customer, for example the installation of IT equipment in the correct orientation in a hot / cold aisle layout data centre. In this case both parties should Implement the Practice themselves and Endorse it to the other party(ies).

3 Data Centre Utilisation, Management and Planning

It is important to develop a holistic strategy and management approach to the data centre. This will enable the Participant to effectively deliver reliability, economic, utilisation and environmental benefits.

3.1 Involvement of Organisational Groups

Ineffective communication between the disciplines working directly and indirectly in the data centre is a major driver of inefficiency as well as capacity and reliability issues.

No	Name	Description	Expected	Value
3.1.1	Group involvement	Establish an approval board containing representatives from all disciplines (software, IT, M&E, procurement). Require the approval of this group for any significant decision to ensure that the impacts of the decision have been properly understood and an effective solution reached. For example, this could include the definition of standard IT hardware lists through considering the M&E implications of different types of hardware. This group could be seen as the functional equivalent of a change board.	Entire Data Centre	5

3.2 General Policies

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

No	Name	Description	Expected	Value
3.2.1	Consider the embodied environmental impact of installed devices	Carry out an audit of existing equipment to maximise any unused existing capability by ensuring that all areas of optimisation, consolidation and aggregation are identified prior to new material investment. The most important element to this in terms of impact is the IT equipment. The severity of impact is related to the frequency of refresh and replacement.	Entire Data Centre	3
3.2.2	Mechanical and electrical equipment environmental operating ranges	Recommend the selection and deployment of mechanical and electrical equipment which does not itself require cooling in normal operation (the exception to this being UPS batteries). Note: UPS batteries require to be kept at lower temperatures to preserve performance and reliability and to maximise operational lifetime.	New build or retrofit	4
3.2.3	Service Charging Models	Co-location and Managed Service providers should employ charging models and tariffs that encourage the use of best practice and improve energy efficiency. Enterprise operators should ensure that the true cost of data centre services are understood and fully reported.	Optional	3
3.2.4	Life Cycle Assessment	Introduce a plan for Life Cycle Assessment (LCA) in accordance with emerging EU guidelines and internationally standardised methodologies. An example of which would be *ISO 14040.* *EN 15978* 'Sustainability of construction works - assessment of environmental performance of buildings - calculation method' is also a standard that is considered relevant to this Practice. Note: This Practice aims to reduce overall carbon footprint and improve sustainability rather than directly improve energy efficiency.	Optional	3
3.2.5	Environmental Management	Introduce a plan for Environmental Management in accordance with emerging EU guidelines and internationally standardised methodologies. An example of which would be *ISO 14001.*	Entire Data Centre	3
3.2.6	Energy Management	Introduce a plan for Energy Management in accordance with emerging EU guidelines and internationally standardised methodologies. An example of which would be ISO 50001. Note: The Code of Conduct can be used effectively to underpin the expectations and reporting requirements specifically for data centres in relation to *ISO 50001.*	Entire Data Centre	3
3.2.7	Asset Management	Ensure that Asset Management for both IT and mechanical and electrical assets etc. is implemented and controlled according to a standard and accepted methodology. An example of which would be *ISO 55000.* Understanding the numbers, types and purposes of the assets deployed in a data centre underpins effective energy management.	Optional	3

3.2.8	Sustainable energy usage	Consider the proportion of energy used by the data centre that comes from renewable / sustainable sources. Recording and reporting on the proportion of sustainable / renewable energy used against the overall energy consumption is expected to become an expected monitoring and reporting requirement in time. Note: Standardised metrics in this area are available as EN 50600-4-3 or ISO/IEC 30134-3. EN 50600-4-3 "Information technology — Data centre facilities and infrastructures — Part 4-3: Renewable Energy Factor" specifies the "Renewable Energy Factor, REF" as the ratio of the renewable energy (in kWh) to the total energy consumption (in kWh). Note: REF covers both renewable energy purchased for the utility (with guarantee of origin) and produced on-site. However, renewable energy produced on-site, that is not consumed on-site and partly or in total sold to the grid, shall be excluded from REF.	Entire Data Centre	1
3.2.9	Powering of devices via the IT cabling	Monitor and report on usage / energy consumption by devices power by IT cabling. IT cabling is increasingly be used to deliver power to devices both inside and outside the data centre. The advantage of this technology is that the same cable can be used for both network connectivity and power. Examples of this include telephony (voice) handsets, cameras, a variety of different environmental sensors even LED lights and lighting control. Note: The risk here is that this power is being taken directly from network switches, which constitute "IT Load". This needs to be considered when looking at energy usage calculations such as DCiE or PUE which may well give false indications if devices are being powered via IT communications cabling and usage is not being taken in to account. Note: This is particularly true if power is being delivered outside the data centre as might be the case with IP Telephony, network switches in the data centre potentially supplying handsets in nearby office spaces.	Optional	1
3.2.10	Impact of mobile / shifting workloads	Consider the type of workload(s) that will be supported both during the design and operation of data centres. Note: Traditionally steady workload levels in data centres have resulted in relatively constant power draws however developments in applications and software is resulting in increasingly fluctuating workloads and even the ability to migrate workloads seamlessly between sites. This not only potentially changes the required equipment resilience and reliability levels at a particular site it also changes the way that the installed power and cooling infrastructure needs to be managed from both a capacity and energy efficiency perspective.	Optional	2

3.2.11	Alternative power generation technologies	Consideration should be given to energy supplies from alternative and sustainable energy sources including fuel cells, wind power, photo-voltaic and shared local-generation using biomass / bio-fuels etc., which might provide a lower carbon footprint, economically attractive and reliable alternative to utility electricity supplies. Note: This Practice aims to reduce overall carbon footprint and improve sustainability rather than provide direct energy efficiency.	Optional	1
3.2.12	Monitor and manage air quality	Ensure that air quality is monitored and managed to ensure that critical equipment is not damaged by particulates or corrosive elements which might impact both IT equipment and cooling equipment in terms of performance, energy efficiency and reliability. This should inform the choice of filters used and the planned replacement schedule as well as the frequency of routine technical cleaning programme (including underfloor and ceiling void areas if applicable). Note: The ASHRAE white paper '2011 Gaseous and Particulate Contamination Guidelines for Data Centers' recommends that data centre air quality is monitored and cleaned according to ISO 14644-1 Class 8. This can be achieved by routine technical cleaning and simple filtration using the following guidelines: • Continuously air filtering using MERV 8 filters. • Air entering a data centre being screened with MERV 11 or MERV 13 filters.	Optional	2
3.2.13	Consider technical areas of data centres as industrial space	The data centre 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. Note: This objective aims to prevent the energy efficiency of the technical space being compromised by the need for human comfort other than to comply with local statutory requirement and law (Health and Safety etc.). Note: Data Centres are primarily technical spaces, not office space, and should therefore only require the control make up air volumes and environmental conditions to pressurise the spaces in order avoid ingress of particles and contaminants rather than for seated human comfort. This only relates to those areas of the centre intended to hold operational IT equipment or supporting mechanical or electrical infrastructure. These areas should not contain desks or workstations. Note: This is not intended to reduce or impose conditions on dedicated and purpose built office space within the data centre building.	Entire Data Centre	3

3.3 Resilience Level and Provisioning

One of the most significant sources of inefficiency in data centres is the over provisioning of space, power or cooling and the facilities being run at part capacity. Monolithic, as opposed to modular design of facilities also represents a significant and frequently unnecessary capital expenditure. Further, as the level of resilience of the data centre increases the inefficiencies due to fixed overheads increase and this is compounded by poor utilisation.

No	Name	Description	Expected	Value
3.3.1	Build resilience to business requirements	Only the level of resilience and therefore availability actually justified by business requirements and impact analysis should be built, or purchased in the case of a collocation customer. 2N infrastructures are frequently unnecessary and inappropriate. If only a single level of resilience is available in the data centre an increased resilience or availability for critical services might be obtained by splitting the IT platform across multiple sites and making applications resilient to the loss of an individual site.	New build or retrofit	3
3.3.2	Consider multiple levels of resilience	It is possible to build a single data centre to provide multiple levels of power and cooling resilience to different floor areas. Many co-location providers already deliver this, for example, optional 'grey' power feeds without UPS or generator back up.	New build or retrofit	3
3.3.3	Lean provisioning of power and cooling for a maximum of 18 months of data floor capacity	The provisioning of excess power and cooling capacity in the data centre drives substantial fixed losses and is unnecessary. Planning a data centre for modular (scalable) expansion and then building out this capacity in a rolling program of deployments is more efficient. This also allows the technology 'generation' of the IT equipment and supporting M&E infrastructure to be matched, improving both efficiency and the ability to respond to business requirements.	New build or retrofit	3
3.3.4	Design infrastructure to maximise part load efficiency	All areas of the data centre should be designed to maximise the energy efficiency of the facility under partial fill / partial load and variable IT electrical and cooling loads. This is in addition to one off modular provisioning and should consider the response of the infrastructure to dynamic loads. E.G. Appropriately controlled Variable Frequency (or speed) Drive for pumps, fans and compressors.	New build or retrofit	3
3.3.5	Design appropriate levels of resilience	Utilise appropriate levels of resilience within the data centre, IT equipment, software and network levels to achieve the service resilience and availability required by the business demands. Installing high levels of resilience require multiple redundant units which reduce overall energy efficiency.	Optional	4

4 IT Equipment and Services

The IT equipment creates the demand for power and cooling in the data centre, any reductions in power and cooling used by or provisioned for the IT equipment will have magnified effects at the utility energy supply.

Note that the specifications of IT equipment operating temperature and humidity ranges in this section do not indicate that the data floor should be immediately operated at the upper bound of these ranges. This is addressed in section **5**. The purpose of the equipment environmental specifications in this section is to ensure that new equipment is capable of operating under the wider ranges of temperature and humidity thus allowing greater flexibility in operating temperature and humidity to the operator.

4.1 Selection and Deployment of New IT Equipment

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

No	Name	Description	Expected	Value
4.1.1	IT hardware – Power	Include the Energy efficiency performance of the IT device as a high priority decision factor in the tender process. This may be through the use of Energy Star, SERT (http://www.spec.org/sert/) or SPECPower. (http://www.spec.org/power_ssj2008/results/) 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. The power consumption of the device at the expected utilisation or applied workload should be considered in addition to peak performance per Watt figures.	New IT Equipment	5

4.1.2	New IT hardware – Restricted (legacy) operating temperature and humidity range	If no equipment can be procured which meets the operating temperature and humidity range of Practice 4.1.3 (ASHRAE Class **A2**), then equipment supporting (at a minimum), the restricted (legacy) range of 15°C - 32°C inlet temperature and humidity from –12°C DP and 8% rh to 27°C DP and 80% rh may be procured. This range is defined as the ASHRAE Allowable range for Class **A1** class equipment. Class **A1** equipment is typically defined as Enterprise class servers (including mainframes) and storage products such as tape devices and libraries. To support the restrictive range of operation equipment should be installed in a separate area of the data floor in order to facilitate the segregation of equipment requiring tighter environmental controls as described in Practices **5.1.11**, **5.1.12** and **5.1.13**. In unusual cases where older technology equipment must be procured due to compatibility and application validation requirements (an example being air traffic control systems), these systems should be considered as subset of this Practice and installed so as not to restrict the operation of other equipment described above.	New IT Equipment	4
4.1.3	New IT hardware – Expected operating temperature and humidity range	Include the operating temperature and humidity ranges at the air intake of new equipment as high priority decision factors in the tender process. Equipment should be able to withstand and be within warranty for the full range of 10°C to 35°C inlet temperature and humidity –12°C DP and 8% rh to 27°C DP and 80% rh. This is defined by the ASHRAE Class **A2** allowable temperature and humidity range. Vendors are required to publish (not make available on request) any restriction to the operating hours within this range for any model or range which restricts warranty to less than continuous operation within the allowable range. To address equipment types which cannot be procured to meet this specification exclusions and mitigation measures are provided in Practices **4.1.2** for new IT equipment, **5.1.11** for existing data centres and **5.1.12** for new build data centres. Directly liquid cooled IT devices are addressed in Practice **4.1.14**.	New IT Equipment	5

4.1.4	New IT hardware – Extended operating temperature and humidity range	Include the operating temperature and humidity ranges at the air intake of new equipment as high priority decision factors in the tender process. Consider equipment which operates under a wider range of intake temperature and humidity such as that defined in ASHRAE Class **A4** (broadly equivalent to ETSI EN 300 019–1-3 Class 3.1). This extended range allows operators to eliminate the capital cost of providing mechanical cooling capability in some hotter climate regions. Note: Many vendors provide equipment whose intake temperature and humidity ranges exceed the minimum sets represented by the described classes in one or more parameters. Operators should request the actual supported range from their vendor(s) and determine whether this presents an opportunity for additional energy or cost savings through extending the operating temperature or humidity range in all or part of their data centre.	Optional	3
4.1.5	Select IT equipment suitable for the data centre power density and cooling delivery capabilities	Select and deploy IT equipment at the designed power density (per cabinet or sq m) of the data centre to avoid running the cooling system outside design parameters. Note: Increasing power density may create cooling and air flow management problems reducing both capacity and efficiency. Power and cooling need to be considered as capacity constraints in addition to physical space as referenced in Practice **5.5.6**.	New IT Equipment	3
4.1.6	IT equipment power usage against inlet temperature	When selecting new IT equipment require the vendor to supply at minimum the total system power for a range of temperatures covering the full allowable inlet temperature range for the equipment at 100% load on a specified recognised benchmark such as Linpack, SERT (http://www.spec.org/sert/) or SPECPower http://www.spec.org/power_ssj2008/). Data should be provided for 5°C or smaller steps of inlet temperature. Optional but recommended; Total system power covering the full allowable inlet temperature range under 0% and 50% load on the selected benchmark. These sets of data shown easily in a single table and single chart will allow a data centre operator to select equipment to meet their chosen operating temperature range without significant increase in power consumption. This Practice is intended to improve the thermal performance of IT equipment by allowing operators to avoid devices with compromised cooling designs and creating a market pressure toward devices which operate equally well at increased intake temperature. Reference and use the current U.S. EPA ENERGY STAR specifications for Servers. Additionally reference and use the current U.S. EPA ENERGY STAR specifications for Data Center Storage.	New IT Equipment	5

4.1.7	Select equipment suitable for the data centre - Air flow direction	When selecting equipment for installation into cabinets ensure that the air flow direction matches the air flow design for that area. This is commonly front to rear or front to top. If the equipment uses a different air flow direction to that defined for the area into which it is installed (such as right to left when the cabinet is intended to be front to back) it should only be used with a correction mechanism such as ducts, or special cabinets that divert the air flow to the defined direction. Equipment with non standard air flow will compromise the air flow management of the data centre and therefore restrict the ability to increase temperature set points. It is possible to mitigate this issue by segregating such equipment according to Practices **5.1.11**, **5.1.12** and **5.1.13**.	New IT Equipment	4
4.1.8	Enable power management features	Formally change the deployment process to include the enabling of power management features on IT hardware as it is deployed. This includes BIOS, operating system and driver settings.	New IT Equipment	5
4.1.9	Provision only to the actual IT power usage required	Provision power and cooling only to the planned power draw of the IT equipment as-configured (based on the components actually installed), rather than the Power Supply Unit (PSU) size or nameplate rating. This is intended to avoid over-sizing of electrical infrastructure resulting in a low (partial) load and therefore inefficient operation. Note: This may require changes to the provisioning if the IT equipment performance is increased or upgraded.	New IT Equipment	3
4.1.10	Energy Star compliant hardware	The Energy Star Labelling programs for IT equipment should be used as a guide to server selection where and when available for that class of equipment. Operators who are able to determine the in use energy efficiency of hardware through more advanced or effective analysis should select the most efficient equipment for their scenario. This Practice should be in line with the current U.S. EPA ENERGY STAR specifications for Servers. Additionally reference and use the current U.S. EPA ENERGY STAR specifications for Data Center Storage.	New IT Equipment	4

4.1.11	Energy & temperature reporting hardware	Select equipment with power and inlet temperature reporting capabilities, preferably reporting energy used as a counter in addition to power as a gauge. Where applicable, industry standard reporting approaches should be used such as IPMI, DCIM and SMASH. To assist in the implementation of temperature and energy monitoring across a broad range of data centres all devices with an IP interface should support one of; • SNMP polling of inlet temperature and power draw. Note that event based SNMP traps and SNMP configuration are not required • IPMI polling of inlet temperature and power draw (subject to inlet temperature being included as per IPMI 2.0 rev 4) • An interface protocol which the operators' existing monitoring platform is able to retrieve inlet temperature and power draw data from without the purchase of additional licenses from the equipment vendor The intent of this Practice is to provide energy and environmental monitoring of the data centre through normal equipment churn.	New IT Equipment	3
4.1.12	Control of equipment energy use	Select equipment which provides mechanisms to allow the external control of its energy use. An example of this would be the ability to externally restrict a server's maximum energy use or trigger the shutdown of components, entire systems or sub-systems.	Optional	5
4.1.13	Select free standing equipment suitable for the data centre – Airflow direction	When selecting equipment which is free standing or supplied in custom cabinets the air flow direction of the enclosures should match the airflow design in that area of the data centre. This is commonly front to rear or front to top. Specifically the equipment should match the hot / cold aisle layout or containment scheme implemented in the facility. Equipment with non standard air flow can compromise the air flow management of the data centre and restrict the ability to raise temperature set points. It is possible to mitigate this compromise by segregating such equipment according to Practices **5.1.11**, **5.1.12** and **5.1.13** Note: Try to avoid free standing equipment as it usually does not allow a well organised airflow through the data centre especially if the major part of the room is equipped with well organised IT equipment mounted in cabinets.	New IT Equipment	4

4.1.14	Operating temperature range – Direct liquid cooled IT equipment	Devices whose primary cooling method is not air and are directly liquid cooled, are not subject to the air environmental requirements specified in **4.1.2 or 4.1.3**. As described in **5.4.2.9** this Practice applies to devices which deliver cooling liquid directly to the heat removal system of the components such as water cooled heat sinks or heat pipes and not the delivery of cooling liquid to an internal mechanical refrigeration system or in chassis air cooling systems which are required to deliver coolant liquid or air to the IT components within the range specified. Direct liquid cooling may offer advantages in very high density applications such as High Performance Computing (HPC), and may demonstrate some energy efficiency advantages including the useful extraction and potential re-use of 'waste heat'. Note: ASHRAE offer guidelines for the use of liquid cooling in data centres.	Optional	4
4.1.15	AC/DC Converter efficiency	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. This Practice should be implemented in line with the *IEC 62040-5* standard currently under development.	New IT Equipment	3

4.2 Deployment of New IT Services

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

No	Name	Description	Expected	Value
4.2.1	Deploy using Grid and Virtualisation technologies	Processes should be put in place to require senior business approval for any new service that requires dedicated hardware and will not run on a resource sharing platform. This applies to servers, storage and networking aspects of the service.	New IT Equipment	5
4.2.2	Reduce IT hardware resilience level	Determine the business impact of service incidents for each deployed service and deploy only the level of hardware resilience actually justified.	New IT Equipment	4
4.2.3	Reduce hot / cold standby equipment	Determine the business impact of service incidents for each IT service and deploy only the level of Business Continuity / Disaster Recovery standby IT equipment and resilience that is actually justified by the business impact.	New IT Equipment	4
4.2.4	Select efficient software	Make the energy use performance of the software a primary selection factor. Whilst forecasting and measurement tools and methods are still being developed, approximations could 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. See "Further development of software efficiency definitions" in section **11**.	New Software	5
4.2.5	Develop efficient software	Make the energy use performance of the software a major success factor of the project. Whilst forecasting and measurement tools and methods are still being developed approximations, could 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 optimisation should not be seen as a low impact area to reduce the project budget. See "Further development of software efficiency definitions" in section **11**.	New Software	5
4.2.6	Incentives to develop efficient software	If outsourcing software development then include the energy use of the software in the bonus / penalty clauses of the contract. Whilst forecasting and measurement tools and methods are still being developed approximations, could 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 optimisation should not be seen as a low impact area to reduce the project budget. See "Further development of software efficiency definitions" in section **11**.	Optional	5

4.2.7	Eliminate traditional 2N hardware clusters	Determine the business impact of short service incidents for each deployed service and replace traditional active / passive server hardware clusters with fast recovery approaches such as restarting virtual machines elsewhere. (This does not refer to grid or High Performance Compute clusters).	Optional	4

4.3 Management of Existing IT Equipment and Services

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.

No	Name	Description	Expected	Value
4.3.1	Audit existing physical and service estate	Audit the existing physical and logical estate to establish what equipment is in place and what service(s) it delivers. Consider the implementation of an ITIL type Configuration Management Data base and Service Catalogue. A useful standard and reference to use in support of this Practice could be *ISO 55000* See Practice **3.2.7.**	Entire Data Centre	5
4.3.2	Decommission and remove unused equipment	Completely decommission and remove any equipment that is not required or used to support services no longer in use. Installed hardware should be regularly examined to ensure that it is still required and is supporting active services.	Entire Data Centre	5
4.3.3	Virtualise and archive legacy services	Servers or services 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. These services can then be brought online when genuinely required.	Optional	5
4.3.4	Consolidation of existing services	Existing services that do not achieve high utilisation of their hardware should be consolidated through the use of resource sharing technologies to improve the use of physical resources. This applies to servers, storage and networking devices.	Optional	5
4.3.5	Decommission low business value services	Identify services whose business value or criticality is low and that do not justify the financial or environmental overhead. Decommission or archive these services or remove to locations with less reliability / resilience to reduce energy and financial overhead.	Optional	4
4.3.6	Shut down and consider removal of idle equipment	Servers, networking and storage equipment that is idle for significant time and cannot be virtualised or archived should be shut down or put into a low power 'sleep' state. Complete removal should also be considered. Note: It will be necessary to validate the ability of legacy applications and hardware to survive these state changes without loss of function or reliability.	Optional	4

4.3.7	Control of system energy use	Consider resource management systems capable of analysing and optimising where, when and how IT workloads are executed and their consequent energy use. This may include technologies that allow remote deployment or delayed execution of jobs or the movement of jobs within the infrastructure to enable shutdown of components, entire systems or sub-systems. The desired outcome is to provide the ability to limit localised heat output or constrain system power draw to a fixed limit, at a data centre, row, cabinet or sub-DC level.	Optional	4
4.3.8	Audit of existing IT equipment environmental requirements	Identify the allowable intake temperature and humidity ranges for existing installed IT equipment. Equipment with restrictive intake temperature ranges should be identified so that it may be either marked for replacement with newer equipment capable of a wider intake range or moved and dealt with according to Practices “Equipment segregation” (**5.1.11**) and “Separate environmental zones” (**5.1.12** and **5.1.13**).	Entire Data Centre	4

4.4 Data Management

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

No	Name	Description	Expected	Value
4.4.1	Data management policy	Develop a data management policy to define which data should be kept, for how long and at what level of protection. Communicate the policy to users and enforce. Particular care should be taken to understand the impact of any data retention requirements.	Entire Data Centre	3
4.4.2	Separate user logical data storage areas by retention and protection policy	Provide users with multiple data storage areas which are clearly identified by their retention policy and level of data protection. Communicate this policy to users to enable them to store data in an area which matches the required levels of protection and retention. This is particularly valuable where strong retention requirements exist as it allows data subject to those requirements to be separated at source presenting substantial opportunities for cost and energy savings. Where possible automate the application of these policies.	Optional	3

4.4.3	Separate physical data storage areas by protection and performance requirements	Create a tiered storage environment utilising multiple media types delivering the required combinations of performance, capacity and resilience. Implement clear guidelines on usage of storage tiers with defined SLAs for performance and availability. Consider a tiered charging model based on usage at each performance level.	Optional	4
4.4.4	Select lower power storage devices	When selecting storage hardware evaluate the energy efficiency in terms of the service delivered per Watt between options. This may be deployment specific and should include the achieved performance and storage volume per Watt as well as additional factors where appropriate, such as the achieved levels of data protection, performance availability and recovery capability required to meet the business service level requirements defined in the data management policy. Evaluate both the in use power draw and the peak power of the storage device(s) as configured, both impact per device cost and energy consumption through provisioning. Additionally reference and use the current U.S. EPA ENERGY STAR specifications for Data Center Storage	Optional	4
4.4.5	Reduce total data volume	Implement an effective data identification and management policy and process to reduce the total volume of data stored. Consider implementing 'clean up days' where users delete unnecessary data from storage.	Optional	4
4.4.6	Reduce total storage volume	Implement the data management policy to reduce the number of copies of data, both logical and physical (mirrors). Implement storage subsystem space saving features, such as space efficient snapshots / copies or compression. Implement storage subsystem thin provisioning features where possible.	Optional	4

5 Cooling

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

5.1 Air Flow Management and Design

The objective of airflow management is to circulate only the necessary amount of air through the data centre at any time that is required to remove the heat actually created by the IT equipment. This means no air returns to the cooling system without absorbing heat and no air circulates more than one time through the IT equipment.

Poor airflow management often results attempts to compensate by reducing cooling unit air supply temperatures or supplying excessive air volumes, which has an energy penalty. Addressing these issues will deliver more uniform equipment inlet temperatures and allow set points to be increased (with the associated energy savings) without the risk of equipment overheating. Implementation of air management actions alone does not result in an energy saving – they are enablers which need to be tackled before temperature set points can be raised or airflow volumes reduced.

Note: Computational Fluid Dynamics (CFD) can help to achieve an optimal airflow design if used during the early planning stages prior to construction or room fit-out.

No	Name	Description	Expected	Value
5.1.1	Design – Hot / Cold aisle	As the power densities and air flow volumes of IT equipment have increased it has become necessary to ensure that equipment shares an air flow direction, within the cabinet, in adjacent cabinets and across aisles. The hot / cold aisle concept aligns equipment air flow to create aisles between cabinets that are fed cold air from which all of the equipment draws intake air in conjunction with hot aisles with no cold air feed to which all equipment exhausts air. Reinforce Hot / Cold aisle design with empty but fully blanked cabinets (or solid doors) rather than leaving gaps in aisles.	New IT Equipment and New build or retrofit	5
5.1.2	Design – Contained hot or cold air	There are a number of design concepts whose basic intent is to contain and separate the cold air from the heated return air on the data floor; • Hot aisle containment • Cold aisle containment • Contained cabinet supply, room return • Room supply, Contained cabinet return, (inc. cabinet chimneys) • Contained cabinet supply, Contained cabinet return This action is expected for air cooled facilities over 1kW per square meter power density. Note: Failure to contain air flow results in both a reduction in achievable cooling efficiency and an increase in risk. Changes in IT hardware and IT management tools mean that the air flow and heat output of IT devices is no longer constant and may vary rapidly due to power management and workload allocation tools. This may result in rapid changes to data floor air flow pattern and IT equipment intake temperature which cannot be easily predicted or prevented.	New build or retrofit	5

5.1.3	Design – Contained hot or cold air – Retrofit	Where hot / cold aisle separation is already in use but there is no containment of hot or cold air it is possible to retrofit to provide basic separation for example using curtains. Care should be taken to understand implications for fire systems.	Optional	4
5.1.4	Cabinet air flow management – Blanking Plates	Installation of blanking plates where there is no equipment to reduce hot air re-circulating through gaps in the cabinet. This reduces air heated by one device being ingested by another device, increasing intake temperature and reducing efficiency.	Entire Data Centre	4
5.1.5	Cabinet air flow management – Other openings	Installation of aperture brushes (draught excluders) or cover plates to cover all air leakage opportunities in each cabinet. This includes; • floor openings at the base of the cabinet • Gaps at the sides, top and bottom of the cabinet between equipment or mounting rails and the perimeter of the cabinet	New build or retrofit	3
5.1.6	Provide adequate free area on cabinet doors	Solid doors should be replaced (where cooling ventilation is necessary), with perforated doors to ensure adequate cooling airflow. Solid doors impede the cooling airflow and promote recirculation within the enclosed cabinet increasing equipment inlet temperatures. ISO/IEC 14763-2 recommends a minimum of at least 66% perforated area.80% is considered an ideal target by other authorities.	New IT Equipment New build or retrofit	3
5.1.7	Raised floor air flow management	Close all unwanted apertures in the raised floor. Review placement and opening factors of vented tiles to reduce bypass. Maintain unbroken rows of cabinets to prevent re-circulated air. If necessary fill with empty fully blanked cabinets. Managing unbroken rows is especially important in hot and cold aisle environments. Any opening between the aisles will degrade the separation of hot and cold air.	Entire Data Centre	3
5.1.8	Raised floor air flow management – Obstructions	Review the placement and level of obstruction created by cabling, cable trays and other structures in the air flow paths, these obstruct airflow and create turbulence, increasing the resistance and increasing the energy requirements of air movement and may increase velocities, causing negative pressure. Ensure that the under floor area is as free of obstructions as possible. The use of overhead cabling trays can substantially reduce the level of obstruction.	Entire Data Centre	3
5.1.9	Design – Return plenums	Consider the use of a return plenum(s) to return heated air from the IT equipment directly to the air conditioning units.	Optional	3
5.1.10	Design – Raised floor or suspended ceiling height	It is common to use the voids in the raised floor, suspended ceiling or both in a data centre to feed cold air to equipment or remove hot air from the equipment. Where they are used, increasing the size of these spaces can reduce the fan losses associated with moving air.	Optional	3

5.1.11	Equipment segregation	Deploy groups of equipment with substantially different environmental requirements and / or equipment airflow direction in a separate area. Where the equipment has different environmental requirements it is preferable to provide separate environmental controls. This objective of this Practice is to address the issue of the data centre cooling plant settings being constrained by the equipment with the most restrictive environmental range or poor air flow control as this compromises the efficiency of the entire data centre. Note: This Practice applies to IT, mechanical and electrical equipment installed in the data centre.	New IT Equipment and New build or retrofit	3
5.1.12	Separate environmental zones	Where a data centre houses both IT equipment compliant with the extended range of Practice **4.1.3** and other equipment which requires more restrictive temperature or humidity control as described in Practice **4.1.2**, separate areas should be provided. These areas should have separate environmental controls and may use separate cooling systems to facilitate optimisation of the cooling efficiency of each zone. Examples are equipment which; • Requires tighter environmental controls to maintain battery capacity and lifetime such as UPS • Requires tighter environmental controls to meet archival criteria such as tape • Requires tighter environmental controls to meet long warranty durations (10+ year) The objective of this Practice is to avoid the need to set the data centre cooling plant for the equipment with the most restrictive environmental range and therefore compromising the efficiency of the entire data centre.	New build or retrofit	4
5.1.13	Separate environmental zones – Colocation or Managed Service Provider	Customers requiring extremely tight environmental control or items such as legacy equipment should not compromise the entire data centre for specific items of equipment. Service providers should design in such a way that discrete areas may be offered to customers with additional “close control” cooling equipment in order to match specific requirements this and therefore offer a tighter SLA that would inevitably involve reduced energy efficiency. These legacy equipment support areas may be differentially priced to include the capital and operational (Metered), cost overhead of supporting a less energy efficient legacy environment as an incentive for customers to install IT equipment in more efficient areas and consider the options for more energy efficient delivery of IT services.	New build or retrofit	4

5.1.14	Control of supplied air flow volume minimizing over pressure	Investigate operating cooling unit fans to ensure a slight oversupply of air compared to IT equipment flow demand to minimise recirculation whilst avoiding oversupply of air volume (results in bypass and fan energy wastage). This principle is particularly applicable contained systems. In contained air systems, ensure that there is a slightly positive pressure (preferably no more than 5Pa) in the cold air stream with respect to the hot air stream.	New build or retrofit	3

5.2 Cooling Management

The data centre is not a static system and the cooling systems should be tuned in response to changes in the facility thermal load or external ambient conditions such as seasonal variation.

No	Name	Description	Expected	Value
5.2.1	Scalable or modular installation and use of cooling equipment	Cooling plant should be installed in a modular arrangement allowing operators to shut down unnecessary equipment. This should then be part of the review at each cooling load change. Design to maximise the part load efficiency as described in sections **3.3.4, 5.4.2.3** and **5.4.2.4.**	Optional	3
5.2.2	Shut down unnecessary cooling equipment	If the facility is not yet fully populated or space has been cleared through consolidation non variable plant such as fixed speed fan CRAC / CRAH units shall be turned off in the empty areas. Note: This should not be applied in cases where operating more plant at lower load is more efficient, e.g. variable speed drive CRAC / CRAH units.	Entire Data Centre	3
5.2.3	Review of cooling before IT equipment changes	The availability of cooling including the placement and flow of vented tiles should be reviewed before all IT equipment changes to optimise the use of cooling resources.	Entire Data Centre	2
5.2.4	Review of cooling strategy	Periodically review the IT equipment and cooling deployment against strategy.	Entire Data Centre	2
5.2.5	Review CRAC / CRAH Settings	Ensure that CRAC / CRAH units in occupied areas have appropriate and consistent temperature and relative humidity settings properly calibrated to avoid units working against each other. For example many CRAC / CRAH units now have the option to connect their controls and run together when installed in the same area. Care should be taken to understand and avoid any potential new failure modes or single points of failure that may be introduced.	Entire Data Centre	3
5.2.6	Dynamic control of building cooling	Consider implementing control systems that take multiple factors including cooling load, data floor air temperature and external air temperature into account to optimise the cooling system, (e.g. chilled water loop temperature) in real time.	Optional	3
5.2.7	Effective regular maintenance of cooling plant	Implement effective regular maintenance of the cooling system in order to conserve or achieve a “like new condition” is essential to maintain the designed cooling efficiency of the data centre. Examples are: belt tension, condenser coil fouling (water or air side), evaporator fouling etc. This includes regular filter changes to maintain air quality and reduce friction losses along with the routine monitoring of air quality and a regular technical cleaning regime (including underfloor areas if applicable).	Entire Data Centre	2

5.3 Temperature and Humidity Settings

Facilities are often overcooled with colder than necessary air temperatures (and hence chilled water temperatures, where used), resulting in an energy penalty. Widening the set range for humidity can substantially reduce humidifier loads. Reviewing and addressing air management issues as described in sections **5.1** and **5.2**, is recommended before set points can be changed in order to avoid risk to operational integrity and expert advice should always be sought before changing the environmental range for the facility. An increase in chilled water temperature set points provides enhanced efficiency for free cooling and a reduction in compressor energy consumption. Unnecessary humidifier loads generated by chilled water or evaporator temperatures below the data hall air dew point causing dehumidification should be eliminated through adjustment of the lower humidity set point.

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

No	Name	Description	Expected	Value
5.3.1	Review and if possible raise target IT equipment intake air temperature	Data Centres should be designed and operated *at their highest efficiency* to deliver intake air to the IT equipment within the temperature range of 10°C to 35°C (50°F to 95°F). The current, relevant standard is the ASHRAE Class **A2** allowable range for Data Centres. Operations in this range enable energy savings by reducing or eliminating overcooling. Note: Some data centres may contain equipment with legacy environmental ranges as defined in **4.1.2**, the maximum temperature for these facilities will be restricted by this equipment until segregation can be achieved as described in Practices **5.1.11**, **5.1.12** and **5.1.13**. Note: Additional Best Practices for airflow management as defined in section **5.1** may need to be implemented at the same time to ensure successful operations. Note: Some, particularly older, IT equipment may exhibit significant increases in fan power consumption as intake temperature is increased. Validate that your IT equipment will not consume more energy than is saved in the cooling system.	Entire Data Centre	4

5.3.2	Review and widen the working humidity range	Reduce the lower humidity set point(s) of the data centre within the ASHRAE Class **A2** range (–12°C DP and 8% rh to 27°C DP and 80% rh) to reduce the demand for humidification. Review and if practical increase the upper humidity set point(s) of the data floor within the current **A2** humidity range of (–12°C DP and 8% rh to 27°C DP and 80% rh) to decrease the dehumidification loads within the facility. The relevant standard is the ASHRAE Class **A2** allowable range for Data Centers. Note: Some data centres may contain equipment with legacy environmental ranges as defined in **4.1.2**, the humidity range for these facilities will be restricted by this equipment until segregation can be achieved as described in Practices **5.1.11**, **5.1.12** and **5.1.13**. Controlling humidity within a wider range of humidity ratio or relative humidity can reduce humidification and dehumidification loads and therefore energy consumption.	Entire Data Centre	4
5.3.3	Expanded IT equipment inlet environmental conditions (temperature and humidity)	Where appropriate and effective, Data Centres can be designed and operated within the air inlet temperature and relative humidity ranges of 5°C to 40°C and 5% to 80% rh, non-condensing respectively, and under exceptional conditions up to +45°C as described in ETSI EN 300 019–1-3 Class 3.1. Note: Using the full range up to 40°C or 45°C will allow for the complete elimination of refrigeration in most climates allowing the operator to eliminate the capital and maintenance cost of the cooling systems.	Optional	5
5.3.4	Review and if possible optimise chilled water temperature	Review and if possible increase the chilled water temperature set points to maximise the use of free cooling and reduce compressor energy consumption. Seasonal impact should be taken into account where applicable. Set points should be raised together with supply air flow set points to avoid reducing capacity. Review and if useful increase the chilled water temperature difference to reduce the water flow and thereby to reduce pump energy consumption. Where a DX system is used the evaporator temperatures should be reviewed. Electronic Expansion Valves (EEVs) allow better control and permit higher evaporator temperatures than Thermostatic Expansion Valves (TEVs).	Entire Data Centre	4

5.4 Cooling Plant

The cooling plant typically represents the major part of the energy used in the cooling system. This is also the area with the greatest variation in technologies.

5.4.1 Free Cooling / Economised Cooling

Free cooling / economised cooling designs take advantage of cool ambient conditions to meet part or all of the facilities' cooling requirements so that the dependency on any form of mechanical cooling including compressors is reduced or even removed entirely, which can result in significant energy reduction. Free cooling can be retrofitted to some facilities. The opportunities for the utilisation of free cooling are increased in cooler and dryer climates and where increased temperature set points are used. Where refrigeration plant can be reduced in size (or eliminated), operating and capital cost are reduced, including that of the required supporting electrical infrastructure. Free cooling technologies should be considered in all new builds, retrofits and upgrades.

No	Name	Description	Expected	Value
5.4.1.1	Direct air free cooling	External air is used to cool the facility with different operating modes usually deployed. When outdoor conditions are cold exhaust air can be re-circulated and mixed with intake air to control supply air temperature and humidity. In many cases full mechanical cooling / refrigeration capacity is required as a backup to allow operation during periods of high airborne pollutant (E.G. External fires). For this reason special attention should be focussed on external air quality monitoring and filtration. Additional backup mechanical cooling with chiller or CRAC may also be considered to ensure cooling at extreme ambient temperature and humidity conditions or for system redundancy. Note: This design tends to have the lowest temperature difference between external temperature and IT supply air. Note: IT equipment is likely to be exposed to a large humidity range to allow direct air free cooling to work effectively. The achievable free cooling hours are directly constrained by the chosen upper humidity limit.	Optional	5
5.4.1.2	Indirect air free cooling	Re circulated air within the facility is primarily passed through an air to air heat exchanger against external air (may have adiabatic cooling) 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. Note: The operating IT equipment humidity range may be well controlled at negligible energy cost in this type of design. Note: Air filtration demand is lower compared to direct air free cooling as data centre air is circulating and no external air is induced.	Optional	5
5.4.1.3	Indirect water free cooling with CRAH and	Chilled water cooled by the external ambient air via a free cooling coil. This may be achieved by dry coolers or by evaporative assistance	Optional	5

	dry cooler or cooling tower	through spray onto the dry coolers. This design tends to have a higher temperature difference between external temperature and IT supply air. Note: Operating IT equipment humidity range may be well controlled at negligible energy cost in this type of design. Note: In this system additional backup mechanical cooling with chiller or CRAC may be considered to ensure cooling at extreme ambient temperature and humidity conditions or for system redundancy.		
5.4.1.4	Indirect water free cooling with CRAC with integrated free cooling coil	Chilled water is cooled by the external ambient conditions via cooling towers or dry coolers, the dry coolers may have evaporative assistance. This chilled water is supplied to the free cooling coil of the CRAC if its temperature is low enough to provide full free cooling or at least partial free cooling. In addition it is supplied to the plate condenser of the CRAC´s closed DX circuit when compressor operation is needed to provide sufficient cooling. This design tends to have a higher temperature difference between external temperature and IT supply air restricting the free cooling hours available and increasing energy overhead. Note: Partial free cooling (Mix mode) starts a few degrees below the return air temperature of the CRAC. Note: Operating IT equipment humidity range may be well controlled at negligible energy cost in this type of design.	Optional	4

5.4.1.5	Indirect water free cooling with CRAH and free cooling chiller	Chilled water is produced by the free cooling chiller either through the free cooling coils in the chiller if ambient temperatures are low or with compressors in operation at higher ambient temperatures. This chilled water is supplied to the CRAH in the data centre. This design tends to have a higher temperature difference between external temperature and IT supply air restricting the free cooling hours available and increasing energy overhead. Note: Partial free cooling (Mix mode) starts a few degrees below the return water temperature. Note: The operating IT equipment humidity range may be well controlled at negligible energy cost in this type of design.	Optional	3
5.4.1.6	Indirect water free cooling with condenser water cooling chilled water	Cooling unit chilled water is cooled via a plate heat exchanger to the condenser water circuit passing through dry/adiabatic coolers / cooling towers. This design usually has a highest difference between the external temperature and IT supply air due to the additional heat exchange process.	Optional	3
5.4.1.7	Alternative cooling sources	Evaluate alternative forms of cooling where available, practical to utilise and offer genuine energy efficiency including Ground Source Cooling from rivers, lakes and seawater etc.	Optional	1
5.4.1.8	Free Cooling installation	Investigate the installation of free cooling in all new builds and retrofits or upgrades of cooling systems.	New build or retrofit	5

5.4.2 High Efficiency Cooling Plant

When refrigeration is used as part of the cooling system design high efficiency cooling plant should be selected. Designs should operate efficiently at system level and employ efficient components. This demands an effective control strategy which optimises efficient operation, without compromising reliability.

Even in designs where the refrigeration is expected to run for very few hours per year the cost savings in infrastructure electrical capacity and utility power availability or peak demand fees justify the selection of high efficiency plant.

No	Name	Description	Expected	Value
5.4.2.1	Chillers with high COP	Where refrigeration[1] is installed make the Coefficient Of Performance (COP) of chiller systems through their likely working range a high priority decision factor during procurement of new plant.	New build or retrofit	3
5.4.2.2	Cooling system operating temperatures	Evaluate the opportunity to decrease condensing temperature and increase evaporating temperature; reducing delta T between these temperatures means less work is required in cooling cycle hence improved efficiency. These temperatures are dependent on required IT equipment intake air temperatures and the quality of air flow management (see Temperature and Humidity Settings).	Entire Data Centre	3
5.4.2.3	Efficient part load operation	Optimise the facility for the partial load it will experience for the majority of operational time rather than max load. Examples are exploiting the heat exchange area, reducing fan energy consumption, sequencing chillers and operating cooling towers with shared load.	New build or retrofit	3
5.4.2.4	Variable speed drives for compressors, pumps and fans	Using variable speed control reduces energy consumption for these components in the part load condition where they operate for much of the time. Consider new or retrofit of Electrically Commutated (EC) motors which are significantly more energy efficient than traditional AC motors across a wide range of speeds. In addition to installing variable speed drives it is critical to include the ability to properly control the speed according to demand. It is of limited value to install drives which are manually set at a constant speed or have limited control settings.	New build or retrofit	2
5.4.2.5	Select systems which facilitate the use of “Free Cooling”	Cooling designs should be chosen which allow the use of as much “Free Cooling” as is possible according to the physical site constraints, local climatic or regulatory conditions that may be applicable. Select systems which facilitate the use of free cooling. In some data centres it may be possible to use direct or indirect air side free cooling. Others may not have sufficient available space and may require a chilled liquid cooling system to allow the effective use of economised cooling.	New build or retrofit	5

[1] Note that this refers to mechanical compressors and heat pumps, any device which uses energy to raise the temperature of the rejected heat

5.4.2.6	Do not share data centre chilled water system with comfort cooling	In buildings which are principally designed to provide an appropriate environment for IT equipment, and that have cooling systems designed to remove heat from technical spaces, do not share chilled water systems with human comfort cooling in other parts of the building. The required temperature to achieve latent cooling for comfort cooling is substantially below that required for sensible cooling of the data centre and will compromise the efficiency of the data centre cooling system. If comfort cooling remains a requirement consider the use of heat pumps to provide either cooling or heating for office area comfort.	New build or retrofit	4
5.4.2.7	Do not allow non IT equipment to dictate cooling system set-points	Where other equipment requires a more restrictive temperature or humidity control range than the IT equipment this should not be permitted to dictate the set points of the cooling system responsible for the IT equipment.	New build or retrofit	4
5.4.2.8	Chilled water pump control strategy	Chilled water systems configured with dual pumps, one active, one on standby, can be reviewed for improved energy efficiency during operation. Using the pump manufacturers' graphs of energy use vs pump speed, evaluate running two pumps in parallel vs a single pump running at a higher speed. If beneficial implement the running of two low speed pumps to reduce energy usage while achieving the same target flow rate and pressure.	New build or retrofit	1
5.4.2.9	Direct liquid cooling of IT devices	In place of air cooling it is possible to directly liquid cool part or all of some IT devices. This can provide a more efficient thermal circuit and allow the coolant liquid system temperature to be substantially higher, further driving efficiency, allowing for increased or exclusive use of free cooling or heat re use. Note: This Practice applies to devices which deliver cooling liquid directly to the heat removal system of the components such as water cooled heat sinks or heat pipes and not the delivery of cooling liquid to an internal mechanical refrigeration plant or in-chassis air cooling systems. Note: ASHRAE offer guidelines for the use of liquid cooling in data centres.	Optional	4

5.5 Computer Room Air Conditioners / Air Handlers

The second major component of most cooling systems are the air conditioning / air handling units within the computer room. The computer room side of the cooling system is frequently poorly designed and poorly optimised in older facilities.

No	Name	Description	Expected	Value
5.5.1	Variable Speed Fans	Many old CRAC / CRAH units operate fixed speed fans which consume substantial power and obstruct attempts to manage the data floor temperature. Variable speed fans are particularly effective where there is a high level of redundancy in the cooling system, low utilisation of the facility or highly variable IT electrical load. These fans may be controlled by factors such as the supply or return air temperature or the chilled air plenum pressure. Note: CRAC / CRAH units with fixed speed compressors have minimum flow requirements which constrain the minimum operating load and therefore minimum air flow.	New build or retrofit	4
5.5.2	Control on CRAC / CRAH unit supply air temperature	Controlling on supply temperature ensures an even supply air temperature independent of the load on each CRAC / CRAH unit. Historically many CRAC / CRAH units were controlled on return temperature which is no longer considered appropriate practice.	New build or retrofit	3
5.5.3	Run variable speed CRAC / CRAH units in parallel	It is possible to achieve efficiency gains by running CRAC / CRAH units with variable speed fans in parallel to reduce the electrical power necessary to achieve the required air movement as electrical power is not linear with air flow. Care should be taken to understand any new failure modes or single points of failure that may be introduced by any additional control system.	Optional	4
5.5.4	Sequencing of CRAC / CRAH units	In the absence of variable speed fans it is possible to turn entire CRAC / CRAH units on and off to manage the overall air flow volumes. This can be effective where there is a high level of redundancy in the cooling system, low utilisation of the facility or highly variable IT electrical load.	Optional	2

5.5.5	Do not control humidity at CRAC / CRAH unit	The only humidity control that should be present in the data centre is that on fresh “Make Up” air coming into the building and not on re-circulating air within the equipment rooms. Humidity control at the CRAC / CRAH unit is unnecessary and undesirable. Humidity control should be centralised. Do not install humidity control at the CRAC / CRAH unit on re-circulating air. Instead control the specific humidity of the make-up air at the supply AHU. This provides better control and allows use of adiabatic humidification (with lower energy consumption) and potential additional opportunities for some free cooling. The chilled water loop or DX evaporator temperature should in any case be too high to provide de-humidification. When purchasing new CRAC / CRAH units select models which are not equipped with humidity control capability, including any reheat capability, this will reduce both capital and on-going maintenance costs.	New build or retrofit	4
5.5.6	Cooling unit sizing and selection	Air volumes required by IT equipment not only depend on the IT load (kW) but also on the IT equipment delta-T, which will also vary with utilisation. Consider these factors, plus likely future utilisation and bypass to size the cooling units design flow rates. As air flow is inversely proportional to delta T for the same load, if the IT delta-T is overestimated, this will result in undersized CRAC / CRAH air volumes and potential air management problems. Additionally if it is underestimated, CRAC / CRAH air volumes will be oversized which makes low part load inefficient operation and air bypass more likely.	New build or retrofit	4

5.6 Reuse of Data Centre Waste Heat

Data Centres produce significant quantities of waste heat, whilst this is typically at a relatively low temperature there are some applications for reuse of this energy. As IT equipment utilisation is increased through consolidation and virtualisation the exhaust temperature is likely to 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.

No	Name	Description	Expected	Value
5.6.1	Waste heat re-use	It may be possible to provide low grade heating to industrial space or to other targets such as adjacent office space fresh air directly from heat rejected from the data centre. This does not reduce the energy consumed by the data centre itself but does offset the total energy overhead by potentially reducing energy use elsewhere.	Optional	3
5.6.2	Heat pump assisted waste heat re-use	Where it is not possible to directly re use the waste heat from the data centre due to the temperature being too low it can still be economic to use additional heat pumps to raise the temperature to a useful point. This can supply office, district and other heating.	Optional	2
5.6.3	Use data floor waste heat to warm office, generator and fuel storage areas	Reduce or eliminate the electrical preheat loads for generators and fuel storage by using warm exhaust air from the data floor to maintain temperature in the areas housing generators and fuel storage tanks and office areas.	Optional	1
5.6.4	Energy reuse metrics and reporting	The opportunity for the reuse of waste heat from data centres is referenced by the Energy Reuse Factor (ERF) and Energy Reuse Effectiveness (ERE) from The Green Grid), and should be used currently for reporting the use of waste heat, however as standardised metrics in this area continually develop (particularly in relation to the work being done within the *ISO*/IEC *30134* series of standards), this nomenclature is likely to change.	Optional	1

6 Data Centre Power Equipment

The other major part of the facility infrastructure is the power conditioning and delivery system. This normally includes uninterruptible power supplies, power distribution units and cabling but may also include backup generators and other equipment.

6.1 Selection and Deployment of New Power Equipment

Power delivery equipment has a substantial impact upon the efficiency of the data centre and tends to stay in operation for many years once installed. Careful selection of the power equipment at design time can deliver substantial savings through the lifetime of the facility.

No	Name	Description	Expected	Value
6.1.1	Modular UPS deployment	It is now possible to purchase modular (scalable) UPS systems across a broad range of power delivery capacities. Physical installation, transformers and cabling are prepared to meet the design electrical load of the facility but the sources of inefficiency (such switching units and batteries) are installed, as required, in modular units. This substantially reduces both the capital cost and the fixed overhead losses of these systems. In low power installations these may be frames with plug in modules whilst in larger installations these are more likely to be entire UPS units.	New build or retrofit	3
6.1.2	High efficiency UPS	High efficiency UPS systems should be selected, of any technology including electronic or rotary to meet site requirements. This Practice should be implemented in line with the *IEC 62040* series for UPS systems.	New build or retrofit	3
6.1.3	Use efficient UPS operating modes	Deploy UPS units in their most efficient operating modes where appropriate. Note Use of alternative UPS technologies such as rotary or direct current systems may be considered. The comparison and evaluation of the technologies shall be based on latest and non-biased information about available products in the market. Some UPS systems may have technologies allowing energy optimisation at partial load levels and these shall be taken into account as appropriate for the application. This may also be particularly relevant for any UPS system feeding mechanical loads e.g. CRAC/CRAH fans.	New build or retrofit	2

6.1.4	EU Code of Conduct Compliant UPS	If static UPS systems are to be installed select UPS systems that are compliant with the EU Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems. A UPS conforming to this standard should be able to perform as rated when operating within the following minimum ambient ranges: Temperature 0°C to +40°C. Relative Humidity 20% to 80% Note: Rotary UPS systems are not included in the EU Code of Conduct for UPS, but this does not in any way suggest that rotary UPS should not be used, rather that rotary technology is not currently covered by the EU Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems. Also reference the current U.S. EPA ENERGY STAR specifications for Uninterruptible Power Supplies (UPS).	New build or retrofit	2
6.1.5	Elimination of Isolation Transformers	Isolation transformers in power distribution to IT equipment down to 120V are typically not required in Europe and should be eliminated from designs as they introduce additional transformer losses unnecessarily.	New build or retrofit	3
6.1.6	Efficient part load operation	Electrical infrastructure should remain energy efficient under partial fill and variable IT electrical loads as described in Practice **3.3.4**.	New build or retrofit	3

6.2 Management of Existing Power Equipment

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No	Name	Description	Mandatory	Value
6.2.1	Reduce engine-generator heater temperature set-point	When using engine heaters to keep generators ready for rapid starts, consider reducing the engine heater set-point. Block heaters for the Standby Generators should be controlled to only operate when the temperature conditions warrant it. Consult manufacturer to understand risk / reliability implications.	Optional	2
6.2.2	Power Factor Correction	Monitor, understand and manage the consequences of the Power Factors of both the Mechanical and Electrical infrastructure and installed IT equipment within the data centre. Poor Power Factor management can lead to higher cable losses and also introduce significant risk to the continuity of power supply. Low cost power supplies often have very poor Power Factors with little or no correction. These can build up to introduce electrical inefficiency and risk. Note: Consider the use of Power Factor Correction where appropriate.	Optional	2

7 Other Data Centre Equipment

Energy is also used in the non data floor areas of the facility in office and storage spaces. Energy efficiency in non-data centre areas should be optimised based on relevant building standards, such as relevant EU standards, LEED, BREEAM etc.

7.1 General Practices

These general practices apply to the data floor and may be extended to the remainder of the building if no sustainable building standard is in use.

No	Name	Description	Expected	Value
7.1.1	Turn off Lights	Lights should be turned off, preferably automatically whenever areas of the building are unoccupied, for example switches which turn off lighting a specified time after manual activation. Motion detector activated lighting is generally sufficient to support security camera systems.	Entire Data Centre	1
7.1.2	Low energy lighting	Low energy lighting systems should be used in the data centre. LED lighting is an example.	New build or retrofit	1
7.1.3	Pale coloured fixtures and fittings	Use pale / light colours on walls, floors fixtures and fittings including cabinets etc. to reduce the amount of lighting required to illuminate a data hall and therefore the energy consumed for lighting. This will also ensure good levels of visibility both throughout the hall and within cabinets.	New build or retrofit	1
7.1.4	Energy & temperature reporting hardware	Select Mechanical and Electrical equipment with direct local metering of power usage and/or temperature reporting capabilities (where appropriate), preferably reporting energy used as a counter in addition to power as a gauge. To assist in the implementation of temperature and energy monitoring across a broad range of data centre infrastructure all monitoring devices installed should be able to use existing networks and operate on an Open Protocol basis. This interface protocol should enable all operators' existing monitoring platform to be able to retrieve data from the installed meters without the purchase of additional licenses from the equipment vendor The intent of this Practice is to provide energy and environmental monitoring of the data centre throughout the entire infrastructure with increasing levels of granularity.	New build or retrofit	3

8 Data Centre Building

The location and physical layout of the data centre building is important to achieving flexibility and efficiency. Technologies such as fresh air cooling require significant physical plant space and air duct space that may not be available in an existing building.

8.1 Building Physical Layout

The physical layout of the building can present fundamental constraints on the applicable technologies and achievable efficiencies.

No	Name	Description	Expected	Value
8.1.1	Locate M&E plant outside the cooled area	Heat generating Mechanical and Electrical plant such as UPS units should be located outside the cooled areas of the data centre wherever possible to reduce the loading on the data centre cooling plant.	New build or retrofit	2
8.1.2	Select or create a building with sufficient 'slab to slab' separation / ceiling height	Where air movement is used to cool the IT equipment, insufficient ceiling height will frequently obstruct the use of efficient air cooling technologies such as raised floor, suspended ceiling, aisle containment or ducts in the data centre.	New build or retrofit	3
8.1.3	Facilitate the use of "Free Cooling"	The physical layout of the building should not obstruct or restrict the use of free cooling (either air or water), or other equipment with an economisation / free cooling mode.	New build or retrofit	3
8.1.4	Location and orientation of plant equipment	Cooling equipment, particularly dry or adiabatic coolers should be located in an area of free air movement to avoid trapping it in a local hot spot. Ideally this equipment should also be located in a position on the site where the waste heat does not affect other buildings and create further demand for air conditioning.	New build or retrofit	2
8.1.5	Minimise direct solar heating	Minimise solar heating (insolation), of the cooled areas of the data centre by providing shade or increasing the albedo (reflectivity) of the building through the use of light coloured roof and wall surfaces. Shade may be constructed, provided by utilising natural features including "green roof" systems. Effective insulation can be provided by using suitable wall and roof coverings. Additionally do not have external windows in the data centre. Failure to protect against solar heating (insolation) will result in additional cooling requirements.	New build or retrofit	2

8.2 Building Geographic Location

Whilst some operators may have no choice of the geographic location for a data centre it nevertheless impacts achievable efficiency, primarily through the impact of external climate.

No	Name	Description	Expected	Value
8.2.1	Locate the Data Centre where waste heat can be reused	Locating the data centre where there are available uses for waste heat can save substantial energy. Heat recovery can be used to heat office space or industrial space, hydroponic farming and even swimming pools.	Optional	2
8.2.2	Locate the Data Centre in an area of low ambient temperature	Free and economised cooling technologies are more effective in areas of low ambient external temperature and or humidity. Note: Most temperature climates including much of Northern, Western and Central Europe present significant opportunity for economised cooling and zero refrigeration.	Optional	3
8.2.3	Avoid locating the data centre in high ambient humidity areas	Free cooling is particularly impacted by high external humidity as dehumidification becomes necessary. Many economiser technologies (such as evaporative cooling) are also less effective.	Optional	1
8.2.4	Locate near a source of free cooling	Locating the data centre near a source of free ground source cooling such as a river or lake etc. subject to local environmental regulation.	Optional	1
8.2.5	Co-locate with power source	Locating the data centre close to the power generating plant can reduce transmission losses.	Optional	1

8.3 Water sources

Data centres can use a significant quantity of water in cooling and humidity control, the use of low energy intensity water sources can reduce the effective energy consumption of the data centre.

No	Name	Description	Expected	Value
8.3.1	Capture rain water	Capture and storage of rain water for evaporative cooling or other non-potable purposes may reduce overall energy consumption	Optional	1
8.3.2	Other water sources	Use of other local non-utility water sources for evaporative cooling or other non-potable purposes may reduce overall energy consumption	Optional	2
8.3.3	Metering of water consumption	The site should meter water consumption from all sources. The site should seek to use this data to manage and reduce overall water consumption. Note: Water consumption cannot be directly compared with energy efficiency unless the energy intensity of the water source is understood. Comparing water consumption between buildings is therefore not useful. Note: Guidelines on this may be taken from The Green Grid's Water Usage Efficiency metric (WUE).	Optional	2

9 Monitoring

The development and implementation of an energy monitoring and reporting management strategy is core to operating an efficient data centre.

9.1 Energy Use and Environmental Measurement

Most data centres currently have little or no energy use or environmental measurement capability; many do not even have a separate utility meter or bill. The ability to measure energy use and factors impacting energy use is a prerequisite to identifying and justifying improvements. It should also be noted that measurement and reporting of a parameter may also include alarms and exceptions if that parameter passes outside of the acceptable or expected operating range.

No	Name	Description	Expected	Value
9.1.1	Incoming energy consumption meter	Install metering equipment capable of measuring the total energy use of the data centre including all power conditioning, distribution and cooling systems. This should be separate from any non data centre building loads. Note: This is required for Code of Conduct reporting.	Entire Data Centre	4
9.1.2	IT Energy consumption meter	Install metering equipment capable of measuring the total energy delivered to IT systems. This may also include other power feeds where non UPS protected power is delivered to the cabinets. Note: This is required for Code of Conduct reporting.	Entire Data Centre	4
9.1.3	Room level metering of supply air temperature and humidity	Install metering equipment at room level capable of indicating the supply air temperature and humidity for the IT equipment.	Entire Data Centre	2
9.1.4	CRAC / CRAH unit level metering of supply or return air temperature	Collect data from CRAC / CRAH units on supply and return (dependent upon operating mode) air temperature.	Entire Data Centre	3
9.1.5	Distribution board level metering of Mechanical and Electrical energy consumption	Improve visibility and granularity of data centre infrastructure overheads	New build or retrofit	3
9.1.6	Cabinet level metering of IT Energy consumption	Improve visibility of IT energy consumption by metering at the cabinet level and individual power strips.	Optional	3
9.1.7	Row or Cabinet level metering of temperature	Improve visibility of air supply temperature in existing hot / cold aisle environments to assist in recognising and dealing with air flow management issues and both over-cooling and under-cooling of IT equipment. Note: This would be applicable in both contained and non-contained aisles.	Optional	3

9.1.8	IT Device level metering of temperature	Improve granularity and reduce metering cost by using built in device level metering of intake and / or exhaust air temperature as well as key internal component temperatures. Note: Most new servers provide this feature as part of the basic chipset functionality.	Optional	4
9.1.9	IT Device level metering of energy consumption	Improve granularity and reduce metering cost by using built in IT device level metering of energy consumption. Note: Most new servers provide this feature as part of the basic chipset functionality.	Optional	4

9.2 Energy Use and Environmental Collection and Logging

Once data on energy use and environmental (temperature and humidity) conditions is available through the installation of measurement devices it needs to be collected and logged.

No	Name	Description	Expected	Value
9.2.1	Periodic manual readings	Entry level energy, temperature and humidity (dry bulb temperature, relative humidity and dew point temperature) reporting can be performed with periodic manual readings of measurement and metering equipment. This should occur at regular times, ideally at peak load. Note: Energy reporting is already mandated for Code of Conduct reporting requirements also that automated readings are considered to be a replacement for this Practice when applying for Participant status.	Entire Data Centre	3
9.2.2	Automated daily readings	Automated daily readings enable more effective management of energy use. Note: Supersedes Periodic manual readings.	Optional	4
9.2.3	Automated hourly readings	Automated hourly readings enable effective assessment of how IT energy use varies with IT workload. Note: Supersedes Periodic manual readings and Automated daily readings.	Optional	4
9.2.4	Achieved free cooling / economised cooling hours	Require collection and logging of full free cooing, partial free cooling and full refrigerant and compressor based cooling hours throughout the year. The intent being to record the amount or time and energy spent running on mechanical refrigerant and compressor based cooling versus the use of 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 data centre 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. Note: This refers to mechanical compressors and heat pumps, any device which uses energy to raise the temperature of the rejected heat.	New build or retrofit	4

9.3 Energy Use and Environmental Reporting

Energy use and environmental (temperature and humidity) data needs to be reported to be of use in managing the energy efficiency of the facility.

No	Name	Description	Expected	Value
9.3.1	Written Report	Minimum reporting consists of periodic written reports on energy consumption and environmental ranges. This should include determining the averaged DCiE or PUE over the reporting period. Note: This is already mandated by the Code of Conduct reporting requirements. This report may be produced by an automated system. Note: All DCiE and PUE calculations should be completed according to the guidelines set out by EN 50600-4-2 which is equivalent to ISO/IEC 30134-2. EN 50600-4-2:2016 "Information technology — Data centre facilities and infrastructures — Part 4-2: Power Usage Effectiveness". Note: Different categories of PUE ranging from 0 to 3 representing increasing levels of reporting granularity. All written reports and submissions should reference the Category being reported and ensure that the required method of data collection and calculation determined by EN 50600-4-2 or ISO/IEC 30134-2.	Entire Data Centre	4
9.3.2	Energy and environmental reporting console	An automated energy and environmental reporting console to allow M&E staff to monitor the energy use and efficiency of the facility provides enhanced capability. Averaged and instantaneous DCiE or PUE are reported. This supersedes Written Report. See Note in section **9.3.1** above with regard to method of calculation.	Optional	4
9.3.3	Integrated IT / M&E energy and environmental reporting console	An integrated energy and environmental reporting capability in the main IT reporting console allows integrated management of energy use and comparison of IT workload with energy use. Averaged, instantaneous and working range DCiE or PUE are reported and related to IT workload. Supersedes Written Report and Energy and environmental reporting console. This reporting may be enhanced by the integration of effective physical and logical asset and configuration data. See Note in section **9.3.1** above with regard to method of calculation.	Optional	4

9.3.4	Achieved free cooling / economised cooling hours	Require reporting of full free cooling, partial free cooling and full refrigerant and compressor based cooling hours throughout the year. The intent being to report the amount or time and energy spent running on mechanical refrigerant and compressor based cooling versus the use of 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 data centre 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. Note: This refers to mechanical compressors and heat pumps, any device which uses energy to raise the temperature of the rejected heat.	New build or retrofit	4

9.4 IT Reporting

Utilisation of the IT equipment is a key factor in optimising the energy efficiency of the data centre. Consider reporting aggregated data relevant to specific internal business needs. This Practice will remain optional while effective open metrics and reporting mechanisms remain under development.

No	Name	Description	Expected	
9.4.1	Server Utilisation	Logging and internal reporting of the processor utilisation of the overall or grouped by service / location IT server estate. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative.	Optional	3
9.4.2	Network Utilisation	Logging and internal reporting of the proportion of the overall or grouped by service / location network capacity utilised. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative.	Optional	3
9.4.3	Storage Utilisation	Logging and internal reporting of the proportion of the overall or grouped by service / location storage capacity and performance utilised. Whilst effective metrics and reporting mechanisms are still under development a basic level of reporting can be highly informative. The meaning of utilisation can vary depending on what is considered available capacity (e.g., ports, raw v. usable data storage) and what is considered used (e.g., allocation versus active usage). Ensure the definition used in these reports is clear and consistent. Note: Mixed incentives are possible here through the use of technologies such as de-duplication.	Optional	3
9.4.4	Business relevant dashboard	Establish sensible and useful business specific metrics and potentially a business relevant efficiency dashboard to accurately reflect, highlight, manage and ideally reduce the overall energy usage required to deliver the IT services defined by specific business requirements. Note: This goes beyond Practice **9.3.3** and the metrics chosen as relevant will vary between different businesses.	Optional	3

10 Practices to become minimum expected

The following Practices are planned to become minimum expected Practices in future updates of the Code of Conduct. The update year of the Code of Conduct in which the Practices will become expected is shown in the table.

No	Name	Description	Expected	Year
3.2.12	Monitor and manage air quality	Ensure that air quality is monitored and managed to ensure that critical equipment is not damaged by particulates or corrosive elements which might impact both IT equipment and cooling equipment in terms of performance, energy efficiency and reliability. This should inform the choice of filters used and the planned replacement schedule as well as the frequency of routine technical cleaning programme (including underfloor and ceiling void areas if applicable). Note: The ASHRAE white paper '2011 Gaseous and Particulate Contamination Guidelines for Data Centers' recommends that data centre air quality is monitored and cleaned according to ISO 14644-1 Class 8. This can be achieved by routine technical cleaning and simple filtration using the following guidelines: • Continuously air filtering using MERV 8 filters. • Air entering a data centre being screened with MERV 11 or MERV 13 filters.	Entire Data Centre	2019

11 Items under Consideration

This section contains suggested items that are under consideration for inclusion in the Best Practices once available from sector research and development or standards bodies etc.

No	Name	Description	Expected	Value
11.1	Utilisation targets	Minimum or average targets for the utilisation of IT equipment (servers, networking, storage). This presents substantial uncertainty when considered without the load to power profiles of the equipment, with cloud and mobile services and the increasing ability to relocate the IT compute function dynamically to an alternate location and better serve customers and optimise costs, this becomes more complex and would require substantial work to usefully determine. This is a specialist area which is being examined in detailed by other bodies specialising in this field. A watching brief will be maintained on the development of metrics and standards in this area, which the Code of Conduct can subsequently reference once published.	Optional	
11.2	Further development of software efficiency definitions	There is much research and development needed in the area of defining, measuring, comparing and communicating software energy efficiency. Suggested examples of this 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 functions. This is a specialist area which is being examined in detailed by projects specialising in this field. A watching brief will be maintained and links established to any ongoing projects on the development of metrics and standards in this area, which the Code of Conduct can subsequently reference once published and use to underpin the expectations detailed in sections **4.2.4** and **4.2.5**.	Optional	

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