# Best Practices

for the EU Code of Conduct on Data Centres

# 1 Introduction

This document is a companion to the EU Code of Conduct on Data Centres v0.9. This document provides the full list of identified best practices for data centre operators as referenced in the Code of Conduct.

## 1.1 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.

## 1.2 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 estate, 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 the existing estate. These practices are identified as being expected either when new IT equipment 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..

Practices are marked in the expected column as;

| | |
|---|---|
| No | Optional |
| Yes | Expected |
| New Software | Expected during any new software install or upgrade |
| New IT Equipment | Expected for new or replacement IT equipment |
| During retrofit | Expected whenever a significant refit of the M&E equipment is carried out or the build of a new data centre |

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.

## 1.3 Application and Assessment

The best practices form part of the application and assessment for Participant status. This process is described in the main Code of Conduct document.

## 1.4 Areas of Responsibility

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 Participant should act as an Endorser for those practices outside of their direct control. An example of this would be a collocation provider who does not control the IT equipment should actively endorse the practices relating to IT equipment to their customers, possibly through 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.

## 1.5 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 within the application for Participant status, alternative best practices from the supplement may be identified as direct replacements if they result in similar energy savings.

## 1.6 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 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 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.

## 2.1 Involvement of Organisational Groups

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

| Type | Description | Expected | Value |
|---|---|---|---|
| Group involvement | Establish an approval board containing representatives from all disciplines (software, IT, M&E). 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. | Yes | 3 |

## 2.2 General Policies

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

| Type | Description | Expected | Value |
|---|---|---|---|
| Consider the embedded energy in 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. | Yes | 2 |

## 2.3 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Build resilience to business requirements | Only the level of resilience actually justified by business requirements and impact analysis should be built. 2N infrastructures are frequently unnecessary and inappropriate. Resilience for a small portion of critical services can be obtained using DR / BC sites. | During retrofit | 3 |
| 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. | During retrofit | 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. | During retrofit | 3 |
| Design to maximise the part load efficiency once provisioned | The design of all areas of the data centre should be maximise the achieved efficiency of the facility under partial fill and variable IT electrical load. This is in addition to one off modular provisioning and considers the response of the infrastructure to dynamic loads.<br>e.g. VFD for compressors and variable speed fan units. | During retrofit | 3 |
| Design effective resilience | Utilise appropriate levels of resilience at the data centre, IT equipment, software and network levels to achieve the required service resilience. High resilience at the physical level is rarely an effective overall solution | No | 4 |

# 3 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.

## 3.1 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Multiple tender for 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 or SPECPower type standard metrics or through application or deployment 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 |
| Multiple tender for IT hardware – Basic operating temperature and humidity range | Include the operating temperature and humidity ranges of new equipment as high priority decision factors in the tender process. The minimum range, at the air intake to servers, is 18-27C and 5.5C dew point up to 15C dew point & 60% RH. The current relevant standard is the ASHRAE ***Recommended*** range for Class 1 Data Centers as described by ASHRAE in “2008 ASHRAE Environmental Guidelines for Datacom Equipment”. | New IT Equipment | 4 |
| Multiple tender for IT hardware – Extended operating temperature and humidity range | Starting 2012 new IT equipment should be able to withstand the extended air inlet temperature and relative humidity ranges of 5 to 40°C and 5 to 80% RH, non-condensing respectively, and under exceptional conditions up to +45°C. The current relevant standard is described in ETSI EN 300 019 Class 3.1.<br><br>All vendors should indicate the maximum allowable temperature and humidity for all equipment to maximise the efficiency opportunities in refrigeration and free cooling.<br><br>It should be noted that where equipment with differing environmental requirements is not segregated, the equipment with the more restrictive temperature range will influence the cooling conditions and corresponding energy consumption for all of the IT Equipment. | New IT Equipment from 2012 | 4 |
| Select equipment suitable for the data centre – | Select and deploy equipment at the design power density (per rack or sq m) of the data centre to avoid running the cooling system outside design parameters. | No | 4 |

| | | | |
|---|---|---|---|
| Power density | | | |
| Select equipment suitable for the cabinet – air flow | When selecting equipment ensure that the air flow direction matches that of the data centre air flow design. Equipment with non standard air intake, outlet or flow direction will require individual assessment for cooling management and detrimental impact to the facility. | No | 3 |
| 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 | 3 |
| Provision to the as configured power | Provision power and cooling only to the as-configured power draw capability of the equipment, not the PSU or nameplate rating. Note that this may require changes to the provisioning if the IT equipment is upgraded internally. | New IT Equipment | 3 |
| Energy Star 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. | No | 2 |
| Energy & temperature reporting hardware | Select equipment with standard protocol energy and inlet temperature reporting capabilities, preferably reporting energy used, not instantaneous power. Proprietary reporting protocols, software or interfaces should be avoided, lower level protocols such as SNMP should be supported for backward compatibility. | No | 3 |
| 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 clock speed in a server to restrict maximum energy use. | No | 4 |

## 3.2 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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 |
| 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 |
| 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 |
| 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 can be used such as the (under load) power draw of the hardware required to meet performance and availability targets. This is an extension of existing capacity planning and benchmarking processes. See “Further development of software efficiency definitions” in section 9. | New Software | 4 |
| Develop efficient software | Make the energy use performance of the software a critical success factor of the project. Whilst forecasting and measurement tools and methods are still being developed approximations, can be used such as the (under load) power draw of the hardware required to meet performance and availability targets. This is an extension of existing capacity planning and benchmarking processes. Performance optimisation should not be seen as a low impact area to reduce the project budget. See “Further development of software efficiency definitions” in section 9. | New Software | 4 |
| 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, can be used such as the (under load) power draw of the hardware required to meet performance and availability targets. This is an extension of existing capacity planning and benchmarking processes. Performance optimisation should not be seen as a low impact area to reduce the project budget. See “Further development of software efficiency definitions” in section 9. | No | 4 |
| 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) | No | 4 |

## 3.3 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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. | No | 3 |
| Decommission unused services | Completely decommission and switch off, preferably remove, the supporting hardware for unused services | Yes | 5 |
| Virtualise and archive legacy services | Servers which cannot be decommissioned for compliance or other reasons but which are not used on a regular basis should be virtualised and then the disk images archived to a low power media. These services can then be brought online when actually required | No | 5 |
| 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. | No | 5 |
| Decommission low business value services | Identify services whose business value is low and does not justify the financial or environmental cost, decommission or archive these services | No | 4 |
| Shut down idle equipment | Servers, networking and storage equipment that is idle for significant time should be shut down or put into a low power ‘sleep’ state. It may be necessary to validate the ability of legacy applications and hardware to survive these state changes without loss of function or reliability. | No | 3 |
| Management software | Consider management software 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 reduce the number of active IT devices at times of low IT workload. | No | 4 |

### 3.3.1 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 stored is either unnecessary or duplicated nor requires high performance access and that this represents an organisational challenge. Some sectors have a particular issue due to very broad and non specific data retention directions from governments or regulating bodies. Where there is little structure to the data storage, implementation of these regulations can cause large volumes of data not required by the regulations to be unnecessarily heavily protected and archived.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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, | Yes | 3 |
| 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. | No | 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 tier. | No | 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.<br>Evaluate both the in use power draw and the peak power of the storage device(s) as configured, both impact per device cost and energy consumption through provisioning. | No | 3 |
| 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. | No | 4 |

| | | | |
|---|---|---|---|
| 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. | No | 4 |

# 4 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.

## 4.1 Air Flow Management and Design

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

| Type | Description | Expected | Value |
|---|---|---|---|
| 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;<br>• Hot aisle containment<br>• Cold aisle containment<br>• Contained rack supply, room return<br>• Room supply, Contained rack return<br>• Contained rack supply, Contained rack return<br>This action is expected for air cooled facilities over 1kW per square meter power density. | During Retrofit | 5 |
| Rack air flow management – Blanking Plates | Installation of blanking plates where there is no equipment to reduce cold air passing through gaps in the rack. This also reduces air heated by one device being ingested by another device, increasing intake temperature and reducing efficiency. | Yes | 3 |
| Rack air flow management – Other openings | Installation of aperture brushes (draught excluders) or cover plates to cover all air leakage opportunities in each rack. This includes;<br>• floor openings at the base of the rack<br>• Gaps at the sides, top and bottom of the rack between equipment or mounting rails and the perimeter of the rack | New IT Equipment | 3 |
| Raised floor air flow management | Close all unwanted apertures in the raised floor. Review placement and opening factors of vented tiles. Maintain unbroken rows of cabinets to prevent bypass air – where necessary fill with empty fully blanked racks. Managing unbroken rows is especially important in hot and cold aisle environments. Any opening between the aisles will degrade the separation of hot and cold air. | Yes | 3 |

| | | | |
|---|---|---|---|
| Design – Return plenums | Consider the use of return plenums to return heated air from the IT equipment to the air conditioning units | No | 2 |
| 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. | No | 3 |
| 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. The use of overhead cabling trays for signalling can substantially reduce these losses. | No | 2 |
| 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 rack, in adjacent racks and across aisles.<br>The hot / cold aisle concept aligns equipment air flow to create aisles between racks that are fed chilled air from which all of the equipment draws intake air in conjunction with aisles with no chilled air feed to which all equipment exhausts air. | New IT Equipment<br><br>During Retrofit | 2 |
| 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 chilled air to equipment or extract heated air from the equipment. Increasing the size of these spaces can significantly reduce pumping losses in moving the air. | No | 2 |
| Equipment segregation | Deploy groups of equipment with substantially different environmental requirements in separate areas of the data centre with separate air flow and cooling provision. This allows the environmental conditions and therefore efficiency to be optimised for each group. | No | 3 |
| Provide adequate free area on rack doors | Solid doors can be replaced (where doors are necessary) with partially perforated doors to ensure adequate cooling airflow which often impede the cooling airflow and may promote recirculation within the enclosed cabinet further increasing the equipment intake temperature. | New IT Equipment<br><br>During Retrofit | 2 |

## 4.2 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Modular installation and use of cooling equipment | Cooling plant should be installed in a modular fashion allowing operators to shut down unnecessary equipment. This should then be part of the review at each cooling load change. Design to maximise the part load efficiency as described in 2.3 | No | 3 |
| 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 units can be turned off in the empty areas. | No | 3 |
| Review of cooling before IT equipment changes | The availability of cooling including the placement and flow of vented tiles should be reviewed before each IT equipment change to optimise the use of cooling resources. | Yes | 2 |
| Review of cooling strategy | Periodically review the IT equipment and cooling deployment against strategy. | Yes | 2 |
| Review CRAC Settings | Ensure that CRAC units in occupied areas have appropriate settings and are set to heat / cool and humidify / dehumidify at the same thresholds | No | 3 |
| Automatic control of cooling | Incorporate control systems that automatically adjust the cooling delivered to the data floor based on the thermal load presented by the IT equipment | No | 3 |
| Dynamic control of building cooling | It is possible to implement control systems that take many 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. | No | 3 |
| Effective regular maintenance of cooling plant | Effective regular maintenance of the cooling system is essential to maintain the design operating efficiency of the data centre. | No | 2 |

## 4.3 Temperature and Humidity Settings

Facilities are often overcooled with air temperatures (and hence chilled water temperatures, where used) colder than necessary resulting in an energy penalty. Increasing the set range for humidity can substantially reduce humidifier loads. Reviewing and addressing air management issues as described in sections 4.1 and 4.2, is required before set points can be changed in order to avoid risk to operational continuity, expert advice should be sought before changing the environmental range for the facility. An increase in chilled water loop temperature provides enhanced efficiency for economisers and can substantially reduce humidifier loads when raised above the dew 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Review and if possible raise target IT equipment intake air temperature | Data Centres should be designed and operated *at their highest efficiency* within the current environmental range of 18-27C. The current, relevant standard is the ASHRAE *Recommended* range for Class 1 Data Centers, as described by ASHRAE in “2008 ASHRAE Environmental Guidelines for Datacom Equipment”. Operations in this range will ensure data centres are not wasting energy through overcooling. This range applies to legacy data centres with existing equipment. Note that other best practices for airflow management (hot aisle/cold aisle, blanking plates, and sealing leaks) may need to be implemented at the same time to ensure successful operations. | Yes | 3 |
| Review and increase the working humidity range | Review and if practical increase the working humidity range of the data floor within current environmental range of 5.5C dew point up to 15C dew point & 60% RH to decrease the humidity control loads within the facility. The current, relevant standard is the ASHRAE *Recommended* range for Class 1 Data Centers, as described by ASHRAE in “2008 ASHRAE Environmental Guidelines for Datacom Equipment”. | Yes | 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 to 40°C and 5 to 80% RH, non-condensing respectively, and under exceptional conditions up to +45°C. The current, relevant standard is ETSI EN 300 019, Class 3.1. | Starting 2012 | 5 |
| Review set points of air and water temperatures | Once air management issues have been addressed and IT equipment target temperatures agreed these temperatures can be increased (using less energy) without increasing server inlet temperatures beyond acceptable levels. Note that some IT equipment may use more power under increased inlet temperatures. | Yes | 3 |
| Review and raise chilled water loop temperature | Increase the chilled water loop temperature to above the dew point of the air within the facility.<br>Increase the chilled water loop temperature to maximise the use of economisers. | No | 3 |

## 4.4 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.

### 4.4.1 Free and Economised Cooling

Free or economised cooling designs use cool ambient conditions to meet part or all of the facilities cooling requirements hence compressor work for cooling is reduced or removed, which can result in significant energy reduction. Economised cooling can be retrofitted to some facilities. The opportunities for the utilisation of free cooling are increased in cooler climates and where increased temperature set points are used

| Type | Description | Expected | Value |
|---|---|---|---|
| Direct air free cooling | External air is used to cool the facility. Chiller systems are present to deal with humidity and high external temperatures if necessary. Exhaust air is re-circulated and mixed with intake air to avoid unnecessary humidification / dehumidification loads. | No | 5 |
| Indirect air free cooling | Re circulated air within the facility is primarily passed through a heat exchanger against external air to remove heat to the atmosphere. | No | 5 |
| Direct water free cooling | Condenser water chilled by the external ambient conditions is circulated within the chilled water circuit. This may be achieved by radiators or by evaporative assistance through spray onto the radiators. | No | 5 |
| Indirect water free cooling | Condenser water is chilled by the external ambient conditions. A heat exchanger is used between the condenser and chilled water circuits. This may be achieved by radiators, evaporative assistance through spray onto the radiators or a evaporative cooling in a cooling tower. | No | 5 |
| Adsorptive cooling | Waste heat from power generation or other processes close to the data centre is used to power the cooling system in place of electricity, reducing overall energy demand. In such deployments adsorptive cooling can be effectively free cooling. This is frequently part of a Tri Gen combined cooling heat and power system. | No | 5 |

### 4.4.2 High Efficiency Cooling Plant

The next preference cooling technology is the use of high efficiency cooling plant. Designs should operate efficiently at system level and employ efficient components. This demands an effective control strategy which optimises efficient operation, without compromising reliability.

| Type | Description | Expected | Value |
|---|---|---|---|
| Higher efficiency system type | Choose water cooled chillers over air cooled over DX due to increased thermodynamic efficiency | No | 3 |
| Chillers with high COP | Make the Coefficient Of Performance of chiller systems a high priority decision factor during procurement of new plant. | During Retrofit | 3 |
| Cooling system operating temperatures | Evaluate the opportunity to decrease condensing temperature or 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 internal air temperatures (see Temperature and Humidity Settings). | Yes | 3 |
| Efficient part load operation | Optimise the facility for the partial load it will experience for most of operational time rather than max load. e.g. sequence chillers, operate cooling towers with shared load for increased heat exchange area | During Retrofit | 3 |
| Variable speed drives for pumps and fans | Reduced energy consumption for these components | No | 3 |

## 4.5 Computer Room Air Conditioners

The second major component of most cooling systems is the air conditioner units within the computer room. The computer room side of the chiller plant is frequently poorly designed and poorly optimised in older facilities.

| Type | Description | Expected | Value |
|---|---|---|---|
| Variable Speed Fans | Many old CRAC units operate fixed speed fans which consume substantial power and obstruct attempts to manage the data floor temperature.<br>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 return air temperature or the chilled air plenum pressure. | During Retrofit | 4 |
| Control on CRAC unit supply air temperature | Controlling on supply temperature ensures the server supply air (key temperature to control) is satisfactory without possible over cooling of air which may result when controlling on return temperature (where sensor location may impact) | No | 3 |
| Run variable speed CRAC units in parallel | It is possible to achieve efficiency gains by running CRAC units with variable speed fans in parallel to reduce the total 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. | No | 4 |
| Direct liquid cooling of IT devices | In place of chilling air it is possible to directly fluid cool some IT devices. This can provide a more efficient thermal circuit and allow the fluid loop temperature to be substantially higher, further driving efficiency, allowing for the potential exclusive use of free cooling or heat re use. | No | 4 |
| Sequencing of CRAC units | In the absence of variable speed fans it is possible to turn entire CRAC units on and off to manage the overall air flow volumes.<br>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. | No | 3 |

## 4.6 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Waste heat re-use | It is frequently possible to provide low grade heating to industrial space or to other targets such as swimming pools directly from the waste side of the heat pumps. This can ameliorate an energy use elsewhere, reducing the total energy use of the data centre and the client of the waste heat. | No | 4 |
| 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. | No | 3 |

# 5 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.

## 5.1 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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 environments these may be frames with plug in modules whilst in larger environments these are more likely to be entire UPS units. | During Retrofit | 3 |
| High efficiency UPS | High efficiency UPS systems should be selected, of any technology including electronic or rotary to meet site requirements. | During Retrofit | 3 |
| Use efficient UPS operating modes | UPS should be deployed in their most efficient operating modes such as line interactive. Technologies such as Rotary and High Voltage DC (direct current) can also show improved efficiency as there is no dual conversion requirement. | During Retrofit | 2 |
| Code of Conduct compliant UPS | Select UPS systems compliant with the EU Code of Conduct for UPS where that UPS technology is included. Rotary UPS are not included in the UPS Code of Conduct. | No | 2 |

## 5.2 Management of Existing Power Equipment

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| Type | Description | Mandatory | Value |
|---|---|---|---|
| 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 | No | 1 |

# 6 Other Data Centre Equipment

Energy is also used in the non data floor areas of the facility in office and storage spaces.

There is discussion as to whether, to eliminate overlap this section should be removed and replaced with a pointer to BREEAM, LEED or EU standards for green buildings. These standards do not define the data centre part of the building.

## 6.1 Office and Storage Spaces

Whilst the non data floor areas of the facility use comparatively little power there are still savings to be made.

| Type | Description | Expected | Value |
|---|---|---|---|
| Turn off Lights | Lights should be turned off, preferably automatically whenever areas of the building are unoccupied | Yes | 1 |
| Low energy lighting | Low energy lighting systems should be used in the data centre. | During Retrofit | 1 |
| Reduce HVAC | HVAC should be reduced or turned off in unoccupied, non data floor areas of the facility. | No | 1 |

# 7 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.

## 7.1 Building Physical Layout

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

| Type | Description | Expected | Value |
|---|---|---|---|
| Locate M&E plant outside the cooled area | Heat generating Mechanical and Electrical plant should be located outside the cooled areas of the data centre wherever possible to reduce the loading on the data centre cooling plant. | No | 3 |
| Select a building with sufficient ceiling height | Insufficient raised floor or suspended ceiling height will obstruct the use of efficient air cooling technologies in the data centre. | No | 2 |
| Optimise orientation of the data centre | Optimise the layout and orientation of the building to reduce the insolation heat loads and optimise the efficiency of heat transfer. | No | 2 |
| Facilitate the use of economisers | The physical layout of the building should not obstruct the use of economisers (either air or water) | No | 3 |

## 7.2 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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 or industrial space, hydroponic farming and even swimming pools. | No | 2 |
| Locate the Data Centre in an area of low ambient temperature | Free and heavily economised cooling technologies are more effective in areas of low ambient external temperature. | No | 2 |
| 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 are also less effective. | No | 1 |
| Locate near a source of free cooling | Locating the data centre near a source of free cooling such as a river subject to local environmental regulation. | No | 3 |
| Co-locate with power source | Locating the data centre close to the power generating plant can reduce transmission losses and provide the opportunity to operate adsorptive chillers from power source waste heat. | No | 2 |

# 8 Monitoring

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

## 8.1 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| 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. Again, this should be separate from any non data centre building loads. Note that this is required for CoC reporting | Yes | 2 |
| IT Energy consumption meter | Install metering equipment capable of measuring the total energy delivered to IT systems, including power distribution units. This may also include other power feeds where non UPS protected power is delivered to the racks. Note that this is required by for CoC reporting. | Yes | 2 |
| 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. | No | 2 |
| CRAC unit level metering of return air temperature and humidity | Collect data from CRAC units on return air temperature and humidity. | No | 3 |
| PDU level metering of IT Energy consumption | Improve granularity in IT energy consumption by metering at the Power Distribution Unit inputs or outputs. | No | 3 |
| PDU level metering of Mechanical and Electrical energy consumption | Improve granularity in understanding data centre infrastructure overheads | No | 3 |
| Row or Rack level metering of temperature and humidity | Improve granularity in understanding air supply temperature and humidity | No | 3 |
| Device level metering of temperature | Improve granularity by using built in device level metering of intake and / or exhaust air temperature as well as key internal component temperatures | No | 3 |

## 8.2 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 in needs to be collected and logged.

| Type | Description | Expected | Value |
|---|---|---|---|
| Periodic manual readings | Entry level energy, temperature and humidity reporting can be performed with periodic manual readings of consumption meters, thermometers and hygrometers. This should occur at regular times, ideally at peak load.<br>Note that energy reporting is required by the CoC reporting requirements. | Yes | 2 |
| Automated daily readings | Automated daily readings enable more effective management of energy use.<br>Supersedes Periodic manual readings. | No | 3 |
| Automated hourly readings | Automated hourly readings enable effective assessment of how IT energy use varies with IT workload<br>Supersedes Periodic manual readings and Automated daily readings. | No | 3 |

## 8.3 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.

| Type | Description | Expected | Value |
|---|---|---|---|
| Written report | Entry level reporting consists of periodic written reports on energy consumption and environmental ranges. This should include determining the averaged DCiE over the reporting period.<br>Note that this is required by the CoC reporting requirements. | Yes | 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 are reported.<br>Supersedes Written report | No | 3 |
| Integrated IT 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.<br>Averaged, instantaneous and working range DCiE are reported and related to IT workload.<br>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. | No | 4 |

## 8.4 IT Reporting

Utilisation of the IT equipment is a key factor in optimising the energy efficiency of the data centre.

| Type | Description | Expected | Value |
|---|---|---|---|
| Server Utilisation | 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. | No | 3 |
| Network Utilisation | 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. | No | 3 |
| Storage Utilisation | 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.<br>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.<br>Note that mixed incentives are possible here through the use of technologies such as de-duplication. | No | 3 |

# 9 Items under Consideration

This section contains suggested items that are under consideration for inclusion in the Best Practices..

| Type | Description | Expected | Value |
|---|---|---|---|
| DC (direct current) power distribution | Consider the use of high voltage DC (direct current) power distribution within the data centre. This can reduce the overall power conversion and distribution losses within the facility. | No | 2 |
| Optimal Power Density | Guideline recommendations on the most efficient range for power density | No | 2 |
| Utilisation targets | Minimum or average targets for the utilisation of IT equipment (servers, networking, storage). This presents substantial risk when considered without the load to power profiles of the equipment and would require substantial work. | No | 3 |
| 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.<br>Suggested examples of this are;<br>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.<br>Software should not gratuitously poll or carry out other unnecessary background "housekeeping" that prevents equipment from entering lower-power states, this includes monitoring software and agents. | No | 3 |
| Further development of storage performance and efficiency definitions | Storage performance has multiple dimensions, including throughput and latency, not all of which can be measured at the storage layer.<br>Capacity also has multiple dimensions, allocation and usage, not all of which can be measured at the storage layer. Technologies such as de-duplication, compression, snapshots, and thin provisioning also need to be accounted for in a consistent and informative manner. | No | 3 |