Green Data Centres Practice Guide

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BEAM

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Acknowledgements

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Table of Contents

1 INTRODUCTION

1.1 Objective of the Green Data Centres Practice Guide

This Green Data Centres (GDCs) Practice Guide (hereafter "the Guide") aims to provide the best practices to assist data centre interested parties in identifying and implementing measures to improve the energy efficiency and environmental performance of their data centres. A list of best practices, which are reviewed by a broad group of expert reviewers from operators, vendors, consultants, academics, professional and government bodies who have contributed to and reviewed the Guide, are provided.

The best practices listed in this Guide provide common terminology and framework of recommendations for describing an energy efficient and environmentally friendly practices to assist data centre industry in identifying and implementing measures to improve the energy efficiency and environmental performance of their data centres.

1.2 Using the Guide

A list of best practices for GDCs are categorised into ten major areas, including General Aspects, Cooling System, Power System, Monitoring and Managing Energy Efficiency, IT Equipment Deployment, IT Application System and IT Service Deployment, Telecommunications & Network Cabling, Green Construction, Management and Maintenance, and Green Disposal.

To assist interested parties in making use of the Guide for choosing the suitable best practices for their individual DC, suggested indicative and qualitative implementation effort (in terms of financial and technical complexity) and effectiveness (refer to the level of benefit to be expected from a practice) are provided for each practice. These values are from 1 to 5 with 5 indicating the maximum value, for example, additional effort is required for implementing practices with value of 5 than 1; on the other hand, practice with effectiveness rating of 5 comparatively, possesses a higher influence/ benefit to the data centres than rating of 1. However, it is noteworthy that the suggested figures for the three items, financial, technical and effectiveness are qualitative and relative in nature and not absolute value. These values are not intended to be aggregated to provide an overall score and should not be mistaken for quantitative and direct comparison; these values aim to provide a quick referencing guide for the readers in picking the most suitable practice for their data centres.

The figures in the three items will be updated in abreast with the advancement in data centre technology and industry input. Users are encouraged to provide feedback to this Guide including the figures quoted for each practice.

This Guide listed more than ten (10) global references (see Section 1.5) of similar in nature. Users are encouraged to make references to those documents to understand more on the finance and implementation effort and effectiveness behind the practices. The figures quoted in other documents could be different and are likely due to the differences in climate and ecosystem between Hong Kong and other places.

1.3 Scope of Application

This Guide in general is applicable to all data centres, including both existing and newly purpose-built data centres.

However, items in this Guide may not be applicable to all types of data centres, and even so not all aspects. For example, a colocation provider, which in a large extent, may not be able to control the type of IT equipment to be procured and / or installed in the data centre.

The best practices and measures cover the whole life cycle of the data centre including: Design & Construction, Procurement, Management, Operation & Maintenance and Disposal.

1.4 Applicability of the Practices

The practices in this Guide are neither intended to be definitive nor exhaustive as each individual DC and site requirements are different depending and / or affected by various factors. Operators should make necessary adaption to meet their specific business needs.

Adoption of each practice should be considered together with the extent that the user can exercise control on the data centre. Based on the extent of control, different user type should determine the applicability of each practice before implementation.

By following this Guide with regard to business needs, building and data centre owners and operators will be able to choose the suitable practices for their specific facility and to determine what changes can be made in order to improve the design, operation and performance of the data centre and subsequently improve the environmental outcomes.

1.5 Reference and Standards

This Guide is prepared with reference to the following materials.

- 2019 Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency by Joint Research Centre, European Commission (2019)
- Australian Government Data Centre Strategy 2010-2025 Better Practice Guide: Data Centre Power by Department of Finance, Australian Government 2014)
- Best Practices Guide for Energy-Efficient Data Center Design, Federal Energy Management Program, Office of Energy Efficiency and Renewable Energy by Department of Energy, United States of America (2011)
- Code of Practice for Energy Efficiency of Building Services Installation 2018 by Electrical and Mechanical Services Department, of the Government of the Hong Kong Special Administrative Region of the People's Republic of China
- Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems by Joint Research Centre, European Commission
- ENERGY STAR Low Carbon IT Campaign guidelines such as "6 Ways to Reduce IT Energy Costs" and "12 Ways to Save Energy in Data Centers and Server Rooms" by United States of America
- Energy Standard for Data Centers ASHRAE 90.4-2016
- Four Metrics Define Data Center "Greenness" by Uptime Institute (2007)
- Green Data Centre Practices (Version 3.0), Office of the Government Chief Information Officer, of the Government of the Hong Kong Special Administrative Region of the People's Republic of China
- Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings in Hong Kong by Electrical and Mechanical Services Department and

Environmental Protection Department, of the Government of the Hong Kong Special Administrative Region of the People's Republic of China (2010)

- ISO 50001: Energy management systems (2018)
- L.1300 Best practices for green data centres, Telecommunication Standardization Section by International Telecommunication Union (2014)
- PUE™: A Comprehensive Examination of the Metric by Green Grid (2012)
- Technical Guidelines on Code of Practice for Energy Efficiency of Building Services Installation 2015 by Electrical and Mechanical Services Department, of the Government of the Hong Kong Special Administrative Region of the People's Republic of China (2015)
- Thermal Guidelines for Data Processing Environments, Fourth Edition by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (2015)

1.6 Abbreviations

A&A	Alterations and Additions
ANSI/ TIA	American National Standards Institute/ Telecommunications Industry Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BIM	Building Information Modelling
BIOS	Basic Input/ Output System
BMS	Building Management System
CIBSE	Chartered Institution of Building Services Engineers
COP	Coefficient of Performance
CRAC	Computer Room Air Conditioners
CRAH	Computer Room Air Handlers
DCiE	Data Centre Infrastructure Efficiency
DCIM	Data Centre Infrastructure Management
DSM	Demand Side Management
EC	Electrically Commutated
EIA	Electronic Industries Alliance
EMSD	Electrical and Mechanical Services Department
EPA	Environmental Protection Agency
ERE	Energy Reuse Effectiveness
FSC	Forest Stewardship Council
FWCT	Fresh Water-Cooling Towers
HKSARG	The Government of the Hong Kong Special Administrative Region of the People's Republic of China
HVAC	Heating, Ventilation and Air-Conditioning
IAQ	Indoor Air Quality
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
LED	Light-emitting diode
MiC	Modular Integrated Construction
PDU	Power Distribution Unit
PUE	Power Usage Effectiveness
REE	Regulated Electrical Equipment
RTI	Return Temperature Index
SRI	Solar Reflectance Index

THD	Total Harmonic Distortion
UPS	Uninterruptible Power Supplies
VOC	Volatile Organic Compounds
WEEE	Waste Electrical and Electronic Equipment
WUE	Water Usage Effectiveness

2 GENERAL ASPECT

Under this section, general guidance and proposed practices are described. In each of the practices, indicative and qualitative implementation effort (in terms of financial and technical complexity), effectiveness (refer to the level of benefit to be expected from a practice), are provided to facilitate the interested parties.

2.1 General Practice

Focus: the practices described under this section should be relevant to all aspects of the data centre.

2.1.1 Mechanical and Electrical Equipment Selection

FINANCIAL EFFORT	■■■□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■■■■□

The selection and deployment of mechanical and electrical equipment should consider with priority, among others, the ones that do not require or use relatively less cooling in normal operations.

2.1.2 Life Cycle Assessment

FINANCIAL EFFORT	■■■□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■■■■□

Introduce a Life Cycle Assessment in accordance with international standards, such as ISO 14040, ISO 15656-5:2008, etc.

The use of life cycle assessment, including cost assessment, is to facilitate investigation of potential requirements/ specifications and design options. One of the main objectives is to determine the Total Cost of Ownership for each of the available options, covering the stages of design, build, operation and maintenance. Without the Life Cycle Assessment, it is difficult to determine the best option for green implementation and the monitoring that follows.

2.1.3 Monitoring and Manage Air Quality in Data Hall

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■■□

Ensure that air quality [1] is monitored and managed to ensure that critical equipment is not damaged by particulates or corrosive elements which might impact both IT equipment and data centre facilities such as power and cooling equipment. Poor air quality will degrade performance, energy efficiency and reliability. Implementation of this practice should include the choice of filters and the planned replacement schedule as well as the frequency of routine technical cleaning programme (including underfloor and ceiling void areas if applicable).

Note: More information on this topic can be found in ASHRAE white paper on "Gaseous and Particulate Contamination Guidelines for Data Centres".

2.1.4 Service Charging Model

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

User awareness of energy efficiency can be raised by charging the amount of electricity they consumed.

2.1.5 Don't Treat Data Centre as Office

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

Data centre space should not be compromised as office space and should be designed and operated for high availability and energy efficiency.

[1] Indoor Air Quality Information Centre, Environmental Protection Department [ONLINE] Available at: https://www.iaq.gov.hk/en/index.aspx

For example, data centre designed with comfort cooling for office will lead to energy inefficiency in particular the cooling system.

2.1.6 Site Documentation

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

A comprehensive documentation of the data centre infrastructure systems, whether new-built or retrofit, should be prepared and maintained. Accurate documentation and records of the infrastructure and systems built are essential to correct operation and use of energy efficient functions. Initial documentation should include information on operation, maintenance, as-built records (including appropriate drawings, design specification and product specifications) and commissioning records. The documentation should be updated whenever changes are made to the data centre.

2.1.7 Alternative/ Sustainable Energy Usage

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■□□□

Consider the use of alternative and sustainable energy sources, e.g. solar panels, building integrated photovoltaic panels, etc. for substituting part of electricity or fuel consumption by renewable energy (for some areas in the data centres). This can help to reduce overall carbon footprint rather than provide direct energy efficiency.

In Hong Kong, data centres owners/ operators can liaise with the power utility companies on the procurement of alternative/ sustainable energy [2][3].

2.1.8 Integrative Design Process

FINANCIAL EFFORT	2/5
TECHNICAL EFFORT	2/5
EFFECTIVENESS	3/5

Early consideration of the integrated building design process regarding whole-system thinking to explore the interrelationships among green building design strategies and systems in the conceptual design stage and long-term operation and maintenance needs, to support holistic and cost-effective outcomes of building performance and environmental benefits.

For example, take into account the whole-system thinking (i.e. multi-disciplinary design) to explore the energy efficiency interrelationships among different systems of the data centre facilities including the component parts of power system and cooling system, and the power needs and disposition of the IT equipment. A disintegrated design faces the risks that different systems of the data centre facilities work against each other and compromise the overall energy efficiency.

2.2 Resilience Level Provisioning

Focus: to optimise utilisation of data centre space and energy efficiency of power, cooling and similar supporting facilities

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2 CLP Renewable Energy Certificates, [ONLINE] available at: https://www.clp.com.hk/en/community-and-environment/renewable-schemes/renewable-energy-certificates

3 HK Electric Renewable Energy Certificates, [ONLINE] available at: https://www.hkelectric.com/en/customer-services/smart-power-services/renewable-energy-certificates

2.2.1 Build Resilience in-line with Business Requirement

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

Level of resilience should match business requirement and not over provisioned. For example, 2N resilience may not be necessary and can probably be replaced by N+1 or application resilience over multiple sites.

2.2.2 Consider Multiple Levels of Resilience

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■□□□

Multi-level resiliency in a single data centre can be considered by providing multiple levels of power and cooling resilience at different floor levels, such as N+1 resilience in some floors and 2N in other floors for critical business applications

In this way, resilience can be shared across floors and reduce overall energy consumption.

2.2.3 Scalable Data Centre

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Unnecessary provisioning of excess power and cooling capacity over the actual IT load leads to wastage of energy. Planning a data centre for scalable expansion with not excessive provisioning of power and cooling capacity at the beginning increases energy efficiency and allows the site to respond quickly to business needs and technological advancements.

2.2.4 Design Infrastructure to Maximise Part Load Efficiency

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■□

Infrastructure should be designed to respond dynamically to variable and partial IT loads so that the right amount of resources are consumed to support the actual IT load without wastages. Examples include the use of variable speed drive for pumps, fans and compressors in the cooling system.

2.3 Water Use/ Sources

Focus: to encourage the use of low energy intensity water use/ sources to reduce the water consumption of the data centre.

2.3.1 Water Recycling

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■□□□

Both the capture and storage of rainwater and grey water for evaporative cooling and other non-potable purposes will help reduce potable water usage which in turn help reducing overall energy consumption for the motor of the water pumps.

2.3.2 Potable Water Usage Monitoring

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■□□□□

Data collected from the metering of water consumption from all sources will help to manage and reduce overall water consumption and to understand the water consumption of different usage.

2.3.3 Water Leakage System

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■□□□□

Install water leakage detection systems in all potable water sources, even in data centres, to reduce water wastage in case of leakage.

2.3.4 Cooling Tower Water

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Reduce the freshwater consumption for cooling tower makeup by installing water treatment systems which can increase the number of times that water can be recycled with acceptable quality and hence save vast amount of water [4].

2.4 Sustainable Site & Building Physical Layout

Focus: a sustainable site location and physical layout of the data centre building are important in achieving flexibility and efficiency and will enhance the effectiveness of the green data centre measures.

2.4.1 Layout of Data Hall

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

Data hall area should be designed and located at the centre of the building and surrounding by other associated areas, i.e. corridor, plant rooms, etc. wherever possible to minimise space heat gain through solar radiation, infiltration, conductive heat gains and to prevent leakage of cooling air.

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[4] Guideline on installation and operation of cooling water tower system, Hong Kong EMSD [ONLINE] Available at: https://www.emsd.gov.hk/en/other_regulatory_services/cooling_towers/

2.4.2 Minimise Direct Solar Heating

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■□□□

Roof materials with Solar Reflectance Index (SRI) of not less than 78 are recommended with an aim to increase the reflectivity of the building which in turn minimise solar heating of the air-conditioned areas of the data centres. Effective insulation can be provided by using suitable wall and roof coverings. Green roof system is also another good measure to minimise direct solar heating as well as enhancing biodiversity.

2.4.3 Power System Plant Location

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Better design of power system location, such as plant room location, to shorten cable path with an aim to reduce power loss during transmission.

2.4.4 Cooling System Location

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Explore the opportunities to bring cooling systems closer to the heat source which could reduce the amount of energy to spend on air movement, for example overhead cooling units above racks, in-row cooling, etc.

3 COOLING SYSTEM

Data centre is a dynamic environment. The cooling system should be designed, managed and operated to respond quickly to changes in IT load, temperature and humidity within the data centre and external seasonal changes. Expert advice such as from the design consultant, facility engineers and maintenance agents should be sought wherever needs are required on the practices described.

Best practices are focused on the design, procurement, operation, on-going commissioning, optimisation and management of Cooling System in data centre, including, but not limited to, cooling plant, computer room air conditioners & air handlers (CRAC/ CRAH), air flow management, cooling management, environmental zoning and temperature & humidity design.

3.1 Cooling System

Focus: energy optimisation through the designing, tuning and operating of cooling systems to respond to changes in thermal load

3.1.1 Power-off Unnecessary Cooling Equipment

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

If data hall is not fully occupied, the unnecessary cooling equipment should be powered off or switch to idle condition.

3.1.2 Review Cooling System Operation

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

The cooling environment, in particular in the cold aisle (with or without containment as described below) should be reviewed before accommodating new IT equipment, especially IT equipment with high power density.

3.1.3 Dynamic Control of Cooling system

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■□□

Consider a design that allows the operation and control systems of the cooling system to take into account of different factors and components, e.g. using systems such as Central Control and Monitoring System or Building Management System to synchronise the operation and control of data centre facility equipment and systems.

3.1.4 Cooling System to Operate Efficiently at Partial Load

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Data centres are mostly operated at partial load rather than maximum load. The cooling system should be tuned to operate efficiently in variable partial load and not only at maximum load.

Chillers can be mixed with large and small capacity to address part load condition.

3.1.5 Use Variable Speed Drives

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Use variable speed control to reduce energy consumption for compressors, pumps and fans to respond automatically to part load and change of load condition. Consider using Electrically Commutated (EC) motors which are more energy efficient than traditional AC motors.

3.1.6 Optimise Chilled Water Pump Operation

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Chilled water systems configured with dual pumps, one active and one on standby, can be reviewed for improved energy efficiency, e.g. whether to run the two pumps at low speed will reduce the overall energy consumption instead of keeping one idle.

3.1.7 Baseline Set Point

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■■

Focus in setting the desired range of intake temperature and humidity for IT equipment, the baseline set point for data centre operation. The cooling system should be tuned to achieve the baseline set point. Depending on the operating environment, one uniform baseline set point may not be applicable to the whole data hall/ data centre, e.g. hot density area may have higher set point.

3.1.8 Monitor Outcomes of Raising Operating Range

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

As a result of raising the baseline operating range of temperature and humidity in data centre/ data hall, the fan of IT equipment may operate at higher speed and consequently consume more power. The total power consumption at each instance of increasing the operating range, usually done incrementally, should be monitored to see if the expected result is achieved.

3.1.9 Segregation of Chilled Water System with Comfort Cooling

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Data Centre designs should ensure that chilled water systems are separated from comfort cooling (dedicated to office areas). This is to address the differences in operation mode and energy use between data centre and comfort cooling chillers.

One single cooling system serving both IT load and comfort should always be avoided.

For data centre installed in part of buildings where implementation of independent cooling system for data centre is not practical, use of water flow control or thermostat control to address the variations of operation mode or temperature requirement should be considered. In this case, provision of adequate sensors and sub-metering system should be considered to monitor and measure the system condition and energy usage.

3.1.10 Reuse of Waste Heat

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■□□□

Data centres can be designed to make use of the residual heat from the facility plants and/ or IT equipment, to heat up, for example, office space and other areas where extra energy will need to be consumed otherwise.

This practice will not only enhance the energy efficiency of the data centre parts of the building (such as the data halls), but also reduce the overall energy use of the building.

3.1.11 Chillers with High COP

Where a separate cooling system is installed for the data centre located in a building, the chiller system should be designed with a high chilled water leaving temperature in order to achieve a high coefficient of performance (COP). Minimum COP requirement for Chillers at Full Load as stated under Code of Practice for Energy Efficiency of Building Services Installation by Hong Kong EMSD [5] can be referred.

3.1.12 Thermal Tank

Consider cooling down water in the thermal tank during non-peak hours, if resilience is not compromised.

3.1.13 CRAC/ CRAH

CRAC/ CRAH should comply with the Code of Practice for Energy Efficiency of Building Services Installation issued by Hong Kong EMSD. Procuring CRAC/ CRAH with a high COP is encouraged.

CRAC/ CRAH unit sizing should be chosen with regard to the IT load on the data centre. Undersized CRAC/ CRAH units will have airflow management problems while

[5] Code of Practice for Energy Efficiency of Building Services Installation, Hong Kong EMSD [ONLINE] Available at: https://www.emsd.gov.hk/beeo/en/pee/BEC_2018.pdf

oversized units are inefficient and can cause condensation and static discharges.

Variable speed fan at CRAC/ CRAH is recommended to allow more precise cooling with regard to different temperature at each zone of racks.

3.1.14 Review CRAC/ CRAH Settings

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

Ensure all the CRAC/ CRAH are operated in tandem and at consistent and appropriate temperature and relative humidity settings to avoid working against each other.

3.1.15 Modular Cooling Plant

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Cooling plant should be installed in a modular arrangement to more easily cope with variable IT load, besides enhancing resilience and enabling maintenance without shutting down the whole cooling system.

3.1.16 Thermal Imaging Camera

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

Using thermal imaging camera to monitor the temperature distribution among server racks is encouraged as it is useful in capturing small temperature gradients. The information provided can facilitate energy efficiency improvement by quickly identifying hot spots.

3.1.17 Proactive Management – HVAC system

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

The cooling system after commissioning and during operation should be monitored continuously for enhancing efficiency, e.g. to ensure the settings are in line with the IT load, alerts are analysed for potential needs of replacing parts, etc.

3.2 Airflow Management

Focus: airflow management is about assuring the right amount of air and at the right temperature is circulated to remove heat generated by IT equipment at any time within the data halls. A well designed and managed airflow management system will not let the air return to the cooling system without absorbing heat and no air should circulate more than once through IT equipment. An inefficient airflow management system risks IT equipment being overheat and wasting energy.

3.2.1 Adequate Perforations Area on Rack Doors

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Rack doors should be provided with adequate perforations to improve airflow. ISO/ IEC 14763 recommends a minimum of at least 66% perforated areas.

3.2.2 Minimise Obstructions under Raised Floor

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

The space under the raised floor should be as free as possible. Structures such as cable trays should not obstruct the airflow. An alternative is to use overhead cabling trays (Structured Cabling System for example).

3.2.3 IT Equipment Segregation

Where the racks have different power density (and hence different cooling requirements), consider grouping them in areas with different environmental control areas, e.g. putting legacy equipment requiring lower temperature into separate areas. The objective is to avoid the need to operate the cooling system with the most restrictive environmental requirements (e.g. legacy equipment) and therefore compromising the efficiency of the entire data centre.

3.2.4 Hot/ Cold Aisle Design

Equipment should be installed in the racks in such a manner to draw cold air from the "cold" aisle and exhaust hot air to the "hot" aisle.

This will minimise the mixing of cold and hot air, which in turn result in energy saving.

3.2.5 Airflow Management in Racks

Unused slots in racks should be installed with proper blanking panels to avoid short circuit of hot and cold air. Other openings in the racks including the base not designed for air circulation should be similarly covered to avoid short circuit of hot and cold air.

Equipment should be installed in the racks in such a manner to draw cold air from the "cold" aisle and exhaust hot air to the "hot" aisle. Where necessary, airflow management accessories should be provided for IT equipment that draws cold air and exhausts hot air in a side-to-side manner (e.g. network switches).

3.2.6 Cabinet Air-flow Management – Other Openings

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

Apertures not for airflow in the raised floor should be closed. There should be no gaps along the rows of racks, especially in the case of hot/ cold aisle environment. If necessary, fill in the gaps along the rows to prevent air leakage.

3.2.7 Hot/ Cold Air Containment Design

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■□

Aisle containment is an extension of the hot/cold air aisle design. Containment, in form of either cold/hot containment, can reduce the amount of conditioned air required and increase the effectiveness of the cooling system. Containment in the simplest form can be retrofitted using materials such as heavy plastic sheet and/ or plywood.

3.2.8 Review before Changing Rack Arrangement

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Deploy IT equipment at the designed rack power density to avoid creating cooling and airflow problems. The cooling capacity and airflow in an aisle, as well as the rack arrangement, should be reviewed for possibility of hot spots, for example, if new racks to be moved in are above the designed rack power density.

3.2.9 Use of Fan Wall

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Consider using modular fan wall system to improve the airflow efficiency in data hall. Comparing with air distribution system at raised floor, static pressure drop can be avoided which in turn resulted in energy saving. Modular design allows easy transportation, assembly and high flexibility.

3.2.10 Opportunity of Using Hard Floors

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Small data centres or server rooms such as less than 50 racks can consider a hard floor design since many cooling technologies are available for smaller rooms that do not use or require a raised floor, e.g. the popular approach of row-based cooling with overhead piping, or refrigerant based systems.

Rooms that have low headroom, such as small data centres installed in part of buildings in Hong Kong, can be difficult to fit with a raised floor sufficient to achieve the power density required, and can consider the use of a hard floor design.

3.3 Operating at Higher Temperature and Humidity

Focus: Data centre should not be operated below the industry accepted normal range of temperature and humidity, e.g. ranges as recommended by ASHRAE for different classes of IT equipment, without justifications. Most IT equipment nowadays are able to tolerate higher temperature and humidity, and therefore offer more opportunities to increase energy efficiency.

3.3.1 Consider Raising Target IT Equipment Intake Temperature

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■□

Data centres in the past are mostly designed to operate at temperature range of 20ºC to 26ºC and humidity of 50% to 60%. Opportunities should be taken, e.g. in procuring new IT equipment, to operate the data centres at higher range as specified in the ASHRAE Thermal Guideline, e.g. beyond 26ºC within the Class A2 range or above, instead of A1, to reduce energy usage. Practices mentioned earlier to segregate IT equipment with different temperature and humidity requirement into different areas can be considered together with this one.

3.3.2 Consider Raising the Working Humidity Range

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Similar consideration should be made, e.g. in procuring new IT equipment, to raise the operating humidity range in data centres as per ASHRAE Class A2 range or above to reduce humidification and dehumidification loads and hence energy consumption.

3.3.3 Optimise Chilled Water Temperature

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■□

Explore opportunities to increase the chilled water temperature differences (the difference of supplied and returned chilled water) to reduce water flow and temperature and hence the pump (due to lower pump speed) and overall cooling system energy consumption.

However, keep the following in mind before adopting the strategies:

- Ensure your chillers are capable of operating at higher chilled water temperatures without impacting their reliability.

- Ensure the cooling capacity of indoor CRAC/ CRAH coils can provide your desired IT supply setpoint at higher chilled water temperatures.

3.4 Cooling Management

Focus: to ensure that cooling systems are tuned in response to changes in the facility thermal load or external ambient conditions such as seasonal variation.

3.4.1 Free Cooling/ Economised Cooling Design

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■■□
EFFECTIVENESS ■■□□□

Despite the tropical weather in Hong Kong, explore the opportunity of making use free cooling where the data centre sites and/ or seasons permit. Free cooling reduces the overall energy cost.

Free cooling/ economised cooling design makes use of low external air temperatures to meet part of the data centres cooling requirements. In Hong Kong, free cooling can be considered during the winter months between November and March. Designs such as the direct air free cooling, indirect air free cooling, indirect water free cooling with CRAH and dry cooler and indirect water free cooling with

CRAC with integrated free cooling coil are some of the possible options.

3.4.2 Fresh Water-Cooling Towers Scheme

FINANCIAL EFFORT	■■■□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■■■□□

The HKSARG's FWCT scheme [6] encourages the wider use of fresh water in cooling towers for energy efficient air conditioning systems for non-domestic buildings. Data Centre designs located within the designated area of the FWCT scheme are encouraged to apply.

[6] Fresh Water-Cooling Towers Scheme, Hong Kong EMSD [ONLINE] Available at: https://www.emsd.gov.hk/en/energy_efficiency/fwct_scheme/

4 POWER SYSTEM

Power System is another major part of the facility infrastructure. It is about the power supply and distribution. Best practices are focused on the design, procurement, operation, on-going commissioning and management of power system of the data centre, including, but not limited to, uninterruptible power supplies (UPS), power quality management, demand response, design for part load operation, lighting system and its control.

4.1 Power System

Focus: to ensure that the design, selection and operation of power equipment will ensure substantial savings throughout the lifetime of the facility

4.1.1 Modular Uninterruptible Power Supplies (UPS)

Conventionally, data centres have been using high capacity UPS. Smaller modular UPS are now available that can be scaled with load demand. In terms of energy efficiency, modular UPS can offer the following benefits:

- Ability to grow capacity on an as-needed basis preventing initial oversizing.

- UPS run at greatest efficiency when they are close to the maximum rated capacity. Without oversizing, modular UPS is more likely to operate close to the maximum rated capacity.

4.1.2 High Efficiency UPS

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■□□

High efficiency rated UPS, in the range of 92% to 95%, can be considered. Reference can be made at time of procurement to U.S. EPA ENERGY STAR specifications for UPS.

4.1.3 Use of Lithium Battery for UPS

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■□□

Explore the opportunities of using lithium battery for UPS system. Lithium battery offers four main benefits:

- Reduced UPS size and weight to allow for a more effective, flexible use of space;
- Reduced cooling requirement;
- Increased energy storage availability and UPS reliability; and
- Extended UPS life and reduced maintenance overhead.

It has to be noted the cost for lithium battery is higher than the conventional lead acid battery. However, considering the whole life cycle including the longer life of lithium battery, less maintenance, etc. the total ownership cost can be lowered.

4.1.4 Power Management Design

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■□□

Power system should remain energy efficient under partial load and variable IT loads. The ongoing needs of supplying additional computer power using less energy and smaller spaces should be addressed by designing power management solutions that are flexible and adaptable. Power management solutions such as those that incorporate overhead busway systems, intelligent PDUs, power management software will provide the lowest long-term cost of ownership.

Examples of power management software for energy efficiency include Power Quality Management and Building Energy Management systems.

4.1.5 High Load Factor

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■■□

Aim to design a power system with a high load factor, which is a ratio of Average Load and Maximum Design Load. A high load factor indicates that the power load in the data centre is using the power system efficiently, meaning with less wastage. The practice essentially implies that do not oversize the power system, by determining as accurate as possible the IT load requirements at design stage.

4.1.6 Prioritise DC Power System Designs

FINANCIAL EFFORT	■■■■□
TECHNICAL EFFORT	■■■■□
EFFECTIVENESS	■■■□□

While it is uncommon, opportunities can be taken to explore converting AC power to DC power for use by IT system equipment. DC power systems require fewer connection steps from power grid to chip which leads to a reduction in cost but increasing efficiency.

4.1.7 Power Quality Management

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

To establish action plan to monitor the quality, and hence the efficiency, of the power system, on items such as the following:

- Power factor monitoring & correction;
- 3-phase Load Balancing;
- Maximum demand monitoring;
- Demand Side Management (DSM);
- Total Harmonic Distortion (THD); and
- Thermal Scan on electrical distribution system

4.2 Lighting systems

Focus: energy saving opportunities on lighting systems

4.2.1 Low Energy Lighting Systems

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■□□□

Low energy lighting systems should be used in data centres. LED lighting is an example.

- ANSI TIA-952-A standard recommends LED lighting over fluorescent options as LED fixtures generate less heat, use less electricity and are 100% dimmable.
- When selecting fluorescent lighting, T5 fluorescent lamps are recommended for their higher luminous efficacy (lm/W) in comparison to T8 and T12 lamps.

Electric ballasts, if needed, should be used over electromagnetic ballasts as they are more energy efficient and generate less heat.

4.2.2 Optimising the Lighting Platform

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■□□□□

Designs should incorporate sensor networks to adjust lighting levels based on occupancy, and motion sensors to reduce wasted lighting energy. LED lighting should be powered with low voltage DC that are less costly in comparison to the traditional AC mains power.

4.2.3 Pale Coloured Fixtures and Fittings

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■□□□□

Pale coloured cabinets, walls and floors reflect more light than dark coloured fixtures and fittings and has the effect of making the data centre seem brighter. Therefore, the amount of lighting needed to illuminate a data centre and the energy consumed for lighting will be reduced.

4.2.4 Maintaining Illuminance

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■□□□□

Illuminance levels decline with age. Lamps/ luminaires need be kept clean and replaced when necessary. The frequency of maintenance and replacement will depend on environmental conditions as well as type of luminaire. The Lighting Maintenance Factor should also be referenced to maintain illuminance. Further details on the maintenance of illuminance levels can be obtained from CIBSE Code for lighting.

5 Monitoring and Managing Energy Efficiency

Best practices are focused on the design, operation, on-going management of the data centre through the usage of data collection, as well as energy usage analysing systems and reporting. In addition, metrics, including both commonly and emerging ones are also included with an aim to provide a comprehensive source to users in handling the overall operational and on-going management processes relating to monitoring, analysing, quantifying and reporting of data centre energy usage and environmental performance.

Measuring energy use and factors that impact energy use is a pre-requisite to implement and sustain energy efficiency programs successfully. Tracking of energy usages can also help discover potential problems of the equipment and improve maintenance effectiveness. This section discusses the practices and metrics generally adopted to achieving the goal.

5.1 Monitoring & Energy Reporting

Focus: to ensure that the chosen monitoring methods and tools will help facilitate energy conservation and efficiency in the Operations & Maintenance stage.

5.1.1 Monitoring System

Financial Effort
Technical Effort
Effectiveness

Data centres have to determine the requirements of the monitoring system based on organisation needs such as the need to adopting charging and the charging model, reporting frequency and the means (e.g. report to be compiled automatically or manually), maintenance procedures, adoption of common metrics, etc.

5.1.2 IT Service/Asset Management

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Consider maintaining a record of physical asset, e.g. IT and E&M infrastructure equipment, etc. against the services they support. Monitoring power consumption of the physical asset over time will reveal whether the equipment is actively used. For example, unused or low usage IT equipment with regard to services they support should be decommissioned or virtualised to preserve energy.

5.1.3 Energy Reporting Hardware

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Select mechanical and electrical equipment, including power supply and distribution and cooling systems, with metering functions and features to meet the metering system requirements as far as possible. The metered data should be downloadable in open standard format to systems such as Building Energy Management or DCIM (Data Centre Infrastructure Management) for further analysis.

Common metered data to be collected and analysed includes: power and energy usage of facility equipment and power usage at rack level, trending of usage, energy usage at different areas of data centre and at different timing, airflow monitoring, PUE (Power Usage Effectiveness), etc.

5.1.4 Metering for User Awareness

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

Where the metered data collected by installed equipment are unable to meet the total needs, consider supplementing data collection with other means, such as collecting power consumption of racks through intelligent power bars installed in the racks. Energy meter down to server rack level enables the cooling to be more concise and to avoid energy wastage.

Power consumption reported at rack level to users will raise their awareness of energy efficiency particularly if it is supported by appropriate charging models.

5.1.5 Row Level Monitoring

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Operation of cooling system in data hall can be monitored with the help of temperature and humidity sensors installed in racks along the cold and hot aisles, as discussed earlier and in the Thermal Guidelines for Data Centres from ASHRAE.

Aisle sensors are particularly useful to monitor the temperature of newly installed high-power density racks and/ or to identify hot spots in an aisle. Data inconsistency between those reported by the installed equipment and aisle sensors can highlight advanced warning of potential problems with the cooling system and/ or insufficient cooling capacity.

5.1.6 Building Management System (BMS)

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

BMS is prominent in their use to ensure that a data centre (and the building service) is safe, secure, energy efficient and reliable. Data centres have to decide the scope and requirements before choosing the appropriate BMS, include ease of integration with other monitoring systems.

5.1.7 Data Centre Infrastructure Management (DCIM)

DCIM is a new breed of BMS, specifically design to manage data centre holistically including the facility infrastructures. It includes additional functions such as big data system, asset management, capacity management, cable management, modelling, integrated control with systems such as Fire Alarm, Physical Security, Computational Fluid Analysis, etc.

DCIM is still at early stage of adoption by data centre, due to high investment cost and implementation effort, but should be considered among others where energy efficiency is a prime consideration for the data centre.

5.1.8 Advancement of Monitoring Systems

Data centre users should take note the development trend of monitoring systems such as the availability of digital remote monitoring architectures, emergence of cloud service and mobile computing functions and features and the use of big data analytics and machine learning, all of which can increase energy efficiency and facilitate energy management and maintenance.

5.1.9 Power Usage Effectiveness (PUE)

PUE is the most common metric adopted by data centres to track energy efficiency. It is defined grossly as:

PUE = Total data centre energy consumption / IT energy consumption

Total data centre energy consumption includes everything that support IT equipment together with the power delivery components such as UPS, switching gear, gensets, cooling systems, lighting, etc.

It should be noted PUE varies with changes in IT energy consumption, and hence the total data centre energy consumption, e.g. PUE for partial load can be different from the full load situation. Trending PUE, which can be done at three different levels (Category), is a good measure of how energy efficiency is improved over time. According to global survey conducted by Uptime Institute in 2018/19, the average PUE reported is around 1.6, a figure that is targeted by many high tier data centres in Hong Kong.

For implementation details, papers from the Green Grid website can be referred [7].

5.1.10 Cooling System Efficiency

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Cooling system is one of the most important infrastructure facilities. Its efficiency can be measured by dividing the total power consumed by the cooling system to remove a given amount of heat generated by the IT equipment as follows:

$$Cooling\ efficiency = \frac{Average\ Power\ Consumed\ by\ Cooling\ System\ (kW)}{Average\ Cooling\ Load\ (kW)}$$

[7] PUE: A Comprehensive Examination of the Metric [ONLINE] Available at: https://www.thegreengrid.org/en/resources/library-and-tools/20-PUE%3A-A-Comprehensive Examination-of-the-Metric

In terms of efficiency, the lower the percentage the better, meaning less power is required to remove the designated amount of heat. For example, a 50% efficiency means the amount of heat (measured in terms of Power in kW) generated required only half of the equivalent power (measured in kW) to remove it.

The efficiency of cooling system depends on many factors including for example how tolerant is the IT equipment to the heat generated, investment made to cooling system equipment, etc. In essence, the cooling efficiency should not be approaching 100% or over, and the efficiency over time can change.

5.1.11 Water Usage Effectiveness

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■□□□

Power consumed to support the IT load is measured by PUE. Similarly, the amount of water required to support the removal of heat generated by IT load is measured by Water Usage Effectiveness (WUE). Given water is a scarce economic mean, the adoption of WUE is getting popular. It is defined as:

$$WUE = \frac{Annual\ Water\ Usage\ (in\ litre)}{IT\ Equipment\ Power}$$

Similar to PUE and Cooling Efficiency, WUE depends on many factors. The less is the figure the better, and it is important that the figure is trending less over time, meaning less amount of water is needed to support the IT load.

Data centres interested with WUE can study the details from papers in the Green Grid website [8].

Note: Water usage effectiveness (WUE): A Green Grid Data Centre Sustainability Metric

5.1.12 Other Useful Metrics

New metrics are coming up for monitoring energy efficiency. The less popular ones are listed below for reference. Interested data centres can visit relevant website for more details.

Data Centre Infrastructure Efficiency, DCiE

DCiE is defined as the ratio of the total power/energy drawn by all IT equipment to the total power/energy to run the DC facility, or the inverse of the PUE:

$$DCiE = \frac{1}{PUE} = \frac{IT\ Equipment\ Power/Energy}{Total\ Facility\ Power/Energy}$$

Units: Dimensionless

Source PUE

$$Source\ PUE = \frac{Total\ Facility\ Energy\ (kWh)}{UPS\ Energy\ (kWh)}$$

Units: Dimensionless

8 Water usage effectiveness (WUE): A Green Grid Data Centre Sustainability Metric [ONLINE] Available at: https://www.thegreengrid.org/en/resources/library-and-tools/238-Water-Usage-Effectiveness-%28WUE%29%3A-A-Green-Grid-Data-Center-Sustainability-Metric-

Energy Reuse Effectiveness, ERE

ERE is defined as the ratio of the total energy to run the DC facility minus the reuse energy to the total energy drawn by all IT equipment:

$$ERE = \frac{Cooling + Power + Lighting + IT - Reuse\ Energy}{Total\ Facility\ Energy}$$

Units: Dimensionless

Heating, Ventilation and Air-Conditioning (HVAC) System Effectiveness

This metric is defined as the ratio of the annual IT equipment energy to the annual HVAC system energy:

$$HVAC\ System\ Effectiveness = \frac{Total\ IT\ Equipment\ Energy\ (kWh/yr)}{Total\ HVAC\ Energy\ (kwh/yr)}$$

Units: Dimensionless

Airflow Efficiency

This metric characterises overall airflow efficiency in terms of the total fan power required per unit of airflow. This metric provides an overall measure of how efficiently air is moved through the data centre, from the supply to the return, and considers low pressure drop design as well as fan system efficiency:

$$Airflow\ Efficiency = \frac{Total\ Fan\ Power\ (kW)}{Total\ Fan\ Airflow\ (L/s)}$$

Units: kW/L/s

Return Temperature Index, RTI

This metric evaluates the energy performance of the air management system:

$$RTI = \frac{\Delta T_{AHU}}{\Delta T_{IT\ EQUIP}} \times 100\%$$

where,
ΔT_{AHU} is the typical (airflow weighted) air handler temperature drop and
$\Delta T_{IT\ EQUIP}$ is the typical (airflow weighted) IT equipment temperature rise.

Ambient Relative Humidity, RH

$$RH_{Ambient} = (RH_1 + RH_2 + \cdots + RH_n)/n$$

where RH_1 and RH_2 is the Relative humidity at measurement points 1 & 2 and n is the number of representative measurement points.

Units: Expressed as a percentage, %

Uninterruptible Power Supply (UPS) Load Factor

This metric is the ratio of the peak load of the uninterruptible power supply (UPS) to the design value of its capacity. This metric provides a measure of over-sizing and redundancy of the installed UPS:

$$UPS\ Load\ Factor = \frac{UPS\ Peak\ Load\ (kW)}{UPS\ Load\ Capacity\ (kW)}$$

Units: Dimensionless

6 IT EQUIPMENT DEPLOYMENT

Best practices are focused on the specification, procurement and on-going management of IT System and Equipment to enhance data centre energy efficiency, and the impacts of the IT equipment to energy efficiency of the power and cooling systems.

The demand for power in data centres and hence cooling comes from IT equipment. An energy efficient facility infrastructure goes hand-in-hand with energy efficient IT equipment. Data centres should use IT equipment that are energy efficient as discussed in the below practices:

6.1 Selection of New IT Equipment

Focus: reduction in power and cooling used by IT equipment will have a magnified effect on utility energy consumption.

6.1.1 Energy Efficient Equipment

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

Use energy efficiency IT equipment, including server and storage, such as the ones labelled with ENERGY STAR, SERT or similar metrics.

6.1.2 A2 or above Class Equipment

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■■

Use ASHRAE Class A2 equipment (or even higher classes such as A3 and/or A4) as long as the processing and performance capability of the equipment meets the business application requirements. A2 or higher classes of equipment is more temperature and humidity tolerant than A1 Class (which is classified as Enterprise Class Servers including tape and mainframe). Information on choosing the energy efficient IT equipment can be found at the summary of ASHRAE environmental guidelines [9] and The Environment Bureau Circular Memorandum No. 6/2015 from the HKSARG [10].

6.1.3 Equipment Power Management

Turn on the equipment power management features, include BIOS, operating system and driver settings for better power management of the IT equipment and to monitor power usage hence, to save energy.

6.1.4 Segregate IT Equipment

IT equipment with stringent environmental requirement should be located in separate areas in data hall in order not to compromise the energy efficiency of the cooling systems. Equipment requiring stringent environmental requirements should be considered for replacement over the long term with better energy efficient ones with priority.

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[9] A summary of ASHRAE environmental guidelines [ONLINE] Available at: https://tc0909.ashraetcs.org/documents/ASHRAE_TC0909_Power_White_Paper_22_June_2016_REVISED.pdf

[10] The Environment Bureau Circular Memorandum No. 6/2015 of HKSARG [ONLINE] Available at: https://www.epd.gov.hk/epd/sites/default/files/epd/english/how_help/green_procure/files/ENB_Cir_6-2015.pdf

6.1.5 Efficient AC/DC Conversion

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

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. Product specifications of the equipment provide the details.

6.1.6 Not Going over Rack Power Density

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Deploy IT equipment at the designed rack power density to avoid creating cooling and airflow problems in the cooling system. The cooling capacity and airflow in an aisle, as well as the rack arrangement, should be reviewed if incoming new racks are above the designed rack power density.

6.1.7 Right Rack Airflow

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■■□

Positioning IT equipment in the rack at the direction that matches the airflow design, which is commonly from front to rear. Equipment (such as switches) uses a different airflow direction should only be placed with a correction airflow device.

6.1.8 Airflow of Custom Rack

Financial Effort	■□□□□
Technical Effort	■□□□□
Effectiveness	■■■■□

Equipment which is housed in custom racks should be positioned at the right direction that matches the air flow design and/ or the hot/ cold aisle layout.

7 IT Application System and IT Service Deployment

Best practices are focused on the specification, procurement and on-going management of IT software and application to enhance data centre energy efficiency, including virtualisation technology, efficient software and data management policy.

IT equipment are installed for the delivery of IT services. Inefficient software can waste a lot of useful energy. Best practices in this area include:

7.1 Selection of New IT Application

Focus: reduction in power and cooling used by IT application systems will have a magnified effect on utility energy supply

7.1.1 Decommission Equipment Not Supporting IT Service

Financial Effort	■■□□□
Technical Effort	■■□□□
Effectiveness	■■■□□

Completely decommission and remove any equipment that is not required to support services and/or no longer in use to save energy use.

7.1.2 Optimum Hardware Resilience

Financial Effort	■□□□□
Technical Effort	■□□□□
Effectiveness	■■■■■

Determine the business impact due to downtime of IT service and deploy only the level of resilience commensurate to business needs, such as cold standby instead of hot standby.

7.1.3 Select Efficient Software

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

Include performance as one of the evaluation criteria for software acquisition and not simply functions and features. In-house developed software likewise should pay attention to software performance.

7.1.4 Deploy Virtualisation Technology

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■■■

Virtualisation should be employed to make better use of IT equipment, hence reducing the amount of IT equipment and reducing energy consumption. This applies to servers, storage and networking in the data centres.

7.1.5 Data Management Policy for IT Service

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■■□

Develop a data management policy to define which data should be kept, for how long and at what level of protection with a view to reduce the amount of storage required for each IT service.

8 TELECOMMUNICATIONS & NETWORK CABLING

Good cabling management can help improving cooling efficiency. Best practices are focused on the design, planning, selection and management of cable installation for IT systems and operation to improve cooling efficiency.

8.1 Cabling Management

Focus: good data centre cabling management can have a magnified effect on reduction in utility energy consumption required for cooling.

8.1.1 Cabling Arrangement

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■■□

Where ceiling height permits, consider using overhead instead of under floor cabling to improve cooling efficiency.

In case underfloor cabling arrangement is unavoidable due to limited head room and has to be adopted with no other choices, use network and cabling design (e.g. top-of-rack switching) to reduce the amount of cabling; select cables with smaller diameters to minimise the volume of underfloor cabling; use higher strand count optical fiber cables instead of several lower count optical fiber cables to minimise the volume of underfloor cabling; route cable pathways under hot aisles so as not to block airflow to ventilated tiles on cold aisle; and size pathways and spaces properly to accommodate cables with minimal obstruction (e.g. shallower and wider trays).

Underfloor cabling arrangement should only be adopted with no other choices since it can have effects such as reducing cooling efficiency and energy saving opportunities. The above underfloor cabling measures only aim to minimise such effects as far as possible.

8.1.2 Cabling Management

Financial Effort	■■□□□
Technical Effort	■■□□□
Effectiveness	■■■■□

Good cabling management practices can be referenced in TIA-942 and TIA/ EIA-568 industry guidelines.

9 GREEN CONSTRUCTION

Best practices are focused on the site planning and management and construction of new data centres development, and existing data centres undergo Alterations and Additions (A&A) works or retrofitting works. Construction site activities can be the significant source of environmental degradation, unless appropriate steps are taken for example to reduce the emissions of pollutants to air, land and water, and to reduce nuisance from construction related noise. In addition, practical considerations and opportunities of using environmentally sustainable natural resources in construction and fitting-out of data centres will also be addressed under this section.

9.1 Green Construction

Focus: to implement green construction practice for new data centre development or A&A.

9.1.1 Nil Usage of Virgin Forest Products

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■□□□

No virgin forest products are used for temporary works.

9.1.2 Local Sourcing of Materials

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■□□□□

Use of locally sourced materials will help reduce the environmental impacts of transportation.

9.1.3 Recycle Materials Usage

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■□□□

Use recycled materials in order to reduce the consumption of virgin resources.

9.1.4 Timber Usage

FINANCIAL EFFORT	■■■□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■■□□□

Timber should be sourced from well-managed forests i.e. FSC™ certification.

9.1.5 Construction Indoor Air Quality Management Plan

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■□□□

Implement a Construction Indoor Air Quality (IAQ) Management Plan to ensure that ventilation systems are not contaminated from construction activities.

9.1.6 Document Management System

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Implement a Document Management System to encourage tidy and digital documentation throughout the design and construction process. This will ensure the ease of transition over to facility management teams.

9.1.7 Building Information Modelling (BIM)

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■■□□

Encourage the design team to discuss and work through the design platform and deliver holistic solution using Building Information Modelling (BIM).

9.1.8 Usage of Modular and Standardised Components

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Increase the usage of modular and standardised components in building designs to enhance buildability and reduce construction waste. For example, site footprint in Hong Kong is usually small, using modular and standardised components can shorten the construction time, in addition to reducing environmental impacts.

9.1.9 Integrative Design Process

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Early consideration of the integrated building design process, buildability and operational issues to support holistic and cost-effective outcomes of building performance, human health and environmental benefits.

9.1.10 Modular Integrated Construction (MIC)

Consider prefabrication of building elements in order to reduce material wastage and the amount of on-site waste.

9.2 A&A Works & Revitalisation of Industrial Building to Data Centres

9.2.1 Reuse of Existing Building Structures

Reuse major elements of existing building structures to help reduce demolition waste, conserve resources and lower the environmental impacts of construction work. For example, this practice is worth applying in converting industrial buildings to data centres, a common development approach in Hong Kong [11].

[11] Using Industrial Buildings or Industrial Lots for Data Centre Development [ONLINE] Available at: https://www.datacentre.gov.hk/en/availablelands_ib.html

10 MANAGEMENT AND MAINTENANCE

An effective management of building operations and maintenance is the key factor for better environmental performance of the data centres, ensuring the data centres are operating in their maximum sustainable potential. Under this section, policies, procedures and strategies that enable data centres to be operated efficiently in a sustainable manner are discussed.

10.1 Management

Focus: an effective management of building and data centre operations and maintenance are the key factors for better energy efficient performance of the data centres, ensuring the data centres are operating in their maximum sustainable potential.

10.1.1 Auditing of Existing Equipment

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■□□□

An audit of existing equipment should be carried out to maximise any unused existing capability by ensuring that all areas of optimisation, consolidation and aggregation are identified before considering new investments on equipment.

10.1.2 Environmental Management System

FINANCIAL EFFORT	■■■□□
TECHNICAL EFFORT	■■■□□
EFFECTIVENESS	■■□□□

Introduce an environmental management system in accordance with international standards, i.e. ISO 14001.

10.1.3 Energy Management System

FINANCIAL EFFORT ■■■□□
TECHNICAL EFFORT ■■■□□
EFFECTIVENESS ■■□□□

Implement an energy management system in accordance with international standards, such as ISO 50001.

Implement an energy management system to manage the expectations of implementing the green measures, including apportioning energy cost to users. Standards such as ISO50001 and software such as Building Energy Management, DCIM, etc. are good examples of energy management system.

10.1.4 Staff Training and Resources

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Operation and maintenance staff are encouraged to have sufficient training to acquire updated knowledge and uphold latest requirements on environmental related and energy efficiency best practices.

Staff skills and experience are important factors in successful implementation of energy efficient programs. The qualifications and experience of the management, operation and maintenance staff should be commensurate with the engineering systems, size and complexity of the data centres.

10.1.5 Data Centre Building and Site Operation and Maintenance

FINANCIAL EFFORT ■■□□□
TECHNICAL EFFORT ■■□□□
EFFECTIVENESS ■■■□□

Planned inspection, maintenance and repairing of the building fabric, structure, and external areas are encouraged, in order to enhance safety and reduce environmental impacts, as well as to retain asset value of the data centre and maintain the performance requirements.

10.1.6 Data Centre Building Services Operation and Maintenance

FINANCIAL EFFORT	■■□□□
TECHNICAL EFFORT	■■□□□
EFFECTIVENESS	■■■□□

Proper and efficient operation of the facility infrastructure by operation and maintenance staff are encouraged. A well-planned operation and effective maintenance would maintain higher operation efficiencies, reduce breakdown rate, prolong the operation life of the systems while the system can still meet with the comfort, health, and safety requirements of the building/ data centre users.

10.1.7 Green Cleaning

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■□□□

Environmentally friendly cleaning products and procedures should be adopted to protect human health and environmental quality. Using less hazardous cleaning products (e.g. biodegradable, low toxicity, lower VOC emission, reduced packaging, etc.) can minimise harmful effect on cleaning staff, occupants and equipment and help maintaining a good indoor air quality.

Furthermore, putting environmental consideration in the first priority when making choice in purchasing cleaning materials and products can reduce related water, waste, and ambient air pollution.

11 Green Disposal

Discussion of the waste management issue in Hong Kong is gaining more attention than before. Apart from general refuse, disposal of obsolete electronic equipment and data centre facilities, are expected to have huge environmental impacts.

Process to handling waste disposal on IT equipment and facilities within data centre is one of the key focuses. Best practices should therefore cover the overall life cycle of data centre. At the design stage, best practices on the development of green disposal policy for IT equipment and facilities will be addressed. At the Operational and Maintenance stage, measures on monitoring and auditing of the waste policy and performance will be addressed. It is expected that the proposed best practices and measures should echo the government policy on Proper Recycling of Regulated Electrical Equipment Turning Waste into Resources.

11.1 Green Disposal

Focus: apart from general refuse, disposal of electronic equipment, i.e. obsolete IT equipment and data centre facilities, are expected to have huge environmental impact and should be handled with reference to the following practices

11.1.1 WEEE Scheme

FINANCIAL EFFORT	■□□□□
TECHNICAL EFFORT	■□□□□
EFFECTIVENESS	■■■□□

The Producer Responsibility Scheme on Waste Electrical and Electronic Equipment covers regulated electrical equipment (REE). The removal of computers and monitors from the data centre should make use of the HKSARG's WEEE Scheme [12].

[12] Waste Electrical and Electronic Equipment Scheme by Environmental Protection Department [ONLINE] Available at: https://weee.gov.hk/?lang=1

11.1.2 Environmental legislations

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■■□□

The removal of equipment including unused UPS battery should comply with relevant environmental legislations such as the Waste Disposal Ordinance CAP 354 [13].

11.1.3 Green Disposal Plan, Policy and Practice

FINANCIAL EFFORT ■□□□□
TECHNICAL EFFORT ■□□□□
EFFECTIVENESS ■■□□□

Providing spaces for collection, storage, sorting and disposal of waste and recovered materials (whole data centre) at prominent locations.

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[13] Waste Disposal Ordinance CAP 354 [ONLINE] Available at: https://www.elegislation.gov.hk/hk/cap354!en@2015-01-29T00:00:00