MCMC MTSFB TC G004:2024

TECHNICAL CODE

SPECIFICATION FOR GREEN DATA CENTRES (FIRST REVISION)

Developed by

Malaysian Technical Standards Forum Bhd

Registered by

MCMC

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MCMC MTSFB TC G004:2024

Development of technical codes

The Communications and Multimedia Act 1998 (Laws of Malaysia Act 588) (‘the Act’) provides for a Technical Standards Forum designated under Section 184 of the Act or the Malaysian Communications and Multimedia Commission (‘the Commission’) to prepare a technical code. The technical code prepared pursuant to Section 185 of the Act shall consist of, at least, the requirements for network interoperability and the promotion of safety of network facilities.

Section 96 of the Act also provides for the Commission to determine a technical code in accordance with Section 55 of the Act if the technical code is not developed under an applicable provision of the Act and it is unlikely to be developed by the Technical Standards Forum within a reasonable time.

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A technical code prepared in accordance with Section 185 shall not be effective until it is registered by the Commission pursuant to Section 95 of the Act.

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Contents

Page

Committee representation

This technical code was developed by the Green ICT, Environment & Climate Change Working Group of the Malaysian Technical Standards Forum Bhd (MTSFB), which consists of representatives from the following organisations:

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EDOTCO Malaysia Sdn Bhd

Huawei Technologies (Malaysia) Sdn Bhd

Maxis Broadband Sdn Bhd

Sustainable Energy Development Authority

UCSI Education Sdn Bhd

Universiti Kebangsaan Malaysia

Universiti Putra Malaysia

Universiti Teknikal Malaysia Melaka

Tele System Electronics (M) Sdn Bhd

TM Technology Services Sdn Bhd

Foreword

This technical code for Specification for Green Data Centres ('Technical Code') was developed pursuant to Section 185 of the Communications and Multimedia Act 1998 (Laws of Malaysia Act 588) by the Green ICT, Environment & Climate Change Working Group of the Malaysian Technical Standards Forum Bhd (MTSFB).

Major modifications are as follows:

a) Include an overview of green data centres clause for foundational context.

b) Include terms and definitions clause for a shared vocabulary.

c) Update the Power Usage Effectiveness (PUE) classification, Supply Air Temperature (SAT), Water Usage Effectiveness (WUE), Carbon Usage Effectiveness (CUE), and Uninterruptible Power Supply (UPS) system efficiency for revised guidance and best practices.

d) Include renewable energy integration clause for deployment strategies and recommendations, including those for Photovoltaic (PV) systems.

e) Include indoor and outdoor modular data centres clause for efficiency and flexibility.

f) Include an efficient battery selection and deployment clause, including lithium battery specifications and safety.

g) Update the guidance on automation and reporting to highlight its role in energy-saving.

h) Include a new annex on green data centres technologies and its applications in Malaysia.

This Technical Code shall replace the MCMC MTSFB TC G004:2015, Specification for Green Data Centres. The latter shall be deemed to be invalid to the extent of any conflict with this Technical Code.

This Technical Code shall continue to be valid and effective from the date of its registration until it is replaced or revoked.

SPECIFICATION FOR GREEN DATA CENTRES

0. Introduction

Malaysia's commitment to a sustainable future is underscored by the National Energy Transition Roadmap (NETR). This ambitious plan outlines a path toward a low-carbon, net-zero emissions energy system by 2050. Data centres represent a critical component in this transition, with their energy consumption making them a prime target for efficiency initiatives. This revised Technical Code for Green Data Centres directly supports the NETR by providing essential guidance for reducing data centre energy consumption and minimizing their environmental impact, incorporating the latest technologies, and aligning with relevant global standards for energy efficiency and sustainability.

This Technical Code is vital in providing a framework for private, government and commercial data centres to optimise their energy practices. While certification is voluntary, it positions organisations to reduce operating costs, lessen their carbon footprint and enhance their competitiveness within the Malaysian data centre industry. Furthermore, it aligns with growing global trends in prioritising sustainability and mitigates the risks of greenwashing. As environmental regulations become increasingly stringent worldwide, this Technical Code will establish Malaysia as a leader in proactive environmental stewardship.

Businesses, government and society gain numerous benefits from adopting this Technical Code. Businesses experience cost savings, enhanced customer satisfaction and the potential for new markets and increased market share. The government benefits from alignment with global sustainability initiatives and expert guidance. For society, this Technical Code contributes to an improved quality of life in various aspects.

1. Scope

This Technical Code establishes the minimum requirements for green data centres, with the aim of promoting energy efficiency and reducing carbon emissions across the data centre industry in Malaysia.

It outlines best practices for achieving sustainability and applies to all data centres operating in the country, whether they are privately owned and operated by a single organisation for their exclusive use or commercial facilities providing services to multiple clients. The Technical Code covers various aspects of data centre operations, including environmental conditions, energy management, air management, cooling management, IT equipment and lighting, power chain management, space management, information management, governance, and guidelines.

2. Normative references

The following normative references are indispensable for the application of this Technical Code. For dated references, only the edition cited applies. For undated references, the latest edition of the normative references (including any amendments) applies.

ISO 50001, *Energy Management System*

ISO/IEC 22237-2, *Information technology - Data centre facilities and infrastructures Part2: Building construction*

ISO/IEC 30134-8, *Information technology - Data centres key performance indicators – Part8: Carbon usage effectiveness (CUE)*

ISO/IEC 30134-9., *Information technology - Data centres key performance indicators – Part 9: Water usage effectiveness (WUE)*

EN 50600, *Information technology - Data centre facilities and infrastructures*

Recommendation ITU-T L.1300, *Best practices for green data centres*

Recommendation ITU-T L.1303, *Functional requirements and framework of green data centre energy-saving management system*

Recommendation ITU-T L.1320, *Energy efficiency measurement and metrics for telecommunication equipment and data centres*

ANSI/TIA-942, *Telecommunications Infrastructure Standard for Data Centers*

SS 564-1, *Sustainable data centres*

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Technical Committee (TC) 9.9*, Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance*

ENERGY STAR®, *Program Requirements Product Specification for Computer Servers, Eligibility Criteria, Version 2.0, www.energystar.gov/specifications*

Green IT Promotion Council, *New Data Center Energy Efficiency Evaluation Index DPPE (Data center Performance per Energy) Measurement Guidelines, Version 2.05*

Green Technology and Water Malaysia and the Green Computing Initiative*, The Green Data Centre: Achieving the True Potential of Sustainable Computing*

Lawrence Berkeley National Laboratory, *Self-benchmarking Guide for Data Center Infrastructure: Metrics, Benchmarks, Actions*

NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*

European Union Battery Regulation (Regulation 2023/1542)

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*

Uptime Institute, *Tier Classification System, https://uptimeinstitute.com/tiers*

WP49-PUE, *A Comprehensive Examination of the Metric Version 6, Green Grid*

3. Abbreviations

For the purposes of this Technical Code, the following abbreviations apply.

AI	Artificial intelligence
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BIPV	Building-Integrated Photovoltaics
CRAC	Computer Room Air Conditioning
CRAH	Computer Room Air Handling

EC	Electronically Commutated
EnMS	Energy Management System
ESG	Environmental, Social, and Governance
GDCMS	Green Data Centre Malaysia Standards
HSSD	High Sensitivity Smoke Detection
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communications Technology
IMDC	Indoor Modular Data Centres
IT	Information Technology
KPI	Key Performance Indicator
M&E	Mechanical and Electrical
MDC	Modular Data Centres
MPPT	Maximum Power Point Tracking
OMDC	Outdoor Modular Data Centre
NETR	National Energy Transition Roadmap
PDU	Power Distribution Unit
PUE	Power Usage Effectiveness
REC	Renewable Energy Certificate
RHR	Relative Humidity Range
RoHS	Restriction of Hazardous Substances
SAT	Supply Air Temperature
SDG	Sustainable Development Goals
SLA	Service Level Agreement
STS	Static Transfer Systems
TCO	Total Cost of Ownership
ULF	UPS Load Factor
UPS	Uninterruptible Power Supply
USE	UPS System Efficiency
VESDA	Very Early Smoke Detection Apparatus
VRLA	Valve-Regulated Lead-Acid
VSD	Variable Speed Drives
VSS	Video Surveillance System

4. Terms and definitions

For the purposes of this Technical Code, the following terms and definitions apply.

4.1 Concurrent maintainability

The ability of a data centre to undergo scheduled maintenance on any single component or distribution path without impacting critical IT operations is achieved through redundant capacity components and multiple independent distribution paths.

4.2 Energy Management System (EnMS)

A systematic framework to manage and continuously improve energy performance within an organisation.

4.3 Environmental, Social, and Governance (ESG)

Factors used to evaluate the sustainability and ethical practices of a company or organisation.

4.4 Fault tolerant

The ability of a data centre to withstand any single failure of a component or distribution path without impacting operations, is achieved through multiple, independent, and physically isolated systems with redundant capacity components and diverse distribution paths.

4.5 Measurements

Measurements are indicators of a system's performance that can be observed, individually or jointly, while executing scenarios. These are directly measurable and can be collected automatically.

4.6 Outages

Periods of time when a system or service is unavailable due to planned maintenance or unexpected disruptions.

4.7 Power Usage Effectiveness (PUE)

A metric measuring the annual average total energy used by a data centre divided by the annual average energy used by Information Technology (IT) equipment.

4.8 Redundancy

The inclusion of multiple or additional critical components or systems to ensure continued operation in the event of a single failure.

4.9 Relative Humidity Range (RHR)

A measurement that covers the range of the IT equipment inlet air humidity set points.

4.10 Supply Air Temperature (SAT)

The temperature of the air being delivered to the IT equipment in a data centre.

4.11 Sustainable Development Goals (SDG)

A comprehensive set of global goals established by the United Nations to address environmental, social, and economic challenges.

4.12 Tier level ratings

A classification system established to categorise data centre reliability and availability.

4.13 Uninterruptible Power Supply (UPS) System Efficiency (USE)

A metric that measures the efficiency of an Uninterruptible Power Supply (UPS) system. It is calculated as the ratio of the output power from the UPS to the input power. A higher USE percentage indicates a more efficient UPS system with less energy lost to internal operating components.

4.14 Uptime availability

The percentage of time a system or service is operational and available for use.

5. Overview of green data centres

Green data centres prioritise sustainability from the outset, beginning with strategic site selection. Ideal locations offer access to renewable energy sources and climatic conditions conducive to natural cooling. Thorough risk assessments for natural hazards (e.g., flooding, seismic activity) and long-term security considerations are integral to site selection. Building design emphasises energy efficiency through factors like orientation, insulation, and the potential for natural ventilation and daylight utilisation. The core infrastructure, encompassing power and cooling systems, is optimised for maximum efficiency. This includes high-efficiency UPS systems, strategic power distribution, and the prioritisation of free air cooling whenever feasible. Green data centres integrate renewable energy sources, such as on-site solar or wind power, or procure energy from clean energy providers to reduce reliance on traditional grid power and minimise their carbon footprint. Operational and maintenance practices focus on continuous monitoring, proactive maintenance, virtualisation, and ongoing optimisation to ensure the data centre consistently meets its energy efficiency and sustainability targets.

Figure 1 provides a clear overview of the green data centre's key components, complementing the description above.

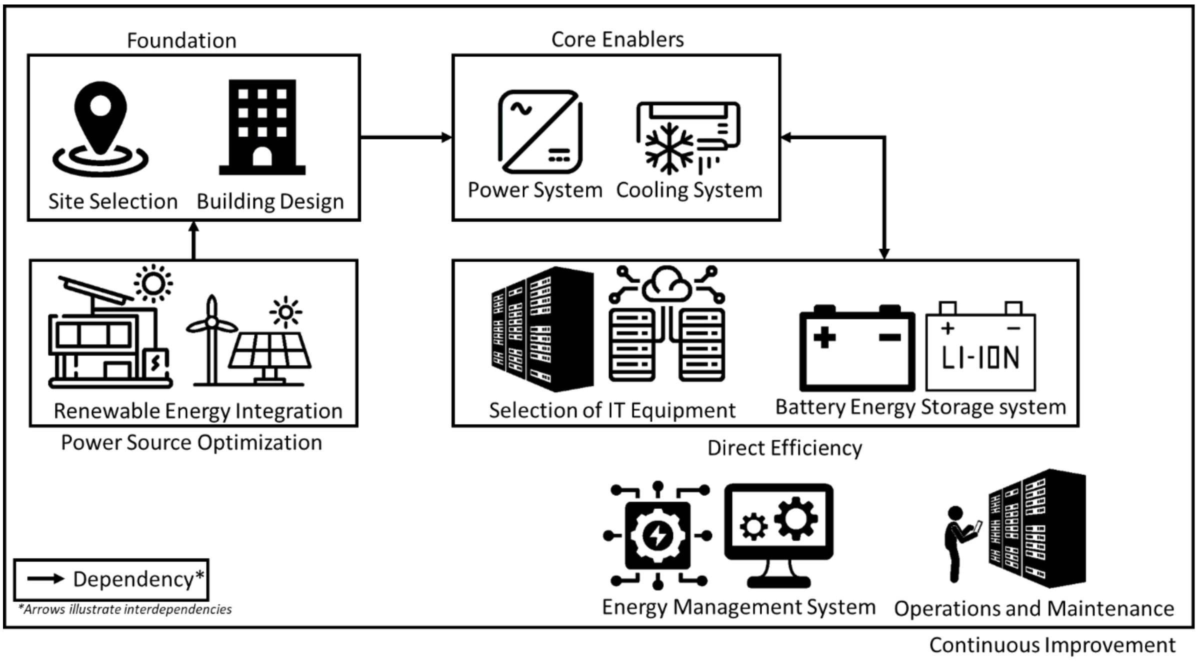

Figure 1. Overview of green data centre key components

To achieve green data centre status, the selection of power systems, cooling strategies, renewable energy integration, battery energy storage, high-efficiency equipment, and energy monitoring systems must align with the requirements and expectations of the targeted reliability tier, as defined by relevant industry standards or frameworks. This alignment ensures that the data centre maintains the desired level of reliability and availability while prioritising energy efficiency and sustainable practices.

Data centre reliability can be classified using tiered frameworks. Table 1 below provides an example tier level rating for data centre reliability.

Table 1. Example of tier level ratings for data centre reliability

Tier level	Description	Expected availability
Tier I	Basic infrastructure with limited redundancy	99.671%
Tier II	Infrastructure with some redundancy components	99.741%
Tier III	Concurrently maintainable infrastructure	99.982%
Tier IV	Fully fault-tolerant infrastructure designed to withstand individual equipment failures and distribution path outages	99.995%

Several energy-efficient technologies and best practices recommended within this Technical Code can support the goals of various reliability frameworks. Careful consideration of the desired level of reliability is crucial when evaluating and implementing these recommendations to optimise a data centre's energy performance.

The examples of how reliability frameworks influence recommendations are as follows:

a) For Tier II (or equivalent) and above

   High-efficiency UPS systems and Power Distribution Units (PDUs) are essential to minimise power losses, increase overall efficiency, and ensure reliable power delivery to critical equipment.

b) For Tier III (or equivalent) and IV

   Redundant power and cooling distribution paths are vital for enabling concurrent maintenance and fault tolerance, ensuring uninterrupted operation even during maintenance or component failures.

c) For all tiers

   i) Integrating renewable energy (solar, wind) and battery storage aligns with green data centre goals and can enhance reliability by providing backup power sources during grid outages.

   ii) Robust energy monitoring systems are critical for tracking PUE, identifying optimisation opportunities, and detecting anomalies that could indicate potential reliability issues. The granularity and capabilities of these systems will scale with the desired tier level.

Green data centres are designed and operated to minimise their environmental impact. They incorporate sustainable practices and technologies to reduce energy consumption, water usage, and carbon emissions. The centres employ a range of technologies to minimise their environmental impact.

Annex A provides examples of green data centre technologies and their applications in Malaysia.

6. Minimum requirements

6.1 Power Usage Effectiveness (PUE)

Power Usage Effectiveness (PUE) is a metric used to measure the energy efficiency of a data centre. It is calculated as the ratio of the total annualised energy consumed by the data centre (including all supporting infrastructure) to the annualised energy consumed by the IT equipment. There are 3 types of PUE categories as defined in EN 50600-4-2:2016/A1 as follows:

a) PUE0**:** This includes all energy consumed within the data centre site boundary.

b) PUE1**:** This is the most common category and is measured at the UPS output.

c) PUE2**:** This is measured at the PDU output and is the category described in this document.

PUE is calculated using the following formula:

$$PUE = \frac{E_{DC}}{E_{IT}}$$

where:

E_{DC} = total annualised data centre energy consumption in kWh.

E_{IT} = total annualised IT equipment energy consumption in kWh.

PUE measurement should consider the following elements.

a) The total data centre energy (E_{DC}) includes all energy used by IT equipment, power delivery components (UPS, PDUs, etc.), cooling systems, and other miscellaneous loads (lighting, etc.).

b) The IT equipment energy (E_{IT}) includes the energy used by servers, storage, network equipment, and any supplemental equipment directly supporting IT operations.

c) Energy measurements should be taken at the utility service entrance after the high-tension (HT) transformer and at the output of the PDUs.

d) For new data centres, a grace period may be allowed to stabilise loads and gather the required data for an accurate annualised PUE calculation.

The following Table 2 denotes the classification of the derived PUE measurement.

Table 2. Classification of the derived PUE measurement

Normal Data Centre		Green Data Centre	
Not efficient	**Efficient**	**Most efficient (Targeted PUE)**	**Exemplary**
1.9	Less than 1.9 and more than 1.5	Less than 1.5 and more than 1.2	Less than or equal to 1.2

Data centres with a PUE of 1.2 or lower will be recognised as having achieved "Exemplary" energy efficiency. To be considered a green data centre, a PUE of 1.5 or lower shall be achieved.

To qualify for the green data centre designation, facilities should strongly consider the following best practices known for their significant impact on energy efficiency.

a) Energy-efficient IT equipment

   Select servers, storage and networking devices with proven energy efficiency certifications (e.g., ENERGY STAR). Implement power management features and right-size equipment to match workloads, reducing idle power consumption. Data centre operators should, to the extent possible, encourage the deployment of energy-efficient equipment by customers.

b) Optimised cooling systems

   Prioritise free air cooling (direct or indirect) wherever feasible. For high-density environments, consider liquid cooling solutions, such as direct liquid cooling or immersion technology, as these offer superior heat transfer efficiency.

c) Explore on-site renewable energy resources (solar, wind, geothermal or energy storage)

   Explore on-site renewable energy sources (solar, wind or geothermal) or procurement agreements with clean energy providers. Integrate energy storage (batteries or thermal storage) to smooth renewable variability and reduce reliance on traditional grid power.

d) Data centre monitoring and management

   In the case of data centre builds, implement robust monitoring systems that track energy use, PUE, and other key performance indicators. Utilise collected data to identify optimisation opportunities, proactively address potential inefficiencies, and drive continuous improvement in power utilisation.

6.2 Supply Air Temperature (SAT)

Supply Air Temperature (SAT) is a measurement that represents the airflow weighted average in the data centre. A low SAT indicates the potential for improving a data centre’s air management and increasing the SAT. Higher SATs allow HVAC cooling systems to operate more efficiently. The metric is derived by measurement at measuring aisle temperature at 1.5 m above the floor at the rack level, establish at least one point for every 3 m to 6 m of the aisle or every fourth rack position.

Recommendations for efficient Heating, Ventilation and Air Conditioning (HVAC) and cooling are as follows.

a) Data centre HVAC systems should adopt variable frequency water chillers or magnetic levitation water chillers, which offer superior efficiency compared to traditional water chillers.

b) Fan walls are recommended as terminal air conditioners, as they enable a higher temperature difference between supply and return chilled water, prolonging natural cooling and reducing pump power consumption.

c) Cold or hot aisle containment should be implemented to isolate airflows, preventing cooling capacity loss, and improving overall energy efficiency.

d) Water pumps should utilise high-efficiency motors and feature variable frequency drives to continuously adjust operation based on load changes.

e) The water system design should adopt a temperature difference between the water inlet and outlet in accordance with ASHRAE TC 9.9 guidelines.

For SAT temperature adjustment, it is recommended to consult ASHRAE TC 9.9 guidelines, which recognise the potential for energy savings with higher SATs.

6.3 Water Usage Effectiveness (WUE)

Water Usage Effectiveness (WUE) is a Key Performance Indicator (KPI) used to quantify the water consumption of a data centre. It is calculated as the ratio of annual water usage to the annual energy consumption of IT equipment. A lower WUE indicates more efficient water usage.

To achieve a lower WUE, data centres should consider the following best practices.

a) Reduce water consumption.

   Implement water-efficient cooling technologies, such as air-cooled chillers, adiabatic cooling, or liquid cooling with minimal water usage.

b) Reuse water.

   Explore opportunities to reuse water within the data centre, such as using treated wastewater for cooling towers or irrigation.

c) Monitor water usage.

   Track water consumption regularly to identify areas for improvement and optimise water usage efficiency.

d) Consider water availability.

   When selecting a data centre site, assess the availability and quality of water resources to ensure sustainable water usage.

For further guidance on measuring and reporting WUE, refer to ISO/IEC 30134-9.

6.4 Carbon Usage Effectiveness (CUE)

Carbon Usage Effectiveness (CUE) is a KPI used to quantify the carbon emissions of a data centre. It is calculated as the ratio of the data centre's annual CO_2 emissions to the annual energy consumption of IT equipment. A lower CUE indicates lower carbon emissions per unit of energy consumed.

To achieve a lower CUE, data centres should consider the following best practices:

a) Increase renewable energy usage.

   Prioritise the use of renewable energy sources, such as solar, wind, or hydropower, to reduce reliance on fossil fuels and lower carbon emissions.

b) Improve energy efficiency.

   Implement energy-efficient technologies and practices throughout the data centre, including IT equipment, cooling systems, and power distribution.

c) Optimise IT workload.

   Optimise IT workloads to minimise energy consumption and reduce associated carbon emissions.

d) Track and report carbon emissions.

   Regularly track and report carbon emissions to identify areas for improvement and demonstrate progress towards sustainability goals.

For further guidance on measuring and reporting CUE, refer to ISO/IEC 30134-8.

6.5 Relative Humidity Range (RHR)

Maintaining appropriate relative humidity levels within a data centre is crucial for ensuring the reliable operation of IT equipment and preventing issues like static electricity discharge. The recommended RHR should align with the manufacturer's specifications for the IT equipment in use.

For further guidance on managing relative humidity in data centres, refer to ASHRAE TC 9.9 guidelines.

6.6 UPS System Efficiency (USE)

The USE metric is the ratio of the UPS output power to the UPS input power. The UPS efficiency varies depending on its load factor. USE is derived by dividing UPS output power (kW) by UPS input power (kW) and then multiplying by 100.
The measurement equation is:

$$USE = \frac{UPS\ output\ power\ (kW)}{UPS\ input\ power\ (kW)} \times 100$$

The UPS efficiency varies depending on its load factor and therefore the benchmark for this metric depends on the UPS Load Factor (ULF) of the UPS system. The ULF metric is the ratio of the peak load of the UPS to the design value of its capacity. This provides a measure of the UPS system over-sizing and redundancy. The measurement is derived by dividing UPS average load (kW) by UPS peak load capacity (kW).

The efficiency targets and recommendations are as follows:

a) For new and reconstructed data centres, UPS systems with double conversion efficiency exceeding 96% are essential for maximising energy savings. This recommendation reflects the evolving landscape of data centre technology and prioritises efficient power management. Note that existing data centres may have lower USE levels due to older equipment, but upgrades to higher efficiency systems should be considered when feasible.

b) To optimise efficiency, UPS systems should support energy-saving operation modes (often referred to as "ECO mode"). These modes can achieve efficiencies of 99% or higher.

c) Hot-swappable critical components (power module, bypass module, control unit, communication cards, etc.) are recommended to minimise downtime during maintenance and mitigate the risk of severe operation breakdowns.

Considerations for ECO mode (or other energy-saving modes) are as follows:

a) When possible, select UPS systems that support active harmonic compensation during energy-saving modes to ensure compatibility with power grid requirements.

b) Prioritise UPS systems offering seamless transitions (0ms transfer time) between energy-saving and double conversion modes for maximum reliability.

6.7 Renewable energy integration

To effectively address rising energy costs and reduce carbon emissions, data centres should actively integrate renewable energy sources into their power strategies. Key technologies include:

a) New renewable energies include fuel cells and hydrogen energy, which are based on new physical power and new substances.

b) Renewable energies include solar thermal energy, solar photovoltaic energy, biomass, wind power, tidal power, hydropower and geothermal power generation.

Data centres can calculate the efficiency of various renewable energy power equipment using the following formulas. These methods and concepts are outlined in clause 9.1.10 of ITU-T L.1300 and clauses 5, 5.1, 5.1.3, and 5.1.3.3 of ITU-T L.1320.

6.7.1 Renewable energy deployment strategies

Innovative approaches to integrating renewable energy technologies into the building design itself offer both energy-saving and aesthetic benefits. Two prominent strategies are:

a) Building-Integrated Photovoltaics (BIPV).

   BIPV seamlessly integrates Photovoltaics (PV) modules into the building envelope, serving as both a power source and a functional building element (e.g., shading, insulation). BIPV can significantly contribute to reducing a data centre's carbon footprint.

b) Rooftop solar.

   On data centre campuses, deploying PV arrays on rooftops offers a practical way to utilize solar energy. While solar energy generation may not offset the data centre's entire energy demand, it provides a valuable supplement to traditional power sources.

6.7.2 Recommendations for PV systems

When designing and implementing PV systems for data centres, these best practices will maximise efficiency and reliability.

a) High-efficiency components

   Prioritise high-efficiency photovoltaic panels and string inverters (98.50% efficiency or higher) for maximum energy yield and reduced carbon emissions.

b) Fault tolerance

   PV systems should be designed with fault isolation mechanisms to ensure continuous operation of unaffected modules when failures occur.

c) Maximum Power Point Tracking (MPPT)

   String inverters must incorporate real-time MPPT functionality to optimise energy efficiency under varying solar conditions.

6.7.3 Renewable energy procurement

Data centres should demonstrate a commitment to renewable energy by implementing one or more of the following strategies.

a) On-site renewable energy generation, with environmental attributes retained, e.g., Renewable Energy Certificates (RECs).

b) Off-site renewable electricity produced by a generation asset(s) built within the last five years or contracted to be operational within two years of building occupancy. For a one-time purchase and delivery of renewable energy credits exceeding 100% of the project's annual electricity use, a recognised third-party certification is required.

c) Off-site renewable electricity that is certified by a recognised third-party organisation or captured bio-methane.

6.8 Modular Data Centre (MDC)

Modular Data Centres (MDCs) employ a highly integrated modular design, incorporating power distribution, cooling, enclosures, wiring, and monitoring into self-contained units. This design isolates hot and cold airflows, preventing cooling loss and enabling precision cooling. MDCs offer a flexible and scalable approach to data centre infrastructure deployment. By utilising pre-engineered and prefabricated components, MDCs can be rapidly deployed and easily expanded to meet evolving capacity demands. MDCs come in various forms, including indoor and outdoor configurations, each with distinct advantages and considerations.

6.8.1 Indoor Modular Data Centre (IMDC)

Indoor Modular Data Centres (IMDCs) employ a highly integrated modular design, incorporating power distribution, cooling, enclosures, wiring, and monitoring into self-contained units. This design isolates hot and cold airflows, preventing cooling loss and enabling precision cooling. Figure 3 illustrates the traditional solutions and modular data centre.

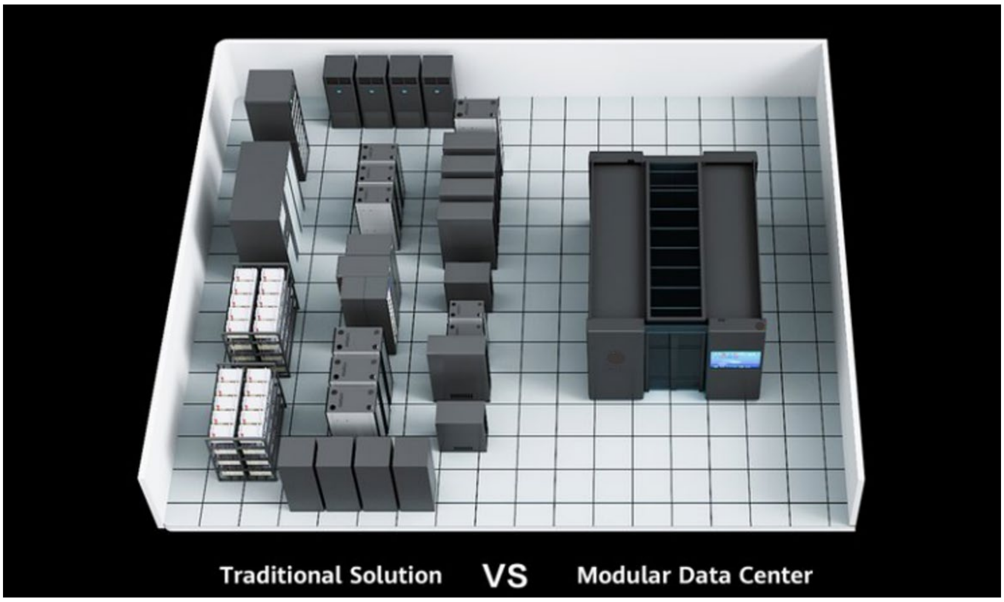

Figure 3. Traditional solution versus modular data centre

The recommended types of components for the modular data centre are listed in Table 3 below.

Table 3. Type of components for modular data centre

Type of components	List of components
Typical IMDC components	Containment structure (cabinets, ceiling, doors)
	Information And Communications Technology (ICT) equipment enclosures
	Electrical subsystem (including optional UPS)
	Intelligent or standard rack PDUs
	Grounding system
	Electrical and telecommunication pathways
	Mechanical subsystems (cooling, if needed)
	Interior lighting
	Fire detection and alarm system
	Monitoring system
Optional components	Flooring
	Static Transfer Systems (STS) switches (for single-corded equipment)
	Access control (e.g., biometric)
	Video Surveillance System (VSS)
	Fire suppression system
	Pressure relief damper (if fire suppression is present)
	Very Early Smoke Detection System (High Sensitivity Smoke Detection (HSSD), Very Early Smoke Detection Apparatus (VESDA), etc.)

6.8.2 Outdoor Modular Data Centre (OMDC)

Outdoor Modular Data Centres (OMDCs) leverage prefabrication techniques to integrate cabinets, power distribution, cooling, and monitoring systems within standardised container units. These units are assembled on-site, significantly accelerating deployment compared to traditional data centre construction. The details of OMDC are as follows.

a) Sustainability focus

OMDCs prioritise environmentally responsible practices by:

i) minimising construction waste; and

ii) utilising materials with low heavy metal content (e.g., lead, chromium).

b) Structural integrity

OMDC design is guided by rigorous structural simulations ensuring compliance with building standards and suitability for multi-layer stacking. This delivers a user experience comparable to conventional data centre buildings.

c) Environmental adaptability

OMDCs are engineered for deployment in diverse climates, withstanding temperatures ranging from -40°C to 55°C.

d) Deployment efficiency

OMDCs offer rapid deployment timelines, typically within 12 to 15 months. Design choices impact achievable PUE, and lifecycle carbon emissions are minimised.

e) Important considerations

Due to the prefabrication of both building and electromechanical components, flexibility for on-site adjustments is limited. Therefore, thorough equipment room layout planning is crucial during the design phase.

6.9 Resilience classifications

Data centres can align their resilience classification with relevant standards, which offer a structured approach to categorising data centres based on redundancy and fault tolerance. Common resilience classifications are described in Table 4 below.

Table 4. Common resilience classifications

Level	Category	Description
1	Basic minimal redundancy	Systems are vulnerable to disruptions. Equipment is N-Capacity without additional components. No redundancy in supply or return paths.
2	Equipment redundancy	N+1 capacity for electrical and mechanical equipment. Supply or return path redundancy is not always mandatory. Structured cabling is recommended (point-to-point allowed only between adjacent cabinets).
3	Concurrent maintainable	Maintenance can occur without dropping below N-Capacity. Redundant equipment and multiple supply or return paths (one active, one standby is typical). Structured cabling with non-crossing, dual-path routes to each ICT cabinet is recommended.
4	Fault tolerant	Can withstand a single fault (equipment or path) at any time without dropping below N-Capacity. Implies Concurrent Maintainability. Structured cabling with non-crossing, dual-path routes to each ICT cabinet is recommended.

6.10 Efficient battery selection and deployment

When selecting batteries for data centre applications, various technologies are available, each with its own advantages and considerations. 2 common options include the following technologies.

a) Lithium-ion Batteries (Li-ion)

Li-ion batteries offer high energy density, fast response times, and long cycle life, making them suitable for a wide range of data centre applications. However, their production and end-of-life disposal raise environmental concerns, prompting ongoing research and development to improve sustainability and recycling processes.

b) Valve-Regulated Lead-Acid (VRLA) batteries

Valve-Regulated Lead-Acid (VRLA) batteries are a mature and well-established technology with high recyclability rates. While they may have lower energy density compared to Li-ion batteries, they offer a cost-effective and reliable energy storage solution for many data centre scenarios.

Data centre operators should carefully evaluate the available battery options, considering factors such as capacity requirements, discharge duration, cost, environmental impact, and regulatory compliance. The European Union's new Battery Regulation (Regulation 2023/1542) introduces requirements for carbon footprint, recycled content, and end-of-life management for batteries, impacting both battery producers and end-users like data centre operators.

6.10.1 Lithium battery specifications

If lithium-ion batteries are employed within data centres, they shall adhere to Restriction of Hazardous Substances (RoHS) guidelines, excluding the 10 substances specified within the directive (lead, mercury, cadmium, etc.).

6.10.2 Lithium-ion battery safety

For enhanced safety, the following measures are recommended for lithium-ion batteries.

a) Battery composition

   Select lithium-ion batteries with olivine-like crystal structures. These offer superior stability, exhibiting high resistance to fire or explosion even under extreme stress conditions.

a) Fire mitigation

   Equip battery packs with dedicated fire extinguishing mechanisms, designed to integrate with room-level fire suppression systems for comprehensive protection.

b) Compartmentalisation

   Lithium-ion battery rooms should feature independent compartments to limit the impact of any potential fire events. Each compartment should have a capacity not exceeding 600 kWh. Battery rooms shall include a water spray fire protection system designed in accordance with NFPA 855.

c) Mandatory safety testing

   Employed lithium-ion batteries must have successfully undergone and passed the Thermal Runaway Fire Propagation Test as outlined in the UL 9540A standard.

7. Design and control

The organisation shall consider green data centre requirements improvement opportunities on energy-efficient and operational control in the design of new, modified, and renovated facilities, equipment, systems, space management, location and processes that can have a significant impact on its performance. The consideration will include the following principles:

a) Operational control

   The purchasing process that prioritises energy-efficient and environmentally friendly IT, electrical, and mechanical equipment.

b) The energy-efficient

   The design principles and the implementation of an effective Energy Management System (EnMS).

7.1 Purchasing

The organisation shall take into consideration the following criteria when purchasing IT equipment (hardware and software), electrical and mechanical equipment for the implementation and operation of the green data centre.

a) The organisation shall establish, implement, and maintain a procedure(s) to identify the environmental aspects.

b) The organisation shall determine those aspects that have or can have significant impact(s) on the environment (i.e., significant environmental aspects). The organisation shall document this information and keep it up-to-date.

c) The organisation shall establish and implement the criteria prior to the purchasing of the IT equipment (hardware and software), electrical and mechanical equipment which are expected to have a significant impact on the organisation's energy performance. The organisation shall define and document the purchasing specifications, as applicable, for effective green data centre implementation and operation.

7.2 Energy Management System (EnMS)

For effective energy management, the organisation shall:

a) establish, document, implement, maintain and improve EnMS in accordance with the requirements of ISO 50001.

b) define and document the scope and boundaries of its EnMS; and

c) determine how it will meet the requirements of ISO 50001 in order to achieve continual improvement of its energy performance and of its EnMS.

8. Monitoring

Effective monitoring of energy use, environmental parameters and system performance is crucial for sustained energy efficiency and green data centre operations.

8.1 Energy metering

The data centre shall install metering equipment capable of measuring the following parameters:

a) The total energy use of the data centre, including all power conditioning, distribution and cooling systems shall track the real-time energy consumption of various components within the data centre. The measured energy shall be separate from any non-data centre building loads.

b) The total energy delivered to ICT systems, including PDUs including other power feeds where non-UPS protected power is delivered to the racks.

c) All relevant data is regularly basic and analyse the data to identify trends and areas of inefficiency.

8.2 Energy reporting

The organisation shall consistently gather data and reports to ensure a comprehensive overview of energy usage towards continuous green developments, which include the following commitment.

a) Energy use of the ICT equipment (server, network, and storage) and environmental (temperature and humidity) data shall be reported on an annual basis.

b) Develop a standardised format for energy consumption reports, including key metrics such as total energy usage, energy intensity (energy per unit of computing workload), PUE and carbon footprint.

c) Ensure transparency in reporting by sharing energy performance data with clients, stakeholders, and regulatory bodies as required.

8.3 Automation for energy-saving

Data centres can significantly improve energy efficiency by implementing automation solutions. These systems analyse complex data, optimise operations and drive continuous improvement of the following key focus area.

a) Intelligent control

   Automation optimises settings for power distribution, cooling and other systems based on factors like IT load and environmental conditions. Algorithms, including Artificial Intelligence (AI)-based models, may be used for these calculations.

b) Predictive optimisation

   Some automation solutions, especially those incorporating AI, build predictive models (including PUE). This enables proactive adjustments for maximum efficiency.

c) Continuous improvement

   Automation systems, particularly those using AI, analyse performance and refine strategies over time, leading to ongoing energy savings.

d) Potential benefits

   Extensive deployment of automation technologies can significantly reduce PUE. For water-cooled chilled water systems, reductions of 8 % to 15 % are achievable.

9. Training and awareness

The organisation shall ensure that all employees involved in green data centre implementation and operation possess the necessary capabilities to effectively manage these activities. This includes having the relevant training, skills, or experience. The organisation must identify and provide training related to green data centre management, covering both technical aspects and energy management and efficiency to promote understanding of sustainable practices. Appropriate records must be maintained.

The organisation shall communicate and ensure that relevant employees are aware of:

a) The importance of understanding green data centre practices.

b) Their roles in achieving green data centre goals.

c) The benefits of green data centres.

d) The environmental impact of their actions and their role in achieving green data centre objectives.

10. Optimising data centre infrastructure and operations

The organisation should emulate the recommended best practices detailed in Annex B which outlines recommendations for various components within a data centre, comprising of civil and structural, mechanical, electrical, IT, monitoring and control, and certification program considerations.

Annex A
(informative)

Examples of Green Data Centre technologies and its applications in Malaysia

Table A.1 outlines key green data centre technologies used in Malaysia, highlighting their features and areas of application across various sectors.

Table A.1. Examples of green data centre technologies and its applications

No	Technology	Description	Reference	Application
1	Water-cooled/Air-cooled/Liquid-cooled Precision A/C unit	These cooling solutions could be used to cool large server rooms or high-performance computing clusters in a hyperscale data centre, maximising energy efficiency and preventing overheating.	see 6.2 (Supply Air Temperature)	Hyperscale Cloud Services
2	Integrated Power Supply with Solar Energy	Integrating solar panels or procuring renewable energy to supplement traditional power sources, reducing reliance on fossil fuels and lowering carbon emissions.	see 6.7 (Renewable energy integration)	E-commerce Platform
3	Edge Data Centre Containment System	A specialised enclosure designed to optimise airflow and cooling efficiency within an edge data centre, minimising energy consumption.	see 6.8 (Modular Data Centre)	Traffic Management Systems
4	Modular UPS with Lithium Battery	A modular UPS system utilising lithium-ion batteries for efficient and reliable power backup, ensuring continuous operation in case of grid outages.	see 6.10 (Efficient battery selection and deployment)	Financial Data Processing
5	Centralised Monitoring System	A comprehensive monitoring system that provides real-time visibility into various data centre parameters, enabling proactive management and rapid response to potential issues.	Clause 8 (Monitoring)	Government Emergency Response Centre

Annex B
(informative)

Optimising data centre infrastructure and operations

B.1 Key components consideration

Table B.1 outlines recommendations for optimising the civil and structural aspects of data centres to ensure efficient space utilisation, building design, operational resilience, lighting, and fire suppression.

Table B.1. Civil and structure

Recommendation	Description
CS1. Internal space management within data centre	Provisioning of space based on actual utilised data centre white space (with power and cooling) and not reserved space
	Implement phased approach in capacity provisioning (on a demand basis)
CS2. External data centre building	Building facility: Data centre building in accordance with sustainability standards in terms of reduce, reuse, recycling, land or environmental impact and consumption of natural resources in the design and build process
CS3. Operational resilience	Centralised view of resilience across all Mechanical and Electrical (M&E) and IT components including an understanding of all upstream and downstream relationships
	Matching data centre resilience to Service Level Agreement (SLA) between operations and business units
CS4.Lighting	Reduce the energy consumption of lighting equipment
	Utilise occupancy sensors and where lighting technologies are installed use components with lower energy consumption, greater quality of light, longer lifespan and from recyclable components
CS5.Fire suppression	Utilise an eco-friendly and sustainable fire suppression gas

Table B.2 outlines recommendations for optimising the mechanical infrastructure within data centres to enhance airflow efficiency, energy consumption, and overall performance.

Table B.2. Mechanical

Recommendation	Description
M1. Air flow	Implement hot and cold aisle layout
	Implement containment or enclosures
	Install blanking panels
	Deploy optimally placed diffusers
	Deploy structured cabling.
	Install floor grommets
M2. HVAC	Server inlet temperature adjustments based on ASHRAE guidelines
	Humidity adjustments based on ASHRAE guidelines
	Deploy Computer Room Air Conditioning (CRAC) or Computer Room Air Handling (CRAH) with Variable Speed Drives (VSD) or Electronically Commutated (EC) fans
	Utilise an eco-friendly and sustainable refrigerant

Table B.3 outlines recommendations for optimising electrical infrastructure to enhance energy efficiency, reliability, and sustainability within data centres. It focuses on scalable power systems, battery recycling, rack alignment, real-time monitoring and control, backup power alternatives, and high-efficiency UPS systems.

Table B.3. Electrical

Recommendation	Description
E1. Energy management	Scalable power infrastructure (modularity)
	Document and participate in the recycling plans for batteries and other consumables
	Align racks depending on power density
	Use monitoring software data and other tools to implement real- time changes (phase balancing, load changes, etc)
	An alternative method of backup power for the data centre based on Total Cost of Ownership (TCO), environmental and sustainability considerations
	Utilise high efficiency UPS

Table B.4 outlines recommendations for optimising IT equipment and practices to enhance energy efficiency, reduce waste, and promote sustainability within data centres.

Table B.4. Information Technology (IT)

Recommendation	Description
IT1. ICT equipment consolidation	Implement server virtualisation
	Decommissioning of unused servers
	Consolidation of lightly utilised servers
	Better management of data storage
IT2. Green procurement	Procure assets that comply with reducing hazardous substances and are recyclable
	Procure energy- efficient equipment that comply with Energy Star or similar standards and metrics
	TCO modelling includes power consumption of the component at the expected or actual utilisation levels
	Cradle to cradle lifecycle view on all M&E and IT equipment - looking at embedded carbon, ease of recycling of the product, etc.
IT3. IT equipment lifecycle extension	Hardware refresh policy set based on TCO model including typical operating cost, capital cost, depreciation costs and value of new technology
	Decommissioning servers based on computing characteristics (e.g., Central Processing Unit (CPU) utilisation, Memory I/O)
	Optimise server configuration based on resource usage
IT4. E-Waste	Reuse policy for assets across the organisation
	E-waste vendor in place to deal with all data centres equipment aligned to local or national mandatory regulations
	E-Waste strategy in place to promote reselling, recycling, donating and disposal of IT assets based on cost, legislation, ethical and sustainable implications across all data centres

Table B.4. Information Technology (IT) *(continued)*

Recommendation	Description
IT4. E-Waste *(continued)*	Supplier and supply chain evaluated for waste management and environmental protection practices
	Supplier and supply chain waste and environmental compliance programs are included as part of procurement/sourcing decision process

Table B.5 outlines recommendations for centralised and automated monitoring systems to ensure optimal performance, energy efficiency, and sustainability in data centres.

Table B.5. Monitoring and Control

Recommendation	Description
MC1. Monitoring and control	Centralised and automated monitoring system inclusive of all mechanical, electrical and facility systems
	Holistic monitoring capability across the data centre - from the source of power to chip performance
	PUE Level measured, plan and actions in place for improvements
	Automated analysis or reporting of data to identify energy-saving opportunities
	IT and facilities collaboration on unified energy efficiency goals

B.2 Certification program consideration

Certification programs often provide structured guidance on applicable environmental regulations and evolving best practices. The certification process itself, including audits and performance assessments, can aid the organisation in proactively identifying potential areas of non-conformity and driving continuous improvement. Additionally, achieving certification provides clear documentation of sustainability and efficiency initiatives, supporting internal record-keeping requirements and enhancing compliance efforts.

Green data centre certification can offer a range of benefits, including enhanced competitiveness, reduced energy costs, regulatory compliance, and improved reputation. It also promotes sustainable practices and energy efficiency.

Table B.6 below outlines a 3-certification level, serving as a guide for data centres to strive towards industry-leading best practices in sustainability. It outlines different stages of a data centre's green transformation.

Table B.6. Level of green data centre certification

Certification Level	Focus	Criteria
Level 1: Certified energy efficient	Significant energy efficiency improvements	a) PUE of 1.5 or lower b) Implementation of recognised energy-saving technologies. c) Documented energy reduction policies.
Level 2: Certified green leader	Exemplary energy efficiency and sustainable practices	a) PUE of 1.3 or lower b) Integration of renewable energy (target of at least 20 % on-site or clean energy procurement) c) Implementation of water-efficient cooling or operations

Table B.6. Level of green data centre certification *(continued)*

Certification Level	Focus	Criteria
Level 2: Certified green leader *(continued)*		d) Responsible waste management practices (target of at least 50 % waste diversion from landfill)
Level 3: Certified net-zero champions	Near complete green energy reliance and minimal impact	a) PUE of 1.1 or lower b) Significant on-site renewable energy or clean energy procurement (target of at least 75 %) c) Innovative resource conservation initiatives (e.g., advanced water recycling) d) Zero-waste initiatives (target of at least 90 % waste diversion from landfill)

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