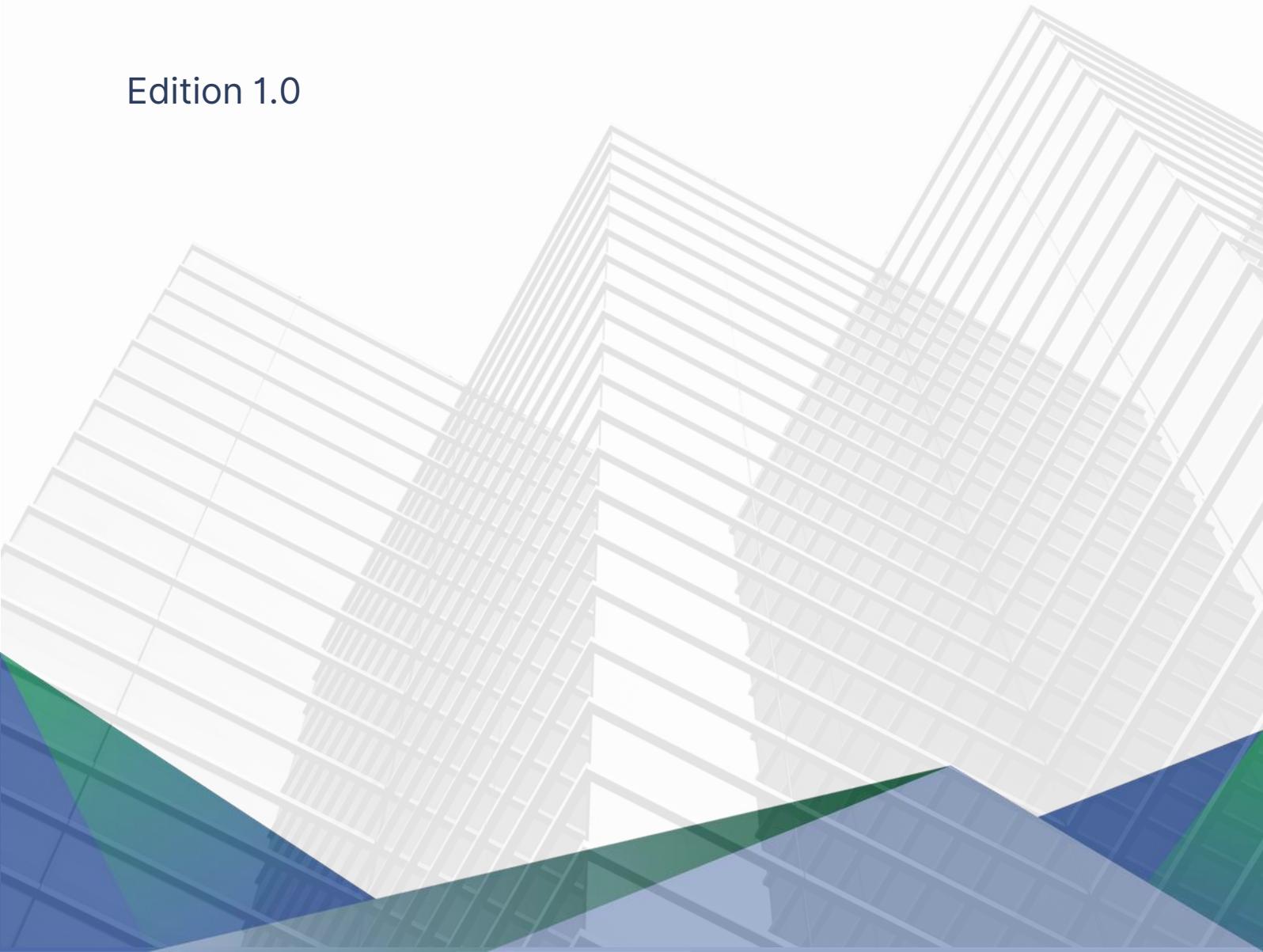


CODE ON

MANDATORY ENERGY IMPROVEMENT

FOR EXISTING BUILDINGS

Edition 1.0



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CODE ON
**MANDATORY ENERGY
IMPROVEMENT FOR
EXISTING BUILDINGS**

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Contents

The Code on Mandatory Energy Improvement for Existing Buildings, Edition 1.0
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INTRODUCTION	1
1 SCOPE	2
2 DEFINITIONS	2
3 STATUTORY REQUIREMENTS	3
3.1 Act and Regulations.....	3
3.2 Reference Codes and Standards.....	3
3.3 Responsibility.....	3
3.4 Specified Reduction in Energy Use Intensity (EUI).....	5
4 EUI CALCULATION AND EUI THRESHOLD	5
4.1 Methodology in calculating the Building’s Energy Use Intensity (EUI)	5
4.2 Energy Use Intensity (EUI) Threshold	5
5 ENERGY AUDIT METHODOLOGY	6
5.1 General.....	6
5.2 Building Level Assessment	7
5.3 System Level Assessment	8
5.4 Audit Findings and Assessment	10
5.5 Energy Efficiency Improvement Plan (EEIP)	11
6 SUBMISSION REQUIREMENTS AND PROCEDURES	11
6.1 General.....	11
6.2 Submission Process and Documentation.....	11
7 REGISTRATION OF ENERGY AUDITOR	13
7.1 Eligibility Criteria.....	13
ANNEX A – Energy Use Intensity (EUI) Threshold	15
ANNEX B – Audit Report and Energy Efficiency Improvement Plan with Appendices	17

INTRODUCTION

Buildings account for over 20% of Singapore's carbon emissions, making them a key focus in our transition towards a low-carbon, climate-resilient built environment. Over the years, the approach to enhancing building energy performance has been centred on progressive performance-based standards, complemented by ongoing improvements in building system efficiency. Considerable adoption of energy-efficient systems and technologies has been achieved through this approach, particularly in new building developments and existing buildings undergoing major retrofits.

However, there is no requirement for owners to improve their building energy performance if they do not undertake any major retrofit or energy use changes. Given the urgency of climate change and Singapore's carbon reduction targets, a new regulatory framework known as the Mandatory Energy Improvement ("**MEI**") Regime has been introduced through amendments to the Building Control Act ("**Act**") in Sep 2024. The MEI regime targets existing buildings that are energy intensive and imposes requirements to reduce energy consumption.

Under this regime, the owner of an energy-intensive building will be required to (i) engage a professional to carry out an energy audit of the building's energy-consuming system and submit an audit report and energy efficiency improvement plan ("**EEIP**"), (ii) implement energy efficiency improvement measures to reduce the building's energy usage intensity by 10% and (iii) maintain this improved energy performance for a period of one year. The detailed requirements can be found in Part 3B of the Act and the Building Control (Environmental Sustainability Measures for Existing Buildings) Regulations 2013 ("**ESM Regulations 2013**").

This Code titled 'Code on Mandatory Energy Improvement for Existing Buildings (referred to as "**MEI Code**")' is referenced in the ESM Regulations 2013 for compliance. It sets out the detailed requirements for building energy audits, with a focus on cooling and other high energy consumption systems. It also outlines the requirements for EEIP and defines the submission procedures.

This Code is not intended to address safety, health, environmental or related requirements contained in other applicable laws, codes or policies administered by relevant authorities.

If you need clarification on any aspect of this Code, please contact the BCA.

1 SCOPE

The MEI regime shall apply to an energy-intensive building with a gross floor area of at least 5000 m² and an energy use intensity (“EUI”) that is above the prescribed EUI threshold for three consecutive years prior to the year of notice.

The regime does not apply to buildings that are solely used as data centres, railway premises, airport service and facilities, port services and facilities, general industrial buildings, light industrial buildings, religious buildings, residential building, special industrial buildings and utility buildings. For details, please refer to Regulation 2B of the ESM Regulations 2013.

This Code elaborates on the requirements in Part 3B of the Act and the ESM Regulations 2013. In particular, this Code :

- (a) sets out the methodology for calculating the annual building energy consumption and energy use intensity (“EUI”) of a building;
- (b) stipulates the prescribed manner to carry out an audit on the energy use of buildings and systems;
- (c) specifies the manner in which an energy audit is to be carried out to determine the energy efficiency standard of building’s cooling system during operation; and
- (d) spells out the submission procedures as well as the qualifications and experience required for registration or renewal of registration as an energy auditor.

2 DEFINITIONS

For the purpose of this Code, the following definitions shall apply:

Building Cooling System	A cooling system installed in a building to provide comfort cooling to the space, which may include chilled water systems with their associated air distribution systems (inclusive of air-handling systems), variable refrigerant flow (VRF) systems, split systems, packaged air-conditioning units, or other cooling technologies.
Chilled Water Plant/System	A centralised air conditioning system that makes use of chilled water as the medium for removing the heat from the buildings. It includes chillers and ancillary equipment such as pumps and cooling towers, where applicable.
Major energy use change	The installation, substantial alteration or replacement of building cooling system as defined in section 22FA of BC Act.
Operating System Efficiency (OSE)	The measured system efficiency of the chilled water plant or condenser unit and air distribution system.
Qualified Professional	A person who is registered under the Professional Engineers Act 1991 in the branch of mechanical engineering and who has in force a practicing certificate issued under that Act (referred to as PE (Mech)), or a person registered with BCA as an energy auditor and who has in force a practicing certificate issued under the Act (referred to as EA).

Specified Individual	A qualified professional appointed to carry out an energy audit under section 22FL of the Building Control Act.
Total System Efficiency (TSE)	It is a measure of how efficiently the building cooling system would function to meet the operating condition and requirements in providing an acceptable indoor thermal environment.
Unitary Air Conditioning System	A factory-made assembly that typically comprising an evaporator or cooling coil and a compressor-condenser combination in a single package or split configuration, designed to condition and deliver air to the space being served.

In instances where terms are not expressly stated in this Code and are defined in other referenced documents, such terms shall have the meanings as determined in those documents.

3 STATUTORY REQUIREMENTS

3.1 Act and Regulations

The following Act and Regulations have relevance:

- (a) Building Control Act
- (b) Building Control (Environmental Sustainability Measures for Existing Buildings) Regulations

3.2 Reference Codes and Standards

The following codes and standards have relevance:

- (a) Code on Environmental Sustainability Measures for Existing Buildings
- (b) SS 530 : Code of Practice for Energy Efficiency Standard for Building Services and Equipment
- (c) SS 531-1 : Code of Practice for Lighting of Work Places - Indoor
- (d) SS 553 : Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings
- (e) SS 554 : Code of Practice for Indoor Air Quality for Air-Conditioning Buildings
- (f) SS 591 : Code of Practice for Long Term Measurement of Central Chilled Water System Energy Efficiency
- (g) ANSI/ASHRAE/ACCA Standard 211 : Standard for Commercial Building Energy Audits
- (h) Mandatory Energy Labelling Scheme and Minimum Energy Performance Standards (MEPS) for Air-Conditioners under the Energy Conservation Act

3.3 Responsibility

MEI Audit Notice Requirements

3.3.1 The building owner on whom an audit notice is served under section 22FL(1) of the Act must appoint a qualified professional to conduct an energy audit of the building and systems and prepare the energy efficiency improvement plan ("**EEIP**"). The appointed qualified professional (known as "**specified individual**" in ESM Regulations 2013) is responsible for preparing and signing both the

audit report and the EEIP. These documents must be submitted within 1 year from the date that the MEI audit notice is issued to the owner or within the period specified in the MEI audit notice.

3.3.2 The specified individual must carry out an energy audit of the building and its systems in accordance with the prescribed manner in this Code. Based on the audit findings, the specified individual must provide:

- (a) a recommendation on whether the building can meet the specified reduction in energy use intensity without undergoing a major energy use change;
- (b) an audit report of the results of the energy audit and energy efficiency improvement plan must be prepared and signed in the form and manner specified on the [BCA website](#); and
- (c) an energy efficiency improvement plan outlining proposed measures to meet the specified reduction in the building's energy use intensity. This plan may include energy efficiency retrofits involving major energy use change, where relevant.

Implementation of Energy Efficiency Improvement Measures

3.3.3. The building owner must implement the measures outlined in the EEIP within 3 years from the date of EEIP submission to the CBC. Upon completion, the building owner must submit a certificate of completion, prepared and signed by the specified individual confirming that all measures have been fully implemented according to the EEIP and the required reduction in energy use intensity has been achieved.

3.3.4 If any changes are made to the measures outlined in the submitted EEIP, the building owner must ensure that the specified individual amends the EEIP to indicate all departures and deviations and certifies that the amended EEIP will meet the required reduction in energy use intensity. The building owner must submit the amended EEIP within 60 days of initiating the changes, in the form and manner specified on the [BCA website](#). For the avoidance of doubt, all measures, including any amendments, must be implemented within the 3-year period unless an extension is granted.

Maintaining the Required Reduction in EUI

3.3.5 Following the implementation of energy efficiency improvement measures, the building owner must maintain the required reduction in EUI in relation to the building for a period of 1 year ("**maintenance period**") after the date that the certificate of completion is submitted to the CBC.

3.3.6 A maintenance report prepared and signed by a specified individual must be submitted within 3 months after the last day of the maintenance period and in the form and manner specified on the [BCA website](#).

3.3.7 The maintenance report must state the energy use intensity of the building during the maintenance period. If the required reduction in EUI is not maintained during such period, the report must contain additional measures to supplement the EEIP.

3.3.8 A written direction may be issued requiring the building owner to ensure that a specified individual prepares a supplemental report to the EEIP with additional measures to be implemented for the building. The building owner must implement these additional measures within the specified period. Following implementation, the building owner must submit a report, prepared and signed by the specified individual, confirming that the required reduction in EUI has been achieved and maintained.

3.4 Specified Reduction in Energy Use Intensity (EUI)

Under the MEI regime, the building owner is required to achieve a reduction of at least 10% in the building's Energy Use Intensity (EUI). This specified reduction is measured by comparing the building's EUI before and after implementation of energy efficiency improvement measures. For consistency, the building's EUI before implementation is taken as the average of its yearly EUI over the three-year period prior to the year of notice

4 EUI CALCULATION AND EUI THRESHOLD

4.1 Methodology in calculating the Building's Energy Use Intensity (EUI)

4.1.1 In the context of this regime, energy consumption calculations will focus on electricity, the primary energy source for most buildings. While buildings may use other energy sources, this framework is based on electrical energy use and the building's EUI will serve as the key energy performance indicator.

4.1.2 The annual energy consumption (in kWh/year) of a building is determined using energy use data from utility bills, energy management systems, and sub-metering over a typical 1-year period. It encompasses the total energy consumption from all activities and operations within the building, including tenant spaces and cooling provided by third-party cooling systems, without any normalisation.

4.1.3 The Gross Floor Area (GFA), a key parameter in calculating the EUI, is defined as the aggregate of the gross areas of all floor spaces that are prescribed in the Act and ESM Regulations 2013. It should be noted that this term holds the same meaning as 'floor area' in the Planning (Development Charges) Rules (Cap. 232).

4.1.4 The methodology in calculating the building's EUI is by dividing the annual energy consumption by the gross floor area, expressed in kilowatt-hours per square metre per year (kWh/m².yr). Building owners can use this metric to understand their building's energy performance relative to similar buildings, as published in the annual Building Energy Benchmarking Report (BEBR) on the [BCA website](#) and to track their building energy performance. The EUI value shows energy consumption per unit area. Buildings with higher EUI values compared to similar building types may have more opportunities for energy efficiency improvements. A higher EUI reflects greater energy use per unit area relative to other similar buildings, indicating potential opportunities for improving energy efficiency and reducing overall energy use.

4.2 Energy Use Intensity (EUI) Threshold

4.2.1 For the purpose of this regime, the threshold level of energy use intensity ("**EUI threshold**") for different building uses have been established and specified in the First Schedule of ESM regulations 2013. These thresholds are subject to periodic review and adjustment to reduce carbon emissions in line with national commitments.

4.2.2 For buildings with inherently high energy uses, such as those housing data centres or laboratories, the EUI threshold can be adjusted to account for these exceptionally high energy demands. For mixed-use buildings, the EUI threshold will be calculated as a weighted average, pro-rated according to the gross floor area percentage of each building use category. (See Annex A for more details).

5 ENERGY AUDIT METHODOLOGY

5.1 General

5.1.1 This section sets out the energy audit methodology comprising building and system level assessments of energy use, cooling system efficiency, and other prescribed high energy consumption systems. These assessments identify opportunities for energy efficiency improvements and provide some basis for developing the EEIP, as summarised in the following chart.

Energy Audit Requirements

01

Building Level Assessment

- Evaluation of overall energy use profiles and consumption of building and systems.
- Walkthrough surveys to assess building conditions, identify major energy-consuming systems, and review maintenance practices to determine areas for improvement.

02

System Level Assessment

- Technical evaluation of building cooling systems and other high energy consuming systems, where relevant.
- Measurement and verification of operating system efficiency and performance.
- Observations on control settings, operating schedules and maintenance conditions to identify specific opportunities for energy efficiency improvements.

03

Energy Efficiency Improvement Plan (EEIP)

- Feasibility study of energy efficiency measures identified.
- Cost and benefits analysis which include energy savings, implementation costs etc.
- Recommended measures to achieve the minimum required EUI reduction.

5.1.2 While adherence to these requirements ensures a consistent approach to assessing building energy performance and identifying improvement measures, the specified individual may enhance the audit process and coverage beyond the minimum requirements stipulated in this Code. To achieve better energy performance outcomes, building owners should work with their appointed specified individual to establish additional audit assessment scope, where relevant.

5.2 Building Level Assessment

Audit on Energy Use of Buildings and Systems

5.2.1 The objective of the audit on energy use of buildings and systems is to establish the energy profile and distribution, which is fundamental to identifying major energy uses and developing cost-effective measures to tackle areas of inefficiencies. To achieve this, the audit must include data collection and analysis to determine the building and system operational characteristics covering the following aspects, but not limited to:

- (a) Building owner's operations and systems:
 - (i) Owner/Landlord-operated systems and equipment and
 - (ii) Central services and shared facilities related to building services and operation.
- (b) Tenant operations:
 - (i) Energy consumption within leased spaces and
 - (ii) Where recommended, tenant-specific equipment and processes that are energy-intensive.

5.2.2 The scope of the audit must include the following areas, as applicable to the building:

- (a) Review of the historical energy consumption data for 3 consecutive years prior to the year of notice, which include the energy bills.
- (b) Walkthrough survey to visually inspect the building and major energy-consuming systems to identify areas of wastage and inefficiencies.
- (c) Data collection of the electricity use which can include gathering sub-metering data for major building systems and obtaining energy bills and records from both landlord and key tenants, where applicable. Spot measurements using portable standard grade instrument may be used as a mean to ascertain the energy consumption of major building uses. The annual electricity consumption of the building may be sourced from energy use data published under the BCA Benchmarking Report (BEBR) on the [BCA website](#), if available.
- (d) Inventory of major energy-consuming systems and equipment which include types, quantities, age, rated capacities, rated power performance and control systems of various building services installation such as building cooling system and centralised hot water system, where relevant;
- (e) Analysis of the collected data to identify the energy use profiles and peak demand period in relation to the building occupancy patterns and operational schedules of major energy-consuming systems and includes the following:
 - (i) Breakdown of the annual electricity consumption by major energy uses, including but not limited to building cooling system, centralised hot water system and charging facility of electric vehicles, where relevant. Other building systems (such as lifts, escalators, and receptacle equipment load etc.) can be assessed collectively if individual data are not readily available. Energy profile and distribution charts that visually represents the proportion of total energy use attributed to each major system and end-use from the landlord and key tenants are to be provided.
 - (ii) For each energy use, provide the measured energy consumption in absolute units (e.g., kWh) and as a percentage of the total annual energy consumption. Should

operation data or record be not fully available, reasonable estimates based on equipment ratings, operating hours, and standard engineering practices may be used, with the estimation methodology and assumptions clearly documented. The on-site energy generated by on-site Photovoltaic (PV) systems can be provided separately, if relevant.

5.3 System Level Assessment

Audit on Energy Performance of Building Cooling Systems

5.3.1 At system level, the audit will cover the assessment of the energy performance of the building cooling systems. This includes the evaluation of the current operating energy efficiency of these systems as compared with their original design specifications and prevailing industry standards. Additionally, the assessment of control system, zoning strategies and maintenance practices that are relevant to identify potential energy efficiency improvements in system operation, maintenance, or controls.

5.3.2 The determination of the energy efficiency of the cooling system must be conducted under normal operating conditions with the indoor space conditions, maintained within the recommended limits stated in SS553 and SS554, where applicable.

Chilled Water Plant

5.3.3 For chilled water plant, the energy performance data shall be obtained during the operating hours of the system and to be sampled and acquired simultaneously and continuously for a minimum of one (1) week at one (1) minute intervals, unless otherwise specified.

5.3.4 The energy performance of the system shall be evaluated based on the normal operating hours defined for each building type, to ensure consistent comparison with prevailing energy efficiency standards. However, it is recommended to consider the energy performance of the system during off-peak or night-time if the cooling demands are significant and present opportunities for energy savings.

5.3.5 If the permanent instrumentations and power meters are used, the accuracy of its permanent temperature sensors must be checked with a portable calibrated temperature sensor before extracting any data for the computation of performance data. Alternatively, the data may be obtained via external instrumentations that are calibrated with comparable accuracy.

5.3.6 The heat balance substantiating test is required for water-cooled chilled water plant to determine the quality of the measurements that is the uncertainty, installation and positioning of the instrumentations are within the prescribed tolerance for the purpose of deriving the Operating System Efficiency (OSE) of the water-cooled chilled water plant.

5.3.7 The OSE of the water-cooled chilled water plant must be verified and carried out by computing the system heat balance of the plant in accordance with the SS591- Code of Practice for Long Term Measurement of Central Chilled Water System Energy Efficiency, and to the extent as prescribed.

Air Distribution System

5.3.8 For the measurement of the air distribution system efficiency, the data on the power consumption shall be obtained from the dedicated power meters that are linked to the Building Management System (BMS) or standalone energy management system (EMS) for a period of 1 week.

5.3.9 In instances, where there is no dedicated power meter for the air distribution systems, the measurement method, duration and coverage in deriving the power consumption from these systems as detailed in the following table are to be adopted for consistency.

Measurement of Air Distribution System Efficiency				
System Components	Measurement Method	Duration	Coverage	Total Power Consumption
(A) Air Handling Units (VAV-AHUs) (CAV-AHUs) excluding Pre-cooled AHUs	Trend data from BMS/EMS	Log for 1 week at 5-min interval	All	kWh
	If there is no linkage with BMS/EMS			
	VAV-AHUs: Trend log input power from VSD	Log for 1 day at 5-min interval	Minimum 10% of the total no. of AHUs or 5 no. of AHUs, whichever is higher (Cap at 10 no.)	kW _{avg} x Number of Operating hours per week x Number of AHUs = kWh
CAV-AHUs : Spot measurements using portable power meters with accuracy of IEC Class 1 or equivalent	Spot measurements during normal operating hours			
(B) Fan Coil Units (FCUs)	Trend data from BMS/EMS	Log for 1 week at 5-min interval	All	kWh
	If there is no linkage with BMS/EMS			
	Spot measurements using portable power meters with accuracy of IEC Class 1 or equivalent	Spot measurements during normal operating hours	Minimum 10% of the total no. of FCUs	kW _{avg} x Number of Operating hours per week x Number of FCUs = kWh
<i>Alternatively, the power consumption of FCUs can be computed based on the nameplate motor power of FCUs instead of measurement.</i>				
<p>Note: In addition to power consumption data, there are other pertinent data to be collected or recommended for collection such as supply air temperature (off-coil and on-coil), space air temperature, and relative humidity (RH%) etc. Please refer to the details provided in Annex B – Section (G) Energy Efficiency of Building Cooling System.</p>				

The efficiency of air distribution systems at building level, η_a (in kW/RT) = $\frac{(\sum A + \sum B)}{C}$

where C is the total building cooling load based on trend data obtained from BMS/EMS for the same one (1) week as that for the measurement for the air distribution system.

Unitary Air Conditioning System

5.3.10 The audit must include the assessment of the energy efficiency of unitary air conditioning systems which can be measured from the permanent measuring instruments, if available. Alternatively, the energy performance data published for air conditioners in the Mandatory Energy Labelling Scheme (MELS) or from the manufacturers' specification can be used as the basis to determine the energy efficiency of the unitary air conditioning system. The system energy efficiency

can be derived based on the concept of Integrated Energy Efficiency Ratio (IEER), which consider the different load capacities with due consideration for part-load conditions.

The IEER is defined as

$$(0.020 \times A) + (0.617 \times B) + (0.238 \times C) + (0.125 \times D)$$

where

A = EER or COP at full load

B = EER or COP at 75% load

C = EER or COP at 50% load

D = EER or COP at 25% load

5.3.11 The terms EER (Energy Efficiency Ratio) (EER) describe the system's level of efficiency and can be defined as the ratio of cooling capacity to effective electrical power input required to provide the cooling. The higher EER, the more energy efficient is the equipment/system.

5.3.12 In the case of single and multiple split unitary conditioners, the efficiency can be computed based on the weighted Coefficient of Performance (COP) measured and registered in accordance with the applicable test standards under the Energy Labelling scheme.

$$COP_{\text{weighted}} = 0.4 \times COP_{100\%} + 0.6 \times COP_{50\%}$$

where

COP_{100%} is defined as the ratio of the cooling capacity to effective power input at full rated capacity

COP_{50%} is defined as the ratio of the cooling capacity to effective power input at 50% rated capacity

5.3.13 Where there is a combination of unitary air-conditioning systems serving different zones, the weighted system efficiency will be determined by pro-ration according to the respective cooling capacity served and expressed as follows:

Energy efficiency of unitary air-conditioning system	$EE_{\text{Weighted}} \text{ (in kW/RT)} = \frac{3.517 / \sum(\text{Cooling Capacity} \times \text{IEER or COP}_{\text{weighted}})_i}{\text{Total Cooling Capacity}_{\text{overall}}}$
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5.3.14 Site derating factor could be included to account for the system efficiency of the condenser units to better reflect its expected operating performance when measured to consider possible efficiency losses due to site inherent constraints and considerations observed.

5.4 Audit Findings and Assessment

5.4.1 The detailed evaluation of building energy consumption profile, combined with the assessment of cooling system efficiency, provides critical insights for identifying potential energy-saving opportunities. These findings can form the basis for developing practical measures to reduce energy consumption and to meet the specified reduction in EUI.

5.4.2 Generally, energy improvement measures can come in many forms. Building owners can engage tenants and occupiers through green lease provisions with energy performance targets, cost-sharing mechanisms and rebate schemes. Beyond these engagement measures, technical and operational improvements can include adjusting system operations (such as AHU operating hours and space temperature settings), replacing equipment/components, adding energy-efficient

technologies, implementing energy recovery strategies, installing renewable energy systems, and enhancing operation and maintenance practices.

5.4.3 Building owners and their appointed specified individual should identify all potential energy efficiency improvement opportunities during the assessment. Priority should be given to immediate, low-cost measures requiring minimal investment - from optimising operating schedules and adjusting temperature set points, to fine-tuning control systems, improving maintenance practices, enhancing building management procedures, and conducting basic system balancing.

5.4.4 Additional opportunities may include medium-cost system modifications and major retrofit opportunities, such as system upgrades, equipment replacements, and significant redesign of building cooling systems. Building owners have the flexibility in planning their approach with various options to maximise the EUI reduction potential. However, to meet the required EUI reduction target, they may need to consider both immediate improvements and, if required, system enhancements.

5.5 Energy Efficiency Improvement Plan (EEIP)

5.5.1 Following the identification of potential energy efficiency improvement measures, the specified individual must work with the building owner to develop the EEIP. The measures selected are to collectively achieve the specified EUI reduction within the stipulated 3-year timeframe.

5.5.2 The building owner and specified individual can determine appropriate criteria for selecting the measures. While these typically include implementation cost and available budget, technical feasibility, complexity of solutions, and operational impacts, other relevant factors may also be considered. As part of this selection process, each measure's contribution to the overall energy reduction target should be clearly established, considering future maintenance and operational requirements.

5.5.3 The EEIP functions as a roadmap outlining the detailed descriptions of recommended measures, implementation timelines, expected energy savings, and implementation cost estimates. It also forms the basis for monitoring the building's progress towards the specified EUI reduction. Where necessary, building owners may be required through a written direction to provide progress updates to ensure implementation remains on track. Please refer to Annex B – Part 2 Energy Efficiency Improvement Plan on the detailed requirements.

6 SUBMISSION REQUIREMENTS AND PROCEDURES

6.1 General

Under the MEI regime, an owner to an energy-intensive building who receives an audit notice must, in accordance with the Act:

- (a) Appoint a specified individual to carry out an energy audit (under sections 22FM and 22FN);
- (b) Submit an audit report of the energy audit carried out and an energy efficiency improvement plan (under section 22FO);
- (c) Ensure that the energy efficiency improvement plan is carried out (under section 22 FQ); and
- (d) Ensure that the specified reduction or approved reduction in EUI is maintained for the maintenance period (under section 22FT).

6.2 Submission Process and Documentation

6.2.1 This section outlines the submission requirements that building owners and specified individuals must comply with to fulfill their obligations effectively. It provides guidance on the

compliance process, from appointing a specified individual to maintaining improved energy performance, including submission requirements, timelines, and documentation formats for each stage.

6.2.2 All submissions must be made through the electronic services provided on the [BCA website](#), unless otherwise specified. Additional documents may be required and must be submitted in the form and manner specified by the Commissioner of Building Control (“CBC”).

Appointment of a Specified Individual

6.2.3 Upon receiving the audit notice, the building owner is required to appoint a specified individual to carry out the energy audit and develop the EEIP. The appointment notification must be submitted within 90 days from the date the MEI audit notice issued or within the period specified in the notice,

6.2.4 The specified individual appointed can be a Professional Engineer (Mechanical) or an energy auditor registered with BCA. Please refer to the listings available on the [PE Board website](#) and [BCA website](#).

6.2.5 In the event that the building owner intends to appoint another specific individual before the expiry of the maintenance period, it is necessary to do so within 90 days after the cessation and notify the CBC of this change within 7 days after the date of appointment.

Audit Report and Energy Efficiency Improvement Plan (EEIP)

6.2.6 The specified individual must prepare and sign an audit report of the result of the energy audit in the form and manner specified on the [BCA website](#) and Annex B of this Code.

6.2.7 The audit report, including the EEIP, must be submitted within 1 year from the date of the MEI audit notice issued or within the period specified in the notice.

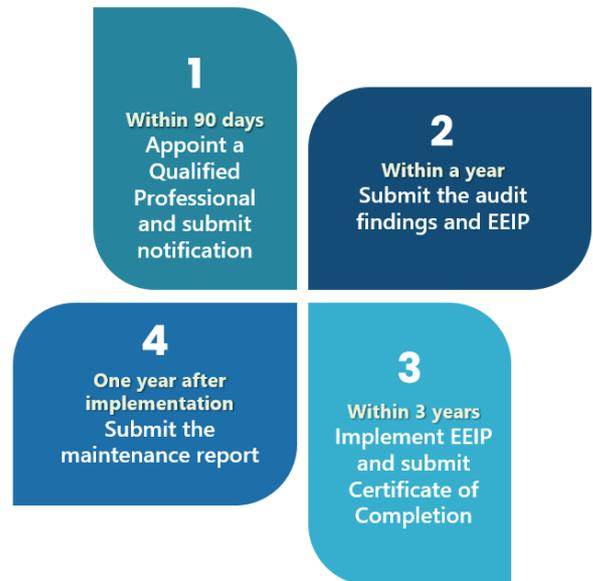
6.2.8 If there are any changes to the measures carried out for the EEIP, the building owner must ensure that the specified individual amends the EEIP, showing clearly the departure and deviations and confirm that the measures in the amended EEIP will meet the specified or approved reduction in EUI. The amended EEIP must be submitted within 60 days after the owner becomes aware of the changes and in the form and manner specified by the CBC.

Implementation of Energy Efficiency Measures and Certificate of Completion

6.2.9 The building owner must implement the measures set out in the EEIP and submit a certificate of completion within 3 years from the EEIP submission date. During this implementation period, progress reports on the status of energy efficiency measures may be required through a written direction.

6.2.10 Upon completion of all measures, the certificate of completion must be prepared and signed by the specified individual, certifying that all measures have been completed and the specified EUI reduction has been achieved.

Key Timelines for Submission



Maintenance of Improved Energy Performance and Report

6.2.11 For a period of 1 year after the certificate of completion is submitted to the CBC, the building owner must maintain, at minimum, the specified EUI reduction and submit a maintenance report within 3 months after this period ends. The report is to be prepared by the specified individual and must state the building's EUI and, if the specified reduction is not maintained, include additional measures to supplement the EEIP.

7 REGISTRATION OF ENERGY AUDITOR

7.1 Eligibility Criteria

7.1.1 An individual will be eligible to be registered as an Energy Auditor with BCA under Section 22FC of the Act if he holds the following qualifications:

- i. Possess at least an engineering or a building-related undergraduate degree in architecture, building science, facility management, or sustainable building design, or any equivalent professional qualification acceptable by the CBC;
- ii. Have at least three (3) years of relevant practical experience in central air-conditioning design and installation, or operation;
- iii. Completed two (2) ASHRAE Level III Energy Audits or three (3) Periodic Energy Audits on Building Cooling Systems under the supervision of a PE(Mechanical) or BCA registered Energy Auditor respectively; and
- iv. Passed the interview and/or exam by the Energy Auditor Registration Committee.

7.1.2 For the purpose of ascertaining whether an individual can carry out the duties of an Energy Auditor, the CBC will consider the recommendations provided by the Energy Auditor Registration Committee appointed by him.

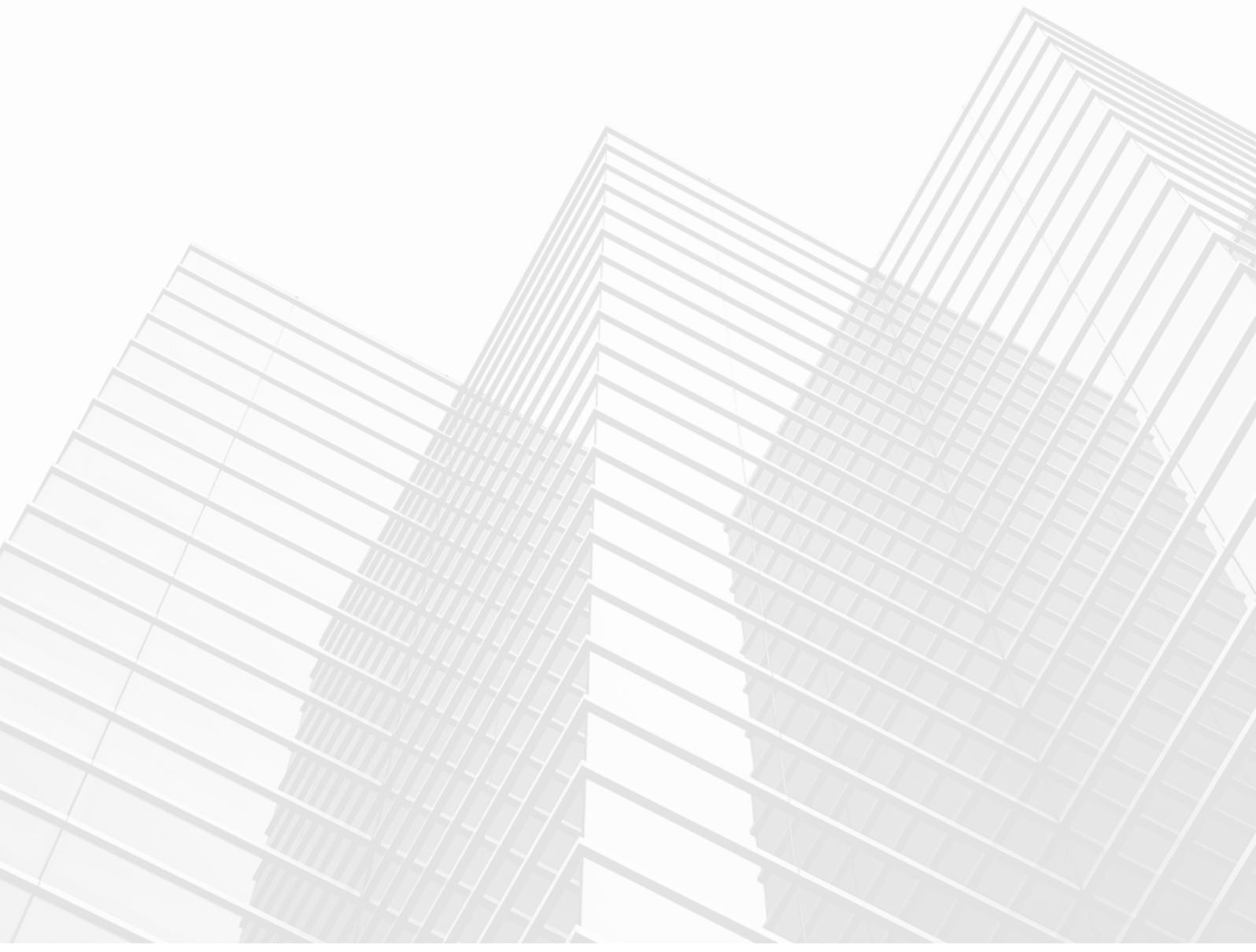
7.1.3 An application to be registered as an Energy Auditor can be made using the application form which is available on the [BCA website](#). All applications must be accompanied with a fully completed form, supporting certificates and evidence of related work experiences as specified in the form.

7.1.4 The registration as an Energy Auditor shall be valid for 3 years, and each renewal of the registration shall also be valid for 3 years. Application for renewal of registration can be made using the application form which is available on the [BCA website](#). All applications must be accompanied with a fully completed form, supporting certificates and evidence of related work experiences as specified in the form and renewal fee.

Annex A

Energy Use Intensity Threshold (EUI)

Reference is made to the First Schedule of Building Control
(Environmental Sustainability Measures for Existing Buildings)
Regulation 2013



Energy Use Intensity (EUI) Threshold

The threshold level of energy use intensity for a building that has one category of building use is as follows:

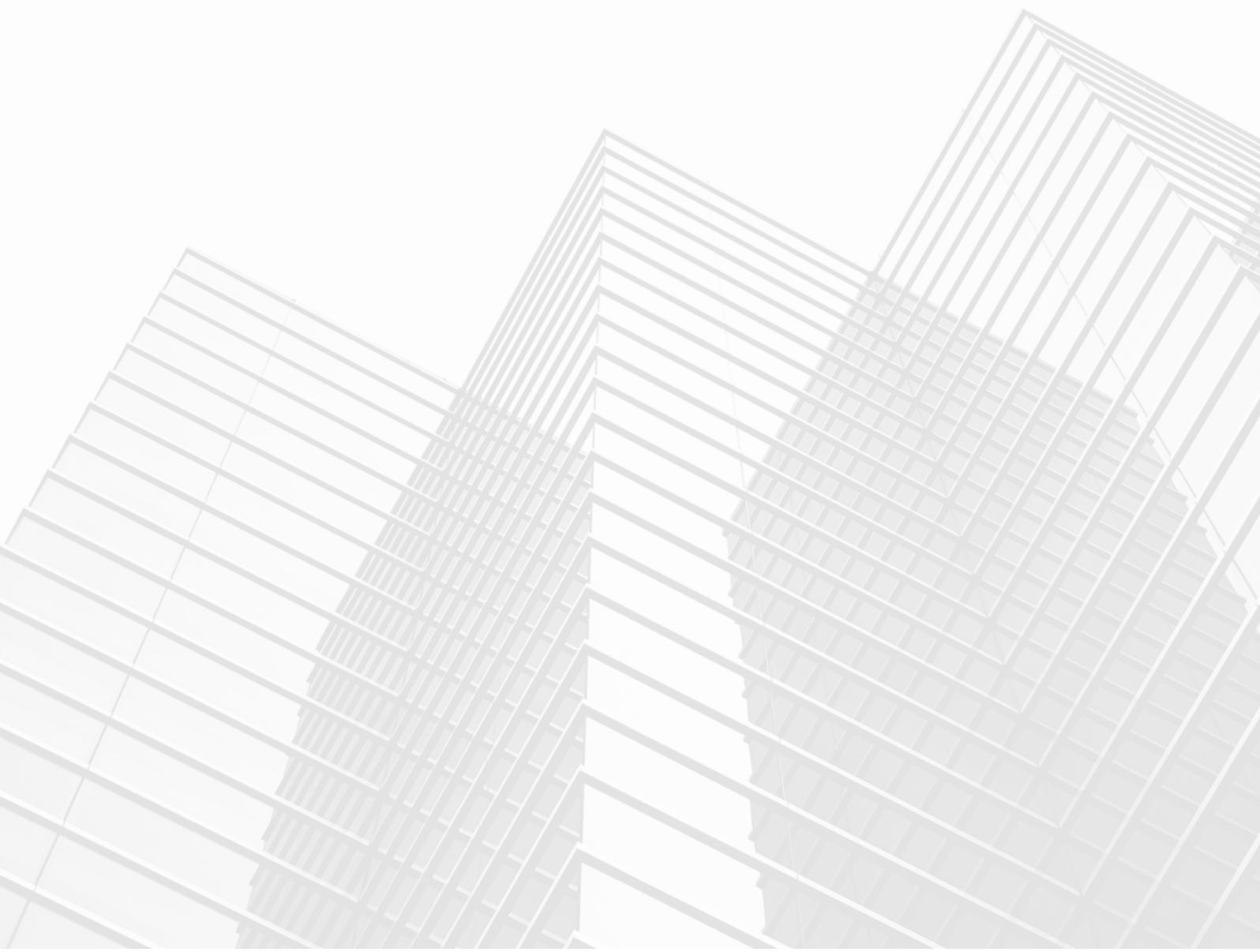
Building Use	EUI Threshold (kWh/m ² .yr)
A. Commercial buildings	
1. Hotel building	310
2. Office building	200
3. Retail building	495
B. Healthcare facilities	
4. Hospital or specialist clinic	360
5. Nursing home	120
6. Polyclinic or private clinic	190
C. Institutional buildings	
7. Autonomous university	190
8. Civic building	195
9. Community institution	155
10. Cultural institution	270
11. Other educational institution	130
D. Sports and recreation centres	
12. Recreation club	275
13. Sports centre	180
E. Other energy uses	
14. Data centre operations	6595
15. Laboratory operations	560
Mixed Categories of Building Uses	
<p>The threshold level of energy use intensity for a building that has mixed categories of building use is the sum of the threshold level of EUI for each of the categories of building use as specified above) prorated in proportion to the percentage of gross floor areas (GFA) of the building that is used for that category of building use.</p> <p>An example of EUI threshold determination for mixed categories of building uses is as follows :</p> <p>A building with total gross floor area of 20,000 m², consisting of 70% office space and 30% retail space.</p> <p>EUI Threshold = (70%*EUI Threshold for Office)+ (30% *EUI Threshold for Retail) = (0.7 * 200) + (0.3 * 495) = 288.5 kWh/m².yr</p>	

Note: For a building that is served by a third-party cooling system, the energy use intensity threshold shall be adjusted by a factor of 0.8 if the energy consumption information for cooling is not available.

Annex B

Audit Report and Energy Efficiency Improvement Plan (EEIP)

Reporting Requirements and Templates



Report Outline

Part 1 - Audit Report

- Audit scope
- Building information
- Historical energy use data and utility cost
- Inventory of major energy-consuming systems and equipment
- Breakdown of energy consumption by end-use
- Energy efficiency of building cooling system
- Key findings and potential energy efficiency improvement measures

Part 2 - Energy Efficiency Improvement Plan

- Feasibility assessment of EUI reduction
- Description of each recommended measures
- Expected energy savings and EUI reduction
- Implementation costs
- Simple payback period for each measure
- Implementation timeline

Part 3 - Appendices

- Appendix A – Supporting documentation in relation to the audit of energy use of buildings and systems
- Appendix B – Supporting documentation in relation to the audit of energy efficiency level of building cooling systems
- Appendix C – Supporting documentation in relation to the EEIP

Part 1 – Audit Report

- Audit Scope
- Building Information
- Historical energy use data and utility cost
- Inventory of major energy-consuming systems and equipment
- Breakdown of energy consumption by end-use
- Energy efficiency of building cooling system
- Key findings and potential energy efficiency improvement measures

Audit Scope

When preparing the audit scope, include the objectives, system covered and extent of coverage, audit methodology and assumption.

Normative Information to be provided

The following are the tabulation and examples for reference and use :

Building Name : Example Building		
(A) Building Information		
Building Address		
Postal Code		
Primary Building Use Type and % Use	Office (50%)	
Other Building Use Type and % Use	Hotel (30%), Retail (10%)	
Building Age		
Typical operation hours	9 am to 6 pm (Office), 24 hrs (Hotel), 10 am to 9 pm (Retail)	
Gross Floor Area (GFA) in m ²		
Total Number of Blocks	2 blocks	
Number of Floors	Block 1 - Office – 15 Block 2 – Retail (3 from Level 1 to 3) Hotel (15 from level 4-18)	
Air-Conditioned Areas in m ²		
Percentage owned (%)		
Percentage leased (%)		
Net Lettable Areas in m ²		
Carpark Areas in m ²		
Common Areas in m ² <i>Note: To include all areas within the building such as lobbies, corridors, staircases, lifts, car parks, toilets, mechanical and electrical rooms, and other shared facilities that are not that are not leased to or owned by tenants.</i>	Air-Conditioned areas in m ²	
	Non-Air Conditioned areas in m ²	

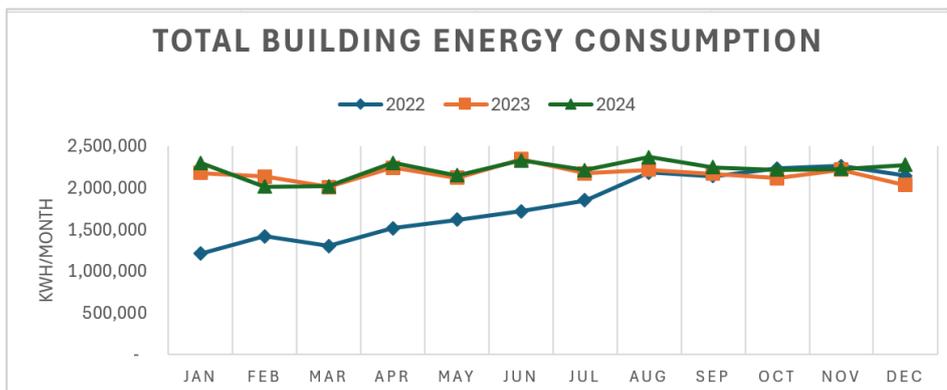
Building Name : Example Building

(B) Historical Energy Use Data

Monthly electricity consumption over the 3 years prior to the year of notice. If the year of MEI audit notice received is in 2025, the energy consumption data for year 2022, 2023 and 2024 is to be provided.

Year of MEI Audit Notice Received	2025		
Building GFA (m²)	XXXX		
Month	Monthly Electricity Consumption		
	2022	2023	2024
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			
Total Building Electricity Consumption (TBEC) (kWh/year)			
Energy Use Intensity (EUI) kWh/m².year			
Average Total Building Electricity Consumption (kWh/year)	$\frac{\sum(TBEC)_i}{3}$		
Average Energy Use Intensity (EUI) (kWh/m².year)	$\frac{\text{Average TBEC}}{\text{GFA}}$		
Remarks	<i>Please highlight any major changes in building operations, occupancy, or requirements that may have affected energy use, if applicable</i>		

Note : The average EUI will be used as the baseline to accord the percentage reduction in EUI after implementation of EEIP.



Building Name : Example Building			
(C) Utility Cost Arrangement			
(1) Utility account under building owner/Landlord. Building owner will charge tenant based on tenancy lease where relevant.			Yes/No
(2) Tenants have direct account with utility provider and pay for their own electricity consumption.			Yes/No
(3) Landlord has the master utility accounts and sub-meter individual units and tenants pay for their metered usage and a share of common areas utilities.			Yes/No
Combination of above or others, pls specify :			
(D) Utility Cost for Building Owner or Landlord			
Type of Electricity Package	Pls state Low tension supplies or High tension (small/large) supplies with contracted or uncontracted charges /reactive power charges		
Year of MEI Audit Notice Received	2025		
Building GFA (m ²)	XXXX		
Month	Monthly Electricity Cost		
	2022	2023	2024
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			
Total Electricity Cost (\$/year)			
Average Monthly Electricity Cost (\$/month)			

Building Name : Example Building

(E) Inventory of Major Energy-Consuming Systems and Equipment

Building Cooling System (Required)

System/Equipment Type	This information can be consolidated and provided under Section (G) – Energy Efficiency of Cooling System.
Chilled Water System	
Chiller	
Chilled Water Pump	
Condenser Water Pump	
Cooling Tower	
VRF System	
Other Unitary Air Conditioning Systems	

Centralised Hot Water System (Required, where applicable)

System/Equipment Type	Quantity	Year Installed	Rated Capacity (kW)	Rated Power (kW)	Control System	Location/Remarks
Electric/Gas Boiler						
Heat Pump						
Ancillary Equipment	Quantity	Pump Head (m)	Flow Rate (L/S)	Rated Pump/ Fan Efficiency (%)	Rated Motor Efficiency (%)	Location/Remarks
Primary Circulation Pump						

Mechanical Ventilation System (Required, if it is in the EEIP)

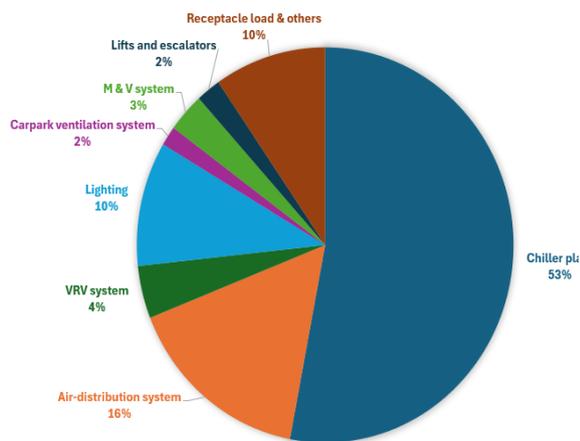
System/Equipment Type	Quantity	Fan Type	Floor Areas served (m ²)	Air Changes per hour (ACH)	External Static (Pa)	Fan Motor Input Power (kW)	Fan Efficiency (W/CMH)	Location/Remarks
Exhaust and Intake Fans for Carparks								

Lighting System (Required, if it is in the EEIP)

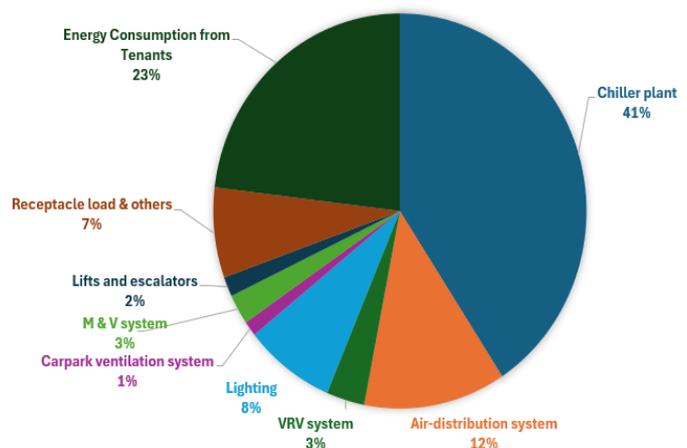
S/No	Fitting Type	Location	Areas Covered (m ²)	Light Fitting Power (W)	No. of Fittings	Total Power Consumption include ballast loss (W)	Operating Hours (h)	Operating Lighting Power Budget (W/m ²)

Building Name : Example Building		
(F) Breakdown of Energy Consumption by End-Use		
End-Use	Energy Consumption (kWh/year)	Data Source
Building Cooling System		
Chilled Water System		To indicate the data source for example data from BMS, sub-meter, spot measurement, spec and calculation. For others, pls specify
Unitary Air-Conditioning System		
Air-Handling and Distribution System		
Centralised Hot Water System		
Electric/Gas Boiler		Ditto
Heat Pump		Ditto
Other Equipment and System		
Lighting System		Ditto
Carpark Ventilation System		Ditto
Mechanical and Ventilation System		Ditto
Lifts and Escalators		Ditto
Receptacle load		Ditto
Others (pls specify)		Ditto
Total Energy Consumption from Building Systems	\sum Energy Consumption from the above systems	
Other Energy Use (if relevant)		
Energy Consumption from Tenants		Electricity bills, sub-meter etc.,
Others (pls specify)		Ditto
Total Building Energy Consumption (TBEC)	\sum Energy Consumption from the above systems and Tenants	
On-site Renewable Energy Generation (if any)		Ditto

Breakdown of Energy Consumption by End-Use (System Level)



Breakdown of Energy Consumption by End-Use (Building Level)



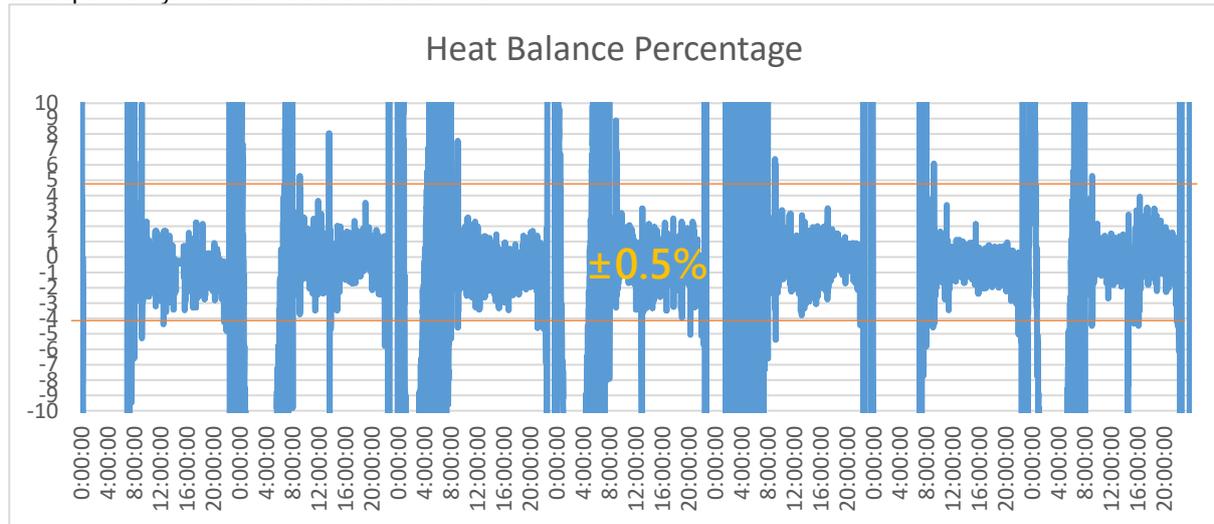
Note : The distribution of energy consumption at system level will include the operation energy demand from the Landlord. If the building is solely occupied by an owner with no other tenancy, the distribution will be the same as that for building level.

Building Name : Example Building	
(G) Energy Efficiency of Building Cooling System	
Audit Information	
Type of Building Cooling System	<p>Pls state the cooling system used : For e.g.</p> <p>(a) Water-Cooled Building Cooling System comprises the following systems and components, where relevant.</p> <ul style="list-style-type: none"> • Water-Cooled Chiller • Water-Cooled Direct-Expansion (DX) System • Chilled Water Pump • Condenser Water Pump • Cooling Tower • Air Handling and Distribution System <p>(b) Air-Cooled Building Cooling System comprises the following systems and components, where relevant</p> <ul style="list-style-type: none"> • Unitary Air-Conditioners (Single or combination of systems) <ul style="list-style-type: none"> ○ Variable Refrigerant Flow (VRF) system ○ Single-Split Units ○ Multi-Split Units ○ Air Handling and Distribution System • Air-Cooled Chilled-Water System <ul style="list-style-type: none"> ○ Air-Cooled Chiller ○ Chilled Water Pump ○ Air Handling and Distribution System <p>(c) District Cooling System comprises the following systems and components, where relevant</p> <ul style="list-style-type: none"> • District level - Central chilled water system with distribution networks • Building level – Air-handling and distribution System
Location of Cooling System	Office Block Basement 2
Energy Audit Period	DD MMM YYYY - DD MMM YYYY
Building Cooling System Normal Operating Hours	<p>For e.g. office</p> <p>Monday to Friday : 0800 – 2000 Hrs</p> <p>Saturday/Sunday : No operation</p>

Building Name : Example Building					
(G) Energy Efficiency of Building Cooling System -Cont'd					
Chilled Water Plant / System					
Measurement of Chilled Water System Energy Efficiency					
Data Logging Interval	1 minute sampling time interval and recorded at 3 rd decimal place for minimum of 1 week				
Trend Logged Parameters <i>Note : The parameters may vary depending on the piping and electrical circuit design</i>	Chilled Water Supply main header temperature Chilled Water Return main header temperature Chilled Water flowrate at Chilled Water Return main header Condenser Water Supply main header temperature Condenser Water Return main header temperature Condenser water flow rate at condenser water return main header Power input to Chiller(s) Power input to Chilled water pump(s) Power input to Condenser water pump(s) Power input to Cooling tower(s) Power input to Pre-AHU(s)/AHU(s)/FCU(s)				
Confirmation on the Accuracy of the Measurement Instrument used for Audit Process					
<u>Instrumentations schedule and points of measurements</u>					
The measuring instruments complying with the standards in accordance with SS591-Code of Practice for Long Term Measurement of Central Chilled Water System Energy Efficiency are to be used for this purpose. The instrumentation schedule and points of measurement should be provided using the format shown in the example below:					
ID / Serial No.	Sensor Type	Installation Location	Measurement Uncertainty (%)	Last Calibration Date	Calibration Laboratory
EP80367	10K Thermistor	CHWS Header	±0.03 °C	09/05/2023	XX laboratory
EP80364	10K Thermistor	CHWR Header	±0.03 °C	09/05/2023	XX laboratory
EP80361	10K Thermistor	CWS Header	±0.03 °C	09/05/2023	XX laboratory
EP80363	10K Thermistor	CWR Header	±0.03 °C	09/05/2023	XX laboratory
3k67201343004	Magnetic Full Bore	CHWR Header	0.50%	29/10/2023	factory calibration
3k67201418063	Magnetic Full Bore	CWR Header	0.50%	09/05/2024	factory calibration
38498	True RMS, 3 phase	MSB Incoming 1	0.50%	08/07/2024	factory calibration
1402404	True RMS, 3 phase	MSB Incoming 2	0.50%	08/07/2024	factory calibration
38491	True RMS, 3 phase	CHW/6-1	0.50%	08/07/2024	factory calibration
38487	True RMS, 3 phase	CHW/6-1	0.50%	08/07/2024	factory calibration
38490	True RMS, 3 phase	CWP/6-1	0.50%	08/07/2024	factory calibration
....					
....					

Summary of System Heat Balance and Checks required before measurement

Example of System Level Heat Balance Plot



	Quantity	Unit	Formula
Sum of total electrical energy used		kWh	(A)
Sum of total cooling produced		RTh	(B)
Sum of total heat rejected		RTh	(C)
Chiller Plant Efficiency		kW/RT	(A) / (B)
Total Heat Balance Data Count		-	(D)
Data Count > + 5% error		-	(E)
Data Count < - 5% error		-	(F)
Data Count within ±5% error		-	(G) = (D) – (E) – (F)
% Heat Balance within ±5% error		%	100 x (G) / (D)

BMS Check

(1) Temperature sensors' ABC coefficient constants input as reflected in the calibration certificate

Power Meter (Consistency Check)

- (2) Check power meter and BMS readings are the same
- (3) Check power meter reading and chiller panel or pump VSD display reading is ≤ 3%
- (4) Check current transformer ratio tally with power meter setting

Flow Meter

- (5) Check the sum of branch flowmeters matches with header flow meter header readings (if flow meters exist at header and individual chillers)
- (6) Check flow meters and BMS readings are the same
- (7) Check flow meters do not have any correction factor or offset factor input

Verified Temperature Sensor Accuracy

- (8) Use calibrated reference temperature sensor with end-to-end uncertainty of ≤ 0.05 °C
- (9) Synchronise the reference temperature sensor device timing with BMS
- (10) Collect at least 20 sets of readings from reference temperature sensor device (after insertion to the available test plug) and BMS
- (11) Compare the difference between both set of readings, with average of absolute difference to be ≤ 0.07 °C
- (12) Temperature verification data and plots are to be provided (see example below)

Verified Temperature Sensor Accuracy (Cont'd)

Example of temperature verification data and plots

Building Name: XXX Building
 Date of Verification: DDMMYY
 Verification by: Name of specified individual

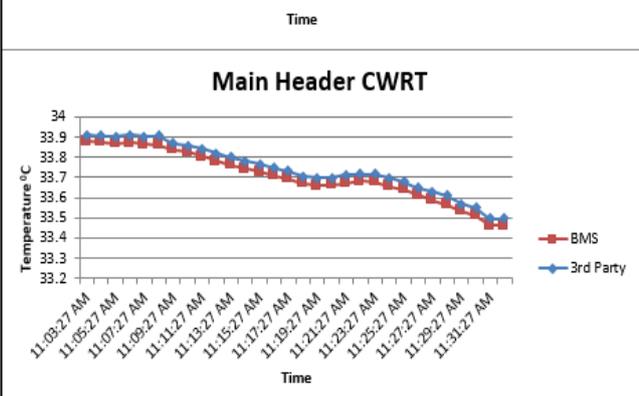
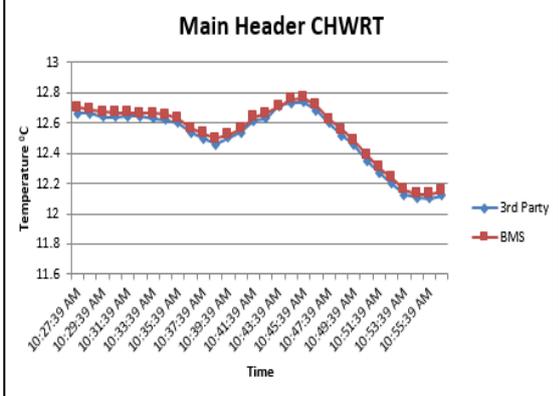
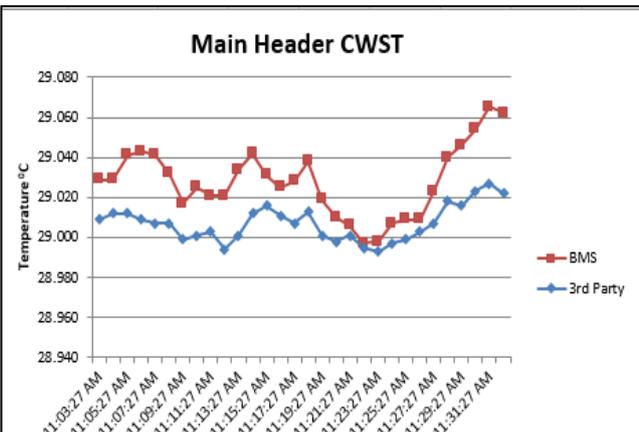
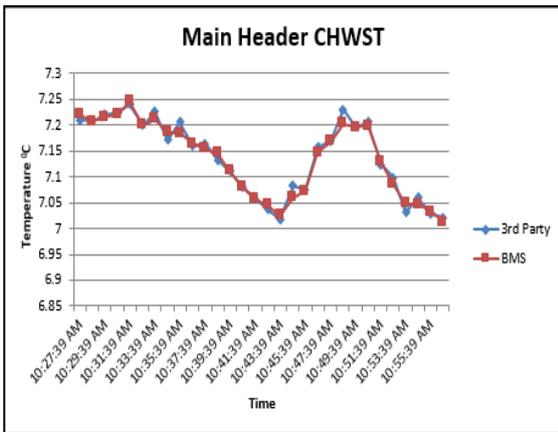
Main Header Chilled Water Supply Temperature				Main Header Chilled Water Return Temperature				Main Header Condenser Water Supply Temperature				Main Header Condenser Water Return Temperature			
Time	3rd Party (°C)	BMS(°C)	ABS	Time	3rd Party (°C)	BMS(°C)	ABS	Time	3rd Party (°C)	BMS(°C)	ABS	Time	3rd Party (°C)	BMS(°C)	ABS
10:27:39 am	7.211	7.220	-0.009	10:27:39 am	12.663	12.703	-0.040	11:03:27 am	29.009	29.029	-0.020	11:03:27 am	33.912	33.879	0.033
10:28:39 am	7.209	7.207	0.002	10:28:39 am	12.665	12.690	-0.025	11:04:27 am	29.012	29.029	-0.017	11:04:27 am	33.907	33.876	0.031
10:29:39 am	7.221	7.216	0.005	10:29:39 am	12.640	12.674	-0.034	11:05:27 am	29.012	29.041	-0.029	11:05:27 am	33.904	33.867	0.037
10:30:39 am	7.225	7.220	0.005	10:30:39 am	12.640	12.671	-0.031	11:06:27 am	29.009	29.043	-0.034	11:06:27 am	33.910	33.874	0.036
10:31:39 am	7.240	7.246	-0.006	10:31:39 am	12.642	12.668	-0.026	11:07:27 am	29.007	29.041	-0.034	11:07:27 am	33.902	33.864	0.038
10:32:39 am	7.200	7.200	0.000	10:32:39 am	12.642	12.663	-0.021	11:08:27 am	29.007	29.032	-0.025	11:08:27 am	33.906	33.862	0.044
10:33:39 am	7.227	7.211	0.016	10:33:39 am	12.628	12.662	-0.034	11:09:27 am	28.999	29.017	-0.018	11:09:27 am	33.867	33.840	0.027
10:34:39 am	7.172	7.186	-0.014	10:34:39 am	12.622	12.653	-0.031	11:10:27 am	29.001	29.025	-0.024	11:10:27 am	33.858	33.826	0.032
10:35:39 am	7.205	7.184	0.021	10:35:39 am	12.601	12.631	-0.030	11:11:27 am	29.003	29.021	-0.018	11:11:27 am	33.841	33.806	0.035
10:36:39 am	7.160	7.164	-0.004	10:36:39 am	12.537	12.567	-0.030	11:12:27 am	28.994	29.021	-0.027	11:12:27 am	33.818	33.781	0.037
10:37:39 am	7.164	7.154	0.010	10:37:39 am	12.499	12.532	-0.033	11:13:27 am	29.001	29.034	-0.033	11:13:27 am	33.801	33.764	0.037
10:38:39 am	7.133	7.146	-0.013	10:38:39 am	12.460	12.497	-0.037	11:14:27 am	29.012	29.042	-0.030	11:14:27 am	33.780	33.744	0.036
10:39:39 am	7.111	7.111	0.000	10:39:39 am	12.501	12.523	-0.022	11:15:27 am	29.016	29.031	-0.015	11:15:27 am	33.767	33.729	0.038
10:40:39 am	7.079	7.080	-0.001	10:40:39 am	12.535	12.560	-0.025	11:16:27 am	29.011	29.025	-0.014	11:16:27 am	33.746	33.709	0.037
10:41:39 am	7.059	7.057	0.002	10:41:39 am	12.614	12.640	-0.026	11:17:27 am	29.007	29.028	-0.021	11:17:27 am	33.734	33.696	0.038
10:42:39 am	7.037	7.046	-0.009	10:42:39 am	12.631	12.664	-0.033	11:18:27 am	29.013	29.038	-0.025	11:18:27 am	33.706	33.672	0.034
10:43:39 am	7.019	7.026	-0.007	10:43:39 am	12.712	12.710	0.002	11:19:27 am	29.001	29.019	-0.018	11:19:27 am	33.697	33.660	0.037
10:44:39 am	7.082	7.060	0.022	10:44:39 am	12.732	12.758	-0.026	11:20:27 am	29.998	29.010	0.988	11:20:27 am	33.698	33.662	0.036
10:45:39 am	7.076	7.073	0.003	10:45:39 am	12.736	12.767	-0.031	11:21:27 am	29.001	29.006	-0.005	11:21:27 am	33.712	33.670	0.042
10:46:39 am	7.157	7.147	0.010	10:46:39 am	12.683	12.718	-0.035	11:22:27 am	28.995	28.997	-0.002	11:22:27 am	33.718	33.681	0.037
10:47:39 am	7.170	7.169	0.001	10:47:39 am	12.600	12.626	-0.026	11:23:27 am	28.993	28.998	-0.005	11:23:27 am	33.718	33.679	0.039
10:48:39 am	7.231	7.203	0.028	10:48:39 am	12.518	12.557	-0.039	11:24:27 am	28.997	29.007	-0.010	11:24:27 am	33.699	33.658	0.041
10:49:39 am	7.198	7.196	0.002	10:49:39 am	12.453	12.484	-0.031	11:25:27 am	28.999	29.009	-0.010	11:25:27 am	33.679	33.642	0.037
10:50:39 am	7.206	7.199	0.007	10:50:39 am	12.351	12.392	-0.041	11:26:27 am	29.003	29.009	-0.006	11:26:27 am	33.648	33.615	0.033
10:51:39 am	7.125	7.128	-0.003	10:51:39 am	12.273	12.305	-0.032	11:27:27 am	29.007	29.023	-0.016	11:27:27 am	33.628	33.586	0.042
10:52:39 am	7.098	7.085	0.013	10:52:39 am	12.201	12.239	-0.038	11:28:27 am	29.018	29.040	-0.022	11:28:27 am	33.611	33.564	0.047
10:53:39 am	7.031	7.048	-0.017	10:53:39 am	12.124	12.161	-0.037	11:29:27 am	29.016	29.046	-0.030	11:29:27 am	33.568	33.535	0.033
10:54:39 am	7.060	7.047	0.013	10:54:39 am	12.106	12.131	-0.025	11:30:27 am	29.023	29.054	-0.031	11:30:27 am	33.549	33.511	0.038
10:55:39 am	7.028	7.032	-0.004	10:55:39 am	12.100	12.129	-0.029	11:31:27 am	29.027	29.065	-0.038	11:31:27 am	33.498	33.463	0.035
10:56:39 am	7.021	7.013	0.008	10:56:39 am	12.122	12.148	-0.026	11:32:27 am	29.022	29.062	-0.040	11:32:27 am	33.496	33.462	0.034
Average	7.138	7.136	0.002	Average	12.508	12.537	-0.029	Average	29.007	29.028	-0.021	Average	33.743	33.706	0.037

Passed

Passed

Passed

Passed



Chilled Water Plant Information based on Design Specifications and Nameplate

Table 1 : Chiller information (Example)

ID	Description	Brand	Type	Name plate motor (kW)	Total Cooling Capacity (RT)	Chilled water LWT/EWT (°C)	Rated Efficiency (kW/RT)	Year Installed	Location
CH01	Chiller 1	Brand X	Centrifugal water-cooled	162.8	300	7.5/13	0.543	2017	B2 plant room
CH02	Chiller 2	Brand X	Centrifugal water-cooled	162.8	300	7.5/13	0.543	2017	B2 plant room
CH02	Chiller3	Brand X	Centrifugal water-cooled	162.8	300	7.5/13	0.543	2017	B2 plant room

Table 2 : Ancillary equipment information (Example)

ID	Brand	Type	Name plate motor (kW)	Pump Head (m)	Flow rate (L/S)	Rated Pump/ Fan Efficiency (%)	Rated Motor Efficiency (%)
CHWP 1	Brand X	end suction	11	23	33.65	80.00%	92.40%
CHWP 2	Brand X	end suction	11	23	33.65	80.00%	92.40%
CHWP 3	Brand X	end suction	11	23	33.65	80.00%	92.40%
CWP 1	Brand Y	end suction	15	16	56.82	79.00%	92.40%
CWP 2	Brand Y	end suction	15	16	56.82	79.00%	92.40%
CWP 3	Brand Y	end suction	15	16	56.82	79.00%	92.40%
CT 1	Brand Z	cross flow	5.5 x 1 Cell	-	66.2	75%	86%
CT 2	Brand Z	cross flow	5.5 x 1 Cell	-	66.2	75%	86%
CT 3	Brand Z	cross flow	5.5 x 1 Cell	-	66.2	75%	86%

Description of Chilled Water System Control Strategy

Please provide a summary of the system control strategy adopted, where relevant. The summary may include, but is not limited to, the following:

Chiller sequencing

Describe how the chiller(s) operate to handle the varying building cooling load

e.g. chiller cut-in/out sequence varying with building load and addressing peak and off-peak load based on (supply water temperature, and/or building load, and/or compressor current running load amps) and time delay.

Chilled water pump

Describe the parameters used to control chilled water pumps

e.g. pump speed modulate based on ((differential) pressure sensor located at chiller header, or remote AHU cooling coil, or several zones of AHU cooling coil, or optimising pump pressure by critical valve control), set-point(s) and bypass valve controls to ensure chillers operate at minimum flow rate

Condenser water pump

Describe the parameters used to control condenser water pumps

e.g. modulate to maintain condenser water differential temperature set point or gpm/ton and the set-point(s).

Cooling tower

Describe the parameters used to control cooling towers

e.g. Modulate based on cooling tower approach temperature (difference between CT leaving water temperature and ambient wet-bulb temperature) set point (adjustable), or scheduled cooling tower leaving temperature set point, or dynamic optimized cooling tower leaving water temperature set point and the set-point(s)

Other optimisation

Describe any other optimisation used

e.g. Chilled water supply temperature reset. At off-peak period, reset based on outdoor air temperature/humidity, or VPF bypass control, or predefined schedule.

(Note: Resetting CHW temperature may incur higher pump power and may compromise on space temperature and relative humidity)

Chiller System Performance Analysis (1 week data)

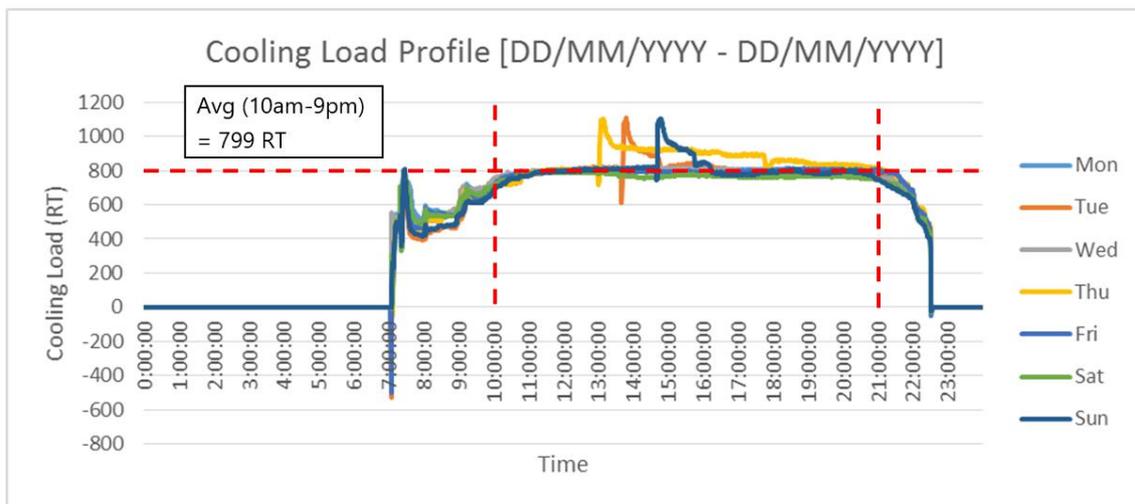


Figure 1: Super-imposed plot of 24 hr Cooling Load Profile RT (Example)

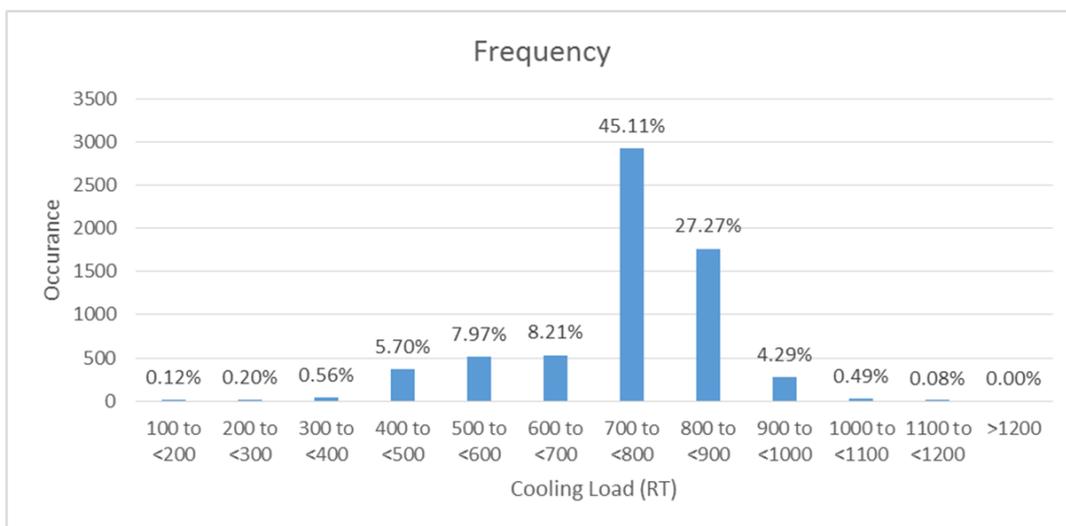


Figure 2: Histogram of Cooling Load Occurrences (Example)

Chiller System Performance Analysis (1 week data) – Cont'd

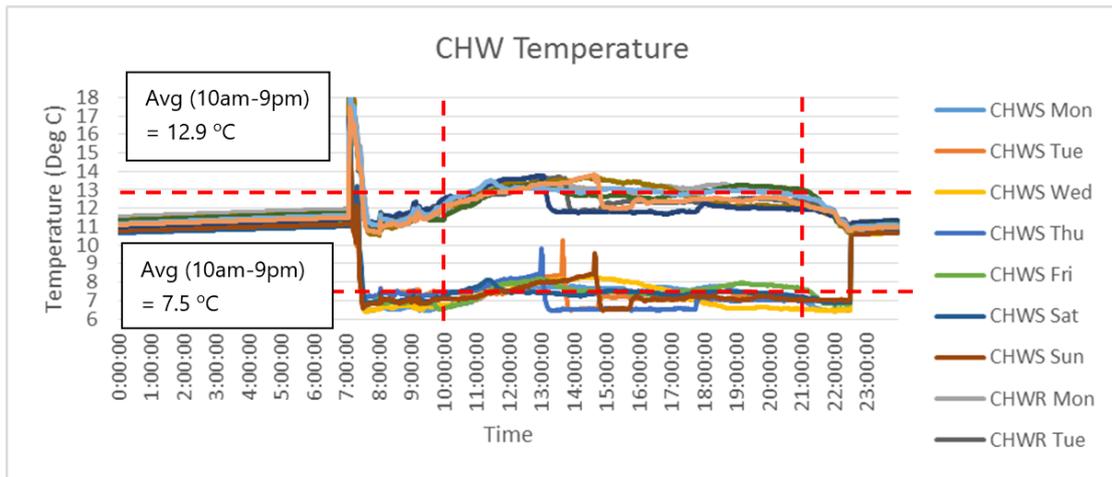


Figure 3: Super-imposed plot of daily chilled water supply/return temperature °C (Example)

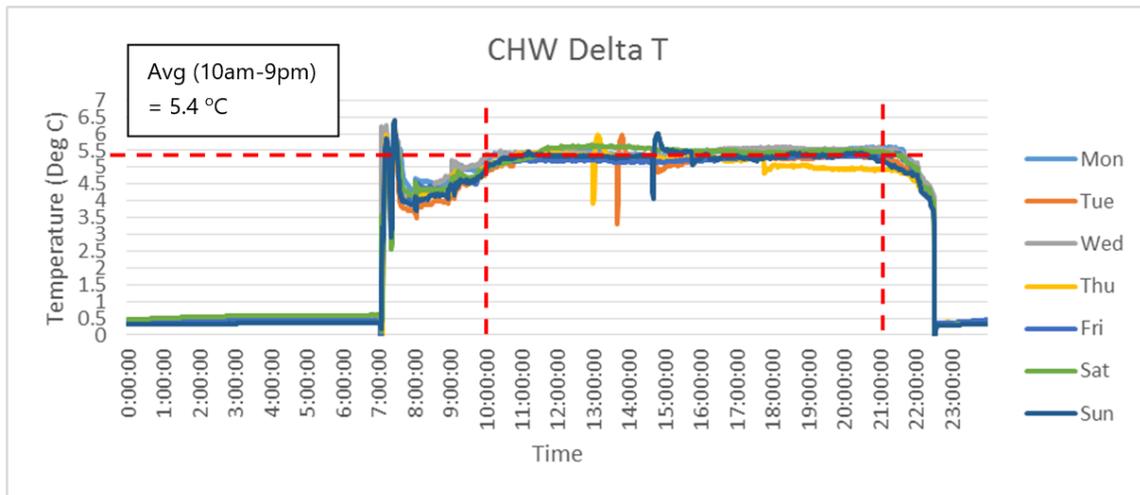


Figure 4: Super-imposed plot of daily chilled water temperature difference °C (Example)

Chiller System Performance Analysis (1 week data) – Cont'd

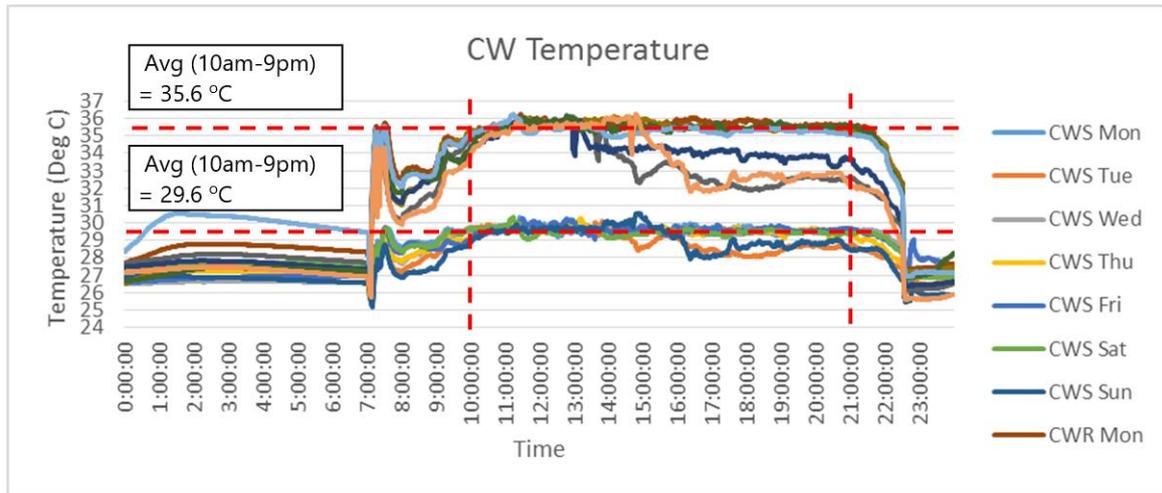


Figure 5: Super-imposed plot of daily condenser water supply/return temperature °C (Example)

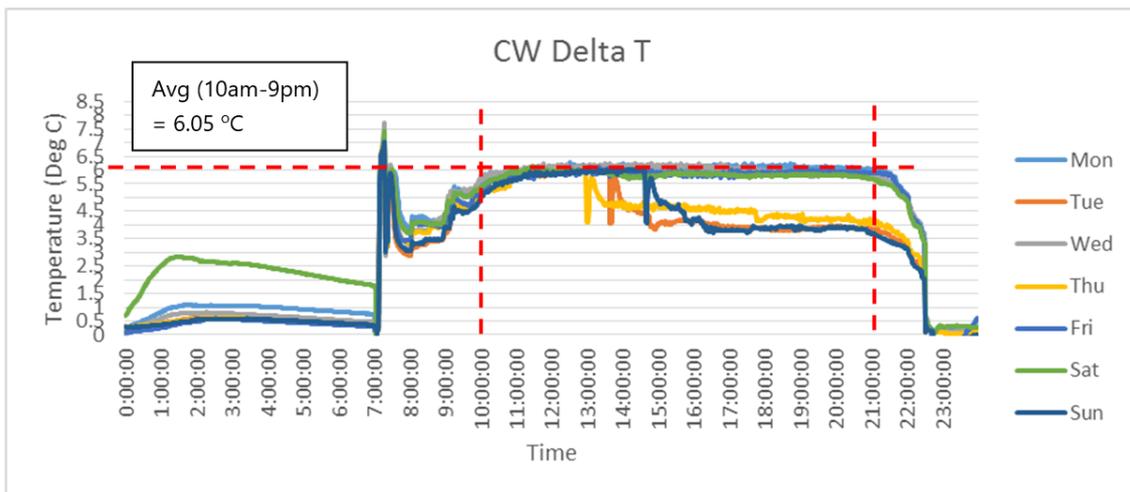


Figure 6: Super-imposed plot of daily condenser water temperature difference °C (Example)

Chiller System Performance Analysis (1 week data) – Cont'd

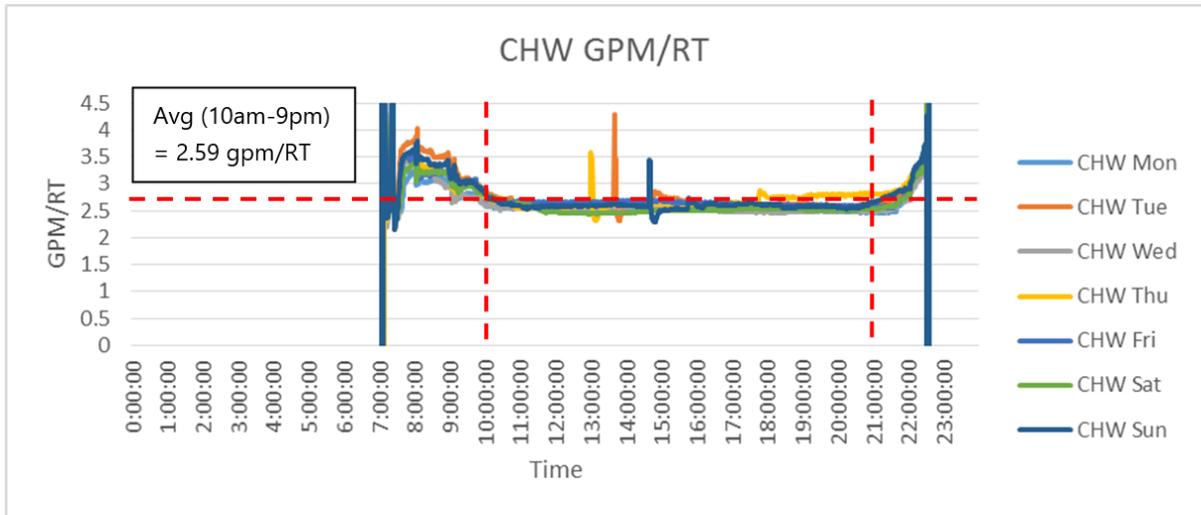


Figure 7: Super-imposed plot of daily chilled water GPM/RT (Example)

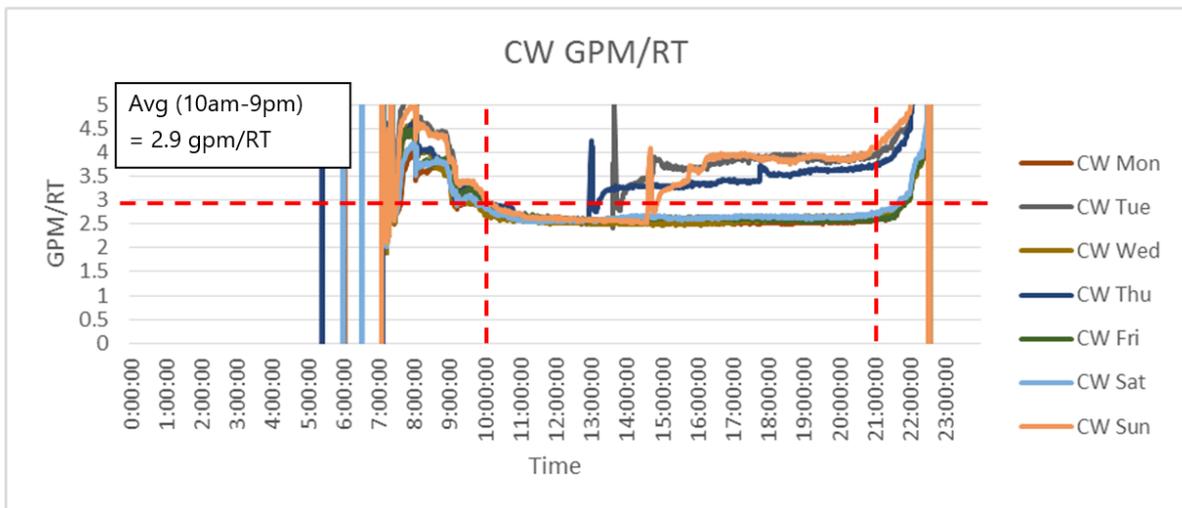
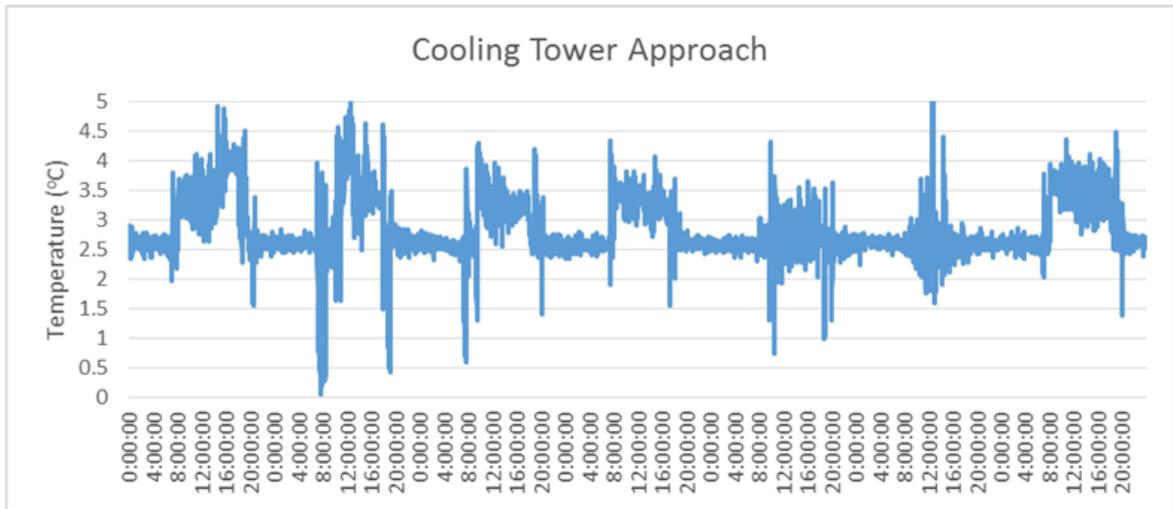


Figure 8: Super-imposed plot of daily condenser water GPM/RT (Example)



*Figure 9: Cooling Tower Approach Temperature (Example)

*This is required if using wet bulb temperature as set point

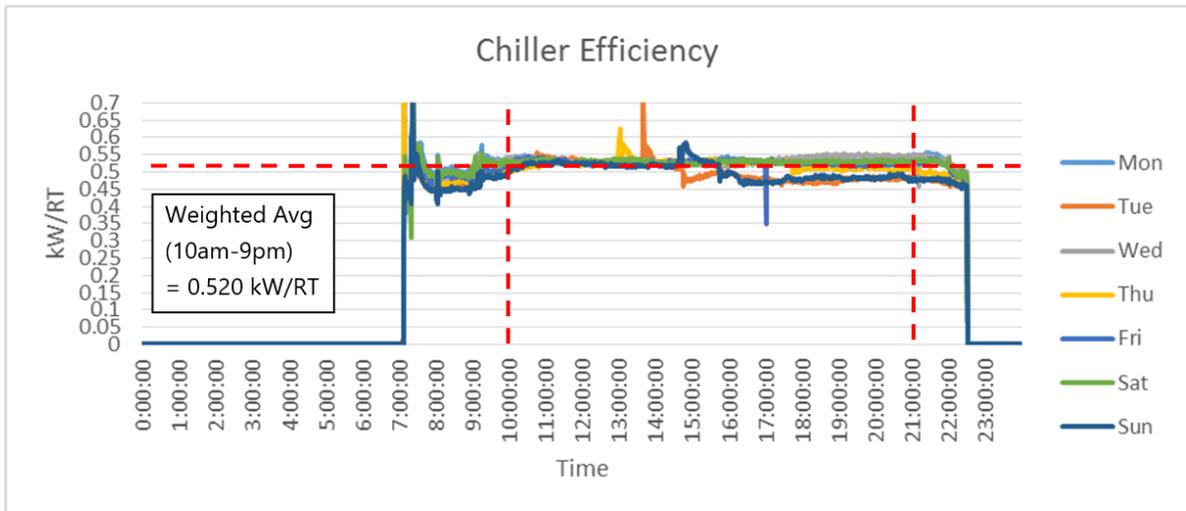


Figure 10: Super-imposed plot of daily chiller efficiency kW/RT (Example)

Note : Weighted average = $\sum \text{kW-hr} / \sum \text{RT-hr}$

Chiller System Performance Analysis (1 week data) – Cont'd

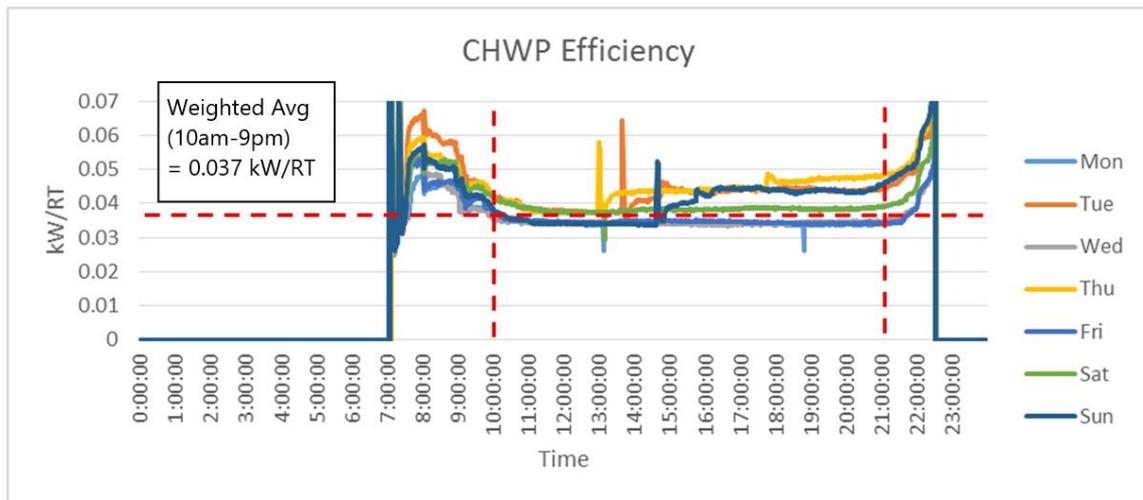


Figure 11: Super-imposed plot of daily chilled water pump efficiency kW/RT (Example)

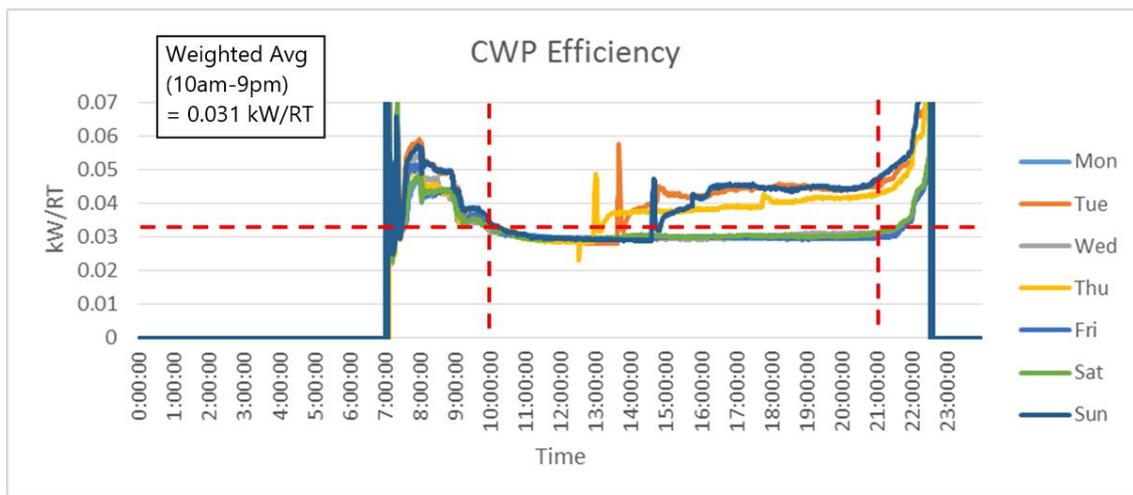


Figure 12: Super-imposed plot of daily condenser water pump efficiency kW/RT (Example)

Chiller System Performance Analysis (1 week data) – Cont'd

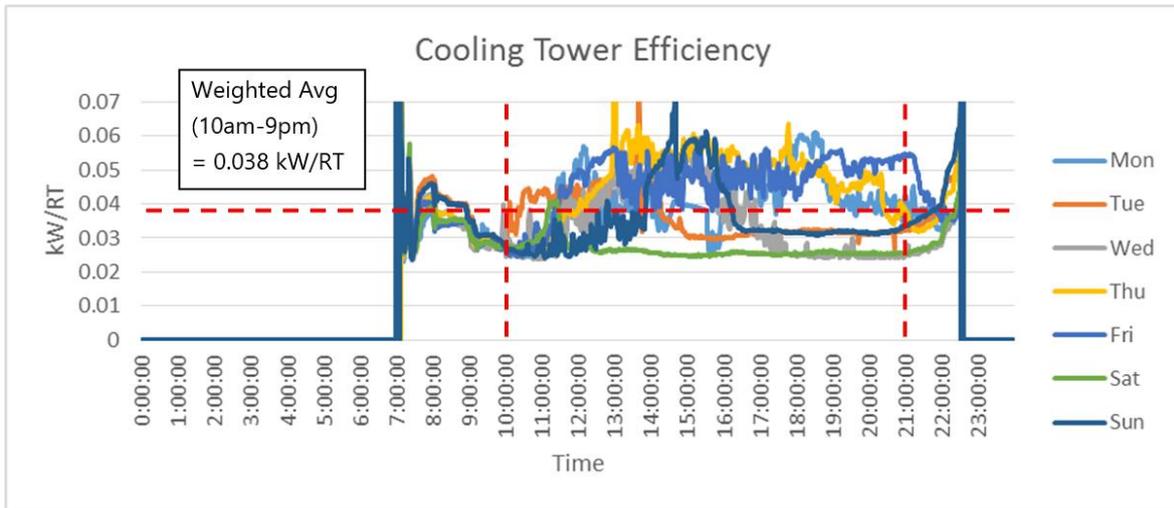


Figure 13: Super-imposed plot of daily cooling tower efficiency kW/RT (Example)

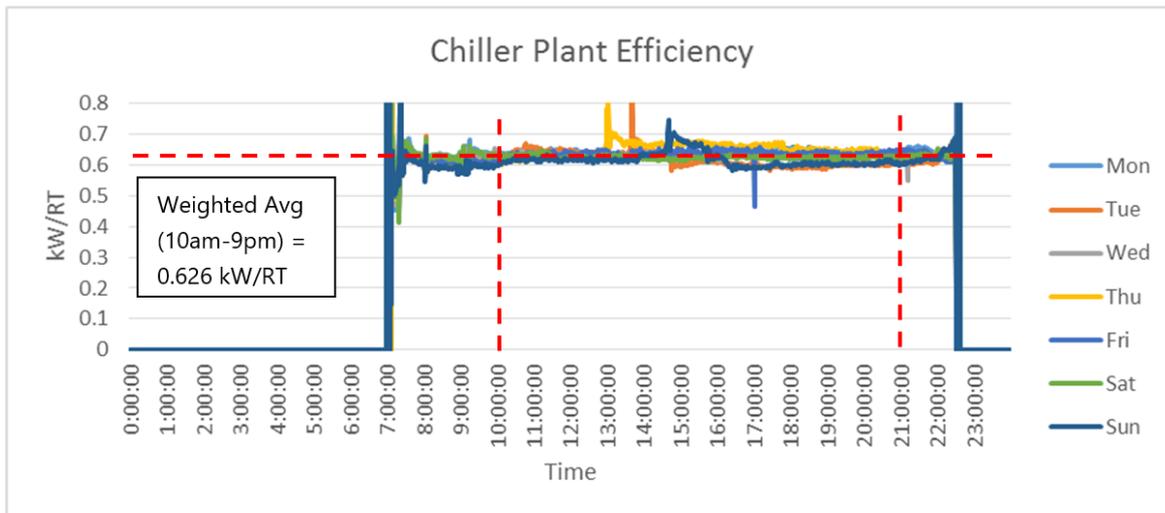


Figure 14: Super-imposed plot of daily chiller plant system efficiency kW/RT (Example)

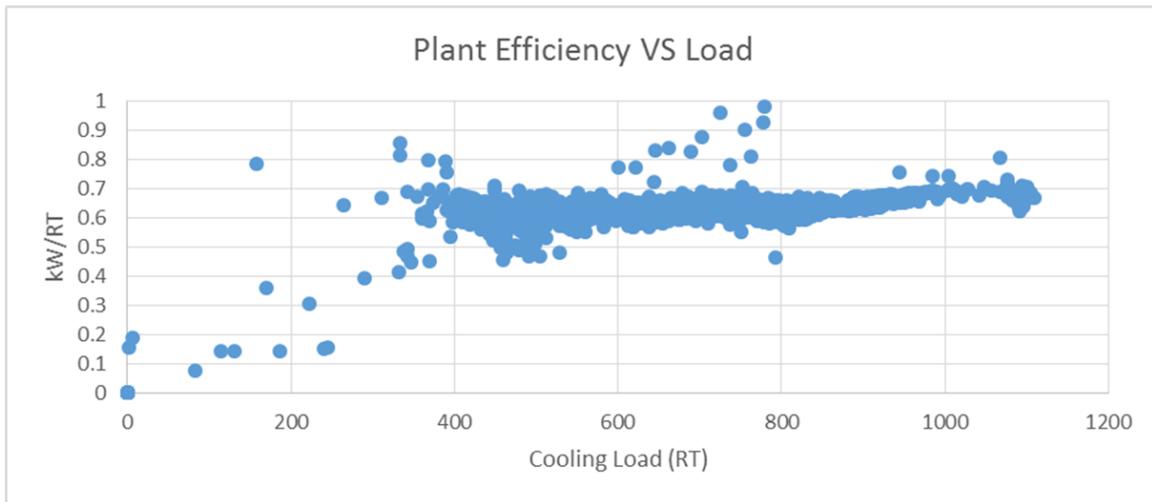


Figure 15: Scatter plot of chiller plant efficiency over cooling load (Example)

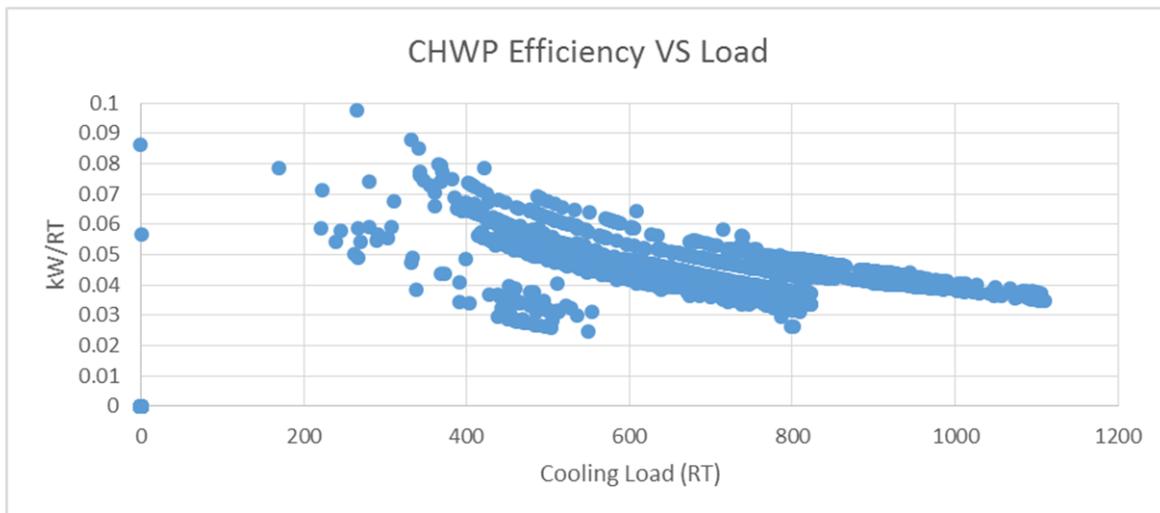


Figure 16: Scatter plot of chilled water pump efficiency over cooling load (Example)

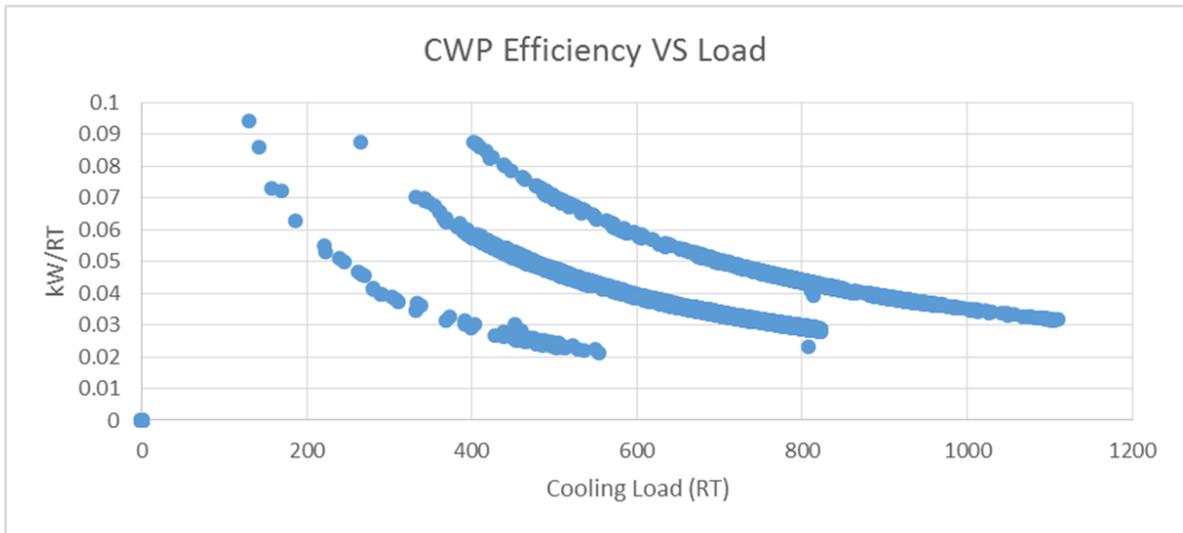


Figure 17: Scatter plot of condenser water pump efficiency over cooling load (Example)

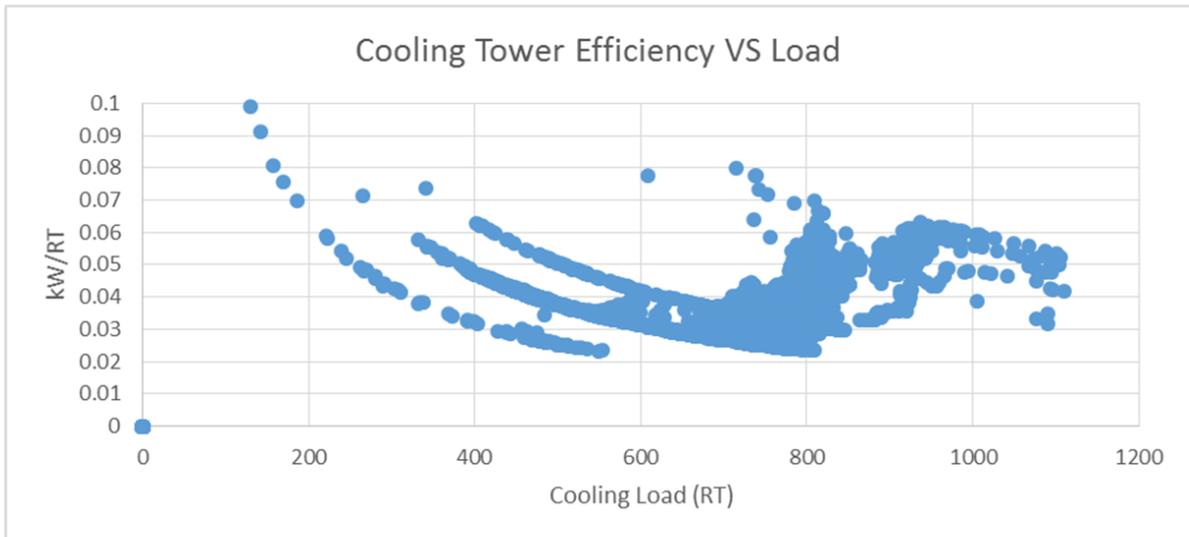


Figure 18: Scatter plot of cooling tower efficiency over cooling load (Example)

Chilled Water System Operating Performance

The following data and performance indicators are to be provided:

Daily Average Reading	Period		Unit
	Day-time	Night-time	
Cooling Load			RTh
Cooling Load Density (Air-con area)			m ² /RT
Power Consumption			kWh
Chilled water supply temperature			°C
Chilled water return temperature			°C
Chilled water delta T			°C
Chilled water flow rate			l/s
Chilled water flow rate vs cooling load			USgpm/RT
*Condenser heat rejection			HRT
*Condenser water supply temperature			°C
*Condenser water return temperature			°C
*Condenser water delta T			°C
*Condenser water flow rate			l/s
*Condenser water flow rate vs cooling load			USgpm/RT
Chiller(s) efficiency			kW/RT
Chilled water pump(s) efficiency			kW/RT
*Condenser water pump(s) efficiency			kW/RT
*Cooling tower(s) efficiency			kW/RT
Overall chilled water system efficiency			kW/RT

Note :

- (1) The data in relation condenser pumps and cooling towers will not be applicable for air-cooled chilled water system.
- (2) For comparison with the prevailing energy efficiency standard set, the energy performance can be determined based on the following operating hours for the different building typologies.

Building Type	Operating Hours
Office Building	Monday to Friday: 9a.m. to 6p.m.
Retail Malls	Monday to Sunday: 10a.m. to 9p.m.
Hotels/Hospital	Monday to Sunday: 24 hours
Other buildings	Building specific operating hours

The energy performance for the off-peak period or night-time should be considered if the cooling load demands are significant and presents opportunities to reduce energy consumption.

Building Name : Example Building			
(G) Energy Efficiency of Building Cooling System – Cont’d			
Air Distribution System			
Measurement of Air Distribution System Energy Efficiency			
Air Handling Units (AHUs)			
Sample size	Minimum of 5 no. of AHUs or 10% of the total number of AHUs, whichever is higher (Cap at 10 no.)		
Measurement Duration	For BMS/EMS integrated systems: 1 week logging period at 5 min interval For systems that are not linked to BMS/EMS systems: Spot measurement or via VSD with 1 day logging period at 5-min interval		
Individual Air Handling Unit (AHU) Operating Performance			
The following data and performance indicators are to be provided:			
Parameters	Units	Measurement Approach	Compliance level
Rated Power	kW	Nameplate	Required
Rated Capacity	kW (RT)	Nameplate	Required
Operating Cooling Load	RT	Trend data from BMS/ EMS or Computation	Required
Input Power	kW	Trend data from BMS/ EMS /VSD or Spot measurement	Required
Off Coil Air Temp, RH	°C, %	Spot measurement	Required
On Coil Air Temp, RH	°C, %	Spot measurement	Required
Space Air Temp, RH, CO ₂	°C, %, ppm	Spot measurement	Required
CHWS Temp	°C	Trend data from BMS/EMS or onsite measurement	Recommended
CHWR Temp	°C	Trend data from BMS/EMS or onsite measurement	Recommended
CHW Flow	l/s or GPM	Trend data from BMS/EMS or onsite measurement	Recommended
Filter Area	m ²	Site measurement or technical specification	Required if no trend data for Air flow rate
Air Velocity	m/s	Spot measurement	
Air Flow Rate	CMH	Trend data from BMS/EMS or Computation	Required
Outside Air Velocity	m/s	Spot measurement	Recommended
Outside Air Flow Rate	CMH	Computation	Recommended
Outside Air Ventilation Rate	CMH/m ²	Computation	Recommended
Fan Efficiency	W/CMH	Computation	Required
Air Handling Unit (AHU) Efficiency	kW/RT	Trend data from BMS/ EMS or Computation	Required

Cont'd

Parameters	Units	Measurement Approach	Compliance level
Differential pressure across filter	Pa	Spot measurement	Recommended
Differential pressure across cooling coil	Pa	Spot measurement	Recommended
External Static Pressure	Pa	Spot measurement	Recommended

Fan Coil Units (FCUs)

Sample size	Minimum of 10% of the total number of FCUs
Duration	For BMS/EMS integrated systems: Logged data for 1 week at 5 min interval For systems that are not linked to BMS/EMS systems : Spot measurement or equipment nameplate

Individual Fan Coil Unit (FCU) Operating Performance

Parameters	Units	Measurement Approach	Compliance level
Rated Power	kW	Nameplate	Required
Rated Capacity	kW (RT)	Nameplate	Required
Input Power	kW	Trend data from BMS/EMS or Computation	Required
Space Air Temp, RH, CO ₂	°C, %, ppm	Spot measurement	Required
Fan Efficiency	W/CMH	Computation	Required
Fan Coil Unit (FCU) Efficiency	kW/RT	Trend data from BMS/ EMS or Computation	Required

Overall Air Distribution System Operating Performance at Building Level

Summary of Air Distribution System Operating Performance

Air Distribution System	No.	∑ Power consumption	Unit
Pre-AHUs			kWh
AHUs			kWh
FCUs (nameplate or input power x operation hrs)			kWh
(A) Total power consumption from all AHUs and FCUs	-		kWh
(B) Chilled water system cooling load	-		RTh
Overall air distribution system efficiency, $\eta_{a (Overall)}$ (A/B)	-		kW/RT

Building Name : Example Building

(G) Energy Efficiency of Building Cooling System – Cont'd

Total System Efficiency (TSE) of Building Cooling System

Total System Efficiency (TSE) of building cooling system is the combined system efficiency of the chiller water system (comprising chillers, pumps, cooling towers) and the air distribution system (comprising air handling system such as AHUs, FCUs etc). The following two tables illustrate the information required to be submitted showing the derivation of the TSE of the building cooling system during building operation and audit duration. The tables are to be read in conjunction with each other.

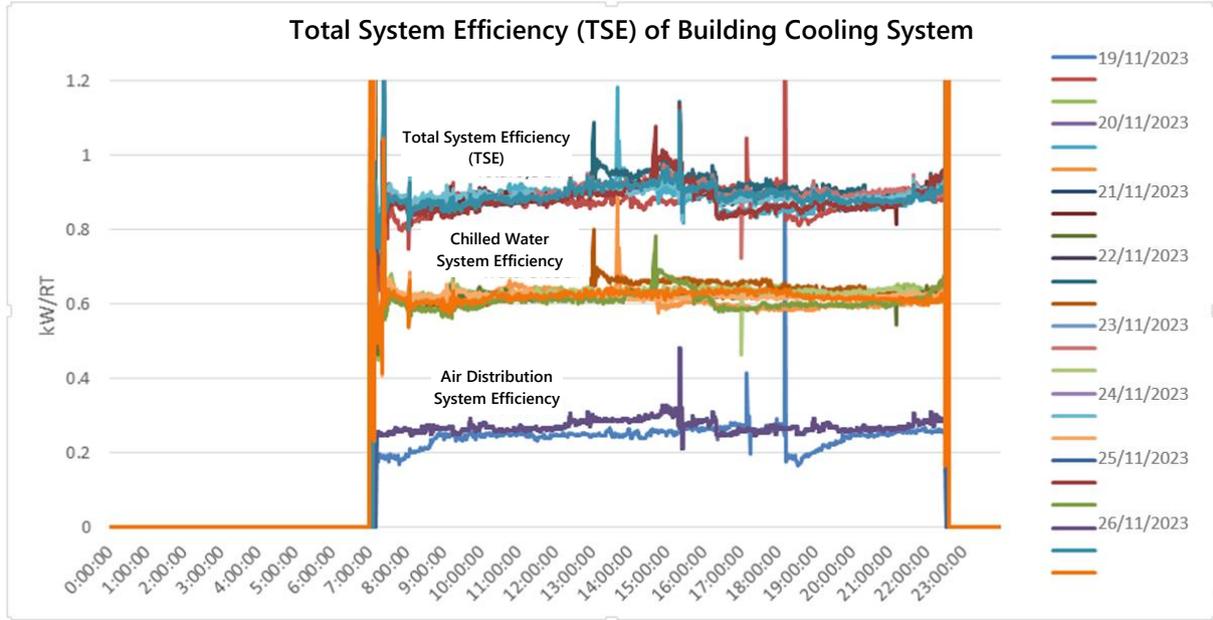
Chilled Water System											
Time	Cooling Load (RT)	No. of Chiller(s) in operation	Chiller(s) power input (kW)	No. of Chilled Water Pump(s) in operation	CHWP Power Input (kW)	No. of Condenser Water Pump(s) in operation	Condenser water pump(s) power input (kW)	No. of Cooling Tower(s) in operation	Cooling Tower(s) power input (kW)	Total Chilled Water System Power Input (kW)	Chilled Water System Efficiency (kW/RT)
	(A)		(B)		(C)		(D)		(E)	(F)=(B)+(C)+ (D) + (E)	(G) = (F)/(A)
9:00											
10:00											
11:00											
12:00											
13:00											
14:00											
15:00											
16:00											
17:00											
18:00											
...											

Air Distribution System								
Time	Please state the Configuration of Air Distribution System (FCU, PAU, AHU (CAV,VAV) etc.	Total CAV AHU Motor Input Power (kW)	Total VAV AHU Motor Input Power (kW)	Total FCU Motor Nameplate Input Power (kW)	Total Air Handling /Distribution System Motor Input Power (kW)	Air Handling/ Distribution System Efficiency (kW/RT)	Total Power Input (kW)	Total System Efficiency of Building Cooling System (kW/RT)
		(H)	(I)	(J)	(K)=(H)+(I)+(J)	(L)=(K)/(A)	(M)=(F)+(L)	(M)/(A)
9:00								
10:00								
11:00								
12:00								
13:00								
14:00								
15:00								
16:00								
17:00								
18:00								
...								

Total System Efficiency (TSE) of Building Cooling System – Cont'd

Summary of Building Cooling System Operating Performance

Example of super-imposed plot of daily Total System Efficiency (kW/RT)



Daily Average Reading	Period		Unit
	Day-time	Night-time	
Air Distribution System Efficiency			kW/RT
Chilled Water Plant/System Efficiency			kW/RT
Total System Efficiency (TSE) of Building Cooling System			kW/RT

Note : For the comparison with the prevailing energy efficiency standard set, the energy performance can be determined based on the following operating hours for the different building typologies.

Building Type	Operating Hours
Office Building	Monday to Friday: 9a.m. to 6p.m.
Retail Malls	Monday to Sunday: 10a.m. to 9p.m.
Hotels/Hospital	Monday to Sunday: 24 hours
Other buildings	Building specific operating hours

The energy performance for the off-peak period or night-time should be considered if the cooling load demands are significant and presents opportunities to reduce energy consumption.

Building Name : Example Building

(G) Energy Efficiency of Building Cooling System – Cont'd

Unitary Air-conditioning Systems

Determination of the Energy Efficiency of Unitary Air-Conditioning System

Unitary Air-Conditioners (Single or combination of systems)

- Variable Refrigerant Flow (VRF) system
- Single-Split Units
- Multi-Split Units
- Air-Distribution System

For VRF system with built-in monitoring capabilities for energy efficiency

Energy efficiency data can be collected from the VRF system's built-in monitoring tools over a 1-week period for all operating hours of the system.

For other VRF system, single-split and multi-split unitary air conditioners

Based on the system's specifications, age, and typical operational patterns to estimate the current energy efficiency of the VRF system to obtain a general gauge of energy performance with due consideration of factors such as maintenance records, actual usage patterns, and site constraints that may influence the actual efficiency.

For consistency, the system energy efficiency can be derived based on the concept of Integrated Energy Efficiency Ratio (IEER), which would consider the different load capacities with due consideration for part-load conditions. However, this could be adjusted based on audit findings of the actual operating conditions to better reflect the energy performance of the system.

VRF System	Single-split and Multi-split Unitary Air Conditioners
$IEER = (0.020 \times A) + (0.617 \times B) + (0.238 \times C) + (0.125 \times D)$ <p>where A = EER or COP at full load B = EER or COP at 75% load C = EER or COP at 50% load D = EER or COP at 25% load</p>	$COP_{weighted} = 0.4 \times COP_{100\%} + 0.6 \times COP_{50\%}$ <p>where <i>COP_{100%} is defined as the ratio of the cooling capacity to effective power input at full load cooling capacity</i> <i>COP_{50%} is defined as the ratio of the cooling capacity to effective power input at 50% cooling capacity</i></p>

Where there is a combination of unitary air-conditioning systems serving different zones, the weighted system efficiency will be determined by pro-ration according to the respective cooling capacity served and expressed as follows:

Energy efficiency of unitary air-conditioning system	$EE_{Weighted} \text{ (in kW/RT)} = \frac{3.517 / \sum(\text{Cooling Capacity} \times IEER \text{ or } COP_{weighted})_i}{\text{Total Cooling Capacity}_{overall}}$
---	---

Determination of the Energy Efficiency of Unitary Air-Conditioning System – Cont'd

Example of determining the Total System Efficiency of VRF system

Step 1 – Determine the individual IEER of the condensing units based on the load conditions of 100%, 75%, 50% and 25% can be based on published technical specifications or verification testing results.

Outdoor Condenser Units / System	Zone	Location Served	Specification of VRF Outdoor Condensing Unit					IEER _i (0.020 x A) + (0.617 x B) + (0.238 x C) + (0.125 x D)	
			Full Installed Capacity (KW)	Designed Cooling Capacity (kW)	100% EER (A)	75% EER (B)	50% EER (C)		25% EER (D)
VRF System 1	1	FCC Room	22.4	14.18	4.1	5.5	7.3	7.6	6.16
		Lift lobby Corridor							
		Reception							
VRF System 2	2	Office 1	44.8	28.36	3.90	5.20	7.10	7.90	5.96
	3	Office 2	44.8	28.36	3.90	5.20	7.10	7.90	5.96
	4	Office 3	44.8	28.36	3.90	5.20	7.10	7.90	5.96
Total cooling capacity :			156.8	99.26	-	-	-	-	-

Step 2 – Determine the overall weighted system efficiency of condensing units by proration.

Weighted Design System Efficiency of outdoor condenser units, $\eta_{c(Overall)}$ (kW/RT) will be as follows :

$$\eta_{c(Overall)} \text{ (in kW/RT)} = 3.517 / \left(\frac{\sum (\text{Cooling capacity} \times \text{IEER}_i)}{\text{Total Cooling Capacity}_{(Overall)}} \right)$$

$$= 3.517 / \left(\frac{(14.18 \times 6.16) + (28.36 \times 5.96) \times 3}{99.26} \right) = 0.608 \text{ kW/RT}$$

If site deration factor is about 10%, corrected $\eta_{c(Overall)} = 0.608 \times 1.1 = 0.668 \text{ kW/RT}$

Step 3 – Determine the individual air distribution system efficiencies. For simplicity, the air distribution system efficiency can be derived based on rated cooling capacity and nameplate motor power from the technical specification in particular for fans coil units with speed determined by the constant frequency of the power supply. The derivation of overall air distribution system efficiency is as follows:

Indoor Unit / System	Zone	Location Served	Specification of Air Distribution Units				Air Distribution System efficiency based on design cooling capacity η_a in kW/RT
			Unit Type	Installed Capacity (kW)	Design cooling Capacity (kW)	Nameplate Motor Power (kW)	
VRF System 1	1	FCC Room	Ceiling Cassette (FCUs)	4.2	2.67	0.043	0.0569
		Lift lobby Corridor	Ceiling Cassette (FCUs)	9.0	5.70	0.092	0.0568
		Reception	Ceiling Cassette (FCUs)	9.0	5.70	0.092	0.0568
VRF System 2	2	Office 1	Ducted FCUs	44.0	27.85	1.8	0.2273
	3	Office 2	Ducted FCUs	44.0	27.85	1.8	0.2273
	4	Office 3	VAV AHUs	44.8	28.36	5.2	0.6449
	Total:				155	98.13	9.027

Determination of the Energy Efficiency of Unitary Air-Conditioning System – Cont'd

Step 4 – Determine the overall weighted system efficiency of air distribution system by proration.

Weighted System Efficiency of air-distribution system, $\eta_{a(\text{overall})}$ (in kW/RT) will be as follows :

$$\begin{aligned} \eta_{a(\text{Overall})} \text{ (in kW/RT)} &= \left(\frac{\sum (\text{Cooling capacity} \times \eta_{a_i})}{\text{Total Cooling Capacity}_{(\text{Overall})}} \right) \\ &= \left(\frac{(2.67 \times 0.0569) + 2 \times (5.70 \times 0.0568) + 2 \times (27.85 \times 0.227) + (28.36 \times 0.645)}{98.13} \right) \\ &= 0.324 \text{ kW/RT} \end{aligned}$$

Step 5 – Derive the Total System Efficiency (TSE) of the proposed VRF system

Total system efficiency, TSE (in kW/RT) = $\eta_c(\text{overall}) + \eta_a(\text{overall})$

$$= 0.668 + 0.324 = 0.992 \text{ kW/RT}$$

For simplicity, the system efficiency of the VAV-AHUs derived was assumed to be at full load condition similar to that for FCUs. To have a better estimate for the energy consumption for the case of Variable Air Volume (VAV) AHUs with VSDs, the part load fan power calculator from ASHRAE 90.1, Table G3.1.3.15, Part-Load Performance for VAV Fan Systems, Method 2 – Part-Load Fan Power Equation can be used to account for the part-load performance.

Building Name : Example Building

(H) Schedule of Space Operating Condition

Other than the energy efficiency of building cooling system, there should have checks on the space operating conditions and thermal comfort by having a minimum of 10 spot measurements of indoor air conditions – dry bulb temperature, relative humidity and carbon dioxide concentration. Any observation on over-cooling/ under-cooling or inadequate ventilation should be highlighted to building owner for further assessment. An example of space condition schedule to be provided is as follows:

Room name (i.e. Air conditioned occupied/ common Spaces)		Normal operating room conditions		Measured		
		Dry Bulb Temperature (°C)	Relative Humidity (%)	*Dry Bulb Temperature (°C)	*Relative Humidity (%)	*CO ₂ Concentration (ppm)
1	i.e. Office 1					
2	i.e. Office 2					
3	i.e. Meeting Room 1					
4	i.e. Meeting Room 2					
5					
6					
7					

Building Name : Example Building

(I) Key Findings and Potential Energy Efficiency Improvement Measures

The key findings are to be provided and should be presented in a clear and concise manner providing the observation and context. Some examples below for reference.

Audit Finding (1)	
Focus Area	Chilled water system efficiency
Key Observations	<ul style="list-style-type: none"> (a) Two 500-ton centrifugal chillers of about 10 years old (b) Serving a 25,000 m² office complex (c) Current chilled water system efficiency : 0.85 kW/RT (d) Industry benchmark: 0.60 kW/ton for similar systems (e) System is operating in bottom 30% of efficiency range (f) Current chilled water system efficiency averages 0.85 kW/ton, about 30% below industry benchmark. Trend logs show frequent cycling at low loads and suboptimal sequencing. The main chillers are operating significantly below the designed efficiency levels, resulting in an estimate increase in energy consumption and operating costs by 30%. It was observed to have some potential issues with maintenance, control settings, and component degradation.
Potential Measures	<ul style="list-style-type: none"> (1) Conduct a comprehensive maintenance, including tube cleaning, refrigerant charge optimisation. (2) Chiller system optimisation, including upgrading control system for improved sequencing and load management. (3) Complement with installation of smaller capacity chiller to cater to low load conditions
Audit Finding (2)	
Focus Area	Air Distribution System Operation
Key Observations	<ul style="list-style-type: none"> (a) Existing AC fan motors in the AHUs are standard efficiency type, operating at constant speed regardless of load variations though they are equipped with VSDs. There are some signs of aging with reduced efficiency. Current fan system efficiency is below optimal levels, with higher energy consumption and maintenance requirements. (b) The supply air temperature setpoint remains constant at 13°C regardless of building load conditions. (c) Dirty cooling coils and blocked filters causing reduced heat transfer and increased fan power.
Potential Measures	<ul style="list-style-type: none"> (1) Optimise existing system: <ul style="list-style-type: none"> • Implement proper VSD control strategies based on demand • Service/repair existing motors and drives • Review and calibrate pressure sensors • Commission proper control sequences (2) Consideration to replace existing AC motors with electronically commutated (EC) fans which come with higher motor efficiency (about 30% energy savings compared to AC motors) and better part-load performance (3) Establish regular cleaning schedule and preventive maintenance programme for cooling coils along with filter differential pressure monitoring.

Audit Finding (3)	
Focus Area	Lighting system efficiency and use
Key Observations	<ul style="list-style-type: none"> (a) Current lighting using T8 fluorescent tubes (32 W) with magnetic ballasts for all office spaces of 20,000 m² (b) No occupancy sensors or daylight harvesting systems (c) Lighting accounts for 15% of the total building energy consumption (d) Current lighting system operates at an average efficacy of 60 lumens/watt, significantly below modern standards. Light level measurements show over-illumination in 50% of the office space, with an average of 650 lux at desk level. Energy monitoring reveals that 30% of lighting energy is consumed outside of standard operating hours. Estimated annual lighting energy consumption: 1,200,000 kWh Calculated lighting power density: 12 W/m², compared to best practice of 5-7 W/m²
Potential Measures	<ul style="list-style-type: none"> (1) Replace existing fixtures with LED panels (efficacy > 120 lumens/watt) (2) Install occupancy sensors in less frequently accessed areas (3) Use time scheduling for open office areas, with manual override capability (4) Integrate lighting control with the building management system upgrade
Audit Finding (4)	
Focus Area	Carpark ventilation system
Key Observations	<ul style="list-style-type: none"> (a) Conventional carpark ventilation system for all zones. (b) It was observed that the carpark ventilation system is operating at full speed with fixed air changes per hour. It is expected to have higher energy consumption due to constant operation.
Potential Measures	<ul style="list-style-type: none"> (1) Upgrade to facilitate demand-controlled ventilation with CO sensors to monitor the air quality and modulate the fan speeds of the supply and exhaust fans based on CO level (2) Reduction in energy consumption by way of operational scheduling. For e.g. to align ventilation with peak usage patterns, to reduce ventilation during low occupancy period and have such interface with carpark management system to facilitate such monitoring.
Audit Finding (5)	
Focus	Excessive air leakage via door openings at entrance A & B
Key Observations	<ul style="list-style-type: none"> (a) Door openings and lobby areas leading to building XYZ are not enclosed. (b) Excessive infiltration of hot/humid outdoor air and loss of conditioned air was observed. This may have attributed to higher cooling load and energy consumption.
Potential Measures	<ul style="list-style-type: none"> (1) Adjustment of pressure control by optimising the AHU settings for proper pressurisation and balance the air distribution. (2) Install automated self-closing doors to minimise excessive air leakage

Building Name : Example Building

(I) Key Findings and Potential Energy Efficiency Improvement Measures – Cont’d

Audit Finding (6)	
Focus Area	Centralised hot water system operation (electric boilers)
Key Observations	(a) The hot water system was operating on a high operating temperature (65°C) maintained throughout the day regardless of demand. (b) Circulation pumps operating at constant speed 24/7 (c) Significant heat loss from poorly insulated distribution pipes
Potential Measures	(1) System Optimisation by implementing demand-based temperature control. (2) Install VSD for circulation pumps and demand-based circulation control (3) Improve on system insulation (4) Replace with high efficiency boiler (5) Tap on heat recovery from chiller condensers
Audit Finding (7)	
Focus Area	Partnership with Tenants and Users
Key Observations	(a) Lack of structured tenant/user engagement in reducing energy consumption. (b) Energy saving efforts are fragmented, with no clear framework for tenant participation or incentives for energy-saving behaviors
Potential Measures	(1) Energy performance requirements in lease agreements (2) Guidelines for fit out works (3) Protocol for air-conditioning usage during off-peak hours (4) Cost-sharing mechanism for energy efficiency improvements (5) Tenant energy management programme (6) Performance-linked rental rebates

Summary List of Potential Energy Efficiency Improvement Measures and Selection

A summary list of all potential measures shall be tabulated in the format shown in the following table. For each measure, indicate:

- The system or initiative involved
- Energy saving potential (at system and building level)
- Potential cost range

For simplicity, the energy saving potential and likely implementation cost shall be classified as High, Medium, or Low, with ranges clearly defined by the specified individual in consultation with the building owner. Key assumptions and relevant factors shall be included where necessary for clarity.

Summary List of Potential Energy Efficiency Improvement Measures and Selection							
S/No.	List of Potential Measures	Building System/ Initiative	Energy Saving Potential (High/Medium/Low)		Potential Cost (High/Medium/Low)	Selection (Y/N)	Remarks
			System Level	Building Level			

Note that the energy saving potential at system level refer to the % savings specific to the system being modified and the energy saving potential at building level refer to the % savings relative to the total building energy consumption.

Building Name : Example Building

(I) Key Findings and Potential Energy Efficiency Improvement Measures – Cont’d

Example of a summary list of potential measures and selection :

Summary List of Potential Measures and Selection (example)							
S/No.	List of Potential Measures	Building System/ Initiative	Energy Saving Potential (High/Medium/Low)		Potential Cost (High/Medium/Low)	Selection (Y/N)	Remarks/ Reasons (if not implementing)
			System Level	Building Level			
1	Conduct comprehensive maintenance including tube cleaning and refrigerant charge optimisation	Chiller system	Low	Low	Low	Yes	
2	Chiller optimisation including upgrading of control system	Chiller system	High	High	Medium	Yes	
3	Installation of smaller capacity chiller	Chiller system	High	High	High	Yes	
4	AHUs system optimisation	AHUs	Medium	Medium	Medium	Yes	
5	Replacement with EC fans	AHUs	High	Medium	Medium	No	To be considered at later stage as existing systems are within service life.
6	Regular cleaning schedule and preventive maintenance programme for cooling coils along with filter differential pressure monitoring	AHUs	Low	Low	Low	Yes	
7	Replacement of existing fixtures with LED panels	Lighting system	Low	Low	Low	Yes	
8	Install occupancy sensors in less frequently accessed areas	Lighting system	Low	Low	Low	Yes	
9	Use time scheduling for open office areas, with manual override capability	Lighting system	Low	Low	Low	Yes	
10	Integrate lighting control with the building management system upgrade	Lighting system	Medium	Low	Medium	No	Incompatible existing lighting circuits/systems

Building Name : Example Building

(I) Key Findings and Potential Energy Efficiency Improvement Measures – Cont’d

Example of a summary list of potential measures and selection – Cont’d

Summary List of Potential Measures and Selection (example)							
S/No.	List of Potential Measures	Building System/ Initiative	Energy Saving Potential (High/Medium/Low)		Potential Cost (High/Medium/Low)	Selection (Y/N)	Remarks
			System Level	Building Level			
11	Upgrade with demand-controlled ventilation with CO sensors to monitor the air quality and modulate the fan speeds of the supply and exhaust fans based on CO level	Carpark ventilation System	Medium	Low	Medium	No	Limited BMS integration capability for carpark systems
12	Change operational scheduling by aligning ventilation with peak usage patterns, to reduce ventilation during low occupancy period	Carpark ventilation System	Medium	Low	Low	Yes	
13	Adjustment of pressure control by optimising the AHU settings for proper pressurisation and balance the air distribution.	AHUs in relation to air leakage	Medium	Low	Low	Yes	
14	Install automated self-closing doors to minimise excessive air leakage	Door provision	Medium	Low	Low	Yes	
15	System Optimisation by implementing demand-based temperature control.	Centralised hot water system	High	Medium	Medium	No	Plan for boiler replacement
16	Install VSD for circulation pumps and demand-based circulation control	Centralised hot water system	High	Medium	Medium	No	Plan for boiler replacement
17	Improve on existing hot water system insulation	Centralised hot water system	Low	Low	Low	No	Plan for boiler replacement
18	Replace with high efficiency heat pump	Centralised hot water system	High	High	High	Yes	
19	Tap on heat recovery from chiller condensers	Centralised hot water system	Medium	Medium	Medium	Yes	Complement boiler replacement

Building Name : Example Building

(I) Key Findings and Potential Energy Efficiency Improvement Measures – Cont’d

Example of a summary list of potential measures and selection – Cont’d

Summary List of Potential Measures and Selection (example)							
S/No.	List of Potential Measures	Building System/ Initiative	Energy Saving Potential (High/Medium/Low)		Potential Cost (High/Medium/Low)	Selection (Y/N)	Remarks
			System Level	Building Level			
20	Energy performance requirements in lease agreements	Tenant partnership programme	NA	Medium	Low	Yes	Limit to new tenants or at lease renewal stage
20	Guidelines for fit out works to required energy efficient equipment	Tenant partnership programme	NA	Medium	Low	Yes	Limit to new tenants or at lease renewal stage
21	Protocol for air-conditioning usage during off-peak hours	Tenant partnership programme	NA	Low	Low	Yes	
22	Cost-sharing mechanism for energy efficiency improvements	Tenant partnership programme	NA	High	Medium	Yes	Subject to tenants' agreement to terms like energy data sharing
23	Tenant energy management programme	Tenant partnership programme	NA	Medium	Low	Yes	
24	Performance-linked rental rebates	Tenant partnership programme	High	High	Medium	No	Subject to tenants' agreement to terms like energy data sharing

Please provide the basis on how the energy saving potential and implementation cost are classified as High, Medium, or Low. For e.g.

Energy Saving Potential (example)		Potential Implementation Cost (example)
System Level	Building Level	
High: > 20% Medium: 5% to 20% Low: <5 %	High: > 1% Medium: 0.5% to 1% Low: <0.5 %	High: > \$1 million Medium: \$300,000 to \$1 million Low: < \$ 300,000

Note : Please state the assumptions, factors considered and other relevant information where relevant.

Part 2 Energy Efficiency Improvement Plan (EEIP)

- Feasibility assessment of EUI reduction
- Description of each recommended measures
- Expected energy savings and EUI reduction
- Implementation costs
- Simple payback period for each measure
- Implementation timeline

Energy Efficiency Improvement Plan (EEIP)

Based on the potential measures evaluated in Part 1, the specified individual, in consultation with the building owner, shall develop an EEIP to address the feasibility of EUI reduction and provide detailed descriptions of recommended measures to be implemented over the stipulated period of 3 years. The plan shall include expected energy and cost savings, implementation costs, simple payback period, and a timeline for implementation.

Feasibility Assessment of EUI Reduction

The specified individual is required to provide a written evaluation of whether the specified Energy Use Intensity (EUI) reduction can be achieved without major energy use change, specifically assessing if the target can be met without the installation, substantial alteration or replacement of the building cooling system.

If the specified EUI reduction of 10% cannot be achieved without major energy use change, please provide a detailed explanation including:

- The current constraints limiting the target 10% reduction in EUI from being met
- Recommendations on the necessary improvements to the cooling system to meet the target
- An estimate of the potential EUI reduction that could be achieved with these improvements.

List of recommended measures for implementation

The recommendations provided can be broadly grouped in two categories :

- (a) **Energy Reduction recommendation** which comprises measures that are not related to the installation, substantial alteration or replacement of the building cooling system such as
 - Maintenance-related works, including:
 - replacement of faulty sensors
 - replacement of air filter
 - hot water system insulation
 - install occupancy sensors for areas with intermittent occupancy
 - tuning of equipment to ensure optimal performance and energy efficiency
 - Chiller system optimisation
 - Air distribution system performance improvement and optimisation
 - Change of air-conditioned zones to naturally ventilated spaces
 - Incentive, collaboration programmes between tenants and owner or green leasing initiatives which impose requirements for tenants to adopt energy efficient practices or equipment
 - Conversion of spaces from full air-conditioning to hybrid cooling or natural ventilation
 - Others

(b) **Capital Investment recommendation** which involves major energy use change and energy efficiency retrofits. For e.g.

- | | |
|--|---|
| <ul style="list-style-type: none"> • System Replacements (Full/Partial) <ul style="list-style-type: none"> ○ Chiller systems/components ○ AHUs and FCUs ○ Pumps ○ Lighting systems ○ Mechanical ventilation ○ Centralised hot water systems | <ul style="list-style-type: none"> • New System Installations <ul style="list-style-type: none"> ○ Additional chiller plant ○ Complementary systems to existing setup ○ Self-closing doors/Air curtain systems • Major System Upgrades <ul style="list-style-type: none"> ○ Building management system overhaul ○ Control system upgrade |
|--|---|

Normative Information to be provided

Detailed description of each recommended measures must be provided along with the following details

- Proposed energy improvement measures to be implemented
- Building systems and initiatives to be addressed
- Electricity consumption before implementing the proposed measures.
- Expected electricity consumption after implementing the proposed measures
- Expected energy savings (in percentage and in kWh) and related cost savings.
- Estimated implementation cost and simple payback period
- Implementation timeline including expected time of implementation and completion

This information is to be provided in the tabulated form as shown below :

S/No.	Proposed Energy Improvement Measures	Building Systems/ Initiatives	Annual Electricity Consumption and Cost Savings					Cost and Simple Payback Period		Implementation Plan	
			Electricity Consumption (before EEIP) (kWh)	Expected Electricity Consumption (after EEIP) (kWh)	Percentage Savings (%)	Electricity Savings (kWh)	Cost Savings (\$)	Estimated Implementation Cost (\$)	Simple Payback Period (Year)	Start Date	Estimated End Date
Energy Reduction Recommendations											
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
Capital Investment Recommendations							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
							\$ -	\$ -			
Remarks :			∑ kWh	∑kWh	%	∑kWh	\$ -	\$ -			

Please provide parameters and documentation to support the energy and cost savings calculation including:

- Baseline data
- Calculation method
- Technical justification where relevant
- Implementation approach
- Verification approach to track results
- Electricity Tariff (cents/kWh)

An example of the tabulation is as shown below. Note that these two tables should be read in conjunction.

S/No.	Proposed Energy Improvement Measures	Building Systems/ Initiatives	Annual Electricity Consumption and Cost Savings				
			Electricity Consumption (before EEIP)	Expected Electricity Consumption (after EEIP)	Percentage Savings	Electricity Savings (kWh)	Cost Savings (\$)
Energy Reduction Recommendation							
1	Conduct comprehensive maintenance including tube cleaning and refrigerant charge optimisation	Chiller system					\$ -
2	Chiller optimisation including upgrading of control system	Chiller system					\$ -
3	AHUs system optimisation	AHUs					\$ -
4	Regular cleaning schedule and preventive maintenance programme for cooling coils along with filter differential pressure monitoring	AHUs					\$ -
5	Install occupancy sensors in less frequently accessed areas	Lighting system					\$ -
6	Use time scheduling for open office areas, with manual override capability	Lighting system					\$ -
7	Change operational scheduling by aligning ventilation with peak usage patterns, to reduce ventilation during low occupancy period	Carpark ventilation system					\$ -
8	Adjustment of pressure control by optimising the AHU settings for proper pressurisation and balance the air distribution.	AHUs in relation to air leakage					\$ -
9	Install automated self-closing doors to minimise excess air leakage	Door provision in relation to air leakage					
10	Energy performance requirements in lease agreements	Tenant Partnership Programme					
11	Guidelines for fit out works to required energy efficient equipment	Tenant Partnership Programme					
12	Protocol for air-conditioning usage during off-peak hours	Tenant Partnership Programme					
13	Cost-sharing mechanism for energy efficiency improvements	Tenant Partnership Programme					
14	Tenant energy management programme	Tenant Partnership Programme					
Capital Investment Recommendation							
15	Installation of smaller capacity chiller	Chiller system					\$ -
16	Replacement of all existing fixtures with LED panels	Lighting system					\$ -
17	Replace with high efficiency heat pump	Centralised hot water system					\$ -
Remarks :			Σ kWh	Σ kWh		Σ kWh	\$ -

S/No.	Proposed Energy Improvement Measures	Building Systems/ Initiatives	Cost and Simple Payback Period		Implementation Plan	
			Estimated Implementation Cost (\$)	Simple Payback Period (Year)	Start Date	Estimated End Date (where applicable)
Energy Reduction Recommendation						
1	Conduct comprehensive maintenance including tube cleaning and refrigerant charge optimisation	Chiller system			15 Oct 2026	15 Dec 2026
2	Chiller optimisation including upgrading of control system	Chiller system			1 Mar 2027	30 Jul 2027
3	AHUs system optimisation	AHUs			1 Mar 2027	30 Jul 2027
4	Regular cleaning schedule and preventive maintenance programme for cooling coils along with filter differential pressure monitoring	AHUs			1 Jan 2027	Ongoing
5	Install occupancy sensors in less frequently assessed areas	Lighting system			1 Jan 2027	Ongoing
6	Use time scheduling for open office areas, with manual override capability	Lighting system			1 Jan 2027	Ongoing
7	Change operational scheduling by aligning ventilation with peak usage patterns, to reduce ventilation during low occupancy period	Carpark ventilation system			15 Feb 2027	Ongoing
8	Adjustment of pressure control by optimising the AHU settings for proper pressurisation and balance the air distribution.	AHUs in relation to air leakage			15 Mar 2027	Ongoing
9	Install automated self-closing doors to minimise excess air leakage	Door provision in relation to air leakage			1 Apr 2027	31 Aug 2027
10	Energy performance requirements in lease agreements	Tenant Partnership Programme			1 Jun 2027	Ongoing Remarks : For new lease
11	Guidelines for fit out works to required energy efficient equipment	Tenant Partnership Programme			1 Jun 2027	Ongoing Remarks : Apply to new leases and lease renewals
12	Protocol for air-conditioning usage during off-peak hours	Tenant Partnership Programme			1 Mar 2027	Ongoing
13	Cost-sharing mechanism for energy efficiency improvements	Tenant Partnership Programme			1 Mar 2027	Ongoing
14	Tenant energy management programme	Tenant Partnership Programme			1 Mar 2027	Ongoing
15	Installation of smaller capacity chiller	Chiller system			1 Sep 2027	30 Mar 2027
16	Replacement of all existing fixtures with LED panels	Lighting system			30 Oct 2027	31 Dec 2027
17	Replace with high efficiency heat pump	Centralised hot water system			30 Mar 2027	30 Oct 2027
Remarks :			∑ kWh	∑ kWh	∑ kWh	

Note : Under the column 'Implementation Plan', the start date refers to the commencement of physical implementation works on site or initiatives/programmes. For measures with defined completion points, an estimated end date is provided based on typical implementation timelines. Ongoing operational measures, such as tenancy agreements, regular maintenance schedule and preventive programmes, they can be recorded as 'Ongoing' as these measures will continue as part of regular operations after implementation. For clarity, please state if implementation is restricted to specific situations.

Determination of Expected EUI Reduction (Percentage)

For consistency, the building's energy use intensity before implementing the efficiency measures is to be determined by taking the average of the building's yearly energy use intensity for the 3-year period prior to the year of notice. The example below shows the required tabulation and computation.

- (1) Determine the EUI_{baseline}

Energy Use Intensity (EUI) (kWh/m ² /year)			Baseline: Average EUI over three years
2022	2023	2024	EUI _{baseline} = $\sum EUI_i / 3 = 400 \text{ kWh/m}^2/\text{year}$
402	403	395	

- (2) Determine the percentage reduction in energy use intensity after implementation of proposed measures under the Energy Efficiency Improvement Plan

Total Expected Energy Savings after implementing EEIP (kWh/year)	Assume : 1,125,000 kWh/year
Energy Use Intensity (EUI) reduction (kWh/m²/year)	Assume : Building's Gross Floor Areas (GFA) of 25,000 m ² Expected EUI reduction = $\frac{\text{Total expected energy savings}}{\text{GFA}}$ $= \frac{1,125,000}{25,000} = 45 \text{ kWh/m}^2/\text{yr}$
	% EUI reduction = $\frac{\text{Expected EUI reduction}}{\text{EUI}_{\text{baseline}}}$ $= 45/400 = 11.25\% > 10\% \text{ ok}$

- (3) Estimate the EUI reduction over 3-year period as the energy improvement measures are progressively completed based on EEIP and implementation plan.

Expected Reduction in Energy Use Intensity (EUI) by Phases (example)					
Details		Year 0	Year 1	Year 2	Year 3
Expected Building's EUI		400	385	365	355
Expected EUI reduction	By phase over 3-year period	0	15	20	10
	Cumulative	0	15	35	45
% EUI reduction (Cumulative)		0	3.75%	8.75%	11.25% > 10%

Part 3 Appendices

Appendix A – Supporting documentation in relation to the audit of energy use of buildings and systems

Appendix B – Supporting documentation in relation to the audit of energy efficiency level of building cooling system

Appendix C – Supporting documentation in relation to Operating System Efficiency (OSE) report of the building cooling system

Appendix A

Supporting documentation in relation to the audit of energy use of buildings and system

S/No.	Supporting documents to be provided	Related Sections under Annex B – Part 1
1.1	Past energy use data: <ul style="list-style-type: none"> • Monthly utility bills over the 3 years prior to year of notice • On-site renewable energy generation over the same period (where relevant) 	(B) Historical energy use data (D) Utility cost for building owner or landlord
1.2	As-built schematic drawings indicating the location of the major energy-consuming systems: <ul style="list-style-type: none"> • Building cooling system • Unitary air conditioners • Centralised hot water system (Required, where applicable) • Mechanical ventilation system for carparks (Required, if in EEIP) • Lighting system (Required, if in EEIP) 	(E) Inventory of major energy-consuming systems and equipment
1.3	Photographic evidence : <ul style="list-style-type: none"> • Major energy-consuming systems and equipment • Areas identified with energy wastage and inefficiencies 	
1.4	Energy use records: <ul style="list-style-type: none"> • Submetering data or energy consumption measurements for: <ul style="list-style-type: none"> ○ Building cooling system ○ Unitary air-conditioners ○ Centralised hot water system (where relevant) 	(F) Breakdown of Energy Consumption by End-use
1.5	Energy consumption calculations and estimates (where relevant), including the following: <ul style="list-style-type: none"> • Equipment specifications and performance data • Building Management System (BMS) data • System operating schedules • Derivation of energy consumption from tenants • Any other relevant supporting basis 	

Appendix B

Supporting documentation in relation to the audit of energy efficiency level of building cooling system

S/No.	Supporting documents to be provided	Related Sections under Annex B – Part 1
2.1	<p>Chilled Water System:</p> <ul style="list-style-type: none"> • As-built schematic drawings of the chiller plant configuration. • As-built drawings of chiller plant room plan layout and locations of the measurement and verification instrumentation. • Data points in file format that are supported in Excel and to be presented with date and time stamp; chilled water supply temperature (°C); chilled water return temperature (°C); condenser water supply temperature (°C); condenser water return temperature (°C); chilled water flow rate (l/s); condenser water flow rate (l/s); electrical power of chiller(s), chilled water 1 week raw data of the pump(s), condenser water pump(s) and cooling tower(s) (kW). The excel file should include all the chart plots specified in Annex B. • Instruments' calibration certificates from the accredited laboratories and their factory calibration certificates from manufacturers. • Calculation of the overall uncertainty of measurement of the resultant chiller plant in kW/RT to be within $\pm 5\%$ of the true value based on instrumentation specifications and calibration certificates for (a) central chilled water system; and (b) for individual chillers (if the permanent measuring instruments or devices are installed at individual chillers and header/risers). • Chiller(s) part load performance (at 10% interval from 100% to minimum value) from equipment supplier at operating conditions. 	(G) Energy Efficiency of Building Cooling System
2.2	<p>Air Handling and Distribution System:</p> <ul style="list-style-type: none"> • As-built schematic drawings of the air distribution system (AHUs / FCUs). • 1-week raw data of the following data points if trended from BMS/EMS in file format that are supported in Excel and to be presented with date and time stamp: electrical power of air distribution system (kW) (AHUs / FCUs). Refer to ANNEX C for more details of the data points, type of instrumentation, measurement uncertainty, and sampling size and interval. 	(G) Energy Efficiency of Building Cooling System
2.3	<p>Unitary Air-conditioning System:</p> <ul style="list-style-type: none"> • As-built plan showing the location of the unitary air-conditioners and VRF system • Records of the energy efficiency data collected from the VRF system's built-in monitoring tools for a period of 1 week • Energy Efficiency calculations and estimates (where relevant) including the technical specification or basis. 	(G) Energy Efficiency of Building Cooling System

Appendix C

Supporting documentation in relation to the Energy Efficiency Improvement Plan (EEIP)

S/No.	Supporting documents to be provided	Related Sections under Annex B – Part 2
3.1	<p>Technical information:</p> <ul style="list-style-type: none">• Equipment specifications/catalogues• Energy savings calculations with assumptions• Calculations showing expected EUI reduction <p>Cost and benefits analysis:</p> <ul style="list-style-type: none">• Indicative cost estimates• Energy cost savings• Simple payback period calculations <p>Implementation feasibility:</p> <ul style="list-style-type: none">• Project schedule outline and alignment with the stipulated 3 year timeframe <p>Tenant partnership or sustainability programme:</p> <ul style="list-style-type: none">• Proposed programme framework• Planned engagement approach• Methodology for estimating tenants' energy savings	Energy Efficiency Improvement Plan (EEIP)

[End of Document]