23/3/2015

Energy legislation codes & standards

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Certified Green Mark Professional
LEED Accredited Professional

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Energy regulations codes & standards

Agenda

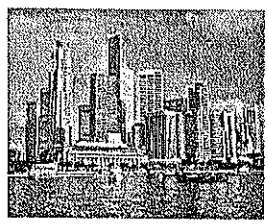
- **Review key energy efficiency requirements in:**
  - Green Mark for Non-Residential New Building (V4.1)
  - Green Mark for Non-Residential Existing Building (V3.0)
  - Building Control Act 2012 and Building Control Regulations 2013 (Environmental Sustainability Measures for Existing Buildings)
  - SS530 – 2006 Energy efficiency standard for building services and equipment.
  - SS553 – 2009 Code of practice for air conditioning and mechanical ventilation in buildings (Formerly CP13)
- **Highlight energy efficiency requirements that are useful for bench marking to energy audit results**

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BCA GREEN MARK

Green Mark Rating System
For New Buildings
NRNB V4.1

Effective in Jan 2013



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Overall framework

Non residential Bldg. Part 1: Energy Related section

Table 5.3.1(b) : Framework and Point Allocations for Non-Residential Building Criteria

	Category		Point Allocations
(I)	**Energy Related Requirements**		
Minimum 30 points	**Part 1 : Energy Efficiency**		
	NRB 1-1 Thermal Performance of Building Envelope - ETTV	Section (A) Applicable to air-con areas	12
	NRB 1-2 Air-Conditioning System		30
	Sub-Total (A) – NRB 1-1 to 1-2		42
	NRB 1-3 Building Envelope – Design/Thermal Parameter	Section (B) Applicable to non air-con areas excluding carparks and common areas	35
	NRB 1-4 Natural Ventilation / Mechanical Ventilation		20
	Sub-Total (B) – NRB 1-3 to 1-4		55
	NRB 1-5 Daylighting	Section (C) Generally applicable to all areas	6
	NRB 1-6 Artificial Lighting		12
	NRB 1-7 Ventilation in Carparks		4
	NRB 1-8 Ventilation in Common Areas		5
	NRB 1-9 Lifts and Escalators		2
	NRB 1-10 Energy Efficient Practices & Features		12
	NRB 1-11 Renewable Energy		20
	Sub-Total (C) – NRB 1-5 to 1-11		61
	Category Score for Part 1 – Energy Efficiency **Prorate Subtotal (A) + Prorate Subtotal (B) + Prorate Subtotal (C)**		**116 (Max)**

Emphasis given to reducing energy related to air-conditioning systems

Energy Section is 61% of max of total 190 pts

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Prerequisites
For energy section of air-conditioned bldg

1. ETTV

Green Mark Gold^{Plus} – ETTV of 42 W/m^2 or lower
Green Mark Platinum – ETTV of 40 W/m^2 or lower

2. Building Energy Efficiency Index (EEI)

Green Mark Gold^{Plus} – At least 25% energy savings
Green Mark Platinum – At least 30% energy savings

3. Air conditioning system Efficiency

(i) For Buildings using Water-Cooled Chilled-Water Plant:

Green Mark Rating	Peak Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency[1] (kW/RT)	
Certified	0.80	0.70
Gold	0.80	0.70
Gold^{Plus}	0.70	0.65
Platinum	0.70	0.65

(ii) For Buildings using Air Cooled Chilled-Water Plant or Unitary Air-Conditioners:

Green Mark Rating	Peak Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency[1] (kW/RT)	
Certified	0.90	0.80
Gold	0.90	Not applicable[2]
Gold^{Plus}	0.85	
Platinum	0.78	

4. Water cooled chiller plant energy efficiency monitoring

Permanent monitoring system to accuracy of +/- 5%

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NRB 1-2 Air conditioning system efficiency

1-2C Airside energy efficiency (Max 6pts)

Fan System Motor Nameplate Power OR **Fan System Input Power**

Baseline Air Distribution System Type	Allowable Motor Nameplate Power	
	(kW/m^3/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.7	0.47
AHUs ≥ 4kW (Variable Volume)	2.4	0.67
Fan systems with nameplate motor power < 4 kW	No baseline	

Baseline Air Distribution System Type	Allowable Fan System Input Power*	
	(kW/m^3/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.5	0.42
AHUs ≥ 4kW (Variable Volume)	2.1	0.58
Fan systems with nameplate motor power < 4 kW	0.6	0.17

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NRB 1-2 Air conditioning system efficiency

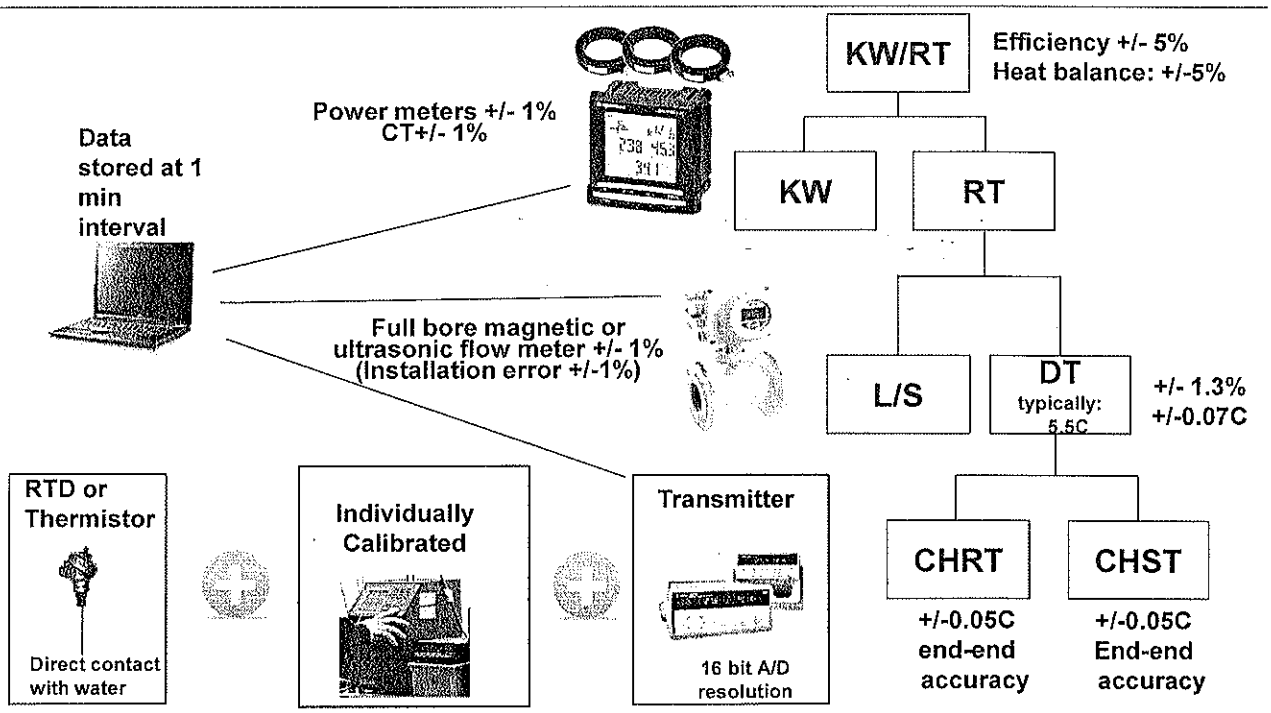
NRB 1-2d Permanent water cooled chiller plant M&V

Pre-requisite for all water cooled chiller plant.

1) Location and installation of instruments to meet manufacturer's recommendations.
2) Data acquisition system to have minimum A/D resolution of 16bit.
3) All data logging with capability to trend at 1 minute time interval.
4) Flow meters are to be provided for chilled water and condenser water loop and shall be of ultrasonic / full bore magnetic type or equivalent.
5) Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty not exceeding +/- 0.05C over the entire measurement or calibration range. All thermo-wells shall be installed in a manner that ensures that the sensors can be in direct contact with the fluid flow. Provision shall be made for each temperature measurement location to have 2 spare thermo well located at both side of the temperature sensor for verification of the measurement accuracy.
6) Dedicated power meters are to be provided for each of the following equipment: Chillers, chilled water pumps, condenser water pumps and cooling towers.

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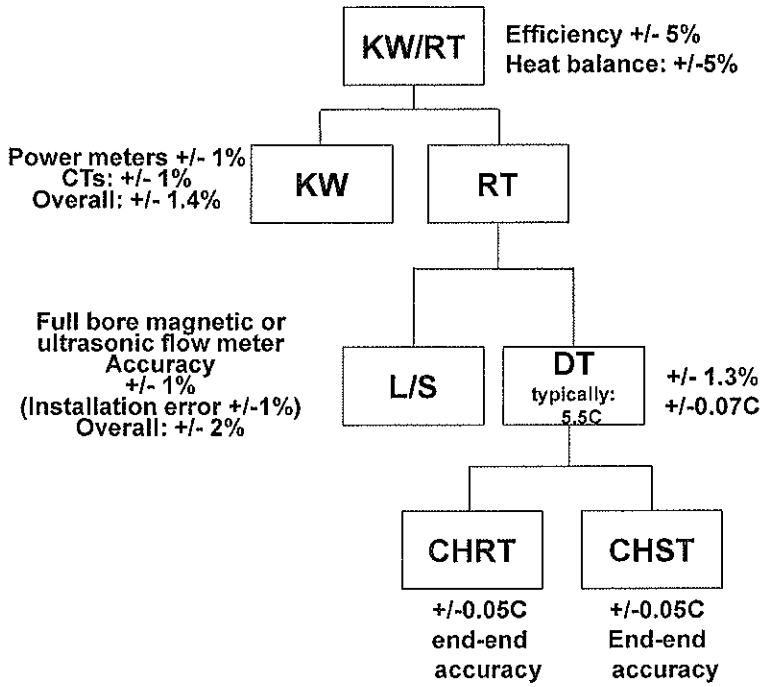
Chiller Plant M&V instrument accuracy



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Chiller Plant M&V instrument accuracy

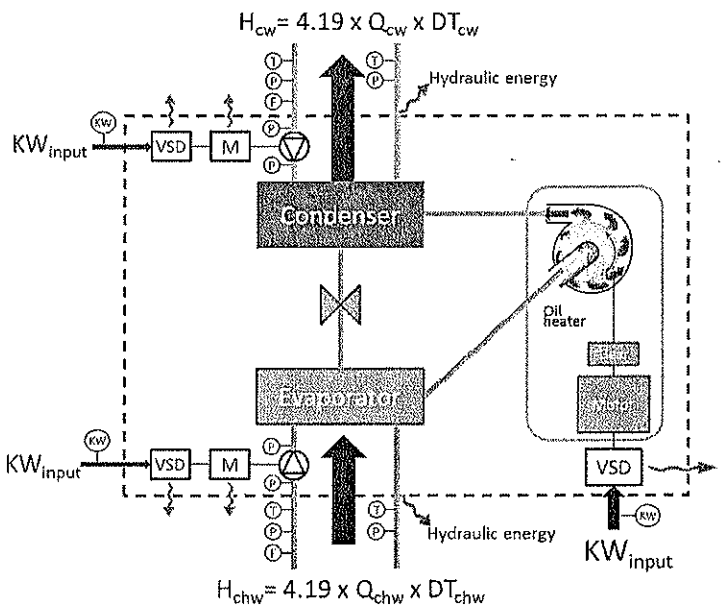
Total Error by Root Sum Square (RSS) error calculation



$$\text{Total Error}_{RSS} = \sqrt{1.4^2 + 2^2 + 1.3^2} = 2.8\ \%$$

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Chiller Plant M&V Heat Balance Validation Check



Optional: 1 point of comply

$$\frac{\text{Heat Input} - \text{Heat Output}}{\text{Heat Output}} \leq \pm 5\%$$

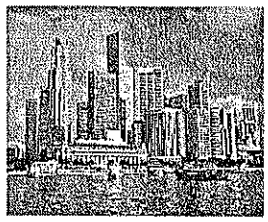
80% of data points must fall within ±5% for 1 week period

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BCA GREEN MARK

Green Mark Rating System for Existing Buildings NREB V3.0

Effective 1 Sep 2012



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Point Allocation (V3.0)

	Category		Point Allocations
(I)	ENERGY EFFICIENCY		
Minimum 20 points to be scored	**Part 1 – Energy Efficiency**		
	ENRB 1-1 Thermal Performance of Building Envelope		5
	ENRB 1-2 Air Conditioning System	(applicable to air-conditioned areas)	32
	ENRB 1-3 Natural Ventilation / Mechanical Ventilation	(applicable to non-air-conditioned areas (excluding carparks) and common areas)	
	ENRB 1-4 Artificial Lighting		13
	ENRB 1-5 Ventilation in Carparks		4
	ENRB 1-6 Ventilation in Common Areas		5
	ENRB 1-7 Lifts and Escalators		2
	ENRB 1-8 Energy Efficient Practices & Features		12
	ENRB 1-9 Energy Policy & Management		1
	ENRB 1-10 Renewable Energy		15
	Category Score for Part 1 – Energy Efficiency		89
(II)	OTHER GREEN REQUIREMENTS		
Minimum 20 points to be scored	**Part 2 - Water Efficiency**		
	ENRB 2-1 Water Monitoring		4
	ENRB 2-2 Water Efficient Fittings		12
	ENRB 2-3 Alternative Water Sources		3
	ENRB 2-4 Water Efficiency Improvement Plans		1
	ENRB 2-5 Irrigation System and Landscaping		2
	ENRB 2-6 Cooling Towers		2
	Category Score for Part 2 – Water Efficiency		24
	Part 3 - Sustainable Operation & Management		
	ENRB 3-1 Building Operation & Maintenance		4
	ENRB 3-2 Post Occupancy Evaluation		3
	ENRB 3-3 Waste Management		7
	ENRB 3-4 Sustainable Products		8
	ENRB 3-5 Greenery		10
	ENRB 3-6 Environmental Protection		3
	ENRB 3-7 Green Transport		4
	Category Score for Part 3 – Sustainable Operation and Management		39
	Part 4 - Indoor Environmental Quality		
	ENRB 4-1 Indoor Air Quality Performance		6
	ENRB 4-2 Indoor Air Pollutants		2
	ENRB 4-3 Lighting Quality		5
	ENRB 4-4 Thermal Comfort		2
	ENRB 4-5 Internal Noise Level		1
	Category Score for Part 4 – Indoor Environment Quality		16
	Part 5 – Other Green Features		
	ENRB 5-1 Green Features & Innovations		10
	Category Score for Part 5 – Other Green Features		10
		Category Score for Other Green Requirements	91
		Green Mark Score	180

Emphasis given to energy conservation (50% of all points)

Energy eff pre-requisite (V3.0)

Green Mark Rating	Minimum points achievement from Part 1 – Energy Efficiency
Green Mark Certified	30 points
Green Mark Gold	35 points
Green mark Gold^{Plus}	40 points
Green Mark Platinum	45 points

Even more emphasis given to energy conservation!

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Chiller plant eff pre-requisite (V3.0)

GM Rating	Water cooled		Air cooled	
	<500	>=500	<500	>=500
Certified	0.85	0.75	1.10	1.00
Gold	0.80	0.70	1.00	Not applicable
Gold+	0.75	0.68	0.85	
Platinum	0.70	0.65	0.78	

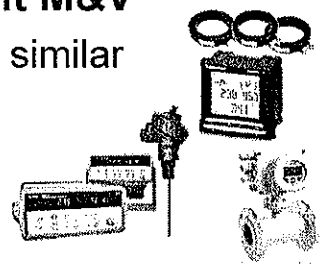
→ **Peak cooling load during OSE verification**

Office Building: Monday to Friday: 9am to 6pm Retail Mall: Monday to Sunday: 10am to 9pm Institutional: Monday to Friday: 9am to 5pm	Hotel and Hospital: 24-hour Industrial and Other Building Types: To be determined based on the operating hours

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Chiller plant M&V pre-requisites

- **Permanent water cooled chiller plant M&V**
  - Instrument accuracy requirements are similar to GM v4.1 for New Buildings

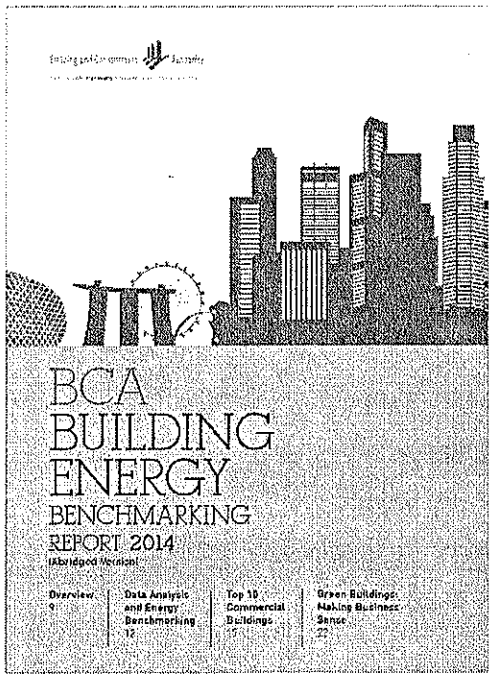


- **M&V accuracy validation by heat balance**
  - A pre-requisite, unlike GMv4.1 for New Buildings which is optional
  - Heat balance requirements are similar to GM v4.1 for New Buildings



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Useful bench mark information from BCA



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EUI Benchmarks

Key Benchmarking Findings of BESS

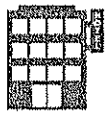
A total of 783 buildings were benchmarked, after the omission of newly constructed or retrofitted buildings which had not undergone full-year operations in 2013, buildings on district cooling plants, and mixed developments with electricity consumption that cannot be separated as there was no sub-metering.



Offices
351



Retail Buildings
145



Hotels
230



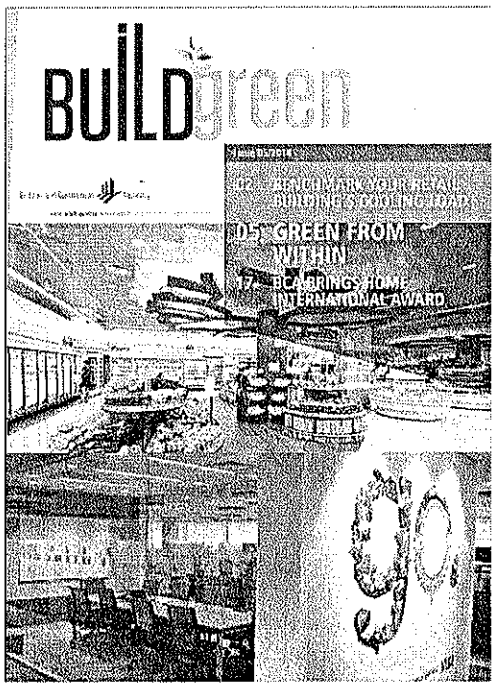
Mixed Developments
57

Energy Benchmarks [EUI (kWh/m².yr)]

EUI by Building Type (kWh/m².yr)	Top Quartile (1%-25%)	2nd Quartile (25%-50%)	3rd Quartile (51%-75%)	Bottom Quartile (75%-100%)
Offices	164	164 - 218	218 - 280	> 280
Hotels	232	232 - 292	292 - 359	> 359
Retail Buildings	259	259 - 405	405 - 554	> 554
Mixed Developments	212	212 - 264	264 - 357	> 357

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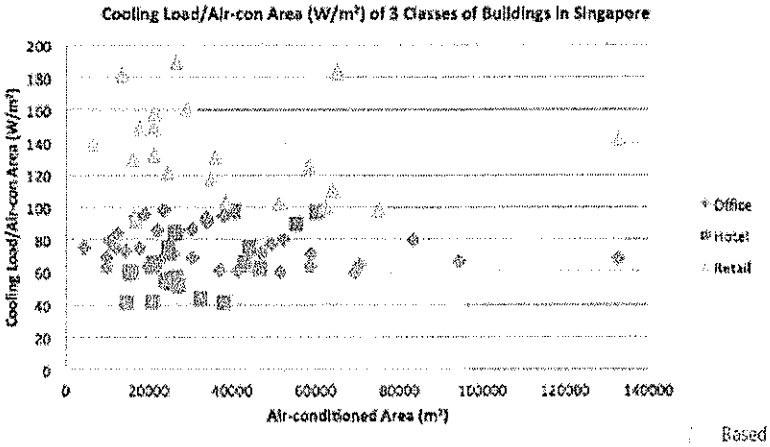
Useful bench mark information from BCA



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Cooling load intensity benchmark

	Measured Cooling Load/Air-con Area (W/m²)	
	Range	Average
Office (35 projects)	60 – 98	76
Hotel (24 projects)	42 – 93	64
Retail (21 projects)	93 – 190	135



Based on data from BCA and NEA

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Building Control Act 2012 and Building Control Regulations 2013 (Environmental Sustainability Measures for Existing Buildings)

THE STATUTES OF THE REPUBLIC OF SINGAPORE

BUILDING CONTROL ACT

(CHAPTER 29)

PART IIIB
ENVIRONMENTAL SUSTAINABILITY MEASURES FOR EXISTING BUILDINGS

22FA. Interpretation of this Part
22FB. Submission of design score for building undergoing major energy-use change
22FC. Deviation from approved design score
22FD. Lapsing or revocation of approval of design score
22FE. Completion of major energy-use change and submission of as-built score
22FF. Periodic audit of energy efficiency of building cooling system
22FG. Persons who may carry out energy audit
22FH. Duties of person carrying out energy audit
22FI. Cancellation or suspension of registration of energy auditor
22FJ. Power to obtain energy consumption and other information

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Building Control Act 2012 and Building Control Regulations 2013 (Environmental Sustainability Measures for Existing Buildings)

New legislations

- Comply with min. GM Standard for Existing Buildings
- Conduct 3-Yearly Energy Audit on Building Cooling Systems
- Annual Submission of Building Info & Energy Consumption Data

Buildings affected

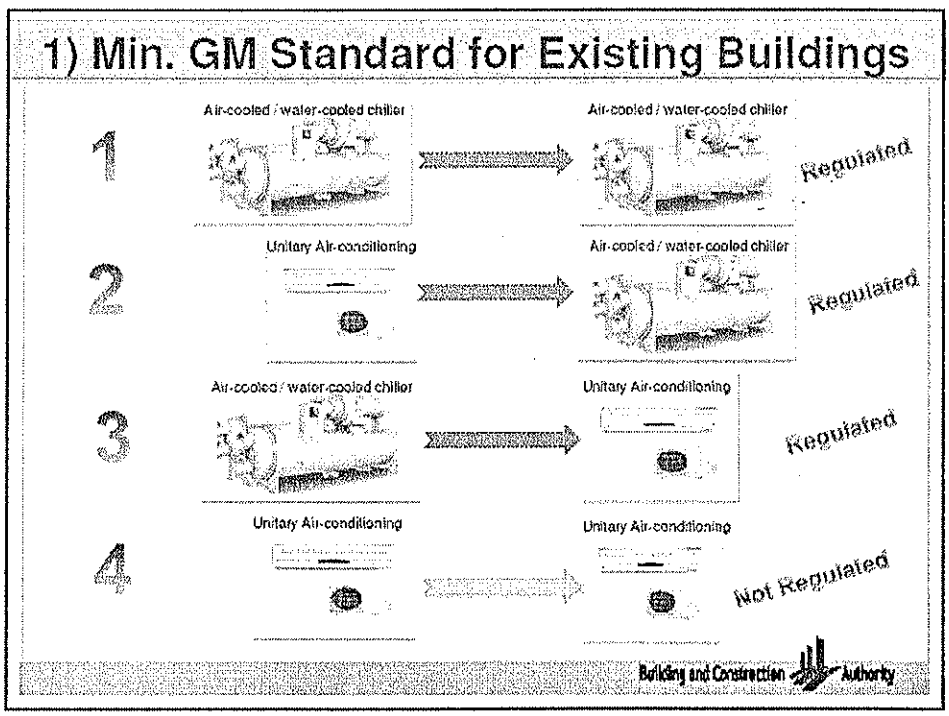
- Any hotel, retail building or office building
  Includes mixed development with the above mix
- GFA > 15,000m2
- Installing/replacing chiller in a central chilled water system

Time line

- Buildings with chiller delivery into building on/after 2 Jan 2014 will have to comply.

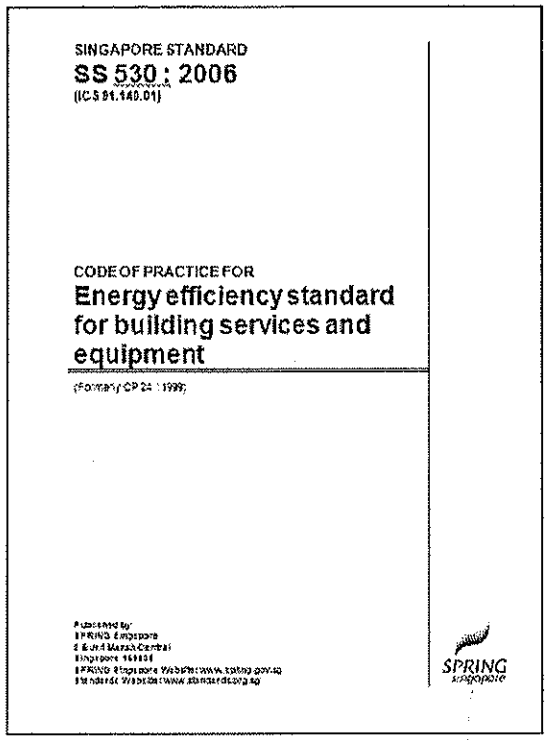
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Definition of "Major Energy Change"



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SS530 – 2006 Energy efficiency standard for building services and equipment



SINGAPORE STANDARD
SS 530 : 2006
(ICS 91.140.01)

CODE OF PRACTICE FOR
Energy efficiency standard for building services and equipment

(Formerly CP 24 : 1999)

Published by
SPRING Singapore
2 Bukit Merah Central
Singapore 159835
SPRING Singapore Website: www.spring.gov.sg
Standards Website: www.standards.org.sg

SPRING singapore

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SS530 – 2006 Energy efficiency standard for building services and equipment

CLAUSES

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Minimum Efficiency Requirements

Unitary air-conditioner and condensing units (from SS530:2006)

Table 1 – Unitary air-conditioners and condensing units, electrically operated – Minimum efficiency requirements

Equipment type	Size category	Sub-category or rating condition	Minimum efficiency	Test procedure
Air-conditioners, air-cooled	< 19 kW	Inverter systems	3.37 COP	JIS C 9612
		Non-inverter	2.49 COP	ISO 5151
	≥ 19 kW and < 40 kW	Split system and single package	3.02 COP	ARI 340/360
	≥ 40 kW and < 70 kW	Split system and single package	2.84 COP	
	≥ 70 kW and < 223 kW	Split system and single package	2.78 COP	
	≥ 223 kW	Split system and single package	2.70 COP	
Air-conditioners, water and evaporatively cooled	< 19 kW	Split system and single package	3.35 COP	ARI 210/240
	≥ 19 kW and < 40 kW	Split system and single package	3.37 COP	ARI 340/360
	≥ 40 kW and < 70 kW	Split system and single package	3.22 COP	
	≥ 70 kW	Split system and single package	2.70 COP	
Condensing units, air-cooled	≥ 40 kW		2.96 COP	ARI 365
Condensing units, water or evaporatively cooled	≥ 40 kW		3.84 COP	

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Minimum Efficiency Requirements

Water chilling packages (from SS530: 2006)

Table 2 – Water chilling packages – Minimum efficiency requirements

Equipment type	Size category	Sub-category or rating condition	Minimum efficiency*	Test procedure
Air-cooled, with condenser, electrically operated	All capacities		2.80 COP	ARI 550/590
Air-cooled, without condenser, electrically operated	All capacities		3.10 COP	
Water-cooled, electrically operated, positive displacement (Reciprocating)	All capacities		4.20 COP	
Water-cooled, electrically operated, positive displacement (Rotary Screw and Scroll)	< 528 kW		4.45 COP	
	≥ 528 kW and < 1055 kW		4.90 COP	
	≥ 1055 kW		5.50 COP	
Water-cooled, electrically operated, centrifugal	< 528 kW		5.00 COP	
	≥ 528 kW and < 1055 kW		5.55 COP	
	≥ 1055 kW		6.10 COP	
Air-cooled absorption single effect	All capacities		0.60 COP	ARI 560
Water-cooled absorption single effect	All capacities		0.70 COP	
Absorption double effect, indirect-fired	All capacities		1.00 COP	
Absorption double effect, direct-fired	All capacities		1.00 COP	

* The chiller equipment efficiency requirements do not apply for chillers used in low temperature applications where the designed leaving fluid temperature is less than 4.4°C.

KW/RT= 3.517/COP

Minimum Efficiency Requirements
Heat rejection (from SS530: 2006)

Table 3 – Performance requirements for heat rejection equipment

Equipment type	Total system heat rejection capacity at rated conditions	Subcategory or rating condition	Performance required[a]	Test procedure
Propeller or axial fan cooling towers	All	35 °C Entering water 29 °C Leaving water 24 °C wb Outdoor air	≥ 3.23 L/s.kW	CTI ATC-105
Centrifugal fan cooling towers	All	35 °C Entering water 29 °C Leaving water 24 °C wb Outdoor air	≥ 1.7 L/s.kW	CTI ATC-105

[a] For the purpose of this table,
- cooling tower performance is defined as the maximum flow rating of the tower divided by the nameplate rated motor power
- air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the nameplate rated motor power

Note
SS530 cites CTI-105 which rates CT at:

CW flow of 3.0 gpm/RT

$$\text{Performance required} = \frac{3.0 \text{ gpm / RT}}{3.23 \text{ l/s.kw} \times 15.87 \text{ gpm / L/s}} = 0.059 \text{ KW/RT}$$

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Minimum Efficiency Requirements
Boilers (from SS530: 2006)

Table 4 – Gas and oil-fired boilers – Minimum efficiency requirements

Equipment type	Size category	Sub-category or rating condition[a]	Minimum efficiency[b]	Test procedure
Boilers, gas-fired	< 88 kW	Hot water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥ 88 kW and ≤ 733 kW	Maximum capacity	75% E_t and 80% E_c	DOE 10 CFR Part 431[c]
	> 733 kW	Hot water	80% E_c	
	> 733 kW	Steam	80% E_c	
Boilers, oil-fired	< 88 kW		80% AFUE	DOE 10 CFR Part 430
	≥ 88 kW and ≤ 733 kW	Maximum capacity	78% E_t and 83% E_c	DOE 10 CFR Part 431[c]
	> 733 kW	Hot water	83% E_c	
	> 733 kW	Steam	83% E_c	
Oil-fired (Residual)	≥ 88 kW and ≤ 733 kW	Maximum capacity	78% E_t and 83% E_c	DOE 10 CFR Part 431[c]
	> 733 kW	Hot water	83% E_c	
	> 733 kW	Steam	83% E_c	

[a] Minimum and maximum ratings as provided for and allowed by the unit's controls.

[b] E_t = Thermal efficiency; E_c = Combustion efficiency (100% less flue losses). See reference document for detailed information.

[c] Alternate test procedures used at the manufacturer's option are ANSI Z21.13 and ASME PTC-4.1 for units over 1465 kW.

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Minimum Efficiency Requirements General purpose motors (from SS530:2006)

Table 6 – General purpose motors – Minimum nominal efficiency

	Minimum nominal full-load efficiency (%)		
	Continuous use [a]		Occasional use [b]
Number of poles	2	4	2 and 4
Motor power (kW)			
1.1	82.8	83.8	76.2
1.5	84.1	85.0	78.5
2.2	85.6	86.4	81.0
3.0	86.7	87.4	82.6
4.0	87.6	88.3	84.2
5.5	88.6	89.2	85.7
7.5	89.5	90.1	87.0
11.0	90.5	91.0	88.4
15.0	91.3	91.8	89.4
18.5	91.8	92.2	90.0
22.0	92.2	92.6	90.5
30.0	92.9	93.2	91.4
37.0	93.3	93.6	92.0
45.0	93.7	93.9	92.5
55.0	94.0	94.2	93.0
75.0	94.6	94.7	93.6
90.0	95.0	95.0	93.9

[a] 'Continuous use' motors are defined as motors that are used for at least 2900 hours per year.
[b] 'Occasional use' motors are defined as motors that are used for less than 2900 hours per year.

Maximum Lighting Power Budget (from SS530:2006)

Table 7 – Maximum lighting power budget (including ballast loss)

Type of usage	Maximum lighting power budget (Watts / m^2)
Offices	15
Classrooms	15
Lecture theatres	15
Auditoriums / Concert halls	10
Shops / Supermarkets / Departmental stores (including general, accent and display lighting)	25
Restaurants	15
Lobbies / Atriums / Concourses	10
Stairs	6
Corridors	10
Car parks	5
Electronic manufacturing and fine detail / Assembly industries	20
Medium and heavy industries	15
Warehouses / Storage areas	10

1. Design service illuminance, lamp efficacies and the light output ratios of luminaires shall be in accordance with Singapore Standard SS 531.
2. The general use of incandescent tungsten lamps is discouraged.
3. The use of High Frequency fluorescent lighting systems is encouraged to achieve good illuminance standards with visual comfort.
4. Display lighting and specialised lighting are to be included in the calculation of lighting power budget.
5. The lighting power budget shall not apply to spaces in individual residences and apartments but shall apply to common stairs, lobbies, corridors and indoor car parks within the residential building.

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Maximum Lighting Power Budget (from SS530:2006)

7.3 Building exterior lighting

In exterior spaces the lighting power budget shall be based on the use for which the space is intended (task performance, safety or security) and on efficient energy utilization.

The lighting power budget for floodlighting of the facade of a building shall not be greater than 5 percent of the total interior lighting load of the building.

The lighting power budget for external car parks, drive-ways, pedestrian malls, landscaped areas, etc. shall not exceed 5.0 W/m^2. The area shall be the net site area excluding the built-up area.

7.4 Lighting control

Lighting control circuits minimise energy usage. Therefore, circuiting / switching or dimming should be provided so that:

(a) lighting in task areas larger than 10m^2 can be reduced to at least half when the task is not being performed or when the task is relocated.

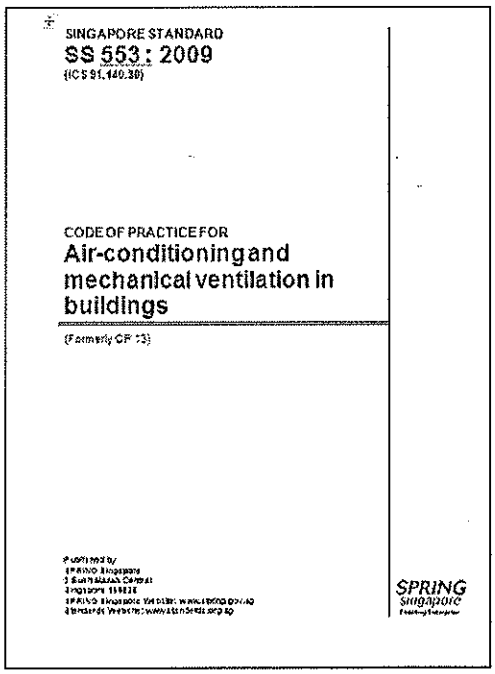
(b) lighting can be reduced when a space is empty and not being used.

(c) lighting can be reduced or turned off (manually or automatically) where daylighting is adequate and can be used without discomfort.

(d) exterior lighting should be controlled by time switches, photo-cells or other devices to turn it off during hours when such lighting is not necessary.

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SS553 – 2009 Code of practice for Air conditioning & mechanical ventilation in buildings


SINGAPORE STANDARD
SS 553 : 2009
(ICS 91.140.30)

CODE OF PRACTICE FOR
Air-conditioning and mechanical ventilation in buildings

(Formerly CP 13)

SPRING Singapore

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Scope of SS553

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Reference building ACMV performance

GreenMark v3 Reference building (CP13)				
Type	Condition	Min Eff	Units	Remarks
Constant volume system	Full load	0.47	W / CMH	
Variable volume system	Full load	0.74	W/ CMH	
	Part load	-		No requirement for part load performance

Superseded

GreenMark v3 Reference building (SS553)				
Type	Condition	Min Eff	Units	Remarks
Constant volume system	Full load	0.47	W / CMH	Allowable nameplate motor KW
Variable volume system	Full load	0.67	W/ CMH	Allowable nameplate motor KW
	Part load	-		Motor >= 11kw must able to modulate to 50% design flow at less than 30% of design KW

For VAV system, 9.5% more eff than CP13

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Pump Power Requirement (from SS553)

CHWP	Full load	349	KWe/cms	
		0.053	KWe / RT	(349KW/cms) x(2.4gpm/RT) / (15873 gpm/cms)
	Part load	-		Motors exceeding 15KW must modulate to 50% of design flow @ no more than 30% of design Kwi
CWP	Full load	301	KWe/cms	
		0.057	KWe / RT	(301KW/cms) x (3gpm/RT) / (15873 gpm/cms)
	Part load	-		Motors exceeding 15KW must modulate to 50% of design flow @ no more than 30% of design Kwi

56% more eff than CP13

37% more eff than CP13

Note
SS530 cites AHRI550 whch rates chiller eff at:

CHW flow of 2.4gpm/RT

CW flow of 3.0gpm/RT

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Reference building ACMV performance

Minimum Chiller Plant Performance (CP13+SS530)

GMV3 (CP13 + SS530)
Reference building

Type	Condition	Min eff	Units	Remarks
Chillers	Full load @ ARI std condn	6.1	COP	
		0.58	Kwi / RT	
	Part load	-		No requirement for part load performance
		-		
CHWP	Full load	30	KWc / Kwi	
		0.12	Kwi / RT	
	Part load	-		No requirement for part load performance
CWP	Full load	40	KWct / Kwi	
		0.09	Kwi / RT	
	Part load	-		No requirement for part load performance
CT	Full load	3.23	L/S / Kwi	
		0.06	Kwi / RT	
	Part load	-		No requirement for part load performance

Superseded

Chilled water plant minimum system efficiency	0.85	Kwi / RT
	4.16	COP

Minimum Chiller Plant Performance (SS553+SS530)

(SS553 + SS530)
Reference building

Type	Condition	Min eff	Units	Remarks
Chillers	Full load @ ARI std condn	6.1	COP	
		0.58	Kwi / RT	
	Part load	-		No requirement for part load performance
		-		
CHWP	Full load	349	KW/cms	
		0.053	Kwi / RT	
	Part load	-		Motors exceeding 15KW must modulate to 50% of design flow @ no more than 30% of design KWi
CWP	Full load	301	KW/cms	
		0.057	Kwi / RT	
	Part load	-		Motors exceeding 15KW must modulate to 50% of design flow @ no more than 30% of design KWi
CT	Full load	3.23	L/S / Kwi	
		0.06	Kwi / RT	
	Part load	-		No requirement for part load performance

Chilled water plant minimum system efficiency	0.75	Kwi / RT
	4.71	COP

11.8% more efficient

Min Outdoor Air Ventilation Requirement (From SS553)

SS 553 : 2009

Table 1 – Outdoor air supply requirement for comfort air-conditioning

Type of building/ Occupancy	Minimum outdoor air supply			Air class [1]
	l/s per m² floor area	m³/h per m² floor area	l/s per person	
Restaurants	3.4	12.2	5.1	2
(1) Dance halls	7.0	25.0	10.5	1
Offices	0.6	2.0	5.5	1
(2) Shops, supermarkets and department stores	1.1	3.8	5.5	1 or 2
Theatres and cinemas seating area	2.0	7.3	3.0	1
Lobbies and corridors	0.3	1.1	3.3	1
Concourses	1.1	4.0	3.3	1
(3) Hotel guestrooms	15.0 l/s per room	54.0 m³/h per room	5.5	1
(3) Classrooms				
Primary school children and above	2.8	10.0	4.2	1
Childcare centres	2.8	10.0	8.4	1

Compared to CP13

+21%

+32%

- 8%

+10%

No change

+20%

No change

+12%

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Thank you for your attention.

Questions?

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