GREEN MARK SUPER LOW ENERGY SOLUTIONS PACKAGE



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Revision	Description	Date Effective
RO	Green Mark Super Low Energy	27 September 2021
	Solutions Package for Various Building	
	Typologies	

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- To push boundaries in terms of energy efficiency and move towards a low carbon built environment, Building and Construction Authority (BCA) developed the Green Mark Super Low Energy criteria (GM SLE) in 2018.
- GM SLE is a rating tool that provides a robust framework for both new and existing (residential and non-residential) buildings and recognises projects that are on the path to net zero energy and beyond.

Solutions Package To Help The Industry Design And Develop Cost-effective SLE Buildings

- BCA has created an ecosystem of supporting tools such as SLE technology Roadmap and SLEB Smart Hub to enable industry to adopt SLE buildings design. Solution Packages is one such tool which is developed based on the awarded SLE projects.
- The solutions package identifies solutions and proven SLE technologies that are available today to help the industry design and develop cost-effective SLE buildings.
- The solutions package is a live document and will be updated periodically as we have more number of GM SLE projects



Institutional Buildings (ND)

Area	% of Aircon	Eacado Borformanco	Innovative Bassive Design	Lighting	Air – Conditioning Sys	tem	EIII	Renewable Energy
sqm	area	raçade renormance	Features (IPDF)	Lighting	System Type & Efficiency	Innovative Technology	kWh/sqm/yr	(RE)
5,000 to 10,000	10% to 40%	ETTV: 22 to 40 W/sqm Façade (Glass) Properties: U-Value : 1.4 to 2.5 SC : 0.25 to 0.35	1. Double Skin Façade 2. Light shelf 3. Operable Iouvers for Natural Ventilation	Type: LED Improvement over Baseline: 40% to 60% Control: Motion/Daylighting Sensors	Cooling System: Plant Efficiency (water cooled system): 0.50 to 0.64 kW/RT Air Side: Air Distribution Efficiency: 0.08 to 0.15 kW/RT	Hybrid Cooling System	30 to 73	On-site RE Energy Replacement:11 to 100% (SLE to ZE)
		ETTV: 21 to 38 W/sam		Type: FD	Cooling System 1.Plant Efficiency (water cooled system): 0.56 - 0.625 kW/RT 2.VRF/VRV: 0.66 kW/RT			
		Façade (Glass)		Improvement over Baseline:	Air Side			On-site RE
10,000 to 20,000	15% to 60%	Properties: U-Value &: 1.5 to 4.5 SC : 0.23 to 0.83	nil	40% to 80% Control: Motion/Daylighting Sensors	1. Air Distribution Efficiency:0.08-0.175 kW/RT 2.FCU: 0.06 kW/RT	Passive Displacement Cooling	65 to 150	Energy Replacement: 12 to > 100% (SLE to PE)
20,000 to 30.000	50%	ETTV: 22 W/sqm Façade (Glass) Properties: U-Value : 1.45 SC : 0.23	1.Long overhangs for east & West façade. 2. NV for common areas	Type: LED Improvement over Baseline: 50% Control: Motion/Daylighting Sensors	Cooling System Plant Efficiency (water cooled system): 0.55 kW/RT Air Side Air Distribution Efficiency: 0.169 kW/RT	Hybrid Cooling System EC FCU Fans	80	nil
> 40,000	38%	ETTV: 37 W/sqm Façade (Glass) Properties: U-Value : 1.53 SC : 0.3	nil	Type: LED Improvement over Baseline: 50% Control: Motion/Daylighting Sensors	Cooling System Plant Efficiency (water cooled system): 0.565 kW/RT Air Side Air Distribution Efficiency: 0.128 kW/RT	PDV System Occupancy Sensor For Demand Control In Classroom	94	Energy Replacement: 100%. (ZE)

Institutional Buildings (EB)

Area	% of				Air – Conditioning System			Renewable Energy
sam	Aircon	Façade Performance	IPDF	Lighting		Innovative	EUI	(RF)
Jan	area				System Type & Efficiency	Technology	kWh/sq/year	(112)
					Cooling System:			
					1.Plant Efficiency (water cooled system): 0.56 -			
				Type: retrofitted LED	0.591kW/RT			
				Improvement over Baseline: 40%	2.VRF : 0.82 kW/RT			On-site RE
				to 50%	Air-side:			Energy Replacement:
< 5,000	37-45%	ETTV: 34-39W/sqm	nil	Control: Motion Sensors	Air Distribution Efficiency: 0.18-0.25 kW/RT	nil	30 to 171	100% (ZE)
					Cooling System:			
				Type: retrofitted LED	Plant Efficiency (Water Cooled system): 0.59 -			On-site RE
				Improvement over Baseline: 40%	0.65 kW/RT			Energy
5,000 to				to 50%	Air-side:	Use of HVLS fan		Replacement:14 to
10,000	45-60%	nil	nil	Control: Motion Sensors	Air Distribution Efficiency: 0.2-0.25 kW/RT	for atrium space	85 to 140	100% (SLE to ZE)
					Cooling System:			
				Type: retrofitted LED	1.Plant Efficiency (Water Cooled System): 056 to			
				Improvement over Baseline:	0.64 kW/RT			On-site RE
				40% to 45%	2. VRF - 0.67 kW/RT			Energy Replacement:
10,000 to				Control: Motion /Daylighting	Air-Side:			10 to 100% (SLE to
20,000	50-90%	nil	nil	sensor	Air Distribution Efficiency: 0.068 – 0.091 kW/RT	nil	77 to 100	ZE)
		Retrofitting of single to						
		double glazed		Type: retrofitted LED	Cooling System:			
		Façade (Glass)		Improvement over Baseline: 40%	Plant Efficiency (Water Cooled system): 0.56 to			
		Properties:		to 45%	0.69 kW/RT			On-site RE
20,000 to		U Value: 1.6		Control: Motion /Daylighting	Air-side:	Hybrid cooling		Energy Replacement:
30,000	55-75%	SC : 0.30	nil	sensor	Air Distribution Efficiency: 0.2-0.25 kW/RT	system	85 to 90	7 to 20% (SLE)
				Type: retrofitted LED	Cooling System:			
				Improvement over Baseline: 40%	Plant Efficiency (Water Cooled System): 0.58 to			On-site RE
	50-90%			to 45%	0.63 kW/RT			Energy Replacement:
			Sun Pipe &	Control: Motion /Daylighting	Air-side:	High Speed Low	70 to 93	10% to > 100% (SLE to
> 30,000		nil	light shelf	sensor	Air Distribution Efficiency: 0.2-0.25 kW/RT	Velocity Fan		PE)

Commercial/Office Buildings (ND)

Area	% of Aircon	Facade	IPDE		Air – Condition	ing System		
Sqm	area	Performance		Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/sqm/yr	Renewable Energy
<10,000	51-76%	ETTV: 26-36 Façade (Glass) Properties: U value: 1.5-1.6 SC: 0.23-0.26	Daylight Optimization	Type: LED Improvement over Baseline : 36 to 59% Control: Motion Sensor with Smart Control System	Cooling System: Plant Efficiency (DCS/ water-cooled system):0.53-0.65 kW/RT Air-side: Air Distribution Efficiency: 0.02 - 0.15kW/RT	Passive displacement ventilation system	58 -95	On-site RE Energy Replacement: 3% - 16% (SLE)
>20,000	87%	ETTV: 35 Façade (Glass) Properties: U value: 1.6 SC: 0.26	Nil	Type: LED Improvement over Baseline : 42% Control: Occupancy and daylight sensors	Cooling System: Plant Efficiency(Water cooled) : 0.54kW/RT Air-side: Air Distribution Efficiency: 0.34kW/ton	Smart Cooling with Passive Under Floor Air Distribution System	82	On-site RE Energy Replacement: 4%(SLE)
>60,000	86%	ETTV: 38 Façade (Glass) Properties: U-Value : 1.6 SC : 0.26	Nil	Type: LED Improvement over Baseline : 50% Control: Motion Sensor	Cooling System: Plant Efficiency (water- cooled system): 0.50 kW/RT Air-Side: Air Distribution Efficiency: 0.10 kW/RT	 Integrated control Dual Temperature Chiller system with optimized compressor impeller Dual Coil Single Fan integrated High Efficiency AHU 	140.57	Nil

Commercial/Office Buildings (EB)

Area	% of Aircon	Facade	IPDE		Air – Condition	ing System		Renewable
sqm	area	Performance		Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/sqm/yr	Energy
>40,000	92%	22% of roof with greenery	Nil	Type: LED Improvement over Baseline : 70% Control: Motion Sensor	Cooling System: Plant Efficiency (Water cooled System) : 0.577 kW/RT Air-side: Air Distribution Efficiency: 0.25 kW/RT	Nil	114	On-site & REC* (<i>ZE project*)</i>

Industrial Buildings (ND)

Area	% of Aircon		IPDF		Air – Condition	ing System		
sqm	sqm area Façade Performance		Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/sqm/yr	Renewable Energy	
10,000 to 20,000	66%	ETTV: 35 W/sqm Façade (Glass) Properties: U value: 0.5 SC: 0.29	Nil	Type: LED Improvement over Baseline: 36% Control: 1.Motion/Daylighting Sensors 2.Occupancy-based sensing to moderate brightness of luminaries	Cooling System Plant Efficiency(Water cooled system) 0.55kW/RT Air-side: Air Distribution Efficiency: 0.08kW/RT	Solar Driven Digitally controlled Chiller plant. This technology operates on DC and can be powered by both solar (DC) and electricity from the grid (AC)	64	On-site RE Energy Replacement: 10% (SLE)
>100,000	1%	ETTV= 30 W/sqm Façade (Glass) Properties: U value: 2.36 SC: 0.21	Largely Naturally ventilated	Type: LED Light Improvement over Baseline : 43% Control: Motion sensor and lighting controls for daylighting optimization	Cooling System : VRF: 0.740 kW/RT Air-side: Air Distribution Efficiency :0.089 kW/RT	Nil	65.58	On-site RE Energy Replacement: 10% (SLE)

Industrial Buildings (EB)

Aroa	% of Aircon	Facado	IPDF		Air – Condition	ing System		
sqm	area	Performance		Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/sqm/yr	Renewable Energy
>20,000	80%	Nil	Nil	Type: LED Improvement over Baseline: 42%	Cooling System : Plant Efficiency (Water Cooled): 0.62 kW/RT Air-side: Air Distribution Efficiency:0.18 kW/RT	Nil	72	On-site RE Energy Replacement : 40% (SLE)
>40,000	48%	Nil	Nil	Type: LED Improvement over Baseline : 27%	Cooling System : Plant Efficiency (Water cooled): 0.63 kW/RT Air-side: Air Distribution Efficiency:0.25 kW/RT	Nil	115	On-site RE Energy Replacement: 25% (SLE)
>90,000	2%	Nil	Nil		Tenants own installed split units	Nil	40	On-site RE Energy Replacement: 68% (SLE)

Other* Buildings (ND)

Area		Facada			Air – Conditionin	ıg System		
Sqm	% of Aircon area	Performance	IPDF	Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/m2/yr	Renewable Energy
< 5,000 5,000 to 10,000	20% - 40% 10% to 25%	ETTV: 37 U-Value: 3.8 - 5.7 SC: 0.36 - 0.94 ETTV:28 W/sqm Façade (Glass) Properties:: U value: 5.7 SC: 0.7	nil 1.Natural ventilation coupled with high volume low speed ceiling fans for functional space 2.Use of sun pipes	Type: LED Improvement over Baseline: 50% to 60% Control: Motion/Daylighting Sensors Type: LED Light Improvement over Baseline : 45% Control: Motion sensor and lighting controls for daylighting optimization	Cooling System: Efficiency(VRF):0.63 - 0.77 kW/RT Air Side FCU: 0.027 – 0.106 kW/RT Cooling System: VRF System : 0.68 kW/RT Air-side: Air Distribution Efficiency: -0.02 kW/RT	Nil Nil	60 to 77 55	On-site RE Energy Replacement: 45 to >100% (PE) On-site RE Energy Replacement: 100% (ZE)
>30,000	29%	ETTV: 33 W/sqm	Workshops and Warehouses are majorly NV	Type: LED Light Improvement over Baseline : 58.3% Control: Motion sensor and lighting controls for daylighting optimization	Cooling System Plant Efficiency (Water Cooled System): 0.594 kW/RT Air-side: Air Distribution Efficiency: 0.195 kW/RT	1.Passive Displacement Cooling 2.Hybrid evaporative cooler with fan assisted cooling	200	On-site RE Energy Replacement: 26% (façade BaPV & Roof) (SLE)

*Other building type: Transit shelters, Gas stations, Camp facilities, etc

Other* Buildings (EB)

Aroa	Area				Air – Conditioning System			
sqm	sqm % of Aircon area Performance	Performance	IPDF	Lighting	System Type & Efficiency	Innovative Technology	EUI Kwh/m2/yr	Renewable Energy
10,000 to 20,000	6%	Nil	Largely Naturally ventilated	Type: T5 Improvement over Baseline: 22%	Cooling System: Split System: 0.813 kW/RT Air-side: Air Distribution Efficiency:0.087 kW/RT	Nil	24	On-site RE Energy Replacement: 100% (ZE)
>20,000	24%	Nil	Largely Naturally ventilated	Type: LED Improvement over Baseline: 55%	Cooling System: VRV: 0.735kW/RT Air-side: Air Distribution Efficiency:0.165 kW/RT	Nil	96	On-site RE Energy Replacement: 31% (SLE)

*Other building type: Transit shelters, Gas stations, Camp facilities, etc

Residential Buildings (ND)

Area	% of Non Aircon		IPDF		Air – Conditio	oning System		
sqm	area	Façade Performance		Lighting	System Type & Efficiency	Innovative Technology	EEI Kwh/sqm/yr	Renewable Energy
10,000 to 20,000	>60% of living rooms & bedrooms are designed to be naturally ventilated.	RETV :17.5 W/sqm Façade Properties: U Value: 4.1, SC value: 0.35	All above ground lobbies and corridors are naturally ventilated.	Type: LED Improvement over Baseline >60% Control: Motion Sensors	Cooling System: Split units - NEA 5 ticks	Use of ceiling fans in dwelling units for thermal comfort	44	On site PV Energy Replacement: 30% of the common facilities energy consumption (SLE)
>20,000	>60% of living rooms & bedrooms are designed to be naturally ventilated.	RETV :19.09 W/sqm Façade Properties: U Value: 3.77, SC value: 0.49	All above ground lobbies and corridors are naturally ventilated. Void spaces in between levels for wind to penetrate.	Type: LED Improvement over Baseline >60% Control: Motion Sensors	Cooling System: Split units - NEA 5 ticks	Use of ceiling fans in dwelling units for thermal comfort	29.61	On site PV Energy Replacement: 30% of the common facilities energy consumption (SLE)
>100,000	>60% of living rooms & bedrooms are designed to be naturally ventilated.	RETV :18.08 W/sqm	All above ground lobbies and corridors are naturally ventilated	Type: LED improvement over Baseline : 80% Control: Motion Sensors	Air conditioning not provided (HDB project)	Nil	5.12	NIL

GREEN MARK SUPER LOW ENERGY CASE STUDY*

*Case Studies mentioned in this document are not exhaustive, it's meant to illustrate the various available GBTs to achieve SLE

SLEB Case Studies

SMU-X [Zero Energy Building (ND)]



1. Passive Strategies

Mass engineered Timber Tropical Vernacular – shading, greenery, breezy non AC spaces

2. Active Strategies

New Cooling system that relies on convection currents of the cool air. Patented **Passive Displacement Cooling system**

3. Smart Energy Management

Full in house bespoke demand control system based on occupancy for lighting, AC and plug loads

4. Renewable Energy

Latest high efficiency photovoltaic (PV) panels

Project Team: Client: SMU | Architect: MKPL | MEP: Meinhardt | ESD Consultant: Web Earth | Specialist: SMU (PDC system) SLEB Case Studies

NUS SDE 4 [Zero Energy Building (ND)]



1. Passive Strategies

Massing to promote comfortable NV spaces. Large roof for shading and to aid with ventilation

2. Active Strategies

Hybrid cooling system using ceiling fans and air-conditioning set at a higher temperature (27°C)

3. Smart Energy Management

Extensive sensors for lighting and cooling systems

4. Renewable Energy

Latest high efficiency photovoltaic (PV) panels to offset 100% of its energy consumption

Project Team:

Client: NUS | Designer: Serie + Multiply Consultants | Architect/MEP/ESD: SJ | Specialist: Transsolar Energietechnik



SLEB Case Studies

80 Anson Road Residential [Super Low Energy Residential Building (ND)]







1. Passive Strategies

Massing and unit layout to promote comfortable NV Dwelling units . Low RETV of 19.09 W/m2 with good glass selection and shading devices to reduce overall building heat gain



2. Active Strategies

Installation of energy efficient air-conditioning systems with 5 ticks rating for all dwelling units Use of 100% energy efficient LED lighting to achieve high energy savings compared to baseline



3. Smart Energy Management

Smart sensors and controls in common areas for lighting and ventilation



Roof top Solar photovoltaic (PV) panels to offset 30% of the common facilities energy consumption.

SLEB Case Studies Keppel Bay Tower [Zero Energy Building (EB)]



Tower

Smart

to

about

Project Team: Client: Keppel | FM: Johnson Controls | ESD Consultant: Johnson Controls

SLEB Case Studies Commercial SLE projects (EB)

KEPPEL BAY TOWER - Keppel Land



ONE RAFFLES LINK - Hong Kong Land



LOGISTECH - CapitaLand



TUAS BIOMEDICAL PARK - JTC



Thank You

Useful Links for Reference

SLE Standard - <u>https://www1.bca.gov.sg/buildsg/sustainability/super-low-energy-programme</u> SLE awarded project - <u>https://www.sleb.sg/Building/GreenMarkBuildingsDirectory</u> SLEB Smart Hub - <u>www.sleb.sg</u>