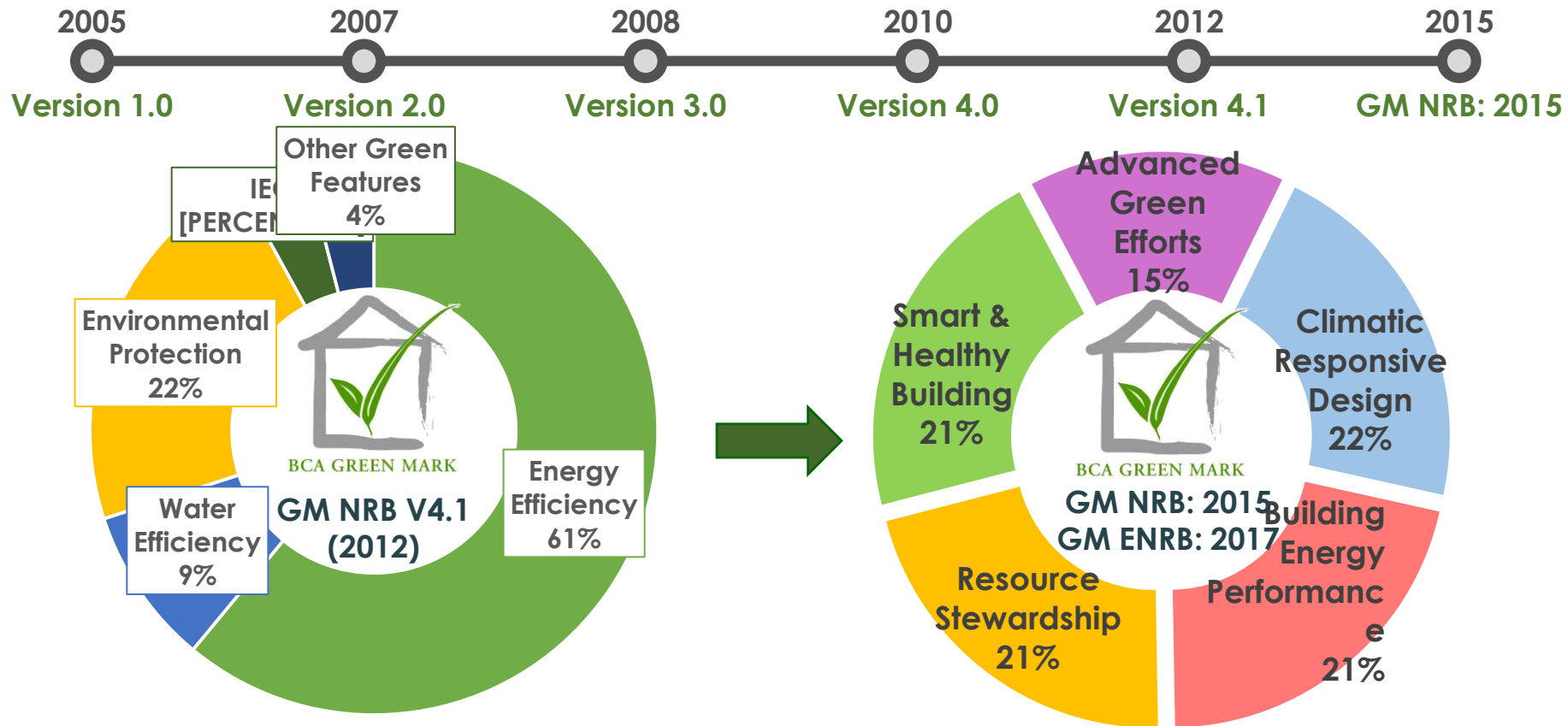


# Singapore's Green Building Energy Efficiency Standards



# Evolution of BCA Green Mark Standard



# BCA Green Mark for Existing Non-Residential Buildings 2017 (GM ENRB: 2017)

- Launched for piloting in September 2017

## ☐ Energy monitoring

- Sub-metering
- Energy dashboard/ portal

## ☐ Demand Control

## ☐ Integration & Analytics

- System integration & optimisation
- Demand response
- Preventive maintenance

## ☐ Occupant Comfort

- Post Occupancy Evaluation
- Thermal comfort with elevated air speed
- IAQ audit

## ☐ Indoor Air Quality

- IAQ trending & monitoring
- IAQ display
- Demand control ventilation
- Local exhaust & air purging system
- Outdoor airflow monitoring system
- MERV 14 filters for outdoor air filtration





# GM ENRB: 2017 – Section 2 Building Energy Performance

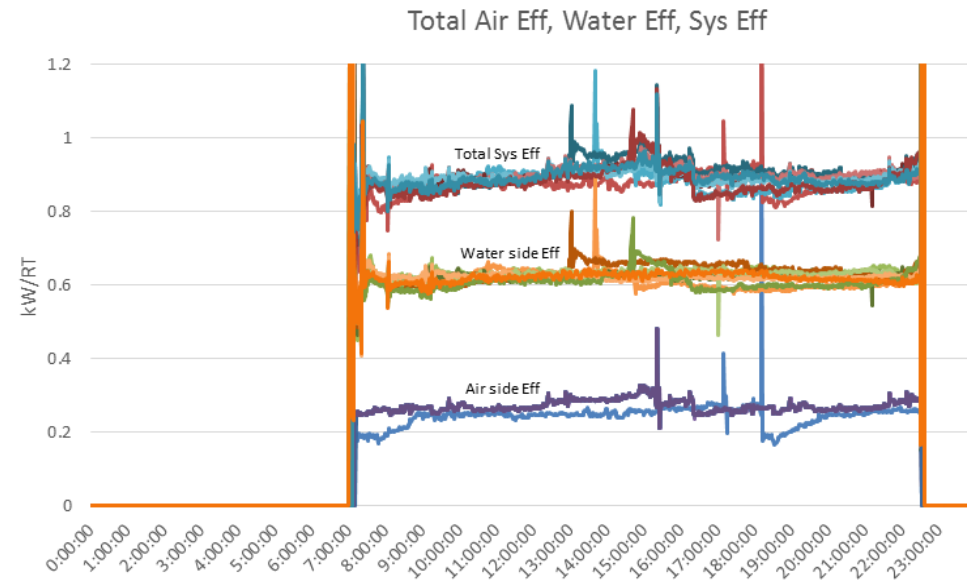
## Air-Conditioning System Efficiency

Encourages measurement of air distribution system efficiency

High potential savings in air distribution system

Green Mark Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Minimum Efficiency (kW/RT)	
Certified	0.85	0.75
Gold	0.80 (v3) → 0.75	0.70
Gold <sup>Plus</sup>	0.75 (v3) → 0.7	0.68
Platinum	0.70 (v3) → 0.68	0.65

Baseline for Air Distribution Efficiency  
(voluntary basis): 0.28 kW/RT



Total air con system score = score<sub>water</sub> + score<sub>air</sub>

# GM ENRB: 2017 – Section 1 Sustainable Management

## Performance-based Procurement for Retrofits and Maintenance

Encourages Energy Performance Contract (EPC) by EPC firms accredited by the Singapore Green Building Council (SGBC)

### For EE Retrofits

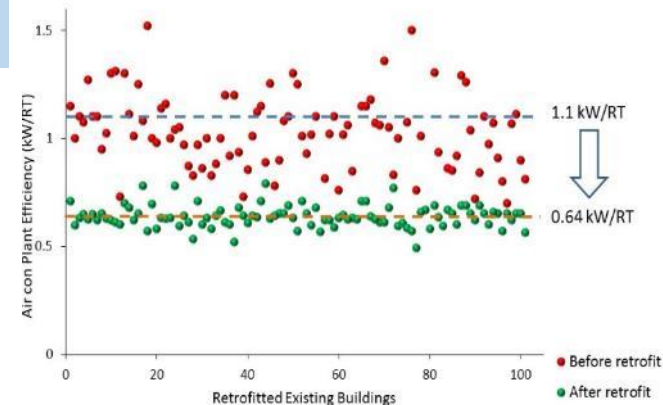
- Centralised chilled water system
- Air distribution system

### For Maintenance (min. 3 years)

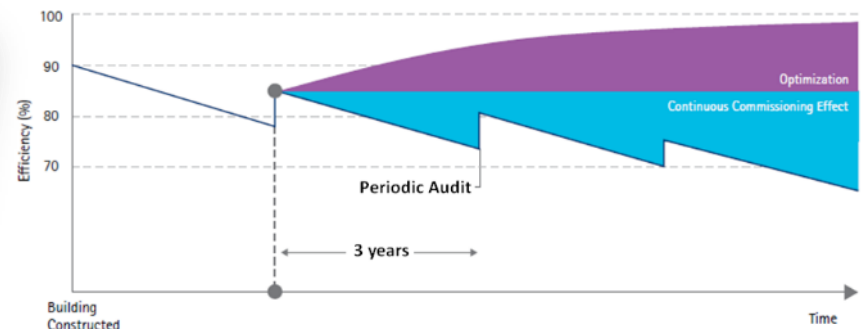
- Centralised chilled water system
- Air distribution system



Retrofitting Existing Chiller Plants



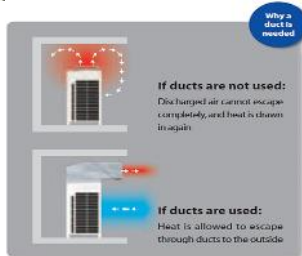
Continuous commissioning benefits (illustrative)



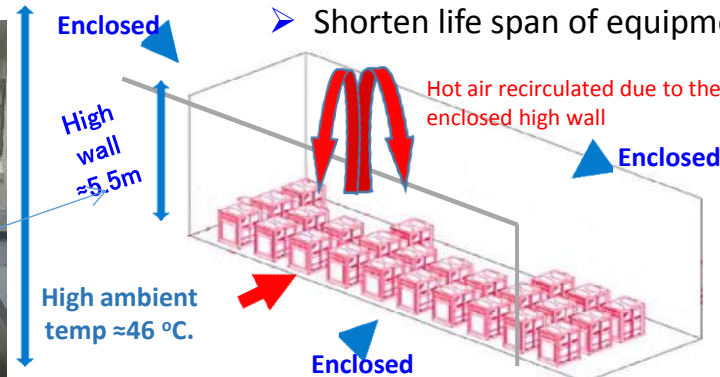
# GM ENRB: 2017 – Measurement & Verification (M&V) for VRF Systems

## Poor Installation Lead to Poor Performance & Breakdown of Aircon

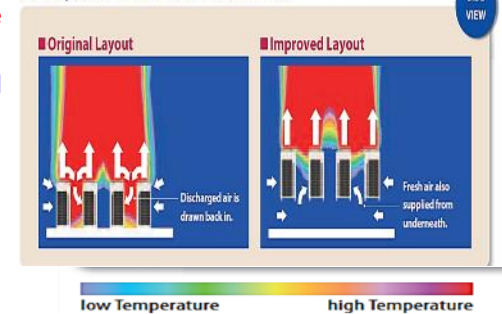
### Poor Location of Outdoor



- Poor heat exchange due to recirculating of the hot air discharged
- Increase in high pressure & energy consumption
  - Poor performance & drop in efficiency
  - Shorten life span of equipment.



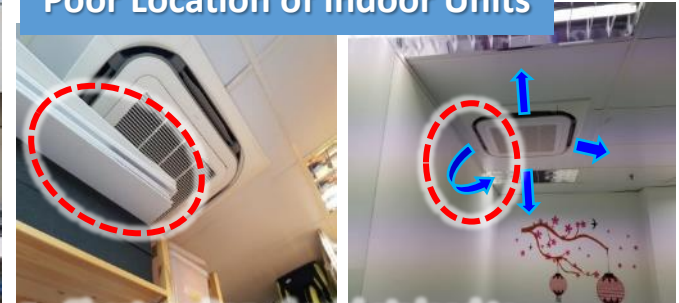
Air temperature and airflow simulation results



Install cowl & Raise Units for better Air Circulation



### Poor Location of Indoor Units



- Short-cycling of cold air lead to poor performance

# Energy Management - VRV System Efficiency

- An efficiency report based on all the VRV systems in a building can be generated.
- Most of the building system efficiency measured does not have a good result

## Before tuning

No	Line Name	Average Outdoor Temperature	Average Room Temperature	Average Room Set Temperature	Average Cooling Capacity	Average Power Consumption	Average Loading of CU in %	COP	Kw/RT
1	CU 2/1F	32.07	23.42	24.07	25.11	6.66	46.17	3.66	0.96
2	CU 2/1N	31.85	24.07	24.19	23.80	6.62	39.14	3.60	0.98
3	CU 2/2F	32.04	23.16	24.08	23.61	6.18	38.83	3.62	0.92
4	CU 2/2N	33.37	24.40	24.59	14.72	3.77	38.33	3.90	0.90
Average		32.33	23.76	24.23	21.81	5.66			
Total Power Input(kw) @Part Load		Total Required Cooling Capacity (kw)		Total Required Cooling Capacity (RT)		Overall operating efficiency for the system (KW/RT)		Overall operating efficiency for the system (COP)	
23.43		87.24		24.81		0.94		AVE COP 3.72	

## After tuning

No	Line Name	Average Outdoor Temperature	Average Room Temperature	Average Room Set Temperature	Average Cooling Capacity	Average Power Consumption	Average Loading of CU in %	COP	Kw/RT
1	CU 2/1F	30.11	24.02	22.90	11.61	2.14	21.34	5.43	0.65
2	CU 2/1N	29.47	23.70	23.36	12.33	2.45	20.28	5.03	0.70
3	CU 2/2F	29.07	23.30	22.82	12.51	2.56	20.58	4.89	0.72
4	CU 2/2N	29.73	25.43	25.25	10.18	1.96	26.51	5.19	0.68
Average		29.60	24.11	23.58	11.66	2.28			
Total Power Input(kw) @Part Load		Total Required Cooling Capacity (kw)		Total Required Cooling Capacity (RT)		Overall operating efficiency for the system (KW/RT)		Overall operating efficiency for the system (COP)	
9.11		46.63		13.26		0.69		AVE COP 5.12	

≈37% Improve!



# Zero Energy Building – Challenges



Climate : Hot & Humid

Land area: Scarce

Renewable Energy Options: Limited

Physical : High-rise & Dense

Roof Space: Small

**BUILDINGS**



**LIFESTYLE**

Behaviour: Reliance on air-conditioners

Energy consumption: High

**Singapore's context:**  
High Rise High Density Urban Tropics



**Solar is the ONLY  
Renewable Energy**



# PE-ZE-SLEB Definition and Targets

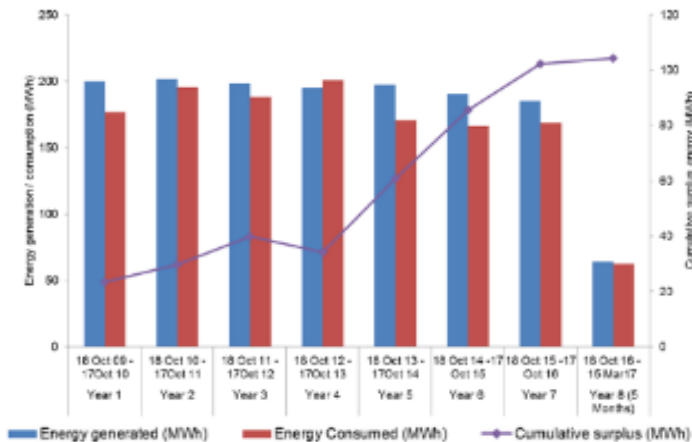
	Positive Energy	Zero Energy	Super Low Energy
Key Characteristics	<ul style="list-style-type: none"> <li>• Highest Energy Efficiency</li> <li>• Consumption Includes Plug Load</li> <li>• On-site and Off-Site Renewable Energy</li> </ul>		
Applicability	<ul style="list-style-type: none"> <li>• Low Rise (1-3 storey)</li> <li>• School, IHL</li> </ul>	<ul style="list-style-type: none"> <li>• Mid Rise (4-7 storey)</li> <li>• School, IHL, Office</li> </ul>	<ul style="list-style-type: none"> <li>• High Rise (<math>\geq 8</math> storey)</li> <li>• Office, Retail, Hotel</li> </ul>
Energy Efficiency & Renewable Energy	<ul style="list-style-type: none"> <li>• <math>RE &gt; EC</math></li> </ul>	<ul style="list-style-type: none"> <li>• <math>EEl: &lt; 100 \text{ kWh/m}^2.\text{yr}</math></li> <li>• <math>EC = RE</math></li> </ul>	<ul style="list-style-type: none"> <li>• <math>EEl: &lt; 100 \text{ kWh/m}^2.\text{yr}</math></li> </ul>
<ul style="list-style-type: none"> <li>• RE : Renewable energy</li> <li>• EC : Energy consumption</li> </ul>			<ul style="list-style-type: none"> <li>• EEl is 60% less than 2005 building code level</li> </ul>

# ZEB @ BCA Academy

More than 30 technologies testbedded



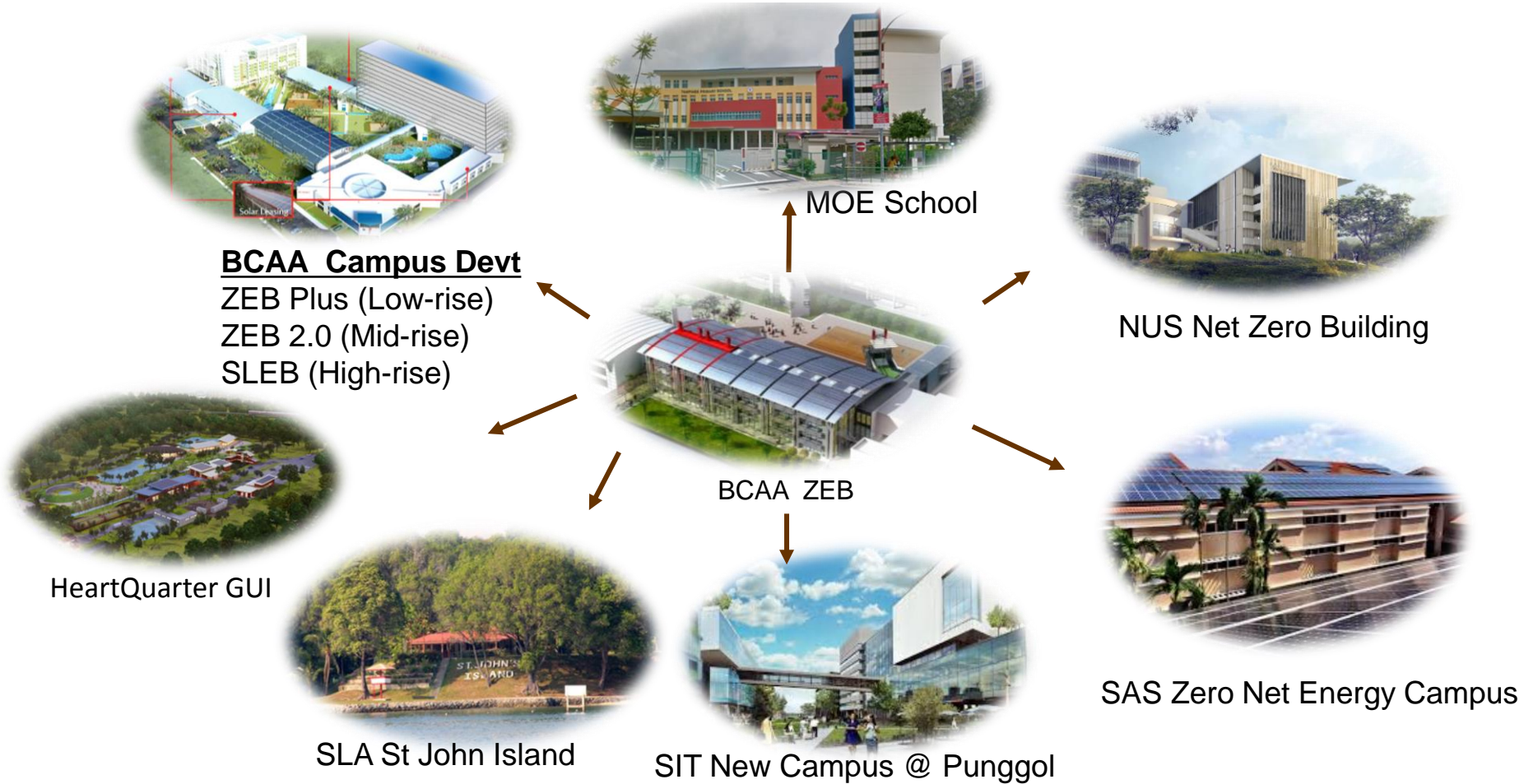
Successful demonstration of solar PV for existing office building



Current EUI (Air-con Area): 82 kWh/m<sup>2</sup>.yr

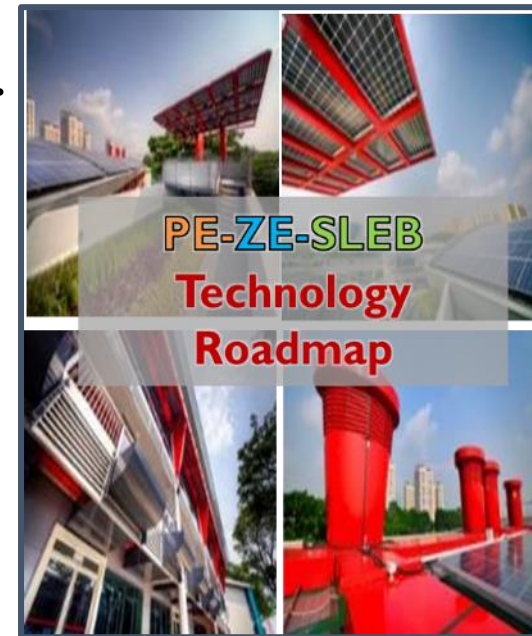
8 years of energy surplus

# ZEB@BCAA Inspires More ZEB Developments



# PE-ZE-SLEB Technology Roadmap

- Defines Singapore's PE-ZE-SLEB
- Comprehensive technology review (incl. solar renewable technologies)
- Policy Recommendations & future research & development and demonstration (RD&D) pathway





# End of Presentation

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Green Mark Department (Existing Building)  
Building and Construction Authority  
Singapore