Building and Construction Authority

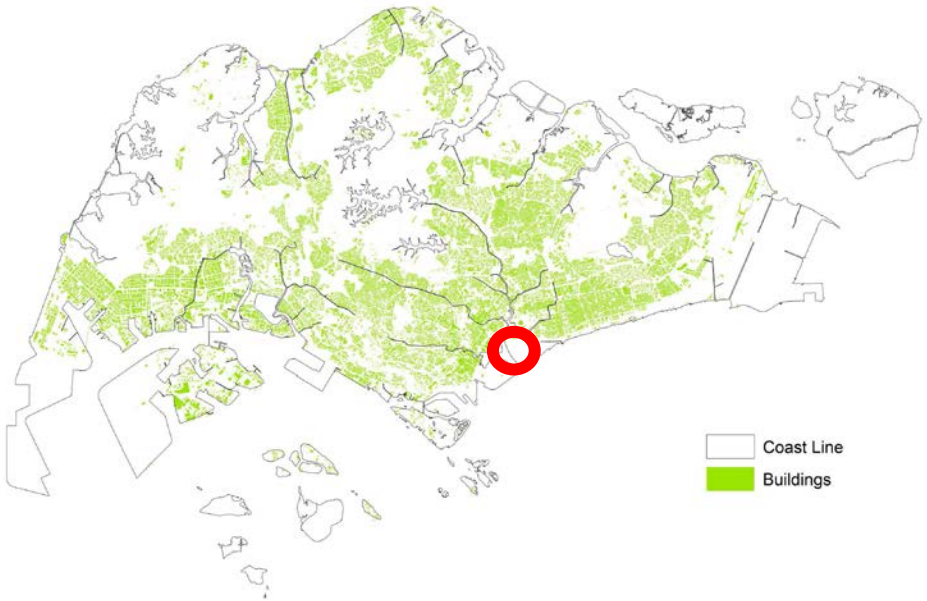
IEA Energy Technology Network

FUTURE BUILDINGS FORUM

IEA Future Building Forum,
24-25 Oct 2017, Singapore

POSITIVE ENERGY LOW-RISE, ZERO ENERGY MID-RISE & SUPER LOW ENERGY HIGH-RISE BUILDINGS FOR THE TROPICS

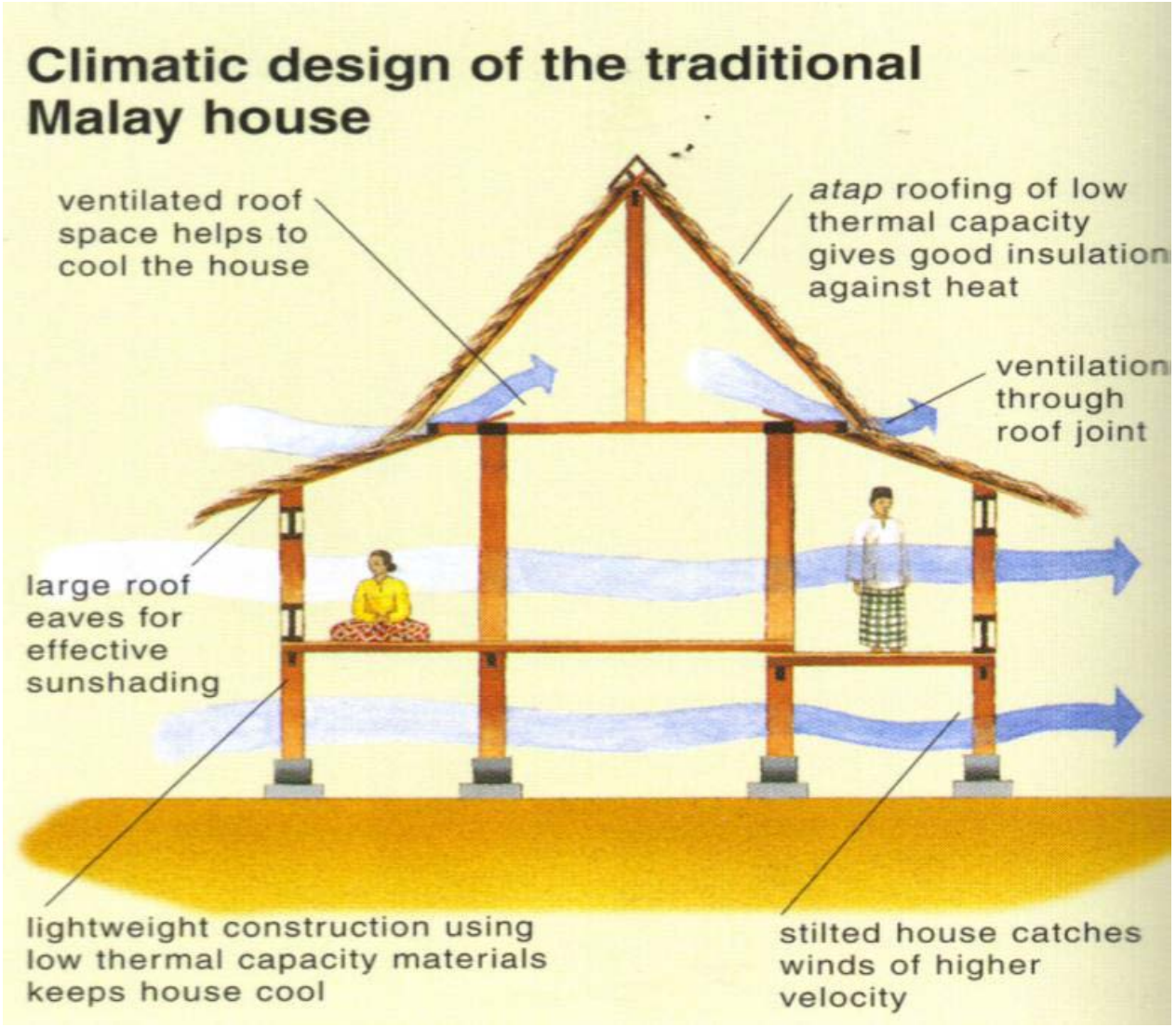
Dr Gao Chun Ping
Building & Construction Authority
Singapore



	1960	2016
	1.64 mil	5.61 mil
	580 sq.km	720 sq.km
	US$ 428 per capita	US$ 52, 962 per capita

BUILDINGS IN HOT AND HUMID CLIMATE

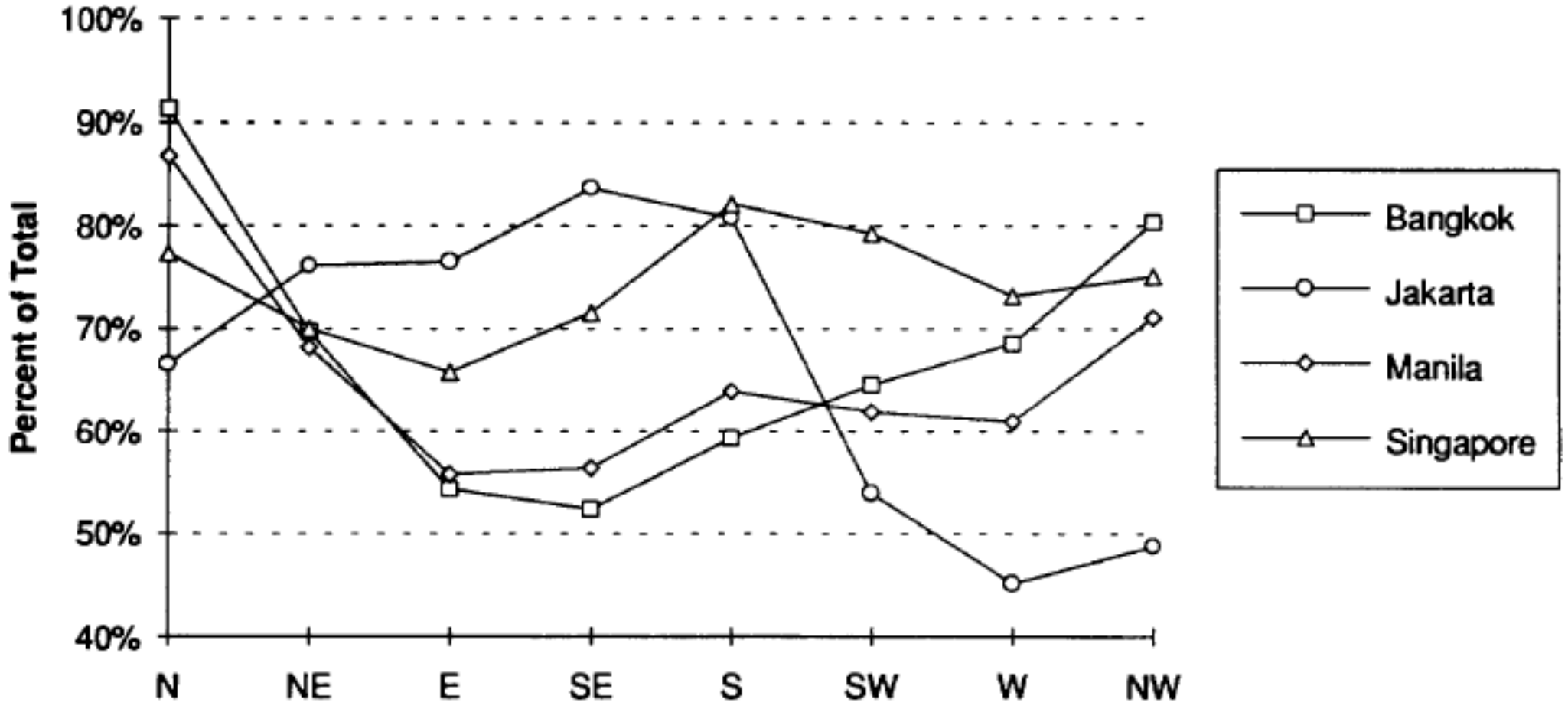
- High solar irradiation (50% more than temperate countries)
- High solar angle (all sides shading)
- High air temperature: 25-32°C
- Small diurnal air temperature range: less than 10°C
- High humidity: >50% and very high at night
- Light winds: 0.5-3 m/s
- Cloudy sky with high diffused light components
- Heavy rainfall (>2000 mm)



source: UTM

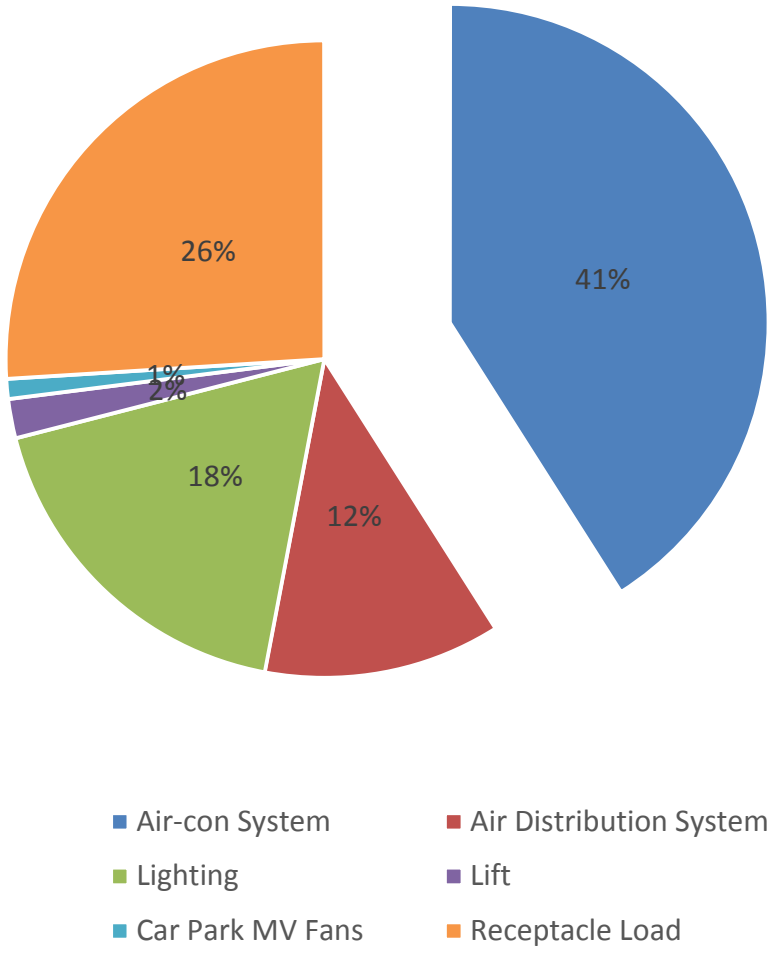
DIFFUSE SOLAR RADIATION IN THE TROPICS

Figure 3-5. Diffuse Solar Radiation as Percent of Total for Vertical Surfaces (0800-1800 hours)

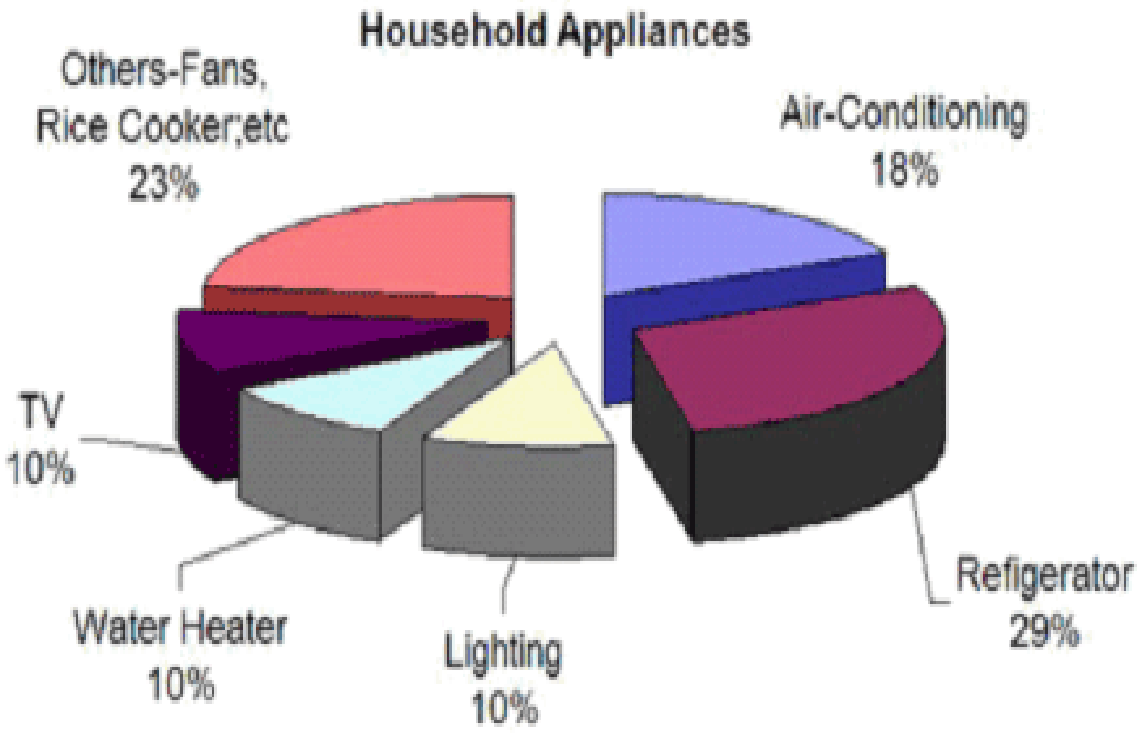


BUILDINGS ENERGY CONSUMPTION

Building Energy Consumption for Commercial Buildings



Energy Consumption for Residential Buildings



Source: BCA, HDB, NEA, NUS

GREEN BUILDING MOVEMENT

Target: greening 80% of the building stock by 2030

5 Key Assessment Criteria

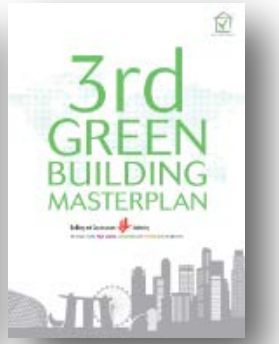
1. Energy Efficiency
2. Water Efficiency
3. Environmental Protection
4. Indoor Env. Quality
5. Other Green Features

BCA GREEN MARK

Green Building Rating System specially for the Tropics

New Buildings

Existing Buildings



Building Occupants

- Public Sector Taking The Lead
- Building Industry Capabilities Through Training
- Spurring The Private Sector
- Legislating Minimum Standards
- Developing Green Building Technology
- International Profiling & Raising Awareness

GREEN MARK BUILDINGS

Target: greening 80% of the building stock by 2030

>33%
of total GFA greened

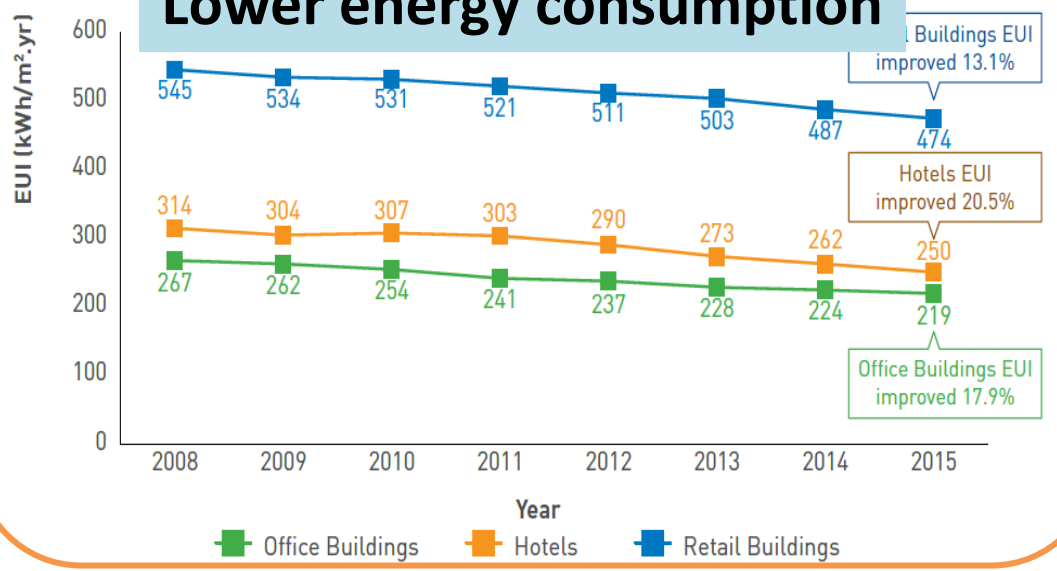
>3,000
Green Building Projects

>89 Mil m^2
of total GFA greened

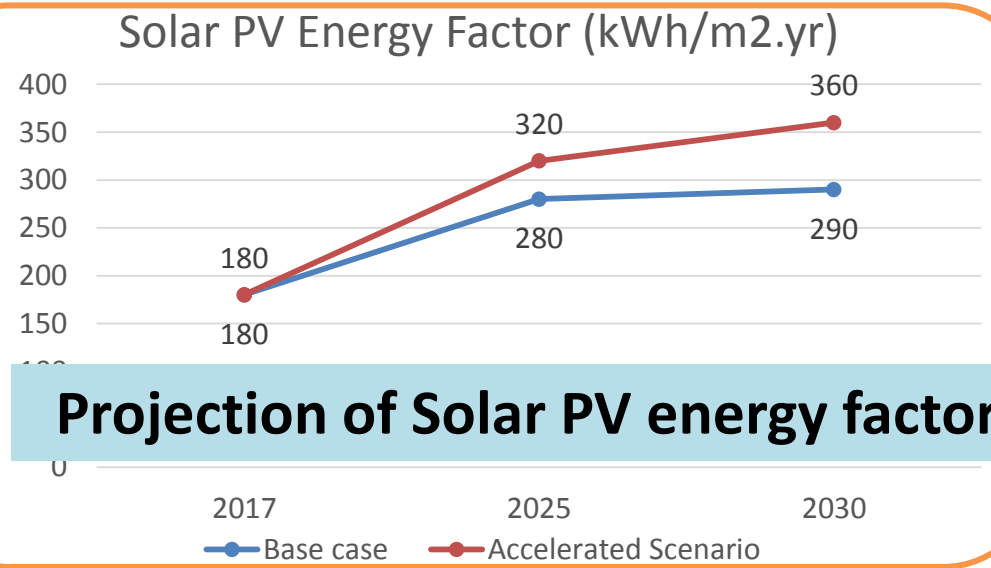
Building and Construction Authority

CURRENT ENERGY TRENDS IN SINGAPORE

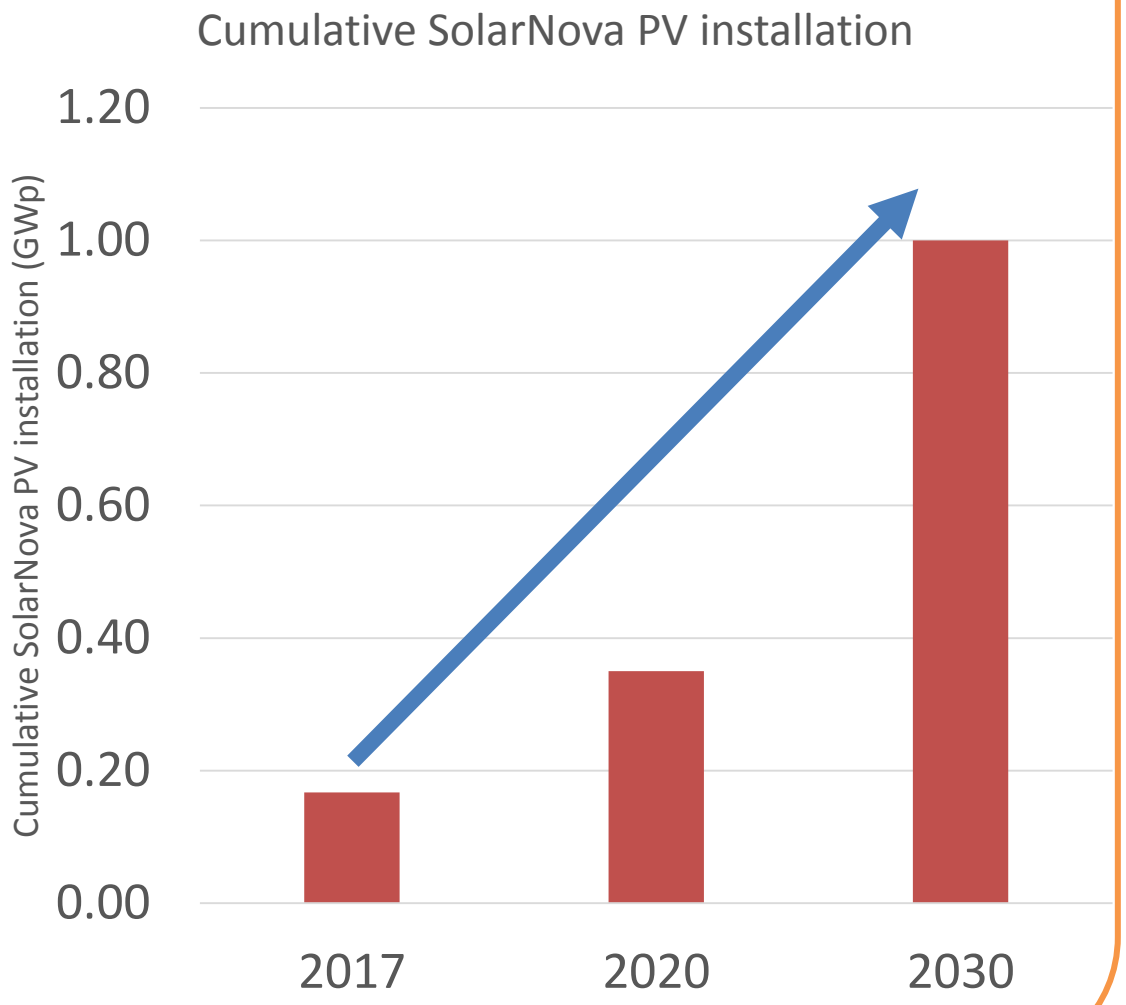
Lower energy consumption



Projection of Solar PV energy factor

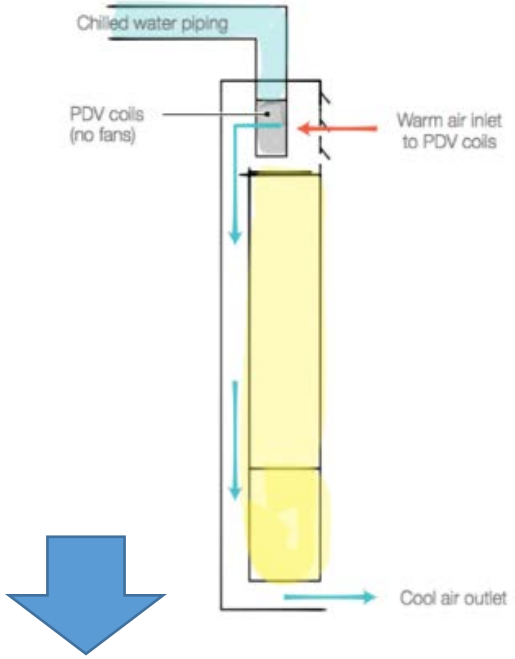


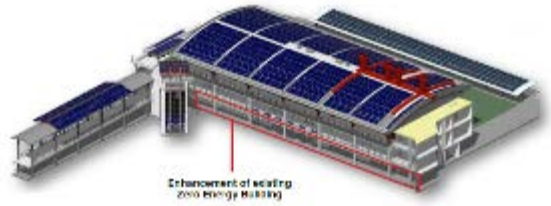
National projection of PV installation

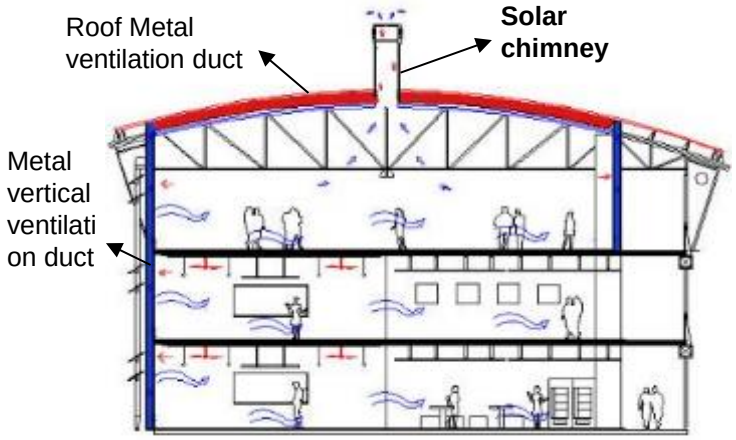


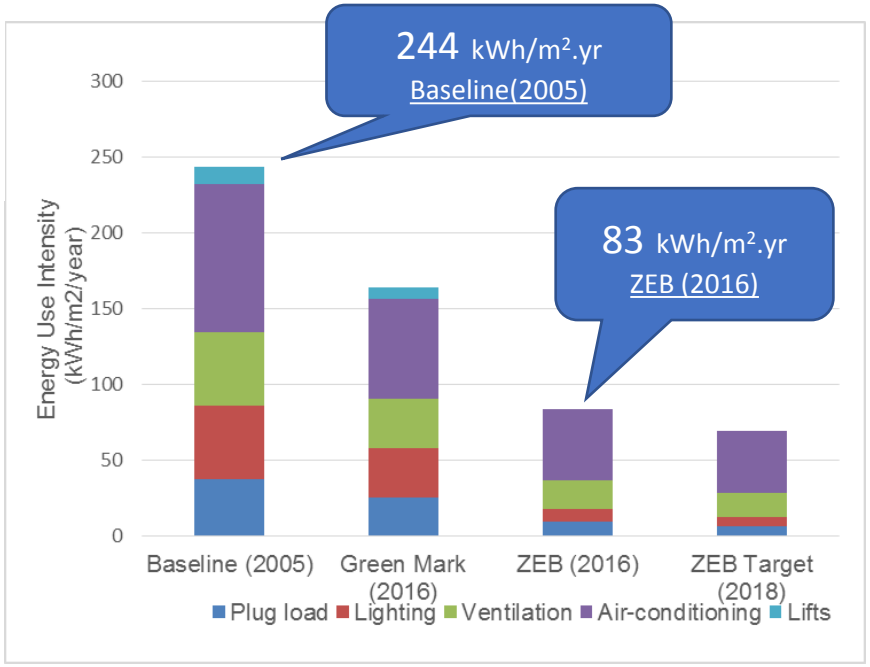
ZEB@BCA Academy

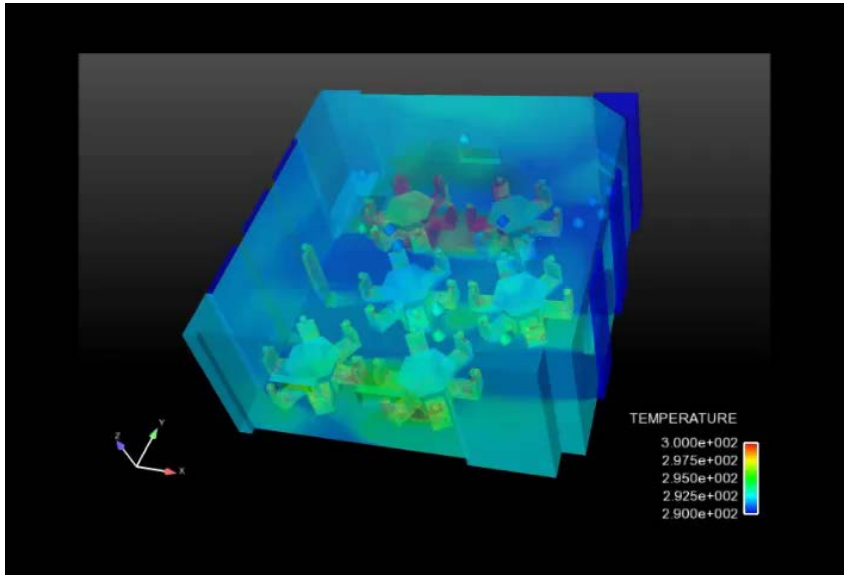
- More than 30 technologies
- 8 years of Net Zero Energy
- 66% Energy Savings











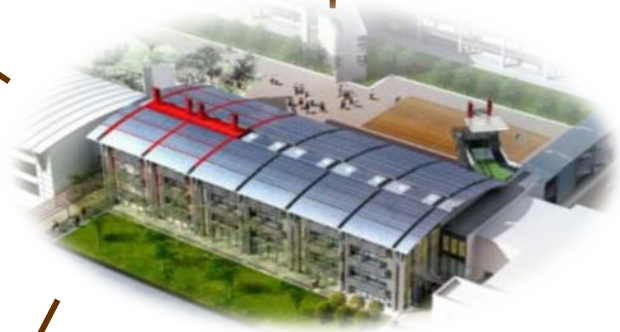
Source: NUS, NTU

ZEB@BCAA Inspires More ZEB Developments

BCAA Campus Devt
ZEB Plus (Low-rise)
ZEB 2.0 (Mid-rise)
SLEB (High-rise)

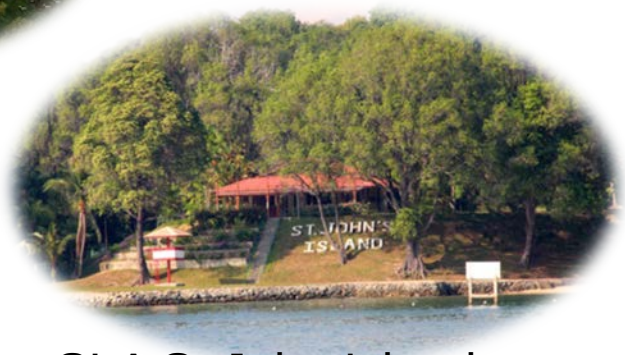
MOE Schools

NUS Net Zero Building



BCAA ZEB

HeartQuarter GUI



SLA St John Island

SIT New Campus @ Punggol

SAS Zero Net Energy Campus

Our Aspiration

Urban ZEB

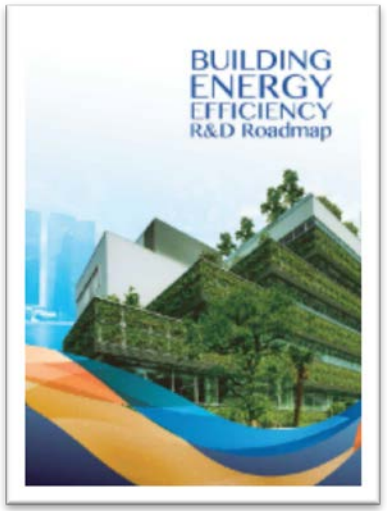
- High-rise high density
- Singapore is renewable energy disadvantage country
- Solar is more promising but constraint by roof space

Tropical ZEB

- High energy to cool buildings
- High humidity
- Design of natural ventilation in commercial buildings is not a norm
- Lifestyle

Positive-Energy Low-Rise*, *Zero-Energy Medium-Rise* & *Super Low-Energy High-Rise Buildings in the Tropics

PE-ZE-SLEB Technology Roadmap



Feasibility study

- International scan
- Data analysis of >1,200 buildings
- 2 separate modelling exercises
- Validation with measurements

Industry consultation

- 4 industry engagement sessions/workshops
- > 10 interviews with stakeholders
- Surveyed 124 stakeholders

PE-ZE-SLEB Roadmap

- Technologies identified and prioritized
- Recommendation for RD&D
- Recommendation for implementation & adoption

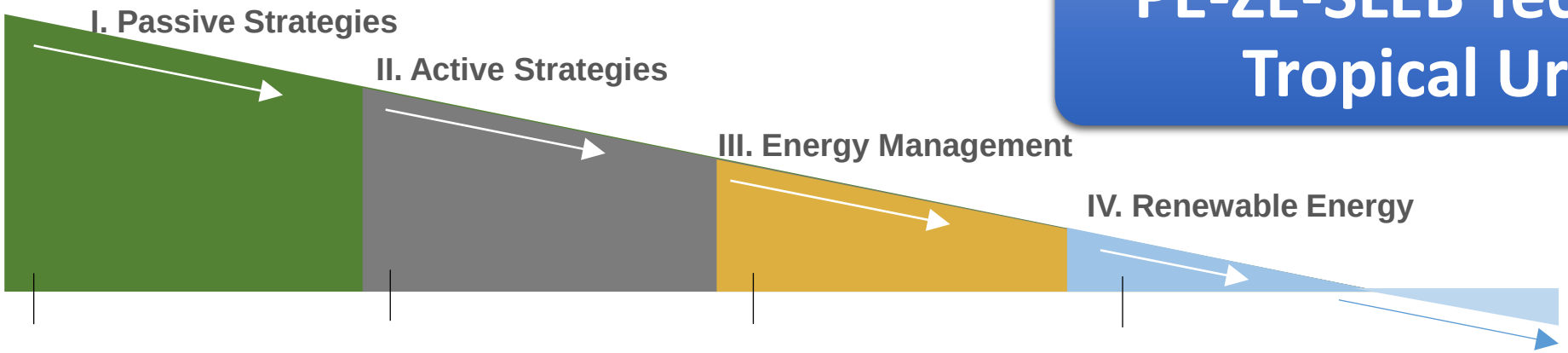
BCA

ERI@N
Energy Research Institute @ NTU

SERIS
Solar Energy Research Institute of Singapore

Jul 2016 – Sep 2017

PE-ZE-SLEB Technologies for Tropical Urban Cities



Building Automation

- Fault detection and diagnostics (FDD)
- Energy Management System
- Occupancy sensoring & demand control
- Weather sensing & system resetting

Smart Control

- Model predictive control
- Machine learning
- IOT integration with BMS
- Personalised control of lighting/ACMV

Plug Load Management

- Smart plug
- Load monitoring and tracking
- Sleep mode optimisation

Roof & Site Optimisation

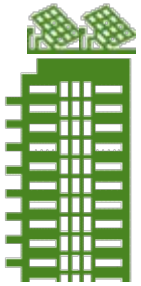
- Maximising roof and façade spaces
- Site planning for solar utilization

PV Technologies

- Highly efficient module
- Anti-shading design
- Anti-degradation system
- High performance BIPV
- PV integration with greenery
- PV energy management

Positive Energy
Low-rise buildings

Zero Energy
Medium-rise buildings



Super Low Energy
High-rise buildings

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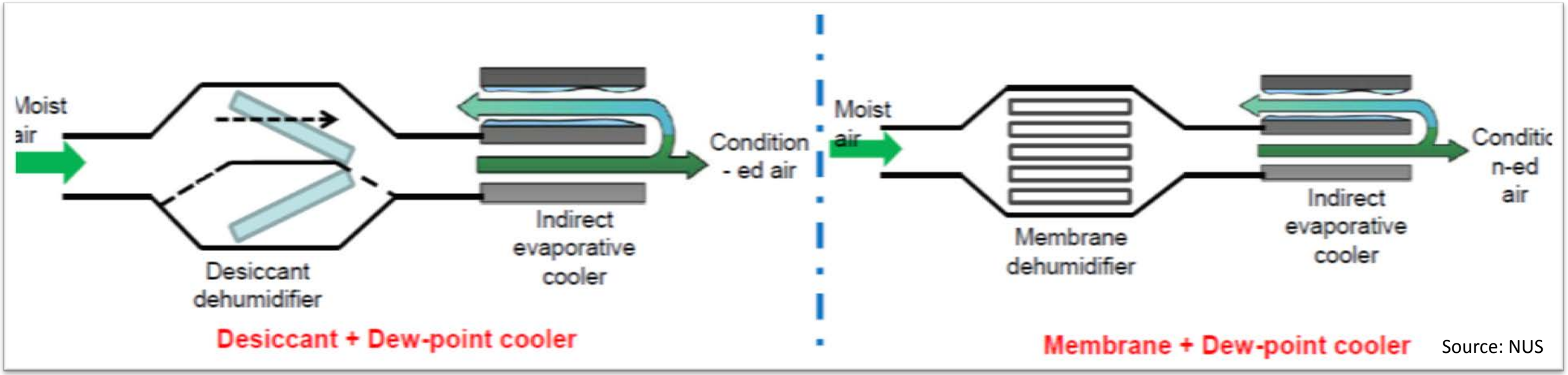
R&D - REINVENTING AIR CONDITIONING



Source: NUS

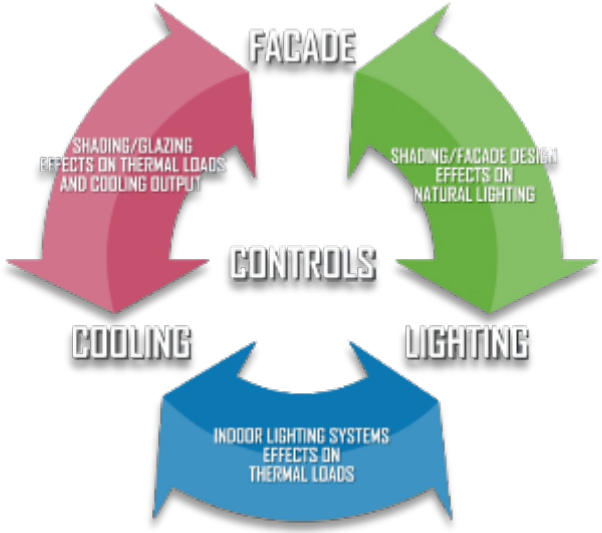
Desiccant / Membrane / Evaporative Cooling Based ACMV System

- **A hybrid system comprising composite desiccant and nano-woven membrane and indirect evaporative cooler (IEC)**
- **No compressor**
- **Improved air dehumidification efficiency up to 85%**
- **40% energy savings for air-con system**
- **Prototyped and patented**

asean Energy Award

Testbed: BCA SkyLab – World's First High-rise Rotatable Lab for the Tropics

PLUG & PLAY
fully configurable



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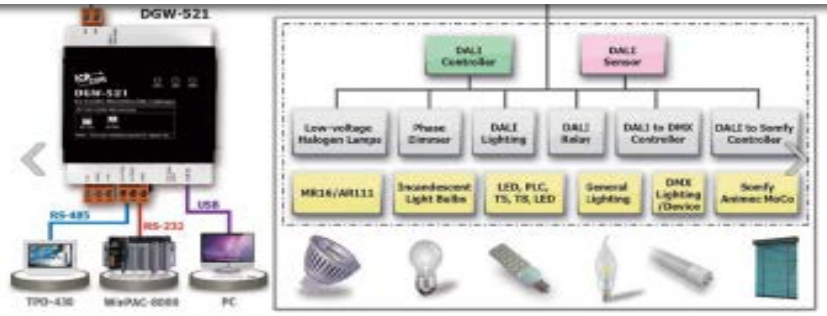
ROTATABLE
in any orientation

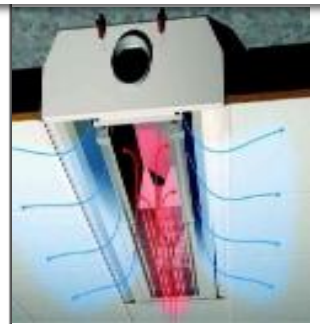
Optimise building designs in

=

REAL-WORLD TROPICAL CONDITIONS

LIGHTING | **ACMV** | **FACADE**

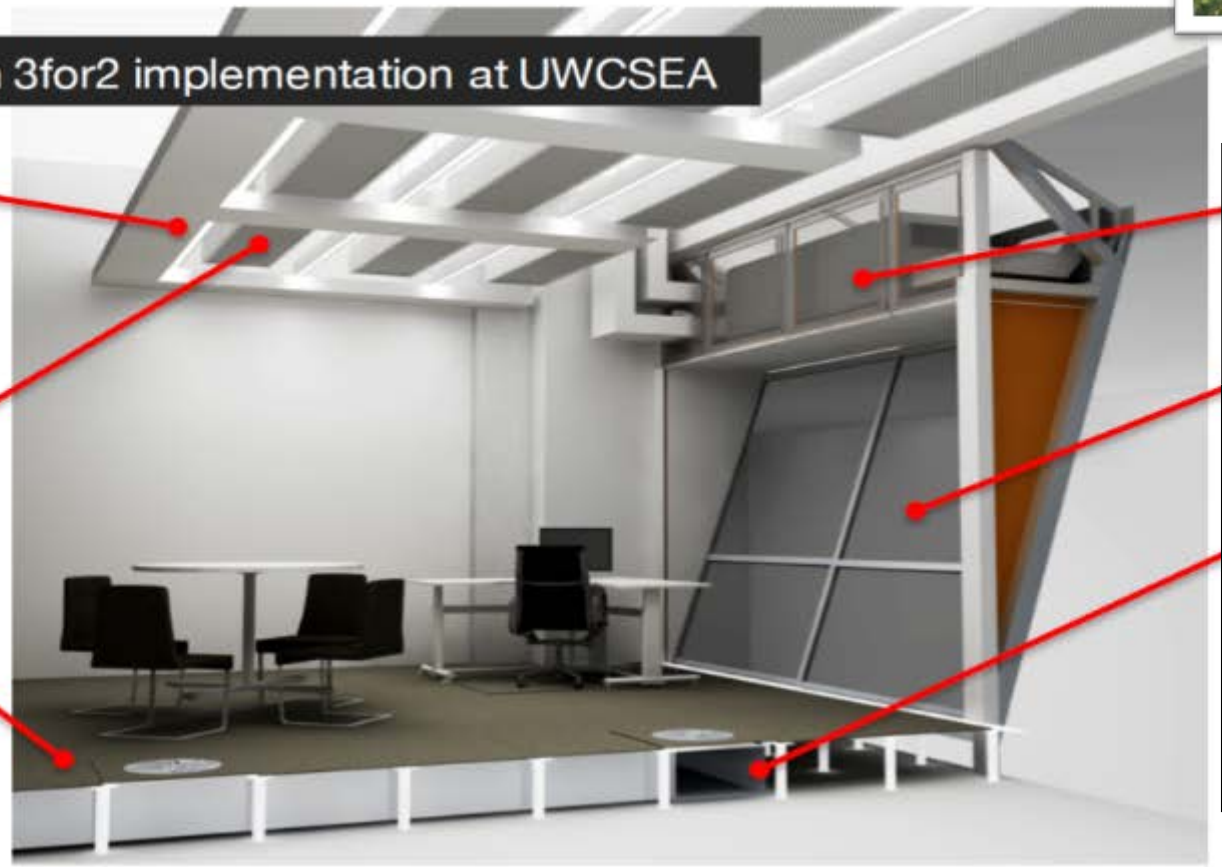




DEMONSTRATION3FOR2@UWCSEA

- **Savings in floor to floor height due to reduced air duct size**
- **Decouple latent & sensible cooling**
- **Decentralised ventilation**
- **Low lift chiller**

Design completed on 3for2 implementation at UWCSEA



Gypsum/plaster conduits hide M&E fittings

Sensible Cooling
Passive chilled beams

Raised Floor System

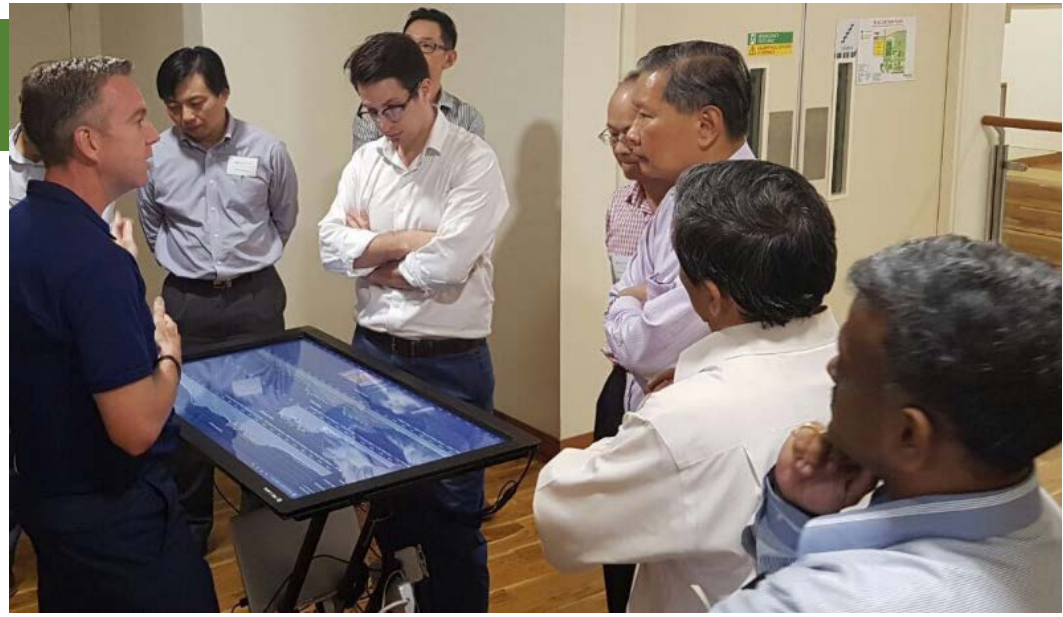
Latent Cooling
Dedicated Outdoor Air System (DOAS)

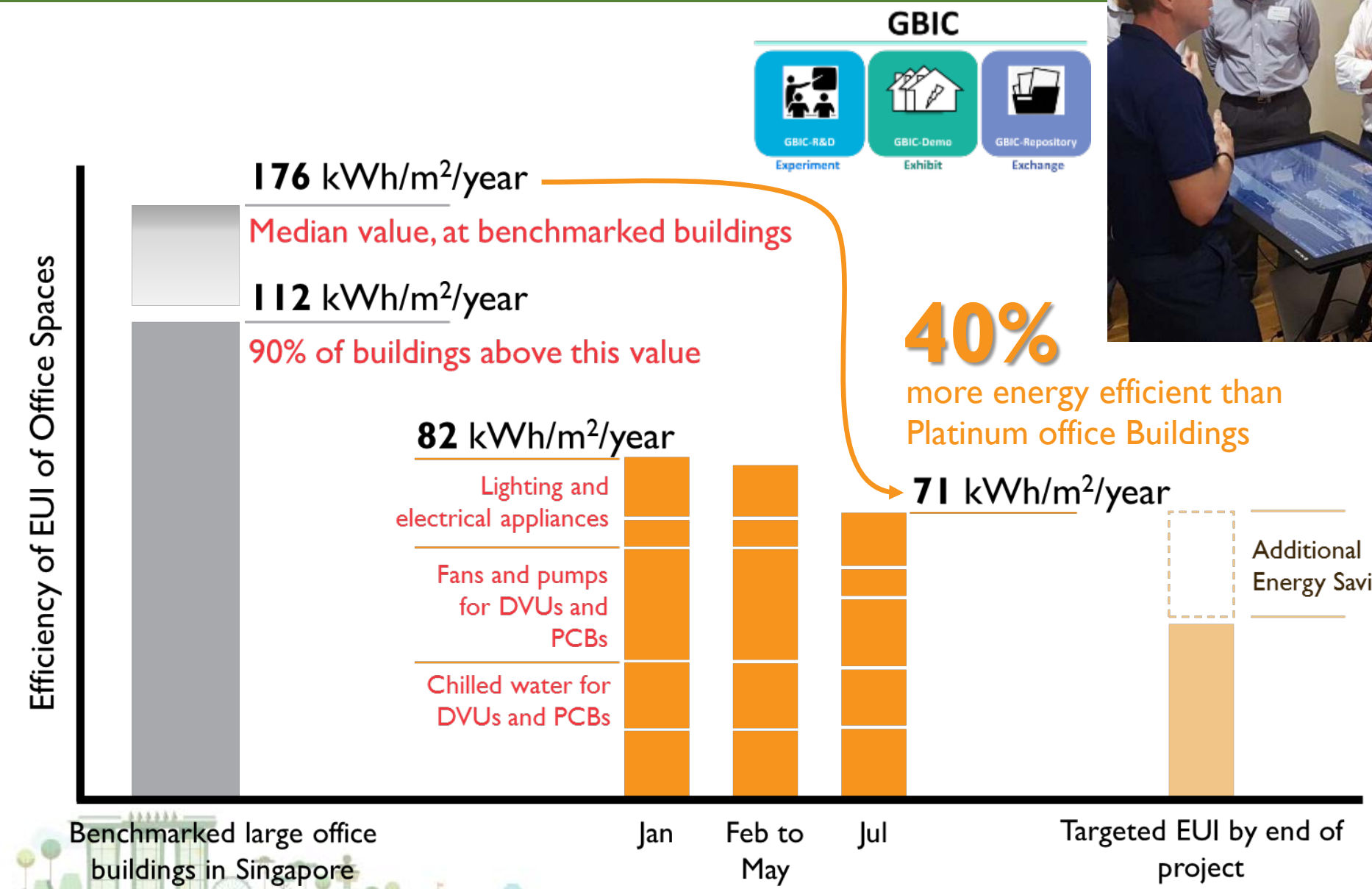
Sloped façade to mount ventilation units

Fresh Air Underfloor Air Distribution Network

Source: SEC-FCL

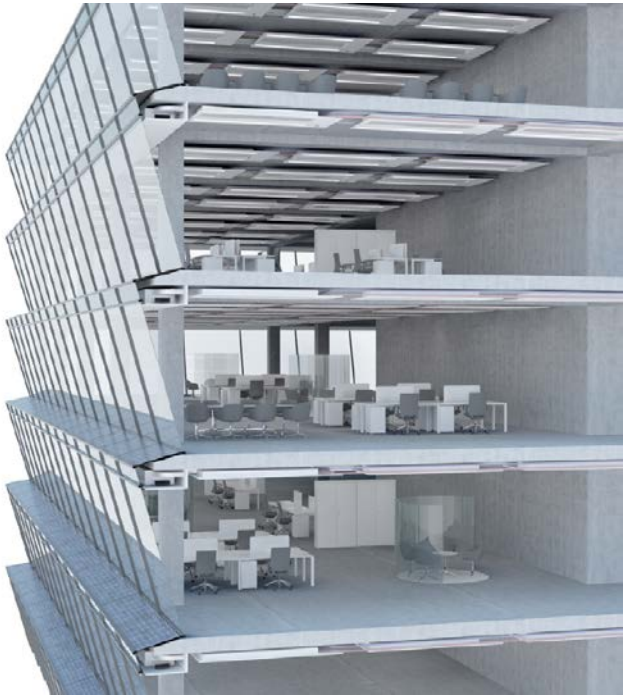
3FOR2@UWCSEA





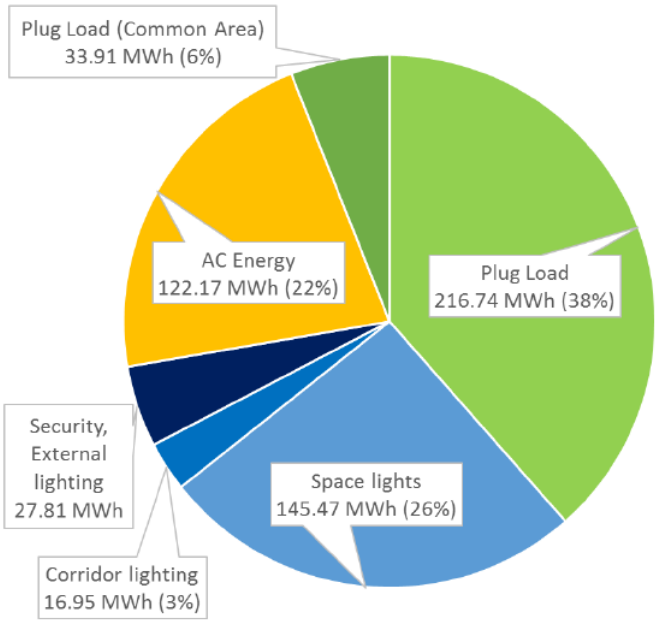
40%

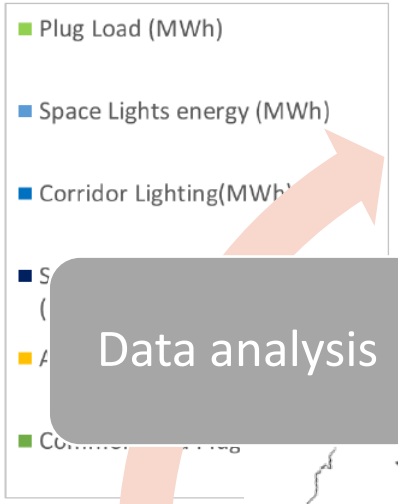
more energy efficient than Platinum office Buildings

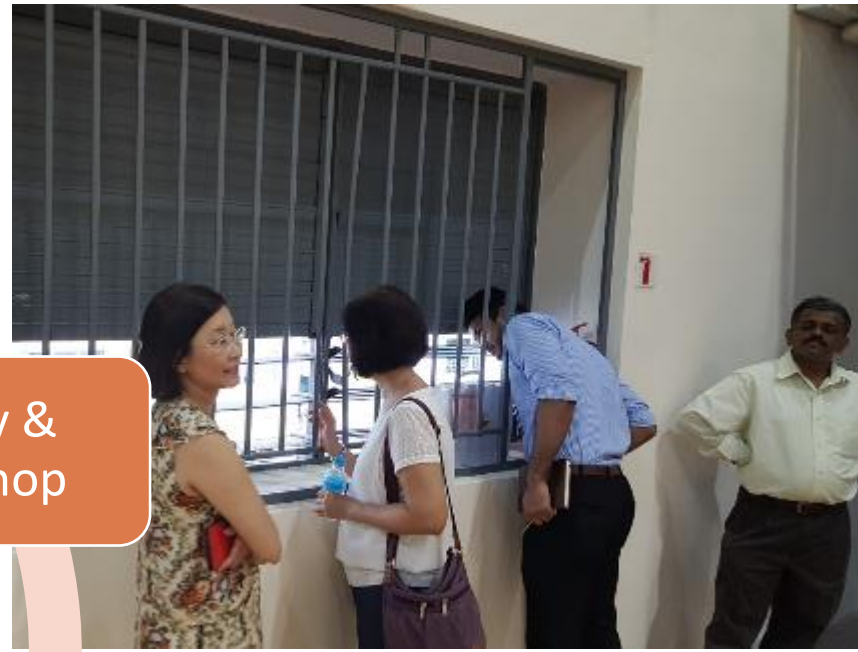


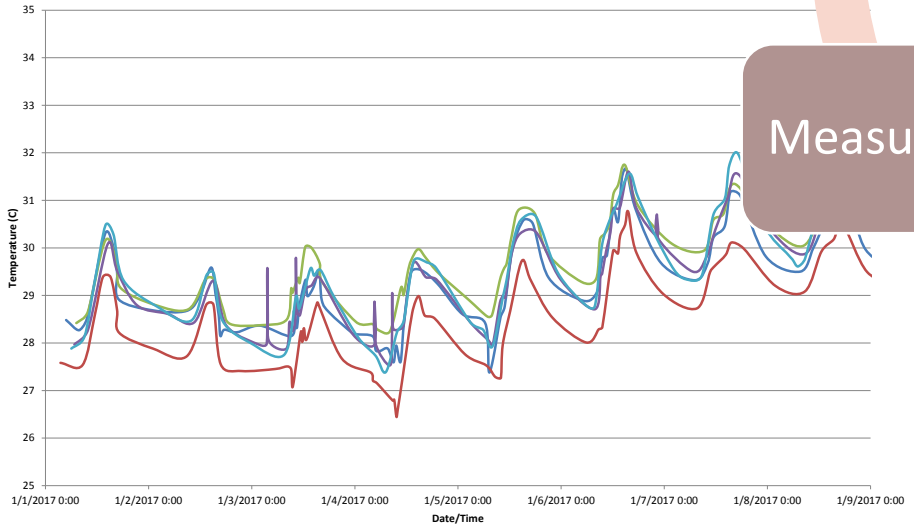
Case Study for Schools

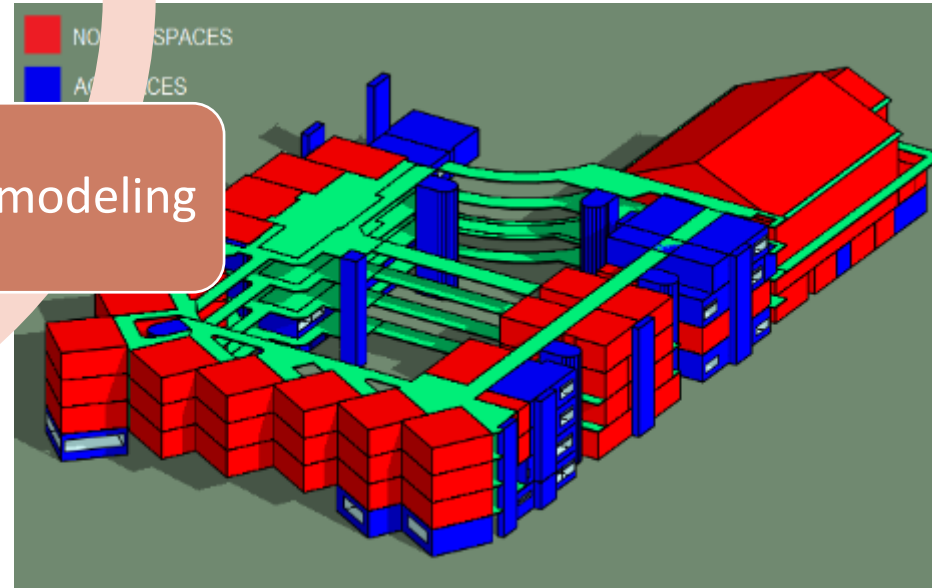
In collaboration with Ministry of Education SINGAPORE











Stocktaking

Survey & workshop

Solar modeling

Energy modeling

Measurements

Data analysis

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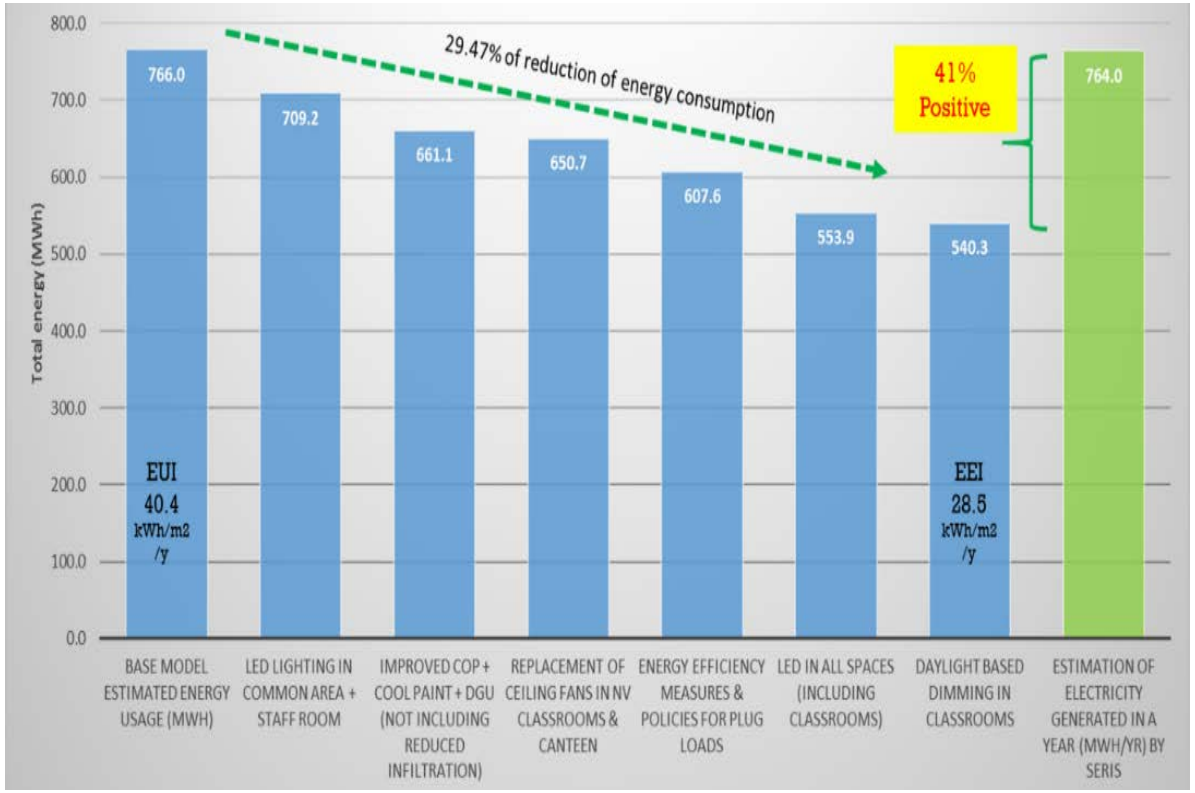
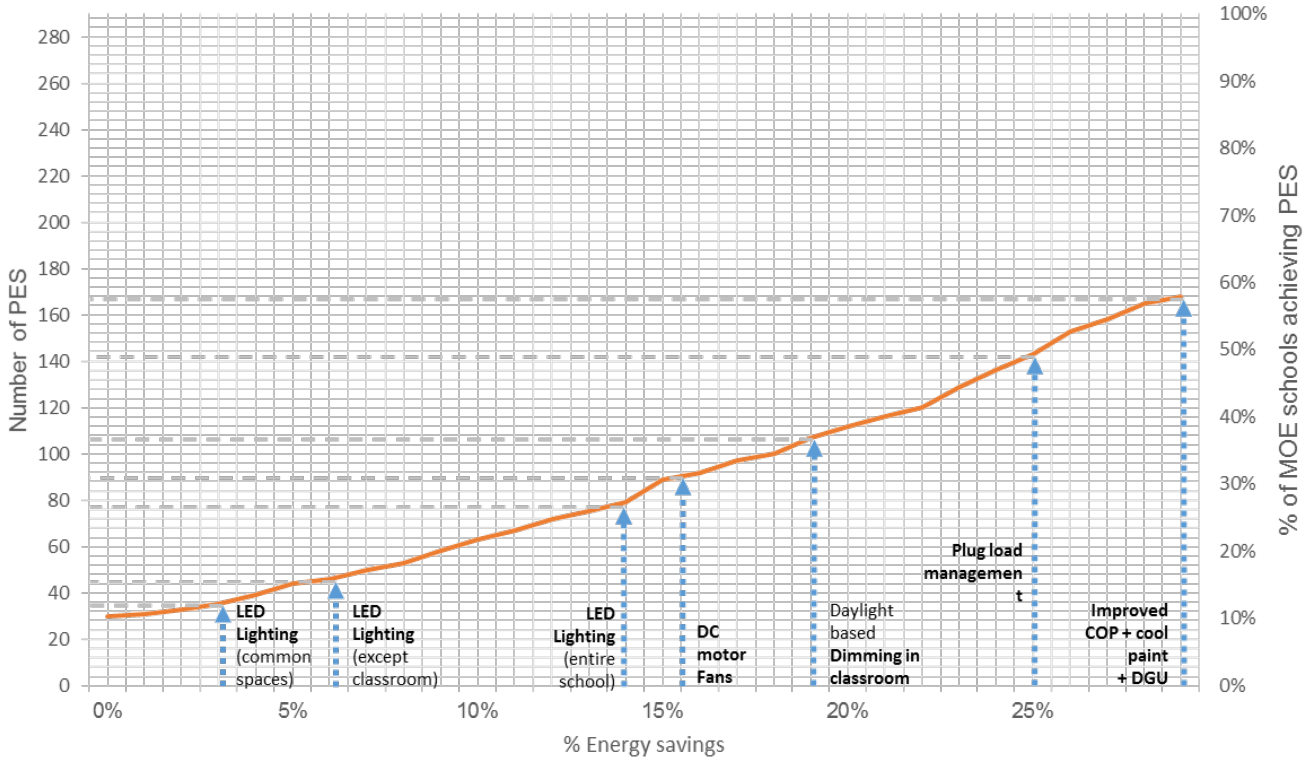
POSITIVE ENERGY SCHOOLS





Positive energy school status is possible with current available technologies

60% of schools have potential of achieving PES/ZES with cost effective energy efficient measures

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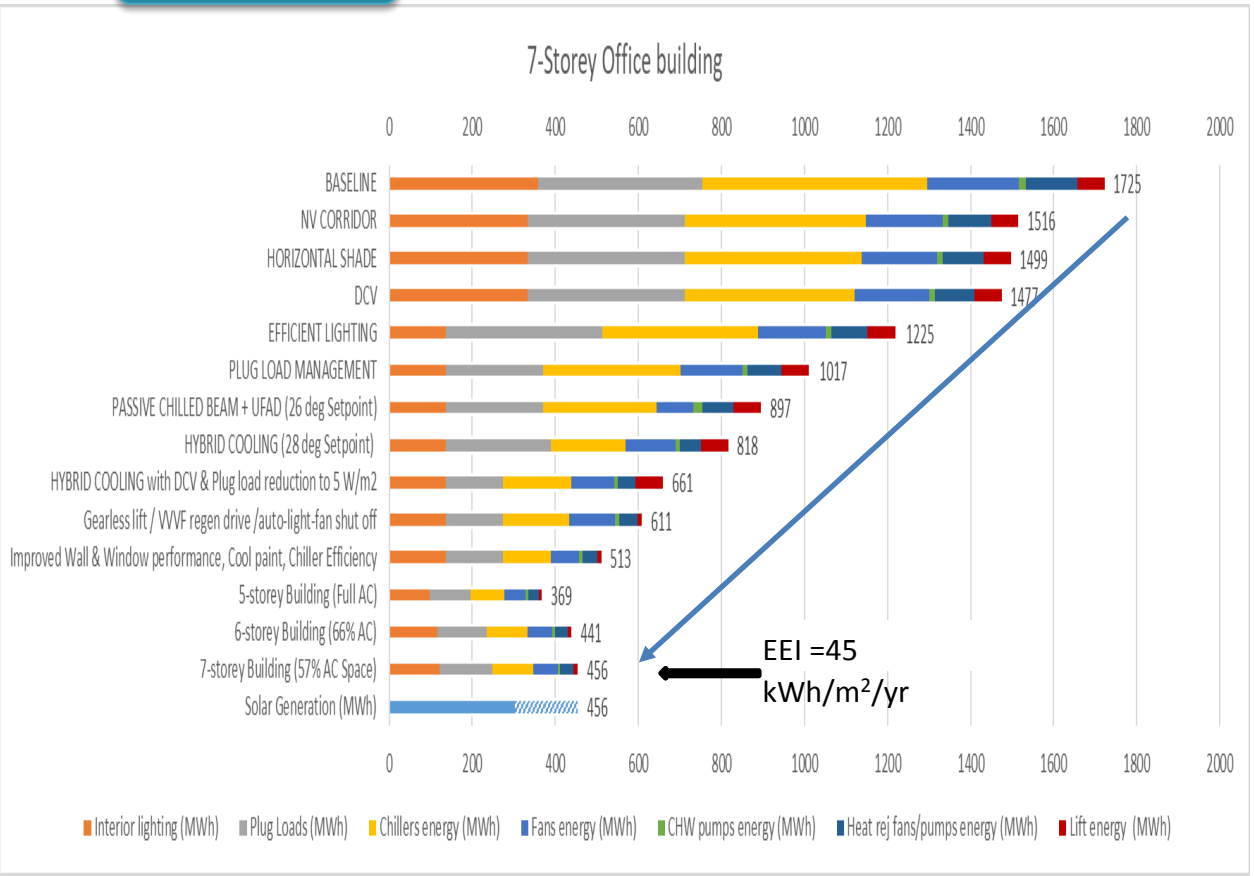
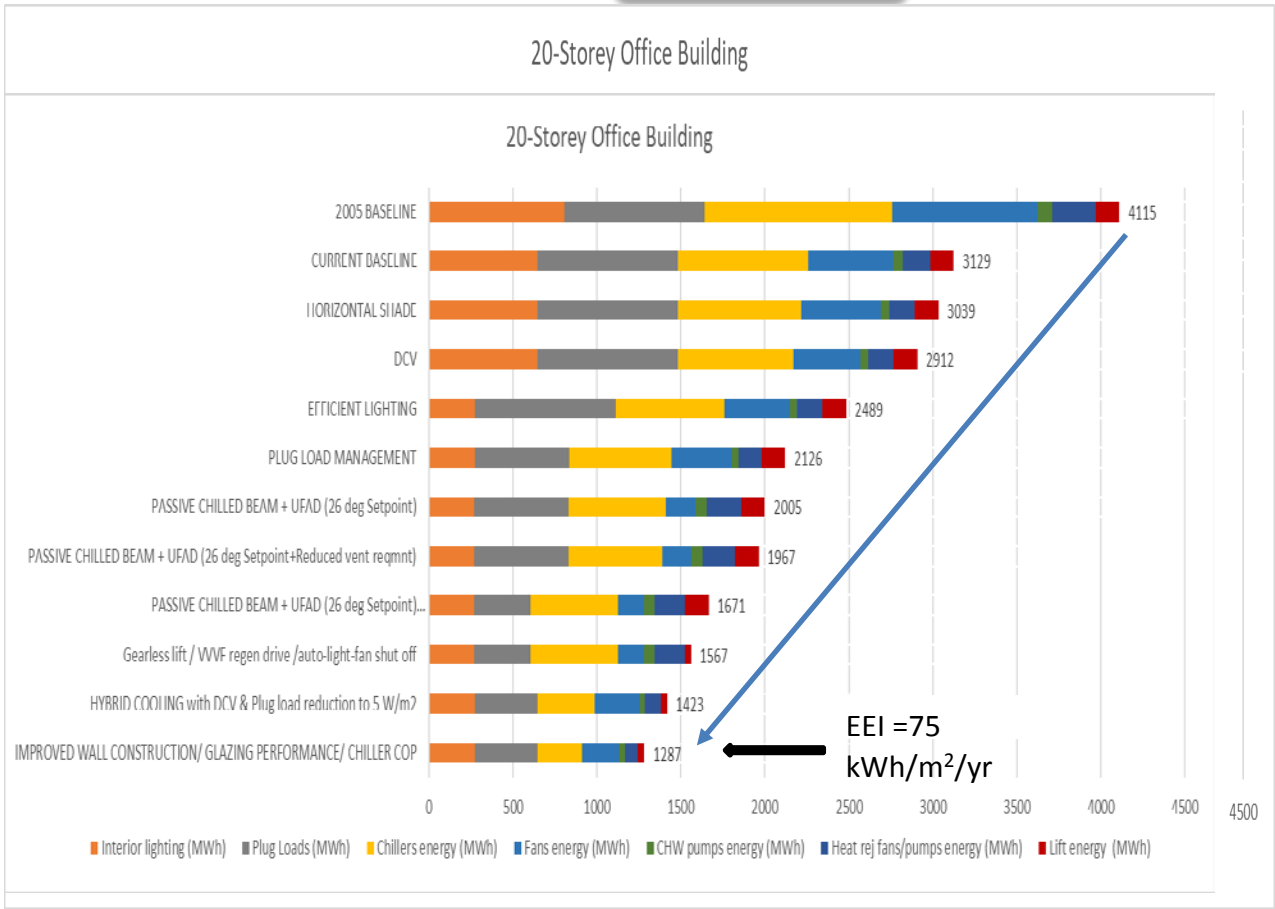
MID & HIGH-RISE OFFICE BUILDINGS - 2017

Total Energy Consumption Breakdown

7 Sty Office



20 Sty Office



Challenging with today's technologies

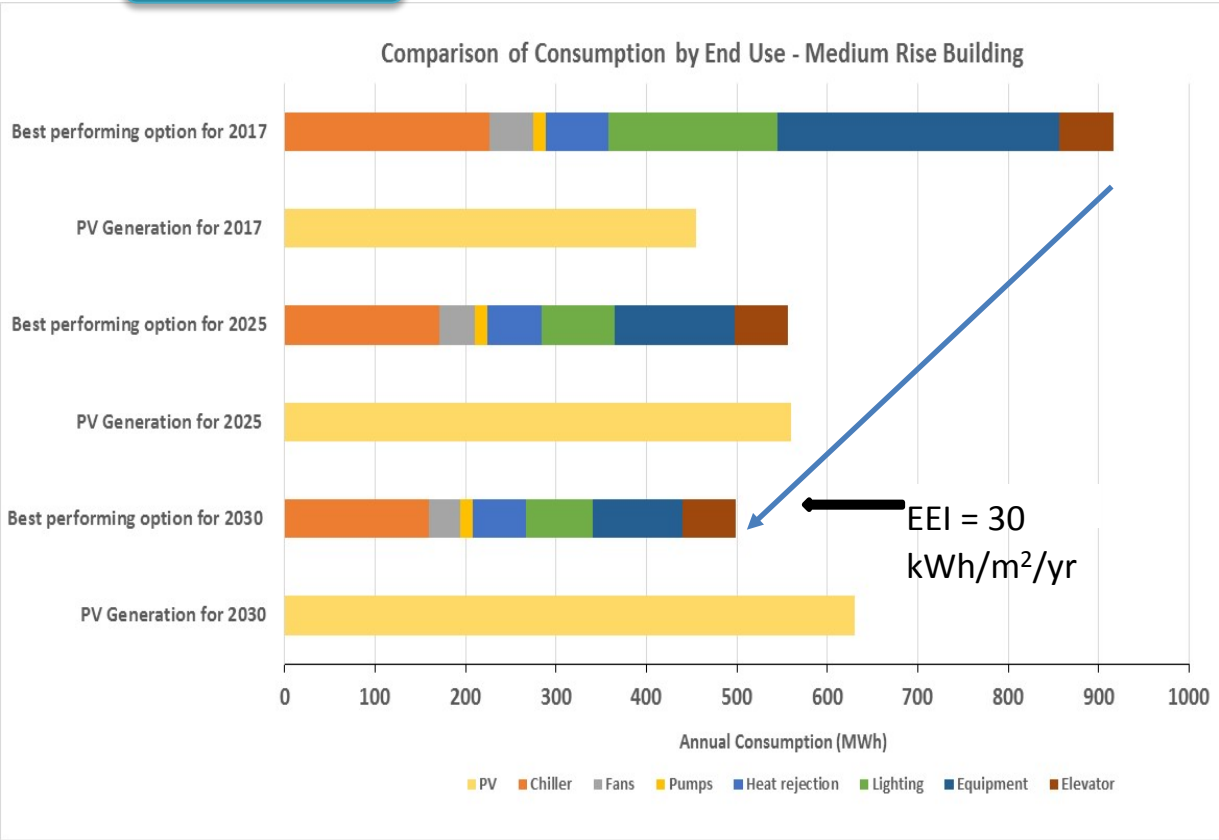
- Bottle necks in cooling & dehumidification
- Plug load management
- Boundary setting for on-site renewable energy

Building and Construction Authority

MID & HIGH-RISE OFFICE BUILDING - 2030

Total Energy Consumption Breakdown

7 Sty Office



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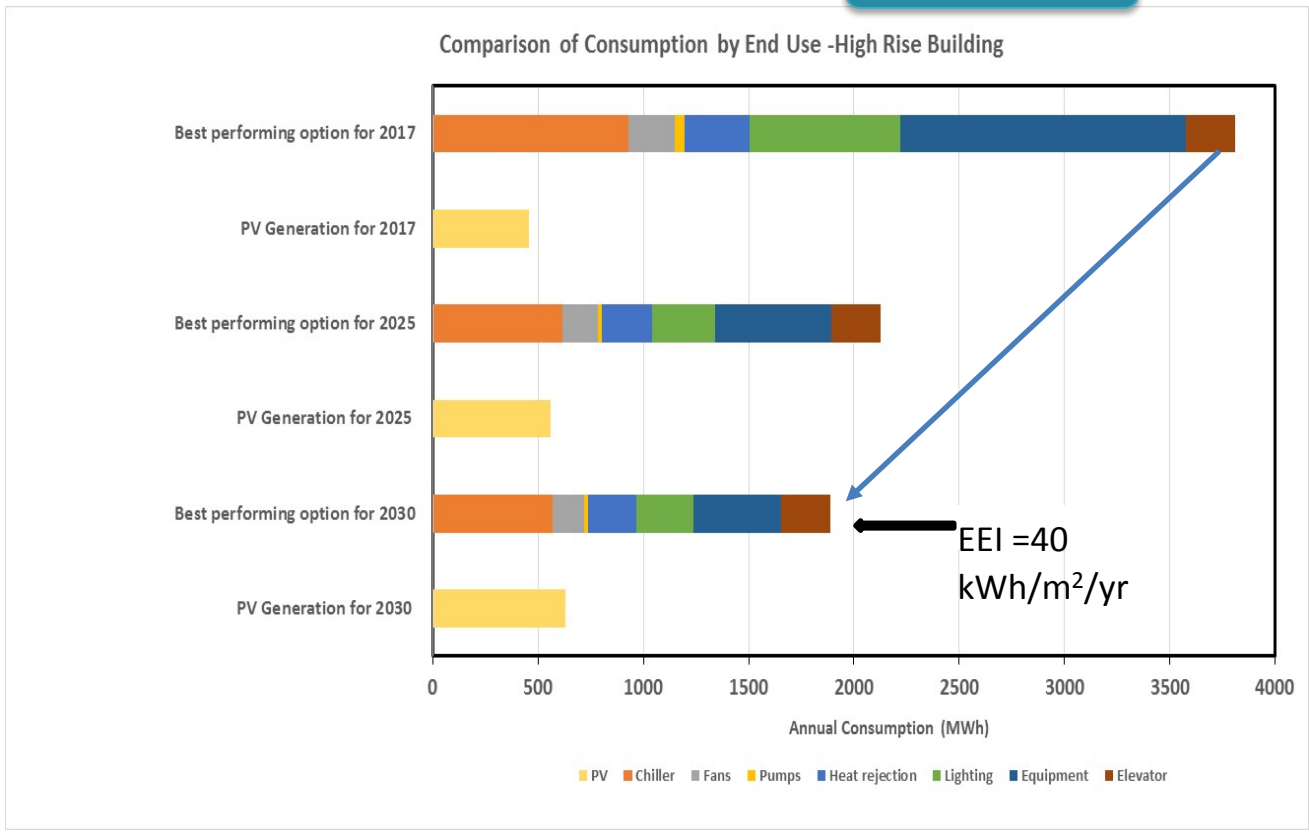


With technological advancement and cost reduction, PE-ZE-SLEB would be technologically and economically viable for mainstream adoption by 2030

PE-ZE-SLEB DEFINITION

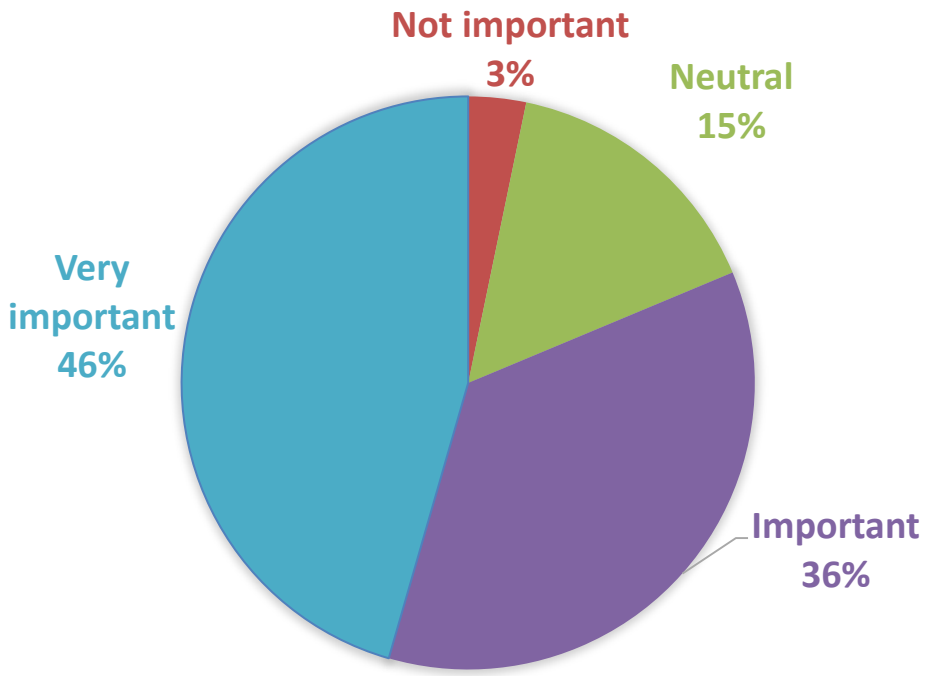
	Positive Energy	Zero Energy	Super Low Energy
Key Characteristics	• Highest Energy Efficiency • Consumption Includes Plug Load • On-site Renewable Energy Preferred		
Applicability	• Low Rise (1-3 storey) • School, Camp, IHL	• Mid Rise (4-7 storey) • School, IHL, Office	• High Rise (>=8 storey) • Office, Retail, Hotel
Energy Efficiency & Renewable Energy	• RE > EC	• EEI: < 100 kWh/m^2.yr • EC = RE	EEI: < 100 kWh/m^2.yr

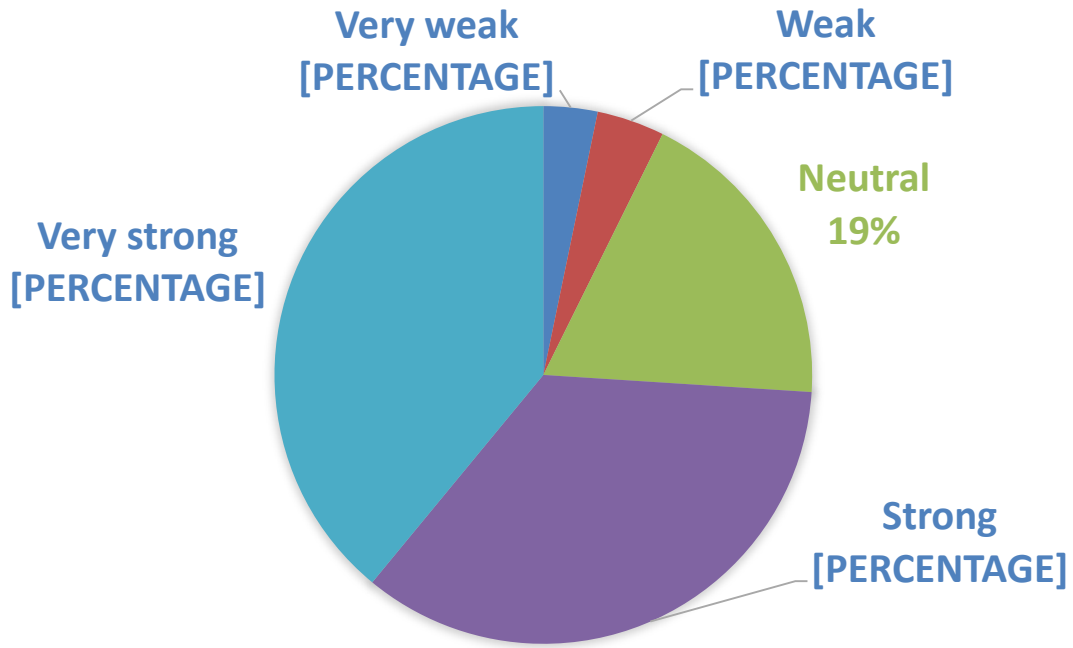
- RE : Renewable energy
- EC : Energy consumption

- EEI is 60% less than 2005 building code level (244 kWh/m2/yr)

POSITIVE RESPONSES FROM THE INDUSTRY

From 124 respondents from industry, academia, developers, and agencies

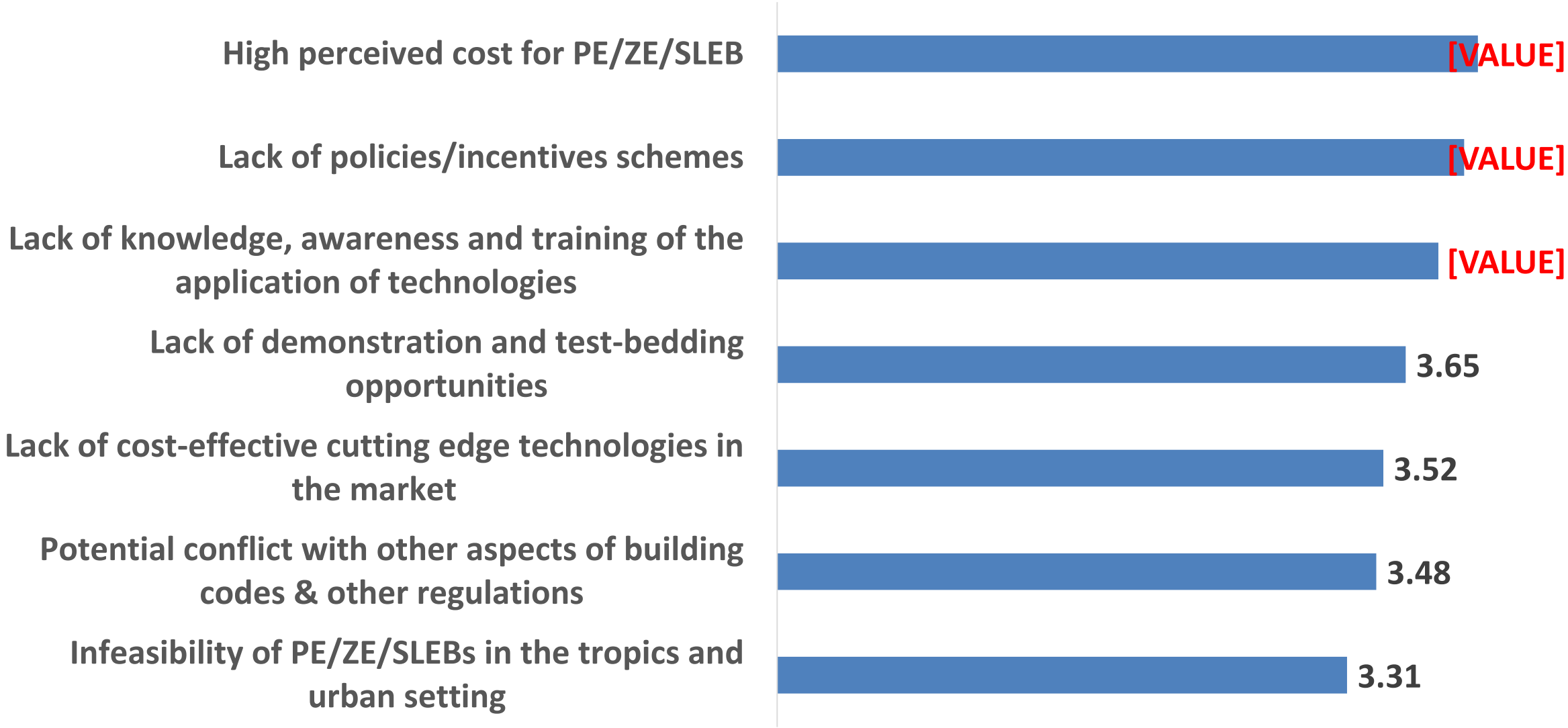




82% of respondents view PE-ZE-SLEB policy is important for national carbon reduction targets

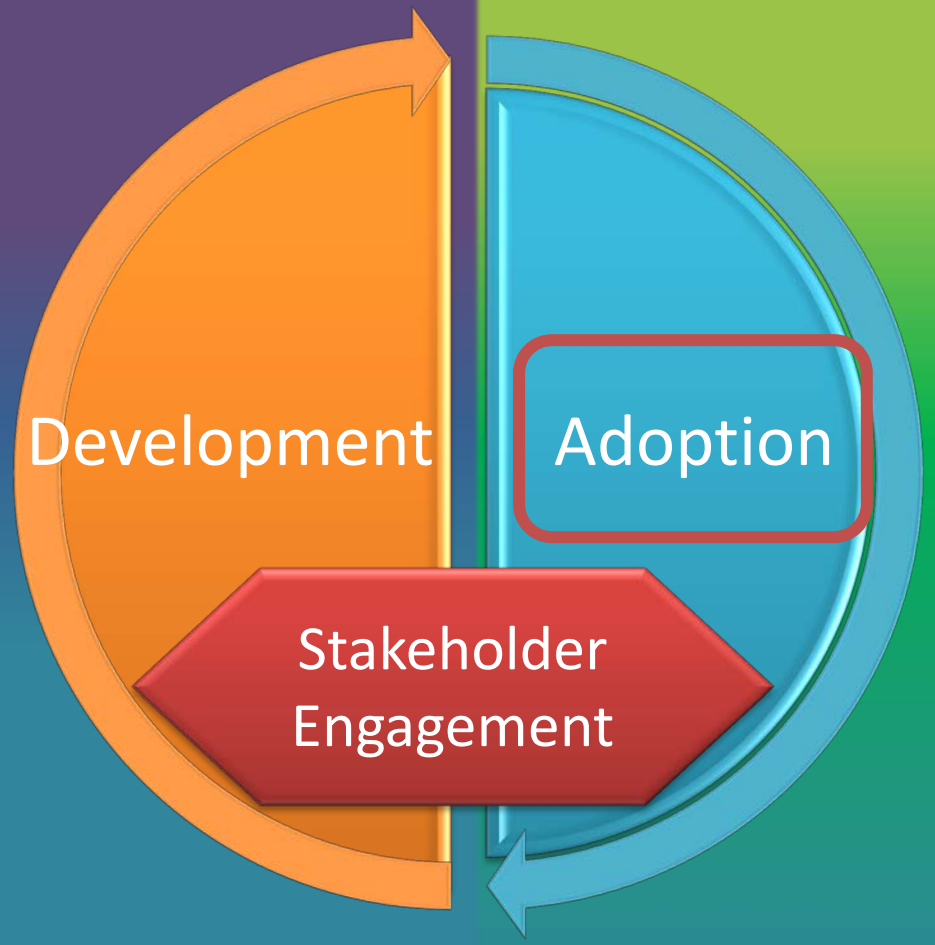
74% of respondents support or strongly support PE-ZE-SLEB policy

BUT THERE ARE CHALLENGES TO BE ADDRESSED...



PE-ZE-SLEB: FROM R&D TO ADOPTION

- PE-ZE-SLEB definition
- Technology feasibility & roadmapping
- Research & development plan
- Testbedding & demonstration



- Creating value
- Public sector taking lead
- Incentivising private sector
- Developing industry capability

FROM R&D TO ADOPTION

Research, Development & Demonstration

- PE Possible for schools with today's technologies
- Achievable for new commercial buildings by 2030
- More RD&D for
  - High temp/hybrid cooling with innovative dehumidification
  - Plug load management, system integration, etc.
- More demonstration and piloting

Deployment & Adoption

- To develop an eco-system to spur adoption
- Starting from schools and low rise office buildings
- Driving PE-ZE-SLEB through Green Building Certification
- Cost-benefit studies for strong business case
- To tackle information & regulatory barriers

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GREEN BUILDINGS INNOVATION CLUSTER

National Research Foundation
Prime Minister's Office
Singapore

$ 52 Mil
FY15-FY20

- A one-stop integrated RD&D hub to **experiment**, **exhibit**, and **exchange** knowledge of promising building energy efficient solutions
- **Accelerate adoption** of promising building energy efficient technologies and solutions

BCA-Keppel Land Joint Challenge Call

To achieve overall energy savings of at least 20% better than the best-in-class Green Mark Platinum buildings

Thank you

Build **Green** - The Future is **Now**