Towards the Next Level of Green Building Modelling and Test-bedding

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Director
Green Building Research
Building and Construction Authority



Agenda

- Background
- Challenges and Opportunities
  - Complexity
  - Integrative modelling
  - Verification and testbedding
  - BIM Integration
- Going Forward





National commitment

National Emissions Reduction Commitment

- Reduce emissions by *7% to 11% below 2020 BAU levels*
- Support Singapore's intention to reduce *Emissions Intensity by 36%*, and stabilize emissions with aim of peaking around 2030

National Green Building Target

- *80%* of all buildings 'green' by 2030



Singapore's BCA Green Mark Scheme

5 Key Assessment Criteria

1. Energy Efficiency



2. Water Efficiency



3. Environmental Protection



4. Indoor Env. Quality



5. Other Green Features

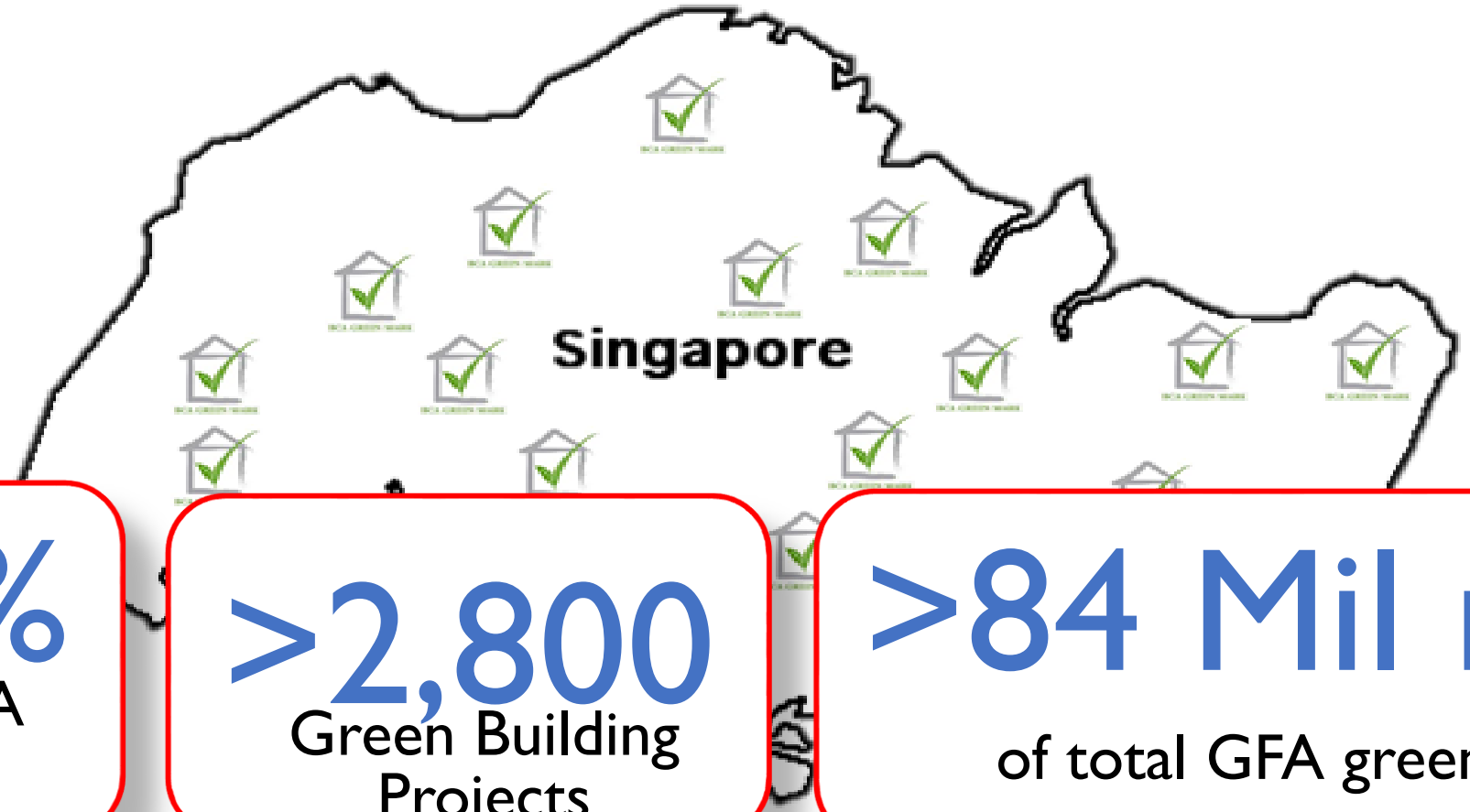


BCA GREEN MARK

Green Building Rating System specially for the Tropics

Green Mark	Try Again	Certified	Gold	Gold Plus	Platinum
Score	0 – 49	50 – 74	75 – 84	85 – 89	90 – 100
Estimated Energy Savings		10% to 15%	15% to 25%	25% to 30%	> 30%

Green Building Advancement



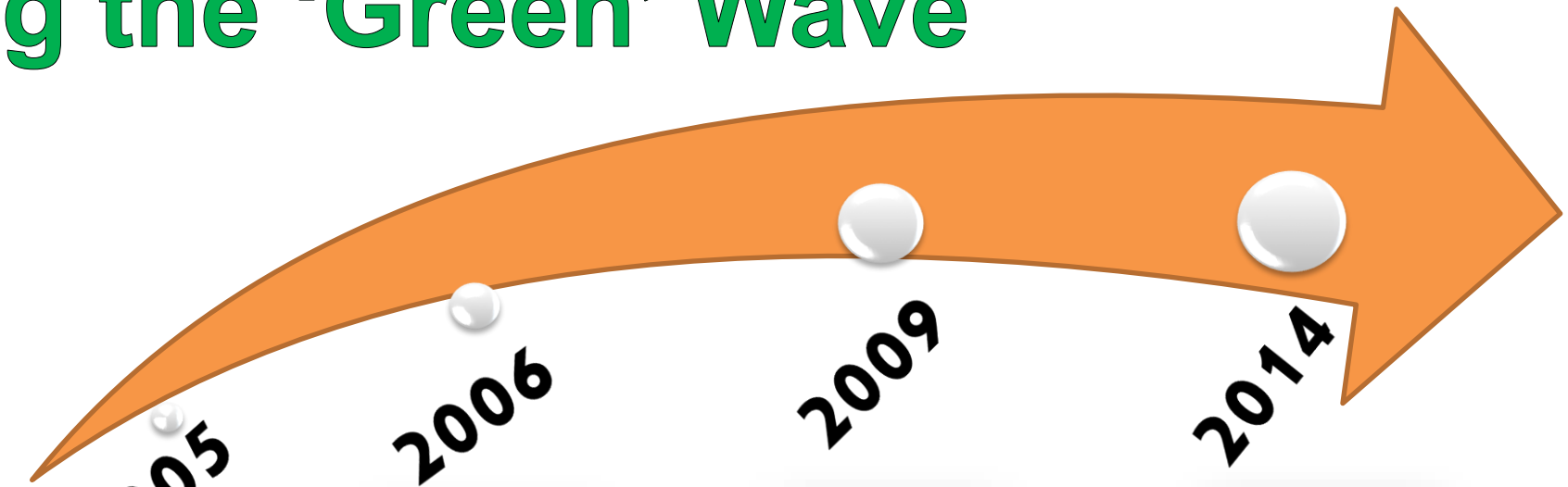
>31%
of total GFA greened

>2,800
Green Building Projects

>84 Mil m^2
of total GFA greened

As of 1 Sept 2016

Creating the 'Green' Wave



New Buildings

Existing Buildings

Building Occupants



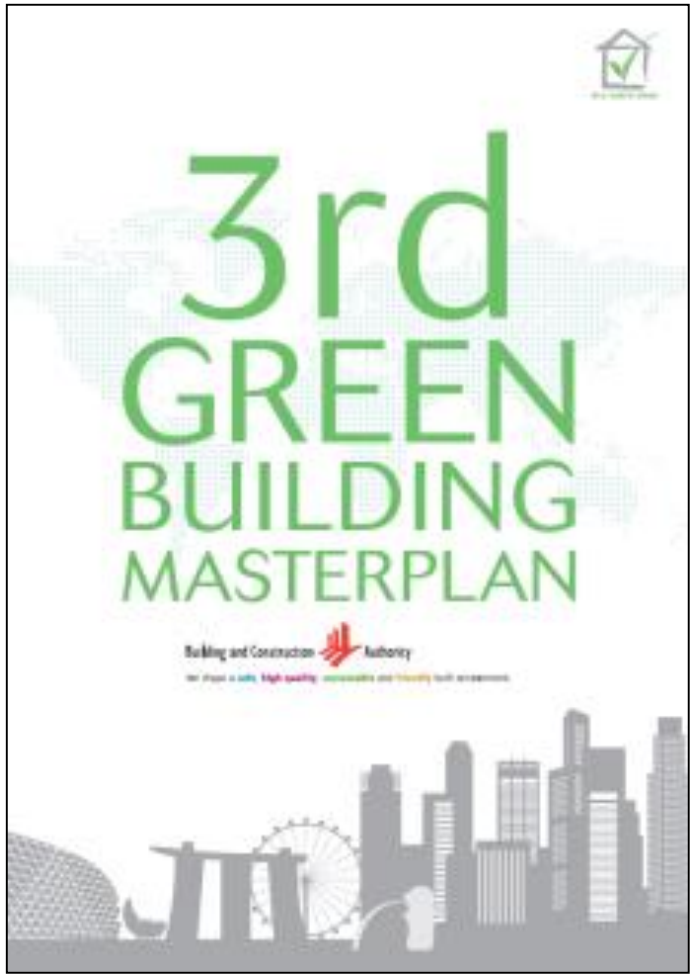
3rd Green Building Master Plan: Why R&I?

Lead in **innovative** and cost-effective solutions

Engage users to improve energy performance and IEQ



Drive sustained performance over building lifecycle



Launched 2014

R&I Programmes

2007 2008 2009 2010 2011 2012 2013 2014 2015

MND Research Fund
$50 Million
Launched 2007

A*STAR-MND
Green Building Research Fund
$13 Million
Launched 2011

S$ 135 Mil since 2007

2-Stage Innovation Grant (iGrant)
$5 Million
Launched 2013

Energy Innovation Research Programme (EIRP) for Building EE
$15 Million
Launched 2013

Green Building Innovation Cluster (GBIC) $52 Million
Launched 2014



R&I Projects Supported (2007 – 2015)

Materials & Façade	Energy Efficiency	IEQ	Smart Building & Control
• Electrochromic glass • Cool paint • Nano materials • Phase change materials	• ZEB for the tropics • Membrane dehumidification • Coil and terminal units optimization • CFD, BIM, simulation tools for NV, Wind Driven Rain • M&V for chiller plants & VRF	• Membrane filtering • Functionalized aerogels • Personalized ventilation & UFAD • Thermal comfort in the tropics	• Adaptive & self learning sensors • Wireless sensor network • Data driven and predictive control • IOT for green buildings

R&I Projects Supported (2007 – 2015)

Sustainable Construction

- Recycling of contaminated clay
- Automatic slump measurement
- Recycling of furnace steel slag
- Recycled Concrete Aggregate (RCA)
- High strength concrete

Construction Productivity

- BIM for DfMA
- Coating for PPVC
- Termite protection for CLT
- Mass timber construction system

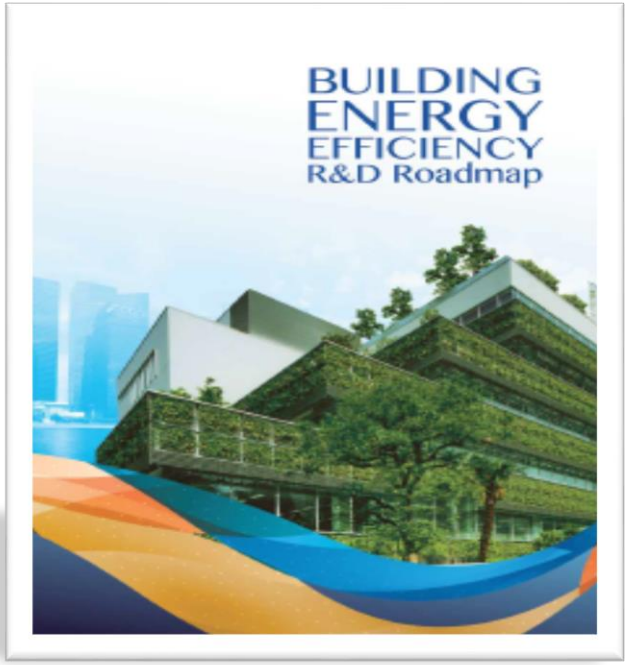
Urban Environment

- UHI and climate mapping
- Vertical greenery system for the tropics
- Urban farming
- Centralised chute system

RD&D Road Mapping

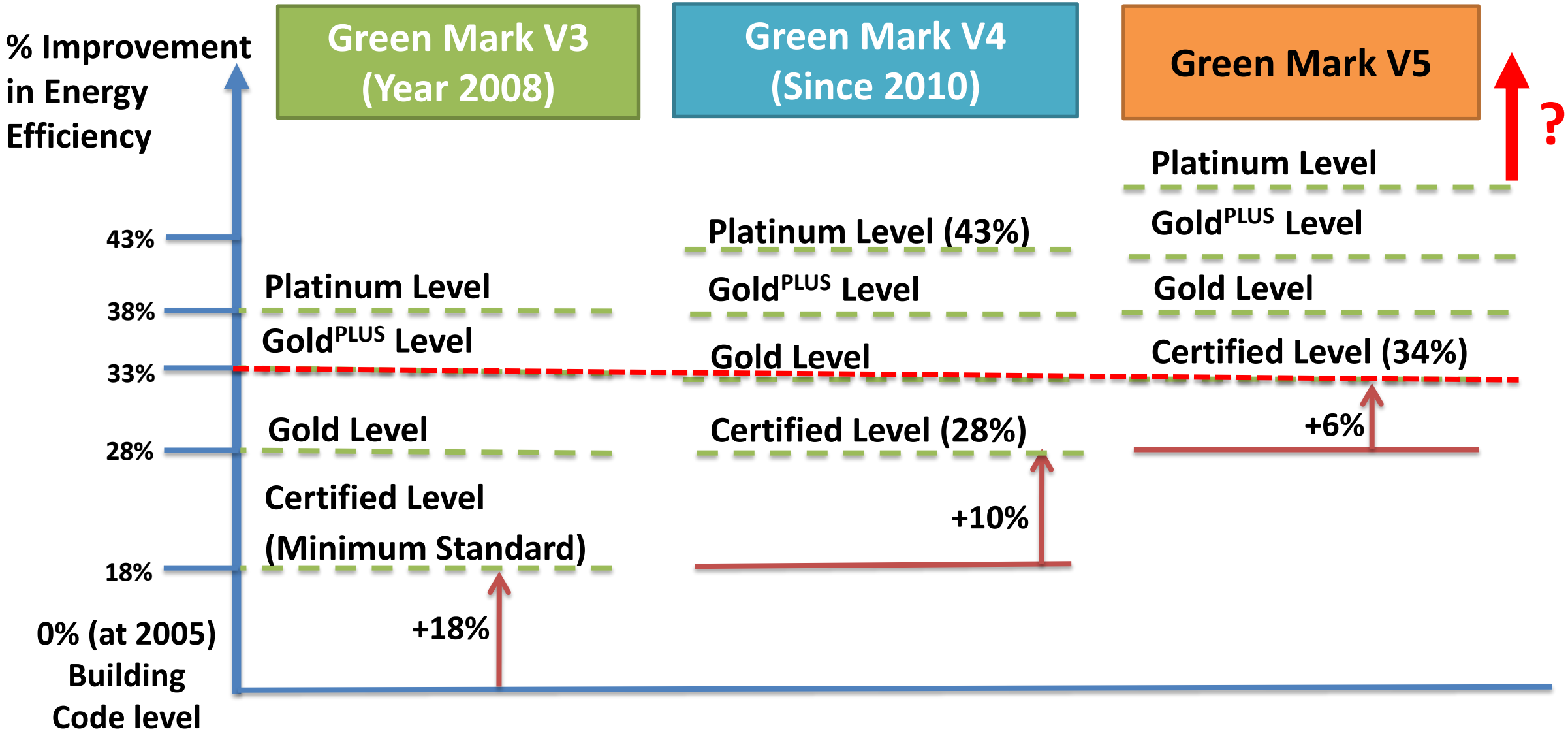
20-40% **more efficient than Best in Class (GM Platinum in 2013)**





- Integrated Design
- Building Management and Information System
- Building Envelope and Façade System
- Air-Conditioning and Mechanical Ventilation
- Policy & Behaviour

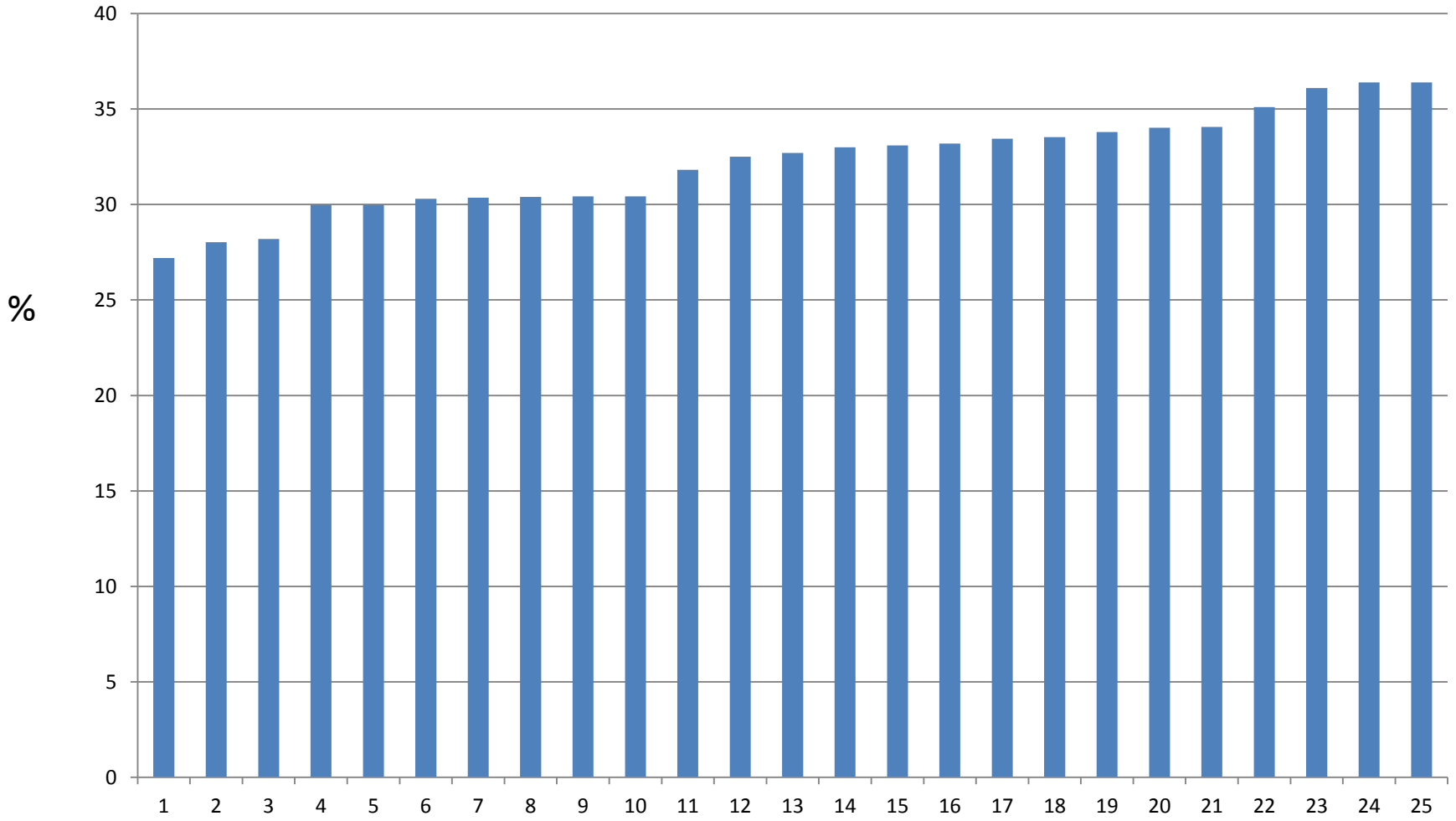
Energy Efficiency of Green Mark Buildings



ENERGY MODELLING FOR GREEN MARK BUILDINGS

Average energy saving from GM Non-residential buildings based on modelling

- 28% for GoldPlus
- 33% for Platinum



GREEN MARK ENERGY MODELLING STATUS

Building Name	Category	Green Mark Rating	Total Designed Energy Savings ($) ($/yr)	Design % Energy Consumption Savings	Verified Total Energy Savings ($) ($/yr)	Verified % Energy Consumption Savings
Tokio Marine Centre	Office	Gold^{Plus}	$ 207,796.25	27.20%	$ 225,161.12	29.59%
9 Tampines Grande	Commercial/ Retail	Platinum	$ 675,150.25	33.00%	$ 387,913.75	32.72%
Standard Chartered Bank (Changi)	Commercial/ Retail	Platinum	$ 405,178.75	36.10%	$ 422,384.00	34.06%
City Square Mall	Commercial/ Retail	Platinum	$ 2,861,316.75	39.00%	$ 3,133,865.31	30.79%
Mapletree Anson	Office	Platinum	$ 570,649.25	30.30%	$ 678,710.25	30.77%

CHALLENGES & OPPORTUNITIES

Increased complexity

More demanding user requirements



Image: Sportshub Pte Ltd



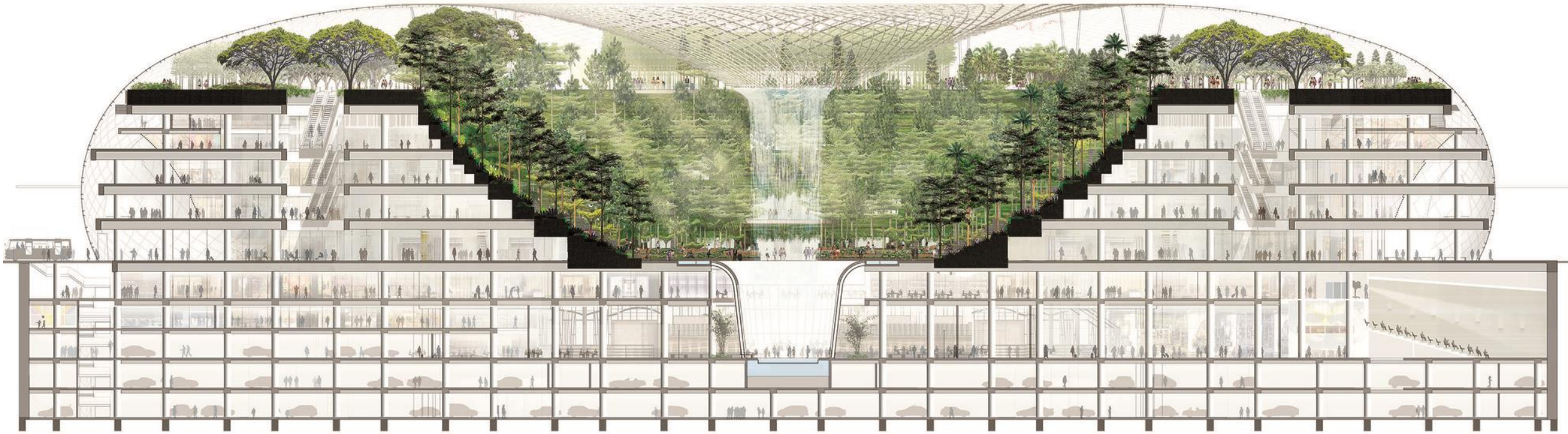
Jewel Changi Airport. Aerial view. Image courtesy Jewel Changi Airport Devt.

COMPLEX MODELLING

Thermal Modelling

Energy Simulation

Wind tunnel Testing



Jewel Changi Airport. Section through retail and gardens. Image courtesy Jewel Changi Airport Devt.

DISTRICT MODELLING

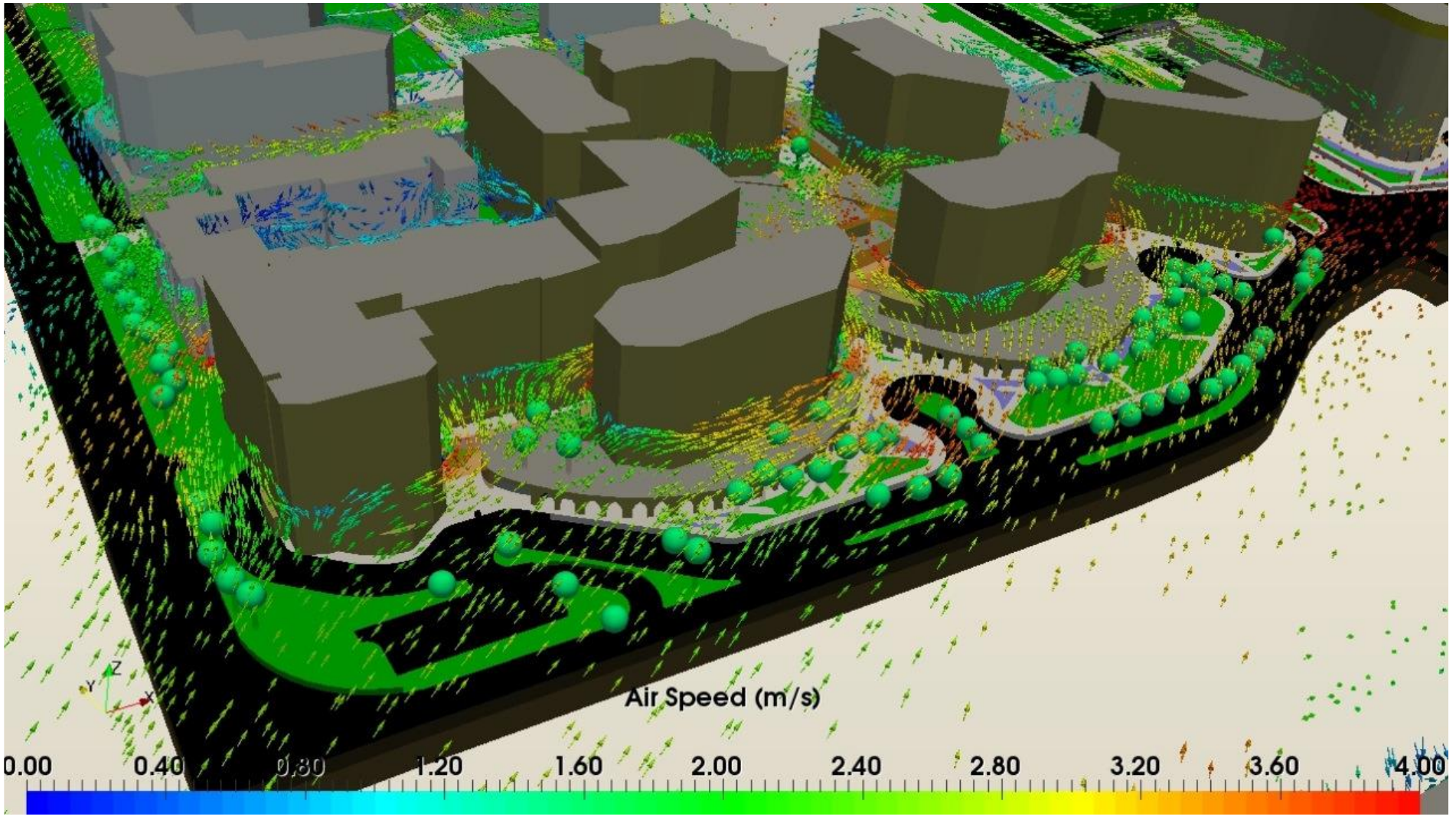
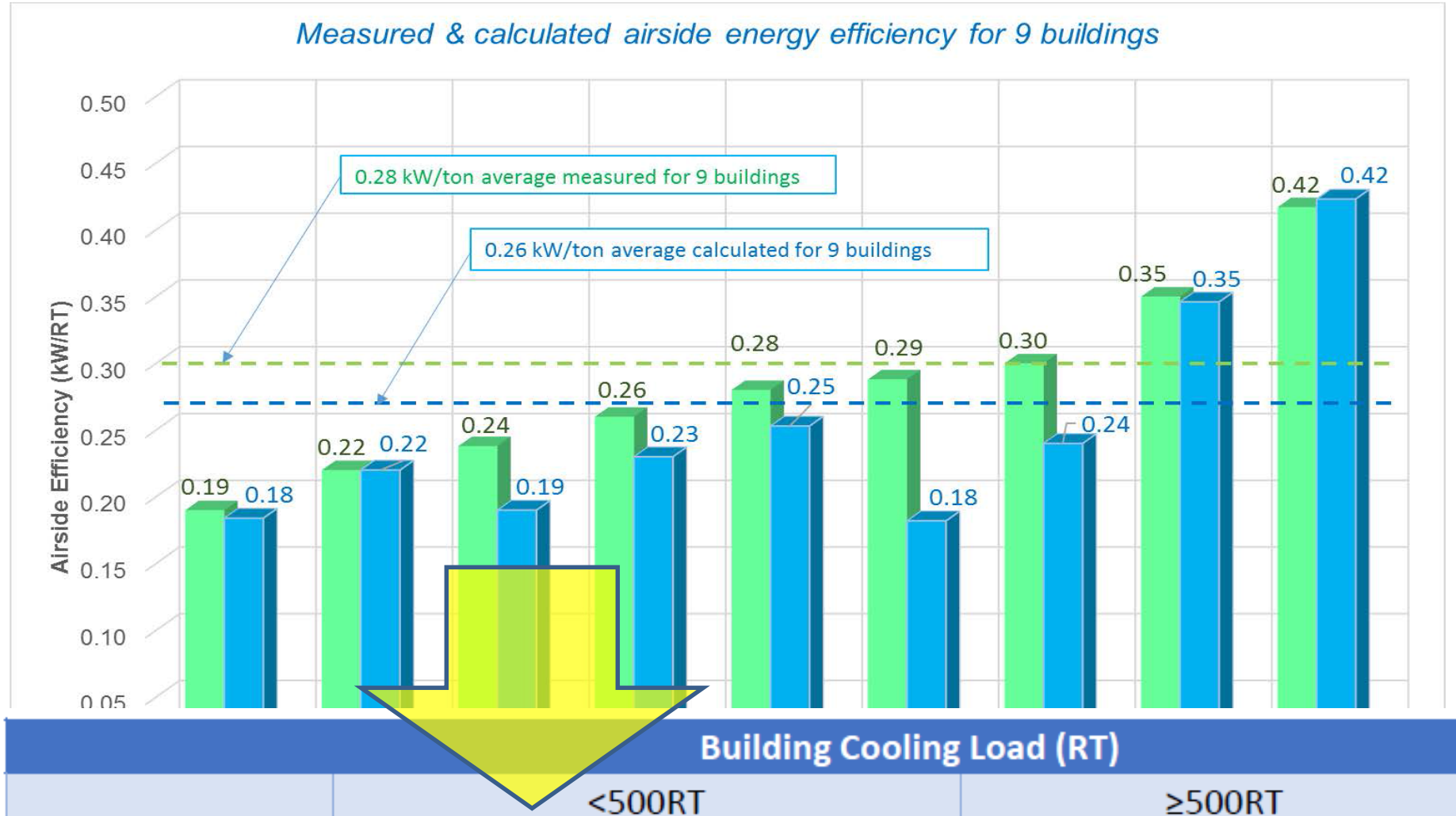


Image: IESVE

Emerging Technology Modelling



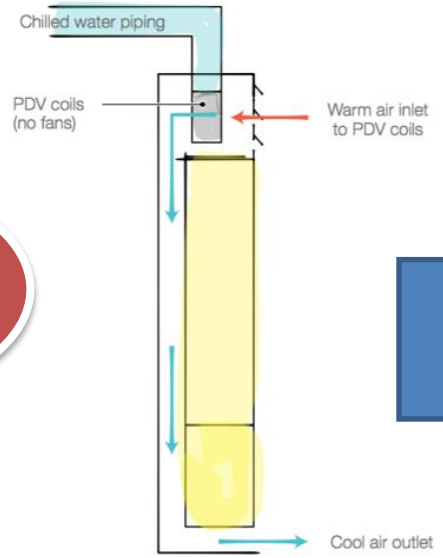


20 % Savings

	Building Cooling Load (RT)	
	<500RT	≥500RT
	Minimum Design System Efficiency including air distribution system (kW/RT)	
Gold^{PLUS}	*(0.7+0.25)* 0.95	*(0.65+0.25)* 0.9
Platinum	*(0.68+0.25)* 0.93	*(0.65+0.25)* 0.9

PASSIVE DISPLACEMENT VENTILATION

Up to 30 % Savings



Testbed at ZEB Level 2





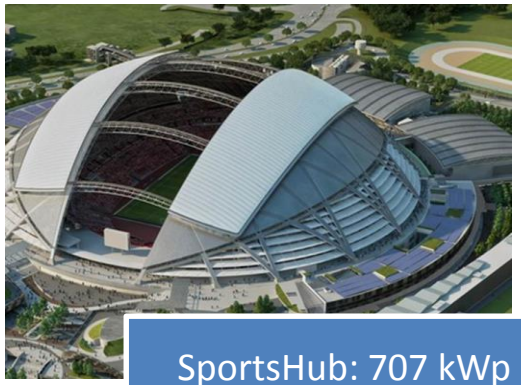


The Hive Building @ NTU

MODELLING OF GLARE & REFLECTANCE



RWS: 500 kWp



SportsHub: 707 kWp



OFC: 75 kWp



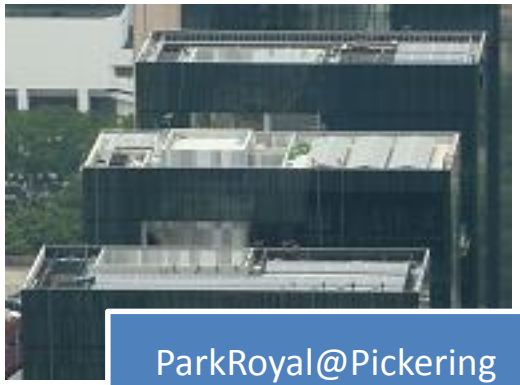
City Square Mall: 10 kWp



HDB Treelodge: 280 kWp



CleanTech One



ParkRoyal@Pickering

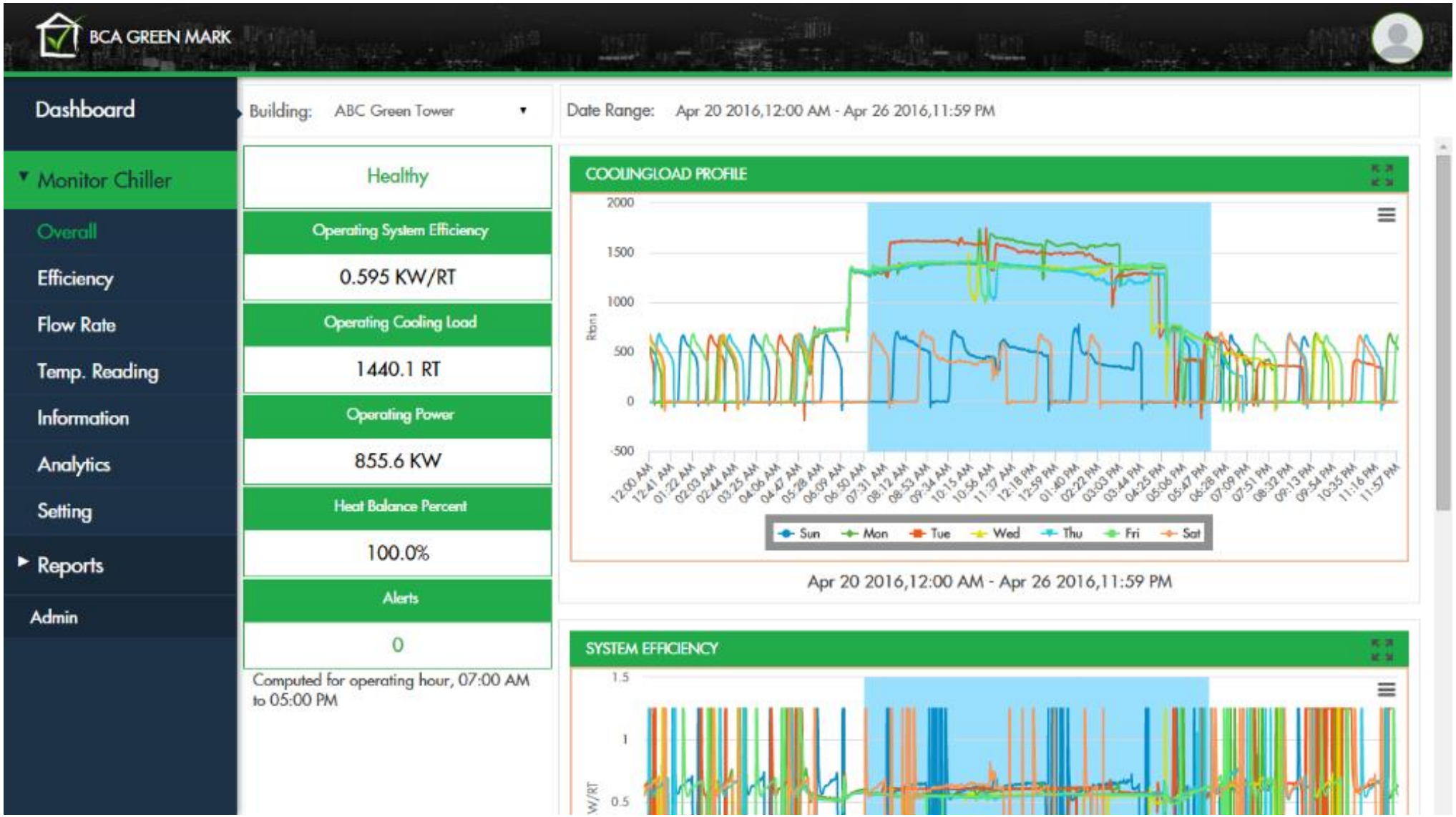


Gardens by the Bay

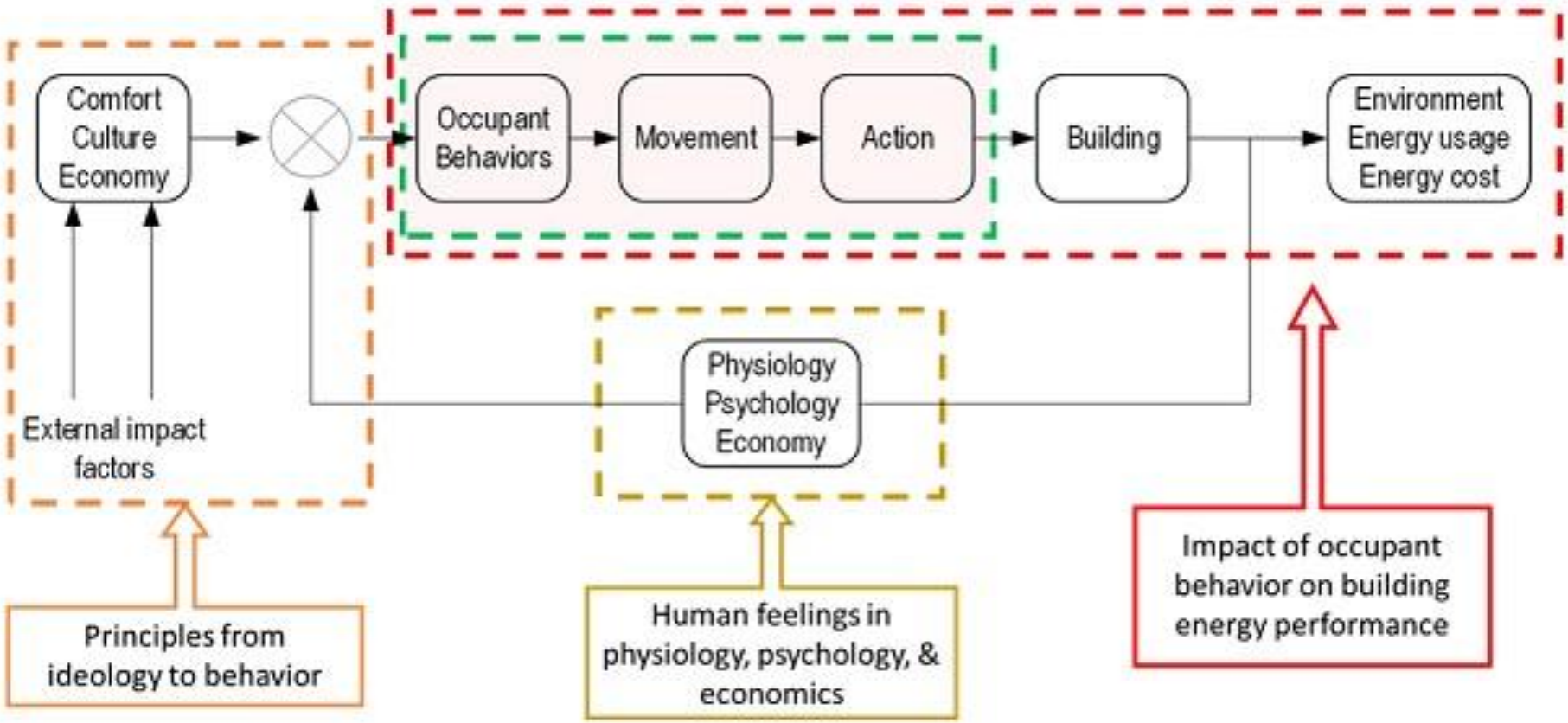
Source: www.solar-repository.sg

Modelling of Smart Control

Chiller Efficiency Smart Portal



Behaviour Modelling

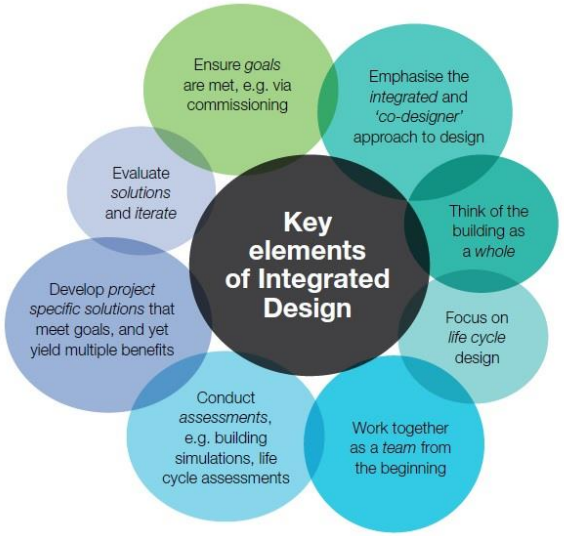


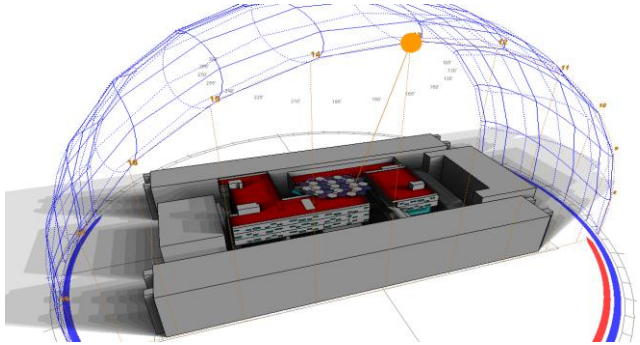
Relationship between occupants and buildings

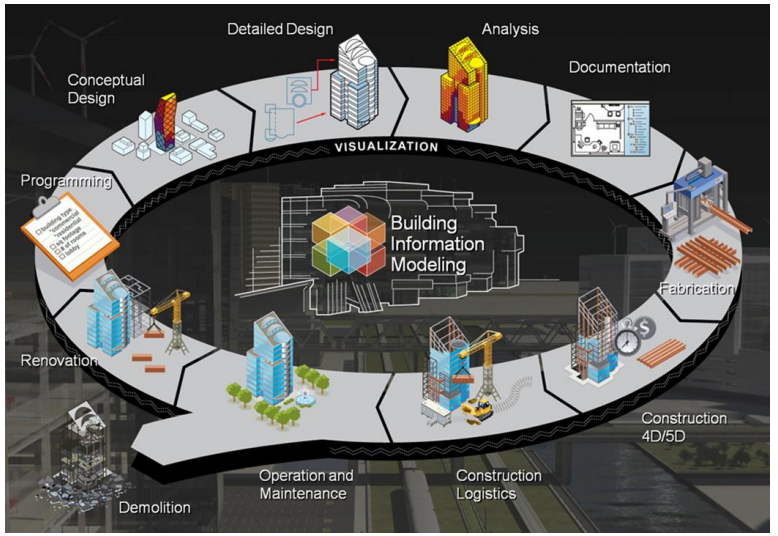
Source: IEA-EBC Annex 66 (2016)

Building and Construction Authority

Integrated Modelling









NTU North Spine Academic Building

NANYANG TECHNOLOGICAL UNIVERSITY

Building and Construction Authority

3 For 2 @UWCSEA

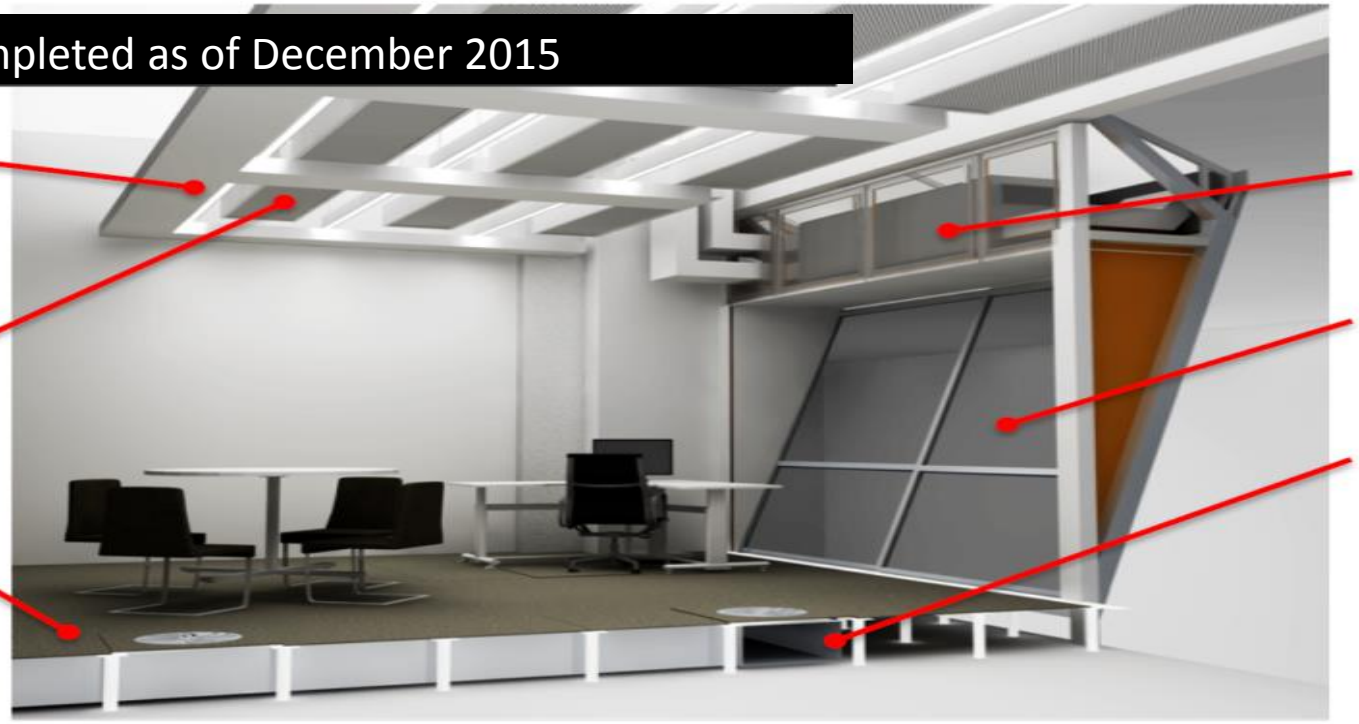
An innovative air-con system design that uses passive chilled beam with a decentralised heat-recovery ventilation system



GBIC-Demo

Project completed as of December 2015

- Gypsum / plaster conduits hide mechanical and electrical distribution fittings (e.g., pipework, connections, wiring, etc.)
- Passive chilled beams are implemented in lieu of radiant chilled panels for sensible cooling
- Raised floor system installed in lieu of void-form concrete slab

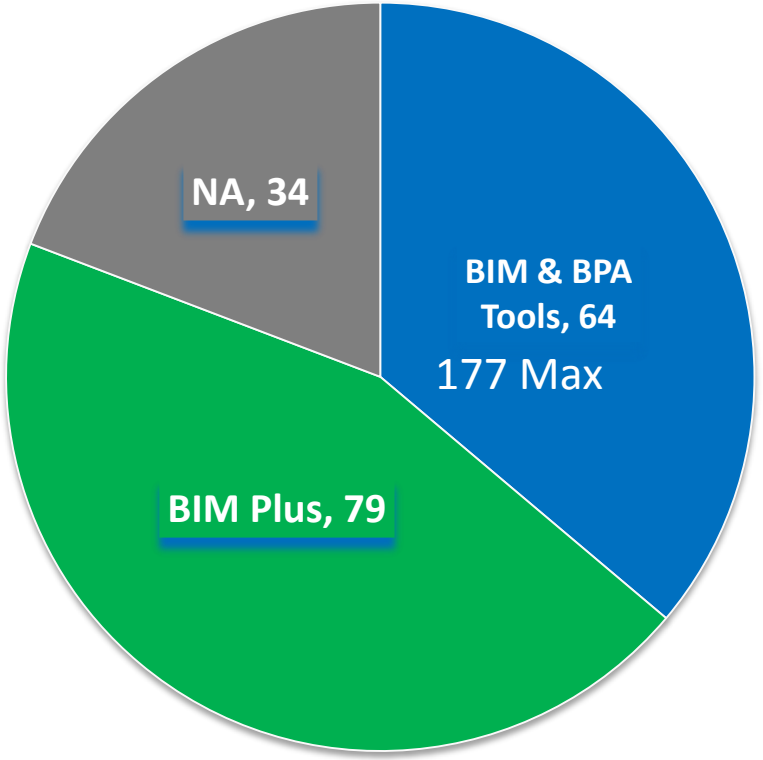


71 kWh/m^2/year!

- Dedicated outdoor air system (DOAS) with built-in energy recovery devices provide latent cooling
- Sloped façade implemented with integrated plenum area for mounting ventilation units
- Fresh air supplied through underfloor air distribution (UFAD) network

Source: SEC-FCL
http://www.fcl.ethz.ch/about/sec/

Green BIM with BPA



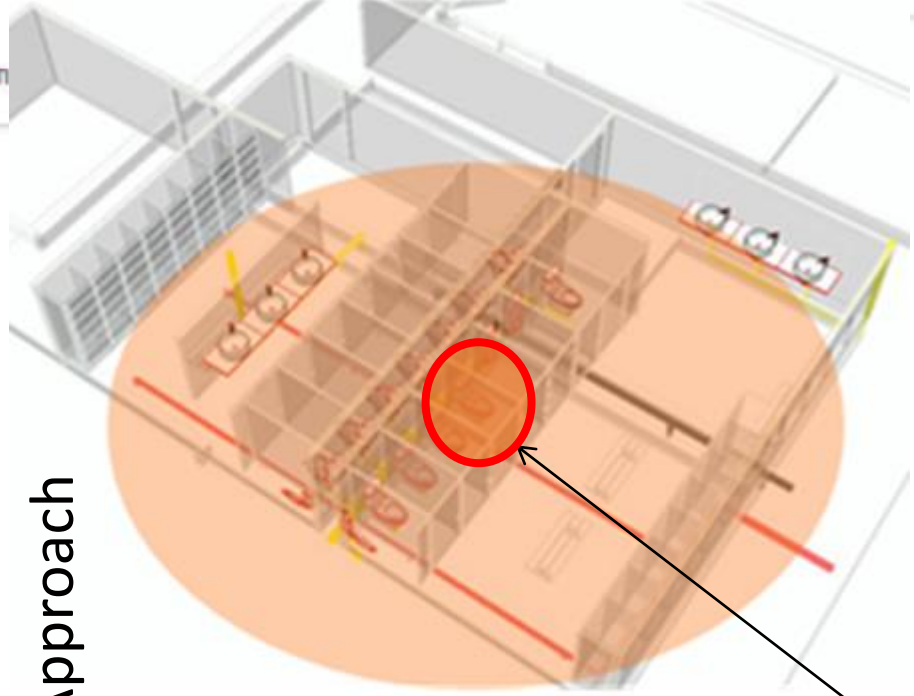
Note: BPA = Building Performance Analysis

Part 1 - Energy Efficiency	116 Points (Max)
1-1 Thermal Performance of Building Envelope - ETTV	12
1-2 Air- Conditioning System	30
1-3 Building Envelope - Design/Thermal Parameter	35
1-4 Natural Ventilation/Mechanical Ventilation	20
1-5 Daylighting	6
1-6 Artificial Lighting	12
1-7 Ventilation in Carparks	4
1-8 Ventilation in Common Areas	5
1-9 Lifts and Escalators	2
1-10 Energy Efficient Practices & Features	12
1-11 Renewable Energy	20
Part 2 - Water Efficiency	17 Points (Max)
2-1 Water Efficient Fittings	10
2-2 Water Usage and Leak Detection	2
2-3 Irrigation System and Landscaping	3
2-4 Water Consumption of Cooling Towers	2
Part 3 - Environmental Protection	42 Points (Max)
3-1 Sustainable Construction	10
3-2 Sustainable Products	8
3-3 Greenery Provision	8
3-4 Environmental Management Practice	7
3-5 Green Transport	4
3-6 Refrigerants	2
3-7 Stormwater Management	3
Part 4 - Indoor Environmental Quality	8 Points (Max)
4-1 Thermal Comfort	1
4-2 Noise Level	1
4-3 Indoor Air Pollutants	2
4-4 Indoor Air Quality (IAQ) Management	2
4-5 High Frequency Ballasts	2
Part 5 - Other Green Features	7 Points (Max)
5-1 Green Features and Innovations	7



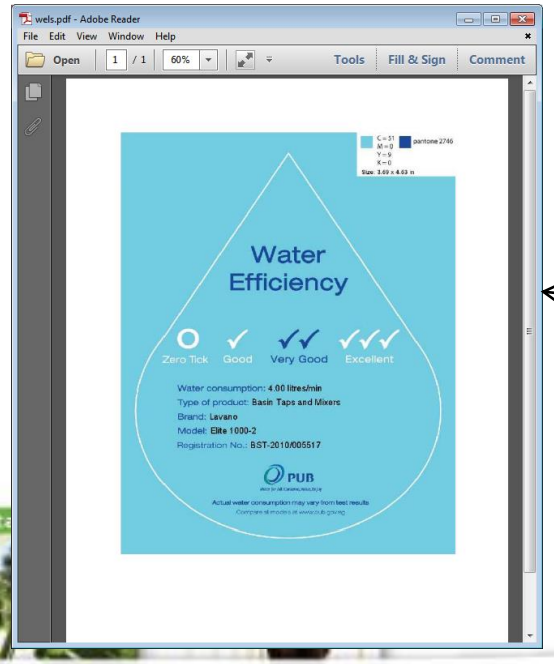
Intelligent Object

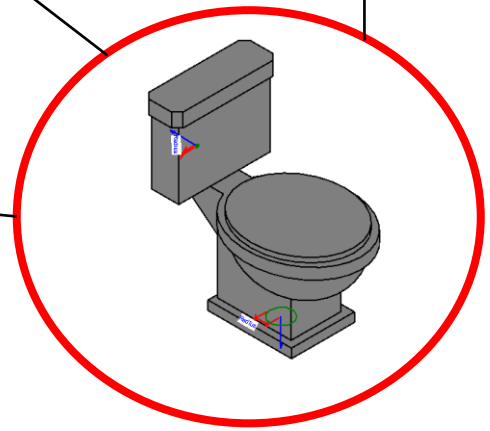
BIM Plus Approach



Type Parameters

Parameter	Value
Assembly Code	
Type Mark	
Cost	
magiPv-1	
magiPv-2	
magiPv-3	
magiPv-4	
magiPv-5	
magiProductCode	
magiNationalCode	
magiUserCode	
magi_description_code	
magi_description_short	
magi_description_long	
OmniClass Number	23.45.05.21.11.11
OmniClass Title	Water Operated Water Closets
Other	
WELS Rating	

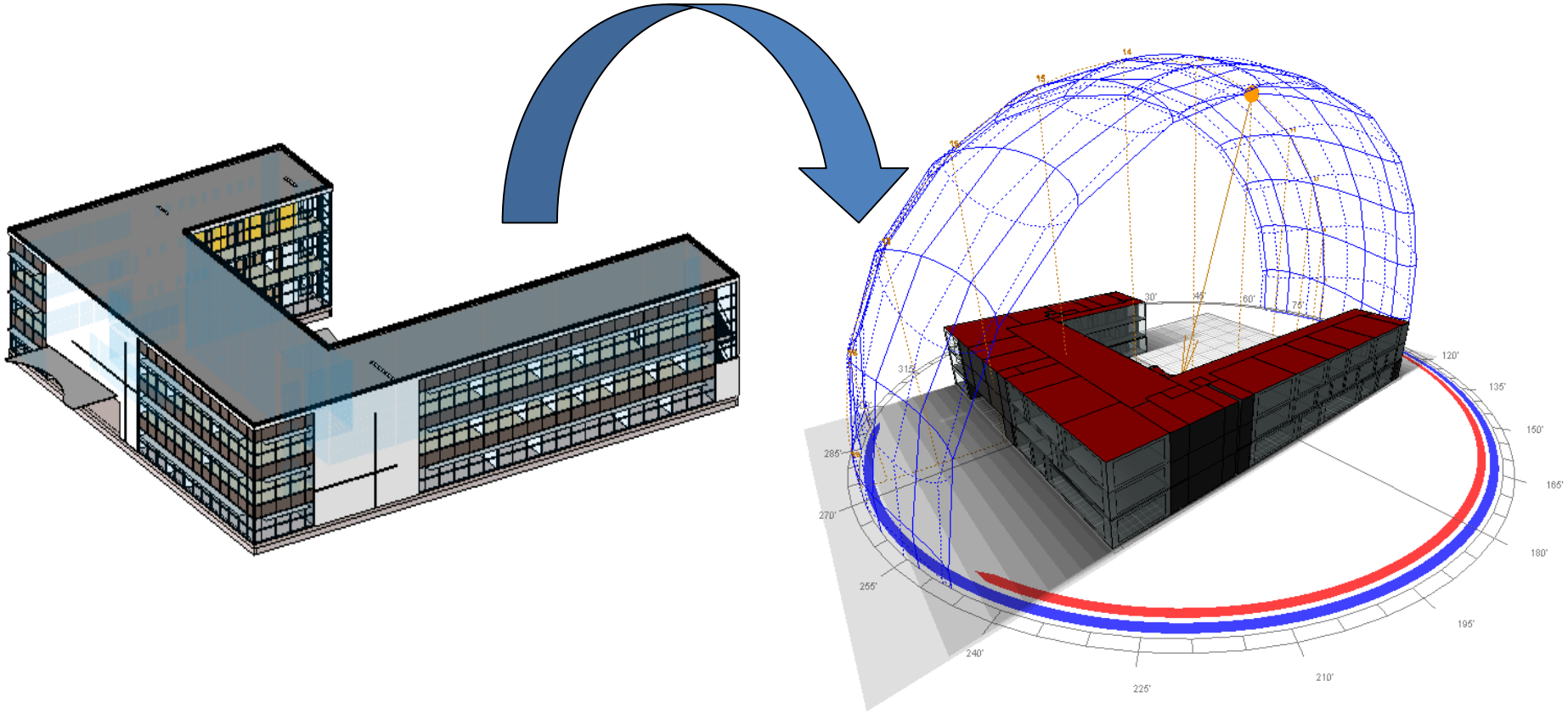




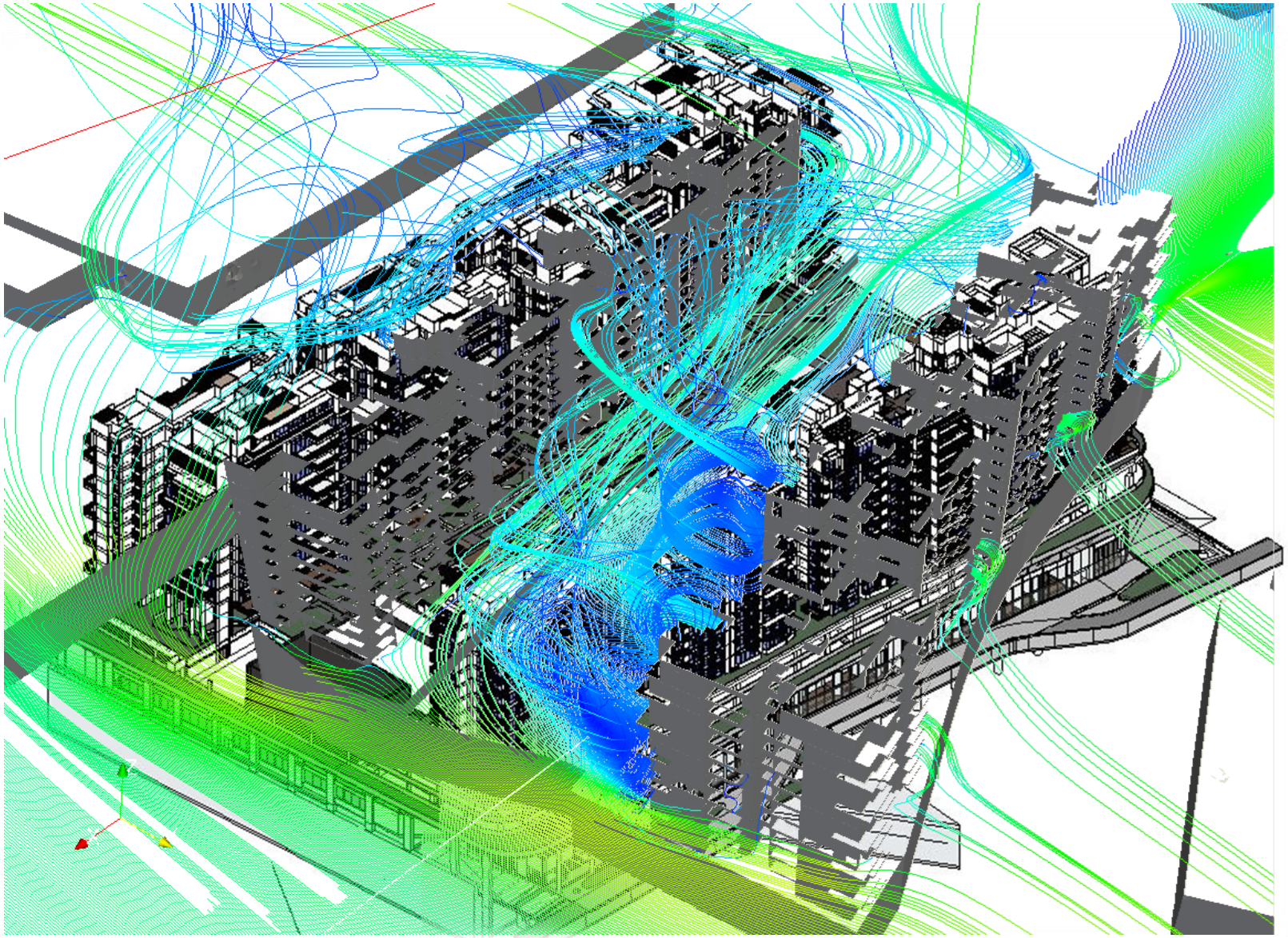
Intelligent Objects with Attributes



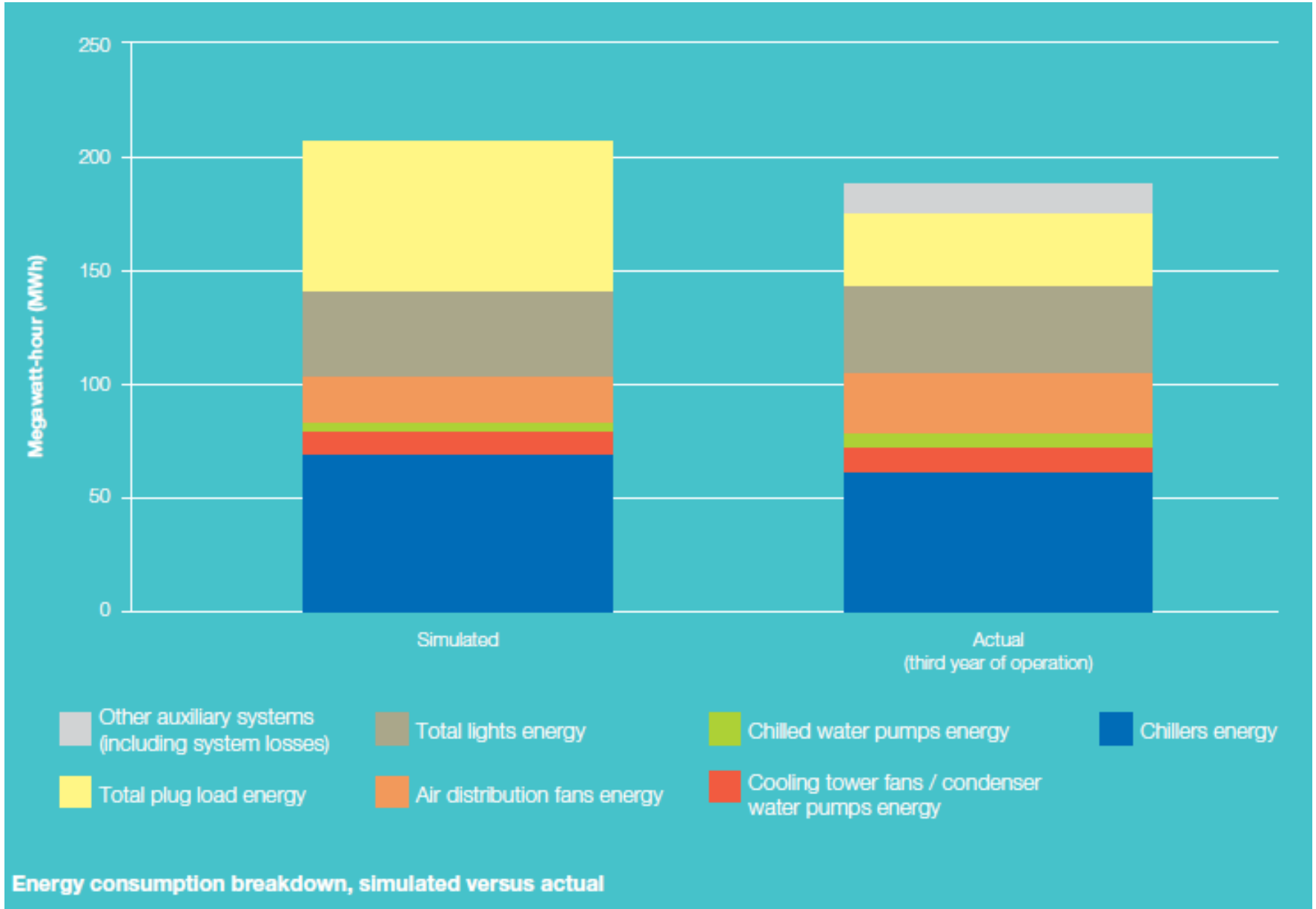
SUNCAST STUDY



BIM to BPA, CFD Study



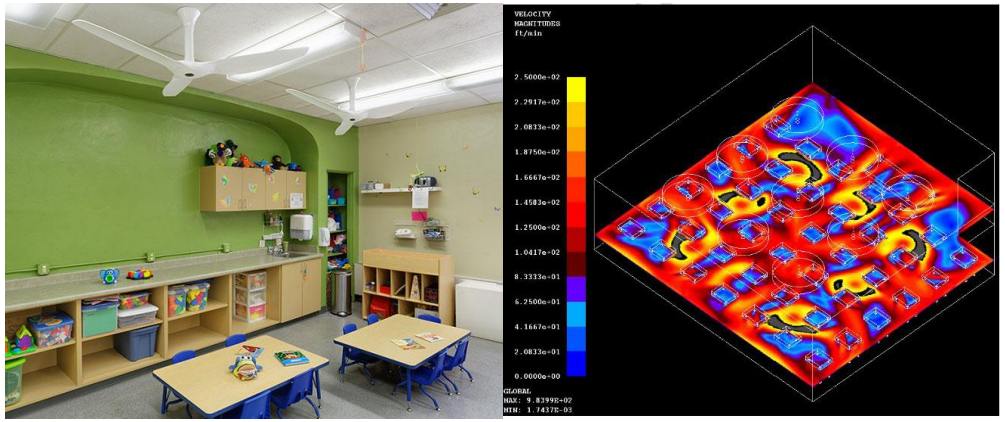
MODEL VS ACTUAL PERFORMANCE



Energy consumption breakdown, simulated versus actual

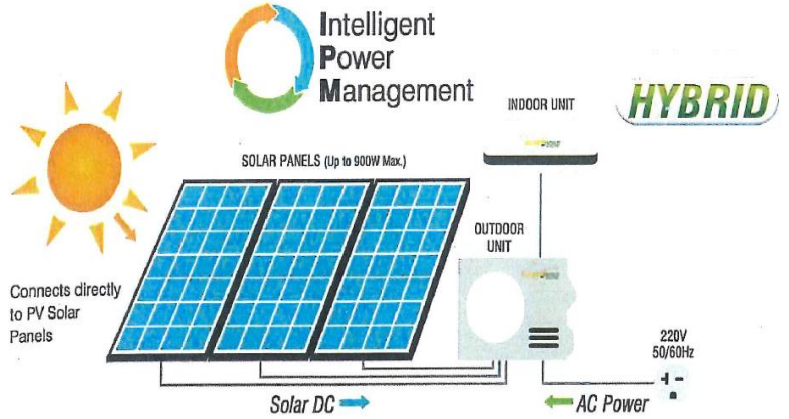
Test Bedding

Changing to High Volume, Low Speed Fan



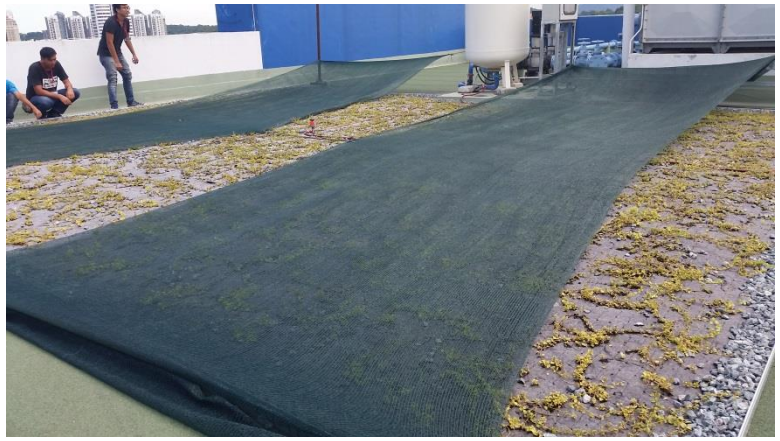
Source: Big Ass Fan (2016)

Solar Air Conditioner



Source: Solair World (2016)

Extensive Green Roof in CHIJ Sec School



Green Roof + PV System



Evaporative Air Cooler



Source: Portacool (2016)

BCA SkyLab

World's First High-Rise Rotatable Laboratory for the Tropics

- State-of-the-art rotatable test facility for developing, evaluating and accelerating innovative energy efficient building technologies
- Developed in collaboration with Lawrence Berkeley National Laboratory
- Real world test facility with the ability to test individual or multiple technologies together





Construction Completed March 2016



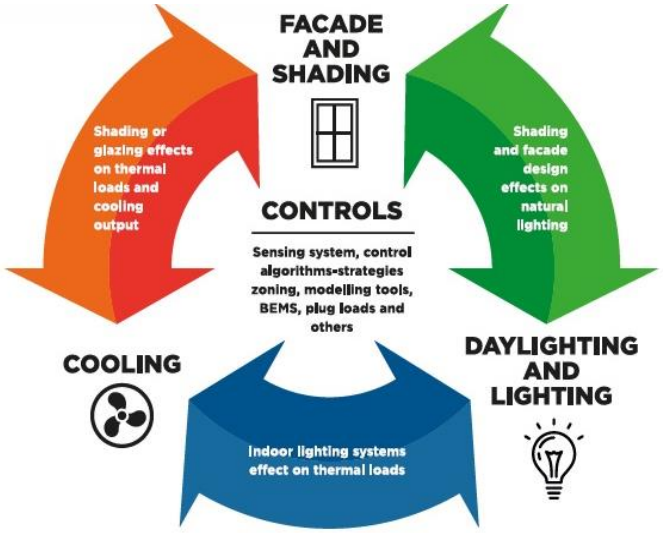
BCA SkyLab

BCA SkyLab

PLUG & PLAY
fully configurable

+

ROTATABLE
in any orientation



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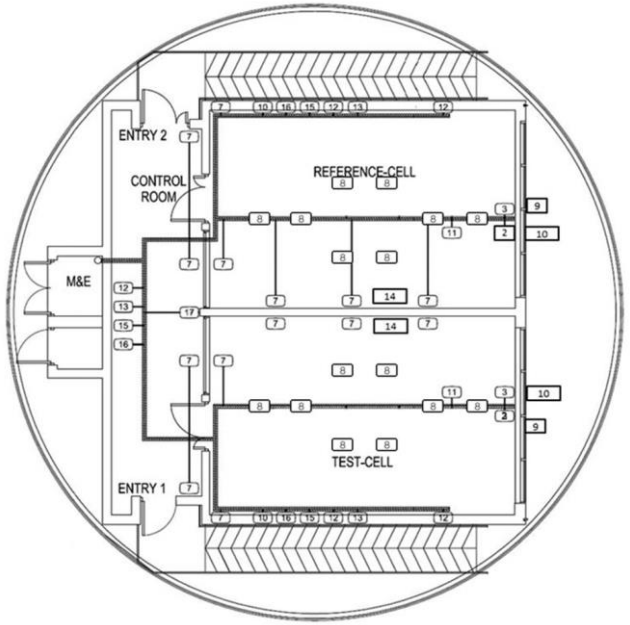
Optimise building designs in

REAL-WORLD TROPICAL CONDITIONS



Modelled after FLEXLAB of LBNL

1st Test Job: 4 In 1







1. LED lights c/w Dali system



Source: BCA UTBF LED Tender Specs and LED Luminaires

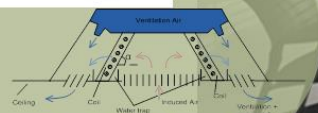
2. Automated blinds



Source: Sun-Seeker Horizontal Blinds Control

3. Chilled beam & FCU





Source: NTU EEE (Active Chilled Beams)

4. Thermochromic glass



Source: BCA UTBF Specification for Glass and Glazing

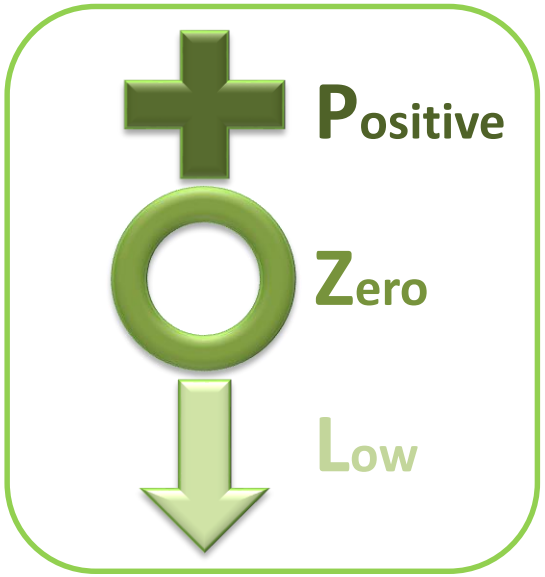
5. Integrated System (Combination of 1-4)

- Test bedding chosen technologies in UTBF

Source: BCA, NTU

Positive-Energy Low-Rise, Zero-Energy Medium-Rise & Super Low-Energy High-Rise Buildings





OUR GREEN BUILDING VISION...

A ***global leader in green buildings,*** *with special expertise in the tropics and sub-tropics – enabling sustainable development and quality living*

Aspiration

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

PE Low Rise



< 6 Storeys

- ZEB Plus @BCAA
- Positive Energy Schools (PES) – MOE

ZE Med Rise



6 – 12 Storeys

- New ZEB at BCAA
- New building at NUS

SLE High Rise



> 12 Storeys

- New Academic Block at BCAA
- High rise office buildings with industry partners

Global leader in green buildings

with special expertise in tropics and sub-tropics



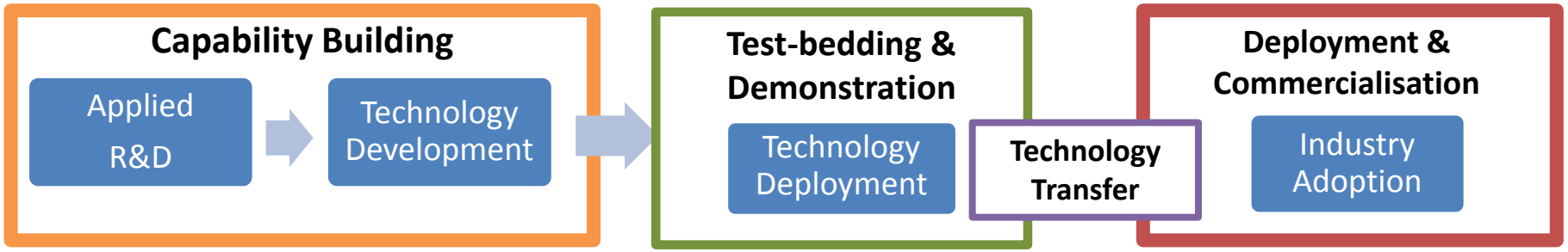
Pushing the boundaries of energy efficiency beyond Green Mark Platinum to achieve 30% -40 % savings with cost effective solutions

Building and Construction Authority

BCA SkyLab

World's First High-Rise Rotatable Laboratory for the Tropics

RD&D Partnership



IHLs / RIs	Designers / Specialist Consultants	Manufacturers /Suppliers	Builders	Developers/ Building Owners
NUS National University of Singapore NANYANG TECHNOLOGICAL UNIVERSITY Agency for Science, Technology and Research SINGAPORE TEMASEK POLYTECHNIC SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN NGEE ANN POLYTECHNIC SinBerBEST	SURBANA JURONG BSD building system & diagnostics RW consulting WOHA PARSONS BRINCKERHOFF G-ENERGY GLOBAL	POSITIVE ENGINEERING PTE LTD AMPOTECH BETTER METERING. BETTER INSIGHT. DAIKIN green koncepts 3M ST Engineering SINGAPORE SAFETY GLASS PTE LTD	SAMWOH TAKENAKA TIONGSENG GROUP 长成控股	jtc Breaking New Ground CITY DEVELOPMENTS LIMITED Keppel Land CapitaLand lendlease MOH HOLDINGS UWC

Thank you !

Terima kasih !

