iHBE
Sustainable Built Environment
Conference Series 2016
SBE16 Sydney

Design and Construction for Energy Efficiency of Residential Buildings in Hong Kong

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Conference Organisation

UNSW Australia | Built Environment

Low Carbon Living CRC

ENERGY SAVING PLAN

For Hong Kong's Built Environment 2015~2025+

Environment Bureau in collaboration with
Development Bureau
Transport and Housing Bureau

May 2015

2 Government buildings to achieve 5% electricity reduction target by 2020 (2014 as base); further reduction from 2020-2025 to be determined in 2019-20

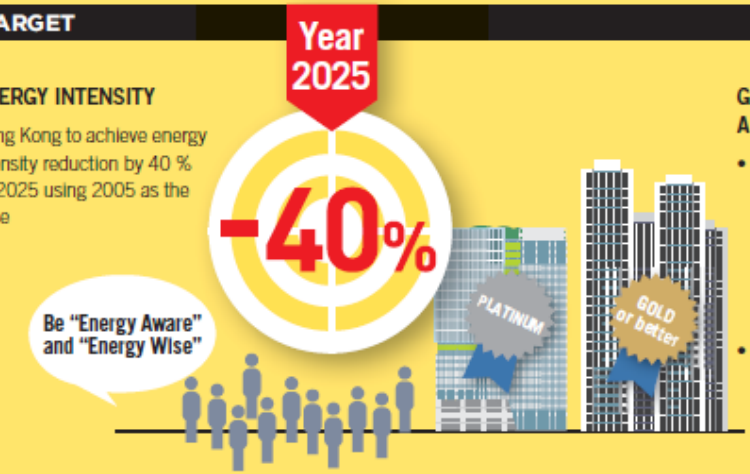
- Gross Floor Area (GFA) concessions for private-sector green building projects;

SUMMARY OF ENERGY SAVING PLAN FOR HONG KONG 2015~2025+

TARGET

ENERGY INTENSITY

Hong Kong to achieve energy intensity reduction by 40 % by 2025 using 2005 as the base



GOVERNMENT BUILDINGS AND PUBLIC HOUSING

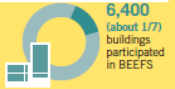
- New government buildings with construction floor area of >5,000 m² with central air-conditioning or >10,000m² to achieve at least BEAM Plus Gold; and
- New public housing to achieve at least BEAM Plus Gold ready

KEY ACTIONS

1 Lead the energy saving and green building transformation through government buildings, public housing and public sector development (see targets)

2 Government buildings to achieve 5% electricity reduction target by 2020 (2014 as base); further reduction from 2020-2025 to be determined in 2019-20

ECONOMICS



☑ **Already in existence**

- 1/7th of buildings in Hong Kong (about 6,400 buildings) participated in the $450 million Building Energy Efficiency Fund Scheme (BEEFS) programme;
- district cooling at Kai Tak;
- Gross Floor Area (GFA) concessions for private-sector green building projects;
- and approximately $100 million power companies' Eco Building Fund (CLP Power Hong Kong (CLP)) and Power Smart Fund (The Hongkong Electric Company Limited (HEC)) for energy saving 2014-18

Periodic review, expand and/or tighten relevant energy-related standards:

3 Buildings Energy Efficiency Ordinance (BEEO);

4 Building (Energy Efficiency) Regulation, (B(EE)R); and

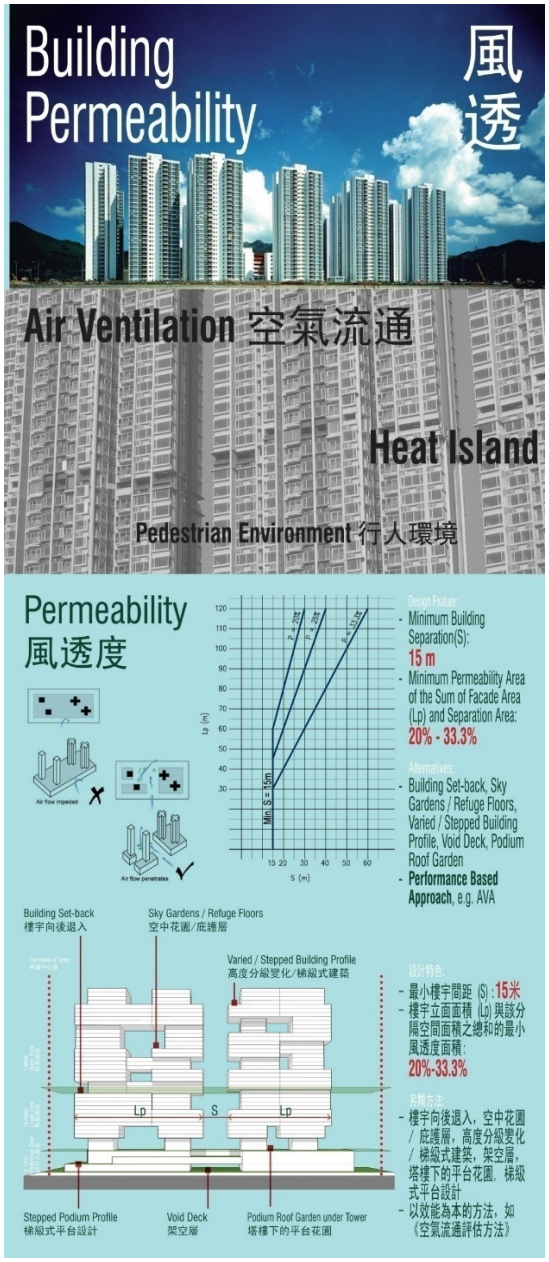
5 Energy Efficiency (Labelling of Products) Ordinance (EELPO)

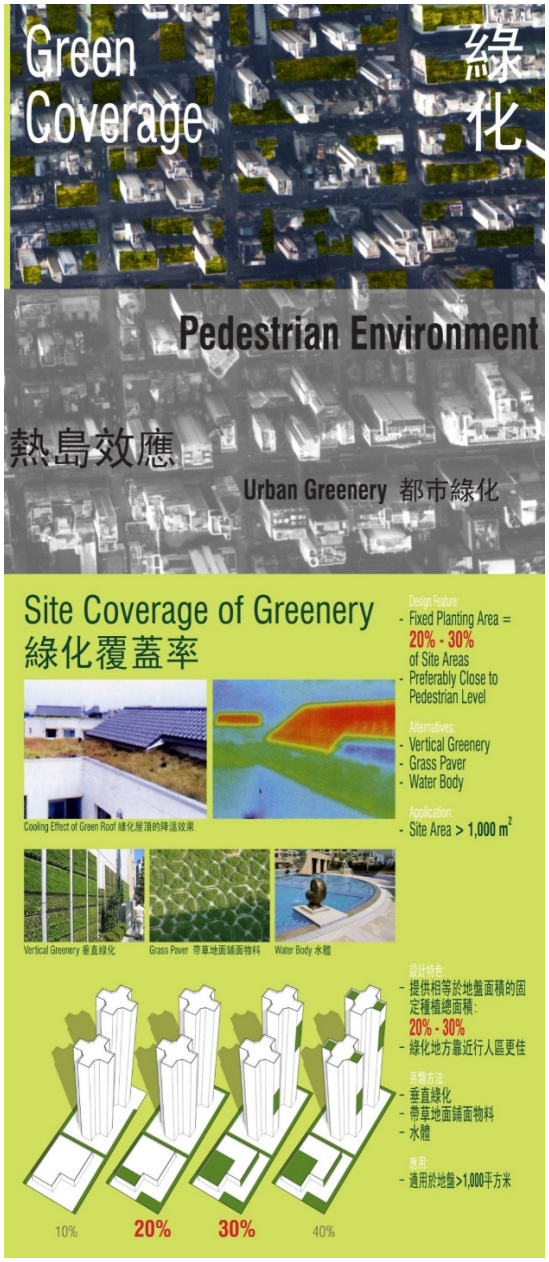
REGULATORY

☑ **Already in existence**
BEEO, B(EE)R and EELPO

Sustainable Building Design Guidelines

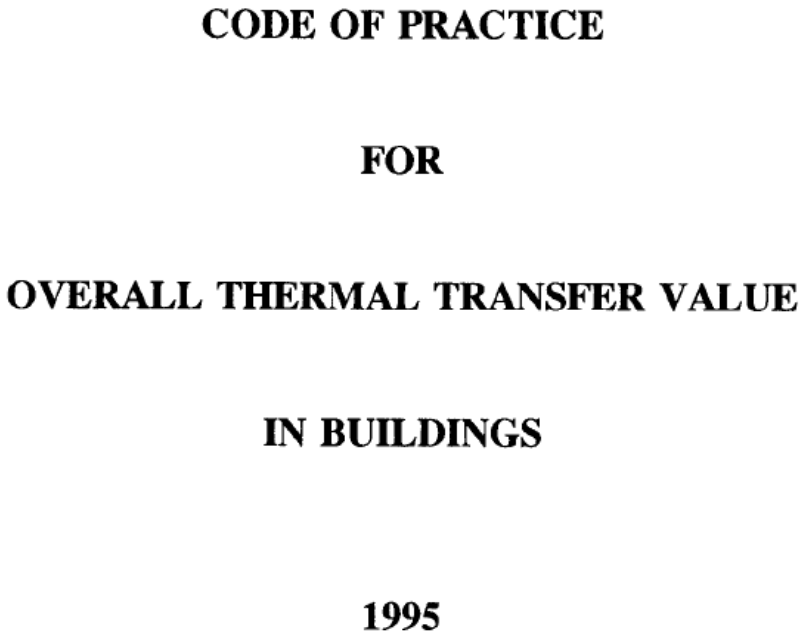
Buildings Department, HKSAR Government





Overall Thermal Transfer Value (OTTV) standard, was first introduced in 1995 and was tightened in 2011.

Extent of Application: Commercial buildings (office, retail), and hotels


CODE OF PRACTICE

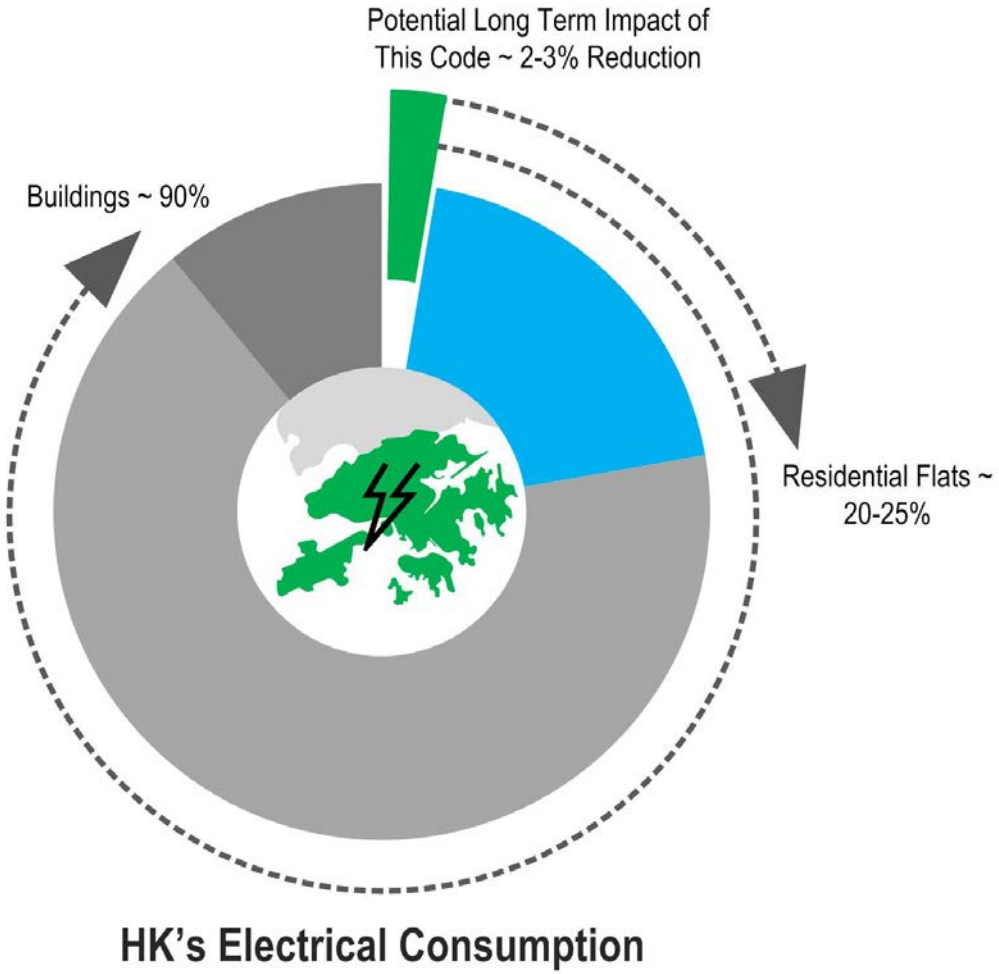
FOR

OVERALL THERMAL TRANSFER VALUE

IN BUILDINGS

1995

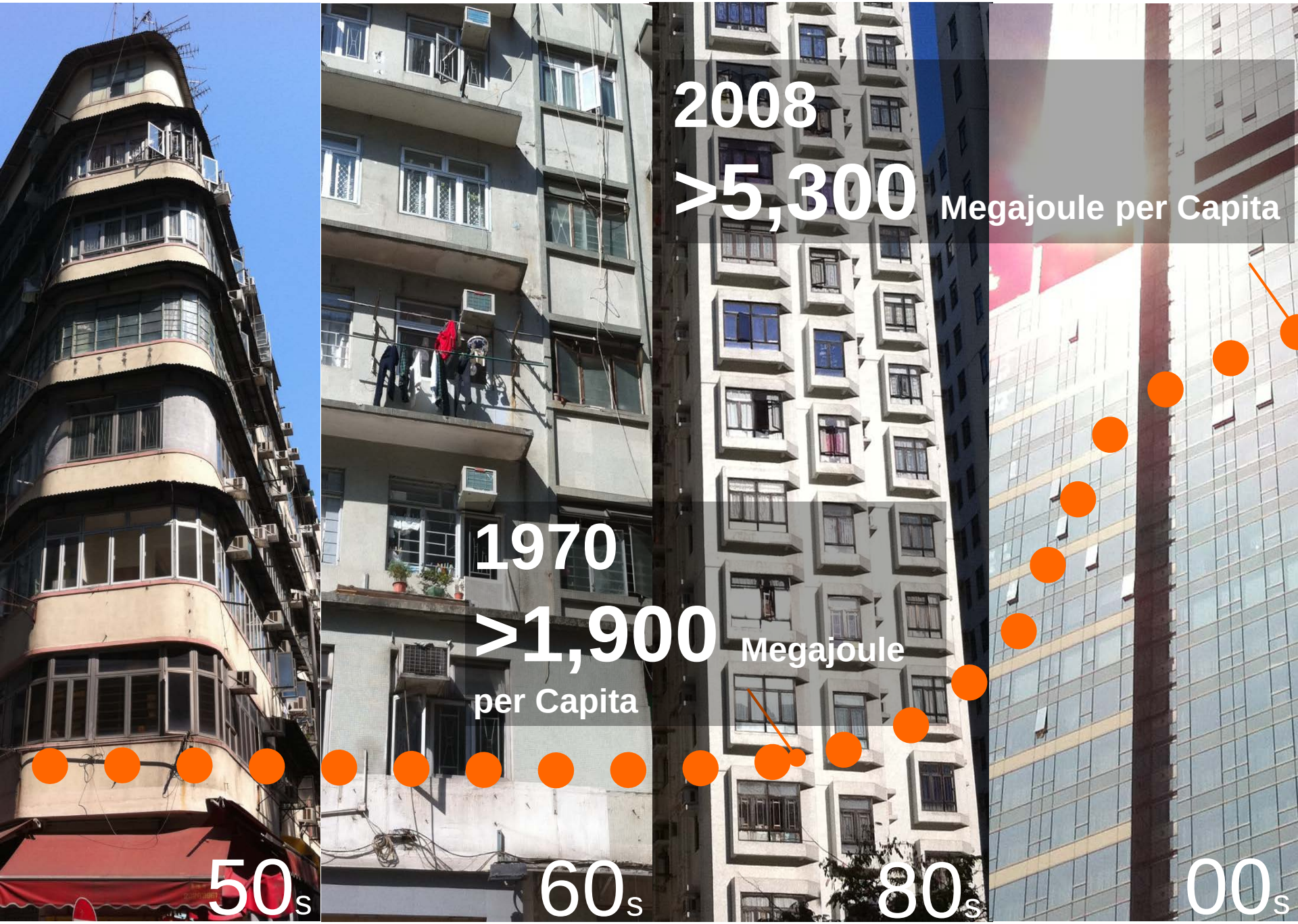
HK Challenges



Rising energy consumption trend in residential sector leading to increased carbon emissions

The Carbon Challenge:

Residential sector Accounting for 25% of total electricity consumption of HK (second largest sector)


2008
>5,300
Megajoule per Capita
1970
>1,900
Megajoule
per Capita
50s
60s
80s
00s

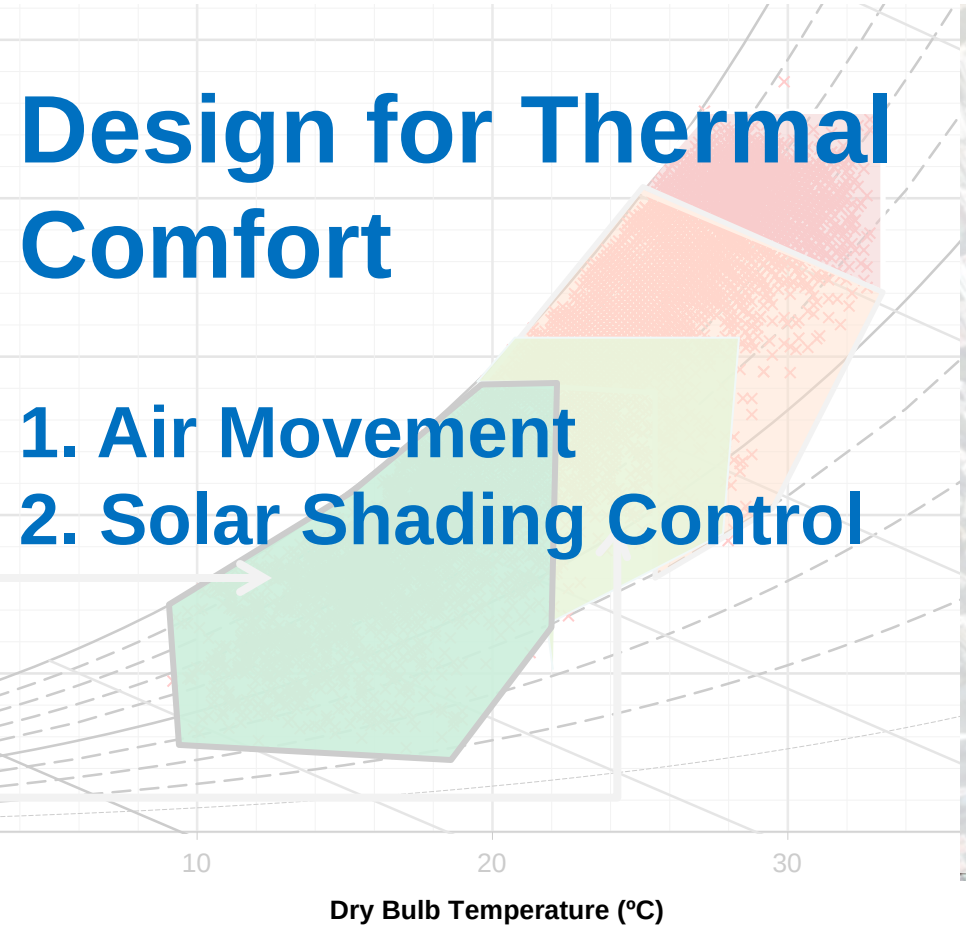
HK Challenges

Humid Sub-tropical Climate

Dense Built Context

Design for Thermal Comfort

1. Air Movement
2. Solar Shading Control



Concerns about Environmental Conflicts

Air Quality
Noise Pollution
Heat Emissions etc.

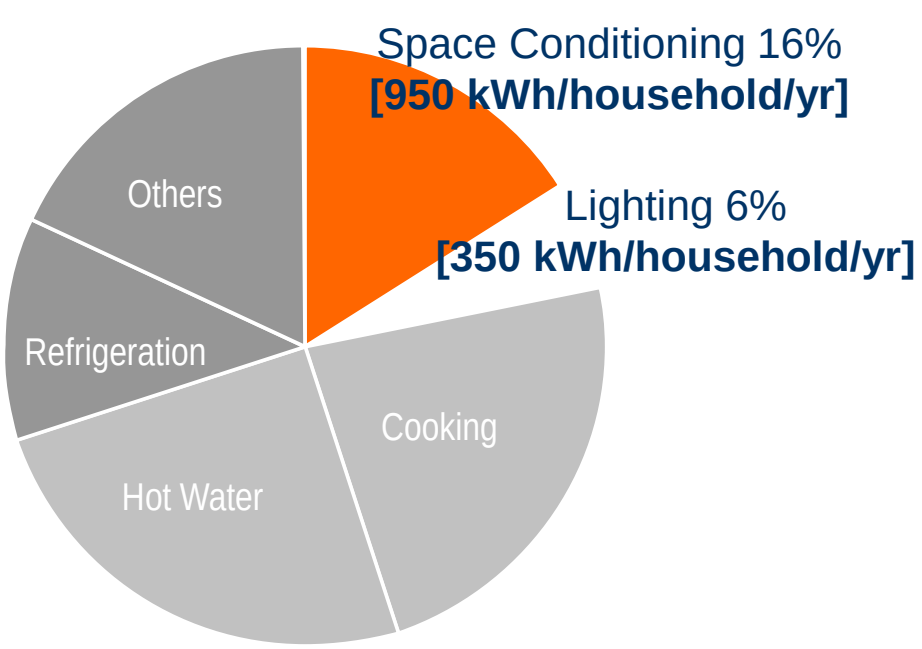
Energy Use in Residential Flat

Annual Energy Use in HK in 2008 (EMSD: HK Energy End-use Data 2010)

PUBLIC

Building-Related Energy

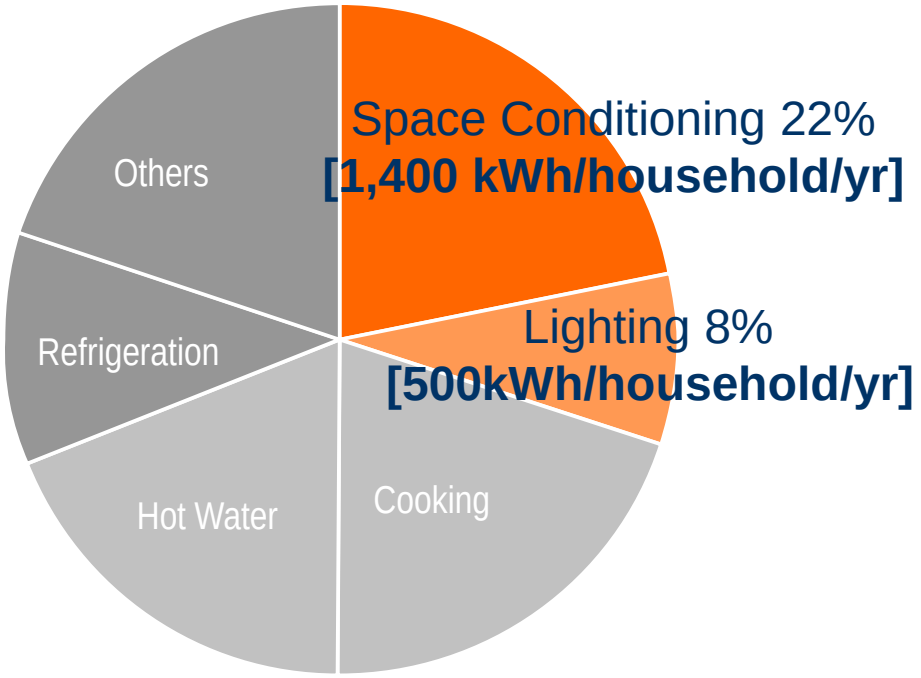
22% [1,300 kWh/household/yr]



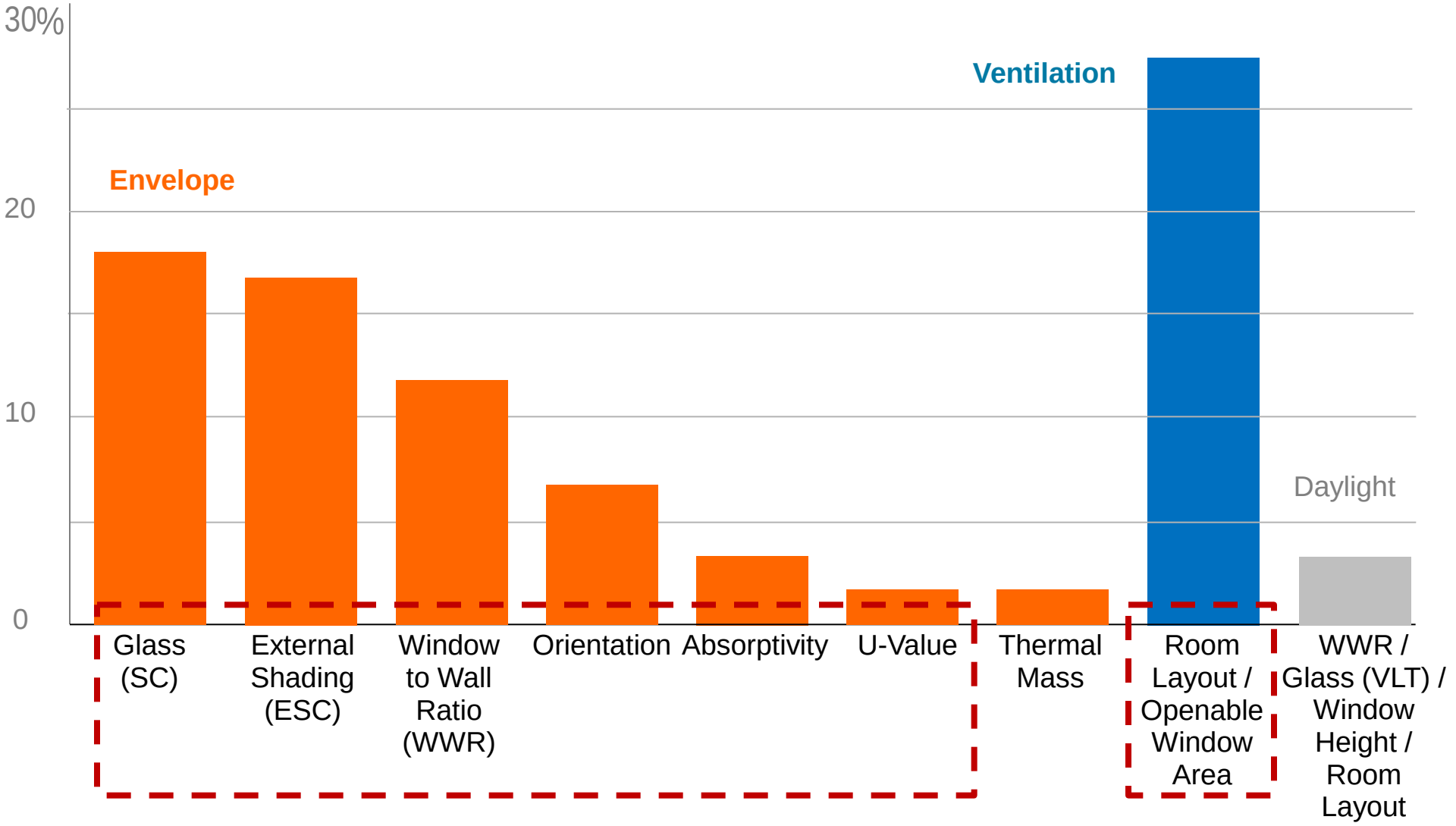
PRIVATE

Building-Related Energy

30% [1,900 kWh/household/yr]



Design Parameters on Building-design-related Energy Use for Residential Buildings

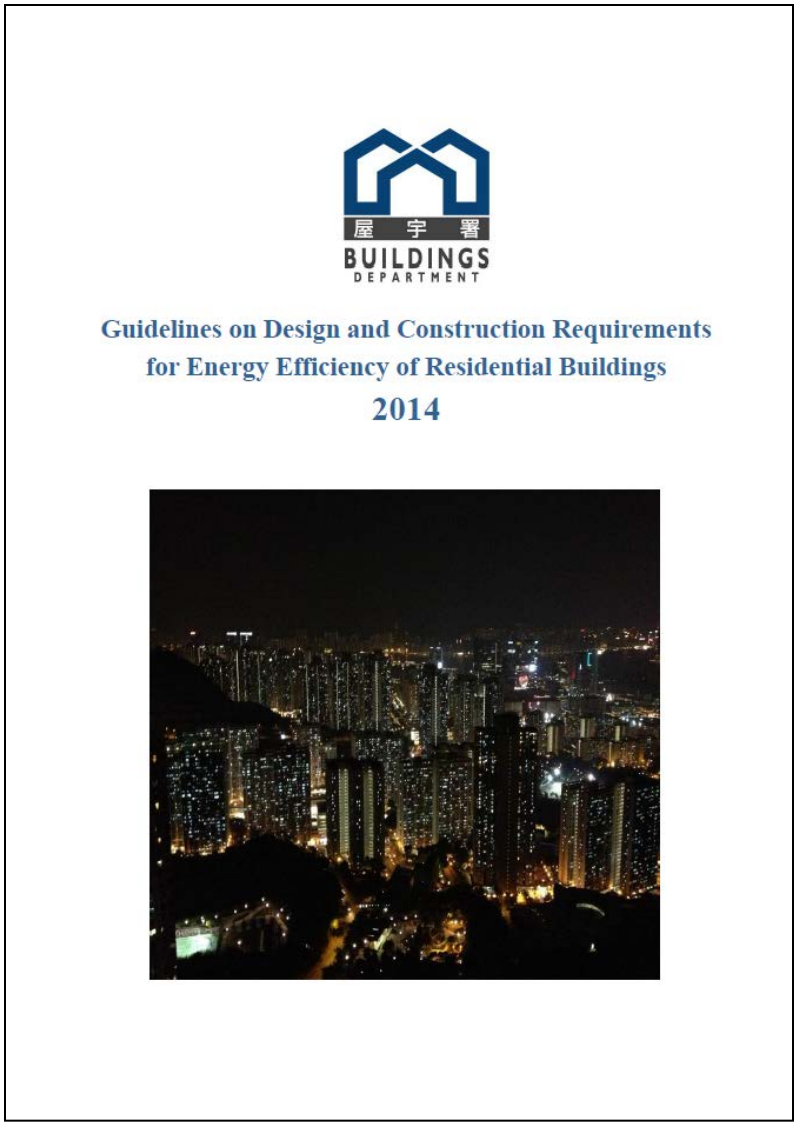


Guidelines

focus on **New** residential buildings

energy efficiency / use related to design and construction of **building fabric**

energy efficiency / use in **operational phase**



APP-156

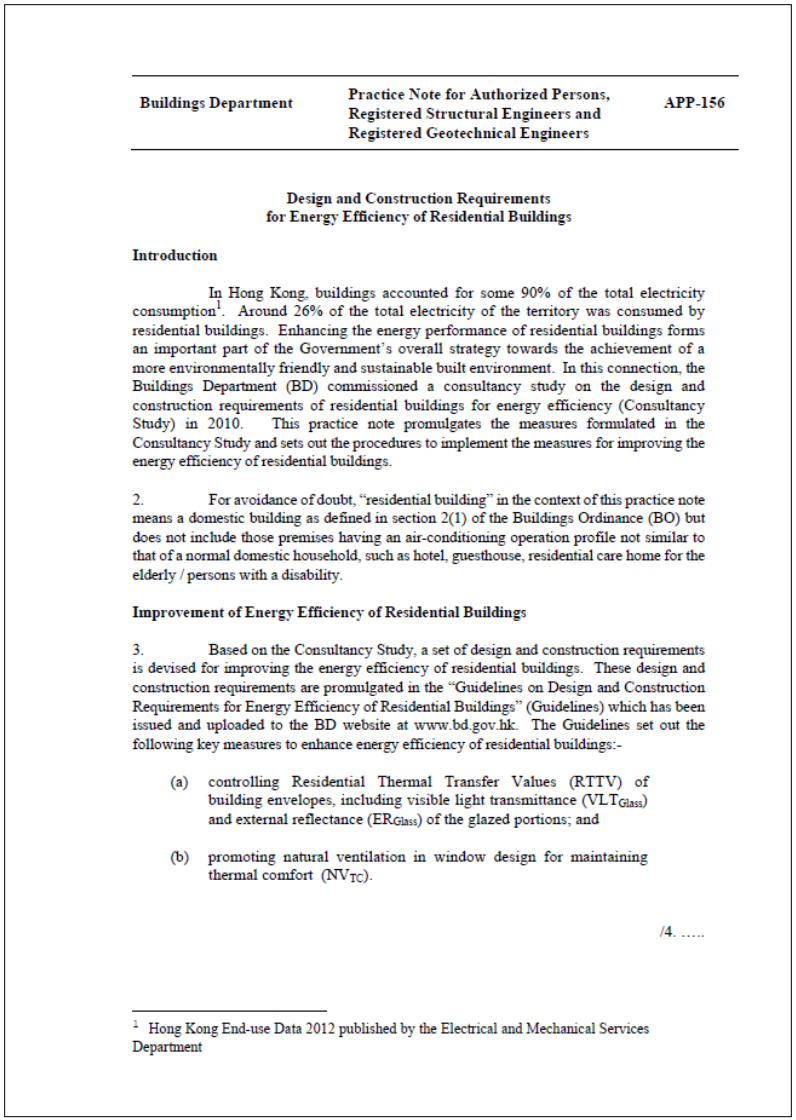
Implementation

16. This practice note is applicable to all new building plans or major revision of building plans for development proposals involving residential buildings submitted to the BA for approval on or after 1 April 2015. For the avoidance of doubt, this practice note is also applicable to building plans which have been previously disapproved and are resubmitted for approval on or after 1 April 2015.

17. This practice note does not apply to alteration and addition works or change in use not resulting in a new residential building.

Effective Date:

1 April 2015



Buildings Department	Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers	APP-156

Design and Construction Requirements for Energy Efficiency of Residential Buildings

Introduction

In Hong Kong, buildings accounted for some 90% of the total electricity consumption[1]. Around 26% of the total electricity of the territory was consumed by residential buildings. Enhancing the energy performance of residential buildings forms an important part of the Government's overall strategy towards the achievement of a more environmentally friendly and sustainable built environment. In this connection, the Buildings Department (BD) commissioned a consultancy study on the design and construction requirements of residential buildings for energy efficiency (Consultancy Study) in 2010. This practice note promulgates the measures formulated in the Consultancy Study and sets out the procedures to implement the measures for improving the energy efficiency of residential buildings.

2. For avoidance of doubt, "residential building" in the context of this practice note means a domestic building as defined in section 2(1) of the Buildings Ordinance (BO) but does not include those premises having an air-conditioning operation profile not similar to that of a normal domestic household, such as hotel, guesthouse, residential care home for the elderly / persons with a disability.

Improvement of Energy Efficiency of Residential Buildings

3. Based on the Consultancy Study, a set of design and construction requirements is devised for improving the energy efficiency of residential buildings. These design and construction requirements are promulgated in the "Guidelines on Design and Construction Requirements for Energy Efficiency of Residential Buildings" (Guidelines) which has been issued and uploaded to the BD website at www.bd.gov.hk. The Guidelines set out the following key measures to enhance energy efficiency of residential buildings:-

(a) controlling Residential Thermal Transfer Values (RTTV) of building envelopes, including visible light transmittance (VLT_{Glass}) and external reflectance (ER_{Glass}) of the glazed portions; and

(b) promoting natural ventilation in window design for maintaining thermal comfort (NV_{TC}).

/4. .....

[1] Hong Kong End-use Data 2012 published by the Electrical and Mechanical Services Department

1 RTTV

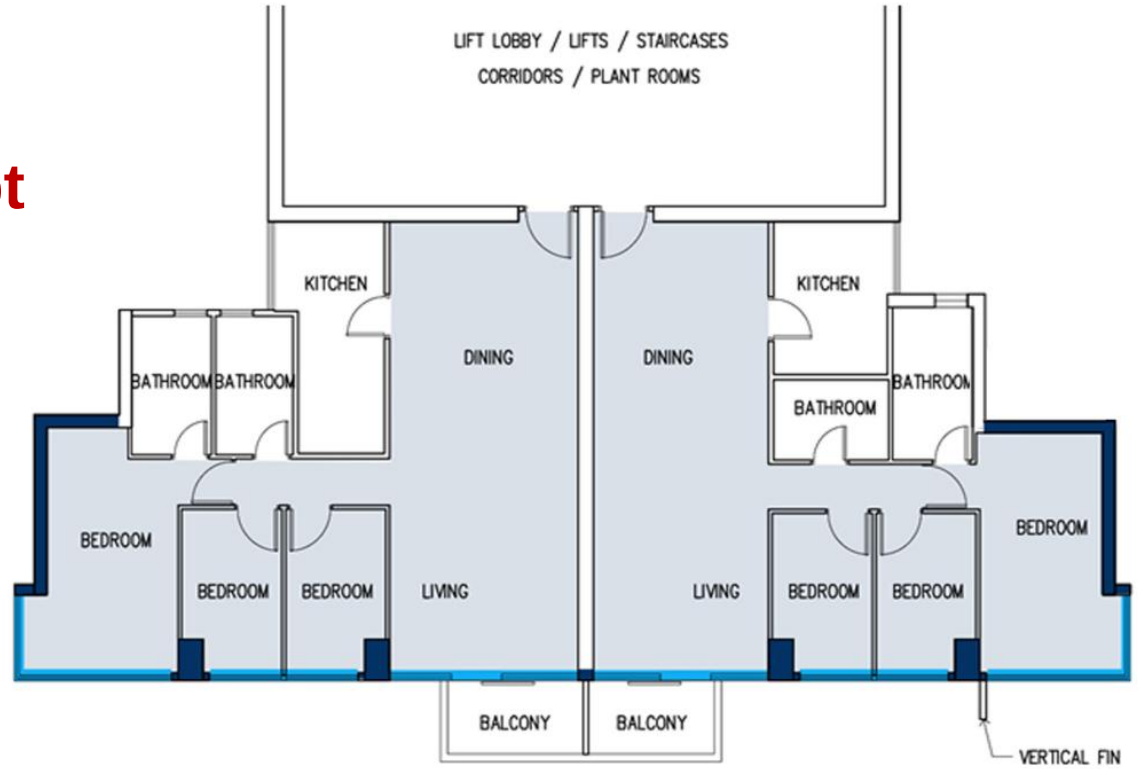
Residential Thermal Transfer Value

NV TC

Natural Ventilation

Wall Areas to be included in $RTTV_{wall}$ calculations

External walls of the **all enclosed spaces of residential units, except those of bathrooms & enclosed kitchens**



RTTV

Average Heat Gain per Unit Facade / Roof Area

Radiation Through Glazing

Conduction Through Opaque Wall / Roof

Conduction Through Glazing




Key Difference with OTTV

Default Operation and Occupancy Patterns for Residential Buildings
Independent Suitable Values for Roof and Wall

Exclusions

Internal shading devices, such as draperies and blinds;
Solar reflection or shading from adjacent developments; and Use of energy-efficient **building services equipment and appliances**.

$RTTV_{wall}$ Calculation Formula

$$= [41.75\ WWR \times SC \times ESC \times G_w] + [3.57(1-WWR) \times U_w \times \alpha \times G_w] + [0.64\ WWR \times U_f \times G_w]$$

Radiation Through **Glazing**	Conduction Through **Opaque Wall**	Conduction Through **Glazing**
	WWR: Window to Wall Ratio	
	G_w : Wall Orientation Factor	
SC : Shading Coefficient	U_w: U-value of the opaque wall	U_f : U-value of the glazing
ESC: Shading Coeff. of External Shades	α : Absorptivity of the wall	

$RTTV_{roof}$ Calculation Formula

$= [41.10(SRR)(SC_r)(G_s)] + [3.47(1-SRR)\ U_r\ \alpha_r\ G_s] + [0.40(SRR)U_{sl}G_s]$

Radiation Through Skylight

Conduction Through Roof

Conduction Through Skylight

SRR : Skylight to Roof Ratio

G_s **:** Roof Orientation Factor

SC_r: Shading Coeff. of Skylight Glazing

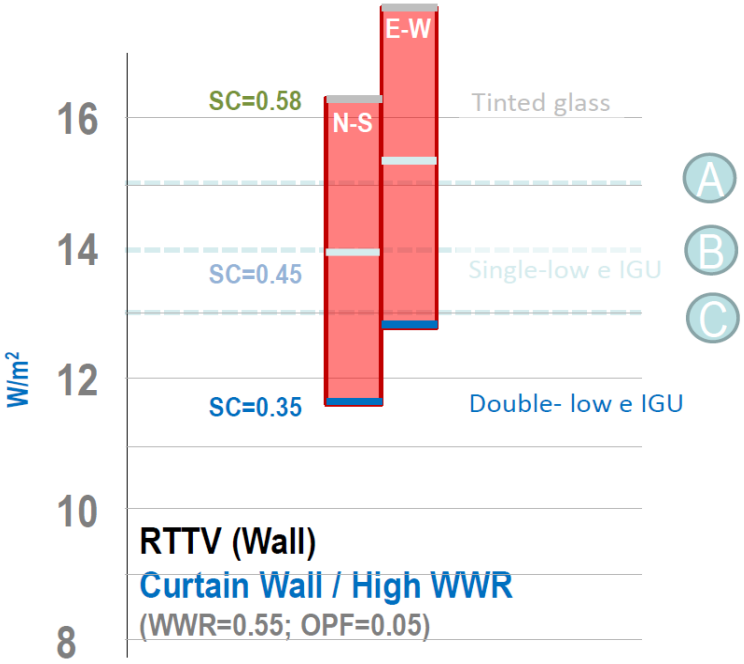
Ur: U-value of the roof

α_r: Absorptivity of the roof

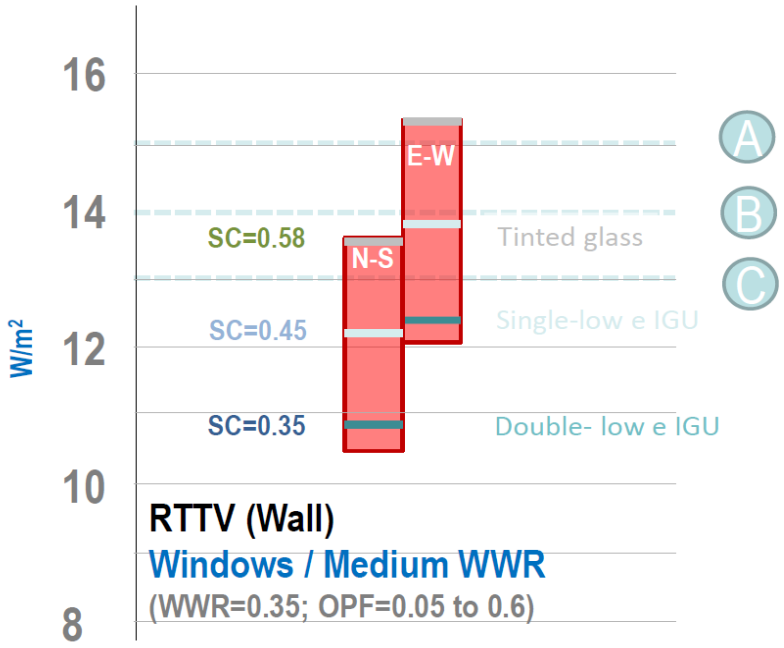
U_{sl} : U-value of the skylight glazing

Sensitivity Tests

RTTV



Average distance between window sill and projection = 2.35m; Projection = 0.1m



Average distance between window sill and projection = 1.85m; Projection = 0.1m

One of the pre-requisites for the granting of GFA concessions under PNAP APP-151 :-

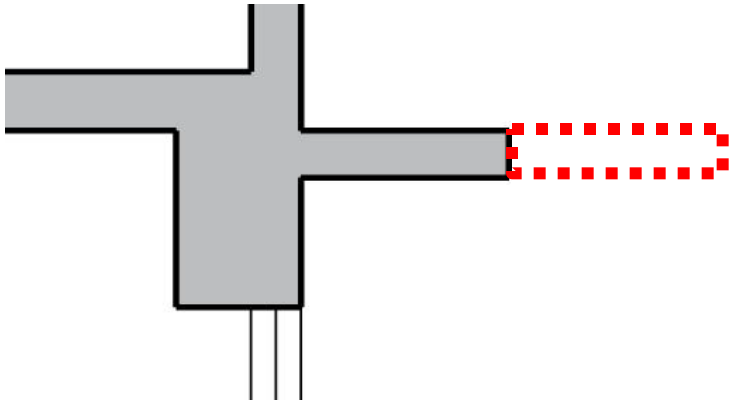
$RTTV_{Wall}$ <= 14 W/m² & $RTTV_{Roof}$ <= 4 W/m² ;

Daylight & Glare Control

Visible Light Transmittance ≥ **50%**

Glass External Reflectance ≤ **20%**

Incentive for Effective Sunshade



For projection
≤ 500mm (facing N [NNW to NNE]) &
≤ 750mm (facing other orientations)

* For sunshades **within re-entrant less than 4.5m**, the projection should not be more than **500mm**

For projection
> 500 and ≤ 1500mm (facing N) &
> 750 and ≤ 1500mm (facing others),

- OPF not less than 0.2 or 0.5 respectively
- Not causing obstruction to prescribed windows

Complex Shading & Self-Shading

Equation:

ESC $=(\sum Er \cdot I_D + I_d)/(\sum I_D + I_d)$

ESC: External Shading Coefficient

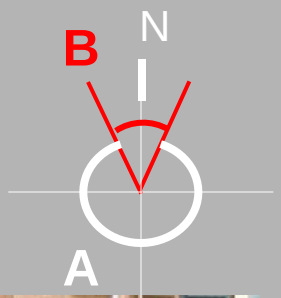
Er: Ae/A is the fraction of area exposed to direct solar radiation

I_D: Direct solar radiation for a specific time given in tables

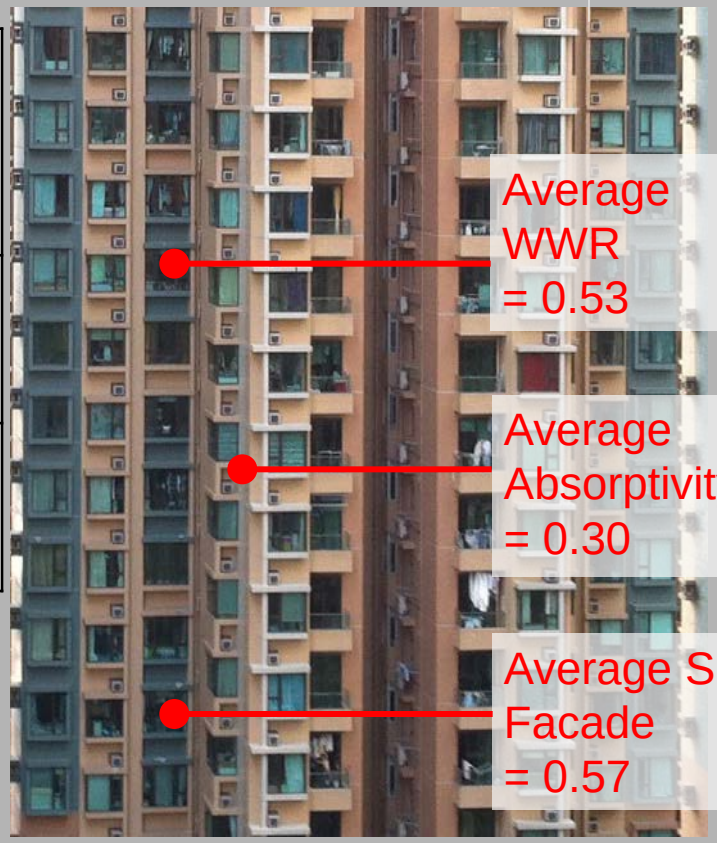
I_d: Diffuse solar radiation for a specific time given in tables

Simplicity

Deemed to Satisfy RTTV Criterion



Category	Average Values		Deem to Satisfy Criteria for SC [Facade]	Average SC [Facade]	
	WWR	Absorptivity*			
NNE to NNW (Category A)	0.38	0.37	≦ 0.56	0.45	OK
NNW to NNE (Category B)	0.53	0.30	**≦ 0.59**	0.57	OK



* Any ONE external finish material applied on the facade in one orientation constituting **more than 60% of the gross wall area** can be regarded as dominant and its absorptivity can be taken as the average absorptivity of the facade in that orientation for compliance check on Deemed to Satisfy $RTTV_{wall}$ Criteria

Facade Facing NNW to NNE (Category B)

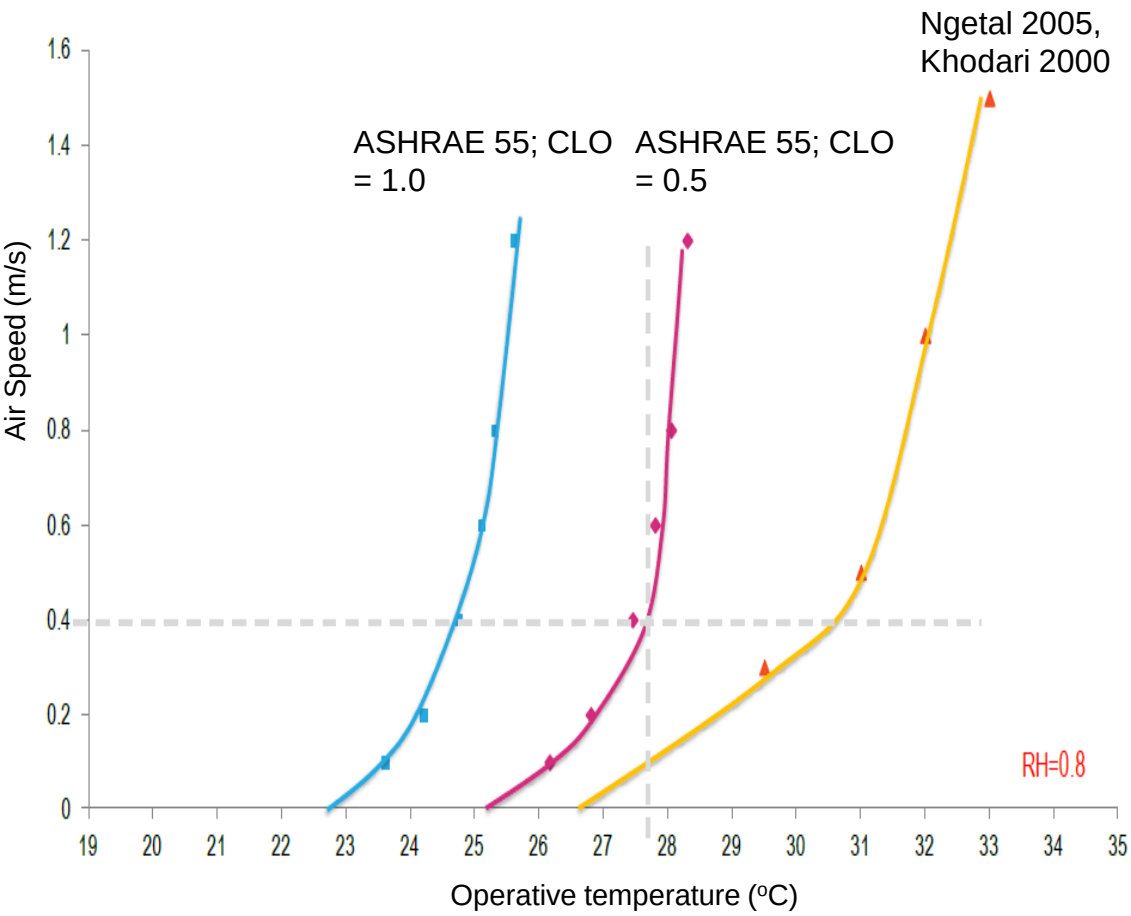
RTTV

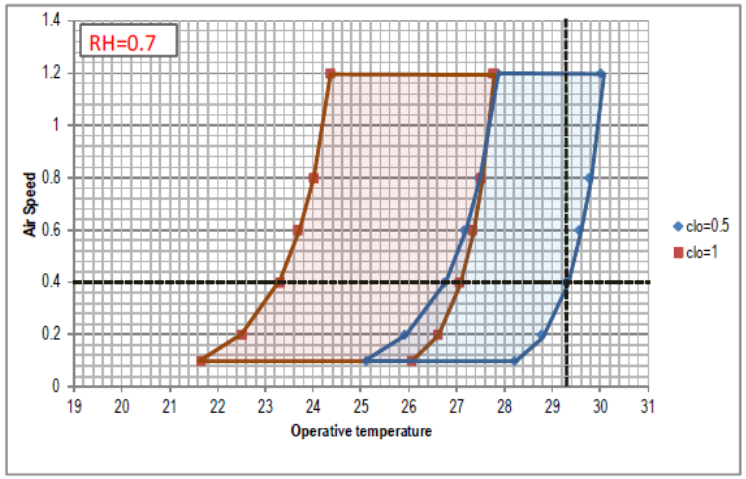
Residential Thermal Transfer Value

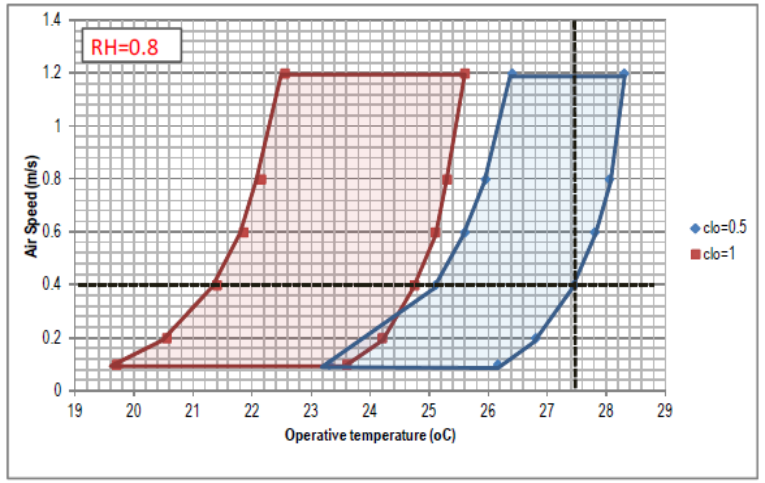
2 NV$_{TC}$

Natural Ventilation

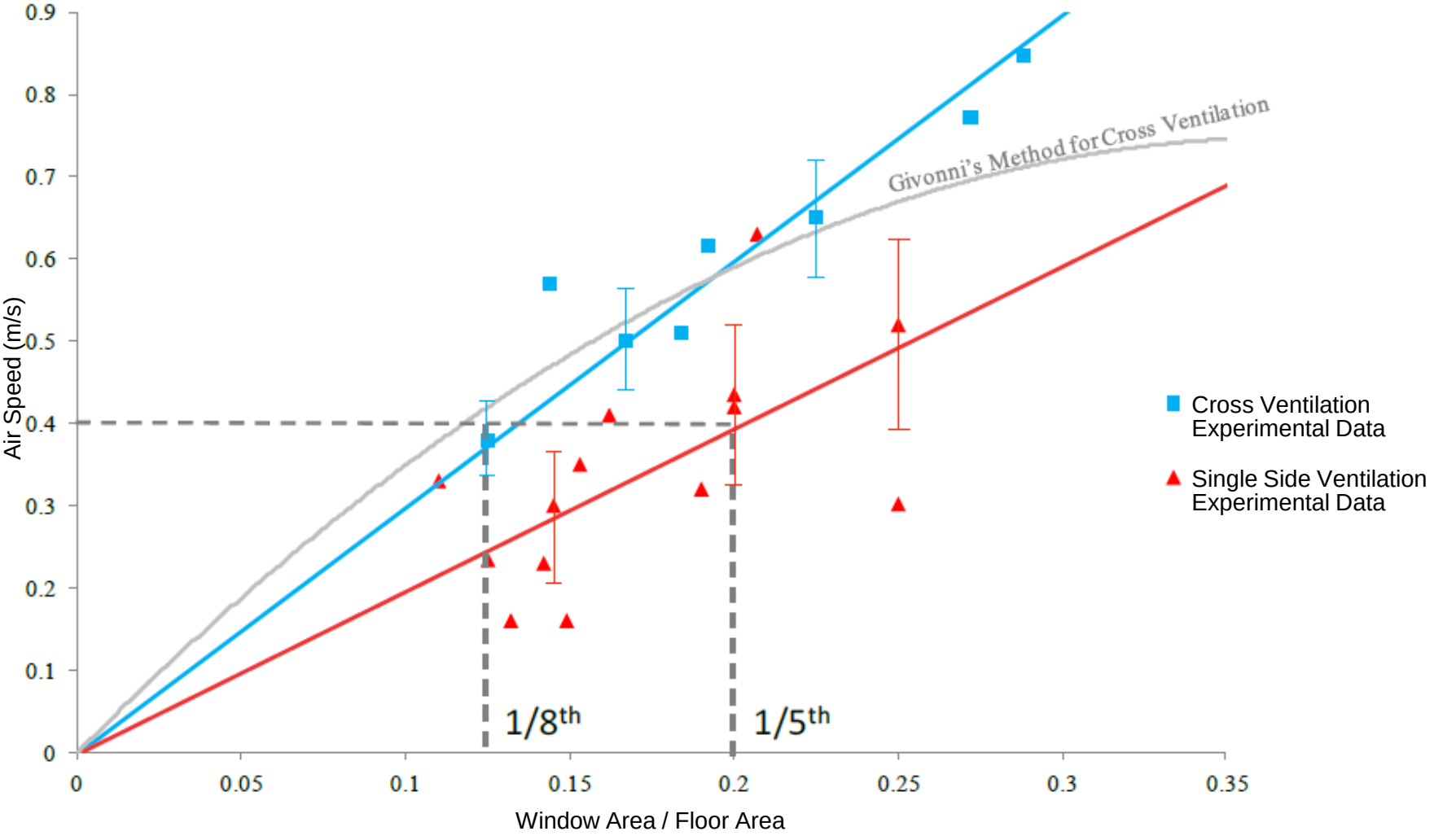
Adaptive Comfort Model



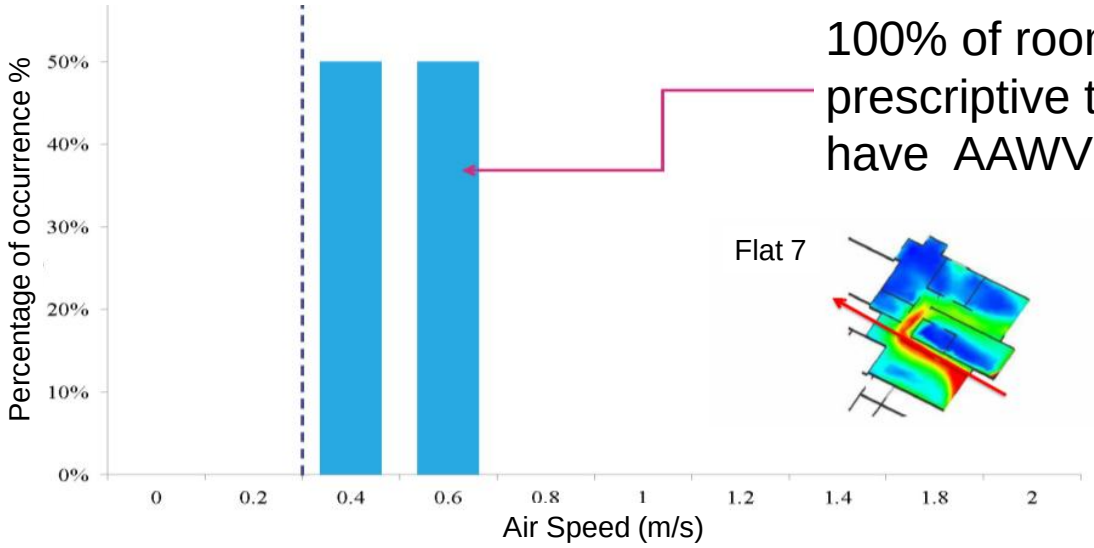




Effect of Window Size

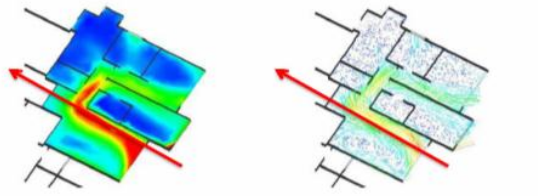


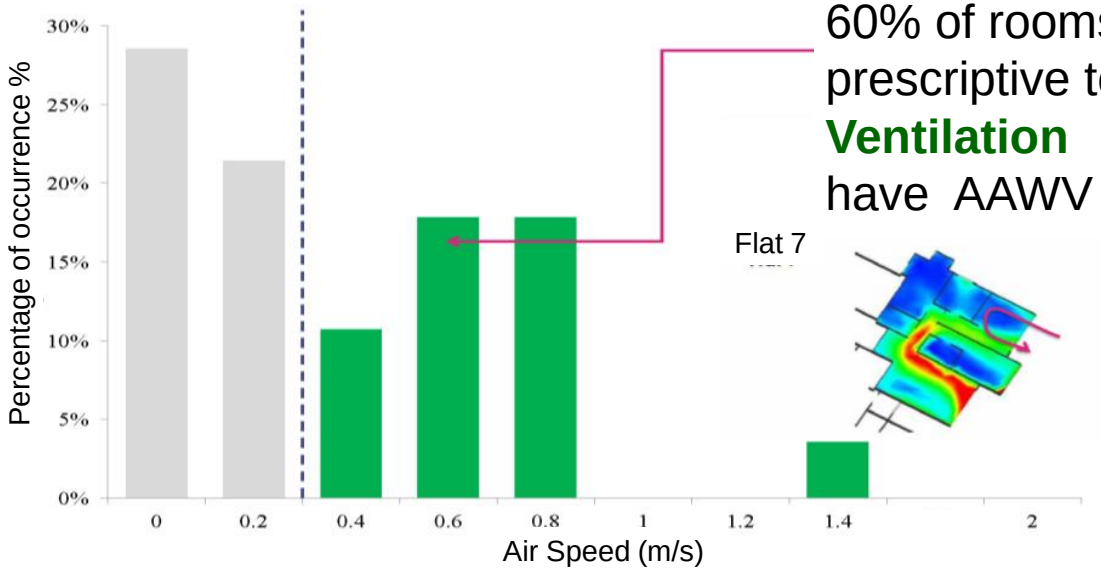
Formulation



100% of rooms that comply with the prescriptive test for **Cross Ventilation** have AAWV > 0.4m/s

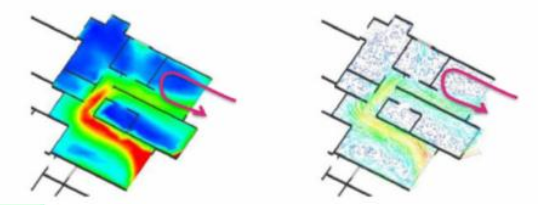
Flat 7



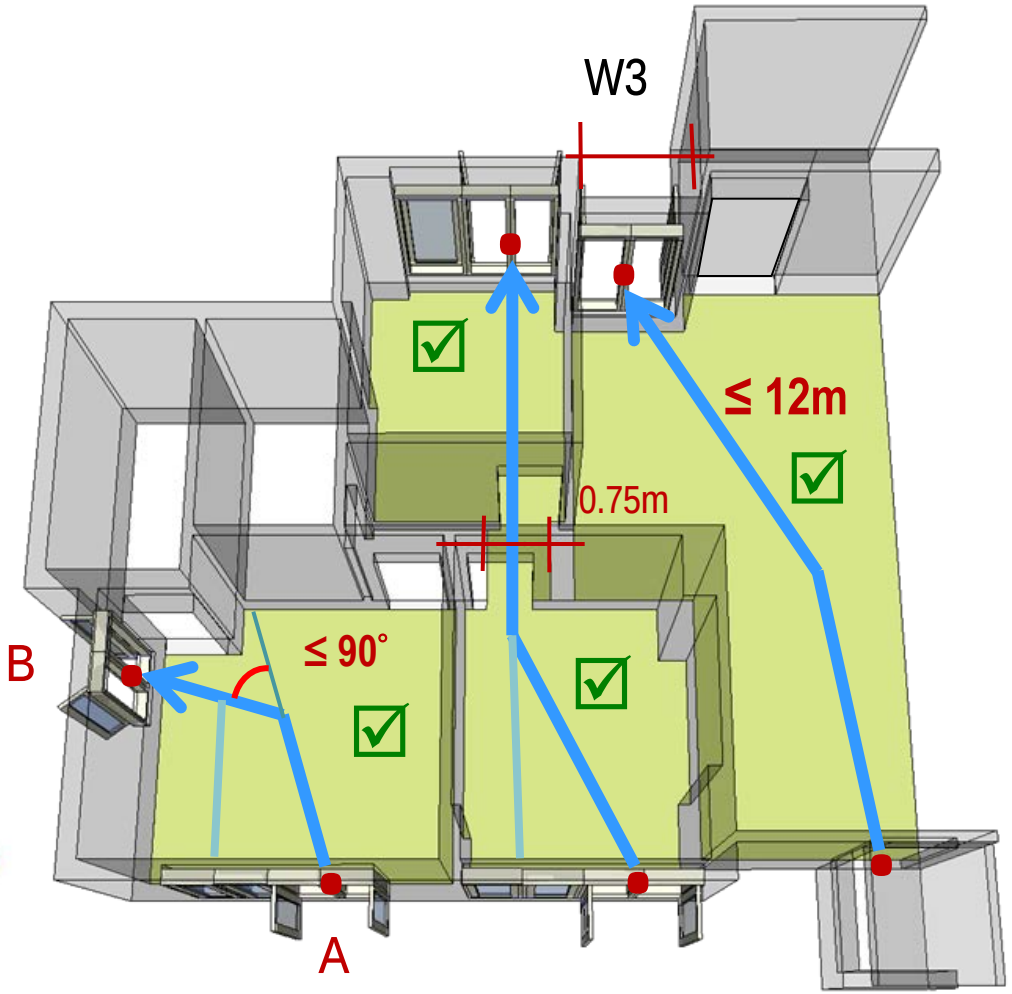


60% of rooms that pass with the prescriptive test for **Single-sided Ventilation** have AAWV > 0.4m/s

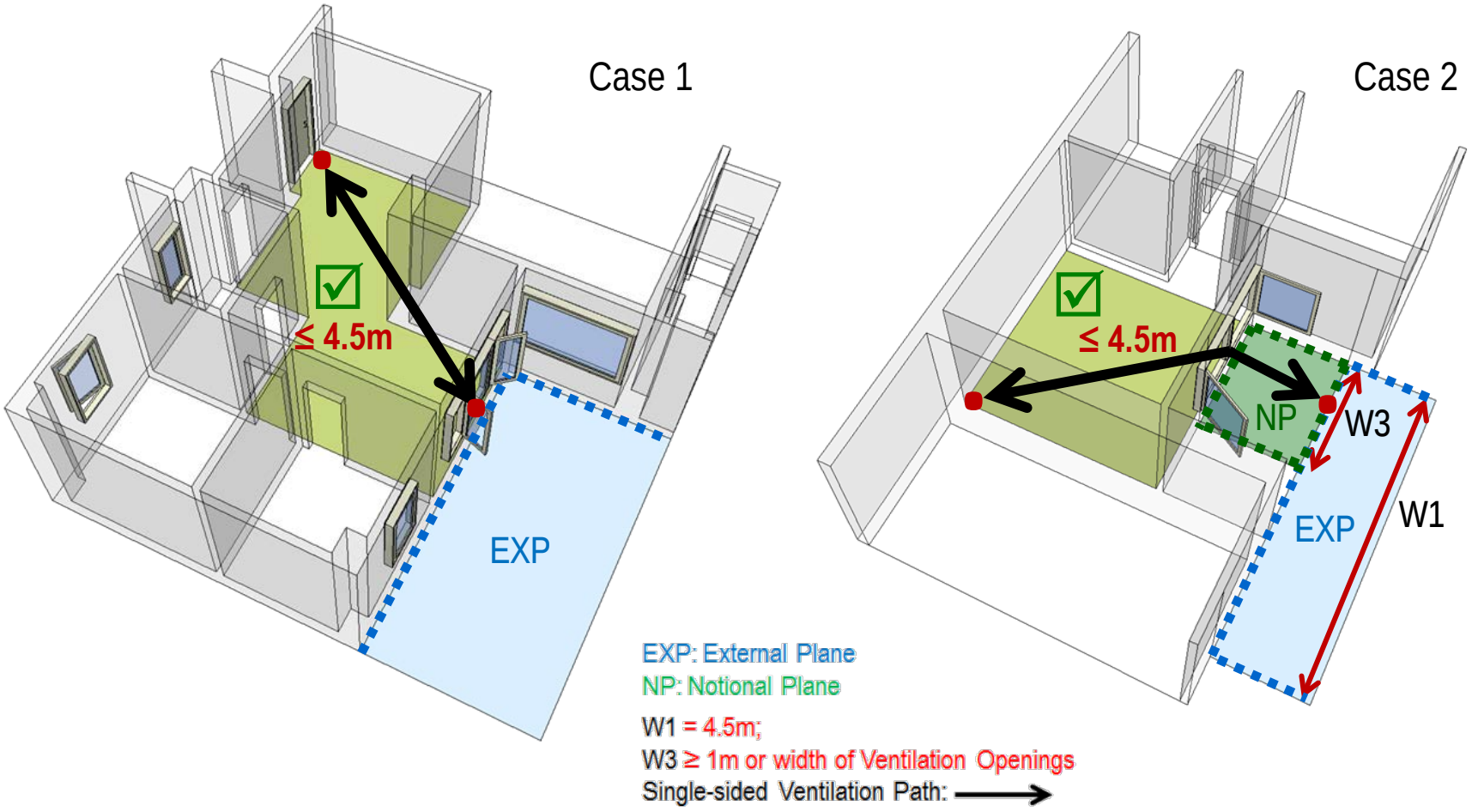
Flat 7



Cross Ventilation NV_C



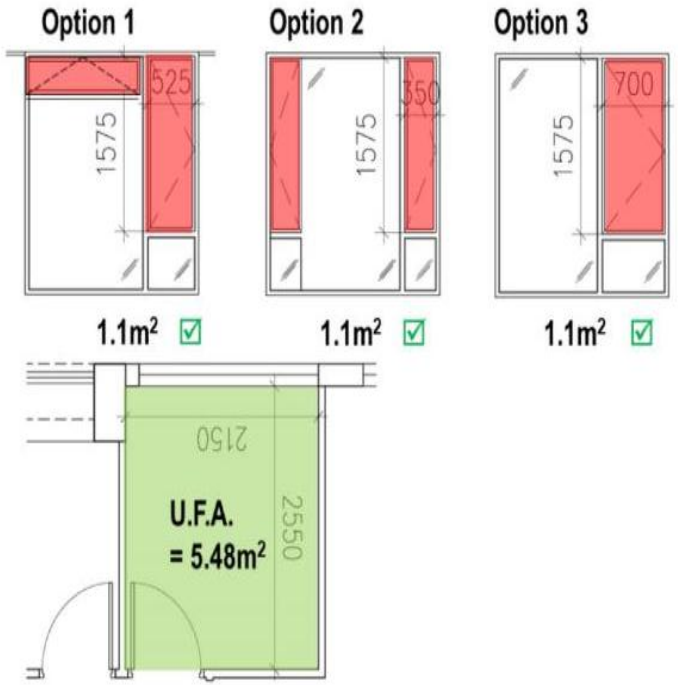
Single-Sided Ventilation NV_{SS}



Single-Sided Ventilation NV_{SS}

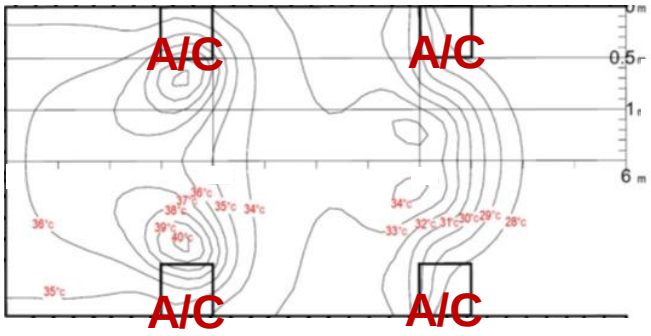
Total openable window area in aggregate

≥ **one-fifth (1/5th)**
of the UFA of the room

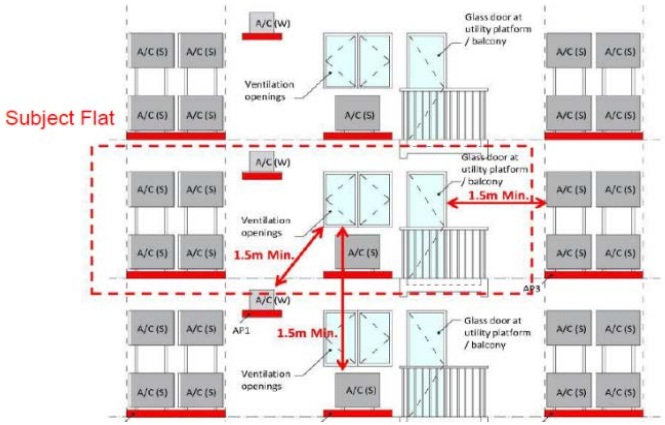


Note: Current min. prescribed openable window area ≥ 1/16th (for reference)

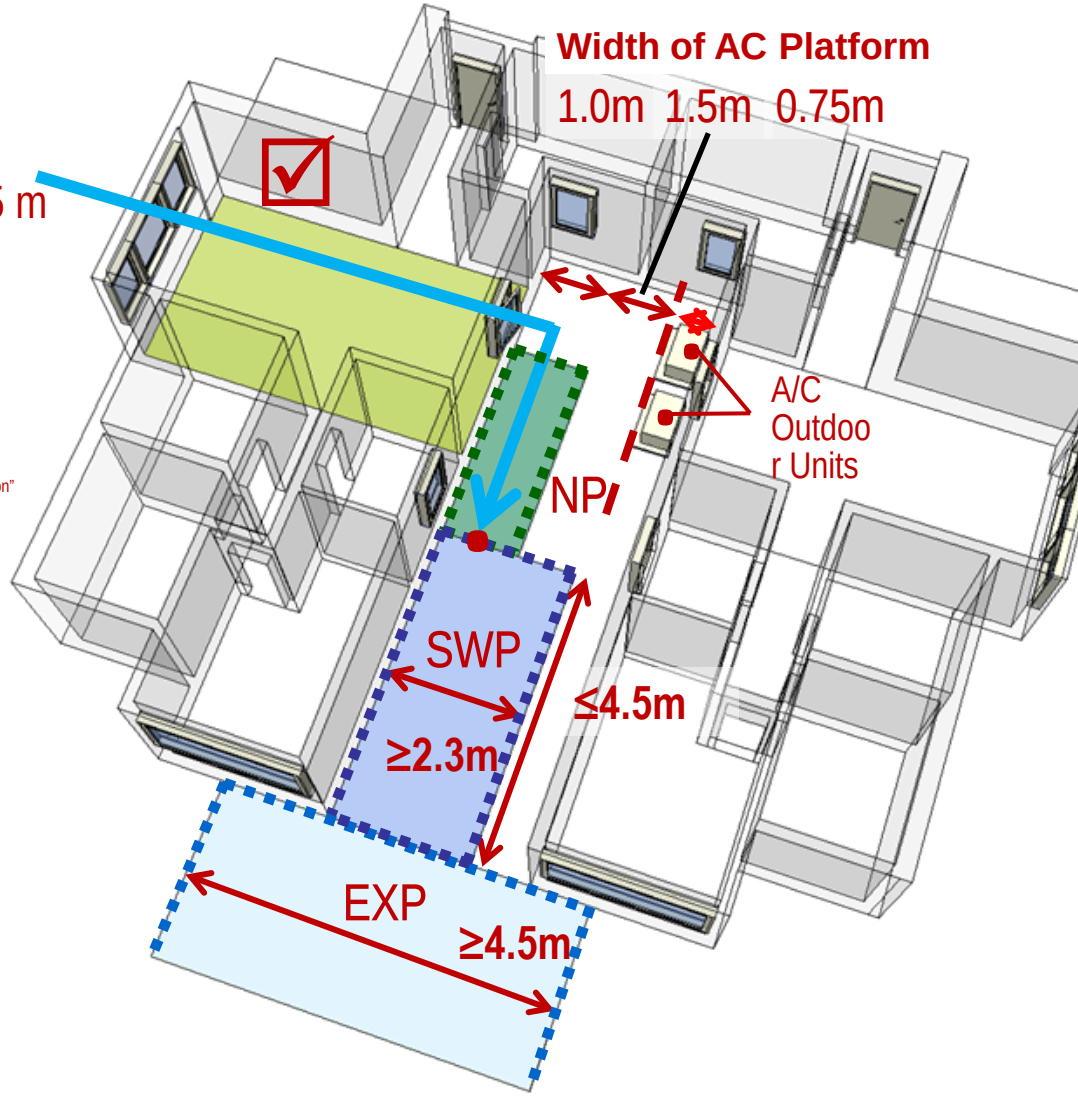
Heat Emissions from Air-conditioners



Francis Yik et al (2002) "Influence of a depth of a recessed space to flow due to air-conditioner heat rejection"



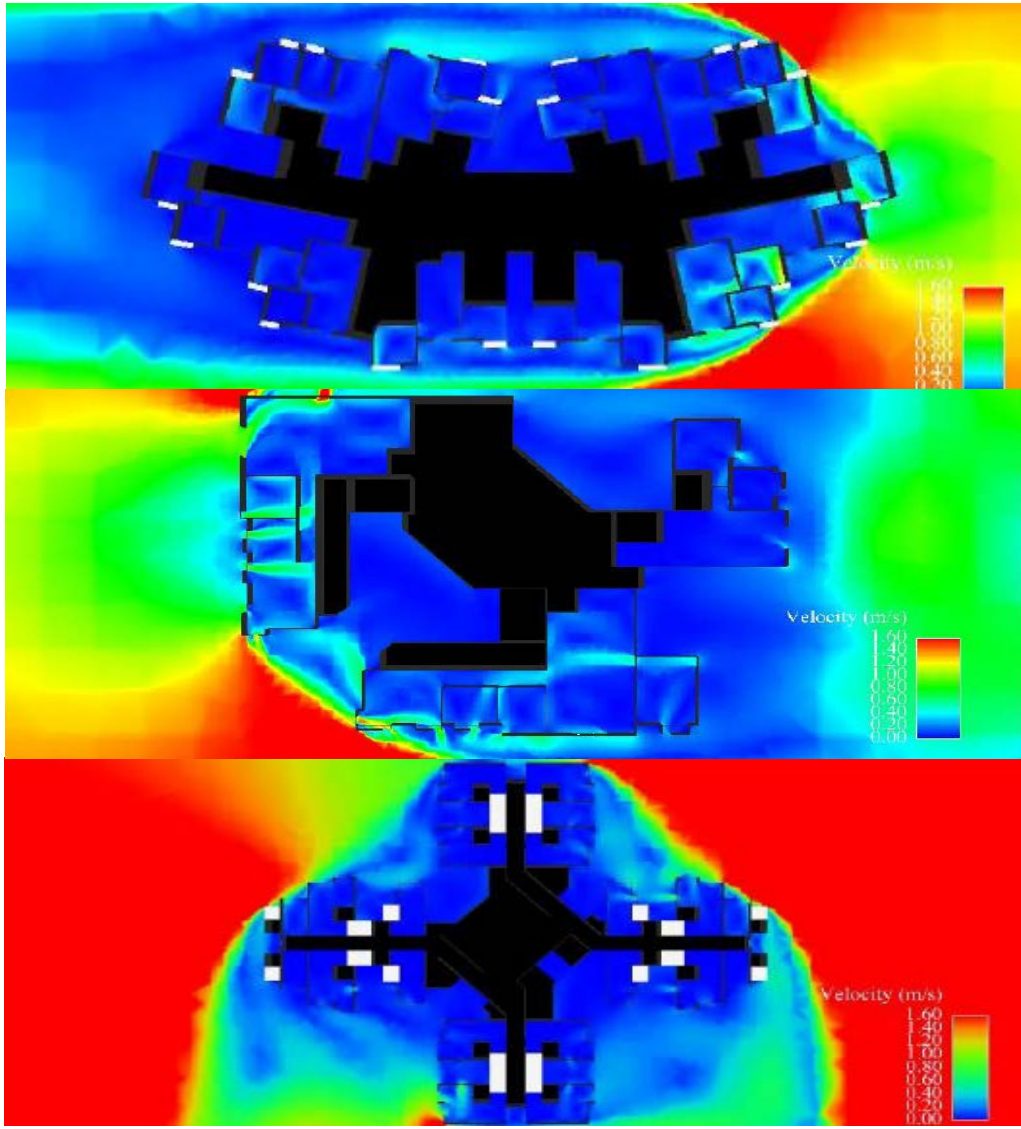
Required width to dissipation heat generated by AC



Performance-based Approach

Alternative Approach Methodology for NV_{TC}

	Simplified Simulation Method	Site Specific Simulation Method
Process	CFD building model to assess internal conditions with standard wind conditions	CFD building & neighbourhood model to assess external & internal conditions with realistic local wind profiling
Features capture	Building layout, building features that affect NV potential	Building layout, building features, neighbourhood massing / topography, local wind conditions that affect NV potential



Sensitivity Tests
NV_{TC} Compliance Check

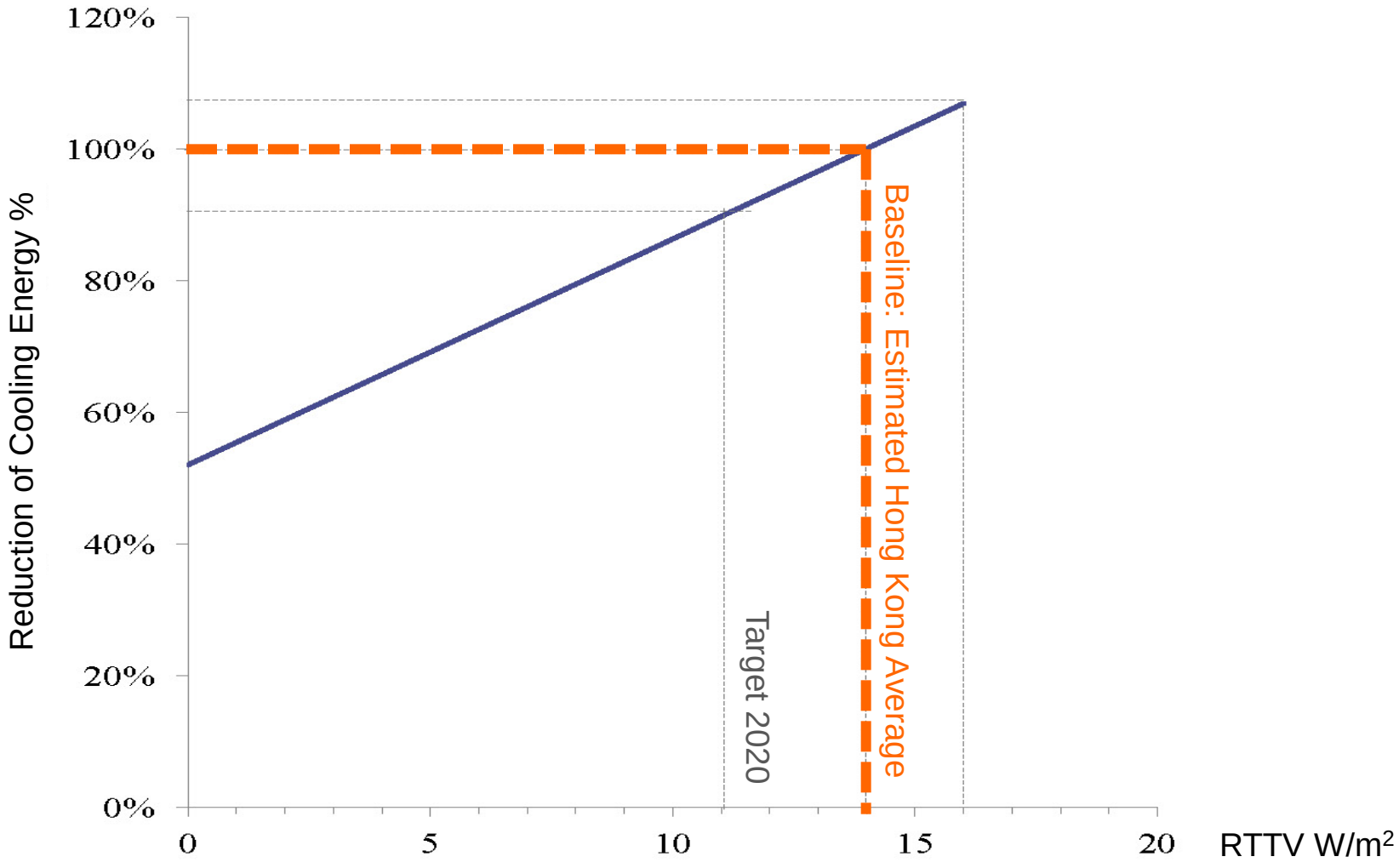
NV_c	11%
$NV_{c\ (at\ re\text{-}entrant)}$	37%
NV_{ss}	34%
Overall NV_{TC}	82%

LEGEND :

- EXP : External Plane
- SWP : Secondary Window Plane
- NP : Notional Plane
- Cross Ventilation Path
- Area of habitable spaces with Cross Ventilation outside re-entrant (NV_c)
- Area of habitable spaces with Cross Ventilation at re-entrant ($NV_{c\ (at\ re\text{-}entrant)}$)
- Area of habitable spaces with single-sided ventilation (NV_{ss})
- Area of habitable spaces that do not satisfy any requirements of the above
- Area of cross ventilation path across a corridor and/or area of other room(s) (e.g. bathroom / toilet, store) with secondary ventilation opening(s)

Potential Energy Saving

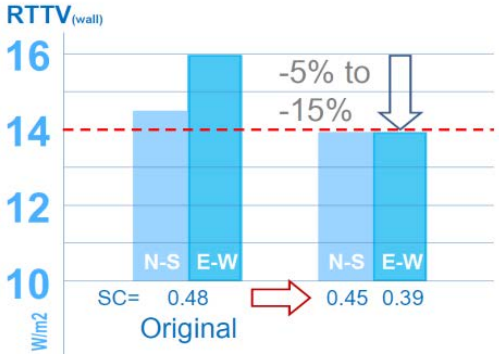
RTTV



Life Cycle Costing

Change of Shading Coefficient (SC)

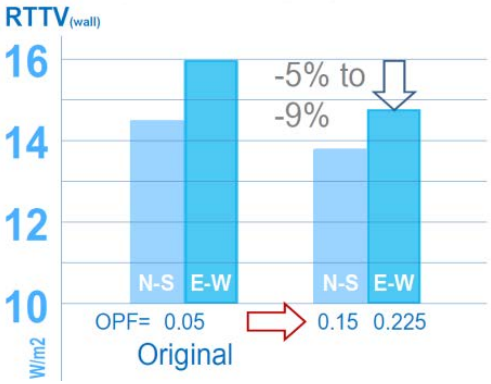
Case 1:
[WWR=0.5-0.6] & [Curtain Wall Construction]



+$
+0.2~0.3%

Change of Overhanging Projection Factor (OPF)

Case 1: [WWR=0.5-0.6] & [Curtain Wall Construction]



+$
+0.4~ 0.6%
+0.8~ 1.1%

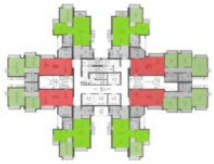
Change of Overhanging Projection Factor (OPF)

Case 2: [WWR=0.3-0.4] & [Window Wall Construction]

+$
+0.2~ 0.3%
+0.7~ 1.1%

Change of Operable Window Area

+$ +0.1~0.2%
Of total construction cost



0% ➡ 70%

Ventilated Layout %
0% ➡ 60%

0% ➡ 46%

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Thank you.

Welcome your comments / questions.

(Please send to mk.leung@hkgbc.org.hk)

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