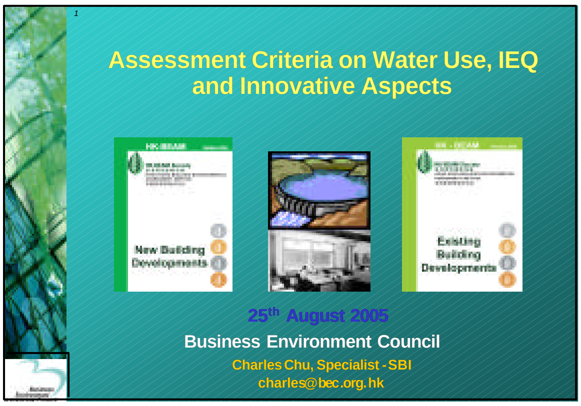
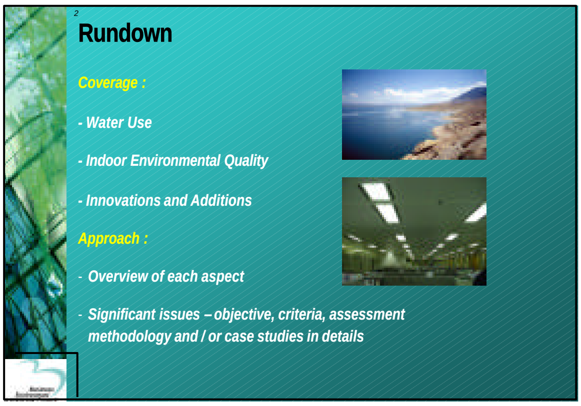
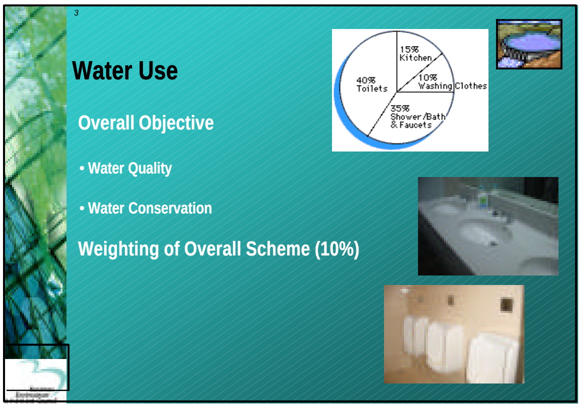
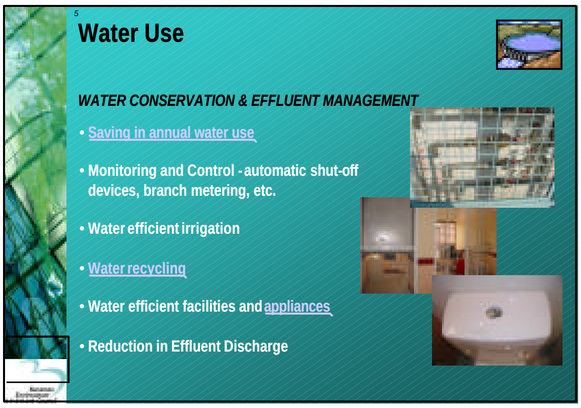

1
Assessment Criteria on Water Use, IEQ and Innovative Aspects
New Building Developments
Existing Building Developments
25th August 2005
Business Environment Council
Charles Chu, Specialist - SBI
charles@bec.org.hk


2
Rundown
Coverage :
- Water Use
- Indoor Environmental Quality
- Innovations and Additions
Approach :
- Overview of each aspect
- Significant issues – objective, criteria, assessment methodology and / or case studies in details


3
Water Use
Overall Objective
• Water Quality
• Water Conservation
Weighting of Overall Scheme (10%)
15% Kitchen
10% Washing Clothes
40% Toilets
35% Shower/Bath & Faucets


4
Water Use
WATER QUALITY
• Fresh Water Plumbing Installation
–COP of Practice for the Prevention of Legionnaires' Disease in Hong Kong
–Fresh Water Plumbing Quality Maintenance Recognition Scheme
• Water Quality Survey
–Analysis of samples from potable water outlets in compliance with the WHO Guidelines


5
Water Use
WATER CONSERVATION & EFFLUENT MANAGEMENT
• Saving in annual water use
• Monitoring and Control - automatic shut-off devices, branch metering, etc.
• Water efficient irrigation
• Water recycling
• Water efficient facilities and appliances
• Reduction in Effluent Discharge


6
Indoor Environmental Quality Aspects
• Safety & Security
• Hygiene
• Indoor Air Quality
• Ventilation
• Thermal Comfort
• Lighting
• Acoustic & Noise
• Building Amenities

7

Indoor Environmental Quality Aspects

- Overall Objective
  - ensure occupants' safety, health and comfort
- Largest Portion of Overall Scheme (30%)
- Minimum Percentage of IEQ

	Overall	IEQ
Platinum	75%	65%
Gold	65%	55%
Silver	55%	50%
Bronze	40%	45%

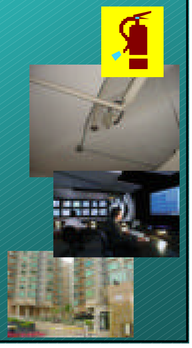
- Area Weighting

8

Indoor Environmental Quality

SAFETY & SECURITY

- Fire safety – Design Integration, Fire Safety Manual
- Electromagnetic compatibility – Reduction of occupant exposure and equipment interference
- Security – Site perimeter controls, surveillance equipment, site / building layout



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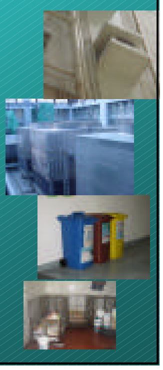
Indoor Environmental Quality

HYGIENE

- Plumbing & drainage – design of drainage and venting stacks, maintenance of water seals
- Biological Contamination – HVAC installation in compliance with the COP – Prevention of Legionnaires Disease
- Waste disposal facilities – hygienic refuse collection system, odour control measures
- Pest management – method, programme, records



10

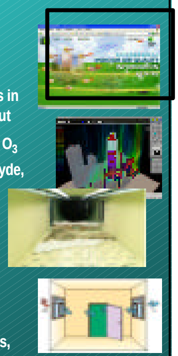
Indoor Environmental Quality

INDOOR AIR QUALITY

- Construction IAQ management – measures to maintain cleanliness of A/C equipment and fittings in construction stage, filter replacement and flush out
- Outdoor sources of air pollution – CO, NO_2, RSP, O_3
- Indoor sources of air pollution – VOCs formaldehyde, Rn
- IAQ in carpark & PTI

VENTILATION

- Ventilation rate, Air change effectiveness, Background ventilation, Uncontrolled ventilation, Localized ventilation, Ventilation in common areas, Use of Natural Ventilation



11

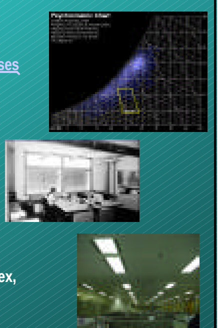
Indoor Environmental Quality

THERMAL COMFORT

- Thermal Comfort in Air-Conditioned Premises
- Thermal Comfort in Naturally Ventilated Premises

LIGHTING

- Natural lighting (daylight factor)
- Interior Lighting Quality - illuminance, illuminance variation, colour rendering index, glare index



12

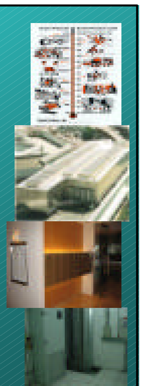
Indoor Environmental Quality

ACOUSTICS & NOISE

- Room acoustics, Noise isolation, Background noise

BUILDING AMENITIES

- Access for disability – enhanced provisions on top of regulatory requirements
- Amenity features – passive and active recreational facilities; provisions to enhance operation and maintenance
- IT provisions – provisions of serviceability measures and facilities for IT and communications



Looking at your Building, Looking for Sustainability

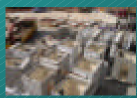
13

Innovations and Additions

- *INNOVATIVE TECHNIQUES*
- *PERFORMANCE ENHANCEMENTS*

5 Bonus Credits – encourage adoption without penalization

Proposals will be referred to HK-BEAM Steering Committee for consideration and approval



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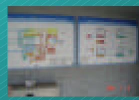
Environmental Innovations

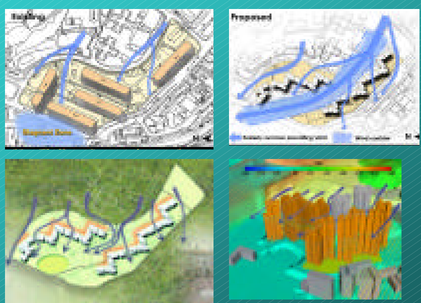
INNOVATIVE TECHNIQUES

- *Advance* practices and new techniques not yet been widely adopted in Hong Kong or even elsewhere.
- E.g. - application of advanced technology such as CFD technique, natural daylight simulation, thermal comfort calculation for integrated building design for energy efficiency



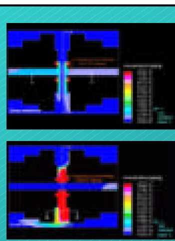
15

Case Study : Upper Ngau Tau Kok Estate Phase 2 & 3



Computational Fluid Dynamics technology is used to study the effect of wind corridor

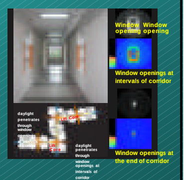
16



Natural Ventilation for Occupant's comfort and health

Cross Ventilated Re-entrants for pollutant control and Ventilation enhancement

Daylight Optimization



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Environmental Enhancements

PERFORMANCE ENHANCEMENTS -

- Strategies and techniques perform significantly better than HK-BEAM requirements (eg. energy, water and materials savings).
- E.g. Achieving Excellent rating in EPD 's IAQ Certification Scheme

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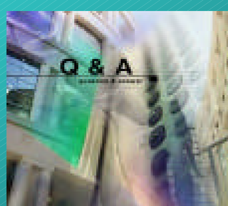
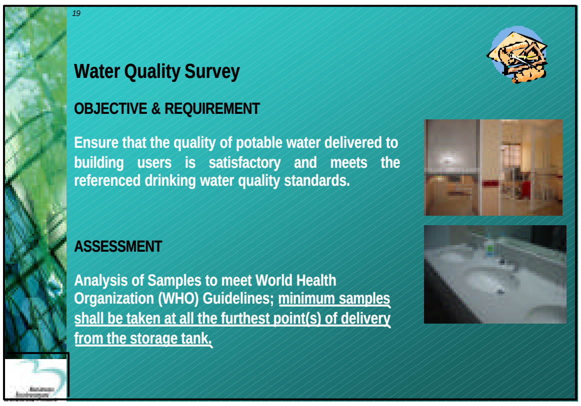
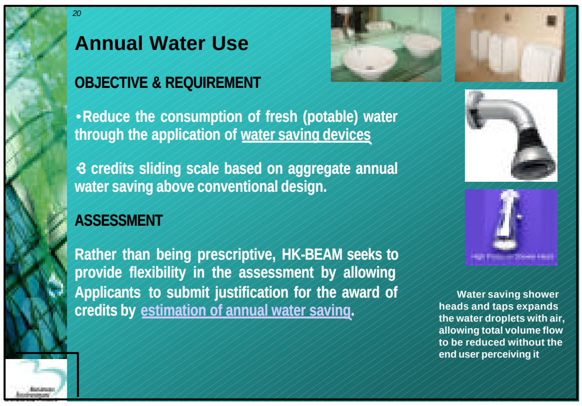
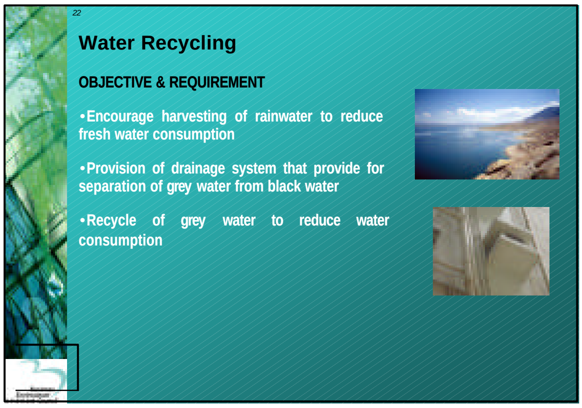



19
Water Quality Survey
OBJECTIVE & REQUIREMENT
Ensure that the quality of potable water delivered to building users is satisfactory and meets the referenced drinking water quality standards.
ASSESSMENT
Analysis of Samples to meet World Health Organization (WHO) Guidelines; minimum samples shall be taken at all the furthest point(s) of delivery from the storage tank.


20
Annual Water Use
OBJECTIVE & REQUIREMENT
•Reduce the consumption of fresh (potable) water through the application of water saving devices
•3 credits sliding scale based on aggregate annual water saving above conventional design.
ASSESSMENT
Rather than being prescriptive, HK-BEAM seeks to provide flexibility in the assessment by allowing Applicants to submit justification for the award of credits by estimation of annual water saving.
Water saving shower heads and taps expands the water droplets with air, allowing total volume flow to be reduced without the end user perceiving it


21
Case Study : Parcville Residential Complex
• Dual low flushing devices
Case Study : One Peking Commercial Premises
•Sensor controlled potable water and flushing systems


22
Water Recycling
OBJECTIVE & REQUIREMENT
•Encourage harvesting of rainwater to reduce fresh water consumption
•Provision of drainage system that provide for separation of grey water from black water
•Recycle of grey water to reduce water consumption


23
Case Study : Villa by the Park Residential Complex
•Rain water recycling system


24
Security
OBJECTIVE & REQUIREMENT
•Engender a feeling of well-being amongst building users.
•Provide sufficient security measures and facilities for the building.
ASSESSMENT
Completion of Assessment Grid CHK-043 with justification for each item; a detailed security manual explaining how the physical provisions (hardware) integrates with the management system (software) for the building.

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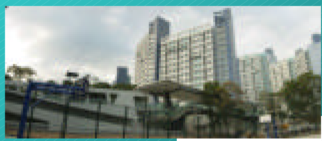
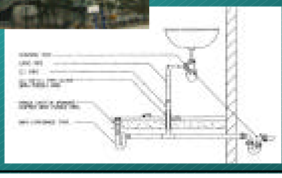
Case Study : CityU Student Hostel

Addition of running traps to secure water seal and prevent ingress of odour and bacteria





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Construction IAQ Management

OBJECTIVE & REQUIREMENT

- Ensure that building ventilation systems are not contaminated as a result of residuals left over from construction activities.
- implement a Construction IAQ Management Plan – Checklist CHK - 032
- replace all filters and flush out of air ducts prior to occupancy.

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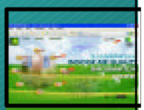
Outdoor and Indoor Sources of Air Pollution

OBJECTIVE



- Demonstrate that airborne contaminants from external and internal sources will not give rise to unacceptable levels of indoor air pollution in normally occupied spaces.
- Comply with the appropriate criteria of each parameter (CO, NO_2, O_3, RSP, VOCs, Formaldehyde and Radon).

ASSESSMENT

- Aligns with HKSAR IAQ Certification Scheme – Good Class;
- Worst Case Scenario measurement

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Worst Case Scenario measurement

For Central A/C Area (both outdoor and indoor sources)

- tests should be undertaken in representative occupied areas with air-conditioning under normal mode of operation.

For Naturally Ventilated Area

(Outdoor Sources)

- carry out tests under open window and naturally ventilated conditions in low level closets to main traffic roads.

(Indoor Sources)

- carry out tests under closed window conditions with mechanical ventilation switched off.

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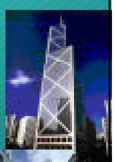
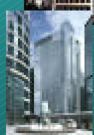
Thermal Comfort in Air-Con Premises

OBJECTIVE & REQUIREMENT





- Ensure that the air-conditioning system can provide the stated design conditions in occupied spaces under changing load conditions.
- Temperature – within ±1° C of the design value
- Room air distribution – where room air diffusers satisfy the Air Diffusion Performance Index to ensure even and effective distribution of conditioned air.

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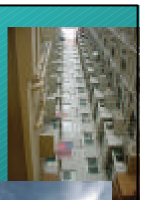
Thermal Comfort in Naturally Ventilated Premises

OBJECTIVE & REQUIREMENT



- Promote the application of measures that reduce elevated temperatures caused by external heat gains
- Encourage Use of Natural Ventilation to achieve Thermal Comfort
- If A/C units were used for certain circumstances, ensure adequate control of indoor temperature (within ±1.5° C of design value).

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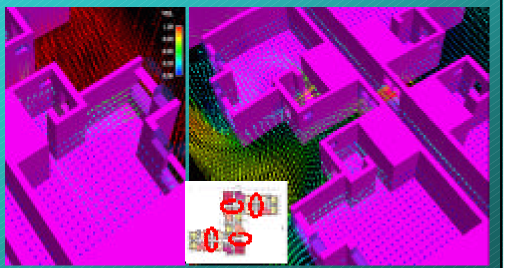
Case Study : Upper Ngau Tau Kok Estate Phase 2 & 3



• The air change rates within the flats by natural ventilation are testified by CFD

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Natural Lighting

OBJECTIVE & REQUIREMENT

•Encourage a holistic examination of site layout, building design, and fenestration design, such as to maximise access to daylight for the purposes of improved health and comfort.

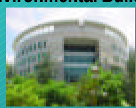
•3 credits' sliding scale for achieving different level of vertical daylight factor OR the average daylight factor (DF) for all normally occupied spaces.

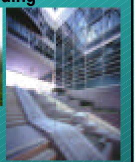
33

Case Study : Jockey Club Environmental Building

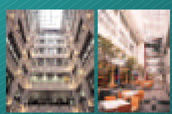
Daylight

• Skylight and glass walls installed to introduce natural light.





Case Study : Cathay Pacific City



• Natural light maximization for retails and offices

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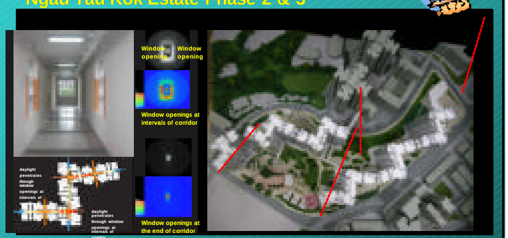
Case Study : Redevelopment of Upper Ngau Tau Kok Estate Phase 2 & 3



• Enhanced by block orientation with minimum overlooking
• Window openings at common corridors and lift lobbies improve daylight provision and hygiene condition of common areas

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Interior Lighting

OBJECTIVE & REQUIREMENT

•Ensure the adequacy and maintenance of visual comfort conditions achieved by the electric lighting provisions in occupied spaces.

•Illuminance – lighting level and illuminance variation as accordance with equivalent guildlines (e.g CIBSE)

•Lighting quality – suitable glare rating ; and light sources have an appropriate colour rendering index.

•fluorescent and other lamps with modulating (fluctuating) output are fitted with dimmable high-frequency ballasts in all work areas.

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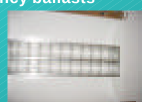
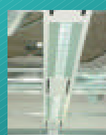
Case Study : Langham Place

• T5 fluorescent tubes with high frequency ballasts



Case Study : One Peking Commercial Premises



T5 fluorescent lamp with high frequency ballasts

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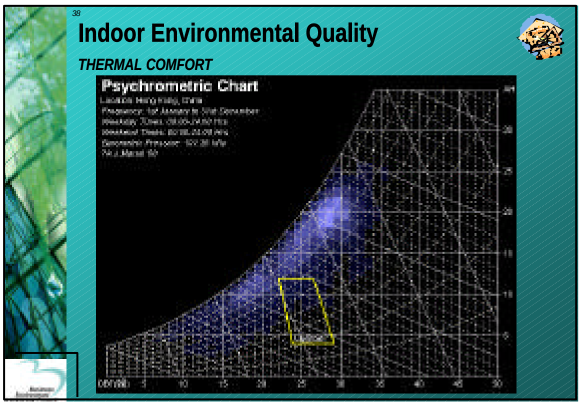
Acoustics & Noise

Example of Acoustic Calculation / Measurement for Domestic Building

Type of Noise	Objective & Requirement	Measurement Locaton
Background Noise	Maintain the background in premises within prescribed criteria (dB L_Aeq)	Worst case scenario (generally, areas nearest to the traffic road and noise source)
Noise Isolation	To improve noise isolation of normally occupied premises to reduce unwanted noise (STC)	Typical wing of domestic block
Room Acoustics	To improve speech intelligibility of rooms (reverberation time)	Typical Bedroom and Living room



BEC Seminar – 25 August 2005

Solar access and daylight availability – computer simulation and spreadsheet-based tools

Dr. CHUNG Tse Ming
Department of Building Services Engineering
Hong Kong Polytechnic University
Hong Kong, China

Meaning of solar access and daylight availability

- Narrow sense:
  - solar access is measure of exposure to sunshine
  - daylight availability is measure of exposure to diffuse skylight
- Broad sense:
  - Solar access = daylight availability = some measure of exposure to available daylight from the sun and/or sky.
- Long discussed as a consideration in urban planning, solar access is a vague quantity that does not yet have a well defined meaning - it means different things to different people.
- Consequently, the role of solar access in building design and urban planning is uncertain.

Commonly perceived notions of solar and daylight access (I)

- Overall perception of a space (internal or external).
  - "Bright, open" or "gloomy, squalid".
- Direct exposure to sunlight.
  - Can the sun be "seen", and for how long?
- Availability of daylight.
  - How "much" of the sky is visible?
- Is there a greater "view" of sky in some directions than others, e.g. to the North or South?

Commonly perceived notions of solar and daylight access (II)

- Direct exposure to sunlight (i.e. solar gain).
  - Positive aspect for domestic drying and hygiene, and even warmth in winter.
  - Negative aspect for air conditioned spaces.
  - Positive aspect for solar-powered renewable energy systems, e.g. photovoltaic panels.
- Availability of daylight (skylight only).
  - Positive aspect for non-domestic buildings.
- Availability of daylight (sunlight and skylight).
  - Positive aspect for public spaces between buildings in dense urban environments.
  - Positive aspect for domestic buildings.

Common measures of solar access and daylight availability (I)

- Shadow area on a fixed date and time, e.g. noon on 21 December – only for sunlight.
- Obstruction angles – can be used for sunlight and skylight - usually requires also a fixed date and time for sunlight.
- Possible sunshine hours – the total number of hours during the year in which the given point receives direct sunlight with a cloudless sky
  - expressed either as a number of hours or as a percentage of possible sunlight hours on unobstructed horizontal plane.

Common measures of solar access and daylight availability (II)

- Probable sunshine hours – the total number of hours during the year in which the given point receives direct sunlight with a cloudless sky
  - can be expressed as a percentage of probable sunlight hours on unobstructed horizontal plane
  - taking into account climate conditions
- Daylight factor – the ratio of the illuminance at the point on the given plane received directly or indirectly from a sky of known or assumed luminance distribution to the illuminance on a horizontal plane due to an unobstructed hemisphere of the same sky – direct sunlight excluded.
  - most widely used
  - based idealised sky condition – no consideration of climate
  - no consideration of façade orientation

New approaches

- Total annual irradiation/illumination (TAI) – a measure of all the energy from the sun and sky that is incident on surfaces over a period of a full year.
  - Equating solar access with **total annual irradiation** (and daylight availability with total annual illumination) is consistent with everyday experience where the sky and sun together interact with the urban form to create the luminous environment.
- Useful daylight illuminance (UDI) – the annual occurrence of illuminances (at a point or across the work plane) within a predefined range (100-2000 lx).
  - Can be expressed as a percentage of the working year
  - Preserves much of the interpretive simplicity of the daylight factor approach
  - Realistically derived from climatic data

Prediction tools for buildings in a dense urban context

- Computer simulation
  - using model or standard skies, e.g. the CIE standard overcast sky – daylight factors
  - using real climatic data, e.g. hourly data from test reference year (TRY) – TAI, UDI etc.
- Calculations based on established formulas modified for dense urban environments
  - average daylight factor, vertical daylight factor, probable sunlight hours
  - can be programmed for a spreadsheet

Advantages of computer simulation

- Accurate prediction of the total annual incident irradiation/illumination based on hourly data.
- Model realistic sky patterns as well as radiation from the sun.
- Account for shading of and inter-reflections between buildings.
- Scalable - no limitations on scene complexity.
- Present results as images.

Computer simulation – image approach

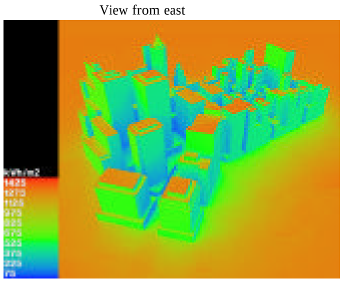
- Every image pixel (360,000 for a 600 by 600 image) represents a point in the scene where the total annual irradiation has been predicted.
- Individual point values can be read off using the display software.
- Each image therefore is equivalent to a visualisation of the annual total of hourly data collected by 360,000 irradiance pyranometers (i.e. "solar energy meters") arranged over building facades, ground, etc.

Example of computer simulation

- Software: RADIANCE
- Climate data obtained from EnergyPlus TRY for HK
- Scene model built with data obtained from digital maps etc.
- Selected part of Central District was modeled.

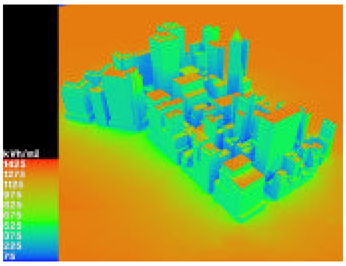
RADIANCE simulation of part of central district (I)

View from east



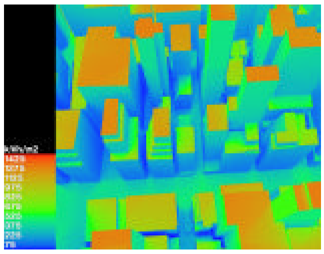
RADIANCE simulation of part of central district (II)

View from north

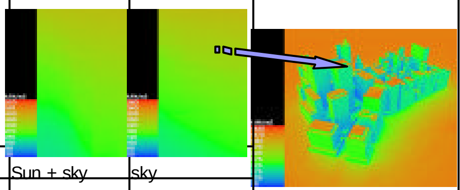


RADIANCE simulation of part of central district (III)

View from above



RADIANCE simulation – TAI values of a selected facade

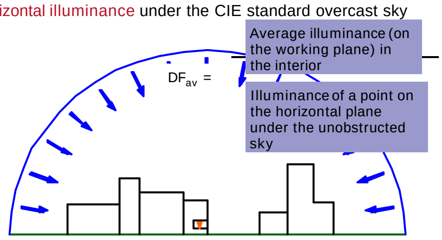


component	Sun + sky	sky
Max TAI (kWh/m²)	408.6	281.6
Min	169.5	113.9
Mean	296.6	198.6

Calculations using a spreadsheet

Average daylight factor (DF_{av})

- Ratio of average interior illuminance to exterior unobstructed horizontal illuminance under the CIE standard overcast sky

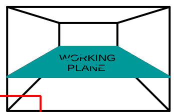


DF_{av} calculation

- Average DF on working plane

$$DF_{av} = tA_w\left(\frac{C}{A_{fw}} + \frac{Cr_{fw} + 5r_{cw}}{A(1-r)}\right)\%$$

Longmore 1975; Tregenza 1989

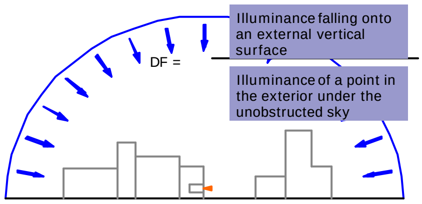


t = glazing transmittance
A_w = Window glazing ar[ea]
A_{fw} = Area of the floor ar[ea] ... window (not including window wall)
A = total area of all the interior surfaces
ρ_{fw} = Average reflectance of A_{fw}
ρ_{cw} = Average reflectance of the ceiling and upper walls above the mid-height of the window (not including window)
ρ = Average reflectance of all the interior surfaces
C = Illuminance ratio component on the vertical surface of the window due to flux incident from above the horizontal, including that reflected from obstructions.

Evaluation of C will be discussed later

Vertical daylight factor (VDF) on façade

- Ratio of illuminance falling onto an external vertical surface to (exterior) unobstructed horizontal illuminance under the CIE standard overcast sky



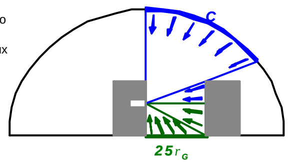
Vertical daylight factor calculation

- Vertical daylight factor VDF on window surface

$$VDF = (C + 25\, r_G)\%$$

where C is the illuminance ratio component on the vertical surface of the window due to the flux incident from above the horizontal (including that reflected from obstructions)

and $25 r_G$ is the illuminance ratio component on the vertical surface of the window due to flux reflected from the ground and parts of the obstructions below the horizontal



Evaluation of illuminance ratio C for DF_{av} and VDF calculation

$$C = \frac{9}{7p} f \left(1 + \frac{r_B g}{p(1 - r_o)}\right) \times 100\%$$

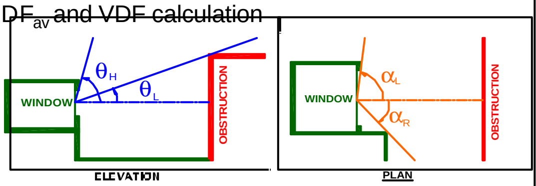
where

$$f = \frac{1}{3}(\sin a_L + \sin a_R)\left(\frac{q_H - q_L}{2} + \frac{\sin 2q_H - \sin 2q_L}{4} - \frac{2\cos^3 q_H - 2\cos^3 q_L}{3}\right)$$

$$g = \frac{p}{2} - (\sin a_L + \sin a_R)\left(\frac{q_H - q_L}{2} + \frac{\sin 2q_H - \sin 2q_L}{4}\right)$$

$$r_o = \frac{r_B + r_G}{4}$$

Evaluation of illuminance ratio C for DF_{av} and VDF calculation

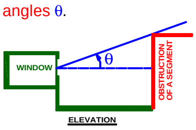


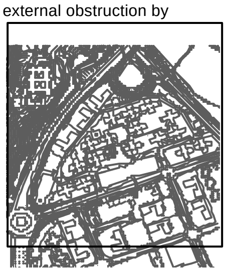
$$f = \frac{1}{3}(\sin a_L + \sin a_R)\left(\frac{q_H - q_L}{2} + \frac{\sin 2q_H - \sin 2q_L}{4} - \frac{2\cos^3 q_H - 2\cos^3 q_L}{3}\right)$$

$$g = \frac{p}{2} - (\sin a_L + \sin a_R)\left(\frac{q_H - q_L}{2} + \frac{\sin 2q_H - \sin 2q_L}{4}\right)$$

DF_{av} and VDF calculation in heavily obstructed scenes

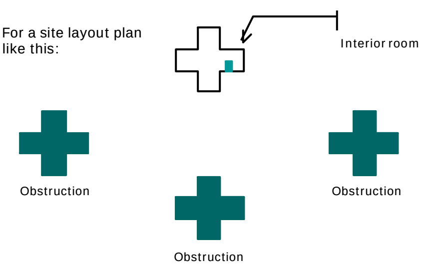
- For a high-rise building environment like that in Hong Kong, it is difficult to quantify the external obstruction by one set of obstruction angles
- Therefore, the external view is divided into 36 segments azimuthally, i.e. 5° each.
- The obstruction is then quantified by 36 obstruction angles θ.





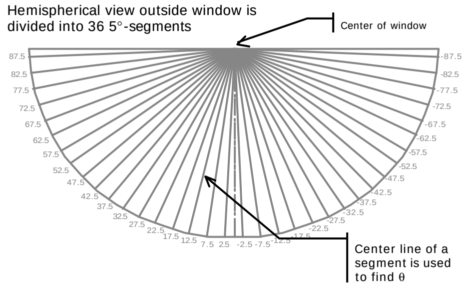
DF_{av} and VDF calculation in heavily obstructed scenes

For a site layout plan like this:



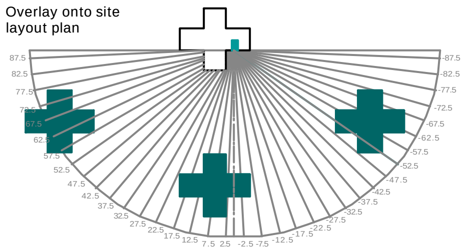
DF_{av} and VDF calculation in heavily obstructed scenes

Hemispherical view outside window is divided into 36 5°-segments



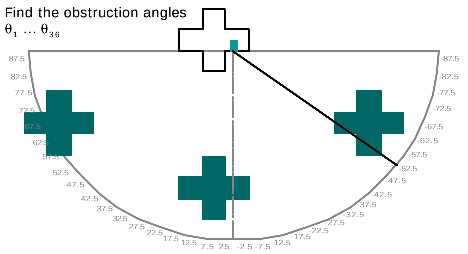
DF_{av} and VDF calculation in heavily obstructed scenes

Overlay onto site layout plan



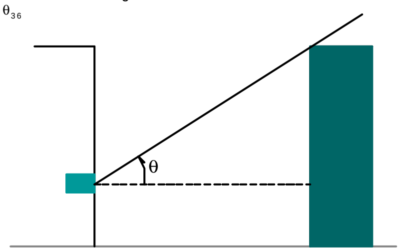
DF_{av} and VDF calculation in heavily obstructed scenes

Find the obstruction angles $\theta_1 \ldots \theta_{36}$



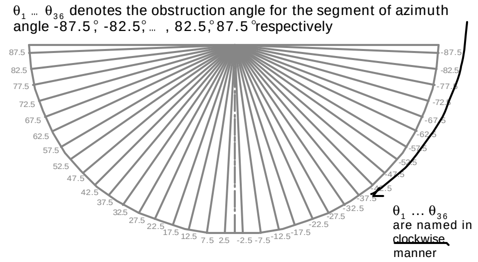
DF_{av} and VDF calculation in heavily obstructed scenes

Find the obstruction angles $\theta_1 \ldots \theta_{36}$



DF_{av} and VDF calculation in heavily obstructed scenes

$\theta_1 \ldots \theta_{36}$ denotes the obstruction angle for the segment of azimuth angle -87.5°, -82.5°, … , 82.5°, 87.5° respectively



DF_{av} and VDF calculation spreadsheet

Input parameters

1. Interior room dimensions

H = room height
W = room width
L = room length
H_{win} = window height
W_{win} = window width
H_{sill} = window sill height

2. Interior surfaces reflectances and window transmittance

ρ_c = ceiling reflectance
ρ_w = wall reflectance
ρ_f = floor reflectance
t = window transmittance

3. External shadings and obstructions:

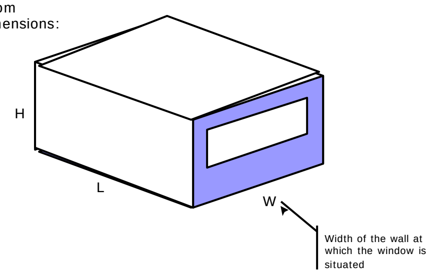
S_x = overhang depth
S_y = side fins depth
$\theta_1 \ldots \theta_{36}$ = obstruction angles
ρ_B = obstruction reflectance
ρ_G = ground reflectance

Output values:

DF = average daylight factor on working plane
VDF = vertical daylight factor on center of window
and others ….

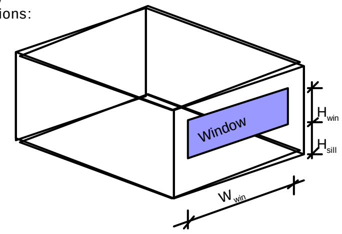
1. Interior room

Room dimensions:



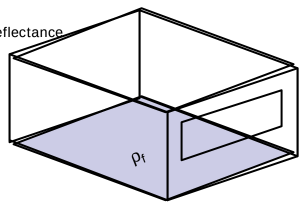
1. Interior room

Window dimensions:



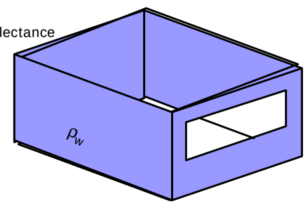
2. Interior surfaces

ρ_f =
Floor reflectance



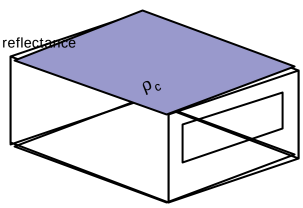
2. Interior surfaces

ρ_w =
Wall reflectance



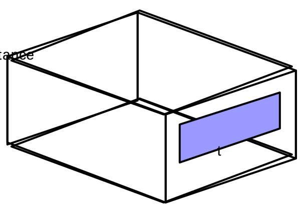
2. Interior surfaces

ρ_c =
Ceiling reflectance

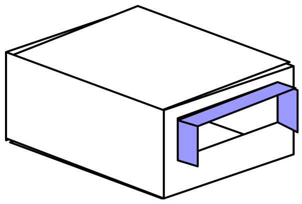


2. Interior surfaces

t =
Window transmittance

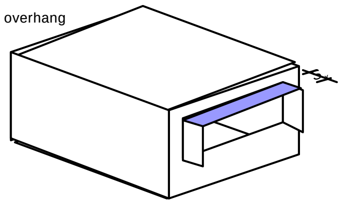


3a.External shadings



3a.External shadings

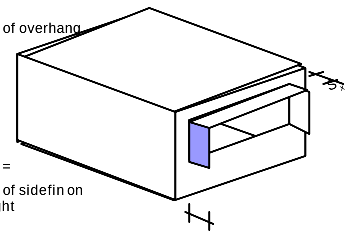
Sx = Depth of overhang



3a.External shadings

Sx = Depth of overhang

Sy,right = Depth of sidefin on the right

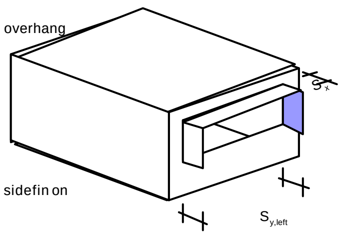


3a.External shadings

Sx = Depth of overhang

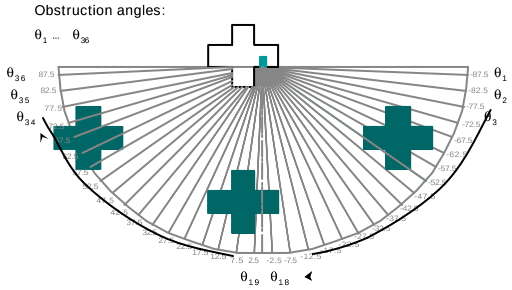
Sy,right = Depth of sidefin on the right

Sy,left = Depth of sidefin on the left

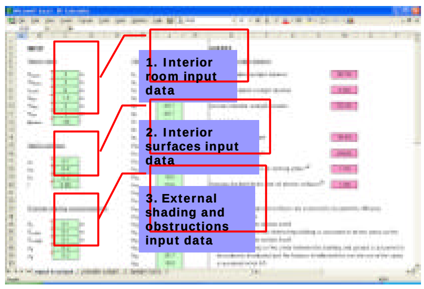


3b. External obstructions

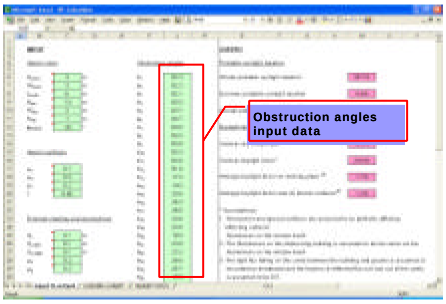
Obstruction angles: θ_1 … θ_{36}



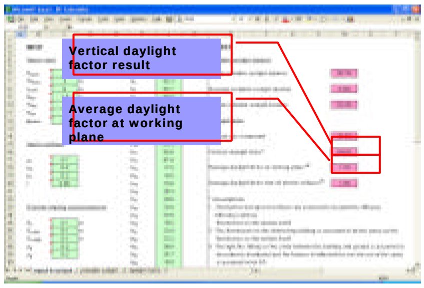
DF_{av} and VDF calculation spreadsheet



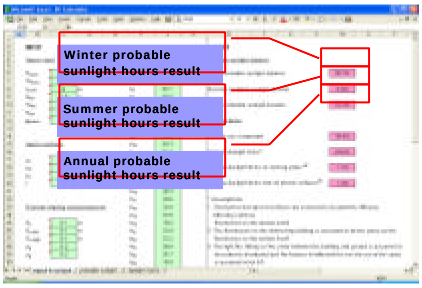
Calculation spreadsheet



Calculation spreadsheet

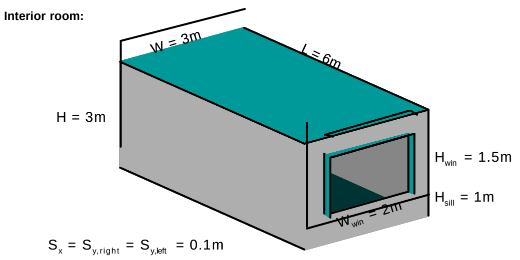


Calculation spreadsheet

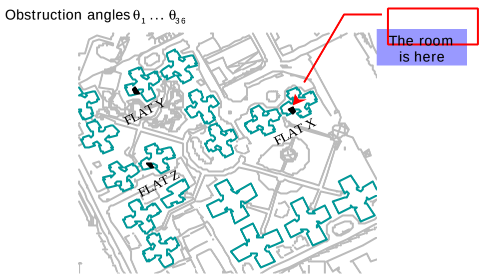


Case study example 1

Case study example 1

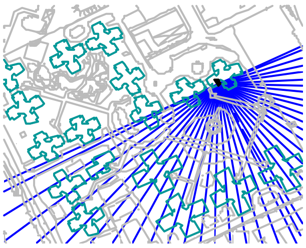


Case study example 1



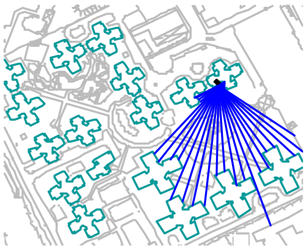
Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$



Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$



Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$

- $\theta_1 \ldots \theta_{36}$ could be calculated by the following equation:
  $\theta = \tan^{-1}(h/d)$
  where h is the height of the obstructions above the window center (h = 50m in this case) and d is its horizontal distance to that obstruction along the azimuth angle plane
- The obstruction angles are named in clockwise manner.
- $\theta = 0$ if no obstruction is encountered in that segment

θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9
82.34	82.27	82.15	82.05	83.68	84.72	84.54	84.21	83.79

θ_{10}	θ_{11}	θ_{12}	θ_{13}	θ_{14}	θ_{15}	θ_{16}	θ_{17}	θ_{18}
83.26	82.56	81.64	16.96	14.04	23.55	28.25	28.57	24.41

θ_{19}	θ_{20}	θ_{21}	θ_{22}	θ_{23}	θ_{24}	θ_{25}	θ_{26}	θ_{27}
24.37	9.98	23.80	23.17	26.64	25.66	19.53	19.52	19.58

θ_{28}	θ_{29}	θ_{30}	θ_{31}	θ_{32}	θ_{33}	θ_{34}	θ_{35}	θ_{36}
19.41	27.25	26.55	24.79	25.64	60.82	61.32	61.64	59.43

Case study example 1

Calculation input parameters

1. Interior room:

H	= 3m	H_{win}	= 1.5m
W	= 3m	W_{win}	= 2m
L	= 6m	H_{sill}	= 1m

2. Interior surfaces:

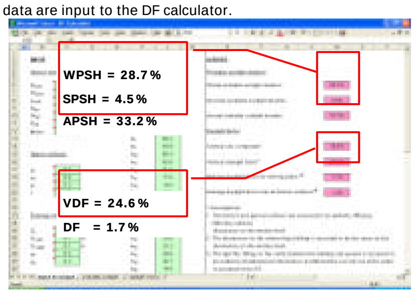
ρ_c	= 0.7	ρ_f	= 0.2
ρ_w	= 0.5	t	= 0.85

3. External shadings and obstructions:

S_x	= 0.1m	ρ_B	= 0.2
$S_{y,left}$	= 0.1m	ρ_G	= 0.2
$S_{y,right}$	= 0.1m		

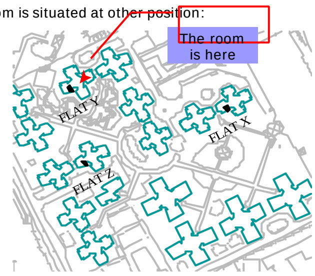
Case study example 1

All data are input to the DF calculator.



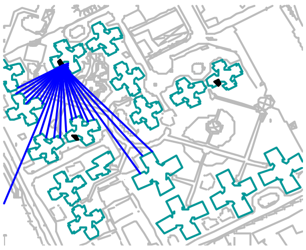
Case study example 1

If the room is situated at other position:



Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$



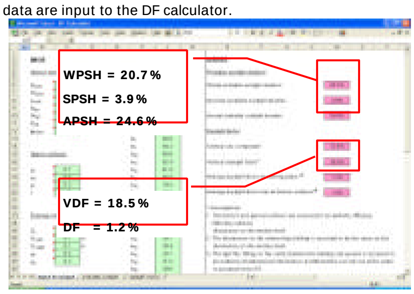
Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$

θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9
82.67	82.61	82.48	82.30	83.05	84.20	84.92	84.58	84.15
θ_{10}	θ_{11}	θ_{12}	θ_{13}	θ_{14}	θ_{15}	θ_{16}	θ_{17}	θ_{18}
83.60	82.87	81.89	80.52	78.48	20.00	20.39	18.53	34.93
θ_{19}	θ_{20}	θ_{21}	θ_{22}	θ_{23}	θ_{24}	θ_{25}	θ_{26}	θ_{27}
35.43	38.38	39.10	38.43	33.11	31.04	30.77	30.56	31.13
θ_{28}	θ_{29}	θ_{30}	θ_{31}	θ_{32}	θ_{33}	θ_{34}	θ_{35}	θ_{36}
0.00	46.30	47.95	47.61	41.10	42.88	43.55	40.28	42.75

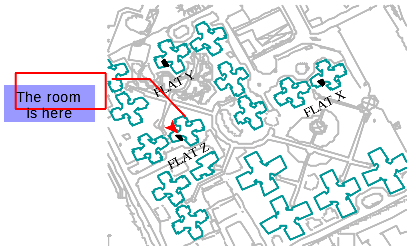
Case study example 1

All data are input to the DF calculator.



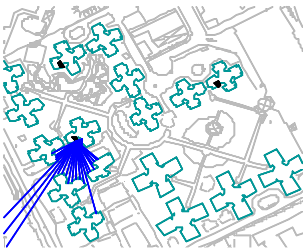
Case study example 1

If the room is situated at other position:



Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$



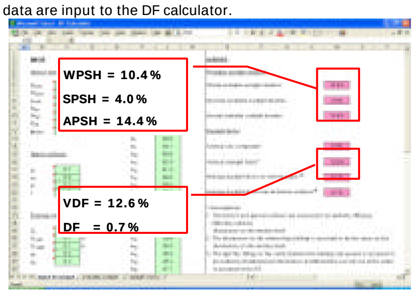
Case study example 1

Obstruction angles $\theta_1 \ldots \theta_{36}$

θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9
82.67	82.60	82.47	82.28	83.14	84.25	84.88	84.55	84.13
θ_{10}	θ_{11}	θ_{12}	θ_{13}	θ_{14}	θ_{15}	θ_{16}	θ_{17}	θ_{18}
83.59	82.88	81.92	80.58	59.00	59.75	60.28	59.31	53.51
θ_{19}	θ_{20}	θ_{21}	θ_{22}	θ_{23}	θ_{24}	θ_{25}	θ_{26}	θ_{27}
53.46	53.20	30.84	45.92	49.37	49.22	47.70	45.50	50.43
θ_{28}	θ_{29}	θ_{30}	θ_{31}	θ_{32}	θ_{33}	θ_{34}	θ_{35}	θ_{36}
51.39	50.01	0.00	0.00	0.00	59.38	61.09	61.46	59.35

Case study example 1

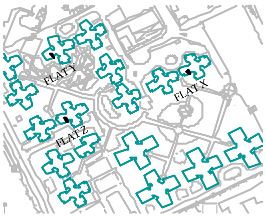
All data are input to the DF calculator.



Case study example 2

Case study example 2

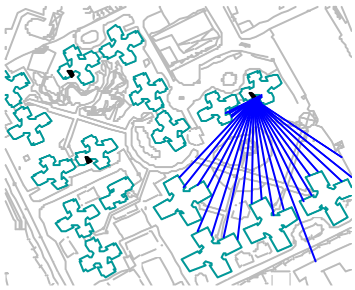
- In this example, the calculation spreadsheet is used to evaluate the daylighting performance of the flats from **1/F to 40/F**.
- The locations of the flats (**Flat X**, **Flat Y** and **Flat Z**) are shown in this figure.
- The room's dimensions and surface characteristics are the same as in example 1.
- The three flats face the same direction.



- The obstruction angles $\theta_1 \dots \theta_{36}$ are calculated by measuring the horizontal distance from the window center to the obstruction along the azimuth angle plane and the height of the obstructions above the window center.

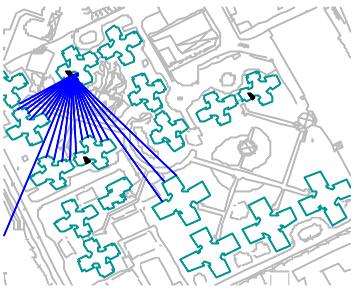
Case study example 2

- For Flat X:



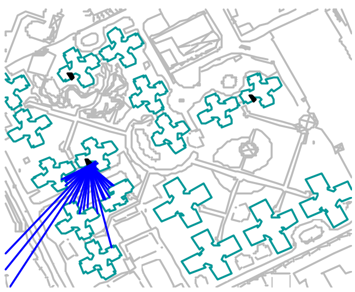
Case study example 2

- For Flat Y:



Case study example 2

- For Flat Z:



Case study example 2

- The obstruction angles for the flats from 1/F to 40/F can be calculated by the following equations:

$$q = \tan^{-1} \frac{H - (n-1) \times H_r}{d}$$

- H is the height of the obstruction above the window center for flats at 1/F (H = 100m in this example)
- H_r is the floor to floor height of the flats (H_r = 2.5m in this example)
- d is the horizontal distance from the window center to the obstruction along the azimuth angle plane
- n is the floor number, i.e. n = 1 for 1/F
- Then a set of obstruction angles can be calculated for every flat from 1/F to 40/F

Case study example 2

- The obstruction angles for the flats from 1/F to 40/F can be calculated by the following equations:

$$q = \tan^{-1} \frac{H - (n-1) \times H_r}{d}$$

φ	d	H	Obstruction angle θ																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
-87.5	6.7235	100	86	86	86	86	86	86	85	85	85	85	85	85	85	84	84	84	84	83	83	83
-82.5	6.7826	100	86	86	86	86	86	86	85	85	85	85	85	85	84	84	84	84	84	83	83	83
-77.5	6.8958	100	86	86	86	86	86	85	85	85	85	85	85	85	84	84	84	84	83	83	83	83
-72.5	6.9854	100	86	86	86	86	86	85	85	85	85	85	85	84	84	84	84	84	83	83	83	82
-67.5	5.5404	100	87	87	87	87	86	86	86	86	86	86	86	86	85	85	85	85	85	84	84	84
-62.5	4.6199	100	87	87	87	87	87	87	87	87	87	87	86	86	86	86	86	86	86	85	85	85
-57.5	4.7827	100	87	87	87	87	87	87	87	87	87	86	86	86	86	86	86	86	85	85	85	85
-52.5	5.0693	100	87	87	87	87	87	87	87	86	86	86	86	86	86	86	86	85	85	85	85	84
-47.5	5.4365	100	87	87	87	87	87	86	86	86	86	86	86	86	86	85	85	85	85	85	84	84
-42.5	5.9095	100	87	87	86	86	86	86	86	86	86	86	85	85	85	85	85	85	84	84	84	84
-37.5	6.5270	100	86	86	86	86	86	86	86	85	85	85	85	85	85	84	84	84	84	84	83	83
-32.5	7.3511	100	86	86	86	85	85	85	85	85	85	85	84	84	84	84	84	83	83	83	82	82
-27.5	98.3710	30	17	16	14	13	11	10	9	7	6	4	3	1	0	0	0	0	0	0	0	0
-22.5	119.9304	30	14	13	12	11	9	8	7	6	5	4	2	1	0	0	0	0	0	0	0	0
-17.5	114.7046	100	41	40	40	39	38	37	37	36	35	34	33	32	31	30	30	29	28	27	26	25
-12.5	93.0496	100	47	46	46	45	44	43	42	42	41	40	39	38	37	36	35	34	33	32	31	29
-7.5	91.8266	100	47	47	46	45	44	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30
-2.5	110.1802	100	42	42	41	40	39	38	38	37	36	35	34	33	32	31	31	30	29	28	27	25
25	110.4032	100	42	41	41	40	39	38	38	37	36	35	34	33	32	31	30	30	29	28	26	25
75	170.5682	30	10	9	8	8	7	6	5	4	3	3	2	1	0	0	0	0	0	0	0	0
12.5	113.3449	100	41	41	40	39	38	38	37	36	35	34	33	33	32	31	30	29	28	27	26	25
17.5	116.8391	100	41	40	39	38	38	37	36	35	34	34	33	32	31	30	29	28	27	26	25	24
22.5	99.6819	100	45	44	44	43	42	41	40	40	39	38	37	36	35	34	33	32	31	30	29	28
27.5	104.0810	100	44	43	42	42	41	40	39	38	38	37	36	35	34	33	32	31	30	29	28	27
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
37.5	141.0608	100	35	35	34	33	33	32	31	30	30	29	28	27	26	26	25	24	23	22	21	20
42.5	140.5401	100	35	35	34	33	33	32	31	30	30	29	28	27	26	26	25	24	23	22	21	20
47.5	141.9324	100	35	34	34	33	32	32	31	30	29	29	28	27	26	25	25	24	23	22	21	20
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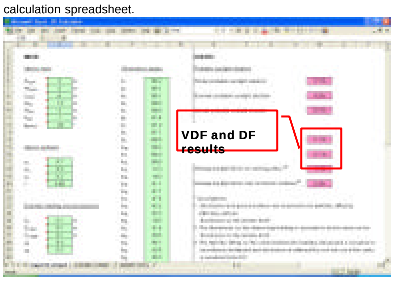
57.5	100.0575	100	45	44	44	43	42	41	40	40	39	38	37	36	35	34	33	32	31	30	29	28
62.5	108.2576	100	43	42	41	41	40	39	38	37	36	36	35	34	33	32	31	30	29	28	27	26
67.5	104.1694	100	44	43	42	42	41	40	39	38	38	37	36	35	34	33	32	31	30	29	28	27
72.5	27.9261	100	74	74	74	73	73	72	72	71	71	70	70	69	68	68	67	66	65	64	63	62
77.5	27.3467	100	75	74	74	74	73	73	72	72	71	71	70	69	69	68	67	66	65	65	64	62
82.5	26.9922	100	75	75	74	74	73	73	72	72	71	71	70	70	69	68	67	67	66	65	64	63
87.5	29.5306	100	74	73	73	72	72	71	71	70	70	69	69	68	67	66	66	65	64	63	62	61

φ	Obstruction angle θ (continued)																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
-87.5	82	82	82	81	80	80	79	78	77	76	75	73	71	69	66	62	56	48	37	20
-82.5	82	82	81	81	80	80	79	78	77	76	75	73	71	69	66	62	56	48	36	20
-77.5	82	82	81	81	80	80	79	78	77	76	75	73	71	68	65	61	55	47	36	20
-72.5	82	82	81	81	80	79	79	78	77	76	74	73	71	68	65	61	55	47	36	20
-67.5	84	83	83	83	82	82	81	80	80	79	78	76	75	72	70	66	61	54	42	24
-62.5	85	84	84	84	83	83	82	82	81	80	80	78	77	75	73	70	65	58	47	28
-57.5	85	84	84	84	83	83	82	82	81	80	79	78	77	75	72	69	64	57	46	28
-52.5	84	84	84	83	83	82	82	81	80	80	79	77	76	74	71	68	63	56	45	26
-47.5	84	83	83	83	82	82	81	81	80	79	78	76	75	73	70	66	61	54	43	25
-42.5	83	83	83	82	82	81	80	80	79	78	77	75	74	71	68	65	59	52	40	23
-37.5	83	82	82	81	81	80	79	79	78	77	75	74	72	70	66	62	57	49	37	21
-32.5	82	81	81	80	80	79	78	77	76	75	74	72	70	67	64	60	54	46	34	19
-27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-22.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-17.5	24	22	21	20	19	18	17	16	15	13	12	11	10	9	7	6	5	4	2	1
-12.5	28	27	26	25	23	22	21	19	18	16	15	14	12	11	9	8	6	5	3	2
-7.5	29	27	26	25	24	22	21	19	18	17	15	14	12	11	9	8	6	5	3	2
-2.5	24	23	22	21	20	19	18	16	15	14	13	12	10	9	8	6	5	4	3	1
25	24	23	22	21	20	19	18	16	15	14	13	12	10	9	8	6	5	4	3	1
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	24	23	22	21	19	18	17	16	15	14	12	11	10	9	8	6	5	4	3	1
17.5	23	22	21	20	19	18	17	16	14	13	12	11	10	9	7	6	5	4	2	1
22.5	27	25	24	23	22	21	19	18	17	15	14	13	11	10	9	7	6	4	3	1
27.5	26	25	23	22	21	20	19	17	16	15	14	12	11	10	8	7	5	4	3	1
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
37.5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
42.5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
47.5	19	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
52.5	27	26	25	24	22	21	20	19	17	16	14	13	12	10	9	7	6	4	3	1
57.5	27	25	24	23	22	21	19	18	17	15	14	13	11	10	9	7	6	4	3	1
62.5	25	24	23	21	20	19	18	17	15	14	13	12	10	9	8	7	5	4	3	1
67.5	26	25	23	22	21	20	19	17	16	15	13	12	11	10	8	7	5	4	3	1
72.5	61	60	58	57	55	53	51	49	47	45	42	39	36	32	28	24	20	15	10	5
77.5	61	60	59	57	56	54	52	50	48	45	42	39	36	33	29	25	20	15	10	5
82.5	62	60	59	58	56	54	52	50	48	46	43	40	37	33	29	25	20	16	10	5
87.5	59	58	57	55	54	52	50	48	45	43	40	37	34	31	27	23	19	14	10	5

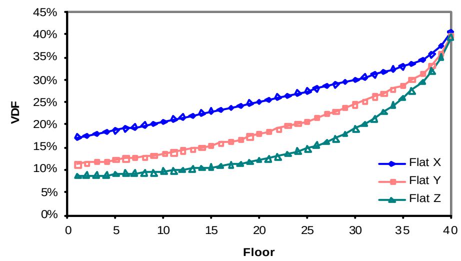
Case study example 2

- All the input parameters, including the set of obstruction angles, are input to the calculation spreadsheet.



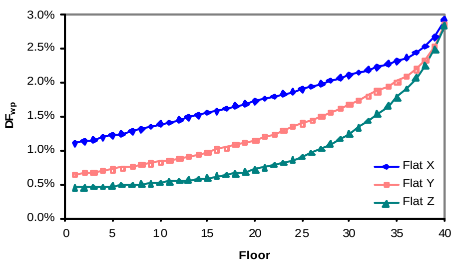
Case study example 2

- The vertical daylight factor results:



Case study example 2

- The average daylight factor results:



Case study example 3

Case study example 3

- In example 2, the VDF and DF values of the flats from 1/F to 40/F are evaluated.
- The depths of the overhang and sidefins are equal to 0.1m.
- In this example, two cases are studied.

  Case 1:

  S_x = 0.3m

  $S_{y,left}$ = 0.3m

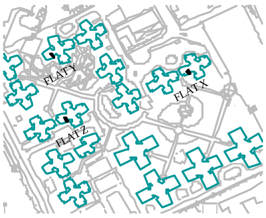
  $S_{y,right}$ =0.3m

  Case 2:

  S_x = 0.5m

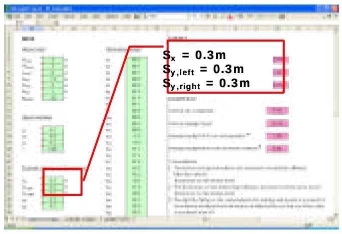
  $S_{y,left}$ = 0.5m

  $S_{y,right}$ =0.5m



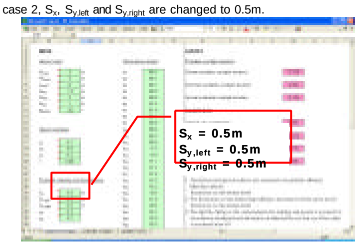
Case study example 3

- The same set of obstruction angles for the corresponding floor and flat is input to the spreadsheet.
- For case 1, S_x, $S_{y,left}$ and $S_{y,right}$ are changed to 0.3m.



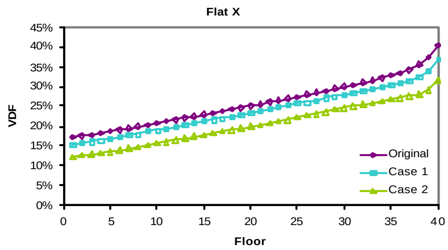
Case study example 3

- The same set of obstruction angles for the corresponding floor and flat is input to the spreadsheet.
- For case 1, S_x, $S_{y,left}$ and $S_{y,right}$ are changed to 0.3m.
- For case 2, S_x, $S_{y,left}$ and $S_{y,right}$ are changed to 0.5m.



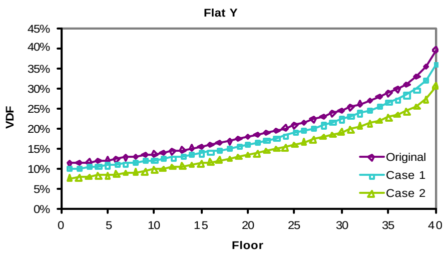
Case study example 3

- Vertical daylight factor results:



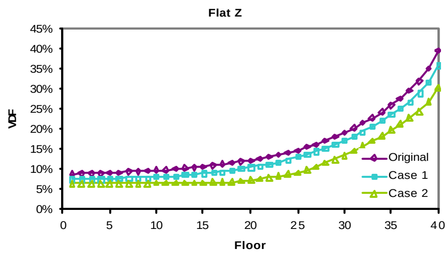
Case study example 3

- Vertical daylight factor results:



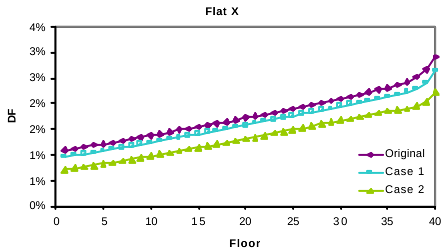
Case study example 3

- Vertical daylight factor results:



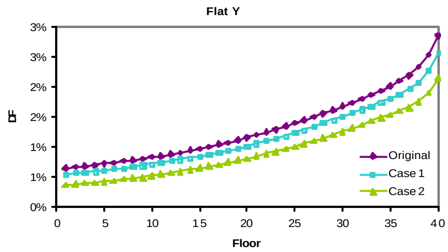
Case study example 3

- Daylight factor results:



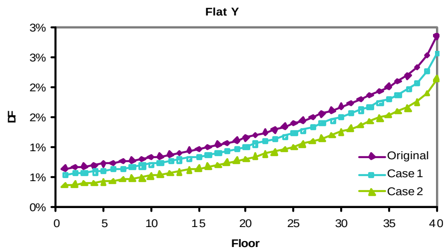
Case study example 3

- Daylight factor results:



Case study example 3

- Daylight factor results:



Thank you

Assessing energy use by energy budget approach

WL Lee

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1

Background

- the latest versions of HK-BEAM (4/04 & 5/04) adopt the energy budget approach for energy assessment;
- unlike the building energy codes, HK-BEAM is an environmental assessment scheme which rates performance by overall grade;
- the default data to be assumed for the baseline building and the factors to include in determining the levels of performance of the assessed building should be carefully considered; and
- the assessment tools should be carefully selected.

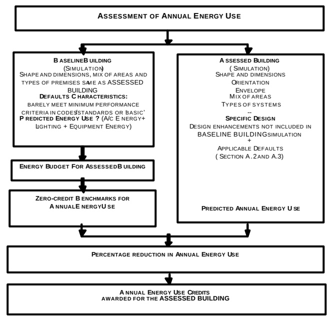
2

PART I

Energy Budget Approach

3

Assessment Framework



4

Key Features

- the 'Energy Budget' for an ASSESSED BUILDING is the predicted Annual Energy Use for a BASELINE BUILDING (zero-credit benchmark);
- the BASELINE BUILDING model has the same shape and dimensions, comprises the same mix of areas and types of premises as the ASSESSED BUILDING (except for window-to-wall ratio adjustment to meet the relevant regulatory requirement);

5

Key Features

- the BASELINE BUILDING model will incorporate a range of standard (default) characteristics such that the model represents a building whose energy performance barely meets the relevant regulatory requirements or meets only 'basic' design quality ;
- as far as possible the predicted Annual Energy Use of the ASSESSED BUILDING will be based on its specific design characteristics ; and

6

Key Features

- the number of credits awarded is determined by the percentage reduction in the predicted Annual Energy Use of the ASSESSED BUILDING relative to the BASELINE BUILDING.

7

Key Features

- Predicted Annual Energy Use of Baseline Building, E_b
  - Default design parameters + Regulatory Requirements + default occupation pattern
- Predicted Annual Energy Use of Assessed Building, E_a
  - Design Values + default occupation pattern

8

Percentage Reduction in Energy Use

$$E_h = \frac{E_a - E_b}{E_b} \times 100\%$$

→ **annual energy use credits**

9

PART II

Commercial Buildings Assessment

10

Assessed Buildings

- Joint User Building, Kennedy Town
- Cathay Pacific Headquarters Building
- Lee Gardens Commercial Complex
- Landmark East Redevelopment

11

Assessment Criteria

12

Assessment Tool - Requirements

- can model all the air-conditioning systems that are commonly used in Hong Kong;
- building layout, fabric construction, daily activities of the occupants, operation characteristics of the air-conditioning system, different design parameters, etc. can be precisely modeled.

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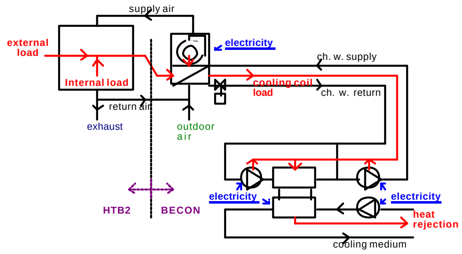
HTB2 and BECON [2]



- HTB2 – to predict the annual cooling profile by finite difference method
- BECON – to simulate energy consumption of different A/C system

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Range of Systems Models in BECON

Air side system	Heat rejection systems for central chiller plants	Chilled water pumping systems
– CAV or fan coil systems – VAV system with inlet guide vane or variable speed control – Dual conduit (CAV/VAV) system with inlet guide vane or variable fan speed control	– Direct air-cooled – water cooled with fresh water cooling towers – Direct or indirect seawater cooled, with or without cooling towers	– Single-loop chilled water pumping system – Two-loop chiller water pumping system, all constant speed pumps or variable speed secondary-loop pumps

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Baseline Building

- Default Design Parameters [3]

Design Data	Office	Retail	Restaurant
Summer Indoor temperature (°C)	23	22	22
Relative Hum. (%)	50	50	50
Lighting Load (W/m²)	25	70	35
Small Power Load (W/m²)	25	30	55
Occupancy at conditioned space (m²/person)	9	4.5	2.5
Ventilation Rate (l/s/person)	10	7	7

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Baseline Building

- Building Characteristics [4]

Building Characteristics		A	B	C	D		
					Office	Retail	Restaurant
Total A/C Area (m²)		5844.1	48527	66273	10613	2683	2192
Window to Wall Ratio		0.93 (N) 0.73 (E) 0.6 (S)	0.92	0.54	0.5	0.98	0.98
OTTV (W/m²)	Tower	30	29.5	29.5	30		
	Podium	--	--	--	70		
Shading Coefficient		0.74	0.27	0.36	0.27		

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Baseline Building

- Air-conditioning system [5]

Air Conditioning System		
Chiller Capacity (kW)		As designed
COP for air-cooled		2.7
COP for water-cooled		5.4
Heat Rejection System		As designed
Air & water side Systems		As designed
Rated Fan Power (W/L/s)	For CAV	1.6
	For VAV	2.1

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Assessed Buildings

- Design Parameters

Design Data	A	B	C	D Office	D Retail	D Restaurant
Set-pt Indoor temperature (°C)	23	24.5	24.5	24.5	22	22
Relative Hum. (%)	50	50	50	55	50	50
Lighting Load (W/m²)	25	10.7	25	25	70	35
Small Power Load (W/m²)	25	25	25	25	30	55
Occupancy at conditioned space (m²/person)	9	9	9	9	4.5	2.5
Ventilation Rate (l/s/person)	10	9	10	10	7	7

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Assessed Buildings

- Building Characteristics

Building Data	A	B	C	D Office	D Retail	D Restaurant
Total A/C Area (m²)	5844.1	48527	66273	10613	2683	2192
Window-to Wall Ratio	0.49 (N) 0.39 (E) 0.32 (S)	0.46	0.48	0.76	0.57	0.57
OTTV (W/m²) Tower	16.5	15.9	26.2		45.7	
Podium	--	--	--		33	
Shading Coefficient	0.74	0.27	0.36		0.27	

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Assessed Buildings

- Air-conditioning System

Air Conditioning System		A	B	C	D Office	D Retail	D Restaurant
Heat Rejection System		Air-cooled	Water-cooled	Air-cooled	Air-cooled/ Water-cooled	Water-cooled	Water-cooled
COP		2.7	5.8	2.9-3.1	2.8 / 4	4	4
Rated Fan Power (W/L/s)	CAV	--	--	--	--	1.6	2.6
	VAV	2.1	1.8	1.5	2.1	--	--

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Output from BECON

```
BUILDING ENERGY CONSUMPTION ESTIMATION
PROGRAM: BECON V1.1 (1/97)
DEPT OF BUILDING SERVICES ENGINEERING
THE HONG KONG POLYTECHNIC UNIVERSITY

A/C POWER CONSUMPTION ESTIMATION FOR:
------------------------------------
Building A
------------------------------------

YEAR ROUND TOTAL POWER CONSUMPTION:
BY AHU AND FAU FANS     =  .99029E+05
BY CHILLERS             =  .48522E+06
BY P.L.CH.W. PUMPS      =  .35528E+05
BY S.L.CH.W. PUMPS      =  .58150E+05
BY C.W. PUMPS           =  .00000E+00
BY S.W. PUMPS           =  .00000E+00
BY COOLING TOWERS       =  .00000E+00

BY THE WHOLE A.C. SYSTEM =  .67793E+06  kWh

PEAK BUILDING A/C POWER CONSUMPTION:  .40722E+03 kW
OCCURING ON DATE (DDMM) 1408 AT HOUR 12:00

TOTAL A/C OPERATING HOURS =  3484
```

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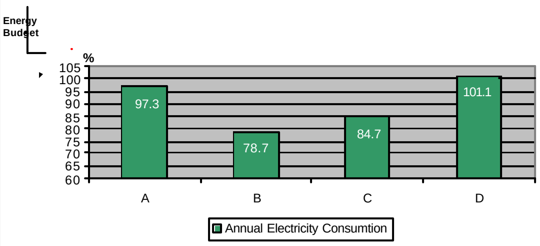
Simulation Results



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Simulation Results

- Observations [6]

	A	B	C	D
E_h (%)	2.7	21.3	15.3	-1.1
Indoor set-pt temperature	–	v	v	–
COP	–	v	v	–
Rated Fan Power	–	v	v	x
Lighting Power Density	–	v	–	–
OTTV	v	v	v	x

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PART III

Residential buildings Assessment

25

Assessed Buildings

- 33 Ka Wai Man Rd Residential Development
- TWTL 398 (Tsuen Wan) Residential Development

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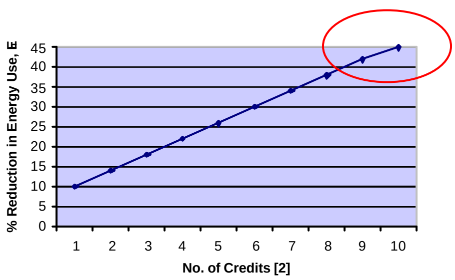
Assessment Criteria



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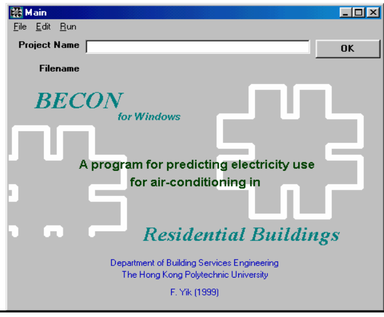
Assessment Tool – HTB2+BECRES



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Key Features of BECRES

- an air-conditioning energy consumption prediction program for residential buildings
- can model the use of split-type and window air-conditioning units
- can model multiple indoor units
- daily operation characteristics of the air-conditioning system, different design parameters, etc. can be precisely modeled.

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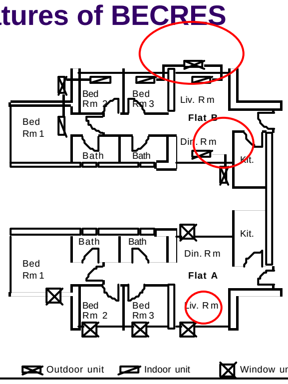
Key Features of BECRES



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Baseline Building

- Design Parameters

Design Data	
Summer Indoor temperature (ºC)	22
Relative Hum. (%)	50
Living Room Lighting Load (W/m²)	14
Bedroom Lighting Load (W/m²)	17
Equipment Load (W/m²)	142
Occupancy (person/room)	2
Ventilation Rate (ach⁻¹)	0.5

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Baseline Building

- Building Characteristics

Building Characteristics	
Window to Wall Ratio	0.65
Major Orientation	West Facing
Shading Coefficient	0.65
Infiltration Rate (ach⁻¹)	3 (non A/C); 12 (Indoor Temp < 22 ℃ & non A/C)

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Baseline Building

- Air-conditioning System [4]

Air-conditioning System		
Type	Split-unit	Window -unit
COP of Equipment	2.2	2.2

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Assessed Buildings

- Building Characteristics

Building Characteristics	A	B		
		Tower 1	Tower 2	Tower 3
Window-to Wall Ratio	0.62	0.63		
Shading Coefficient	0.74	0.65		
Major Orientations	NW / SE	SW/ N	SE / W	SE / NW

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Assessed Buildings

- Air-conditioning System

Air Conditioning System	A	B		
		Tower 1	Tower 2	Tower 3
Type	Split-Type	Split-Type		
COP	2.44 to 2.9	2.5		

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Output from BECRES

Summary of Simulation Results for Project: Building B TOWER 1

Flat	Pk CL (kW)	Pk Time	Pk Power	Pk Time	AEC (kWh)
57AT1	10.42141	7/ 7/ 14	10.7892	7/ 7/ 14	25083.63
57BT1	6.725872	8/ 15/ 14	8.418585	8/ 15/ 14	19740.56
57CT1	6.510972	8/ 15/ 14	7.711016	8/ 15/ 14	17303.75
57DT1	7.2239	7/ 7/ 18	7.870249	7/ 7/ 18	17297.46
57ET1	8.704531	7/ 7/ 18	7.466145	7/ 7/ 18	14970.38
57FT1	5.208626	7/ 7/ 18	6.402493	7/ 7/ 18	13924.14
57GT1	7.066234	7/ 7/ 18	7.170147	7/ 7/ 18	14291.28

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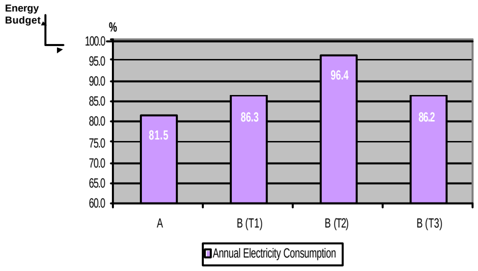
Simulation Results



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Simulation Results

- Observations

	A	B		
		Tower 1	Tower 2	Tower 3
E_h (%)	18.5	13.7	3.6	13.8
COP	v	v	v	v
Orientation	v	v	–	v
Shading Coefficient	x	–	–	–
WWR	–	–	–	–

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The End

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