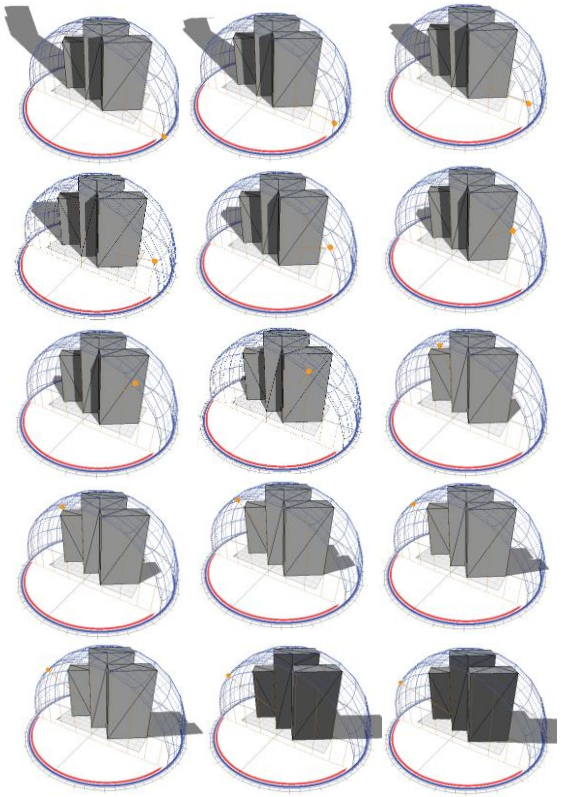


Daylight performance metrics in air-conditioned office buildings in Tropics

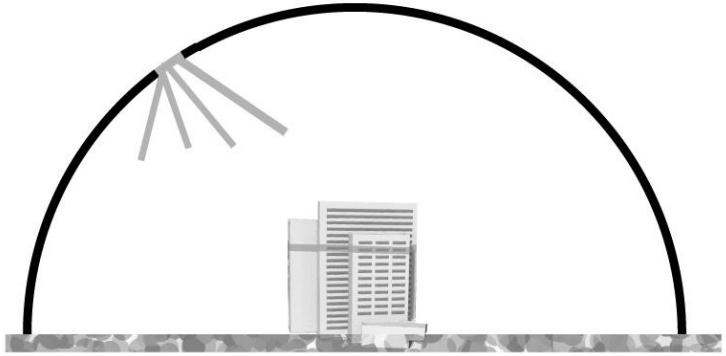
CHIEN Szu-Cheng

Berkeley Education Alliance for Research in Singapore (BEARS) center

Jan 10, 2013

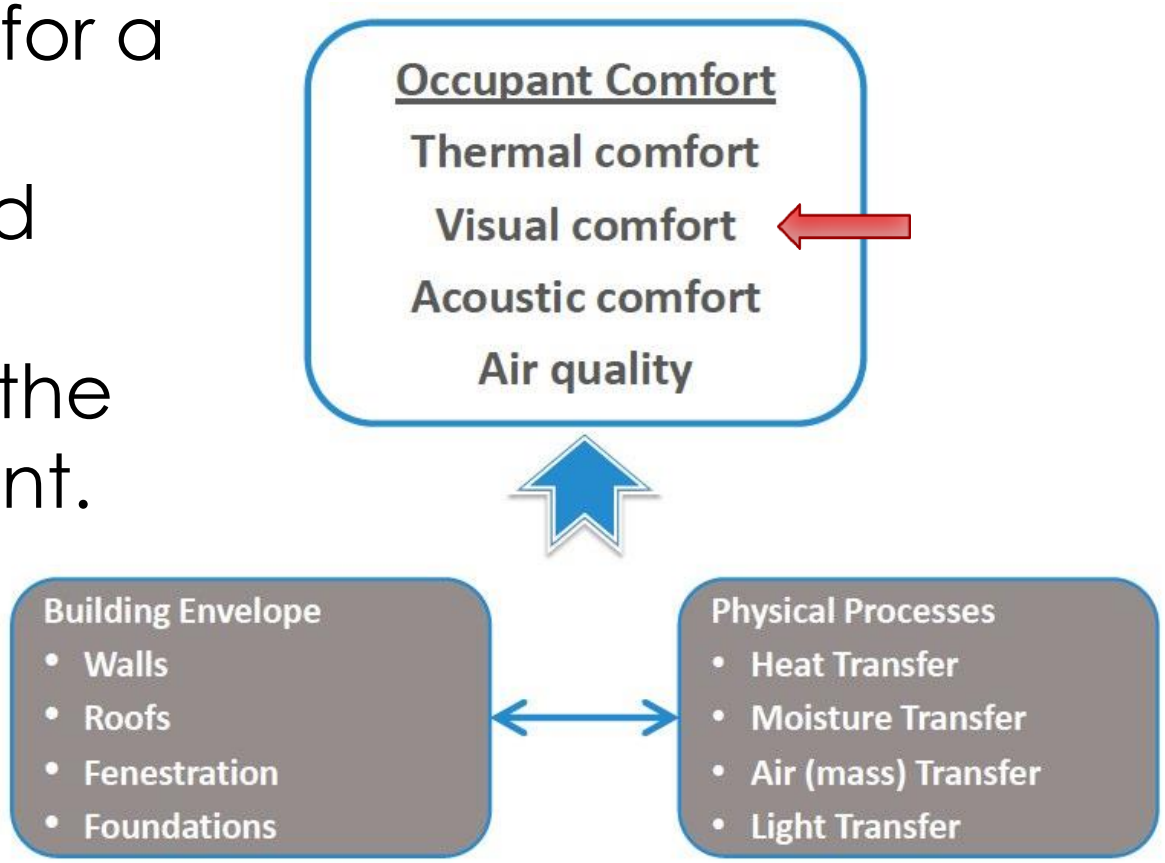
Outline

- Introduction
- Methods
- Preliminary study
- Remarks and ongoing work



What is Visual Comfort

A visual comfort for a person is that condition of mind which expresses satisfaction with the visual environment.



Purposes of Buildings

Visual performance and design strategies

External Factors (Climate)
- Daylight Availability
- Building Site and Obstructions

Internal Factors (Loads)

Space characteristics
- Fenestration
  - Location
  - Position
  - Design – glazing, shading
- Room surfaces – color, texture
- Space plan

Occupant behaviour
- Nature of activity (Lighting requirements)
- Controls

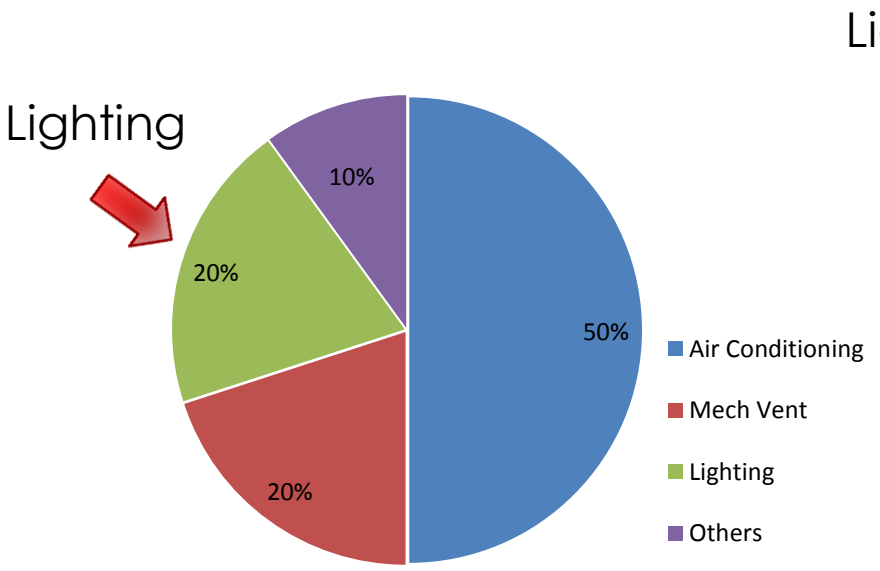
Electrical Lighting

Passive Strategies
- Appropriate orientation
- Skylights, atria
- Elements – light shelves, reflectors, louvers, blinds
- Fenestration Design - Glazing selection
- Light transport systems

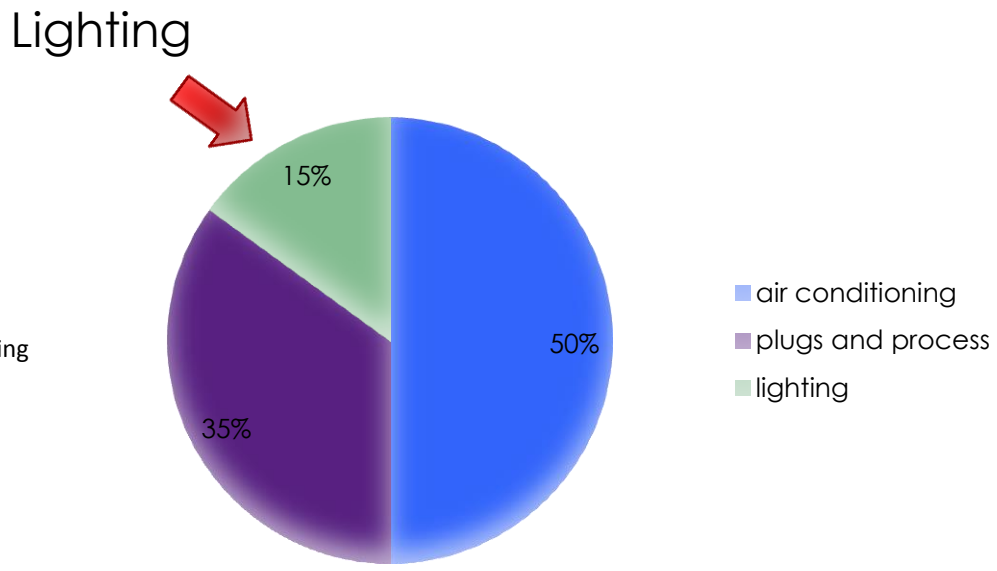
Active Strategies
- Efficient electrical lighting
- Lighting controls

Motivation

- Break-down of building energy consumption in SG



Break-down of building energy consumption in typical office buildings in Singapore
(Source: NEA)

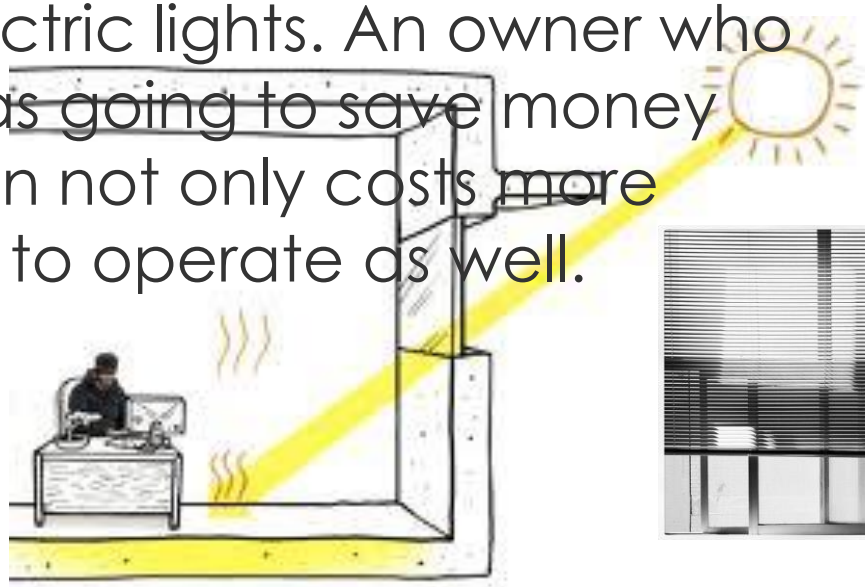


Break-down of building energy consumption at NTU campus, Singapore
(Source: NTU Facilities Office)

Motivation

- Typical case ➔
- Occupants demand blinds to cut down on glare. As a result, the blinds are drawn much of the day, requiring the use of electric lights. An owner who thought daylighting was going to save money finds out that the design not only costs more upfront but costs more to operate as well.

Plenty of glass for light ↑, solar heat gain↑, then the cooling load ↑.



Main Objectives

- Explore the effects of daylighting/building envelope interactions on the Building energy consumptions in the tropics
- Optimize the visual performance of built environment while meeting the goal of energy efficiency

Benefits

i) User's satisfaction with visual environment and productivity;

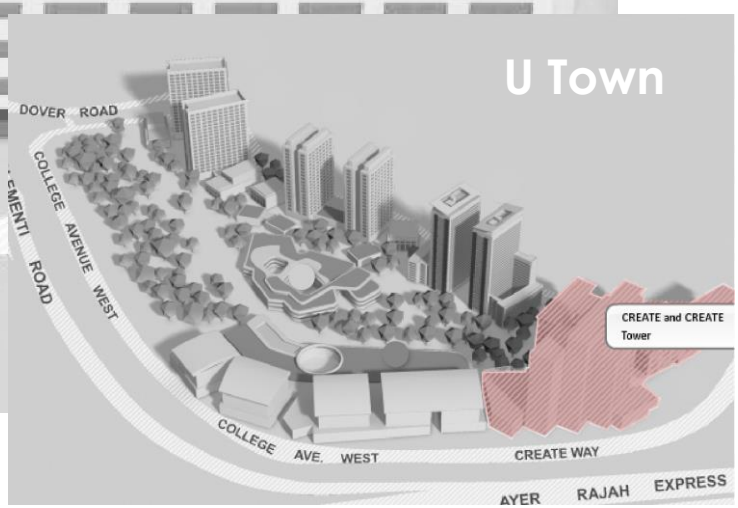
ii) Reduction of luminaires' electrical energy use and buildings' cooling energy demand.

iii) Successive building performance improvement and optimization can strategically benefit from the analyses of updated building energy and performance data bases.

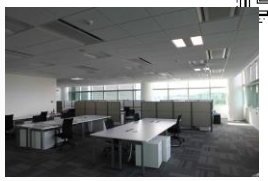
iv) A solid basis for further development (e.g. model predictive lighting control system)

Testbed location

SinBerBEST, Level 11, Create Building

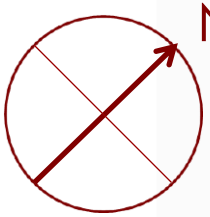


Testbed as Office-based Environment



Zone 2

Zone 1



Daylight Assessment for post occupancy stage

Comfort

Daylight

Energy

Daylight Glare Probability

Daylight Autonomy (DA)

Useful Daylight Illuminance (UDI)

Daylight Availability

Lighting Energy Use

Building Energy Use

Proposed Metrics

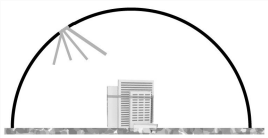
Methods

Geometry, Construction

Occupancy, systems

Weather data

Preliminary model



Simulated-based performance analysis

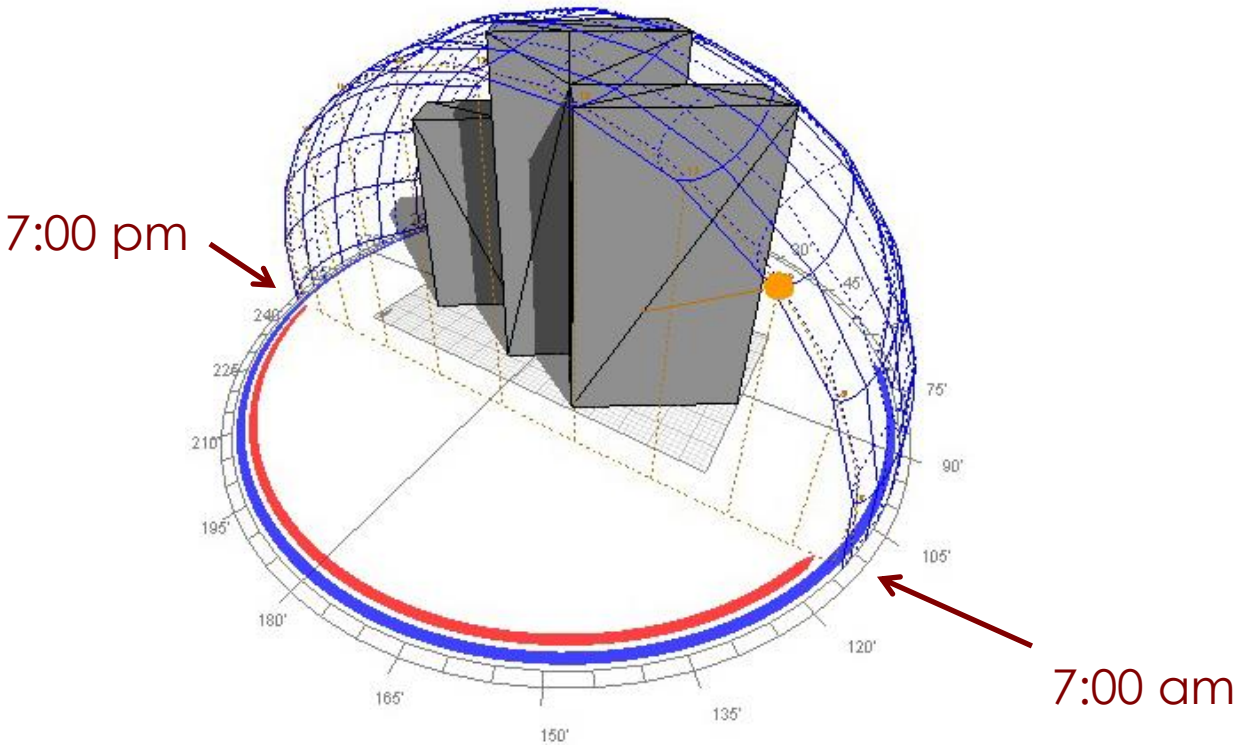
Measured performance analysis

Calibrated model

Comparison/evaluation of base case/retrofit alternatives

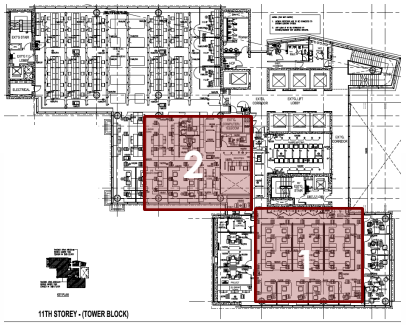
Preliminary Study

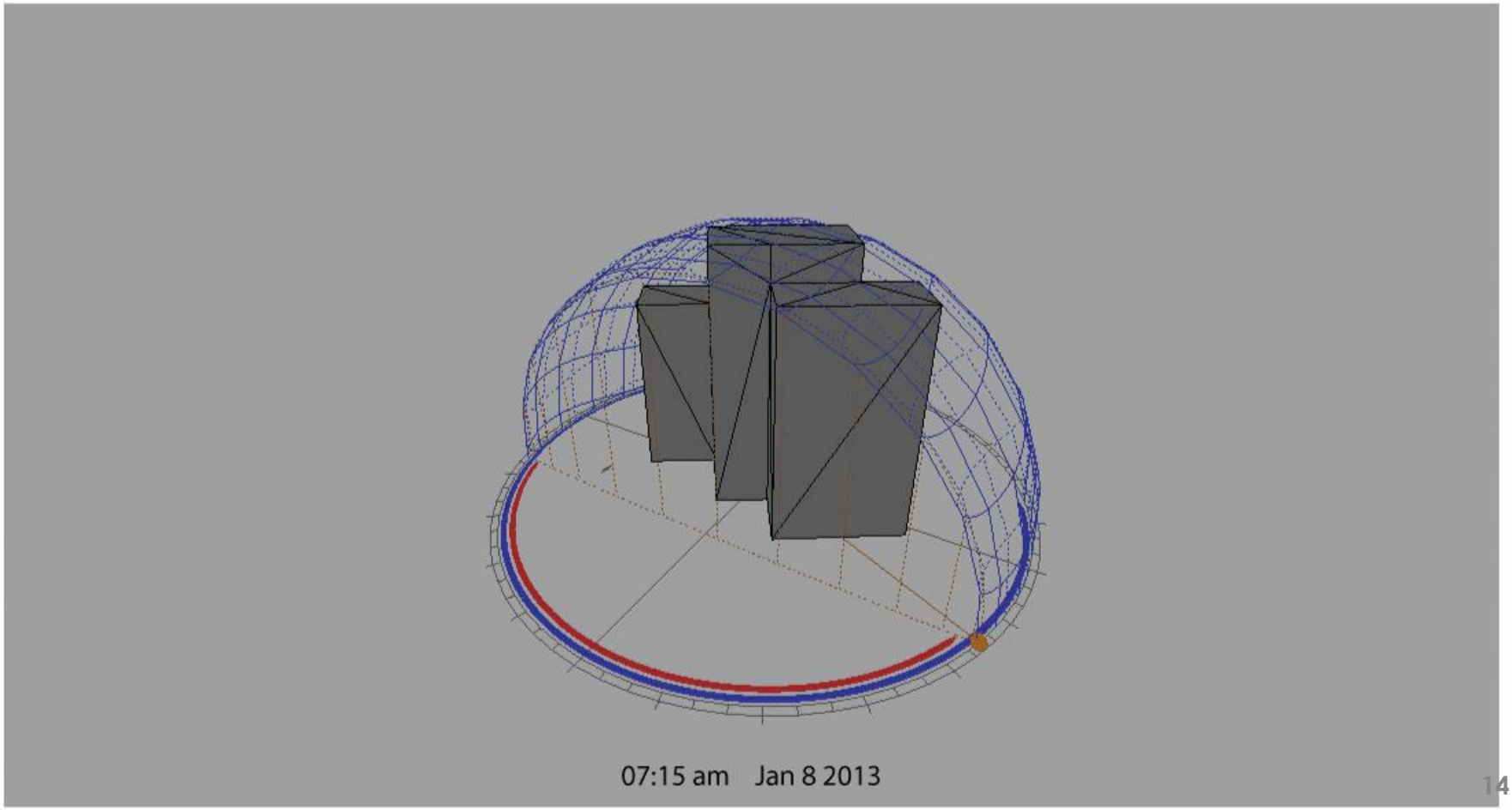
- Daily Sun Path (Jan 08 2013)



Preliminary Study

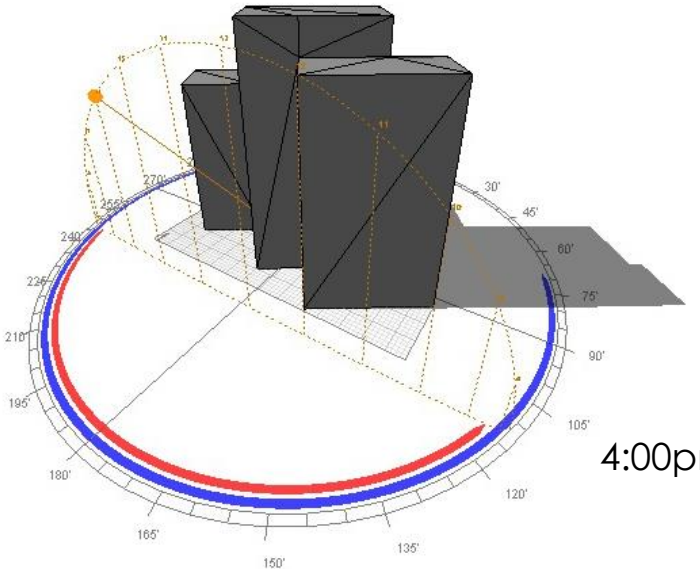
- Daily Sun Path (Jan 08 2013)





Preliminary Study

- Daily Sun Path (Jan 08 2013)



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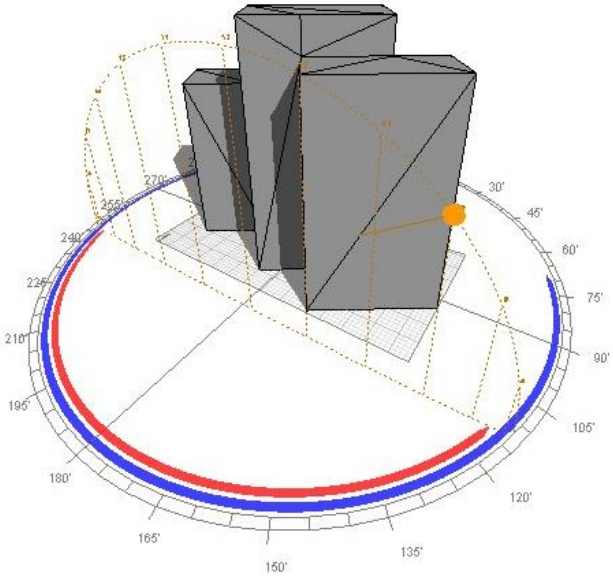

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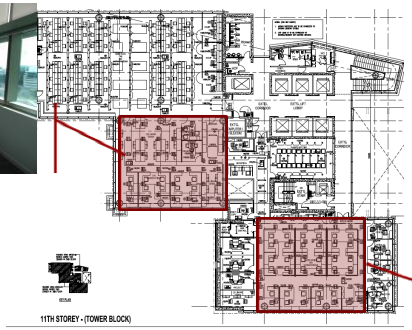
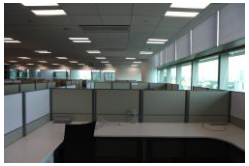
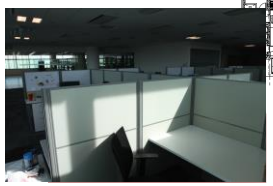
Zone 2

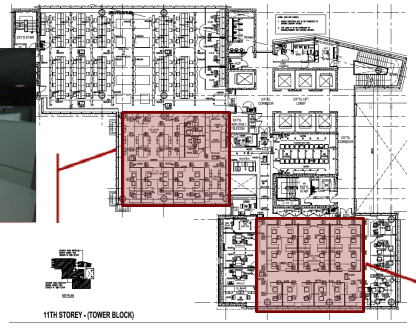




Zone 1

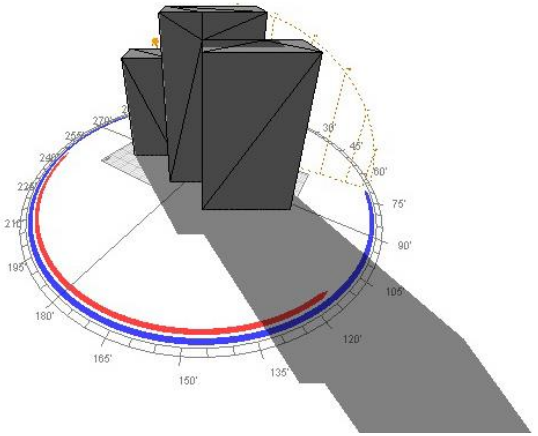


Zone 2

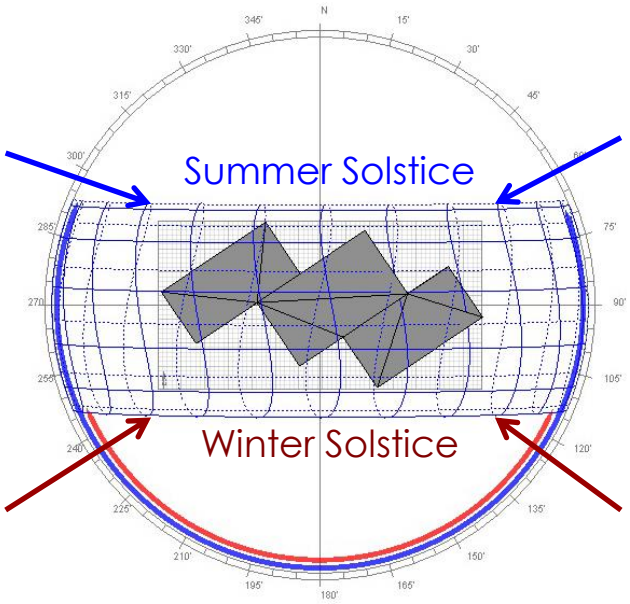


Zone 1

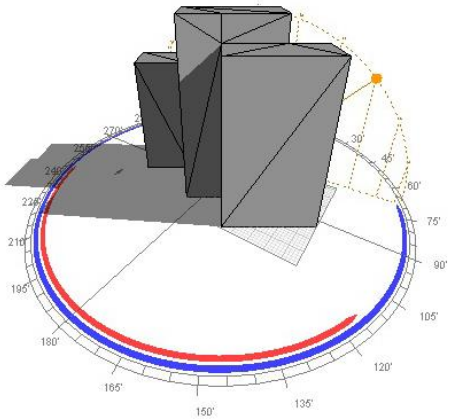
Preliminary Study
-Annual Sun path



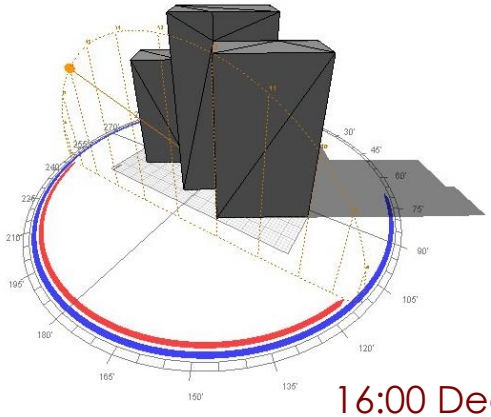
16:00 June 21



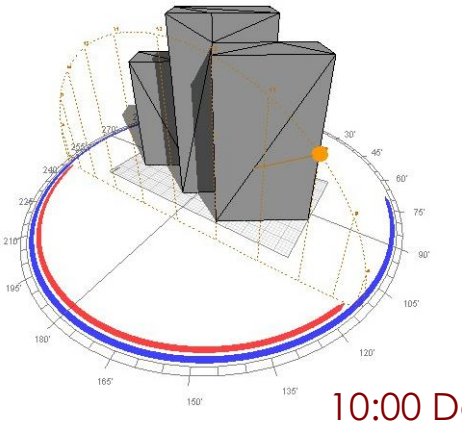
Sun path diagram for Singapore



10:00 June 21



16:00 Dec 21



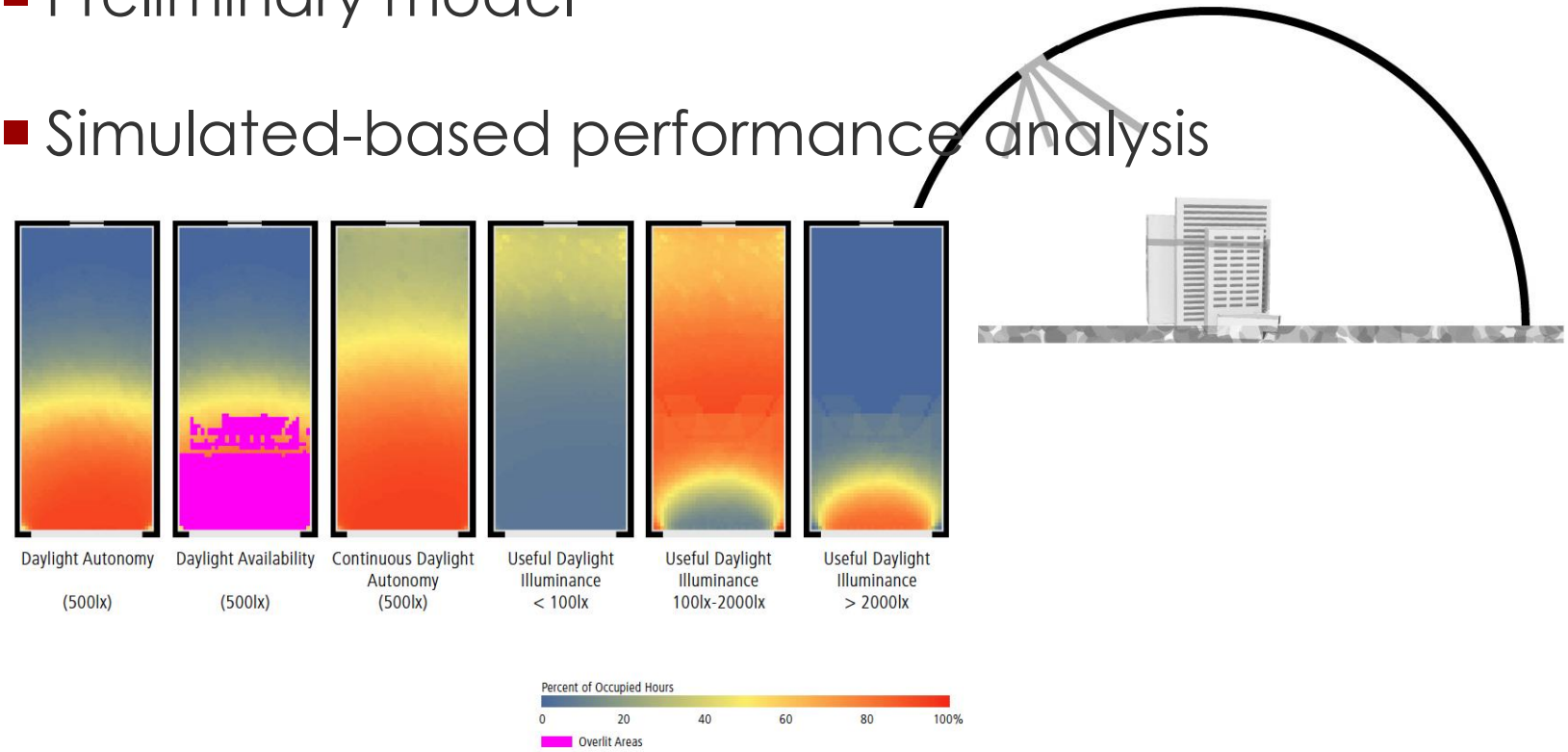
10:00 Dec 21

Concluding remarks

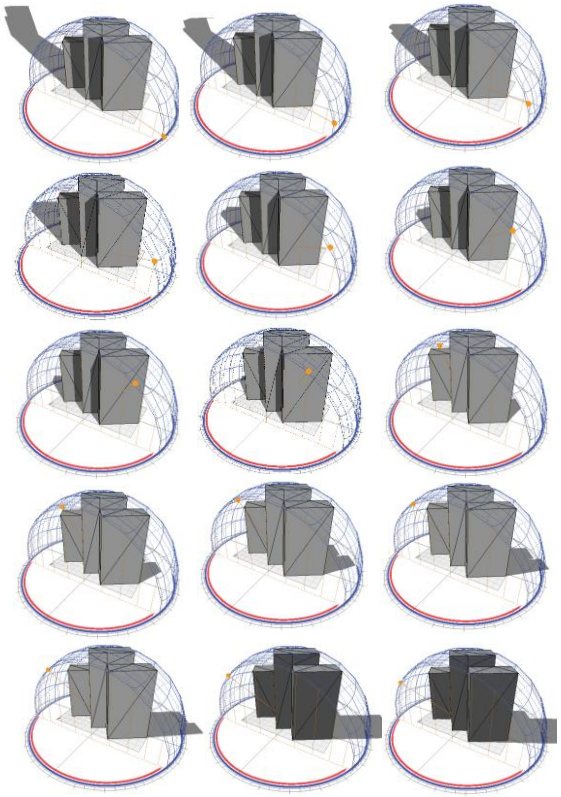
- Daylight harvesting and glare(comfort) issue
- If an equal significance was given to both daylight (quality and quantity) and energy consumption, what (which factors) will be assumed as the better solution to improve the visual performance based on the analysis?

Ongoing work

- Preliminary model
- Simulated-based performance analysis



Source: Jakubiec and Reinhart 2012



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Thank you for your attention

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Jan 10, 2013