The dawn of

Energy Efficient Architecture

dominating the skylines of SEA

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Singapore | Malaysia | China

I|E|N CONSULTANTS

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Contents

Presentation will focus on air-conditioned office buildings

"If you're involved in a new project and you are not making it as green and low energy as possible, it will be functionally obsolete the day it opens and economically disadvantaged for its entire lifetime"

Mr. Jerry Yudelson (2008)
national board member
US Green Building Council

ENERGY EFFICIENCY

Three Fundamental Observations

FACTOR

× 130

LEVEL PLAYING FIELD?

APPROPRIATE SOLUTIONS?

ENERGY EFFICIENCY

Three Fundamental Observations

FACTOR

$\times$ 130

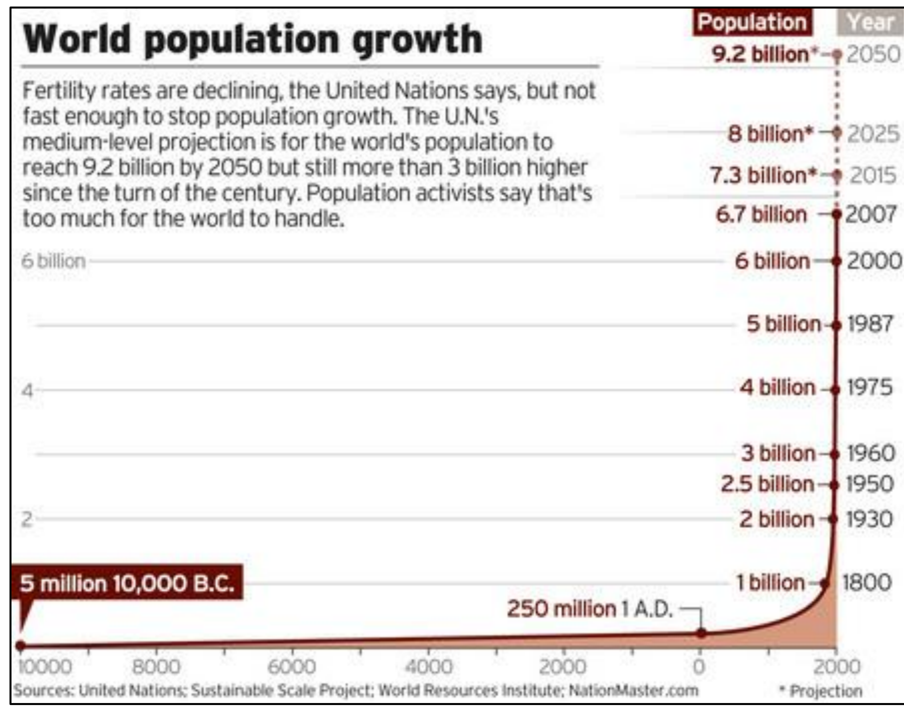
By year 2050, the global economy must be 130 times more carbon efficient

Or rather, the carbon intensity (CO_2 emissions per GDP) must be 6 grams CO_2/USD, which is 130 times lower than the current global value 768 grams CO_2/USD .

The basis for this calculation is:

- Greenhouse gas levels are maintained below 450 ppm recommended by IPCC (4th report)
- Global population at 9 billion by year 2050
- Global income levels are equitable to EU-levels
- Global economy growth level at 2% per annum

Source:
"Prosperity without Growth: Economics for a Finite Planet", by Tim Jackson, Economics Commissioner for the Sustainable Development Commission, SDC, UK, 2009



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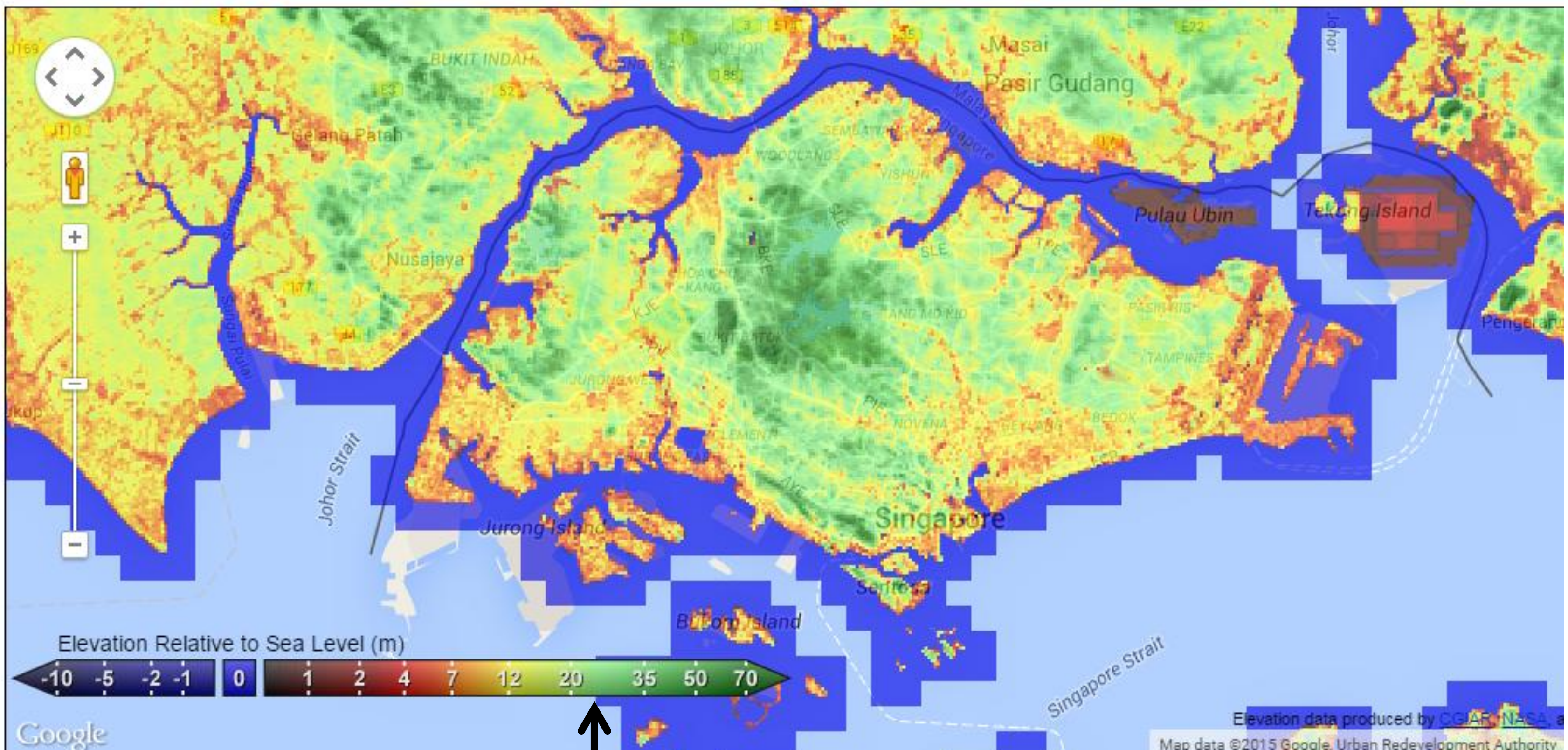
ENERGY EFFICIENCY

Three Fundamental Observations

FACTOR

× 130

Sea Level was 25 meters higher - last time Earth had this much greenhouse gasses in the atmosphere



25 meters

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Source:
http://www.globalwarmingart.com/sealevel?lat=4.741&lng=127.002

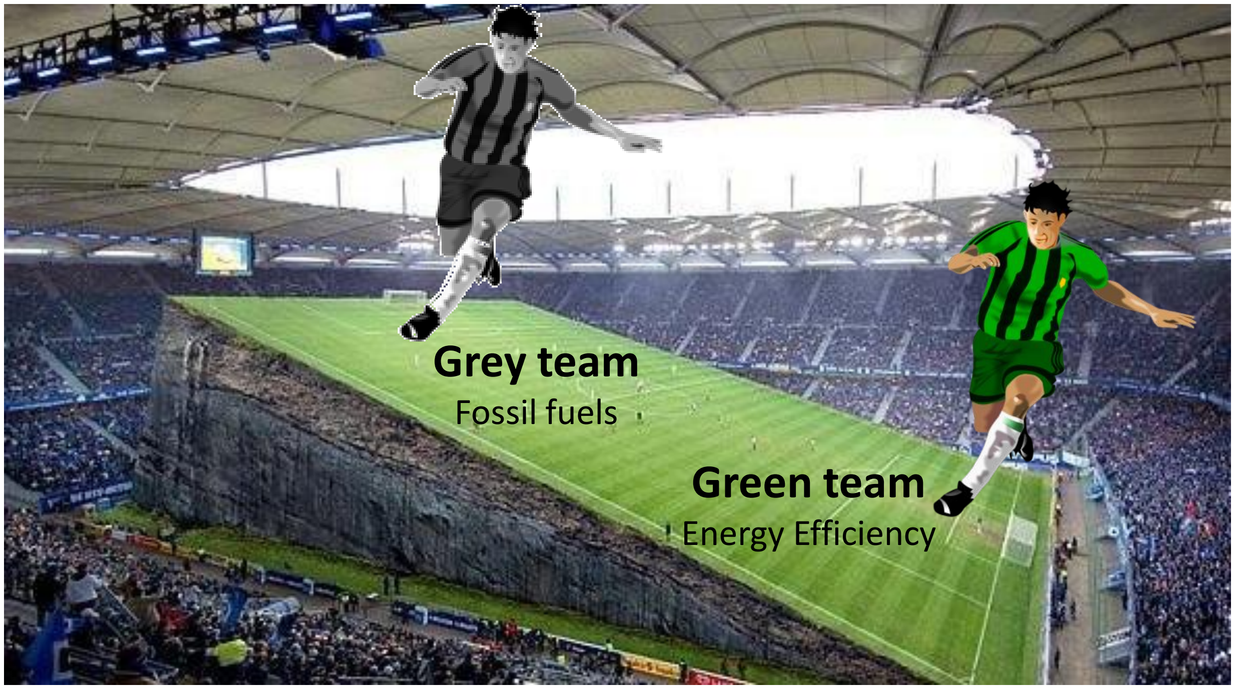
ENERGY EFFICIENCY

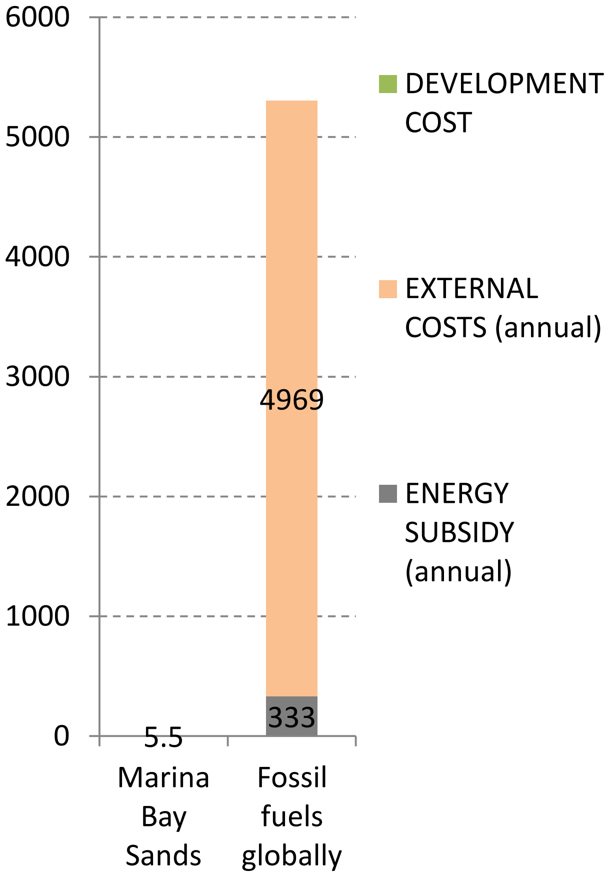
Three Fundamental Observations

The playing field is NOT level

LEVEL PLAYING FIELD?

Fossil fuels are subsidized and underpriced. In fact, the annual cost of fossil is USD5.3 trillion – or 6.5% of the global GDP (Source: IMF, 2015)





EXTERNAL COST break-down:
19% (Traffic congestion), 26% (Extreme weather) and 55% (Air Pollution Health Costs)

ENERGY EFFICIENCY

Three Fundamental Observations

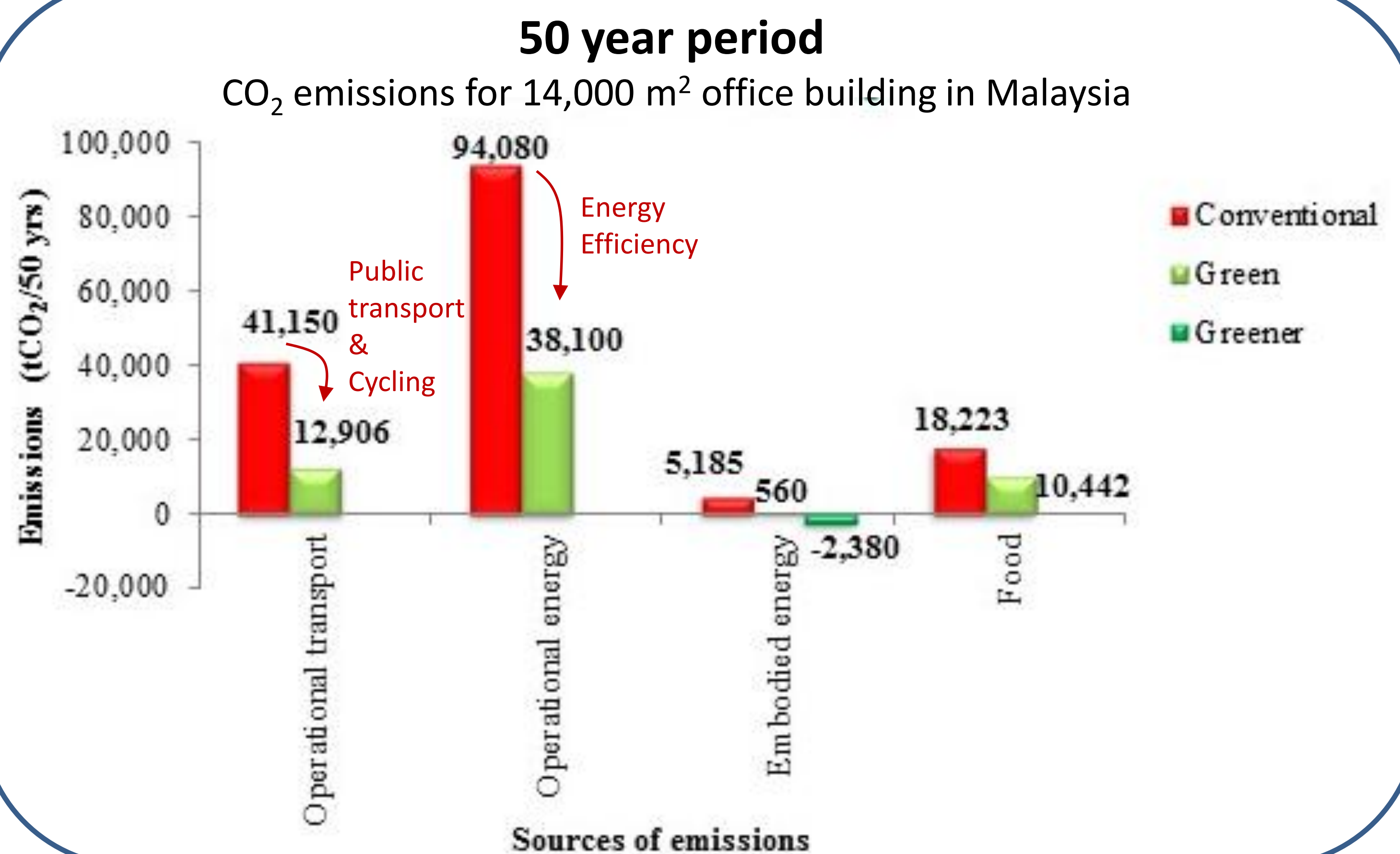
Full height glass | **Glary & hot**

Wonderful design!? | Blinds everywhere

APPROPRIATE SOLUTIONS?

BUILDING ENERGY

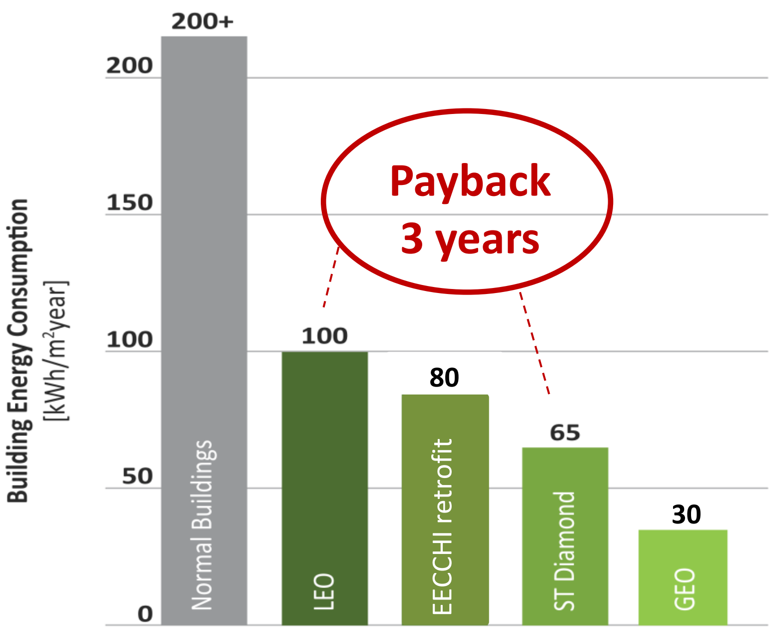
Where is the energy spent?
And where are the energy efficiency potentials?



Source: IEN Consultants. The green case is based on the ST Diamond Building (2010) with Singapore-style transport of high public transport + bicycling

Energy Efficient Buildings with Good Payback time

Case studies from the SEA countries



Energy Consumption of Green Office Buildings

Measured data for New and Retrofitted Buildings by IEN Consultants

Completion year	-	2004	2010	2010	2007

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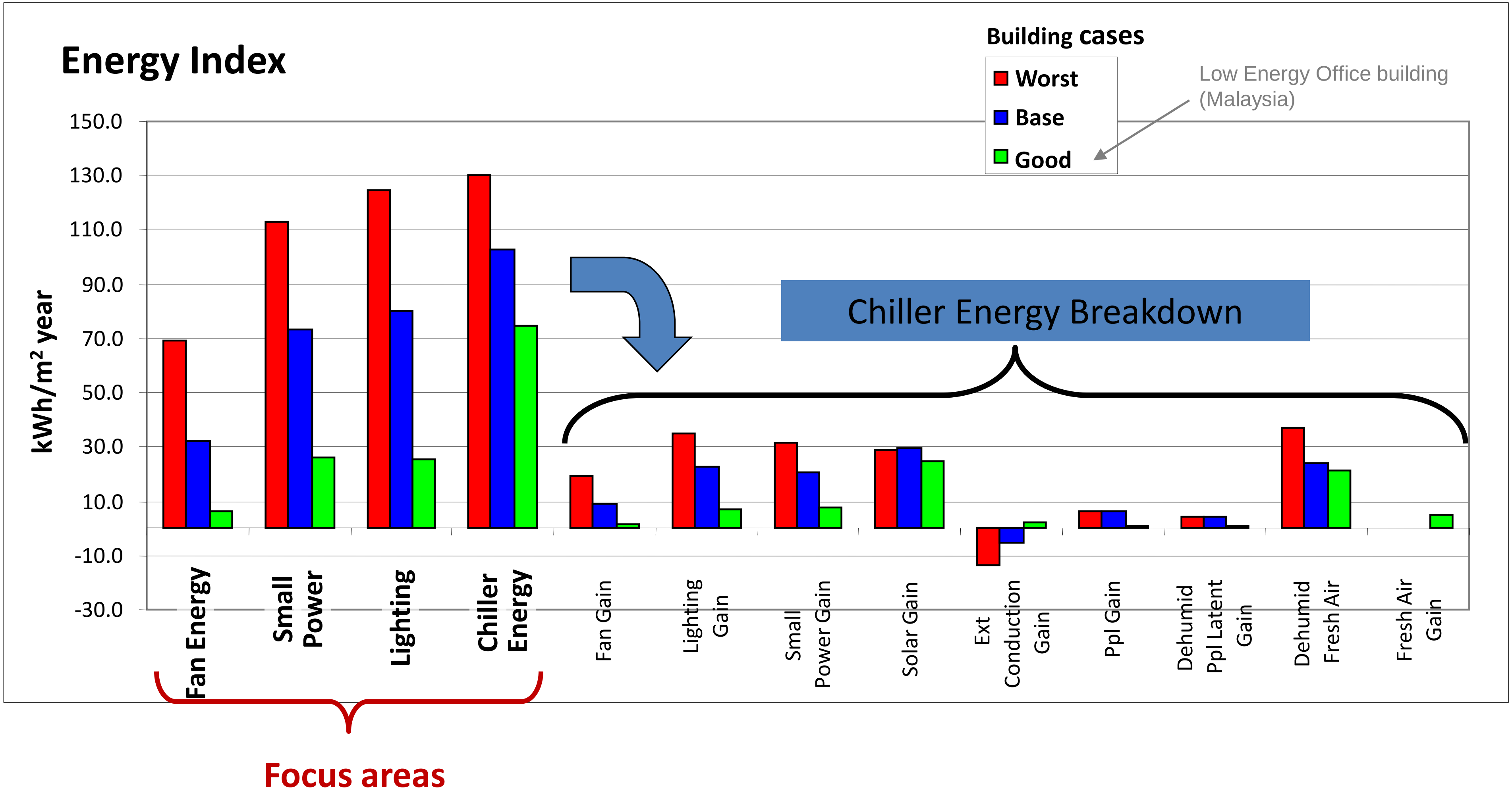
BUILDING ENERGY BREAK-DOWN

Understanding why the air-conditioner has to run in the first place



Case study no. 1

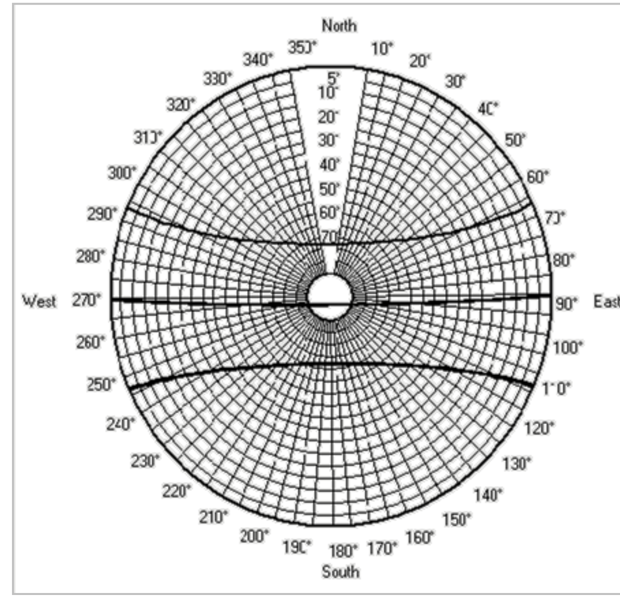
Energy Efficient Office case study

GEO BUILDING

(MALAYSIA. FORMERLY “ZERO ENERGY OFFICE” (ZEO) BUILDING, 2007)

Good Orientation for Daylighting

Solar chart for Kuala Lumpur (3.15° North)



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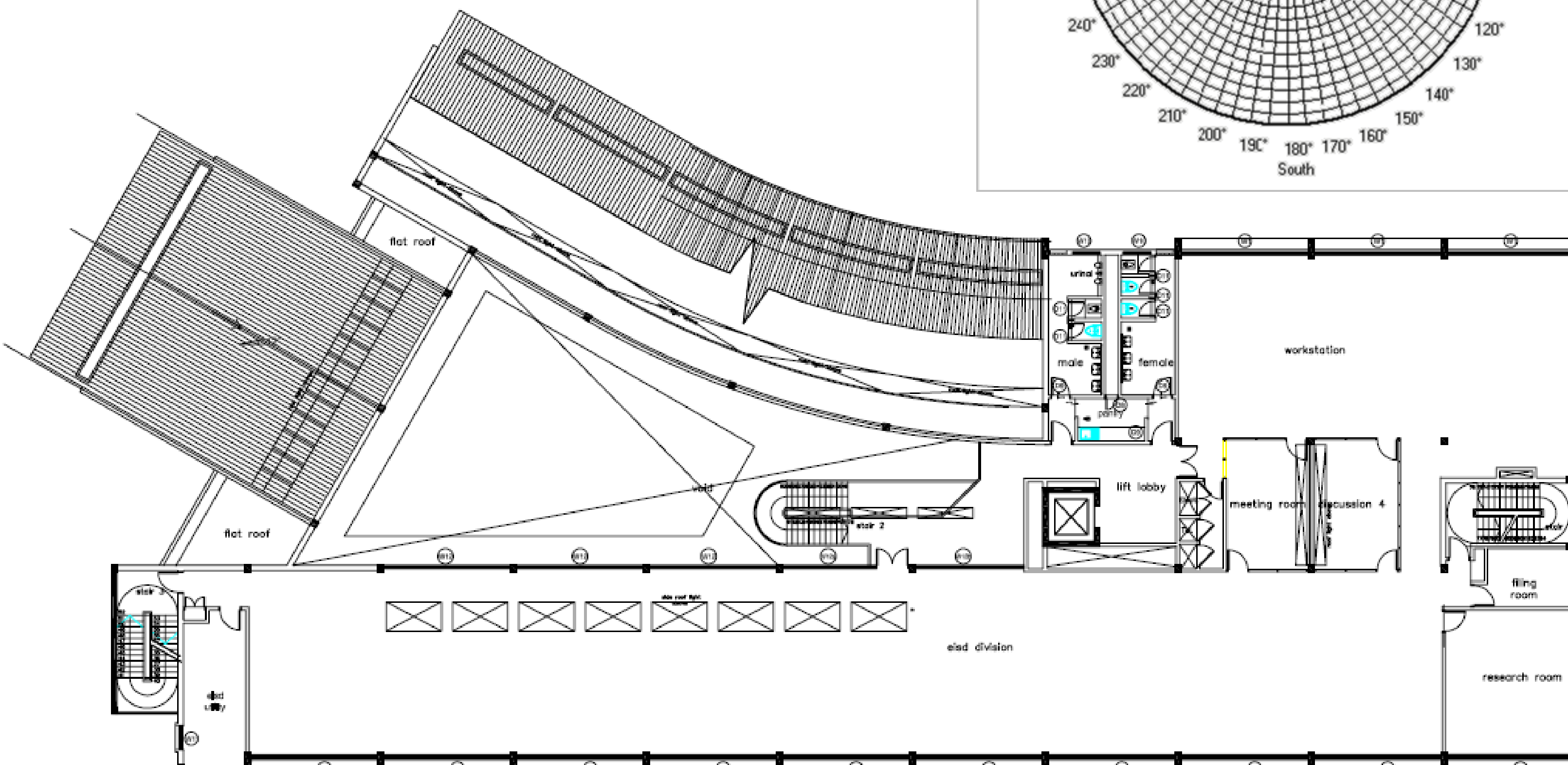
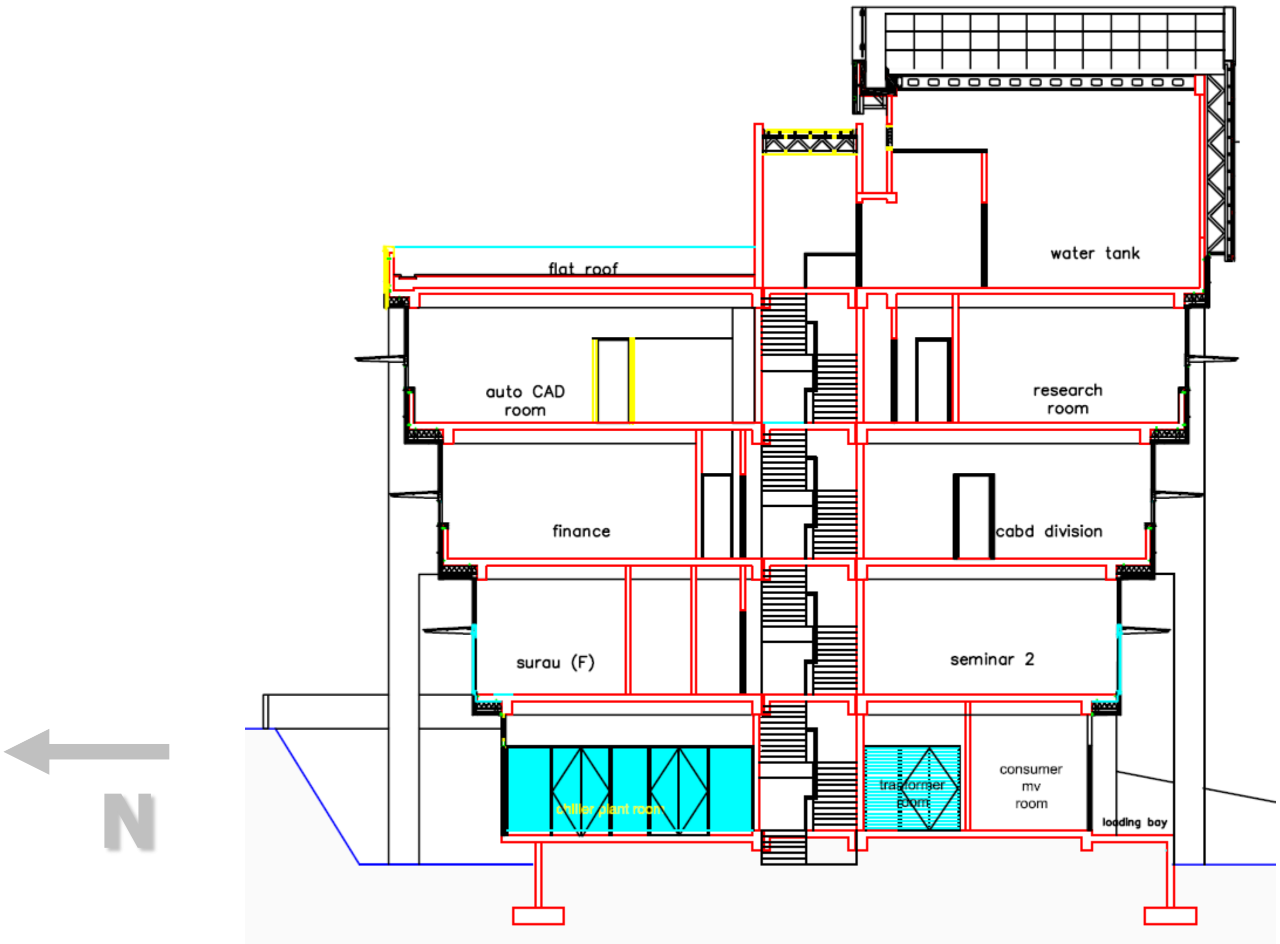


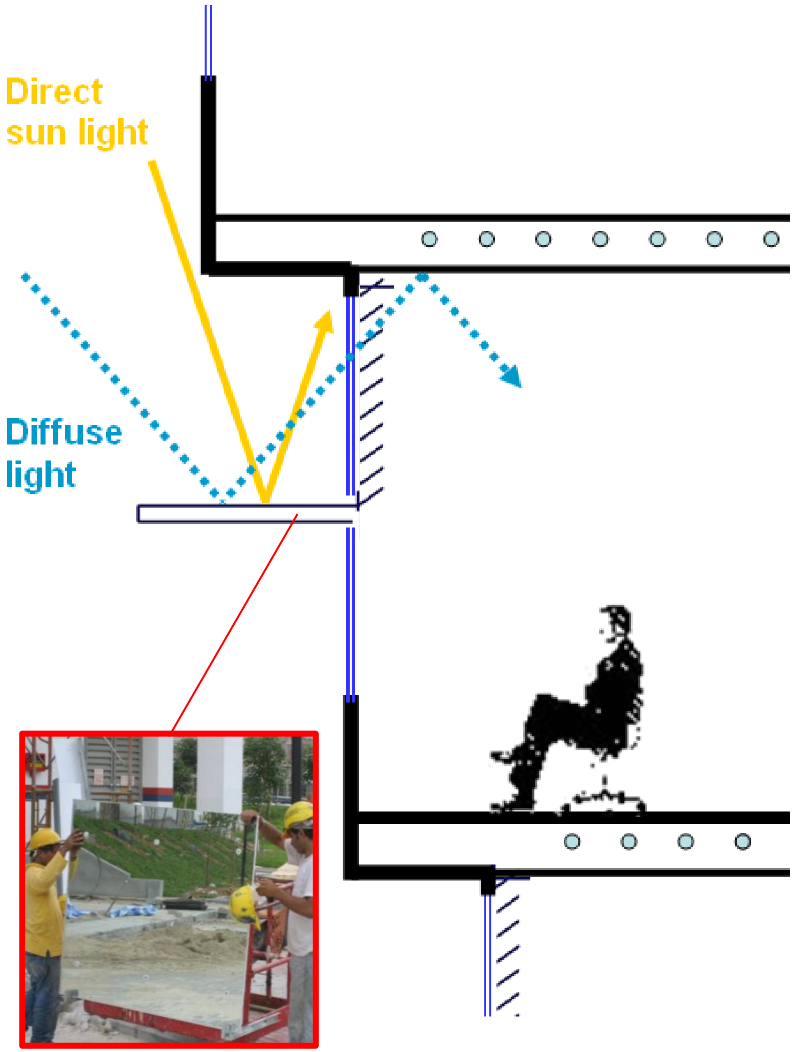
Step-in Design (Self-Shading)



Daylight Facade with Mirror Lightshelves

MIRROR LIGHTSHELVES:

Direct Sunlight Cut Off, Only Diffuse Light Enters Rooms



Mirror lightshelf

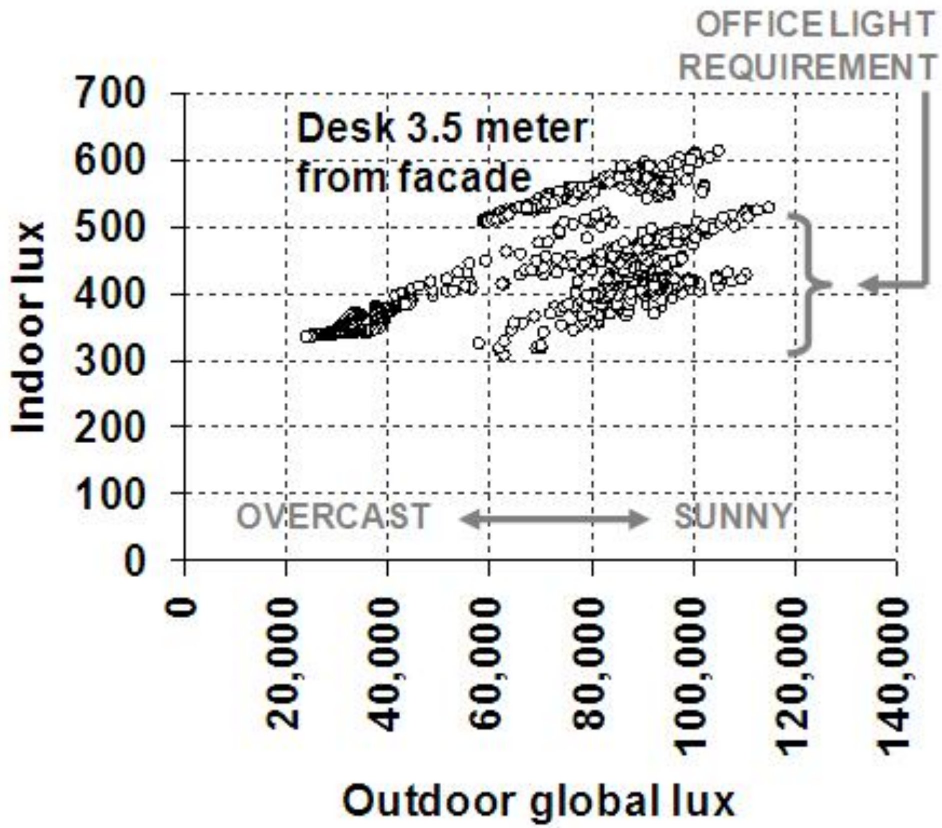
Photo taken on 12 June 2007 (North facade)

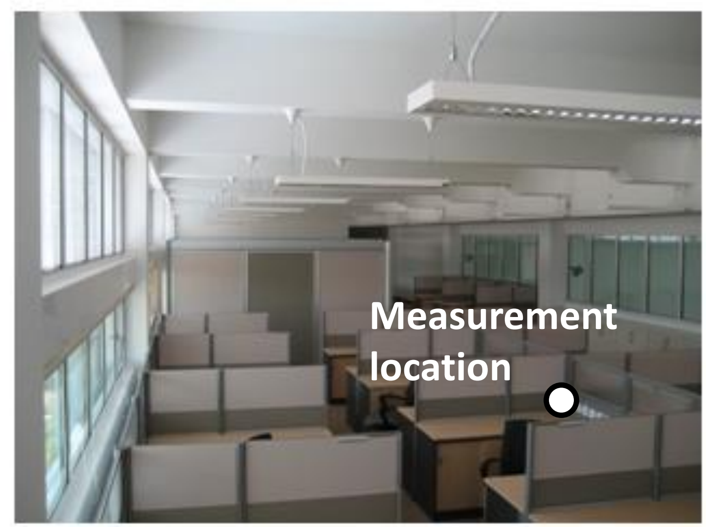
Split Window Design with Fixed Blind inside Double-Glazed Unit

Blind encapsulated in double glazing, no maintenance needed. Looks as good as new after seven years and counting….!

Semi-specular tannenbaum reflector in the ceiling. Maintains inward light reflection without causing glare to the occupants. Translucent cubicle walls parallel to the façade ensures daylight passage to table top.

Daylight Measurements

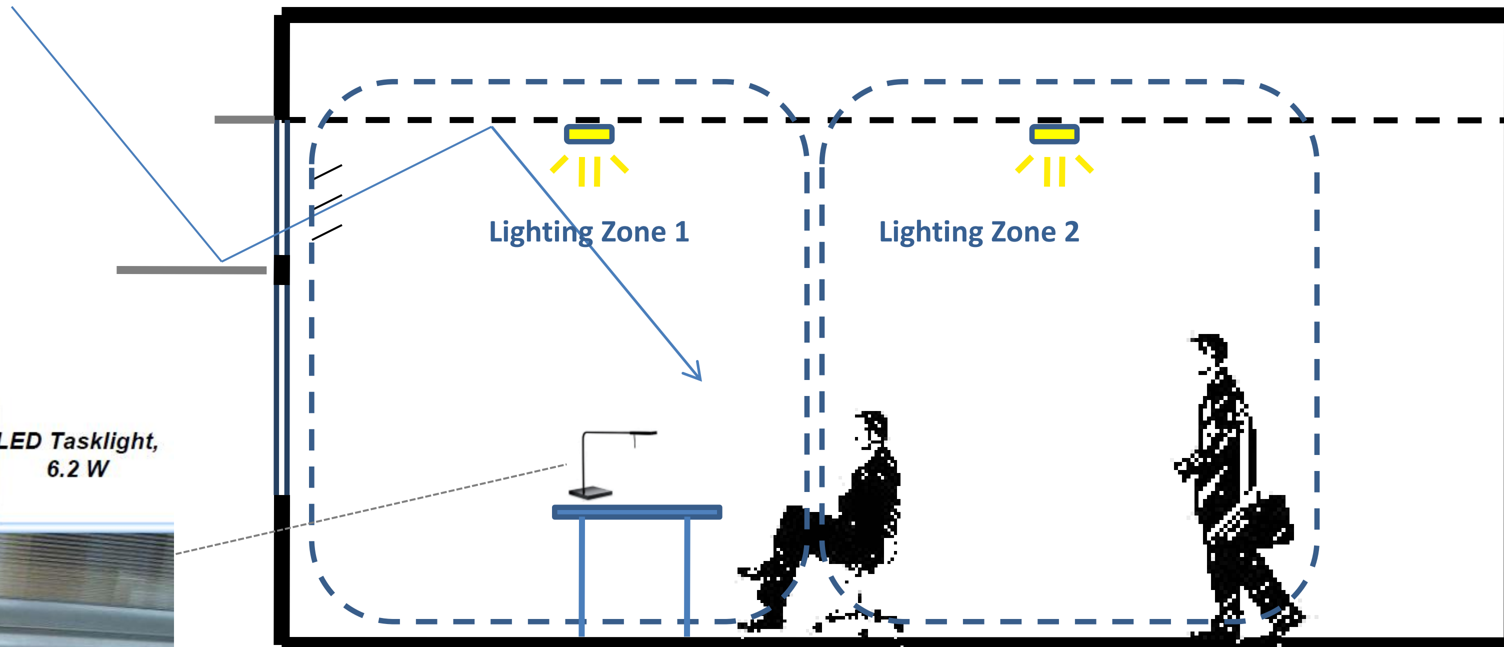




- Lighting consumption: 0.56 W/m^2
- Code requirement: 15 W/m^2

25 times more efficient

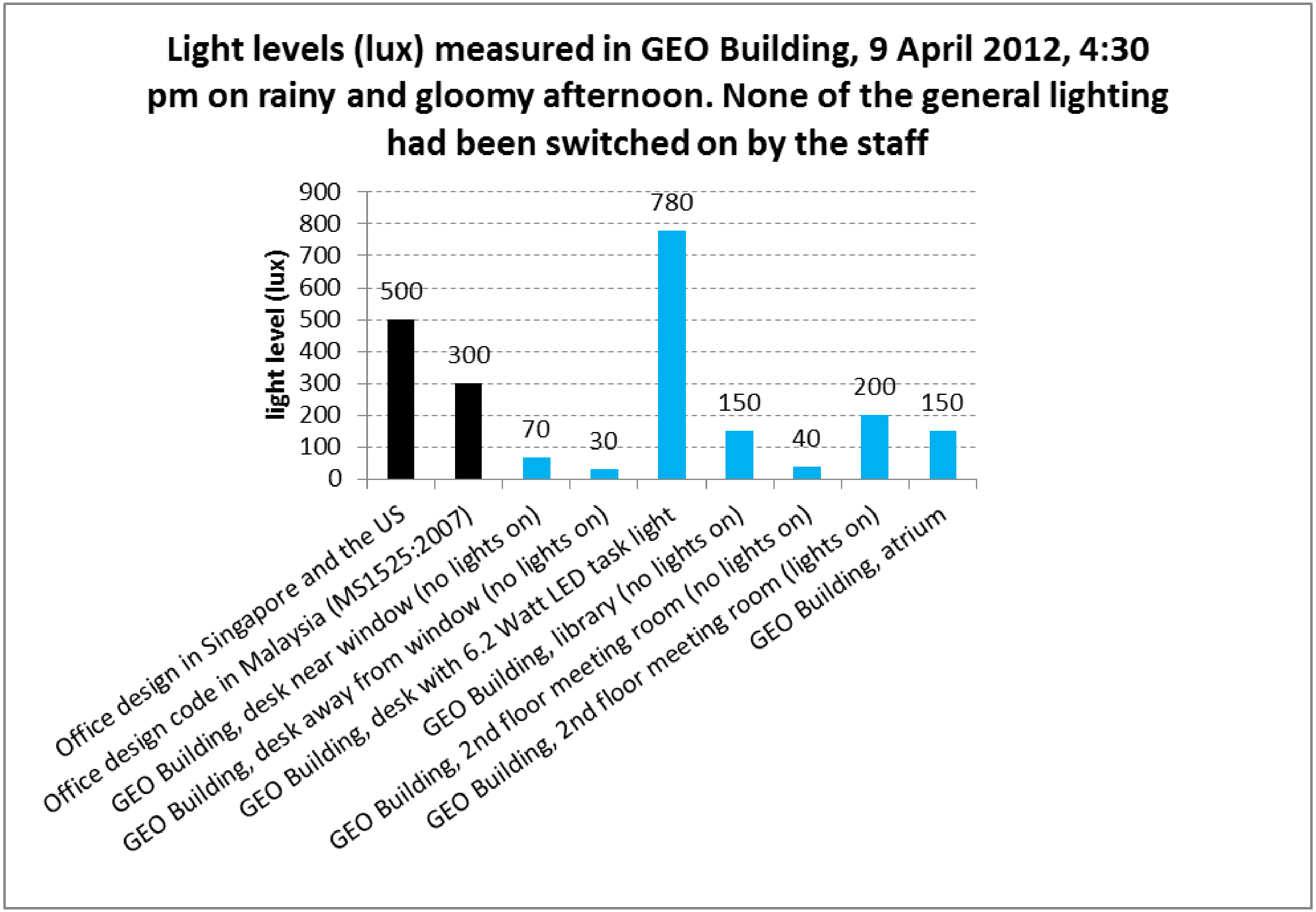
Daylight Responsive Lighting



Lighting Control

- Automatic off (light sensor and/or occupancy sensor)
- Manual on (people press the wall switch)
- Use task light (table lamp)

GEO Building Daylight Measurements



Transparent / Transluscent Walls Parallel Not to Block Daylight
+ No Suspended Ceiling with Slab Cooling (high 3.6 m floor to ceiling height)

Roof Lights taking in diffuse soft daylight from the North

Transparent PV atrium roof

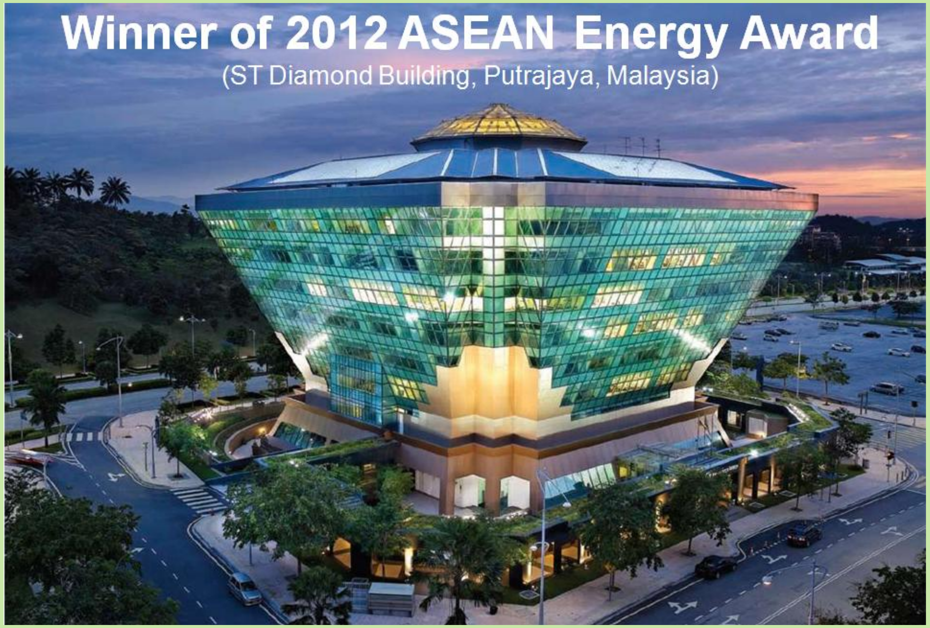
- PV sandwiched in low-e glass
- 13% transparent area

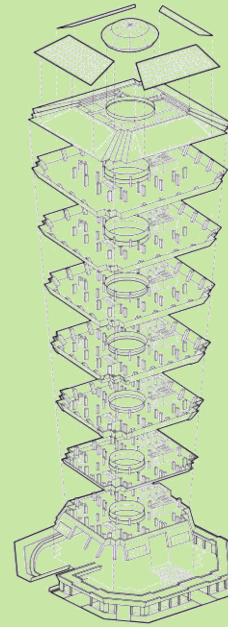
Daylight factor in atrium about 1 – 1.5%

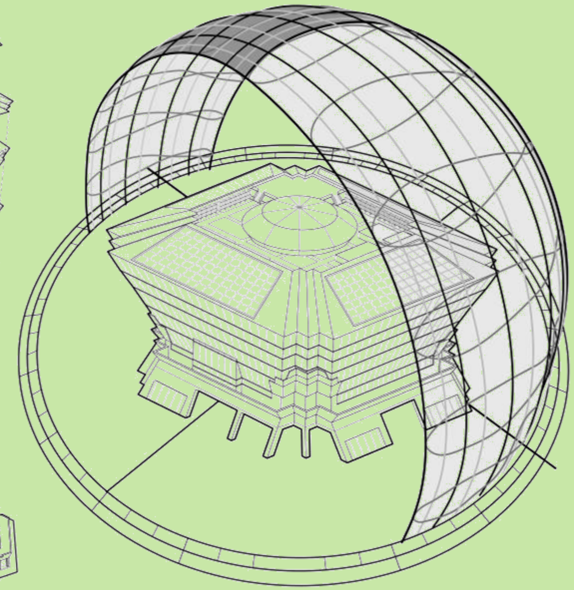
Nice light pattern through PV atrium roof

Nice atrium staircase made people take the stairs instead of lift

Case study no. 2







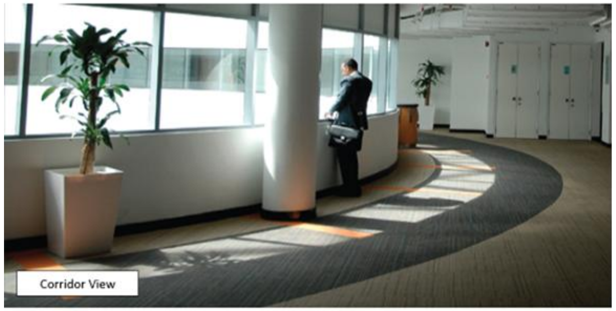
Energy Efficient Office case study

ST DIAMOND BUILDING

(SURUHANGJAYA TENAGA, 2010)

1/3 Energy Consumption

ST Diamond Building



Key Data
Gross Floor Are: 14,000sqm
Year of Completion: 2010
Building Energy Intensity: 69kWh/m2*year
Total Construction Cost: RM60mil
Additional EE Cost: 3.2%
Payback Period: **< 3years**
IRR: 34% (based on 7year Lease Term)

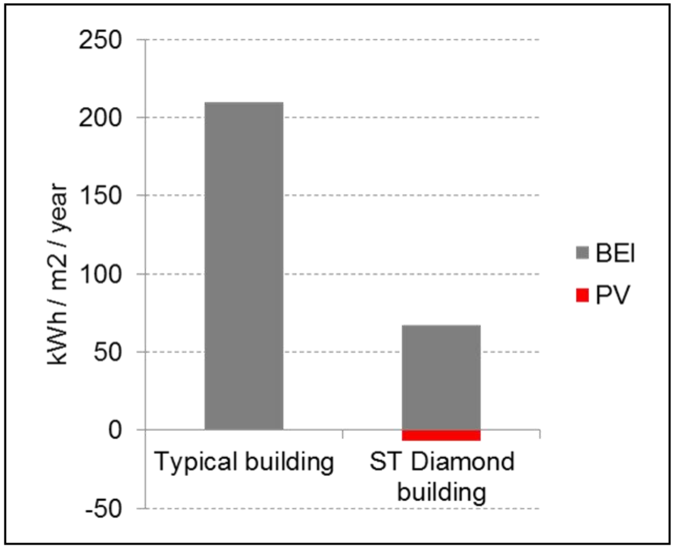
GBI
Platinum

Green Mark
Platinum

2012 ASEAN energy award **Winner**

&

2013 ASHRAE Technology Award (2nd place)



ST Diamond juxtaposed with Sarawak Longhouse

(in the book “The Cooperation”, 2012)

Malaysia and Denmark's, commitment to the field of

Green Energy in Architecture

as well as in cooperation and capacity building within the field, can be illustrated by the mutually beneficial involvement of IEN Consultants with the development of this field in Malaysia over the years. IEN Consultants was originally a proprietorship established by a Danish Chief Technical Advisor involved in the identification of energy projects in Malaysia. When the company took on the LEO Building projects it gained recognition in Malaysia and IEN Consultants managed to build up a team of consultants, most of them Malaysian, who with their experience on the LEO Building, became known further afield. This helped gain further commissions on such projects as the Green Tech Building and what has become known as The Diamond Building in Putrajaya.

“Green Buildings” are perceived to be expensive, both because of the costs of employing the expertise necessary to develop and refine the building and system designs, and because of the relatively high capital costs of green technology items. It takes time for reduced operating costs, which come with reduced energy usage, to counterbalance the increased capital investment and this has been a significant brake on development worldwide. However, given that approximately 40% of worldwide carbon emissions come from buildings, it is clear that the there is a need for the “greening” of buildings to make a significant contribution to carbon reductions.

As a result much effort has gone into the dissemination of green ideas to the Malaysian building industry, including the idea that the advantages of reduction of whole life costs of buildings as opposed to just capital costs are worthwhile. The fact that some “green” input to building design in Malaysia has moved from a subsidised base, using for example Danish funding for the LEO Building and European Union funding for the Green tech Office Building, to a fully Malaysia funded base in the case of the so-called “Diamond Building” indicates some success in changing attitudes to operating costs vs capital costs ascribed to “Green Buildings”.

Improved energy efficiency is already recognised by the Malaysian government to be more important than mere certification under the Green Building Index (GBI) scheme. That scheme therefore carries tax and stamp duty benefits to encourage the real application of green ideas in the design and operation of buildings.

Beyond this, IEN Consultants is now involved with a UNDP funded project, with the Ministry of Works, to promote low carbon buildings in Malaysia. It is hoped, amongst other things that it will lead to a building code by 2015 specifying much lower carbon footprints even than the LEO Building or the Diamond Building.

Modern sunshade
Diamond Building in festive season lighting

Traditional sunshade
Rungus Longhouse, Sabah

Another major area of involvement was in

Capacity Building for Malaysian Industry and Academia in EE Building design.

The objective of the scheme, which was implemented by the Ministry of Energy, Communications and Multimedia (now Ministry of Energy, Green Technology and Water), was to develop capacity in the optimisation of energy efficient building design. This was done through training sessions, seminars, specific analysis of existing buildings and design development of new buildings. A key partner in this endeavour was the Public Works Department (JKR) and there was close cooperation with Schools Division and Healthcare Division, so the lessons learned were comprehensive, and the dissemination of the results widespread.

The project produced reports outlining design strategies for new buildings, making lessons learned from the LEO Building described above available to practitioners and academics across Malaysia. The project also produced reports on “Energy Efficiency Promotion: Lessons Learned and Future Activities”, and undertook an evaluation of JKR design standards.

The project certainly raised awareness and improved the country's knowledge base regarding energy efficiency in buildings and made recommendations to Ministry of Energy, Green Technology and Water and JKR to set up demonstration offices, a very successful example of which was in Wisma Damansara.

Interestingly, both buildings reached the same design concept of blocking the sun while allowing diffuse daylight to enter

Book available free online:
http://um.dk/da/~/media/Malaysia/Documents/Other/Book%20Finalist%20LR.ashx

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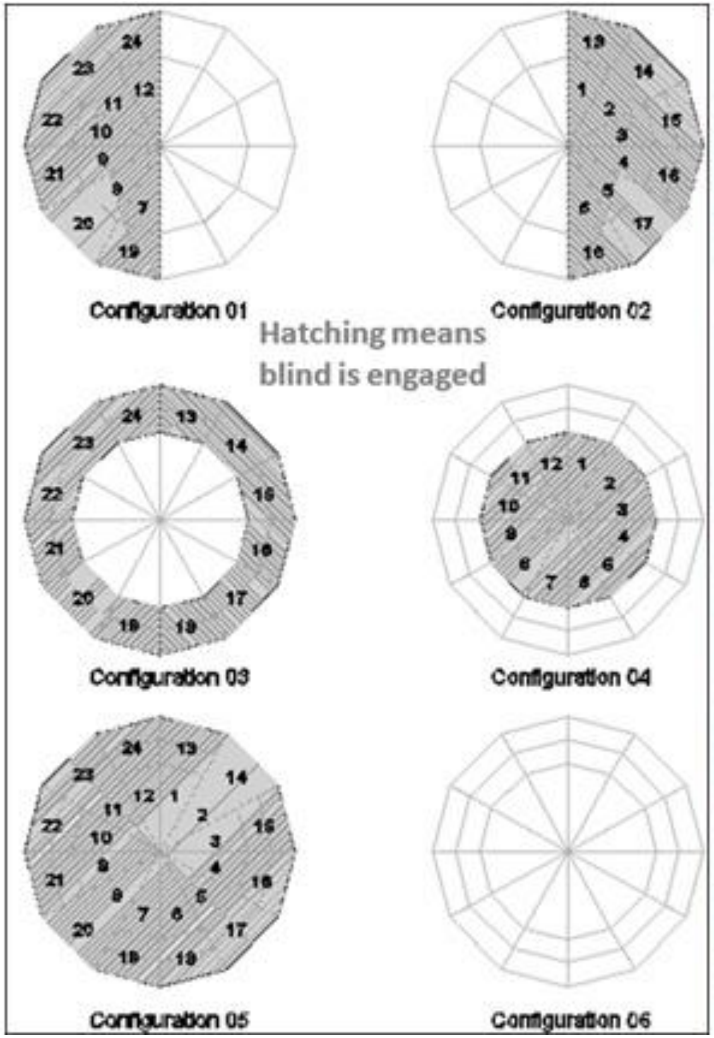
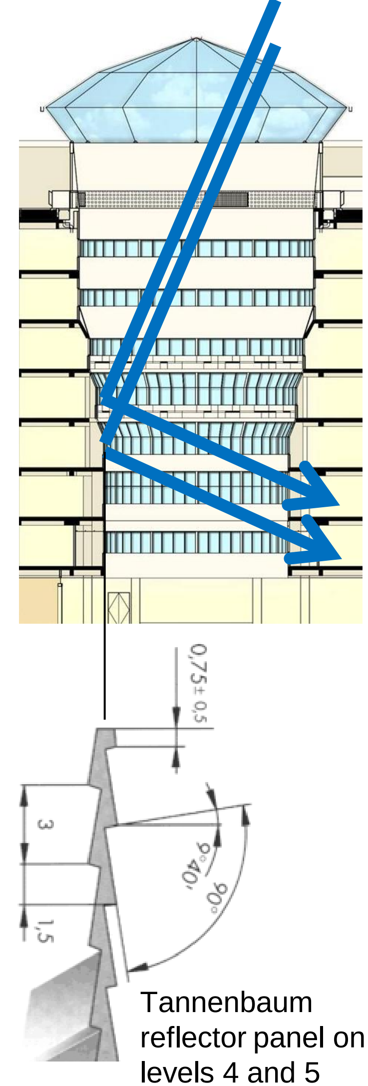


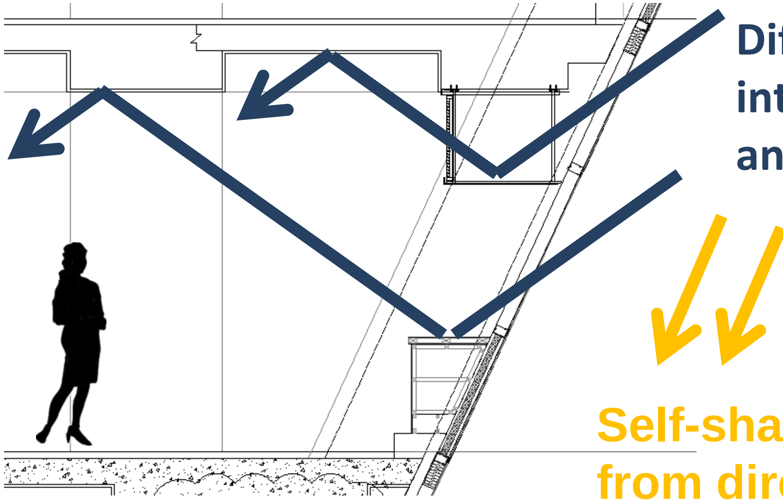


Atrium Daylight Design

The atrium has been carefully designed optimize daylight utilization for each floor employing the combination of the following three strategies:

1. Automated blind with six different configuration to maintain the appropriate daylighting levels at all times. The blinds with 30% light transmittance are adjusted every 15 minutes and follow a three different control strategies for morning, mid-day and evening
2. The windows size becomes larger deeper into the atrium to cater for lower daylight levels
3. A band of Tannenbaum reflector panels are applied to 4th and 5th floor to deflect daylight across the atrium to 1st and 2nd floor where daylight levels are the lowest. The 'christmas tree' profile reflectors have an inclination of 10° and reflect about 85% of the light in semi-diffuse manner, hence, avoiding visual glare issues for the building occupants.

FACADE

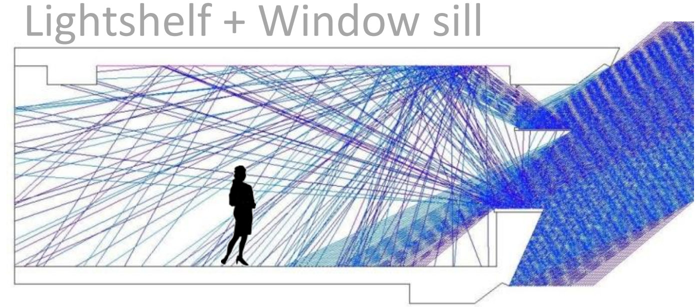


Diffuse light deflected into room by lightshelf and window sill

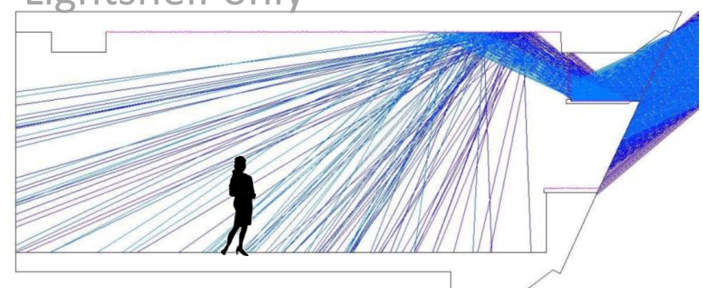
Self-shaded facade from direct sun

LIGHT REFLECTIONS FROM:

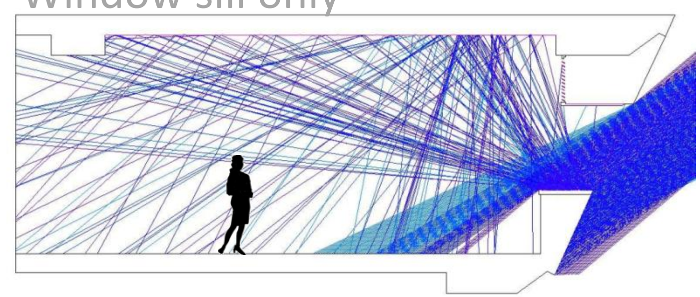
Lightshelf + Window sill



Lightshelf only



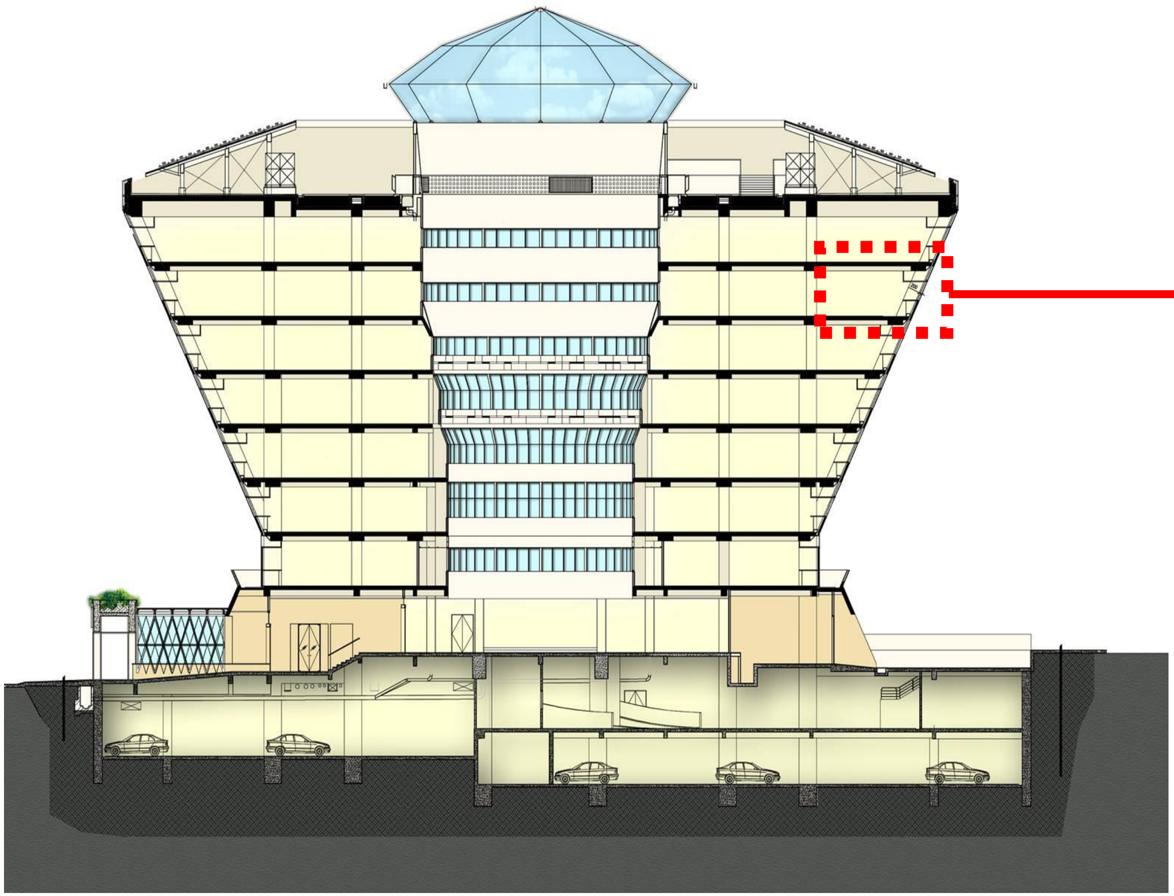
Window sill only



Façade Daylight Design

The building is 50% daylit. The façade daylighting system consists of a mirror lightshelf and a white painted window sill. Both deflect daylight onto the white ceiling for improved daylight distribution until 5 meters from the façade + 2 additional meters of corridor space. Installed office lighting is 8.4 W/m2, but 1-year measurements show consumption of only **0.9 W/m2** showing high reliance on daylighting

Day-Lighting- Office



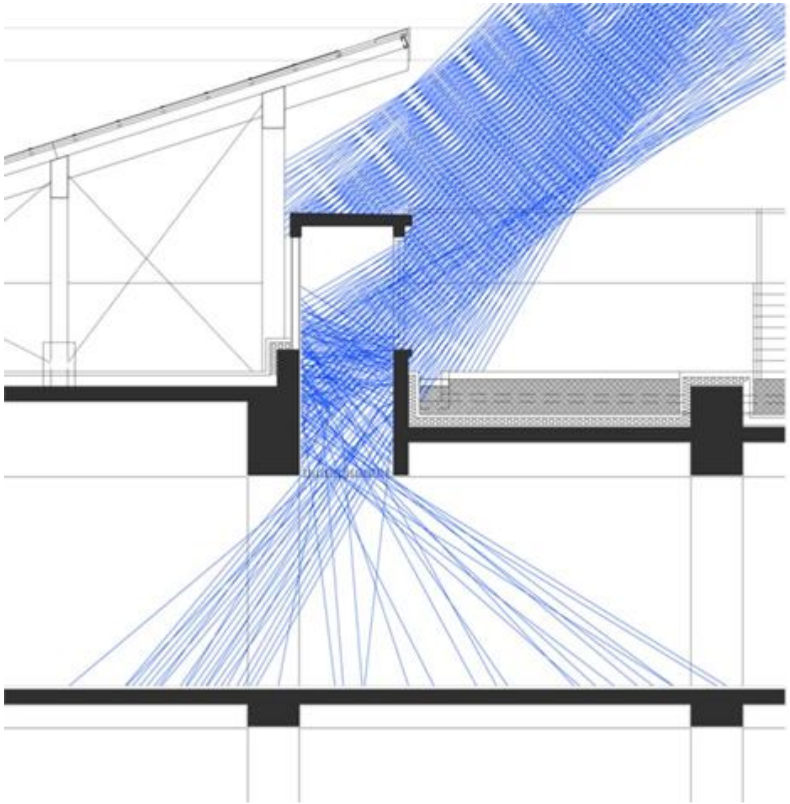
Mirror lightshelf

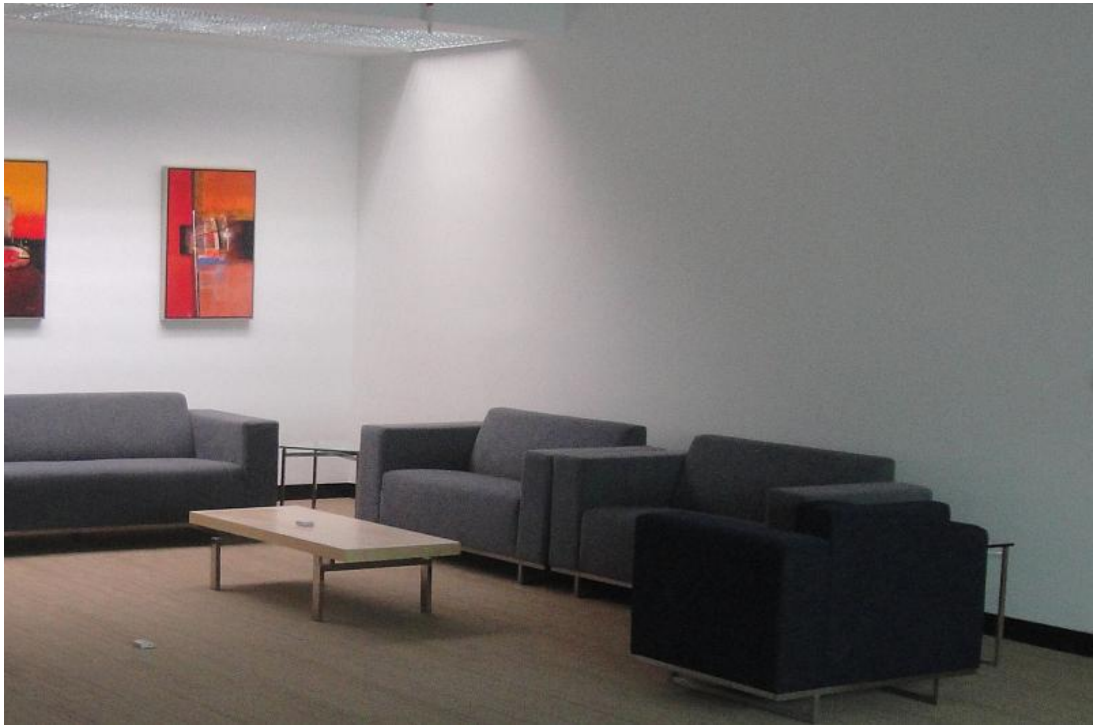
Fixed blinds for glare control

Daylight reflected onto ceiling

Daylight Skylight through Roof

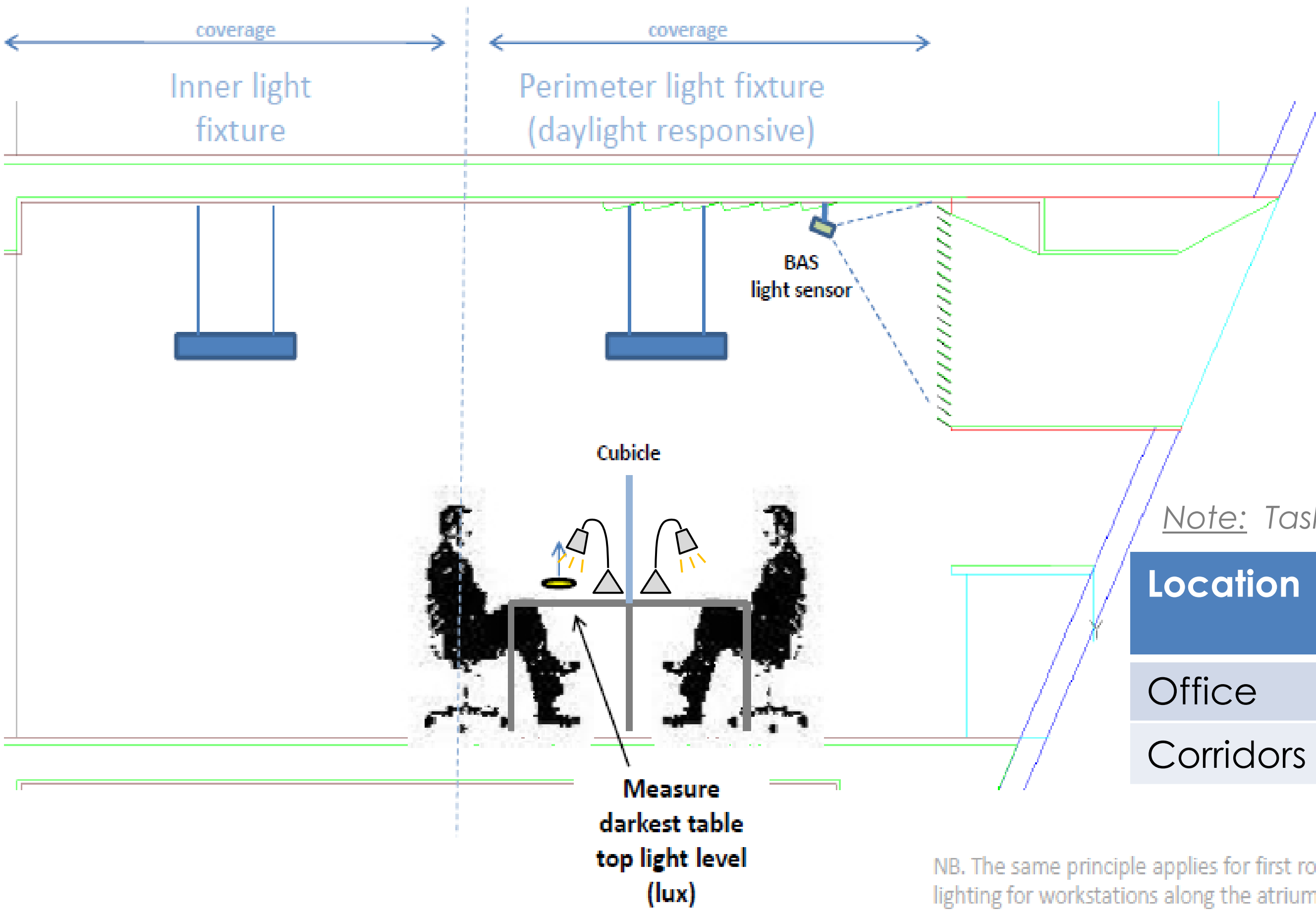
Take in diffuse light only





Lighting Control Strategy

No.	Lux sensor	Switch	Electric light	Remark
1	Above setpoint	Off	Off	If necessary, use task light
2	Above setpoint	On	Off	If necessary, use task light
3	Below setpoint	Off	Off	If necessary, use wall switch or task light
4	Below setpoint	On	On	If nobody around, switch off switch



Note: Task Lights to be distributed

Location	Setpoint (current)	Setpoint (with task lights)
Office	300 lux	120 lux
Corridors	100 lux	40 lux

NB. The same principle applies for first row of lighting for workstations along the atrium

Floor Slab Cooling in ST Diamond Building

Floor slab cooling system embedded in RC slab

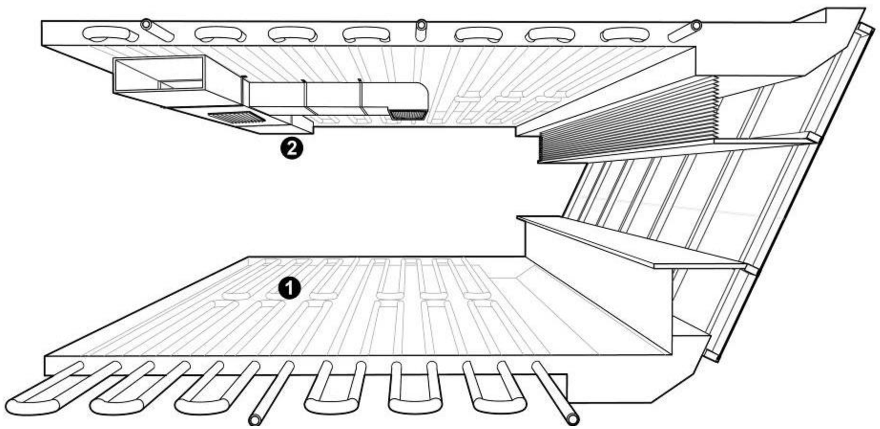
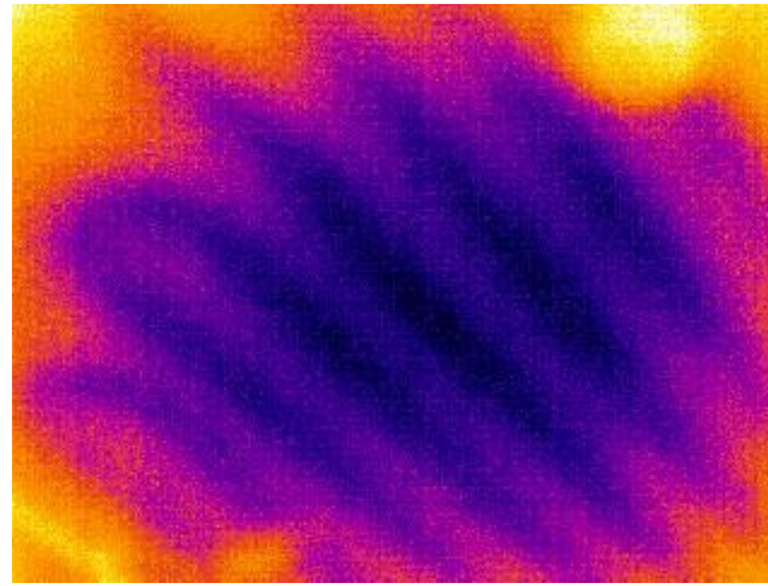
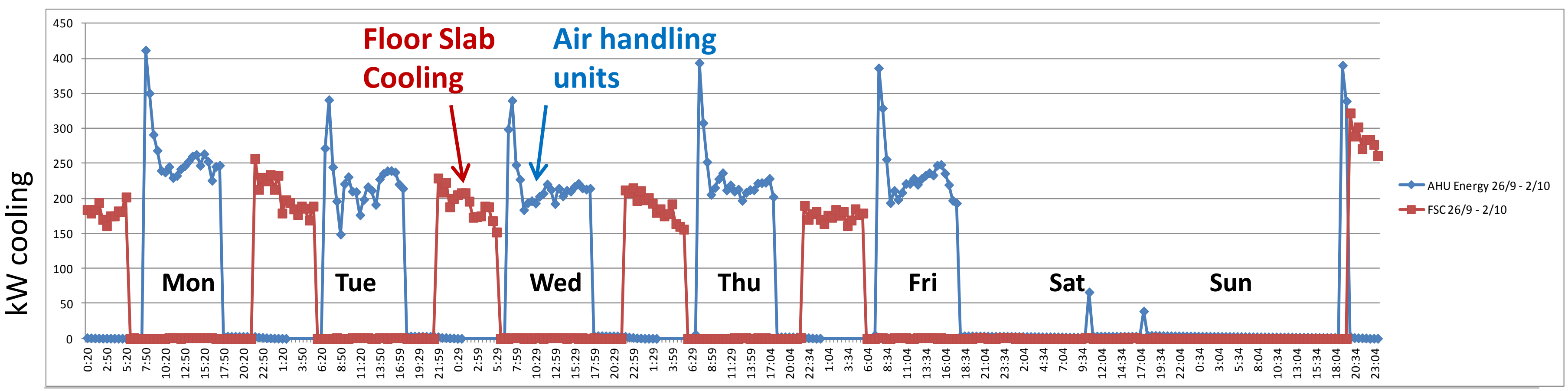


Illustration courtesy of:
Greening Asia – Emerging Principles for Sustainable Architecture.
Copyright: Nirmal Kishnani, 2012. Publisher: FuturArc



Thermographic image of floor slab cooling in ST Diamond
Picture courtesy of: PS Soong, Pureaire



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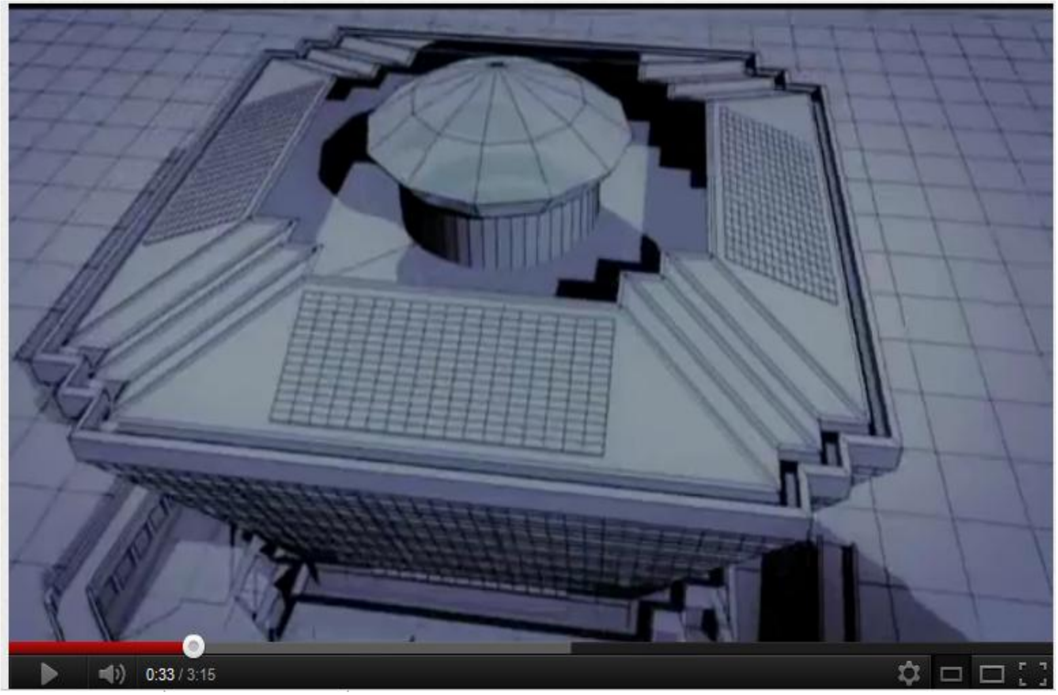
3-minute video



Sustainable Features of ST Diamond Building.

Available at YouTube:

http://www.youtube.com/watch?v=3H_sXCtDayc

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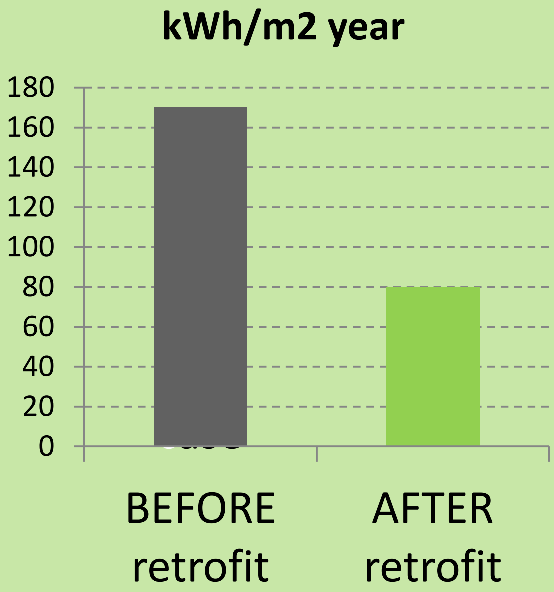
Case study no. 3



Energy Efficient Retrofit case study

EECCHI OFFICE RETROFIT

(JAKARTA, 2011)

BEFORE		AFTER

Energy

Before	After
170 kWh/m² yr	80 kWh/m² yr

Comfort

Before	After
26-31 temp (°C)	24-26 temp (°C)
75 RH (%)	55 RH (%)

Noise

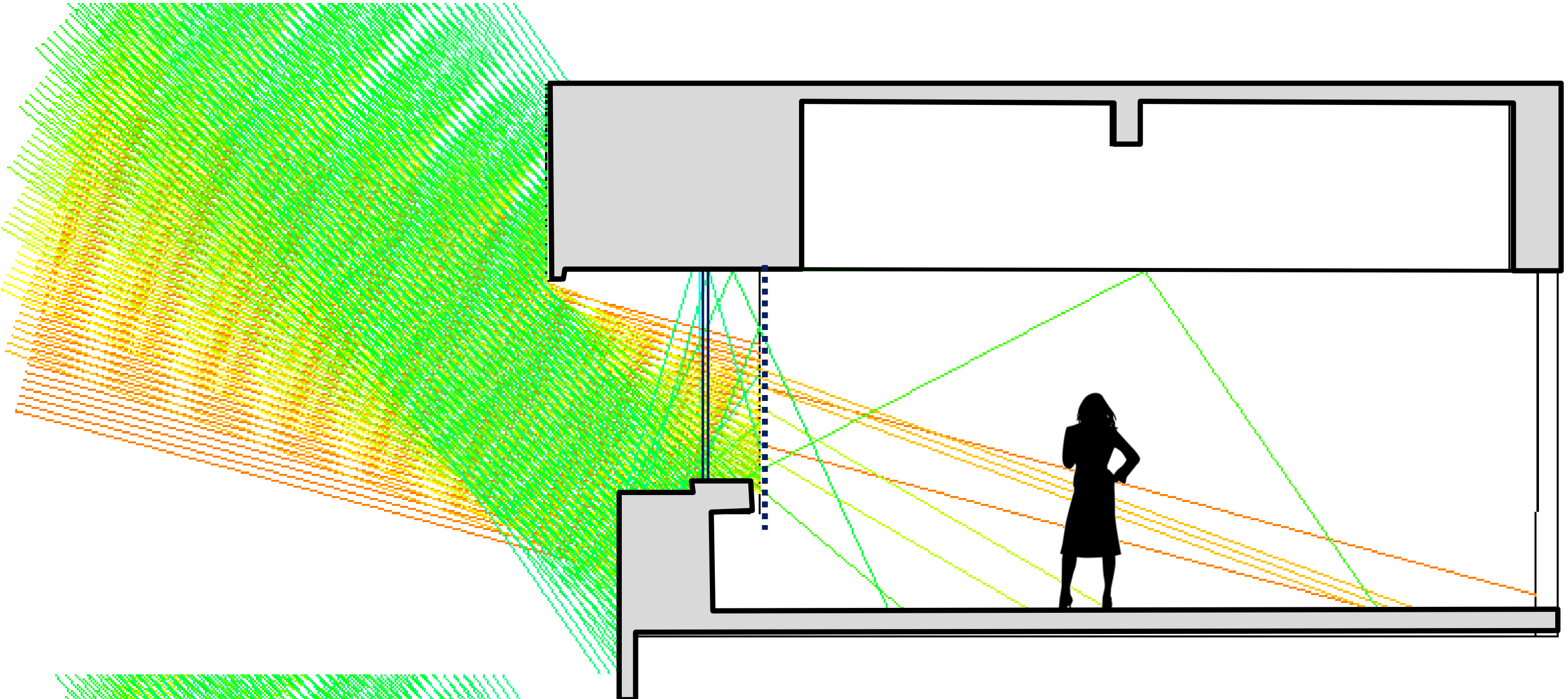
Before	After
57 dB	53 dB

Daylight

Before	After
No	Yes

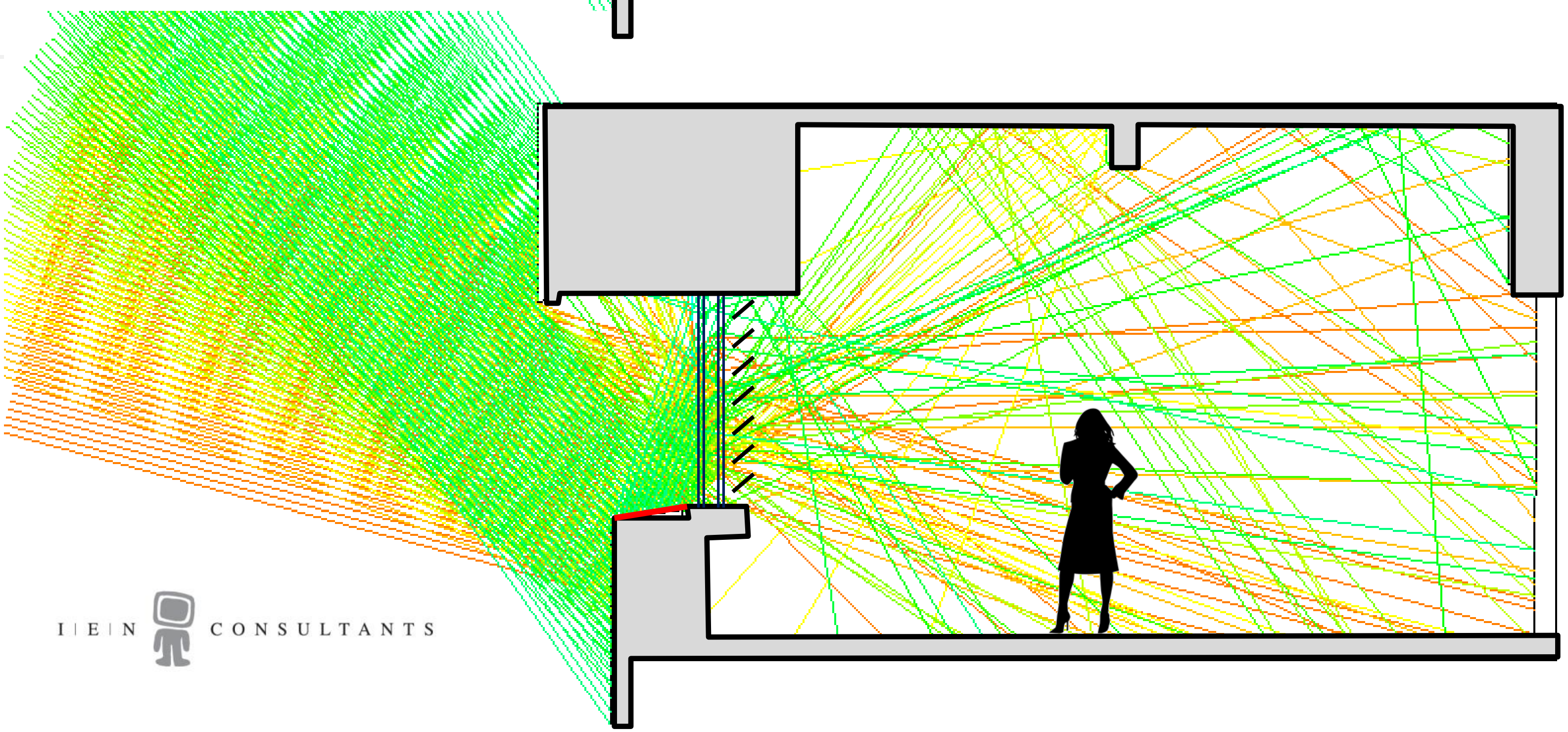
View out

Before	After
No	Yes



BEFORE RETROFIT

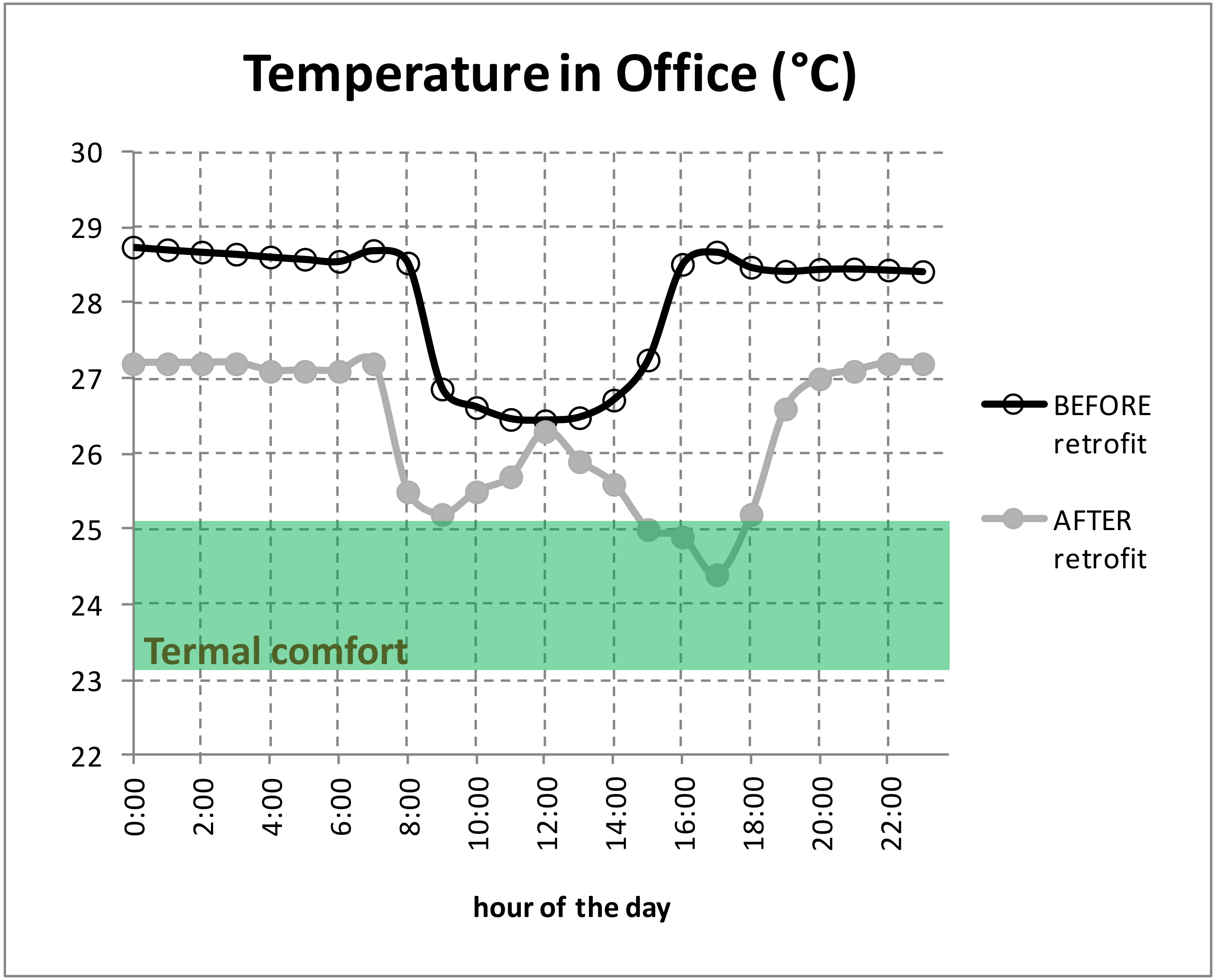
- Vertical blinds blocking most of the daylight
- Suspended ceiling
- Central air-conditioning
- Leaky windows



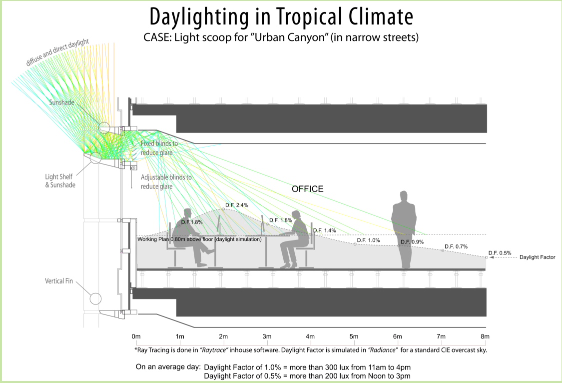
AFTER RETROFIT

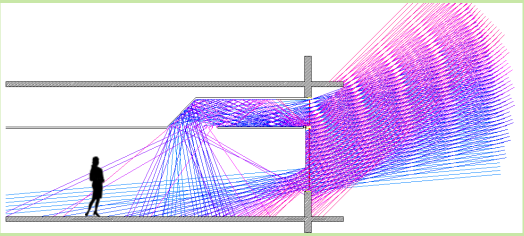
- Mirror lightshelf on external ledge reflecting diffuse daylight onto the high ceiling (suspended ceiling removed)
- Perforate venetian blinds
- Extra window pane
- VRF air-con with CO_2 sensor

Measured indoor climate: Before vs. After



Case studies (ongoing)





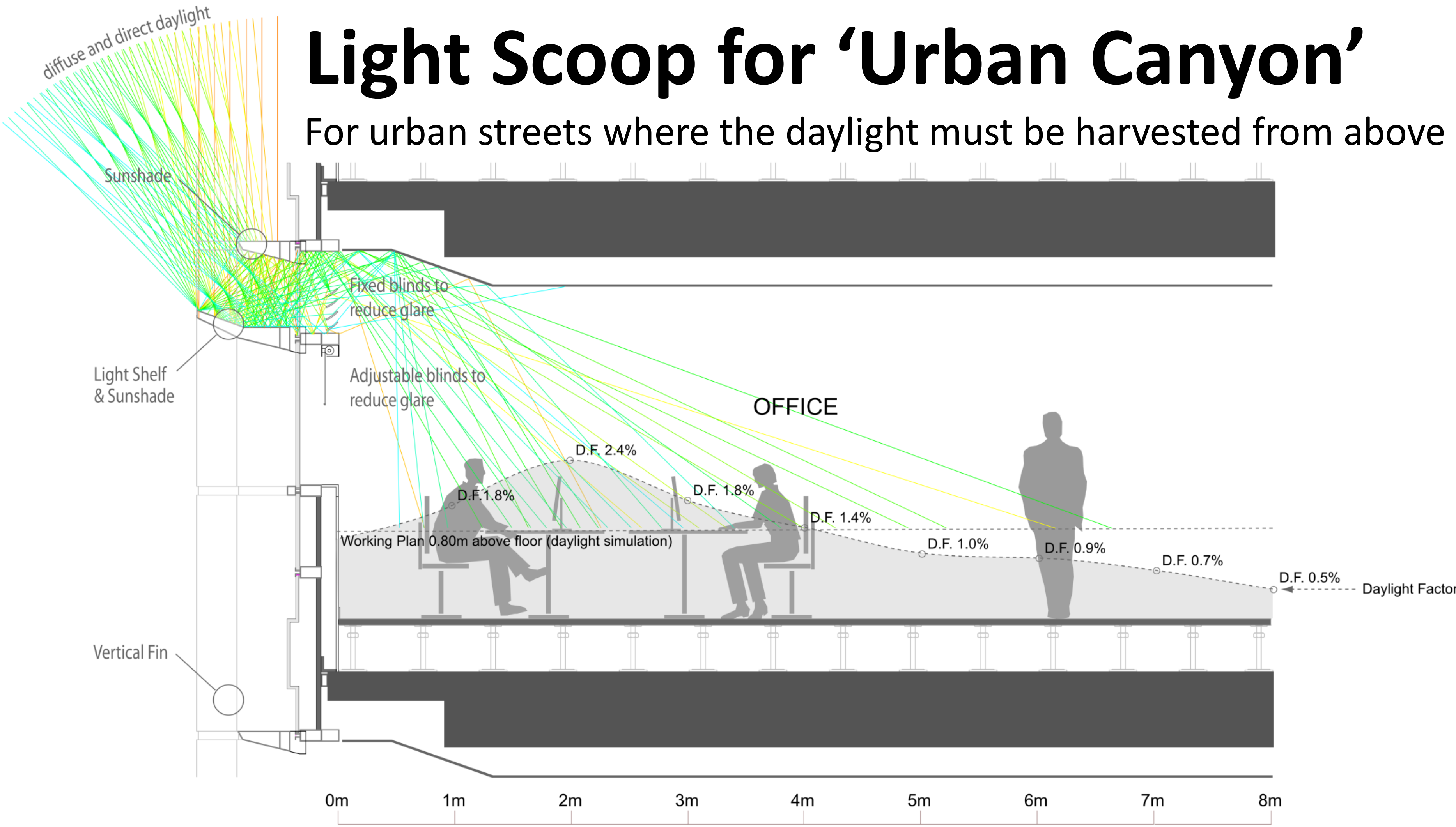
Tropcial highrise energy efficient facade case studies

INNOVATIVE DESIGNS

(MALAYSIA AND SINGAPORE, 2015)

Light Scoop for 'Urban Canyon'

For urban streets where the daylight must be harvested from above

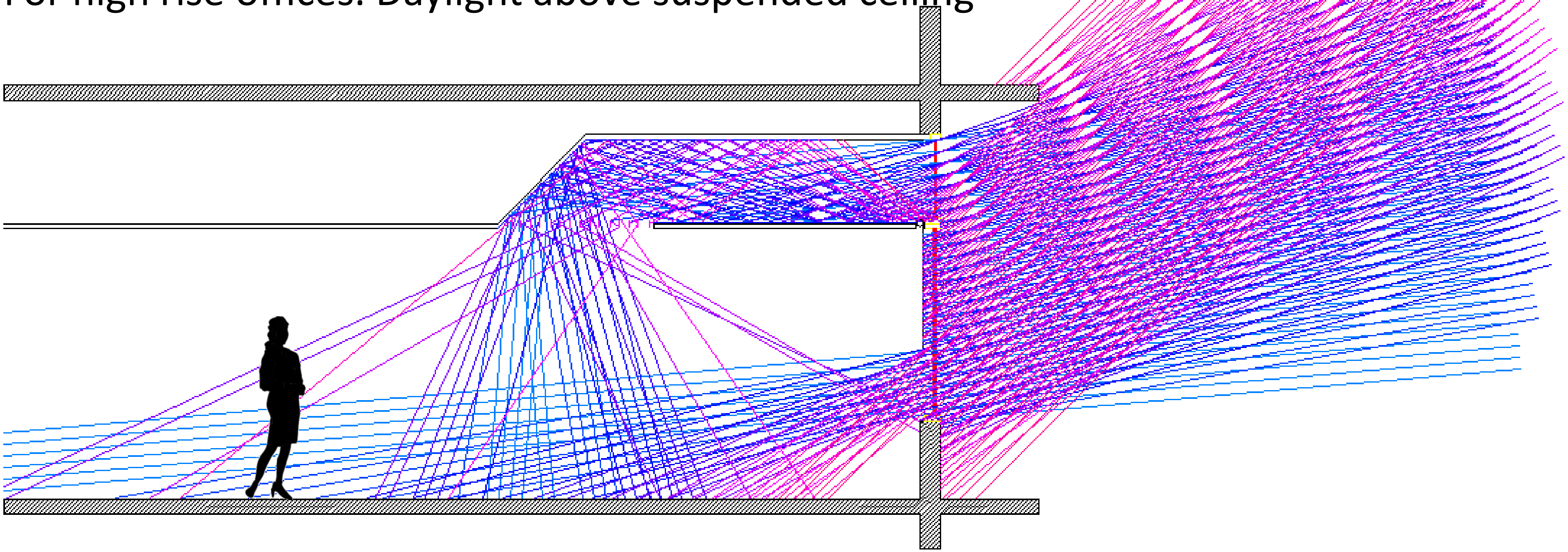


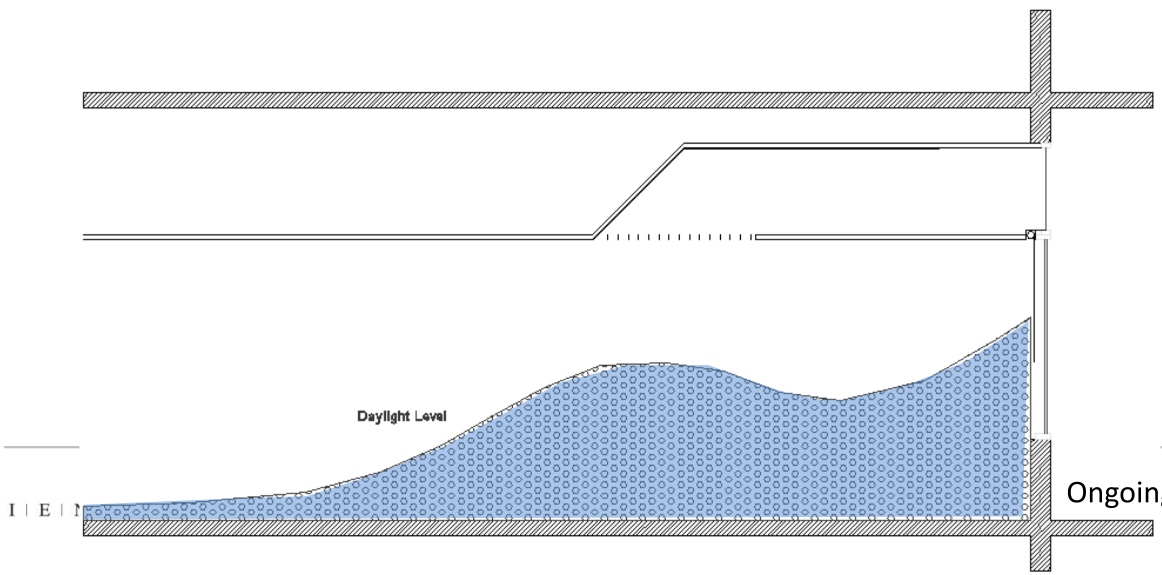
*Ray Tracing is done in *"Raytrace"* inhouse software. Daylight Factor is simulated in *"Radiance"* for a standard CIE overcast sky.

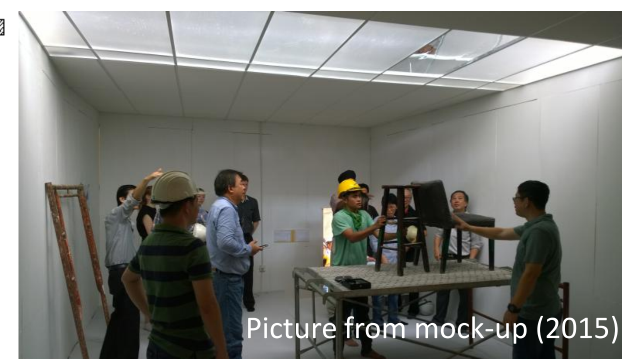
On an average day: Daylight Factor of 1.0% = more than 300 lux from 11am to 4pm
Daylight Factor of 0.5% = more than 200 lux from Noon to 3pm

Horizontal Light Trough

For high rise offices. Daylight above suspended ceiling







Picture from mock-up (2015)

Ongoing project in Kuala Lumpur, completion 2016

Window film instead of Lightshelf

This will solve the maintenance issue lightshelf cleaning

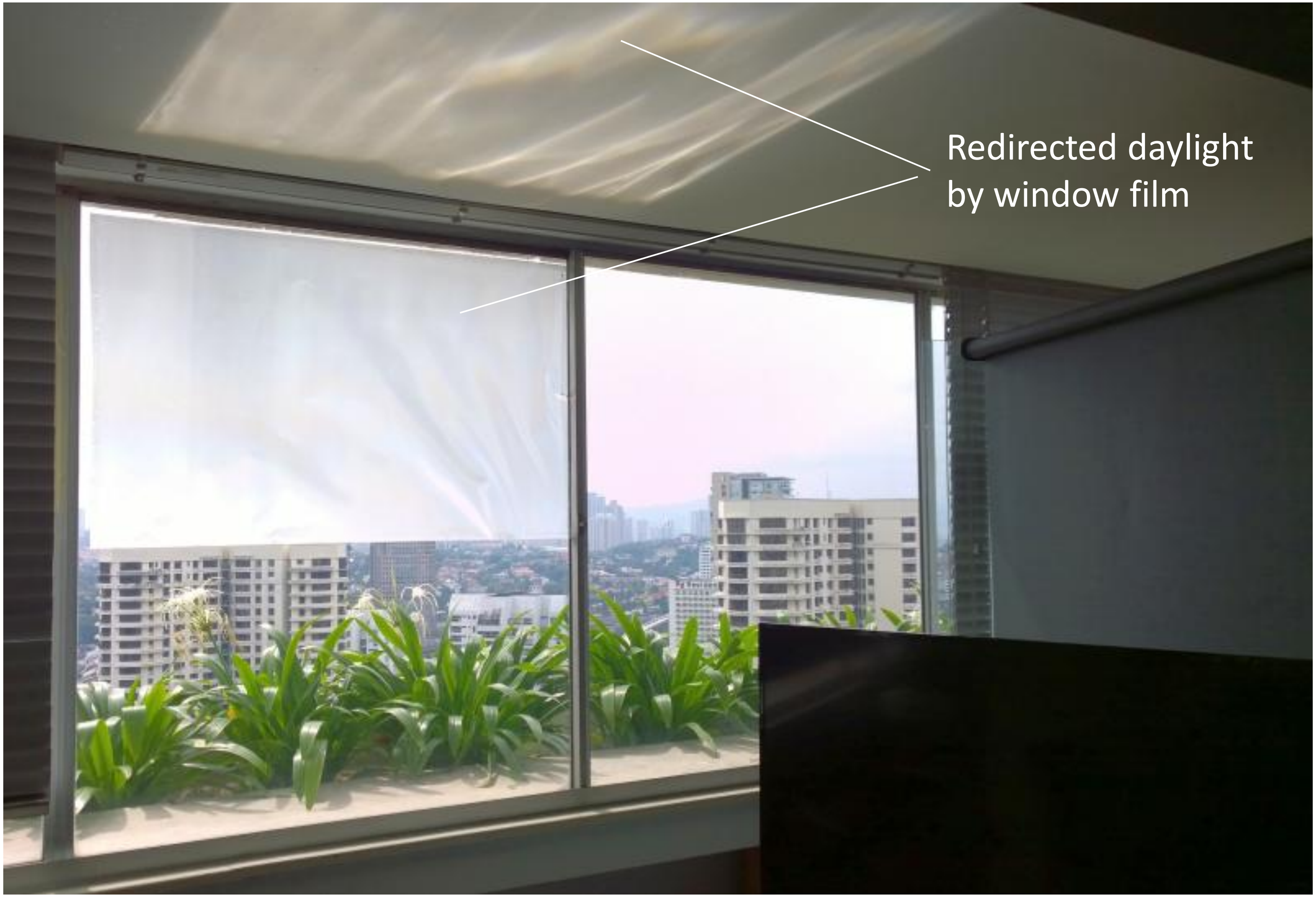


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Photo from IEN Consultants office (Kuala Lumpur)
in preparation for demonstration project in Singapore (2015/2016)

Conclusions

- **Paradigm shift** for energy efficiency. It's a must!

- **Buildings** and **City Planning** (transport) play a key role to achieve global environmental targets

- **Architecture** must adhere to climate & culture

  Commercial buildings architecture:
  1) Design for daylight
  2) Limit solar heat gain

  Residential buildings architecture:
  1) Design for cross ventilation / elevated air velocities

Buildings are Like a Leaky Bucket

with lots of unnecessary wastages

Plug the holes, and you are well on the way to a green inexpensive buildings that people appreciate to use

Thank you

Gregers Reimann

Managing director, IEN Consultants

gregers@ien-consultants.com | +60122755630

Singapore | Malaysia | China

Thank you

Let's flip it around!

Gregers Reimann

Managing director, IEN Consultants

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Singapore | Malaysia | China

Appendix slides

Energy Efficiency consultancy
Senior Consultant curriculum

Nationality: Danish
Language Skills: EN | DA
Based in: Kuala Lumpur, Malaysia

Education:
•MSc Energy Engineering (Technical University of Denmark)

Gregers REIMANN
Roles: **Energy Efficiency Consultant**

Gregers is the managing director of IEN Consultants, the pioneering green building consultancy in Malaysia, with offices in Singapore as well as China. He specialises in building designs that have good daylighting, are highly energy efficient and have excellent thermal and visual comfort.

Key project references during his 10 years of working in Asia include the Setia City Mall (first green certified shopping mall in Malaysia), the new IKEA in Kuala Lumpur (ongoing), ST Diamond Building (2012 ASEAN Energy Award winner) and the GEO Building designed to be a zero energy office building. Other green projects include the KLIA2 airport terminal, the KL Eco City, energy efficiency building retrofit works, and the Pertamina Energy Tower – the first skyscraper designed to be ZERO energy. Gregers has also been a technical reviewer for the EU Energy-Efficiency Buildings project and is newly appointed Chairman of the "Green Buildings and Sustainable Communities" committee under the EU-Malaysian Chambers of Commerce and Industries (EUMCCI).

Gregers regularly contributes to green building articles and frequently guest lectures at universities internationally. He has a keen interest to pursue innovative and integrated design solutions bridging the gap between architects and engineers. Gregers is also 'walking the talk' with respect to green living habits, which includes commuting to work by a foldable electric bicycle that combines easily with public transport.

Green Building consultancy
Senior Consultant curriculum

Nationality: American
Language Skills: EN | FR
Based in: Singapore

Education:
• MCP in Urban Planning (MIT)
• MA in Urban History (Columbia University)

Kevin SULLIVAN
Roles: **Green Building Consultant**

Kevin has been a carpenter, community organizer, educator, and environmental entrepreneur. Since 2008 he has founded and led two leading sustainability consulting firms in India and Singapore. Kevin has been a design consultant on more than one hundred building projects across the United States, Middle East, India and Asia.

An expert on green schools, Kevin has developed energy-efficiency strategies and educational tools to teach and engage students in green design concepts for top international K-12 schools across Asia. In 2006 he served as a Fulbright Scholar at India's premier environmental think tank, The Energy and Resources Institute in New Delhi. Before moving to India, Kevin was a Policy and Project Director for one of the largest US community-based housing NGOs, where he pioneered the first low-cost urban green homes. Kevin was an Adjunct Professor in the Urban Environment at Queens College as the City University of New York.

Kevin is trained as an architect and urban planner and writes and speaks widely on urban and environmental issues. He has an MCP in Urban Planning from the Massachusetts Institute of Technology and an MA in Urban History from Columbia University. He lives with his family in Singapore.

Different Glazing Performances

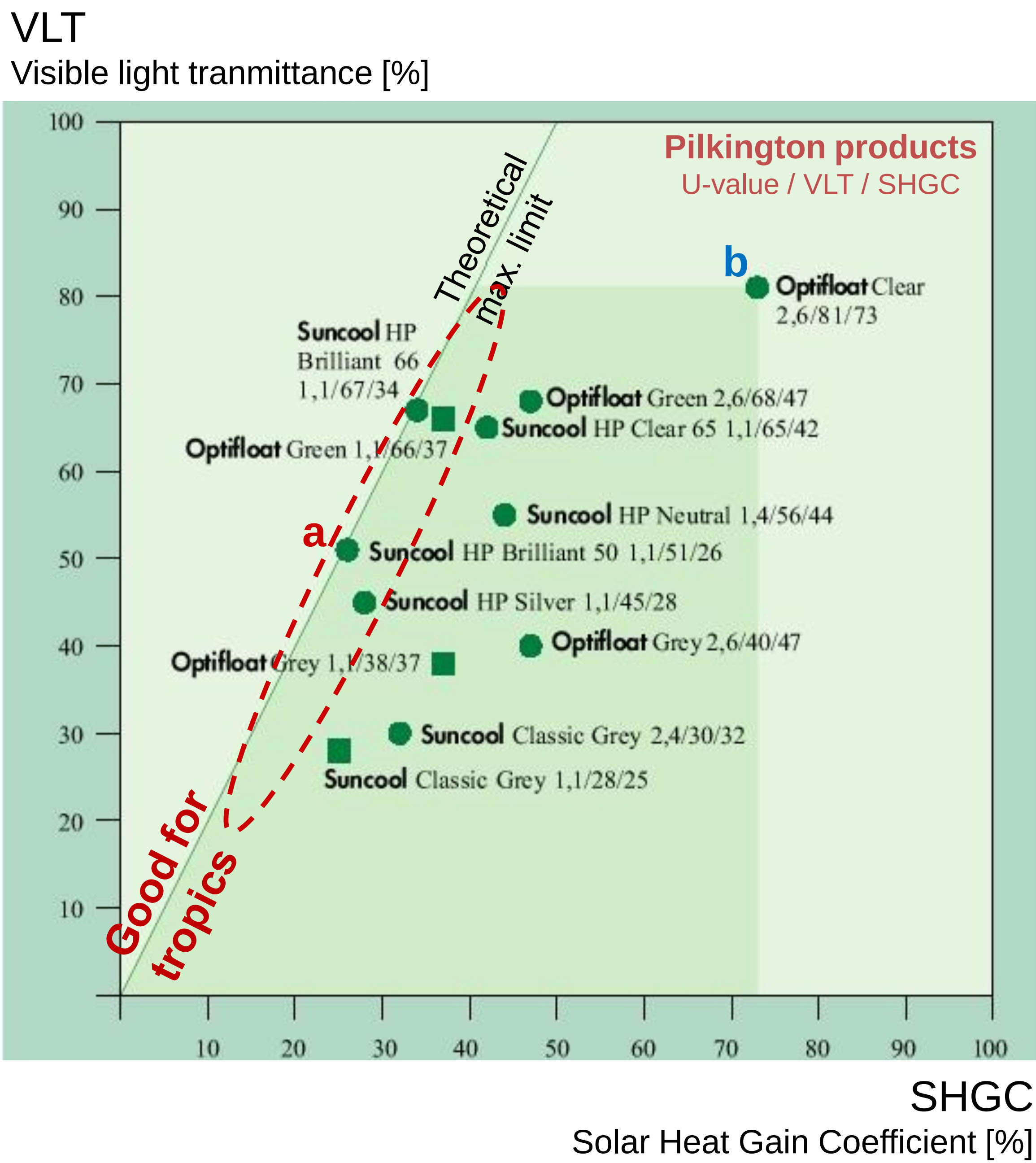
Examples

a) Suncool HP Brilliant 50
- VLT: 51%
- SHGC: 26%
- VLT/SHGC ratio: 1.96

NB. Spectrally selective, allowing light, blocking heat

b) Optifloat Clear
- VLT: 81%
- SHGC: 73%
- VLT/SHGC ratio: 1.11

NB. Only slightly spectrally selective



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Daylight is ‘Cool’