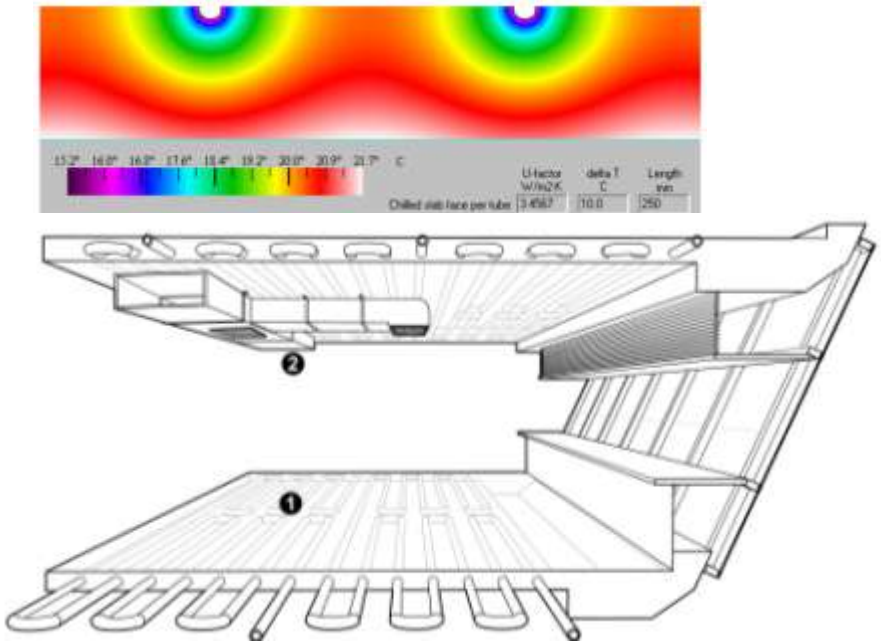
Innovative Energy Concepts for Buildings in Tropical Climates

Case Studies: Office buildings | Residential buildings | New & Retrofits



Gregers Reimann

Managing director, IEN Consultants

Energy Efficiency & Green Building Consultancy

gregers@ien.com.my | +60122755630

Singapore | Malaysia | China

Buildings & Energy

Buildings are like a leaky bucket with lots of unnecessary wastages

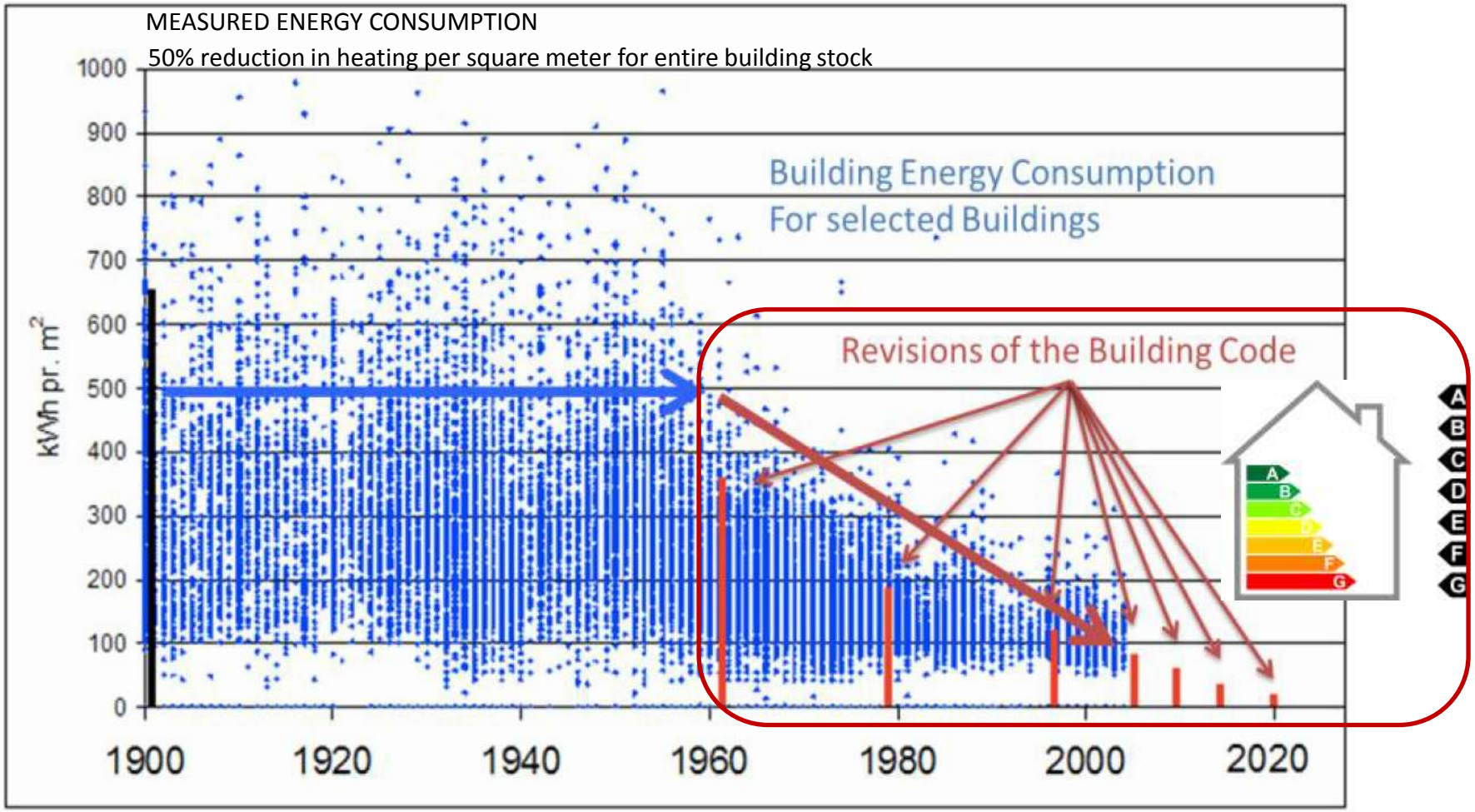
ENERGY SUPPLY
(renewable) energy

ENERGY STORAGE
electric cars/batteries/thermal

ENERGY DEMAND

Let’s plug the holes!

50% Energy Savings in Danish Building Stock



Let's do the same in Asia!

Energy Efficient Buildings with Good Payback time

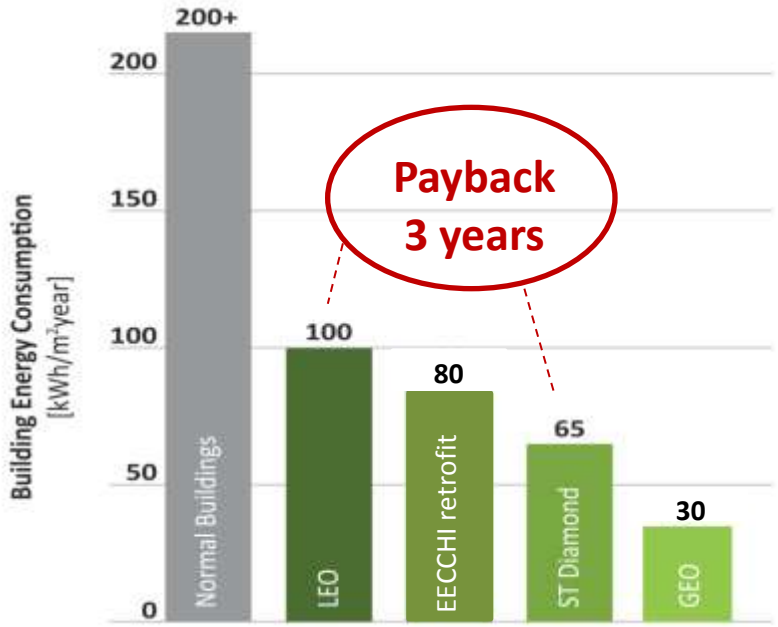
Case studies from the South East Asian countries

LEO Building

GEO Building

ST Diamond Building

EECCHI retrofit



Energy Consumption of Green Office Buildings

Measured data for New and Retrofitted Buildings by IEN Consultants

Completed year:	2004	2010	2010	2007

IEN CONSULTANTS

Two Tropical Office Building Case Studies

“Energy Efficient Buildings”
Malaysian stamp series

All buildings by IEN Consultants

GEO
building

DIAMOND
building

Where?
Both located about 25 km south of the capital, Kuala Lumpur, in Bangi and Putrajaya, respectively

Climate Data of Malaysia: Hot & Humid

MONTHLY DIURNAL AVERAGES
ASHRAE Standard 55

LOCATION: **KUALA LUMPUR, -, MYS**
Latitude/Longitude: 3.12° North, 101.55° East, **Time Zone from Greenwich** 8
Data Source: IWEC Data 486470 WMO Station Number, **Elevation** 22 m

LEGEND

HOURLY AVERAGES

TEMPERATURE: (degrees C)
- DRY BULB MEAN
- WET BULB MEAN
- DRY BULB (all hours)

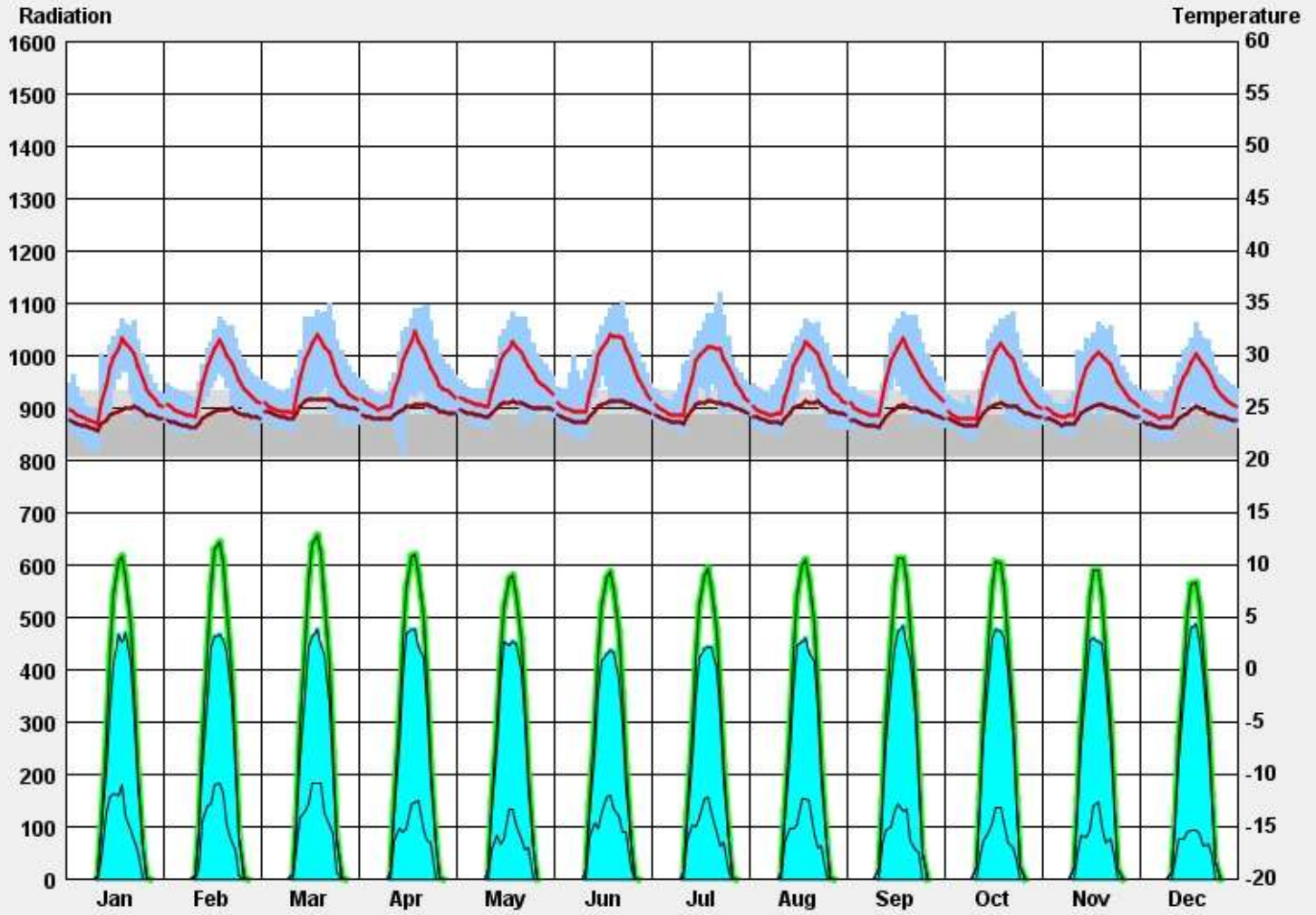
COMFORT ZONE
- SUMMER
- WINTER

(At 50% Relative Humidity)

RADIATION: (Wh/sq.m)
- GLOBAL HORIZ
- DIRECT NORMAL
- DIFFUSE

☑ Display Dry Bulb Temp
(all hours)

TEMPERATURE RANGE:
- ◉ -10 to 40 °C
- ○ Fit to Data



Case study no. 1

Energy Efficient Office case study in Bangi:

GEO BUILDING

(MALAYSIA, 2007)

GEO Building (formerly ZEO) in Malaysia

Key data:

- Gross Floor Area: 4,000 m²
- Energy Index: 64 kWh/m²/year (excl. PV)
- Energy Index: 30 kWh/m²/year (incl. PV)
- Additional construction cost: 18% (excl. PV)
- Additional construction cost: 33% (incl. PV)

EE Features:

- Daylighting (almost 100%)
- EE lighting + task lights
- EE office equipment
- EE server room
- Floor slab cooling
- EE ventilation
- Controls & Sensors
- Double glazing
- Insulation

Greentech Malaysia office, Bangi, Malaysia (Occupation Oct 2007)

Energy Design Concepts

of GEO Building

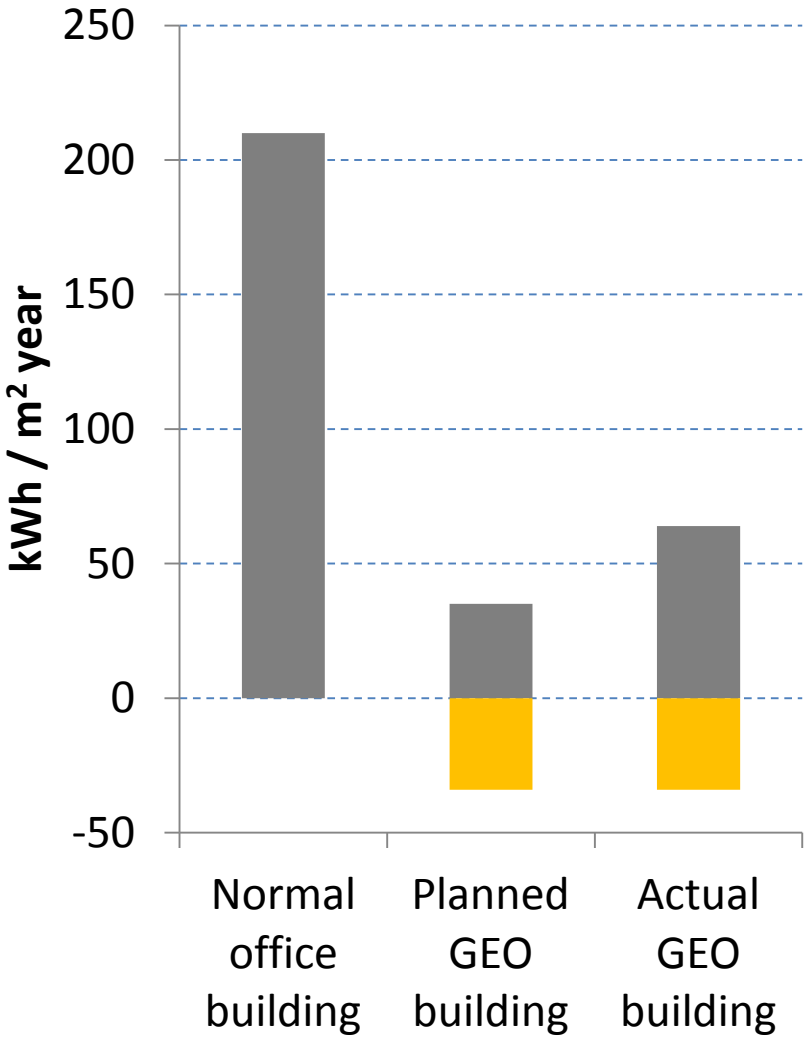
Concept no. 1

Zero Energy Building

Concept no. 2

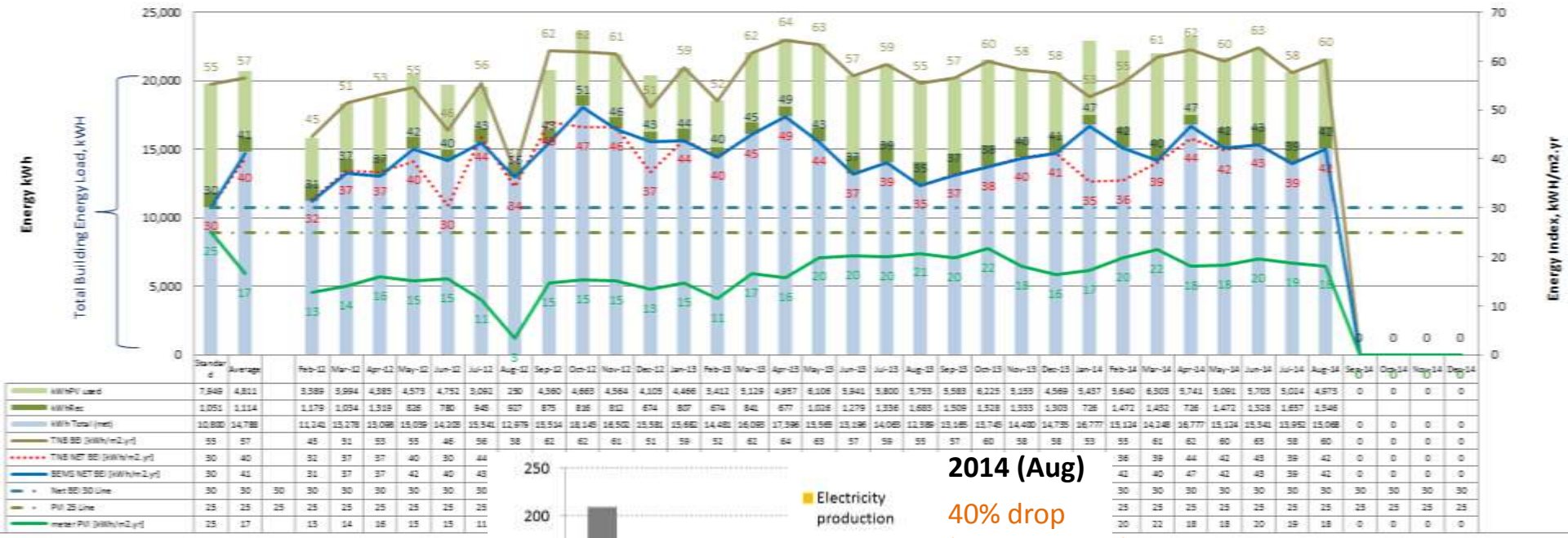
Shift load to the night, hence, reducing peak demand for power utilities

Concept no. 1: Zero Energy Building

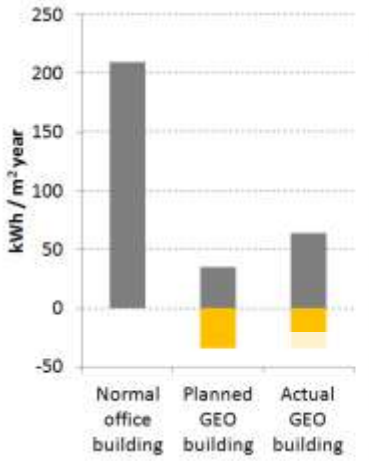


GEO building: Latest energy measurements

Graph 1 : GEO Building Energy Usage & Generation Performance , 2012-2014(Aug)



	Standard	Average		Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
kWhPV used	7,849	4,811		3,389	3,994	4,385	4,573	4,752	3,092	290	4,360	4,663	4,564	4,105	4,466	3,412	5,129	4,957	6,106	5,941	5,800	5,753	5,583	6,225	5,155	4,569	5,457	5,640	6,303	5,741	5,091	5,703	5,014	4,573	0	0	0	0
kWhRec	1,051	1,114		1,179	1,034	1,319	826	780	945	927	875	836	812	674	807	674	841	677	1,026	1,279	1,336	1,683	1,509	1,528	1,333	1,303	726	1,472	1,432	726	1,472	1,328	1,657	1,546				
kWh Total (net)	10,800	14,788		11,141	13,278	13,098	15,099	14,205	15,541	12,979	15,514	18,145	16,502	15,581	15,662	14,481	16,098	17,396	15,565	13,196	14,045	12,986	13,165	13,745	14,400	14,795	16,777	15,124	14,248	16,777	15,124	15,341	13,952	15,068	0	0	0	0
TNB BD (kWh/m2.yr)	55	57		45	51	53	55	46	56	38	61	63	61	51	59	52	62	64	63	57	59	55	57	60	58	58	53	55	61	62	60	63	58	60	0	0	0	0
TNB NET BD (kWh/m2.yr)	30	40		32	37	37	40	30	44	34	44	51	46	43	44	40	45	49	44	37	39	35	37	38	40	41	35	36	39	44	42	43	39	41	0	0	0	0
BEMS NET BD (kWh/m2.yr)	30	41		31	37	37	42	40	43	36	43	47	45	37	44	40	45	49	43	37	39	35	37	38	40	41	47	41	40	47	42	43	39	41	0	0	0	0
Net BD 30 Line	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
PV 25 Line	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
meter PV (kWh/m2.yr)	25	17		13	14	16	15	15	11	5	15	15	15	13	15	11	17	16	20	20	20	21	20	22	18	16	17	20	22	16	18	20	19	18	0	0	0	0



2014 (Aug)

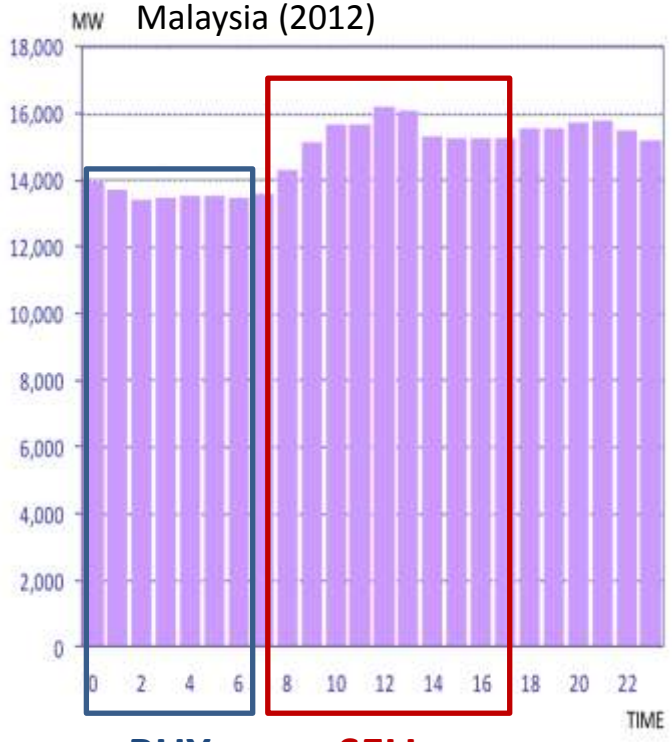
40% drop
(inverter problem)

No change

Concept no. 2: Shift load to the night

Electricity demand curve

Malaysia (2012)



	BUY	SELL
	electricity from the grid	electricity to the grid
How?	Thermal storage	Solar PV

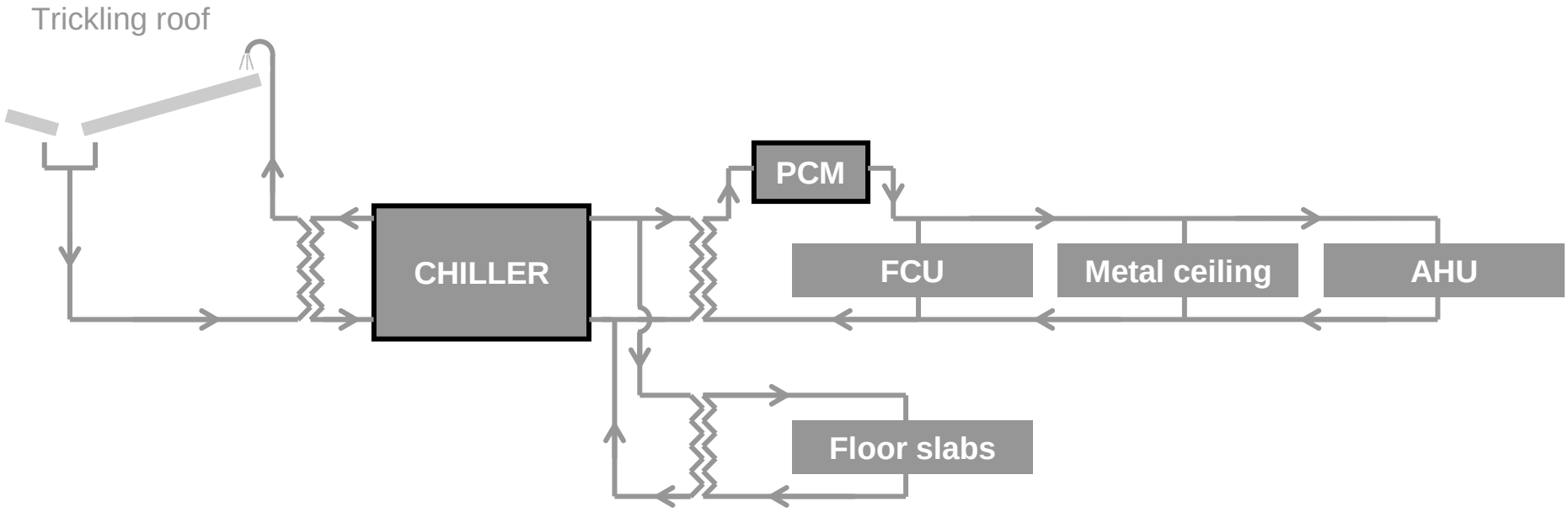
Building integrated photovoltaic (91 kW_p)

Floor slab cooling (18°C) and Phase Change Material tank (10°C)

IEN CONSULTANTS

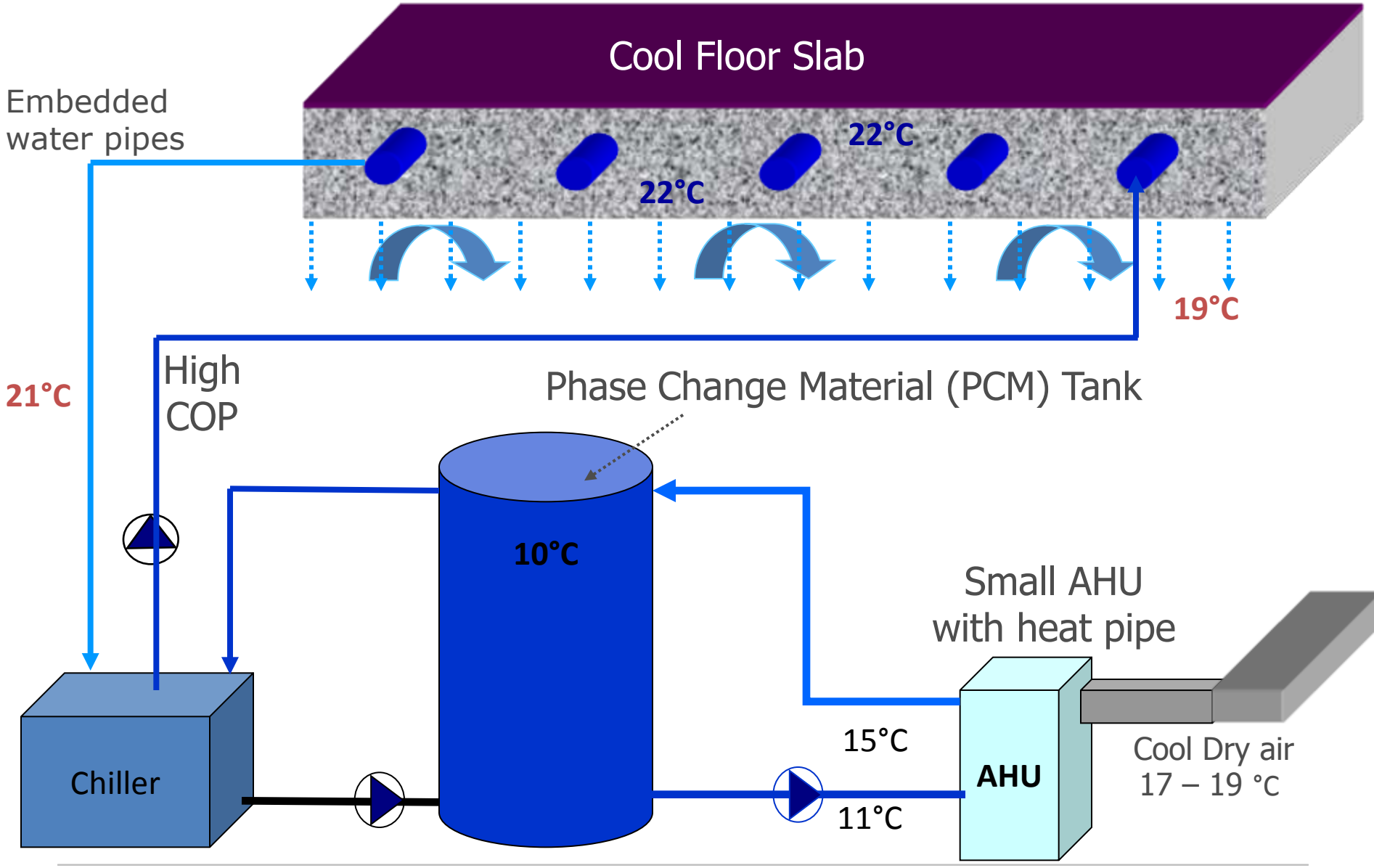
Schematic Design of Cooling System

GEO building



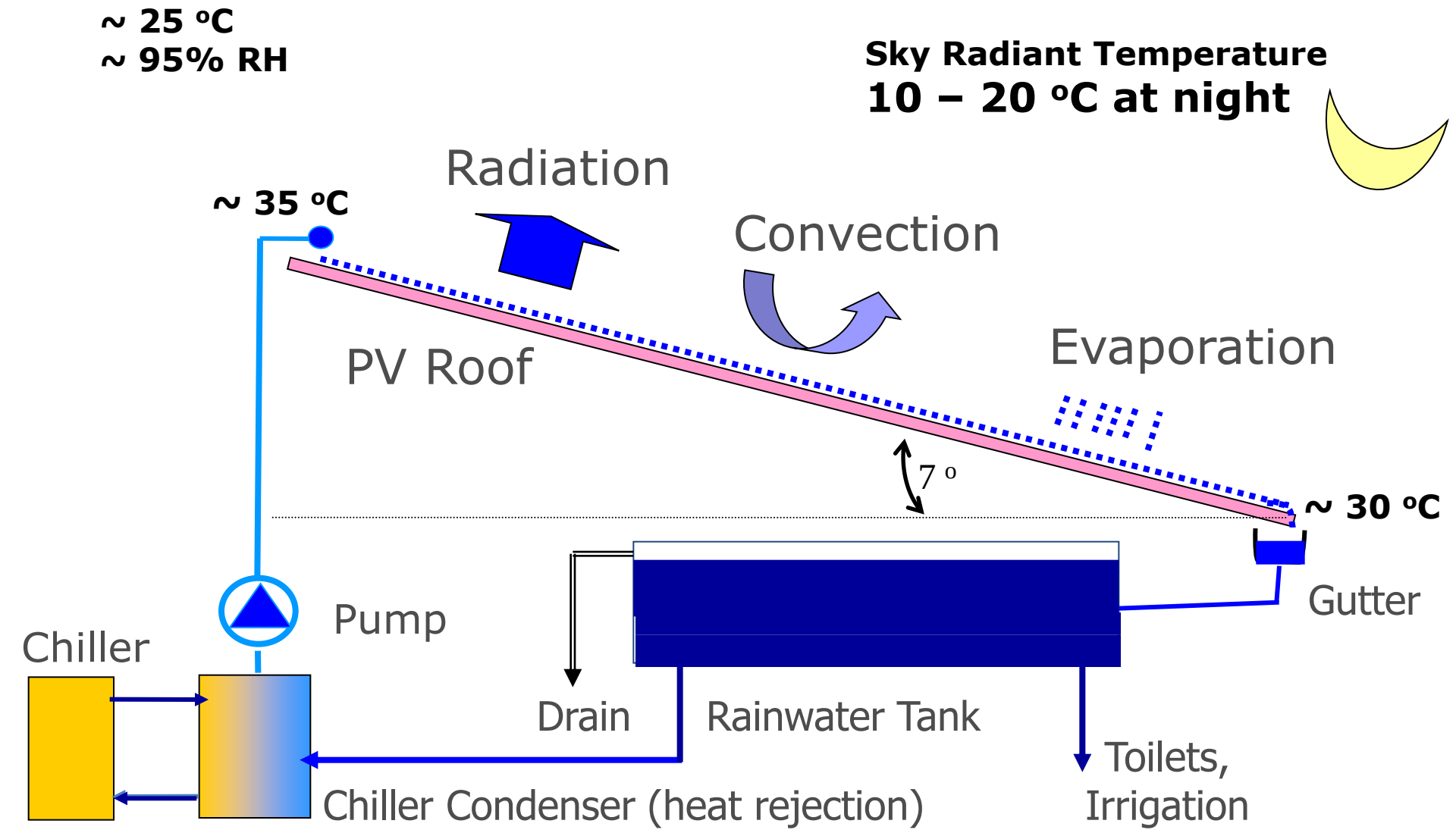
PCM:	Phase Change Material (thermal storage tank with “10°C ice”)
FCU:	Fan Coil Units
Metal ceiling:	Radiant cooling metal ceiling
AHU:	Air handling unit
Floor slabs:	Concrete floor and ceiling slab cooling (TABS, thermally activate building structure)
Trickling roof:	7° tilt flat roof flooded with condenser water at night to eject heat (replaces cooling tower)

Cooling Storage in Floor Slabs and PCM Tank



Rainwater Collection and River Roof

(alternate cooling tower)



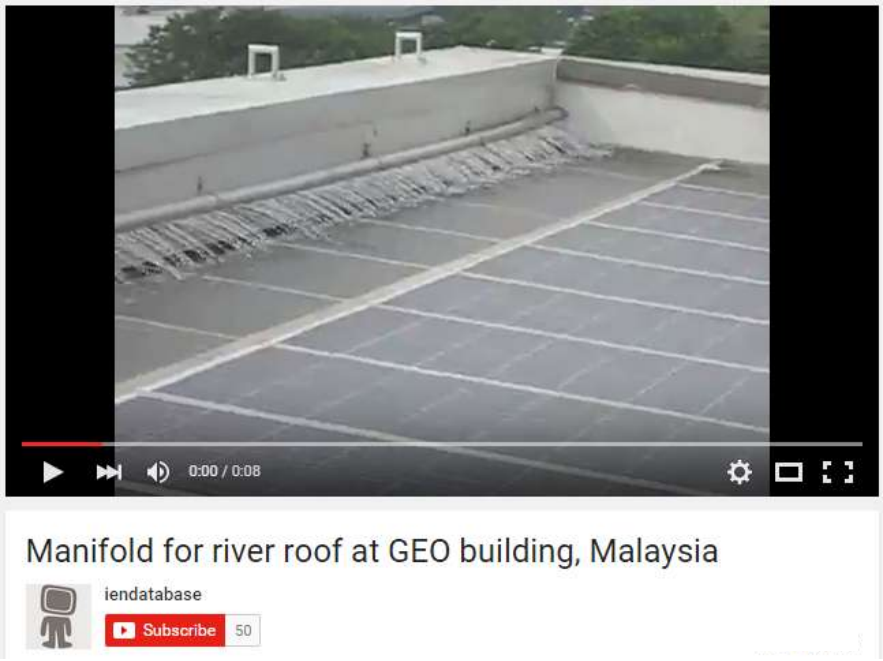
The River Roof of GEO Building

to be operated at night only

Video 1:
Gutter for ‘cooling tower’ water & rainwater

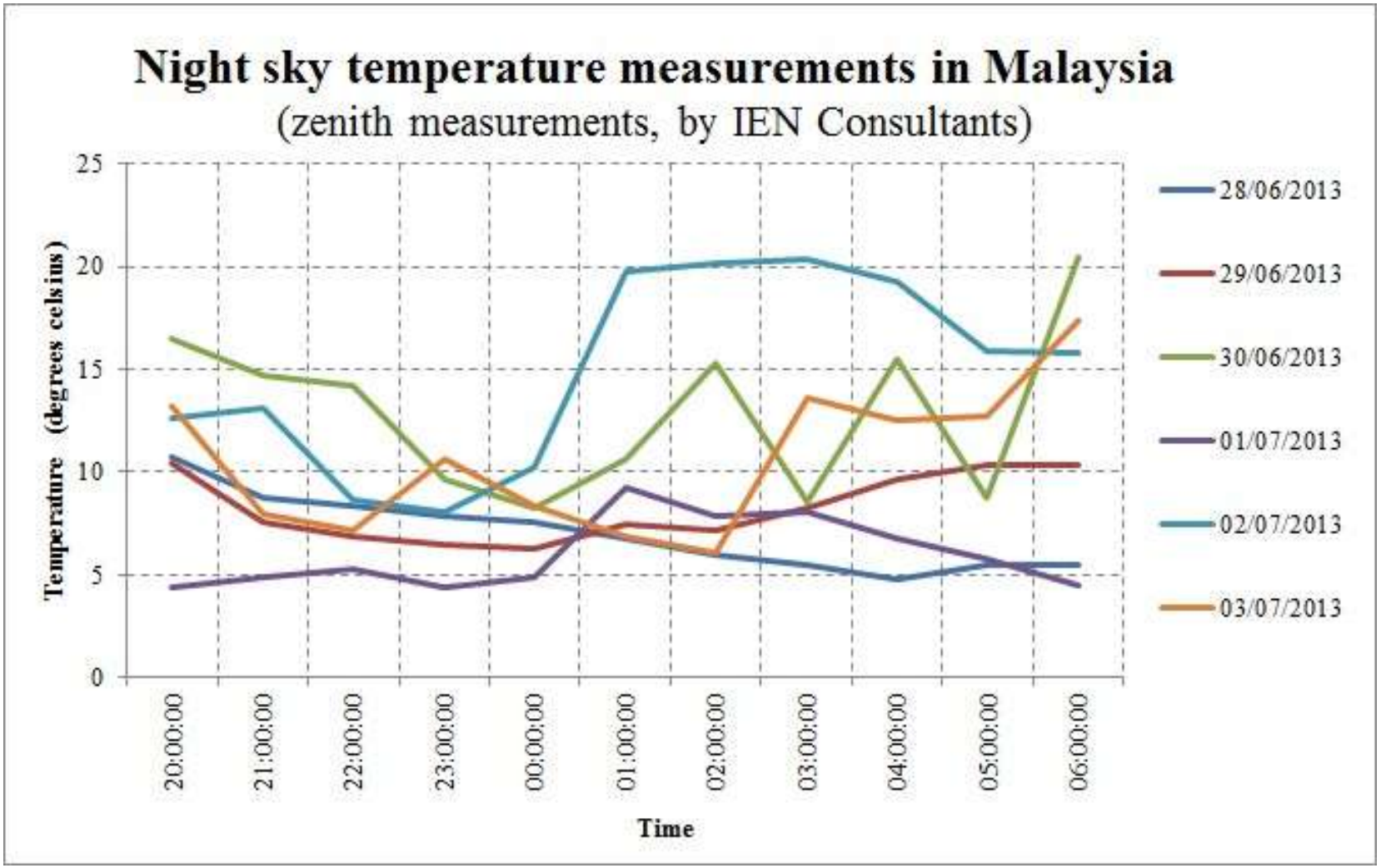
Video link:
https://www.youtube.com/watch?v=h8gC4dlB330

Video 2:
Manifold splashing water onto PV roof



Video link:
https://www.youtube.com/watch?v=nb_JntSXoiA

River roof cooling primarily through sky radiation



Phase Change Material Tank

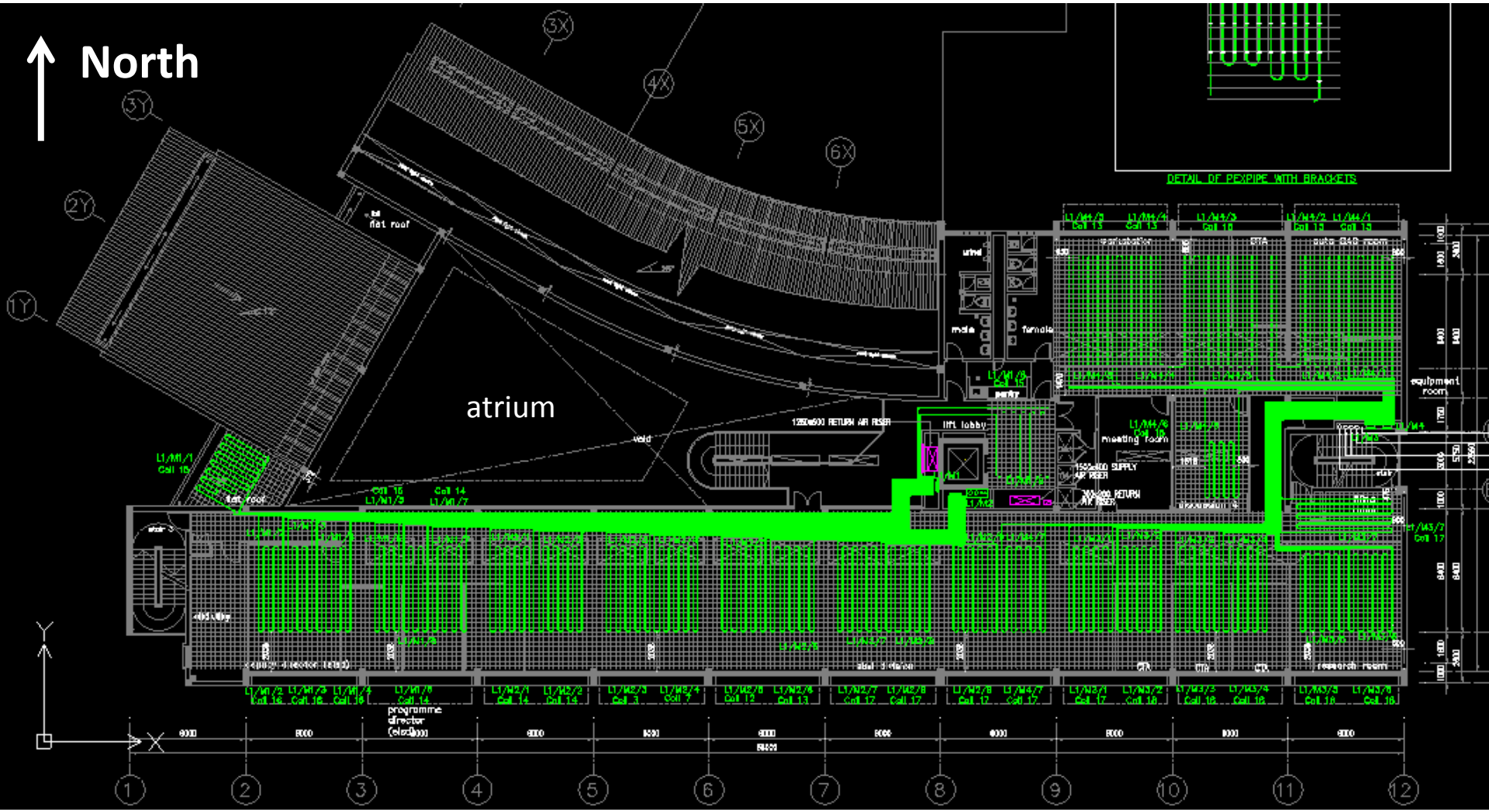
- Melting point: 10°C
- Total storage capacity: 580 kWh
- Charged with 7°C water (night time)
- Used for dehumidification of air: 19 → 8 g/kg

Dimensions: ~ 3 x 3 x 2.5 meters

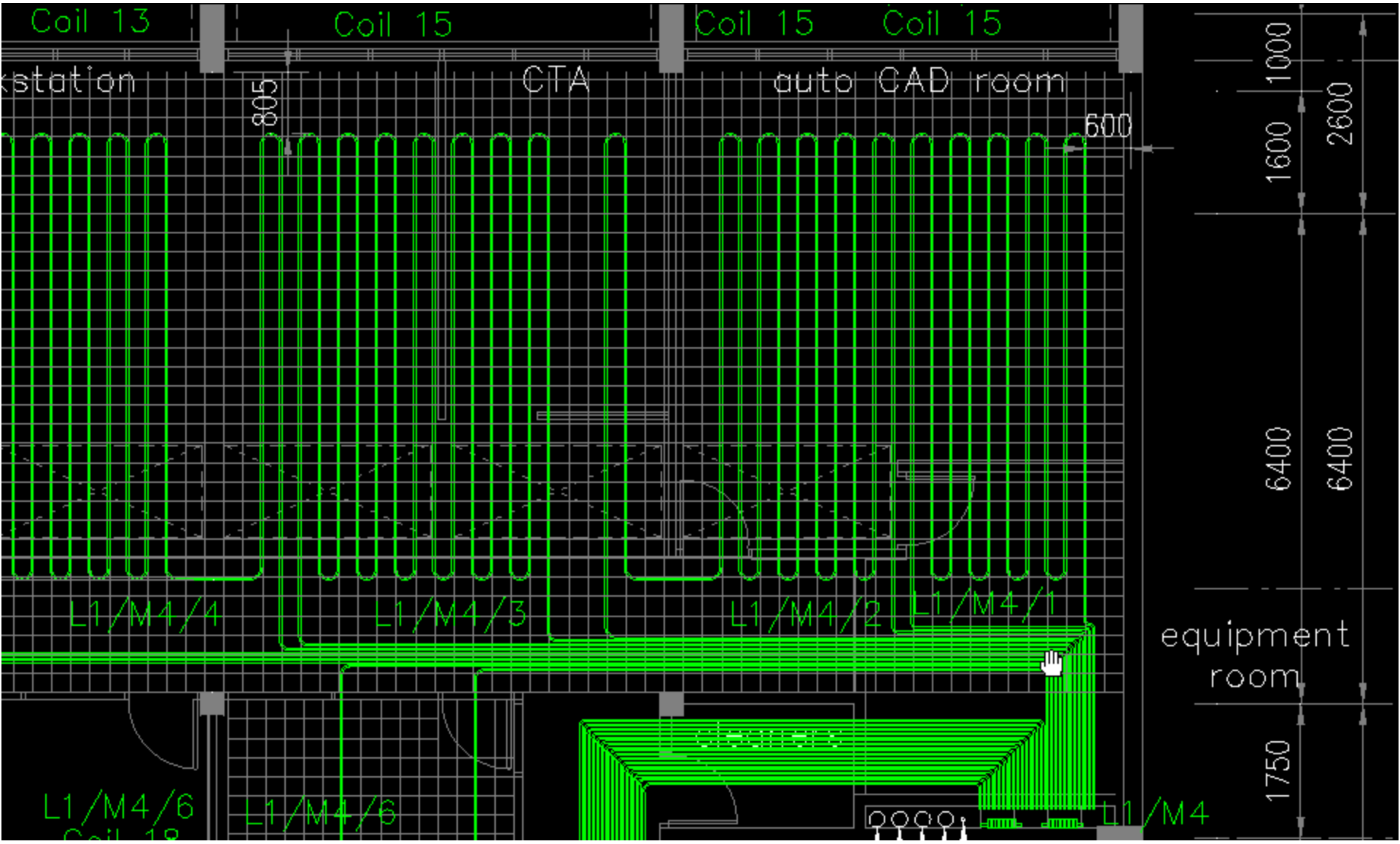
GEO building: Floor Slab Cooling

- PEX pipes
- Embedded in concrete slab
- Supply temperature: 18-20°C
- Return temperature: 22-24°C
- Night time operation only

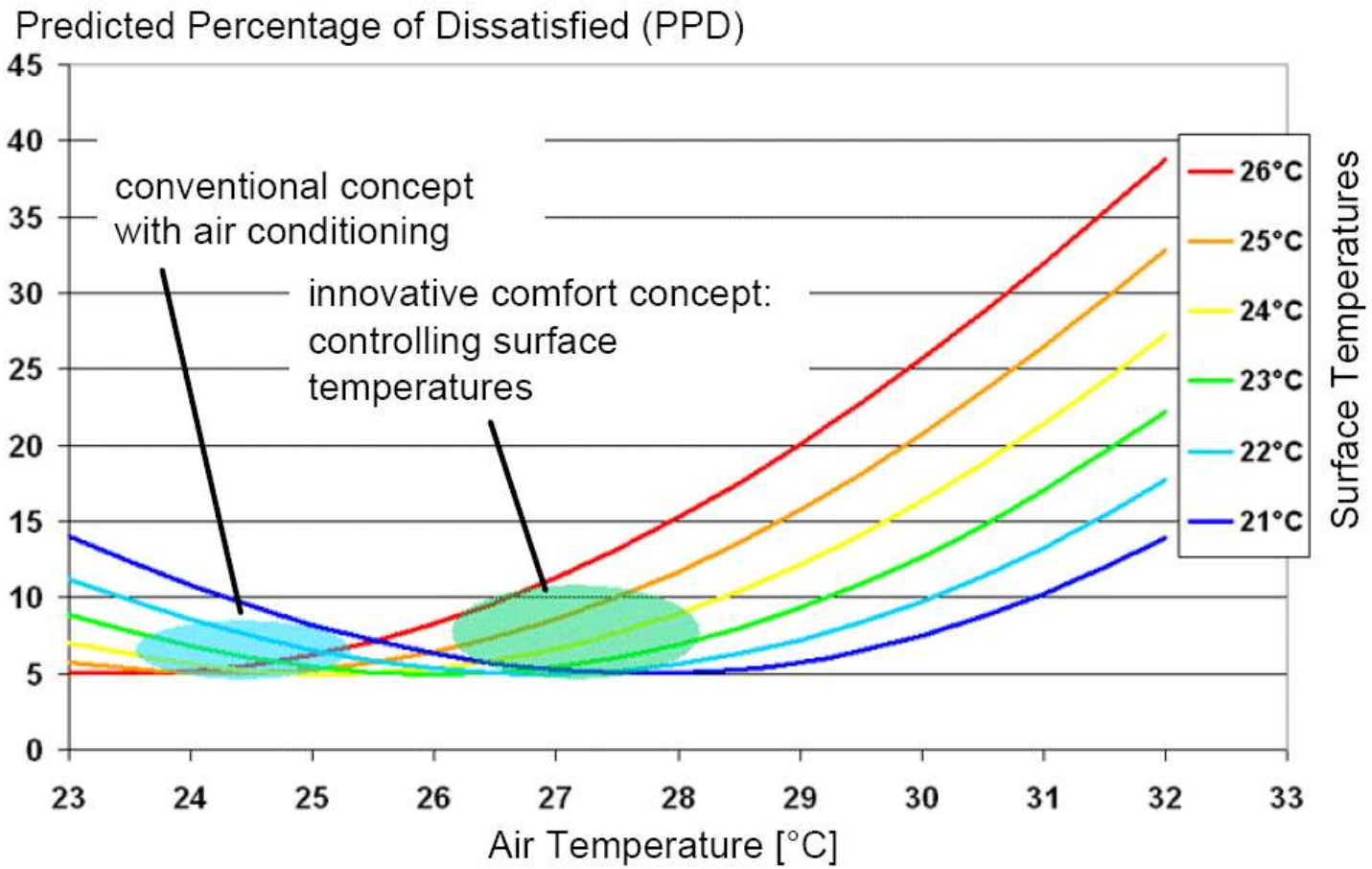
GEO building: Floor Slab Cooling



GEO building: Floor Slab Cooling



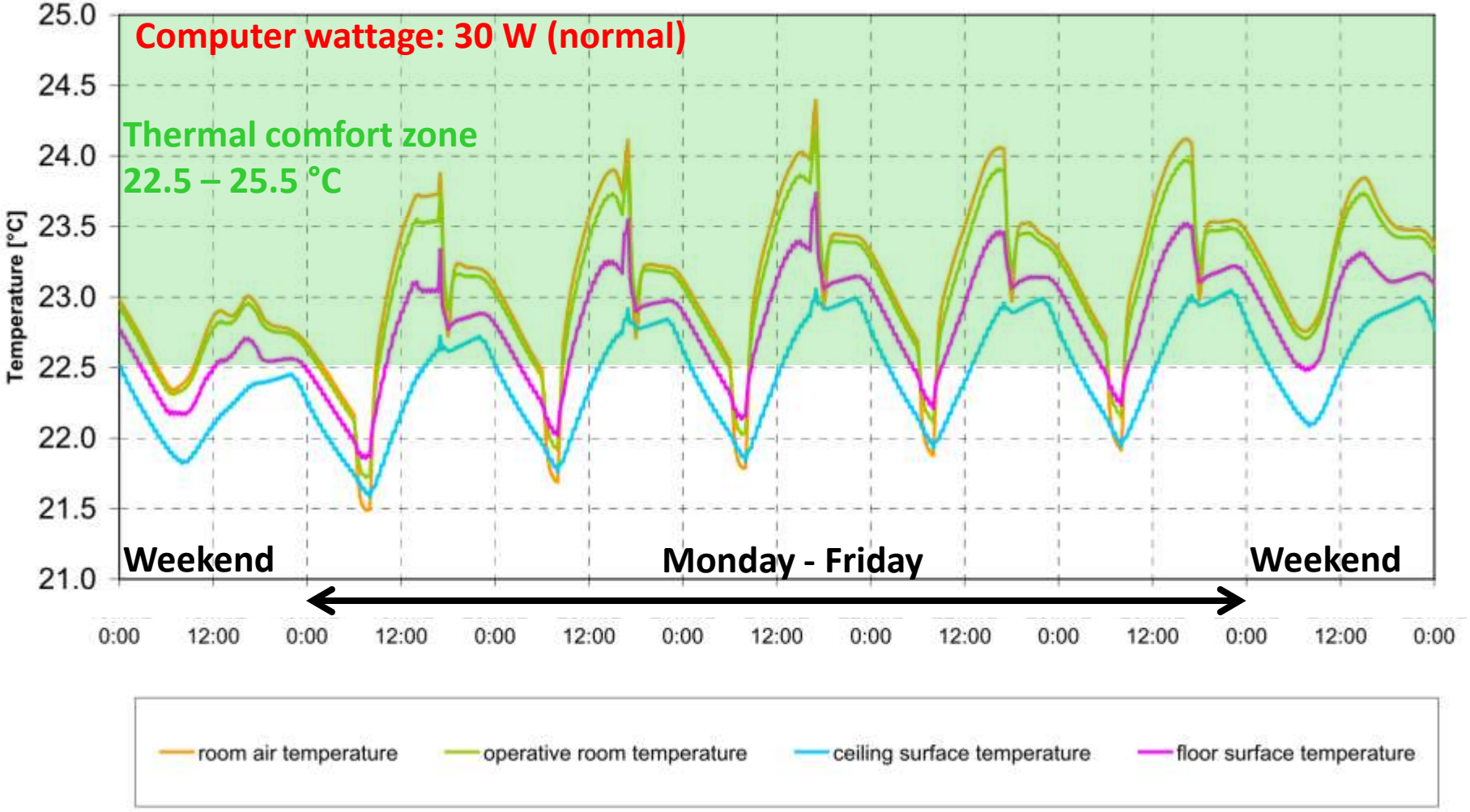
Radiant Cooling allows Higher Air Temperature



Predicted percentage of dissatisfied (PPD) according to Prof. O. Fanger
different surface temperatures; no direct radiation
office work, light clothing air velocity 0.15 m/s; humidity 11 g/kg

Thermal Comfort for Concrete Floor Slab Cooling

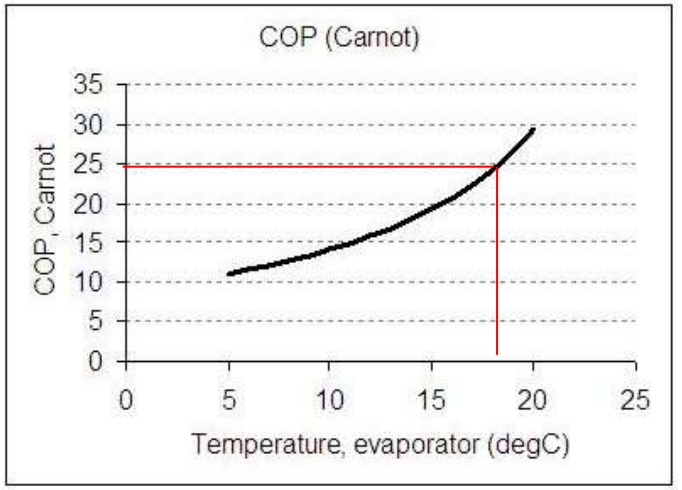
Slab cooling 10 pm – 8 am



Efficient High Temperature Cooling

$$COP_{refrigerator} = \frac{T_c}{T_H - T_C}$$

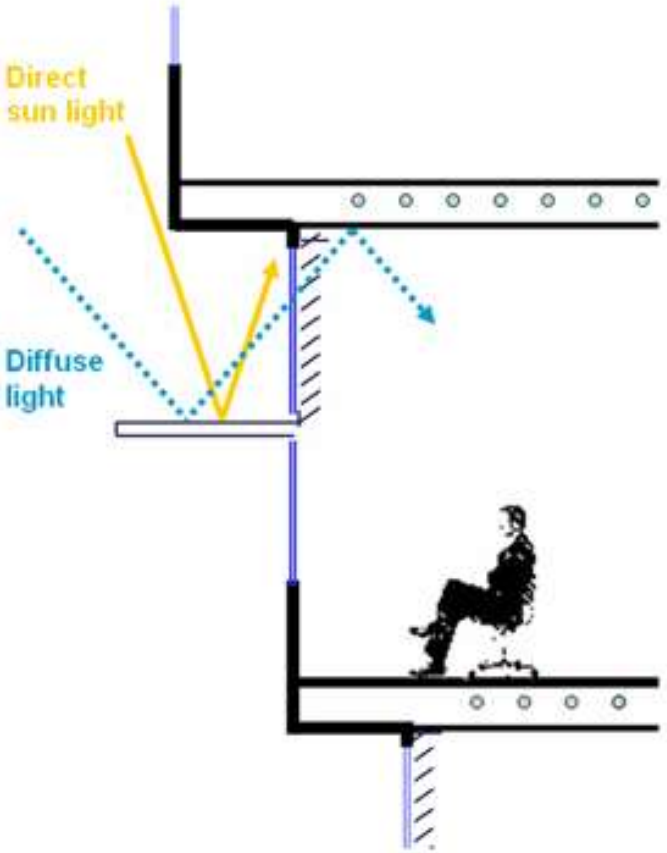
- 2 Chillers:
  a) High Temperature cooling (18°C) for Floor Slab Cooling system **(very high COP possible)**
  b) Conventional chiller (7°C) for fresh supply
- Chiller Operation Primarily at Night (lower temperature at condensing side → **higher COP**)
- Chillers only supply cooling to thermal storages, hence, **maximum COP** for chiller operation can be ensured at all times. NB. Maximum COP is at part load (~75% load)



The COP increases with increasing temperature of the evaporator, for example for high temperature cooling at 18°C instead of at the conventional 7°C. Here, the theoretical maximum COP (Carnot) is shown for a constant condenser temperature of 30°C

Almost 100% Daylit Building

Block direct sunlight | Reflect diffuse daylight onto ceiling | Glare protection



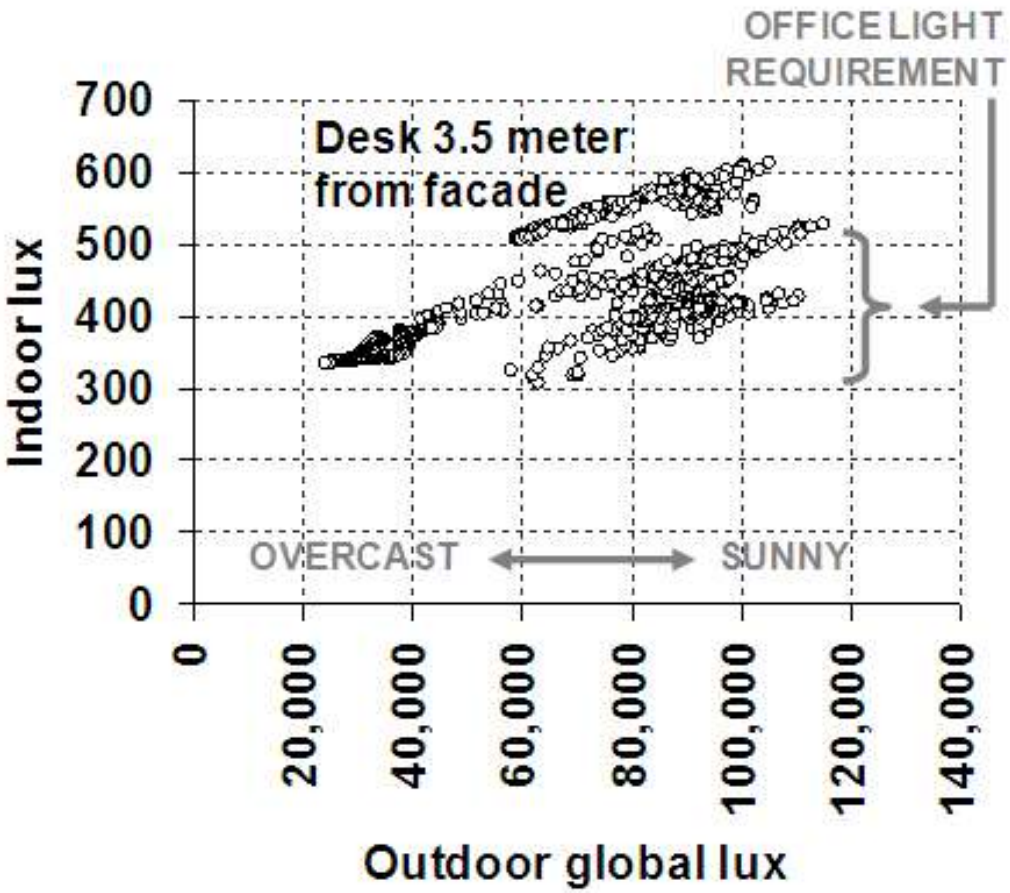
South facade

Almost 100% Daylit Building

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



Measured lighting consumption during office hours is only 0.56 W/m^2

1. Occupants prefer working in daylight
2. Electrical lighting consumption is 25 times lower than the code requirement


Daylight design by IEN Consultants

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

Case study no. 2

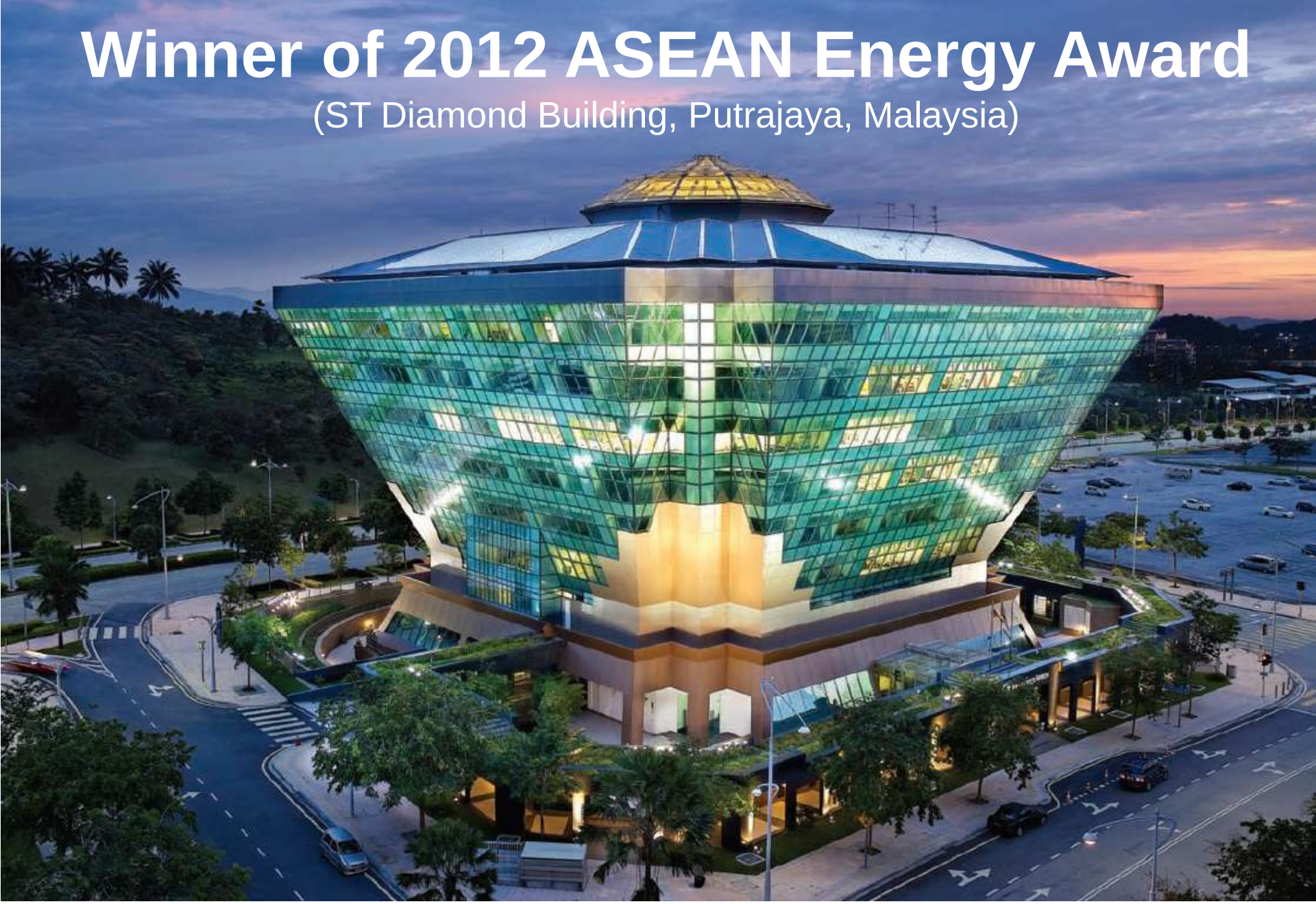
Green Office case study in Putrajaya:

DIAMOND BUILDING

(MALAYSIA, 2010)

Winner of 2012 ASEAN Energy Award

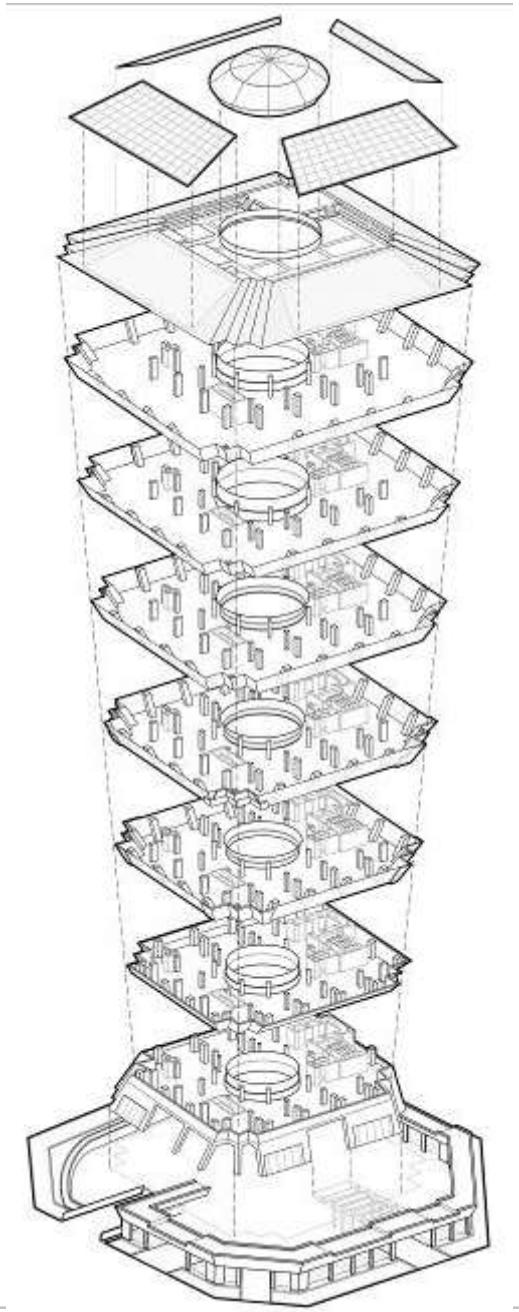
(ST Diamond Building, Putrajaya, Malaysia)

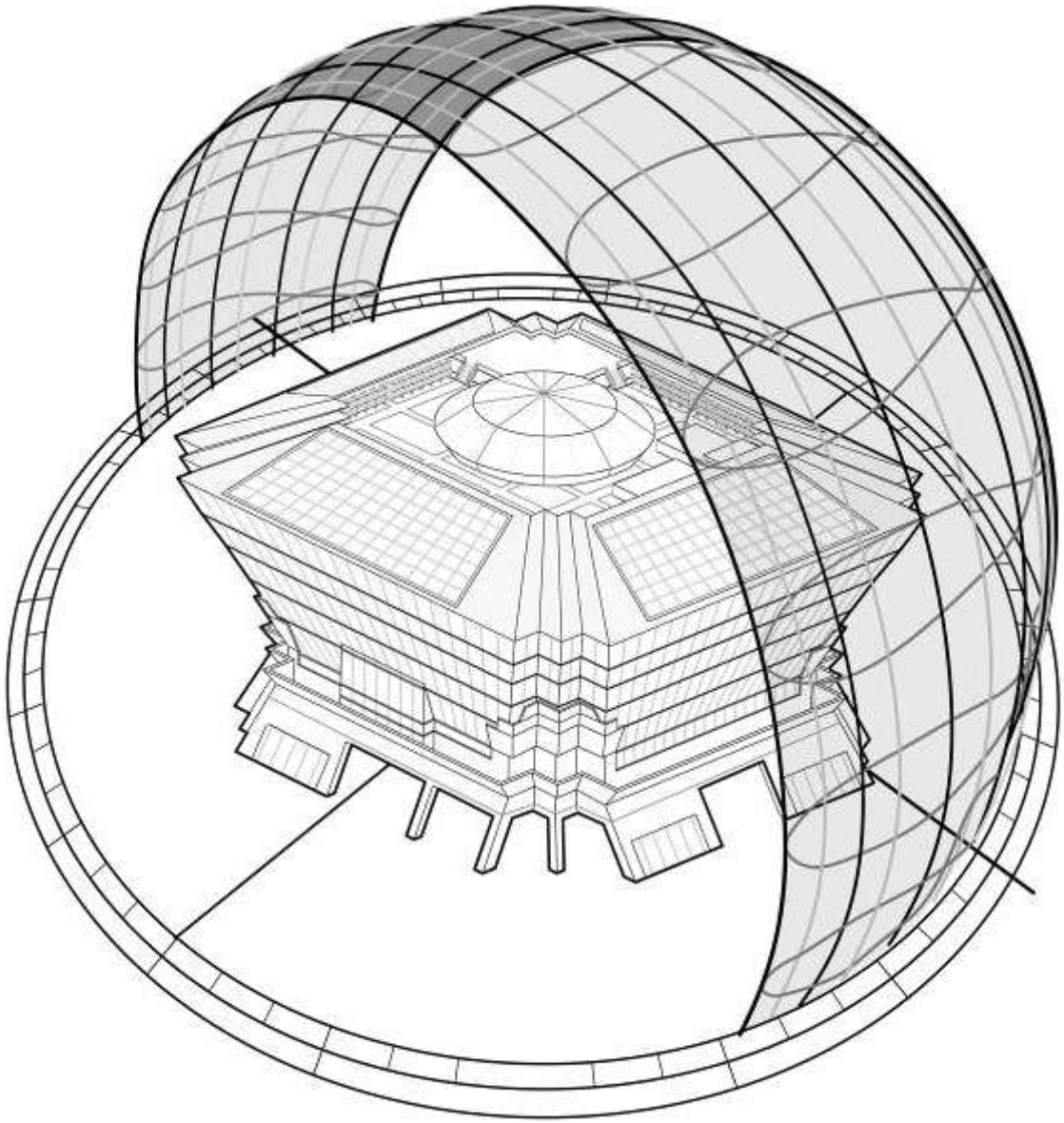


I|E|N CONSULTANTS

Architects: Soontorn Boonyatikarn (Thailand)
and NR Architect (Malaysia)
Energy efficiency and sustainability: IEN Consultants

Mechanical & Electrical: Primetech Engineers
Contractor: Putra Perdana Construction
Client: Malaysian Energy Commission

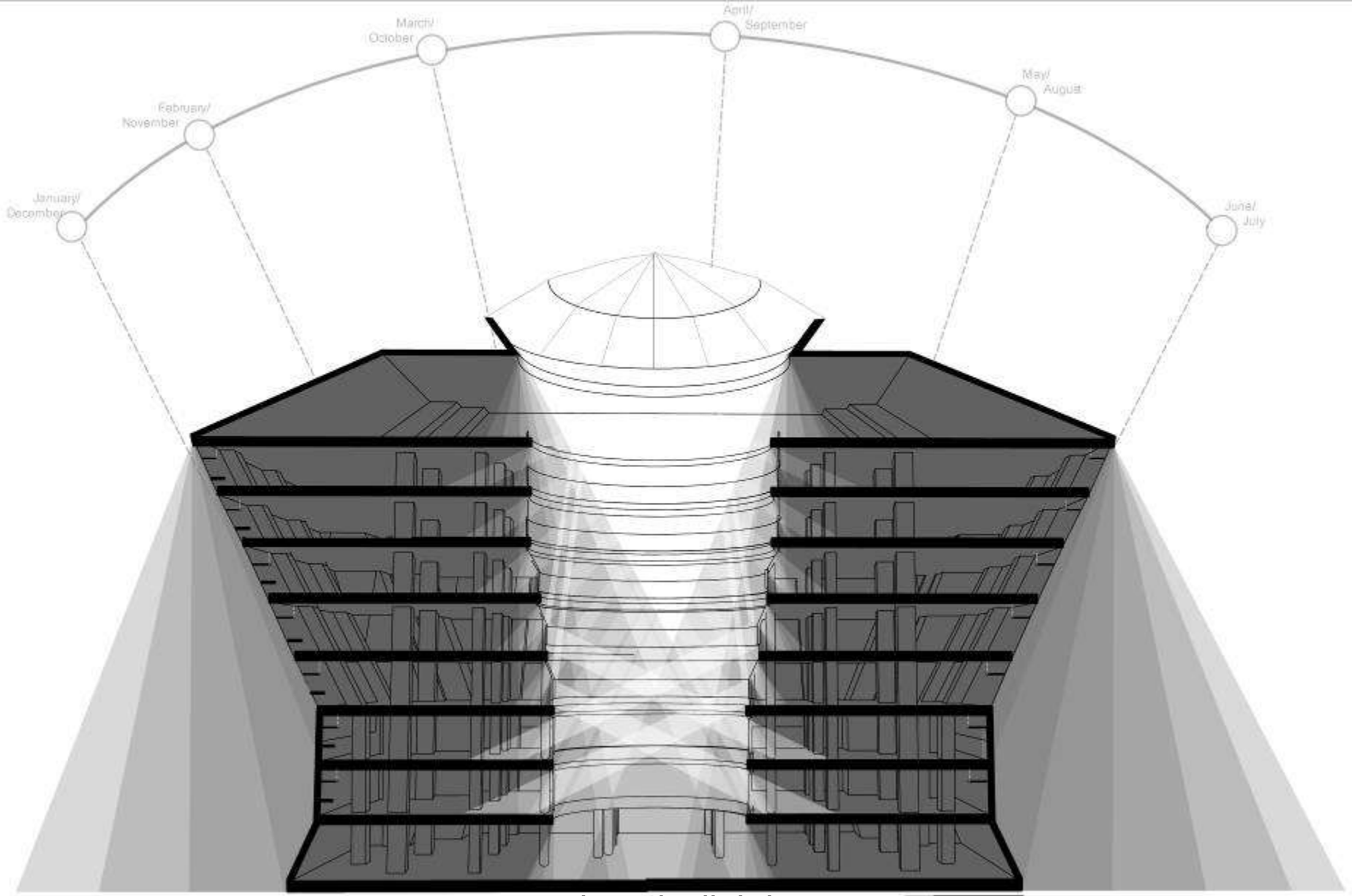




Self-shading facades

I|E|N CONSULTANTS

Source: Greening Asia – Emerging Principles for Sustainable Architecture.



Atrium daylighting

I|E|N CONSULTANTS

DIAMOND BUILDING similar design with vernacular buildings

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.

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.

Result of many SIMULATIONS

Result of many GENERATIONS

I|E|N CONSULTANTS

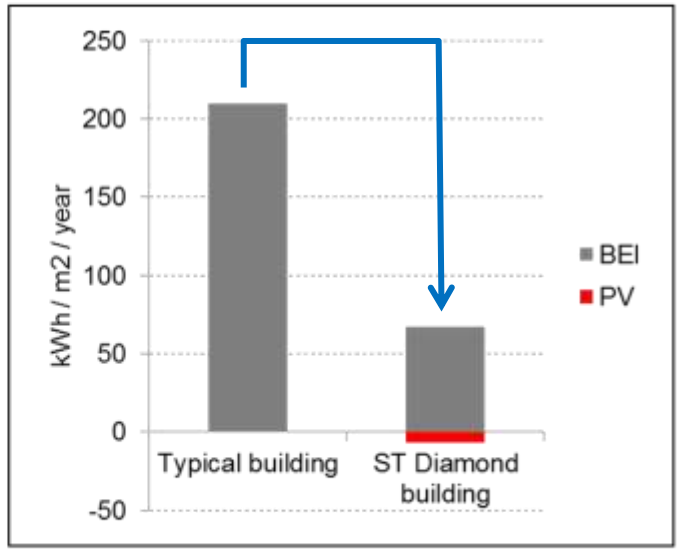
Book available free online:
http://um.dk/da/~/media/Malaysia/Documents/Other/Book%20Finalist%20LR.ashx

1/3 Energy Consumption

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**

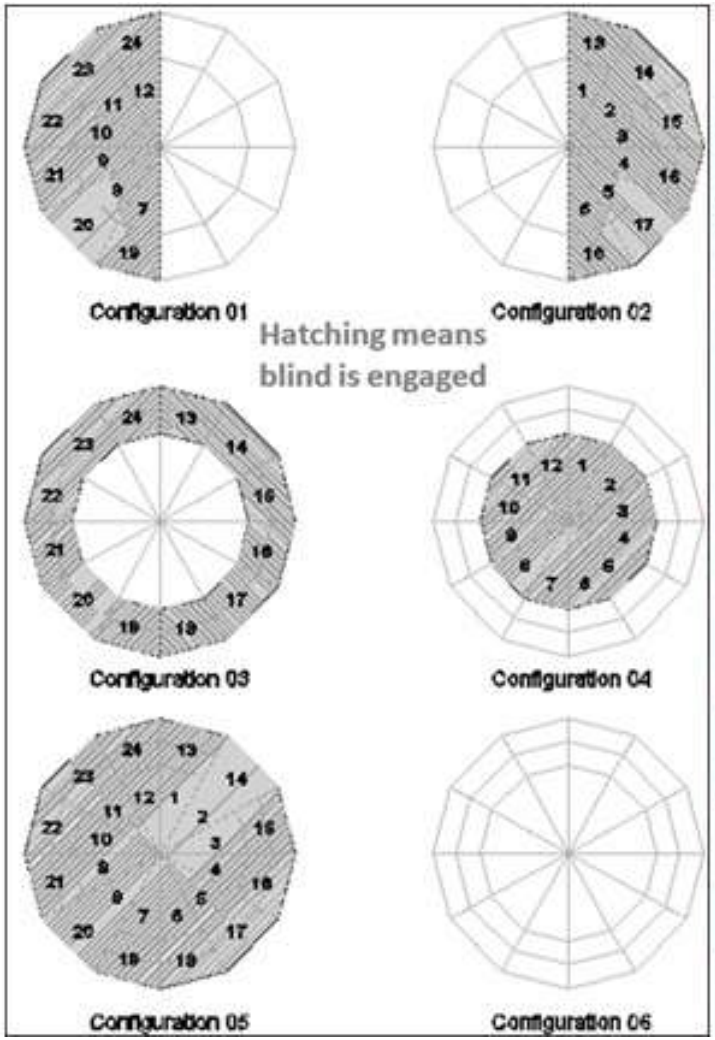


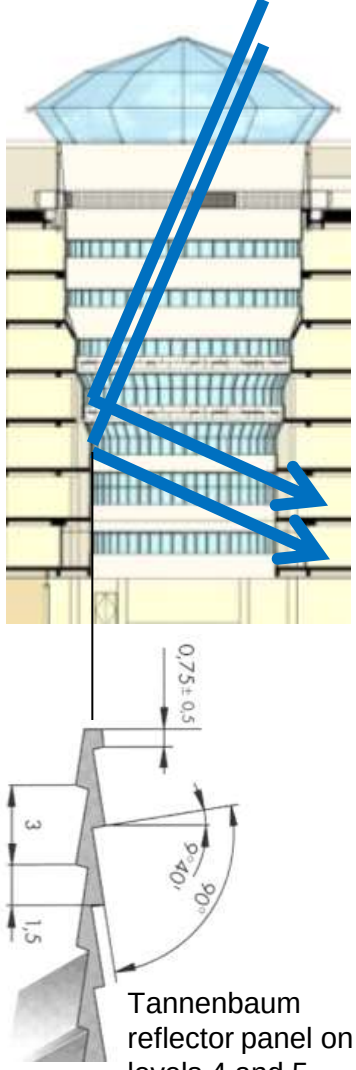
AWARDS:

2012 ASEAN energy award **Winner**

&

2013 ASHRAE Technology Award (2nd place)



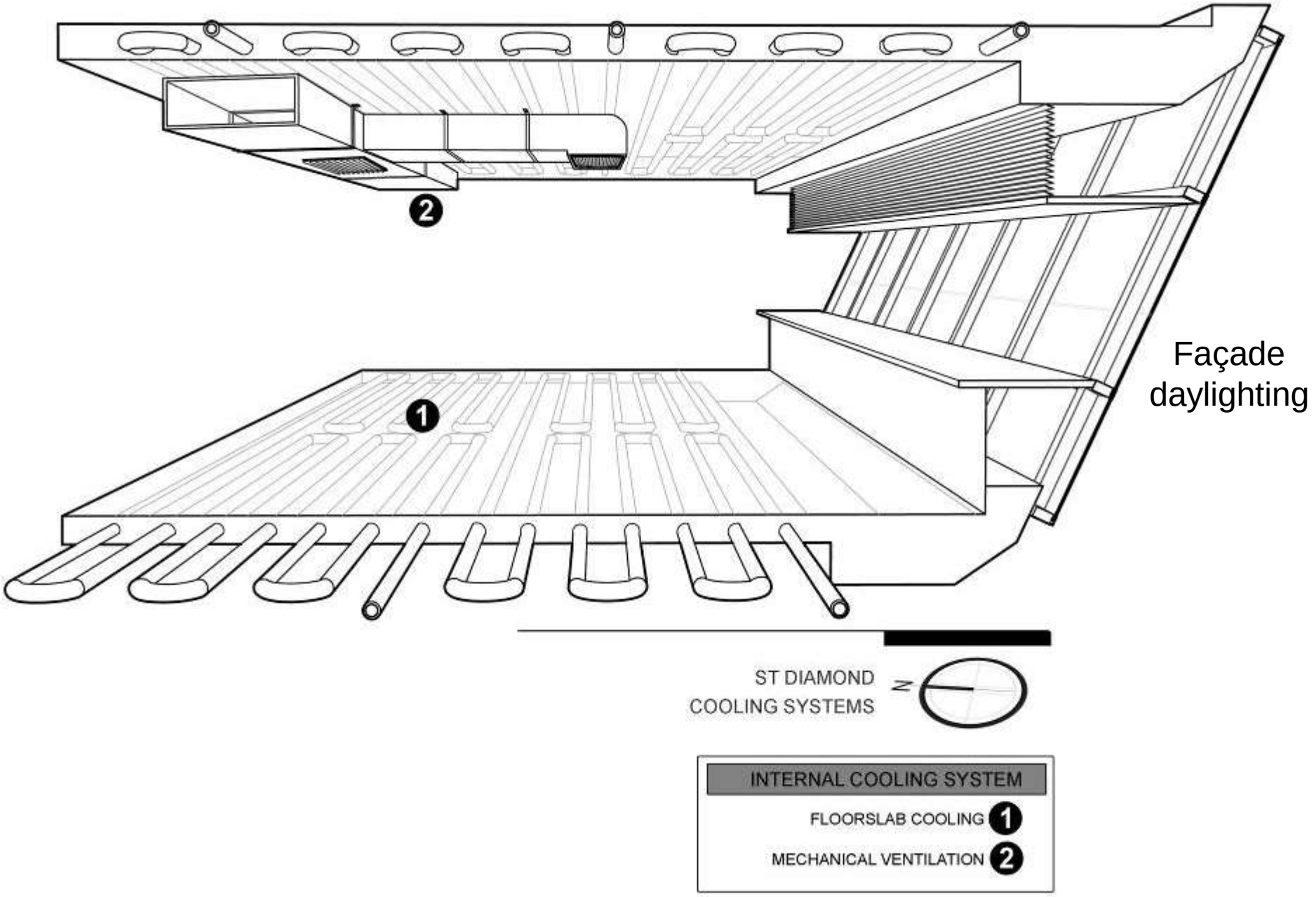


Tannenbaum reflector panel on levels 4 and 5

Atrium Daylight Design

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

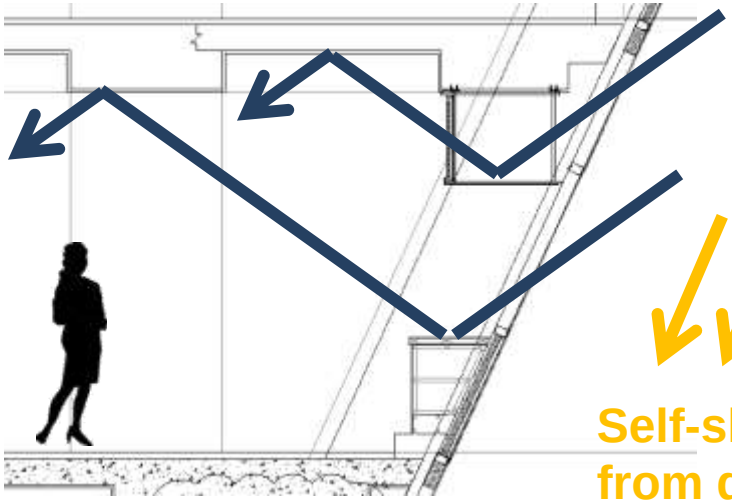
1. Automated blind with six different configuration to maintain the appropriate daylighting levels at all times. The blinds with 30% light transmittance are adjusted every 15 minutes and follow a three different control strategies for morning, mid-day and evening
2. The windows size becomes larger deeper 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.



I|E|N CONSULTANTS

Source: Greening Asia – Emerging Principles for Sustainable Architecture.

FACADE

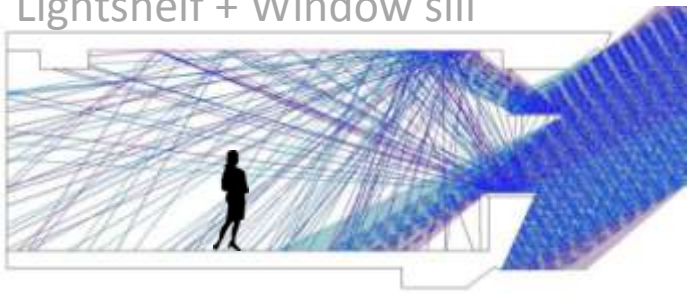


Diffuse light deflected into room by lightshelf and window sill

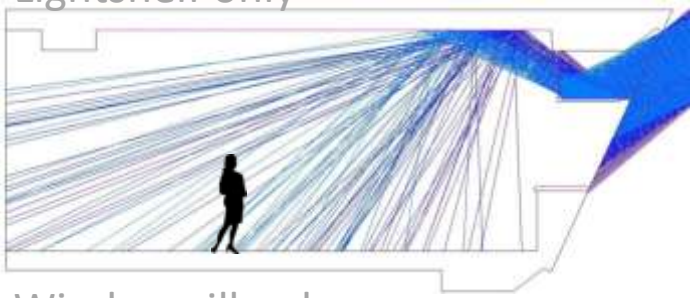
Self-shaded facade from direct sun

LIGHT REFLECTIONS FROM:

Lightshelf + Window sill



Lightshelf only

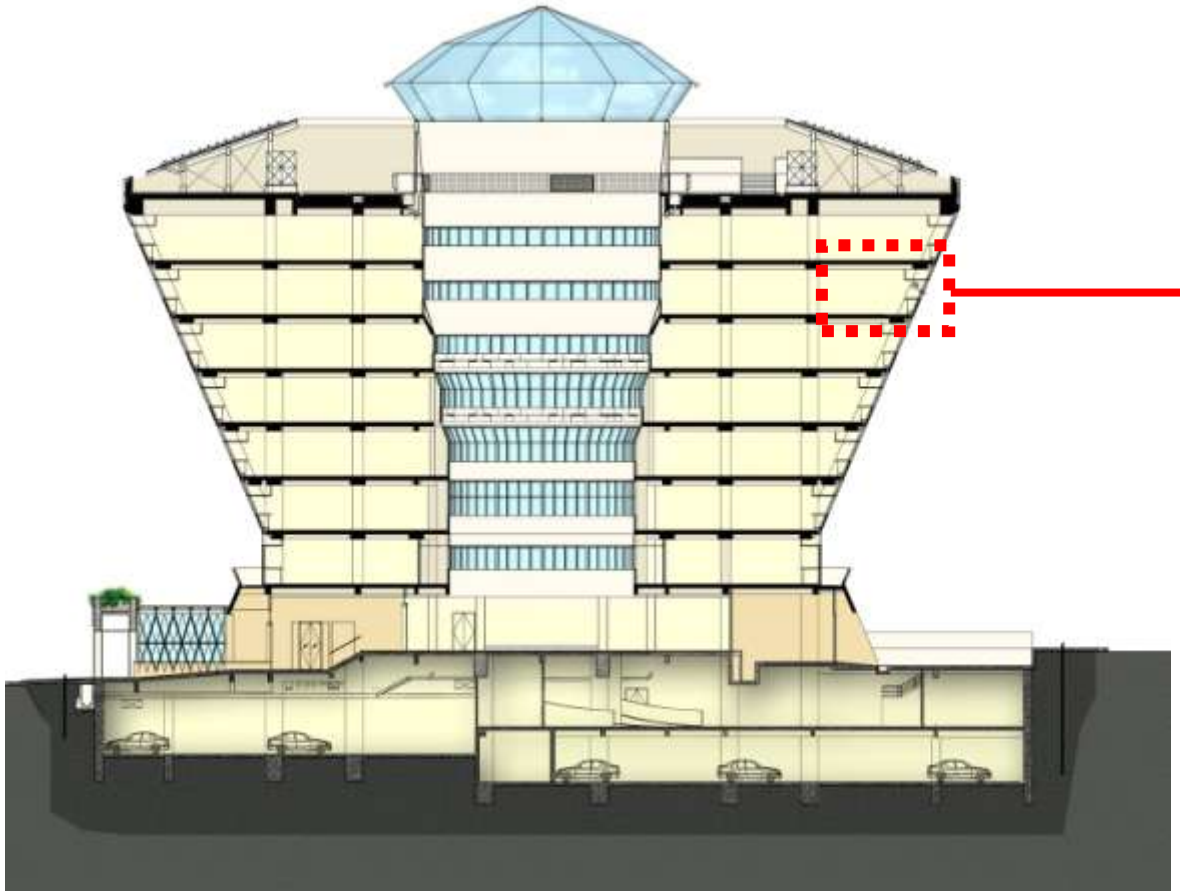


Window sill only

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. Some people worked down to 33 lux without switching on the lighting.

Day-Lighting- Office



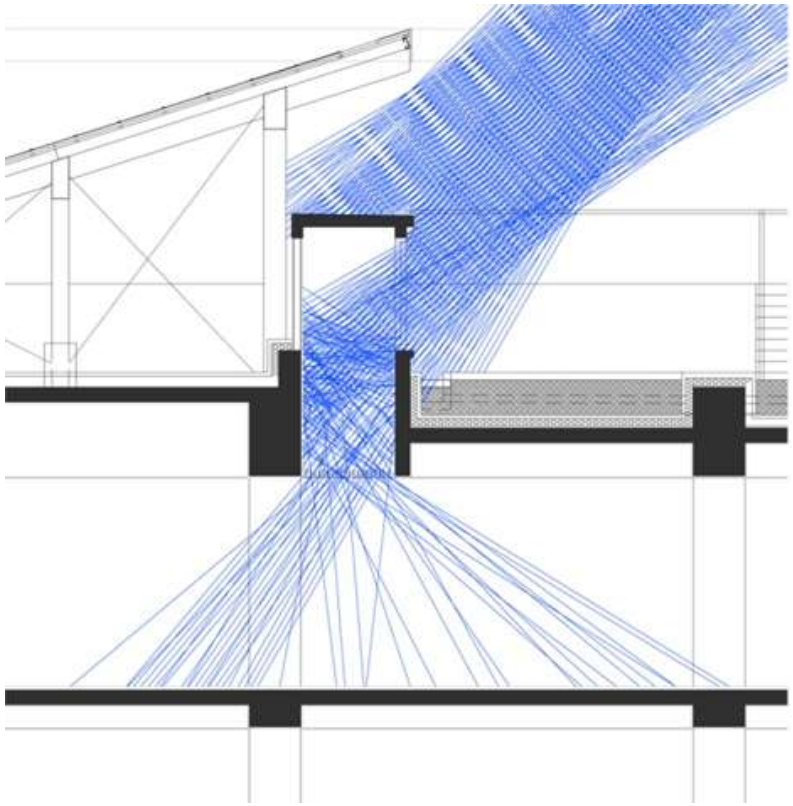
Mirror lightshelf

Fixed blinds for glare control

Daylight reflected onto ceiling

Daylight Skylight through Roof

Take in diffuse light only



Floor Slab Cooling in ST Diamond Building

Floor slab cooling system embedded in RC slab

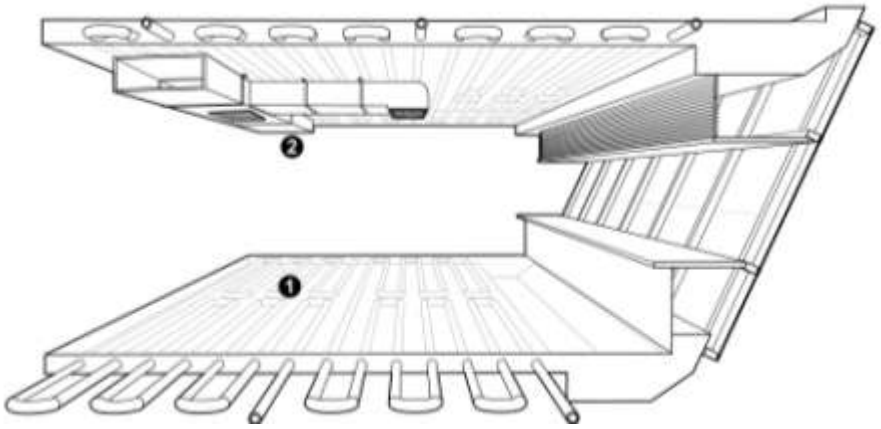
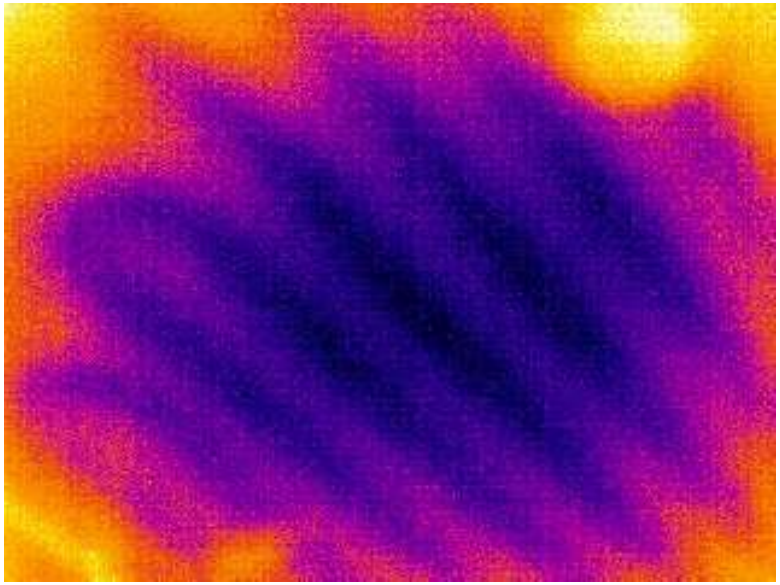
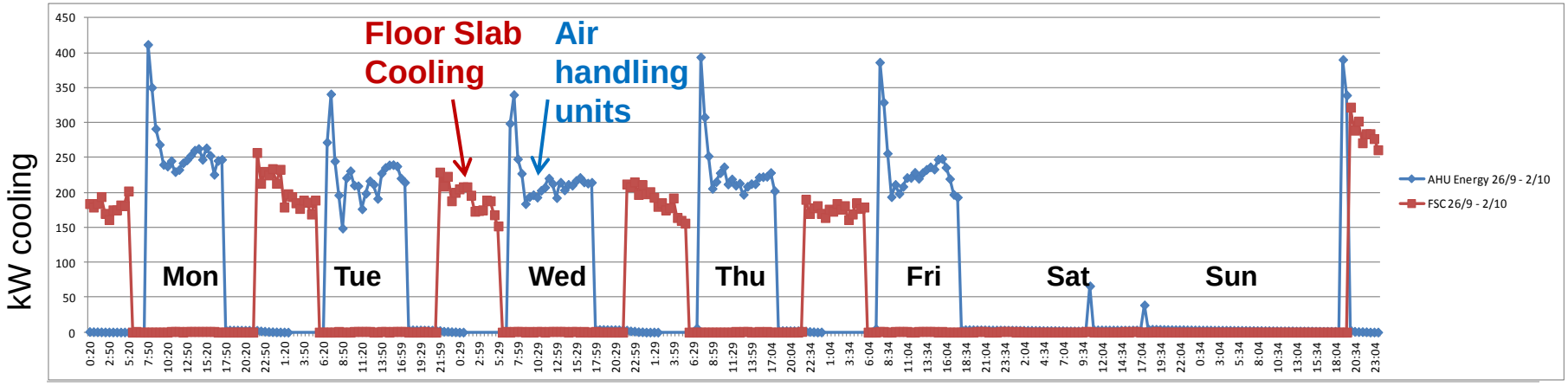


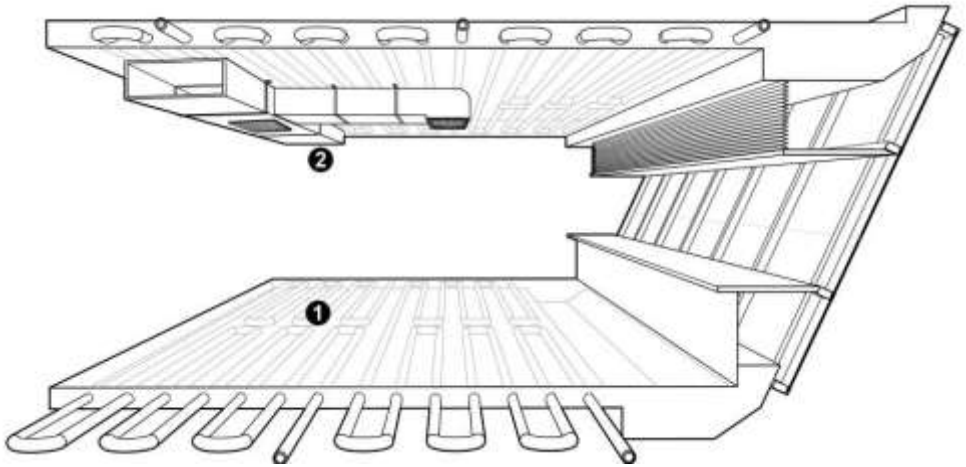
Illustration courtesy of:
Greening Asia – Emerging Principles for Sustainable Architecture.
Copyright: Nirmal Kishnani, 2012. Publisher: FuturArc



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



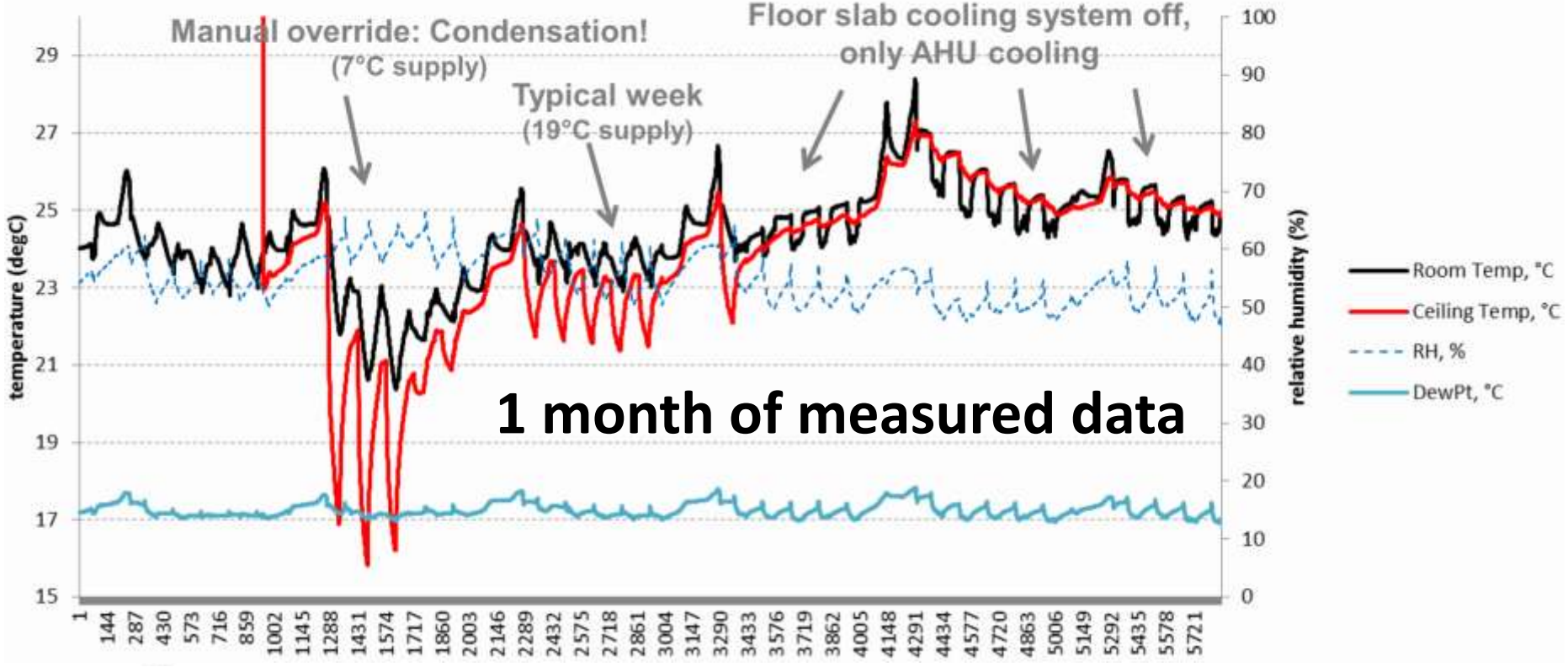
I|E|N CONSULTANTS



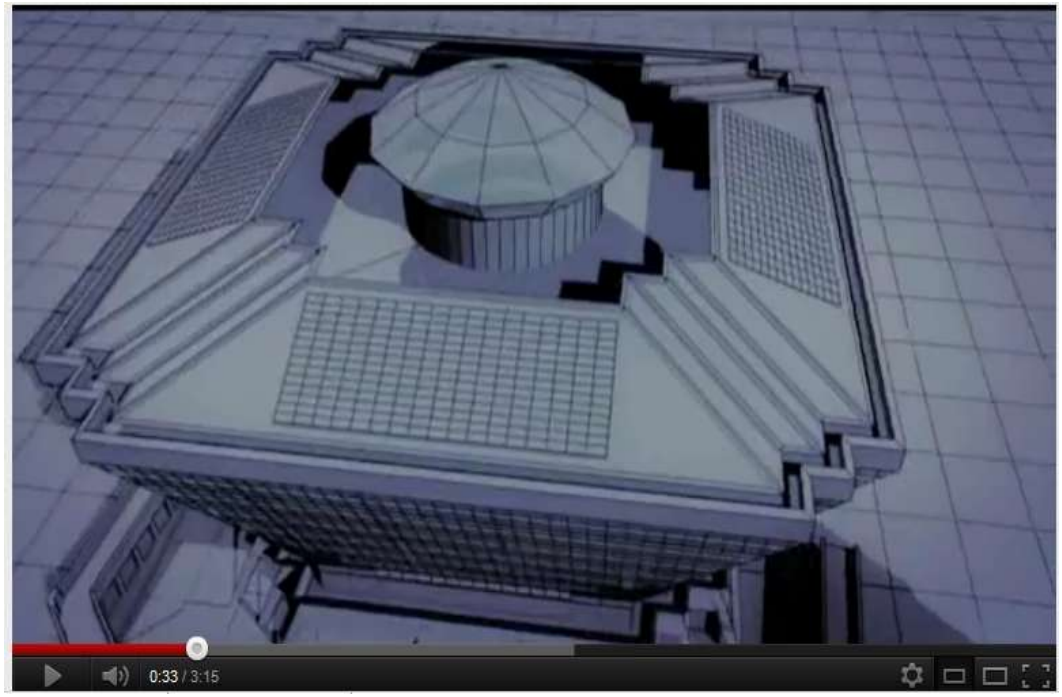
Source: Greening Asia – Emerging Principles for Sustainable Architecture.

ST Diamond Building: Floor slab cooling measurements

ST Diamond Building: Level 6, West, Hamidah room (8 Sept - 18 Oct, 2012)

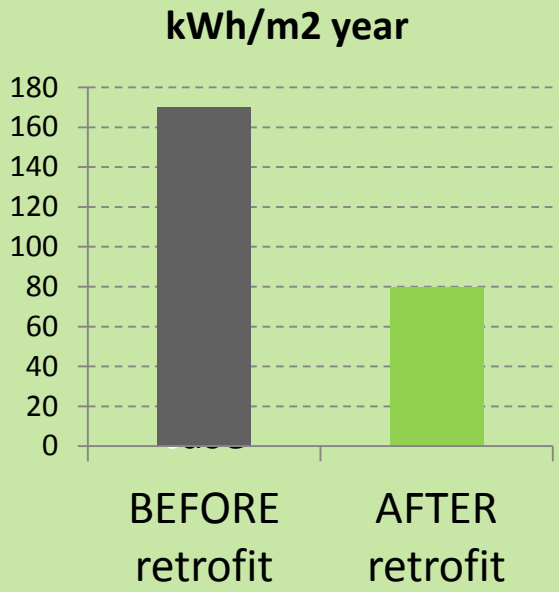


3-minute video



Sustainable Features of ST Diamond Building.
Available at YouTube:
http://www.youtube.com/watch?v=3H_sXCtDayc

Case study no. 3

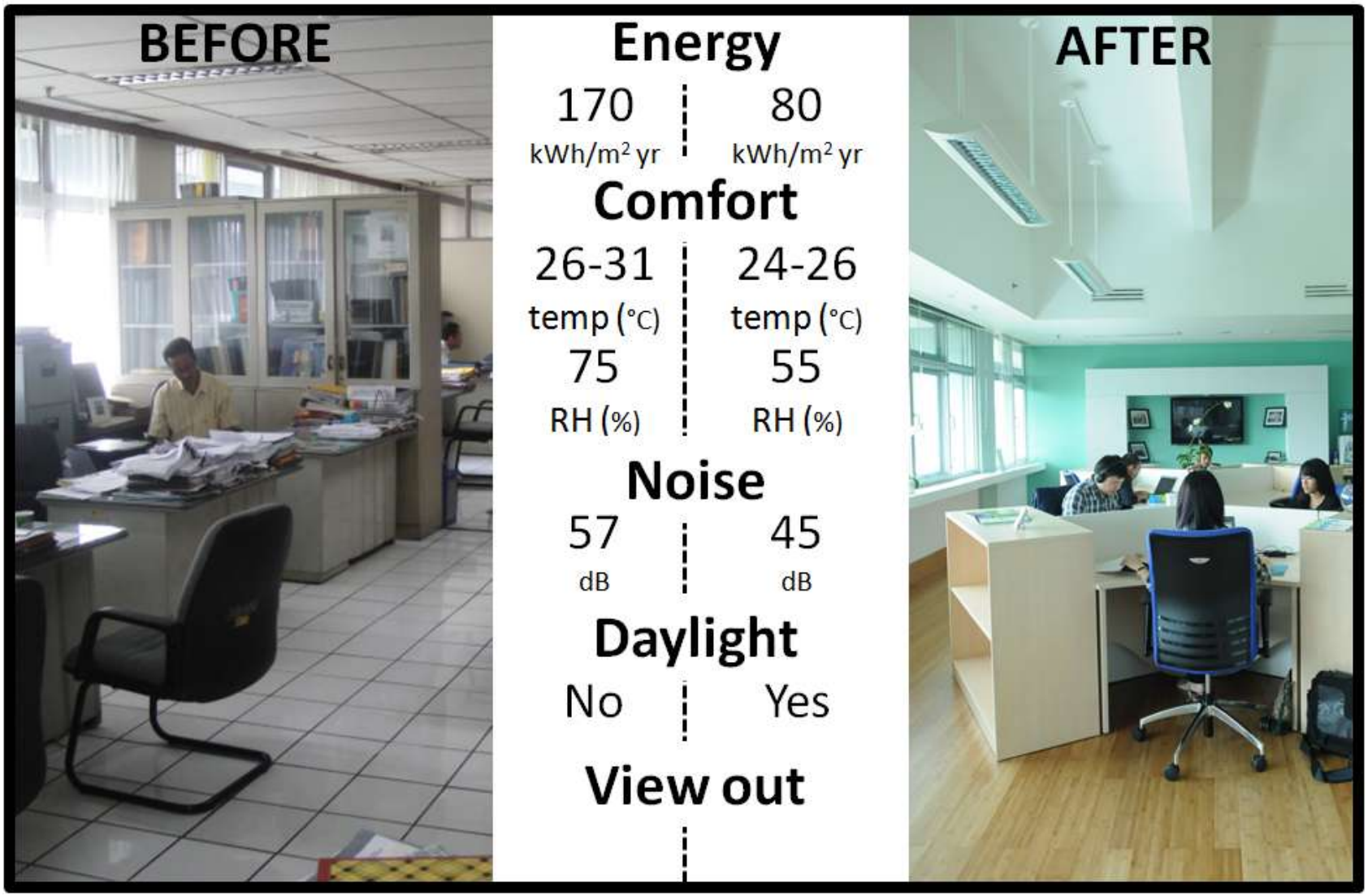


Energy Efficient Retrofit case study

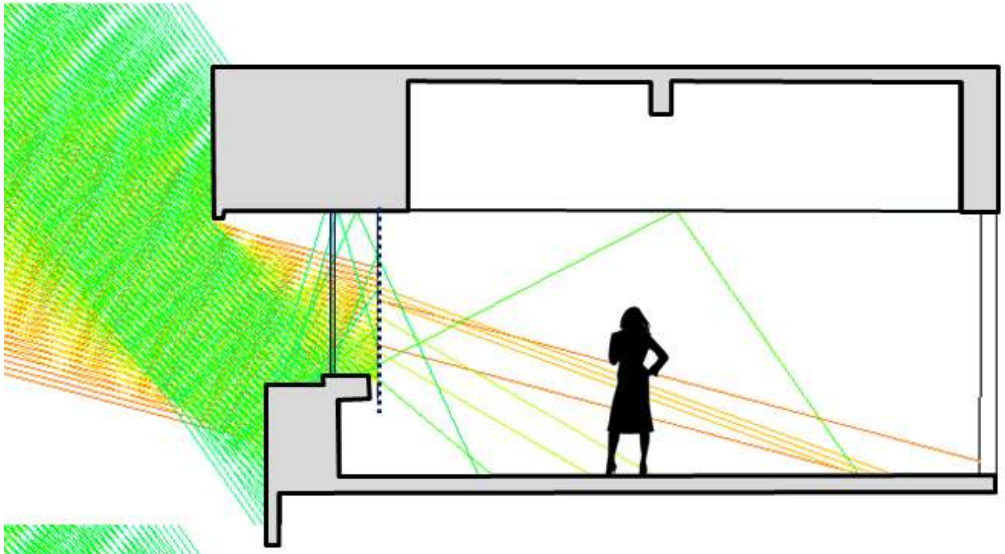
EECCHI OFFICE RETROFIT

(JAKARTA, 2011)

53% Measured Energy Savings

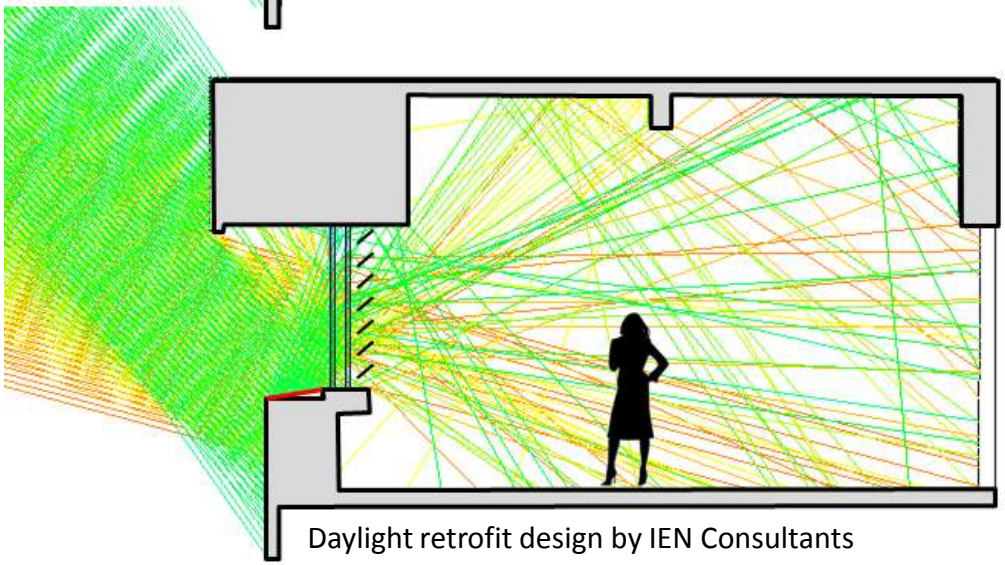


Retrofit & Improved Thermal Comfort



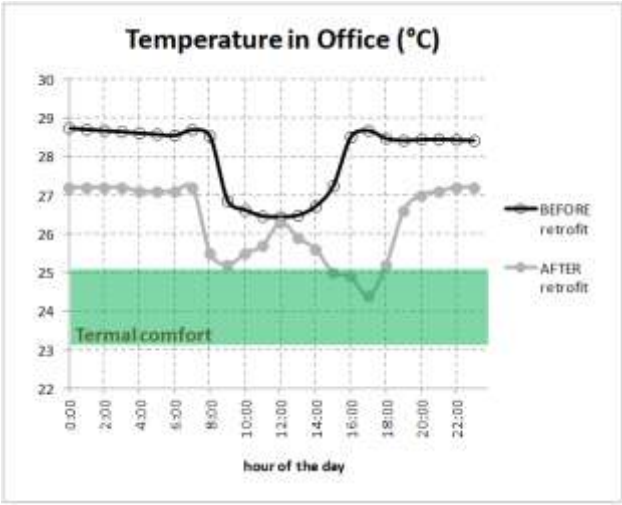
BEFORE RETROFIT

- Vertical blinds blocking most of the daylight
- Suspended ceiling



AFTER RETROFIT

- Mirror lightshelf on external ledge reflecting diffuse daylight onto the high ceiling (suspended ceiling removed)
- Perforate venetian blinds
- Extra window pane



Daylight retrofit design by IEN Consultants

Case study no. 4

Innovative daylighting facade for highrise building

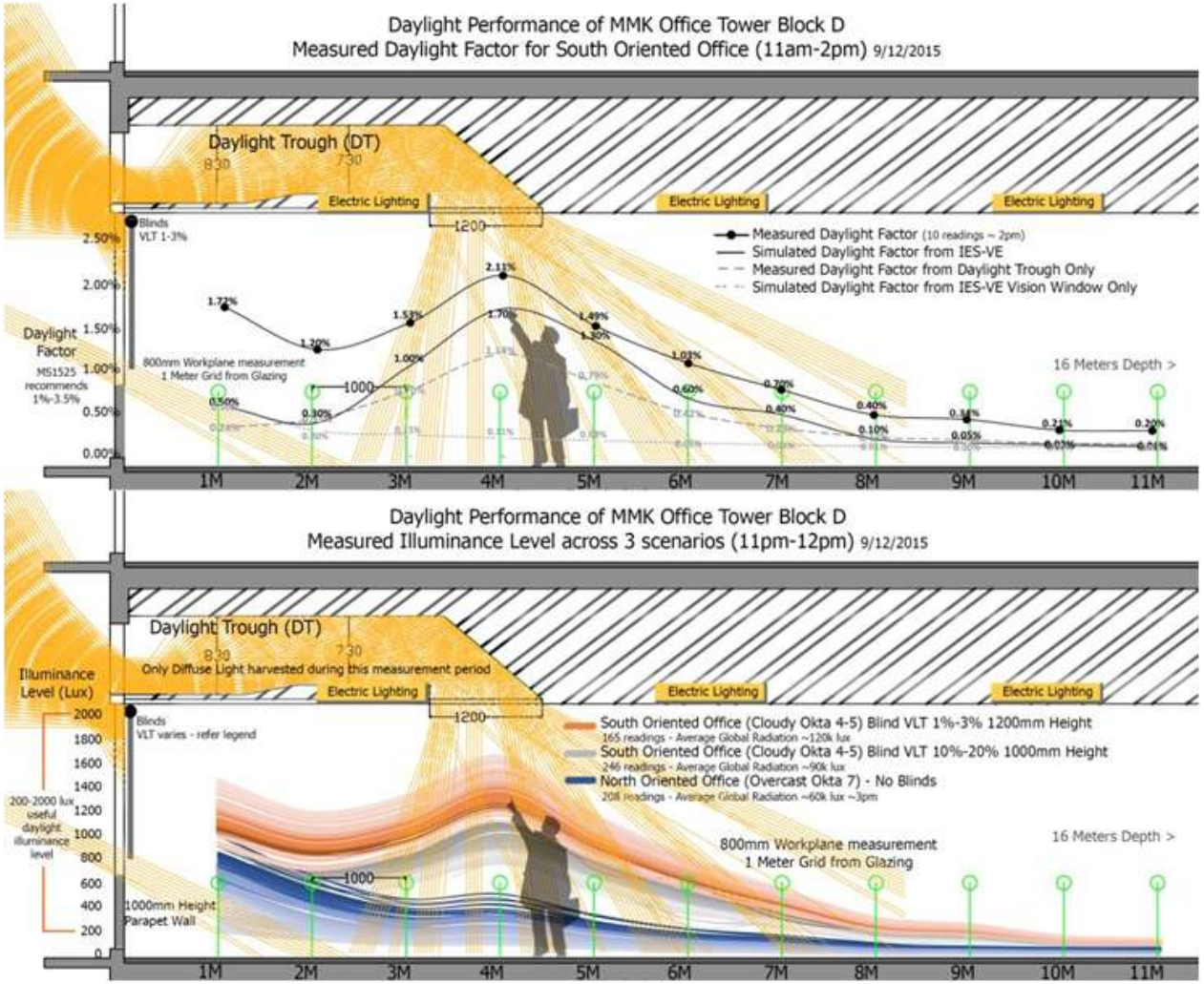
MMK OFFICE TOWER

(KUALA LUMPUR, 2015)

Innovative façade daylighting

The MMK high rise office tower @ Damansara Perdana, Malaysia

7 meters daylight with blinds down



Measured daylight show that the first **7 meters** can be daylit, even when the blinds are fully engaged

Daylight design by IEN Consultants

Case study no. 5

ZERO Energy Bungalow

EARTH BERM HOUSE

(KUALA LUMPUR, 2016)

INNOVATION: Night Sky Cooling

Bungalow 100% natural cooling, no air-conditioning

To be completed next month!

Similar design by Design Unit Sdn. Bhd.

CONCLUSION

”Expensive not to go green”

Buildings are
Like a Leaky Bucket

with lots of
unnecessary wastages

Plug the holes, and you are well on the way to a green energy efficient inexpensive building

Thank you

How I commute in Kuala Lumpur
(video link)

Gregers Reimann

Managing director, IEN Consultants

gregers@ien-consultants.com | +60122755630

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, the Pertamina Energy Tower – the first skyscraper designed to be ZERO energy – and energy efficiency building retrofit works incl. daylight retrofitting of the Asian Development Bank in Manila.

Gregers has also been a technical reviewer for the EU Energy-Efficiency Buildings project and is newly appointed Chairman of the “Energy Efficient Buildings” committee under the EU-Malaysian Chambers of Commerce and Industries (EUMCCI).

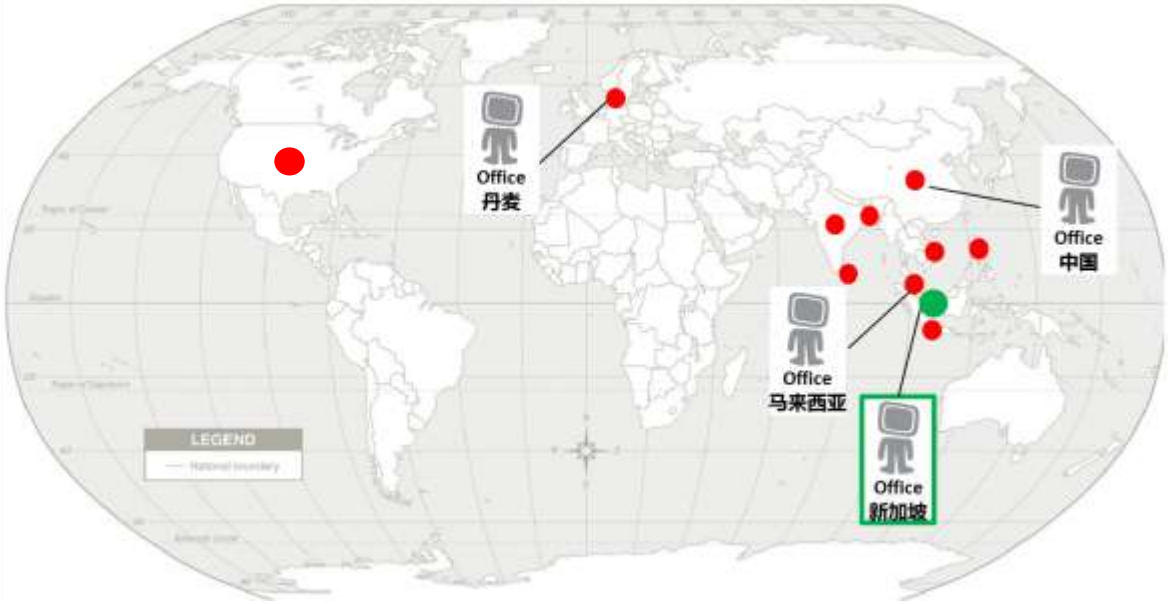
Gregers regularly contributes to green building articles and frequently guest lectures at universities internationally. He has a keen interest to pursue innovative and integrated design solutions bridging the gap between architects and engineers. Gregers is also ‘walking the talk’ with respect to green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

IEN Consultants

3.2 million square meters
of green building space

Gregers (MD) Poul (Founder)

Malaysia | Singapore | China



IEN Consultants Expert Staff

IEN Consultants

Hover the cursor over a person's head to see a short presentation and click to see a detailed personal description or click on a name in the list below.

We are a diverse group of individuals

5 different degrees
6 different nationalities
4 LEED AP
8 GBI Facilitators