INCREASED OCCUPANTS WELLBEING & BUILDING ENERGY EFFICIENCY WITH ACTIVE HOUSE DESIGN PRINCIPLES

以提升使用者健康舒适与建筑能效为核心的Active House 设计理念与实践

NEXT GENERATION SUSTAINABLE BUILDINGS WITH A FOCUS ON USER WELL-BEING

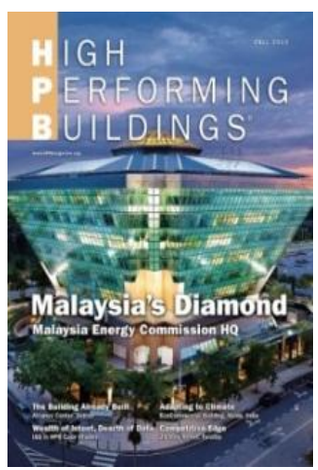
IEN CONSULTANTS

Gregers Reimann, Managing Director, IEN Consultants 爱易恩工程设计顾问有限公司

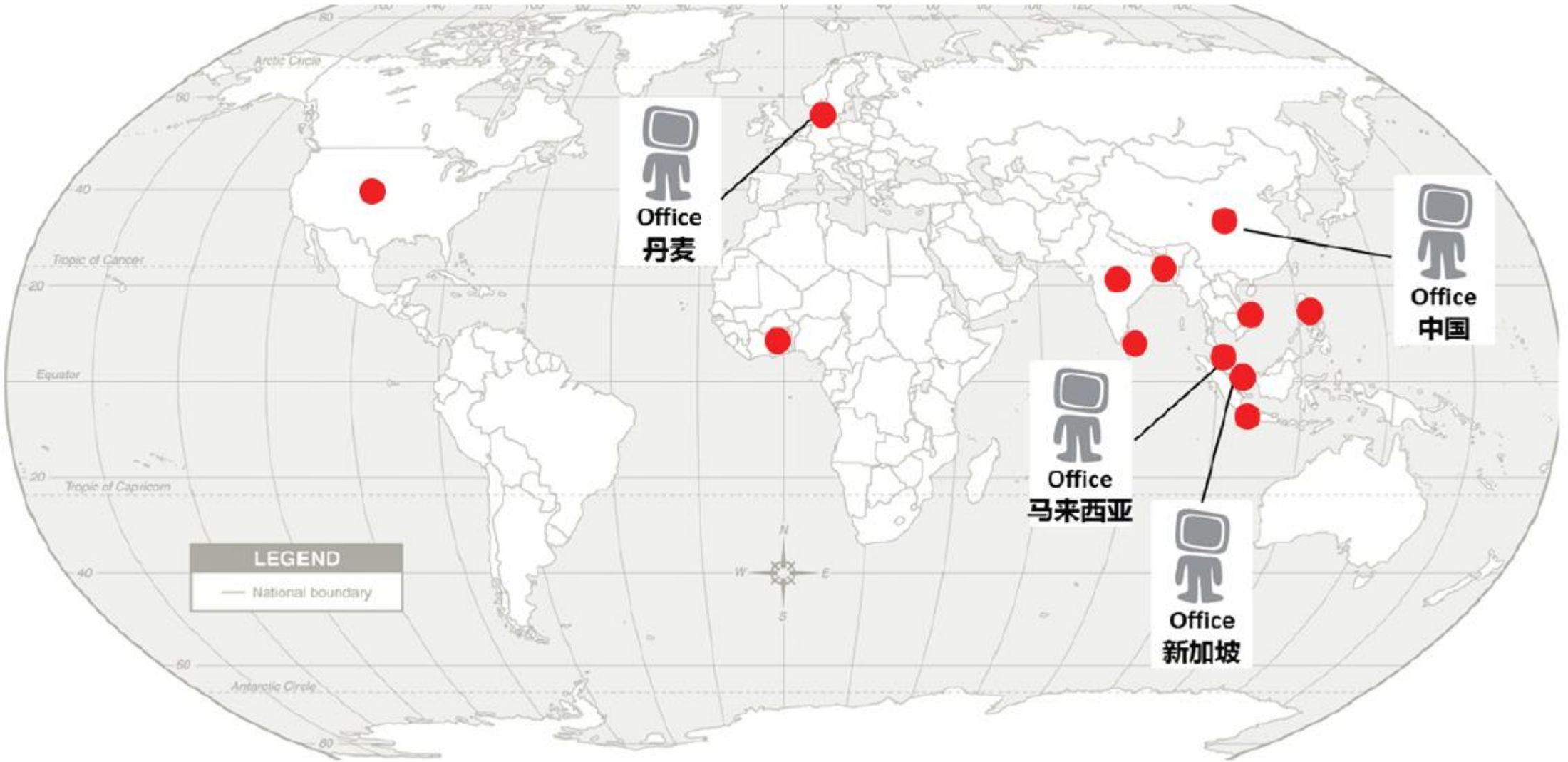
Forum of Active House Research and Practice of Green Building, 31 Mar, 2016

IEN源于丹麦的理念经验 + 在亚洲10年被证明的成绩

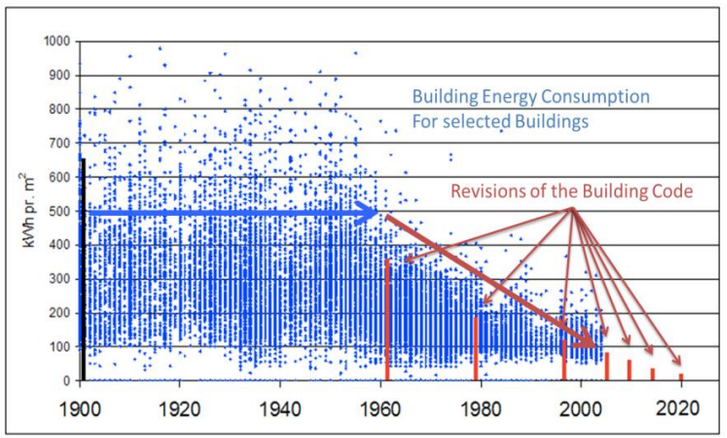
爱易恩工程设计顾问有限公司（IEN Consultants）是一家专注于节能与可持续发展的国际工程设计顾问公司。2000年成立丹麦哥本哈根，IEN致力于将丹麦追求真正的绿色和持久的解决方案的理念与技能投入亚洲。IEN已完成超过320万平米的绿色建筑项目，遍及10多个国家，其中包括35个美国LEED认证的项目。我们的成就包括（两次基于建筑一年实测能耗数据）从东盟十国脱颖而出的东盟节能高效办公建筑的能源大奖，著名的美国ASHRAE技术奖（第二名），美国《HPB高性能建筑》封面。另外，我们的项目被制成绿色节能建筑的系列邮票。



320多万平米的绿色建筑与商业开发项目业绩，遍及10多个国家



实现实测建筑能耗降低50%以上，回收期小于3年



Annual energy bills show

- 50-80% energy savings
- 3 year pay-back time

IEN Core Values

- Effective design solutions
- Ensure long-term benefit to client, occupant and environment

实测
建筑能耗

新建与既有建筑
IEN Consultants 代表作品

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aktivhus

"…Active House builds on the knowledge of Passive House but takes a step further to also encompass comfort and energy efficiency aspects in a holistic way…"

"…Active House's ultimate ambition in the EU is to showcase that nearly zero energy buildings (nZEB) can be built at an optimal cost and with a good and healthy indoor climate… which should become the norm by 2020 ".

-Kurt Emil Eriksen, Secretary General Active House Alliance

VISION

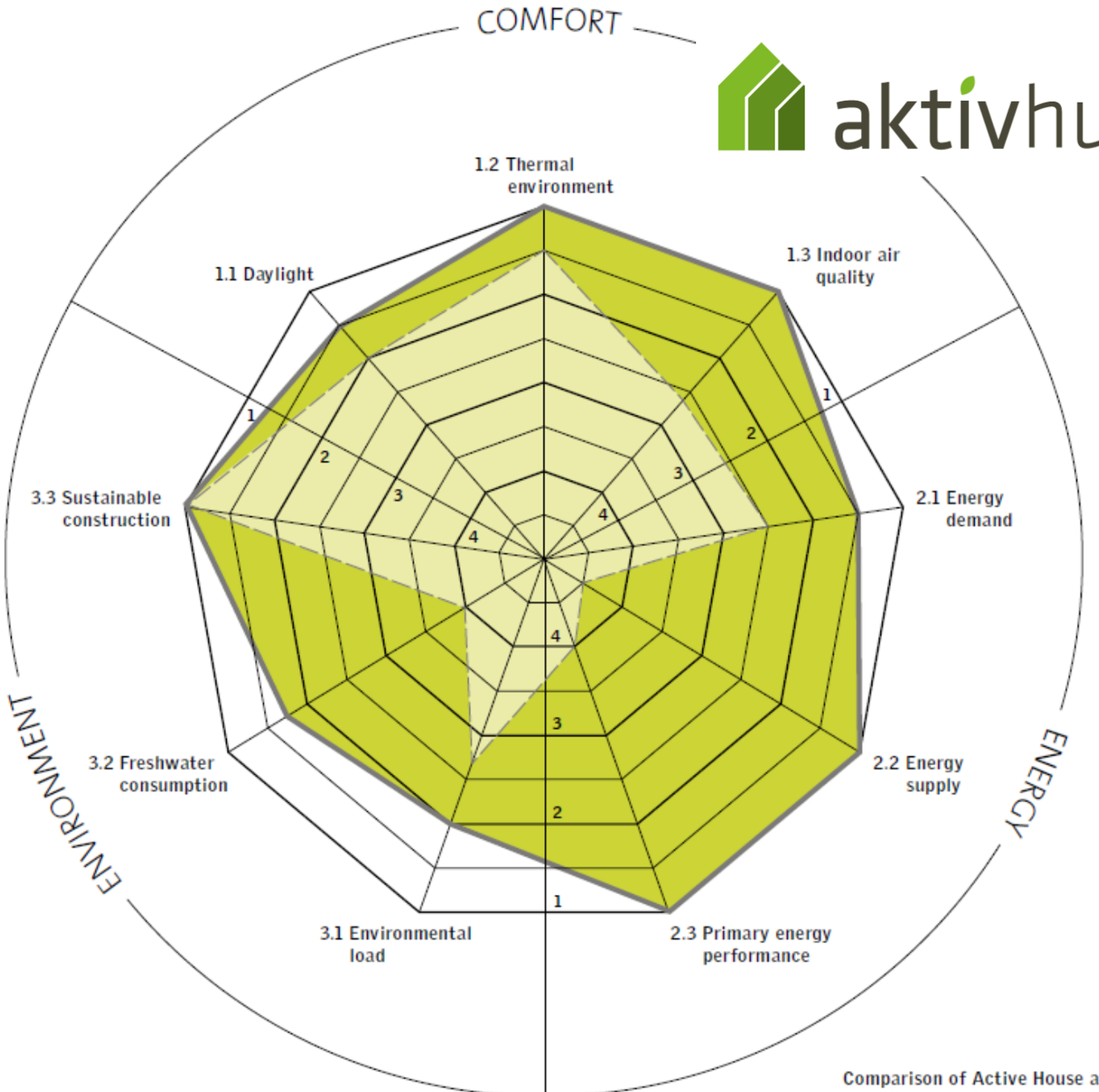
Active House is a vision of buildings that creates healthy and comfortable lives for their occupants without negatively influencing the climate and environment – moving us towards a cleaner, healthier and safer world.

Active House proposes a target framework for how to design and renovate buildings that contribute positively to human health, safety and wellbeing by focusing on the indoor and outdoor environment and efficient use of energy.

HOLISTIC APPROACH

Comfort
Energy
Environment

Affordable
Monitoring
Specification and calculation tool



Comparison of Active House and sta
according to the building code.

AFFORDABLE

Sustainable buildings should be designed with an overall focus on affordability. The Active House vision and the developed tools offer opportunities for a balanced design with focus on affordability and cost efficiency across different topics, technologies and solutions.

The designers can reduce the costs for projects by defining the requirement and ambition of the performance levels in the very early design process. By doing so the balance between the requirement and overall costs can be identified and discussed, as well as it will reduce the risk of unexpected costs in a later stage of the design process.

MONITORING

The ambition and the performance of an Active House is based on calculation, including pre-defined values and expectations of user behaviour. In order to secure that the final project meets the expected levels and ambitions, it is strongly recommended to include monitoring of the project. Such monitoring should take place during one year as minimum and the differences between the calculated performance and the specific performance can be described in the Active House Radar and calculation tool. It is recommended to follow up and adjust where needed.

COMPARISON

	Comfort	Energy	Environment
Active House	Daylight + Natural Ventilation + Adaptive Thermal+ IAQ	40-120 kWh/m2/year. Renewable: 25-100%	Life Cycle Analysis of Environmental Load+ Water + Materials
Passive House	Thermal Comfort + Air flow rate	30-60 kWh/m2/year. Renewable:133-400%	
Denmark 2020	Local Standard	20-25 kWh/m2/year	
WELL	Daylight + Natural Ventilation + IAQ + Water + Biophilia + Food + Fitness		

Residential case study

CoolTek House (Melaka, Malaysia)

BACKGROUND OF COOLTEK HOUSE

- Built by British couple that moved to Malaysia for their retirement
- Climatic design used to make CoolTek House energy efficient
- Year of completion: 2004
- CoolTek website: www.ien.dk/cooltek

COOLTEK HOUSE KEY DATA

- 200 m² air-conditioned floor space
- Occupied by 2 persons
- 24-hour air-conditing (24°C set point)

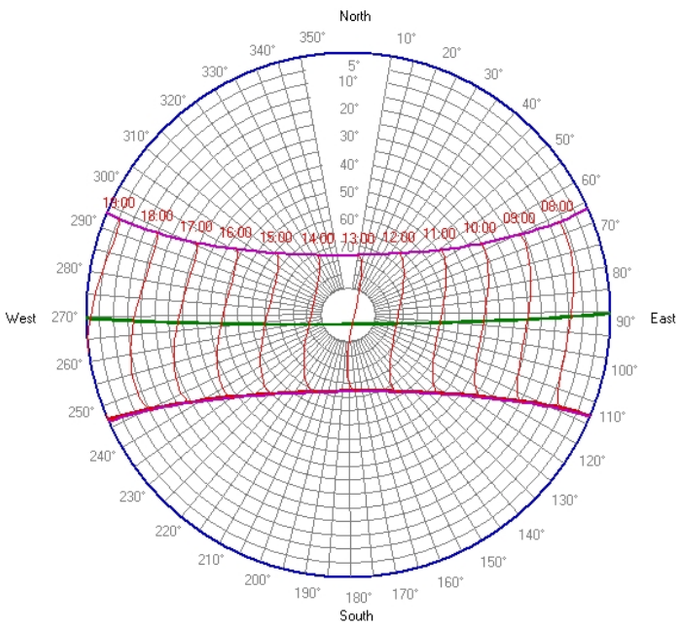
Daily air–con consumption

8.6 kWh / day → 5 yuan per day

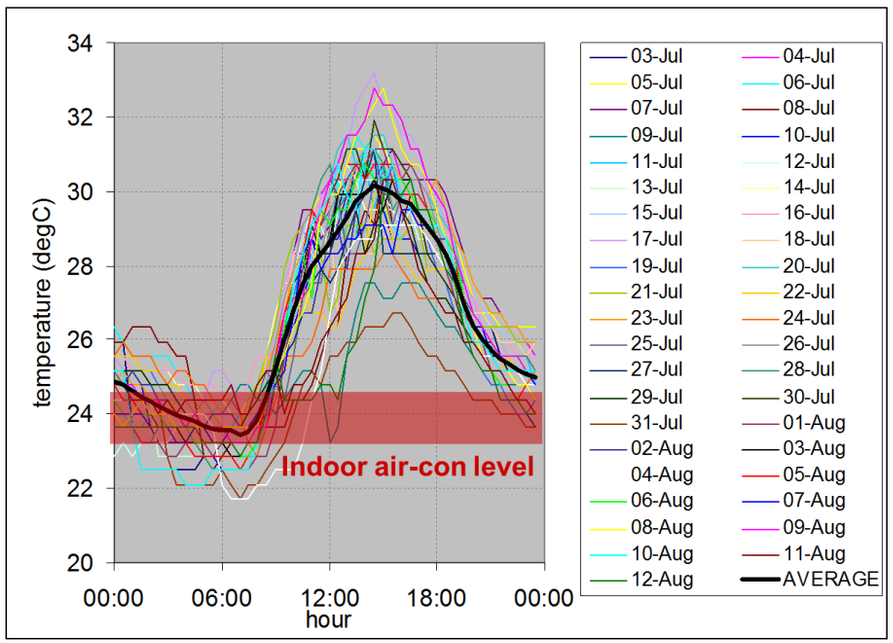
Energy Plus house with

4.8 kWp PV installation

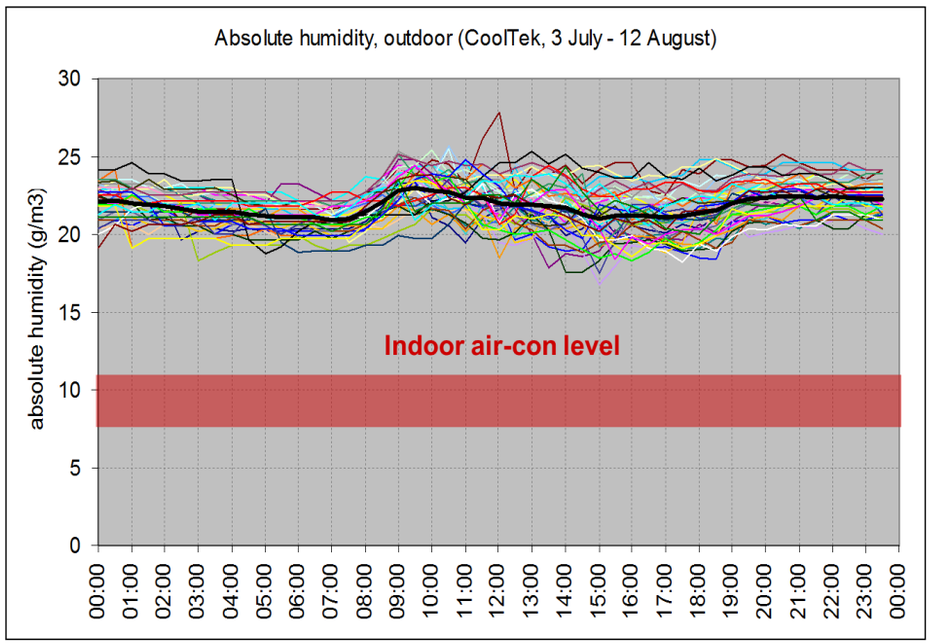
MALAYSIA CLIMATIC DATA



Sun Path



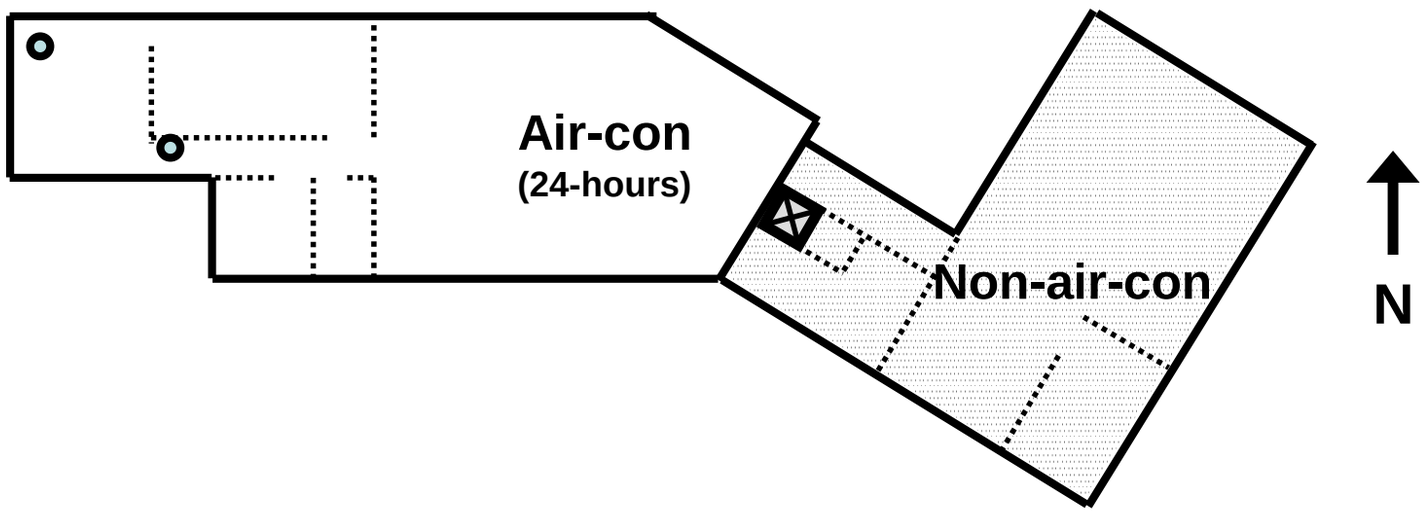
Outdoor Temperature



Outdoor Humidity

CLIMATE RESPONSIVE DESIGN

PLAN



Climatically justified orientation

(only windows facing North and South)

CLIMATE RESPONSIVE DESIGN

- Window overhang?
  (small, medium, large)

  → **Large**
  (much sky diffuse radiation)

- Ventilation?
  (small openings, medium openings, large openings)

  → **Small openings**
  (24-hour air-con space)

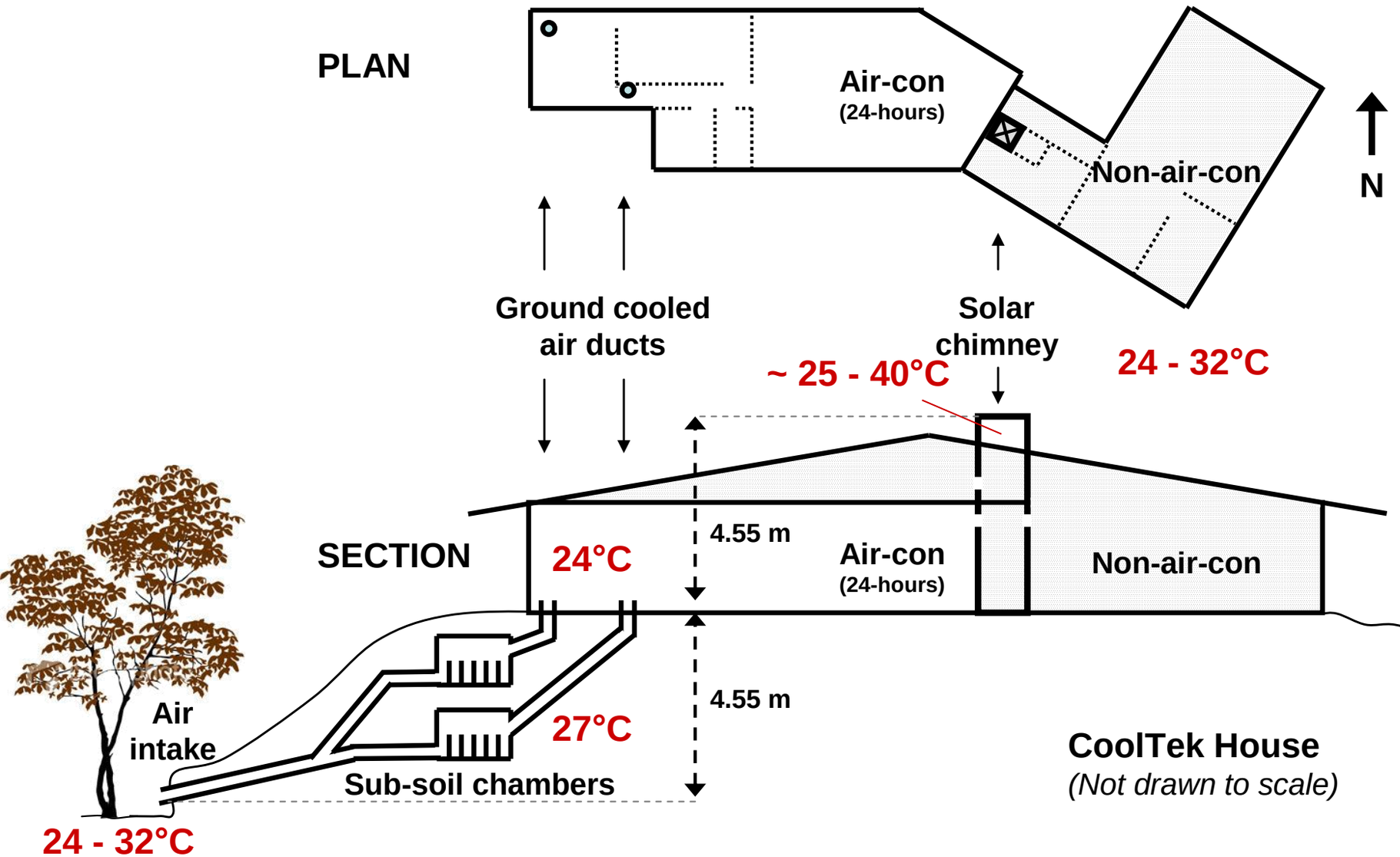
- Building Colours?
  (dark, medium or light colours)

  → **Light colours**
  (to reflect sunlight)

- Thermal insulation?
  (none, medium, thick)

  → **Medium/thick**
  (24-hour air-con space)

GROUND COOLED VENTILATION WITH SOLAR CHIMNEY



CoolTek House
(Not drawn to scale)

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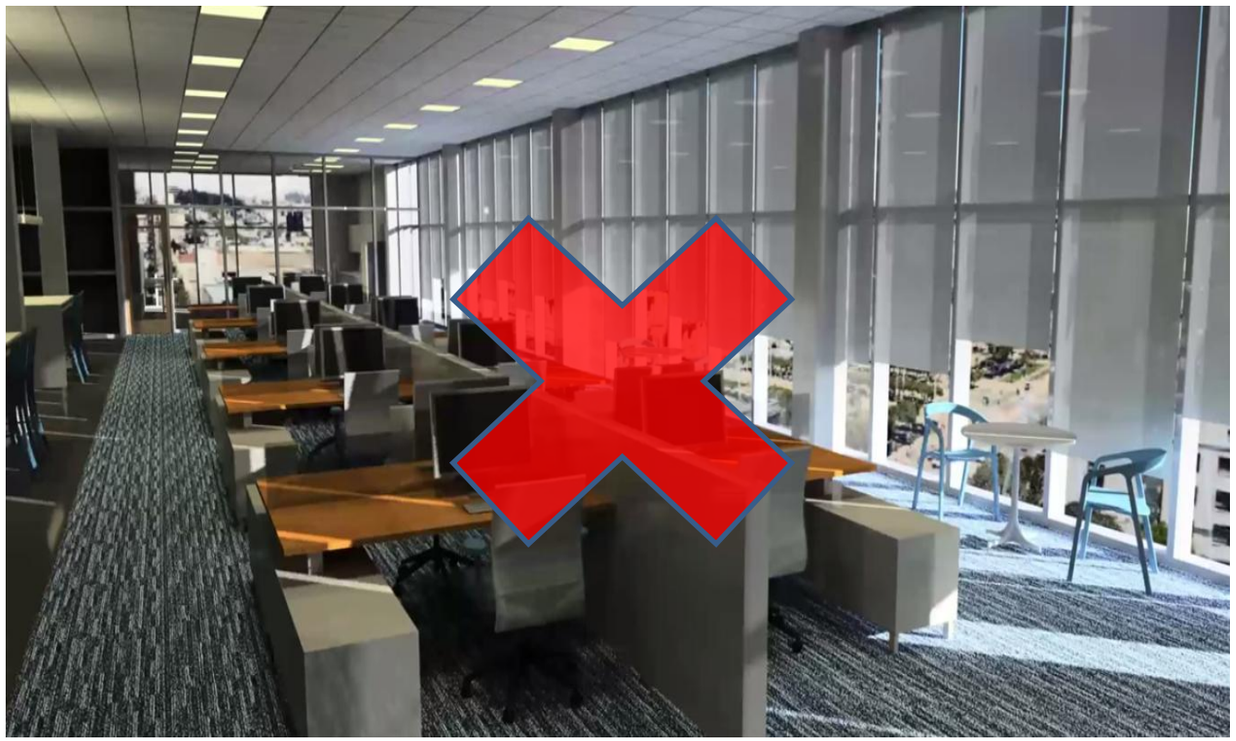
Comfort – Daylight

眩光是影响建筑实际采光效果的关键问题　Glare control for daylighting

Control glare from clear sky and direct sun, Denmark



Glare from overcast sky may inhibit daylight system, California

2012年东盟节能建筑大奖获得者

ST钻石大厦(马来西亚）

总建筑面积: 14000 m2
竣工: 2010年
实测能耗: 65 kWh/m2/年 (不包括光伏),
60 kWh/m2/年 (包括光伏)
建筑节能达65%，3年投资回收期

1st green building index GBI **Platinum**

BCA GREEN MARK Green Mark **Platinum**

2012 ASEAN Energy Award winner

2013 ASHRAE Technology Award (2nd place)

建筑外形与当地气候相适应

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.

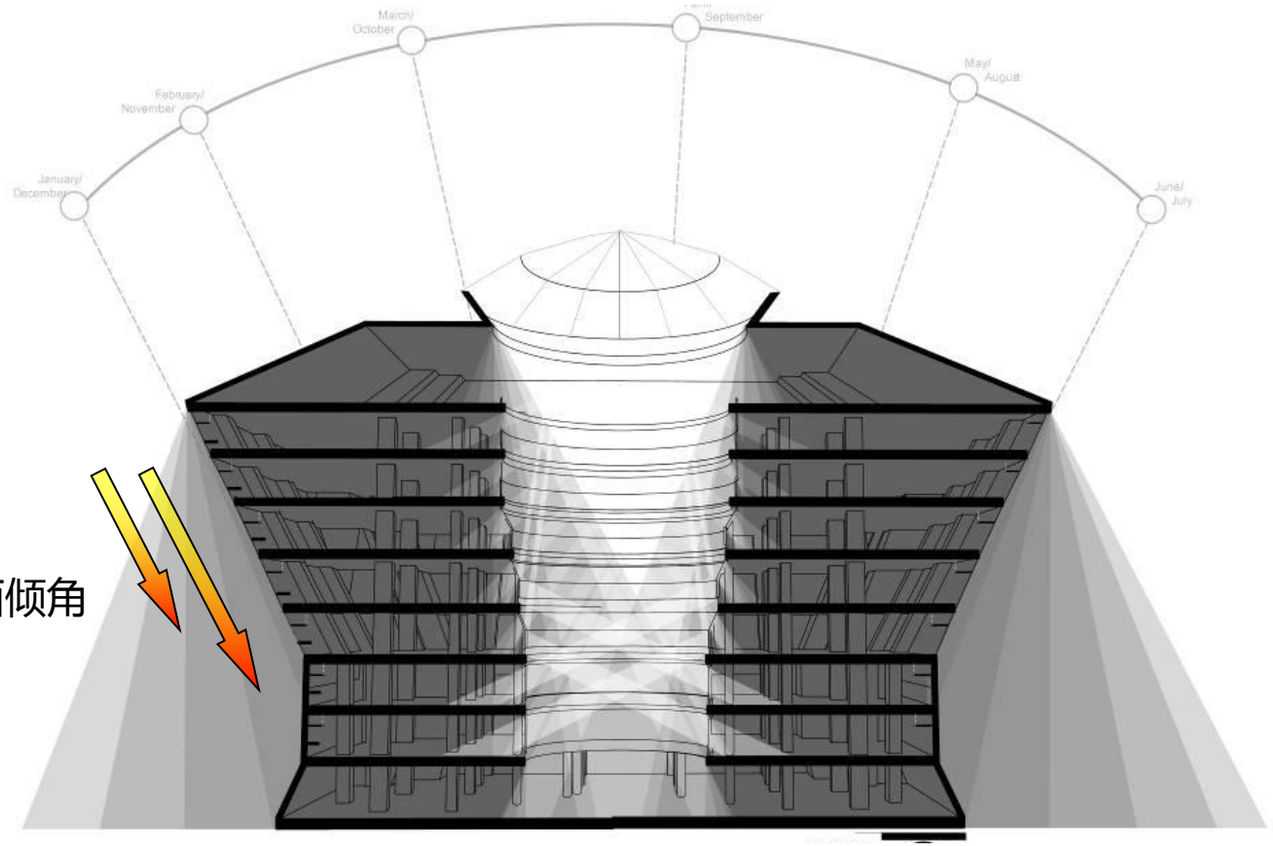
The objective of the scheme, which was implemented by the Ministry of Energy, Communications and Multimedia (now Ministry of Energy, Green Technology and Water), was to develop capacity in the optimisation of energy efficient building design. This was done through training sessions, seminars, specific 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.

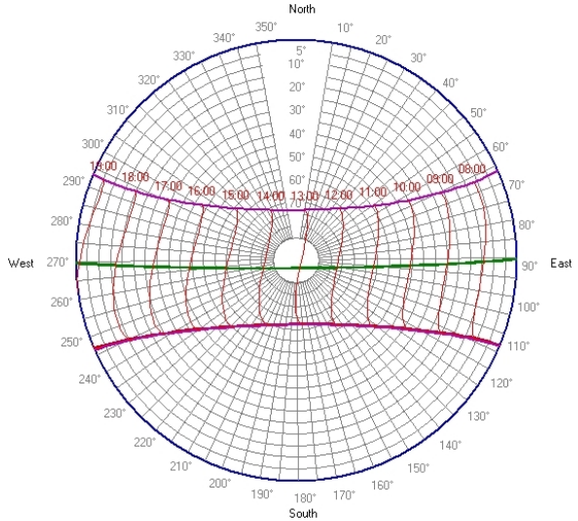
Examples and Initiatives

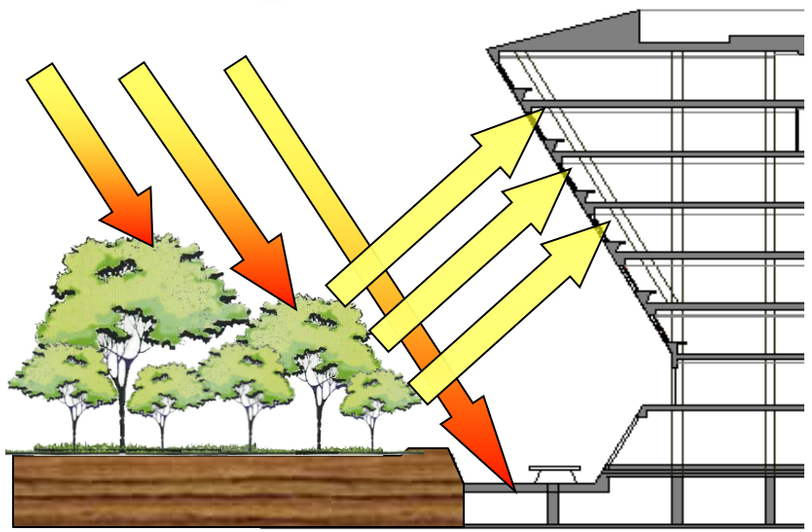
建筑外形自遮阳　Building shaded by itself



25° 外立面倾角

The building design allows for ample internal daylighting via the atrium and self shading on the north and south facades.

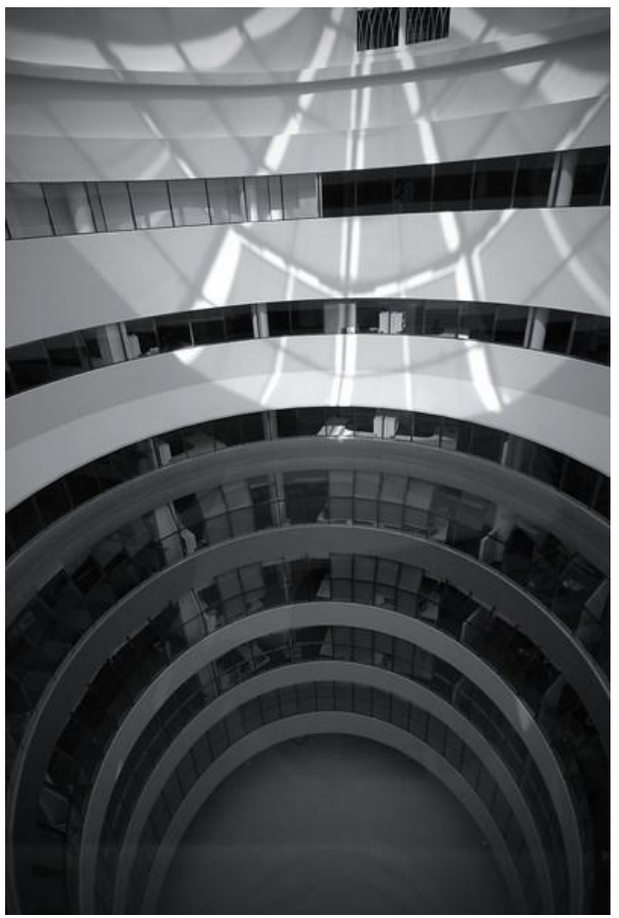




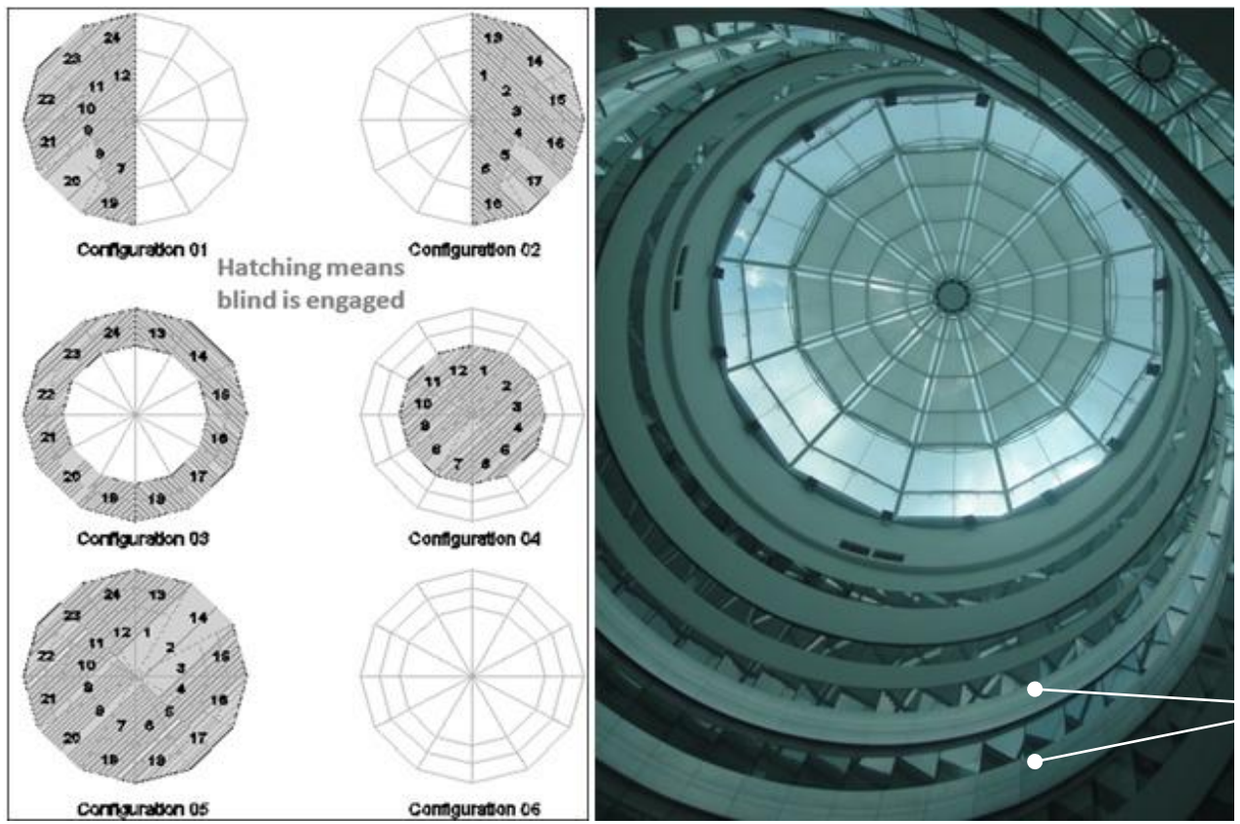
建筑的中庭设计允许充分的建筑内区自然采光，同时建筑巧妙的体型设计允许建筑南北立面自己给自己遮阳。

采光中庭　Daylight atrium

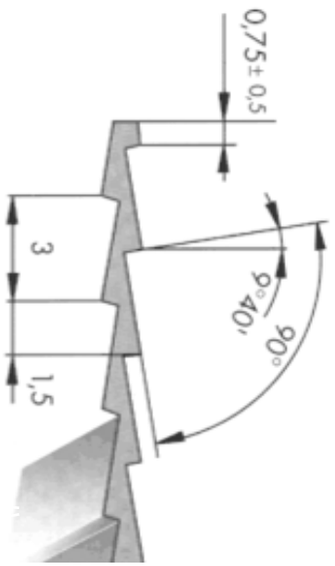
采光中庭



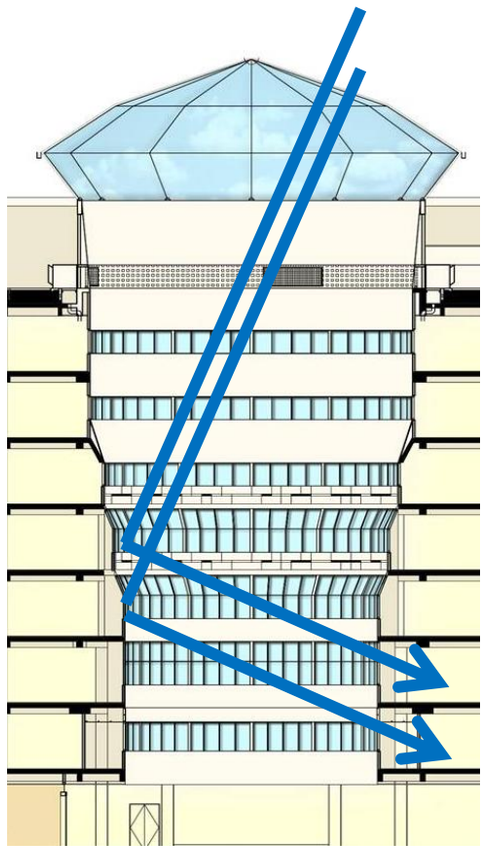
采光中庭自动可调遮阳　Skylight automatic internal shading



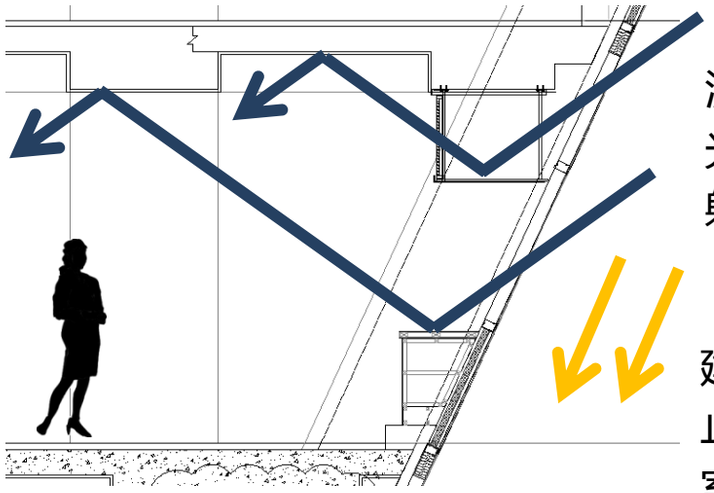
中庭天窗6种组合模式的可调节内遮阳系统



位于第4与第5层的
圣诞树形的反光板。



办公室无眩光采光　Glare free daylighting for office

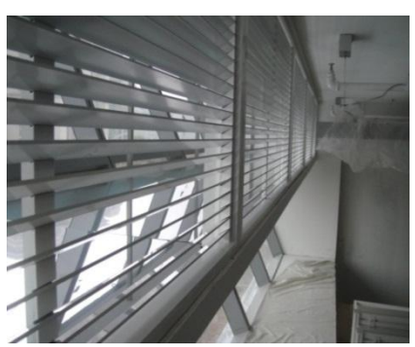


漫射光通过导光板与窗台斜射入室内

建筑自遮阳防止太阳直射入室内

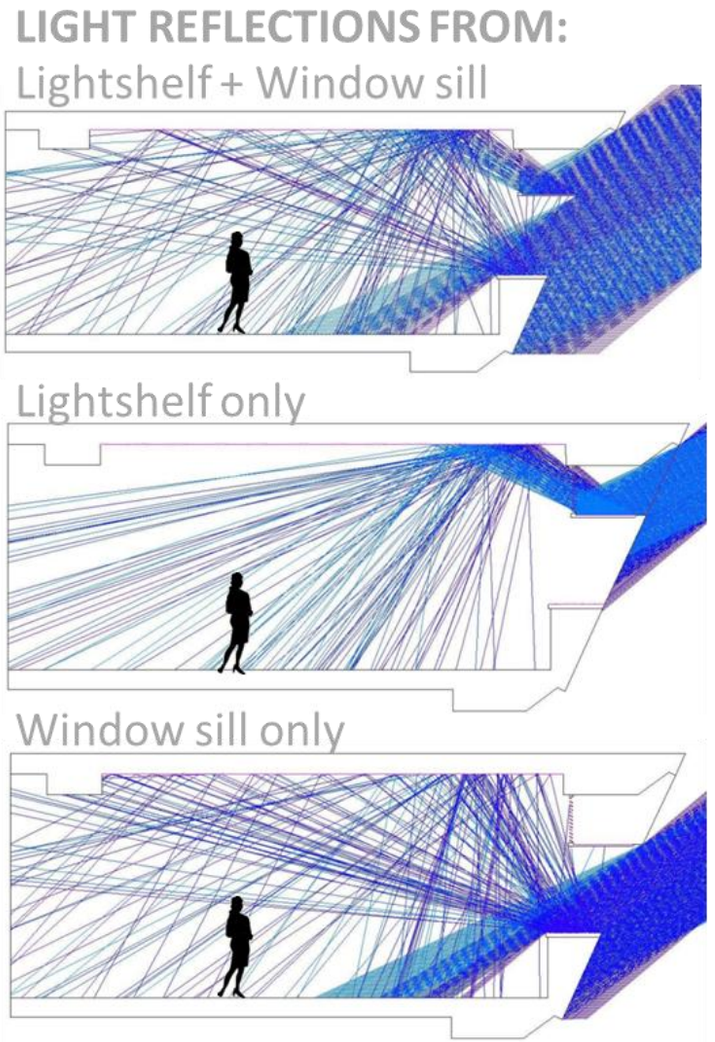
东西立面内遮阳

镜面导光板



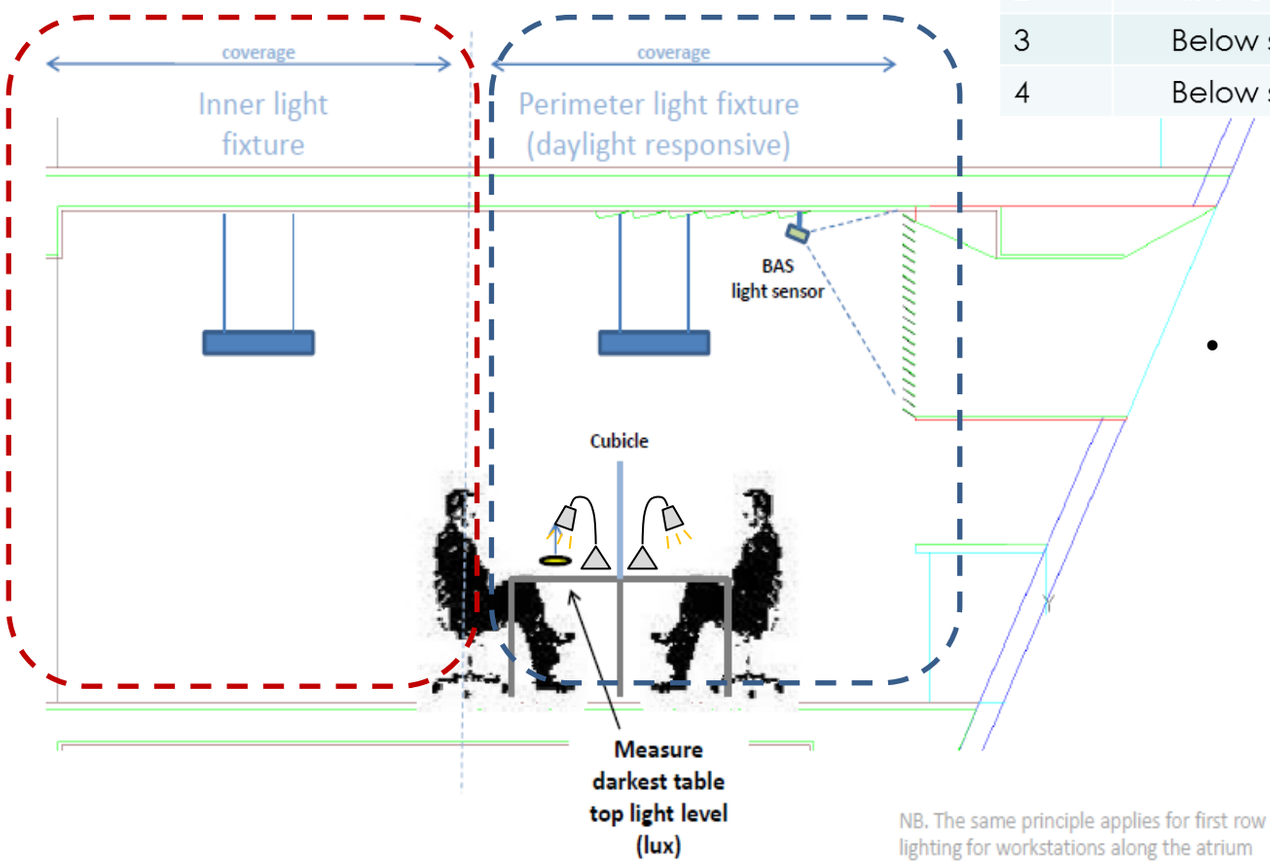
特定角度的固定百叶控制眩光

南北立面自然光被反射到天花板上



采光感应智能照明控制　Daylight responsive lighting control

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



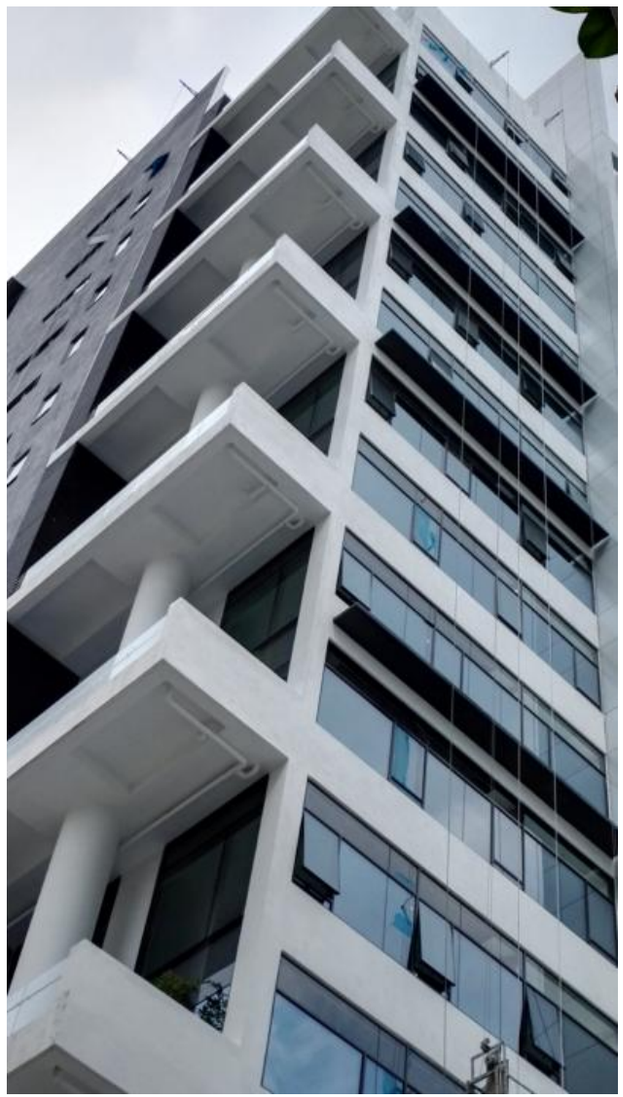
NB. The same principle applies for first row of lighting for workstations along the atrium

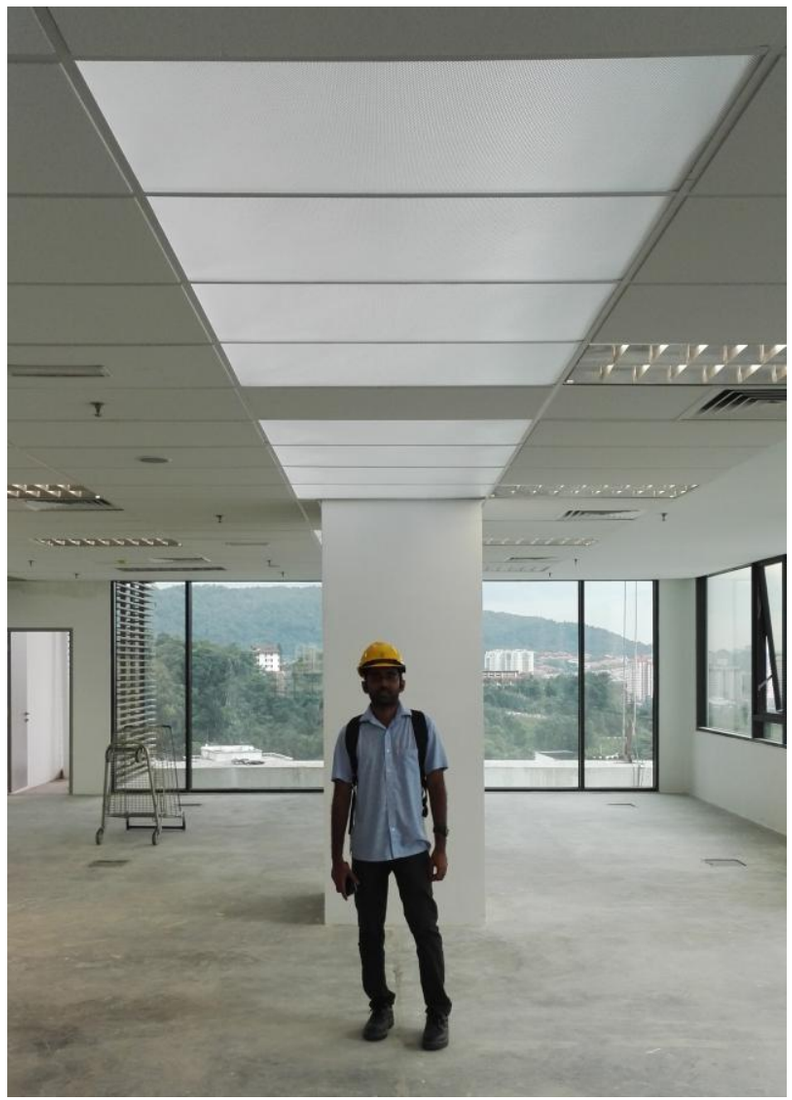
- With the glazing on all sides and fairly large windows , perimeter space should be sufficiently daylit for 3-4hrs per day. Ensure that lighting circuit for these spaces (3-5m from façade) are separated from internal spaces.

Measured lighting consumption: 0.9 W/m2

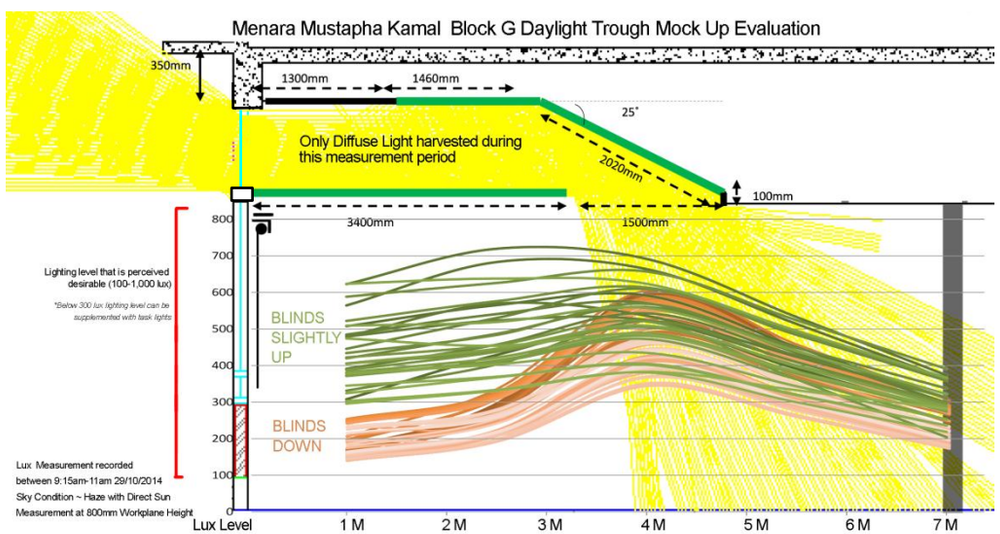
15 times lower than code requirement

MMK大厦，“隐形”的建筑幕墙采光系统　Daylight Trough

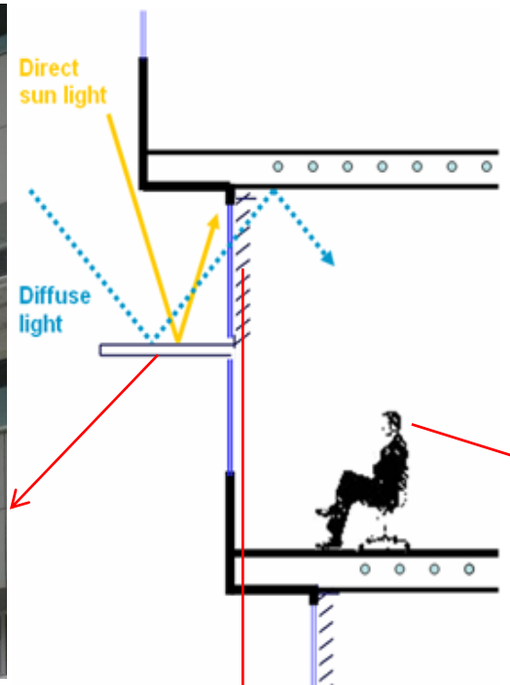


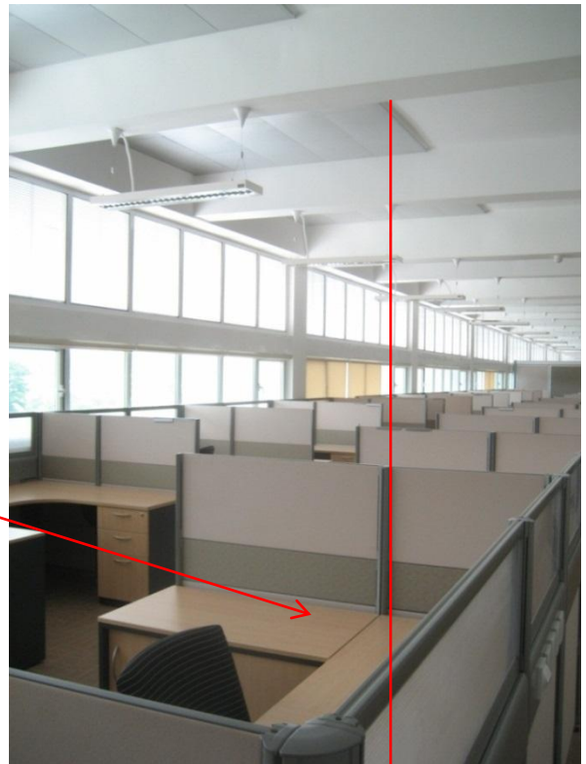


Measured daylight show that the first **7 meters** can be daylit even with the blinds down

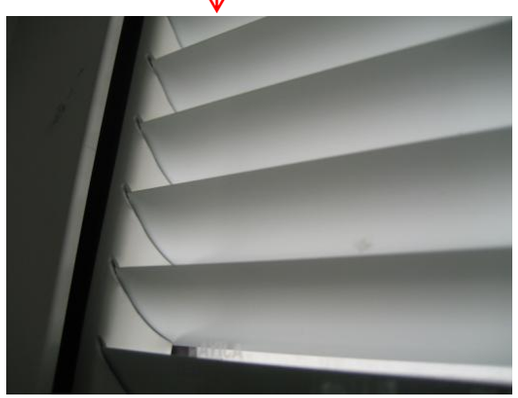


近零能耗办公楼GEO， Split Window Design

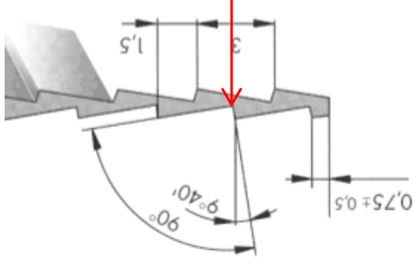




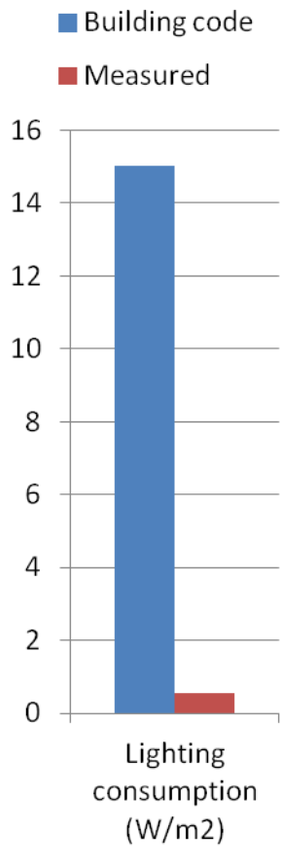
采光围护结构上的镜面反射导光板



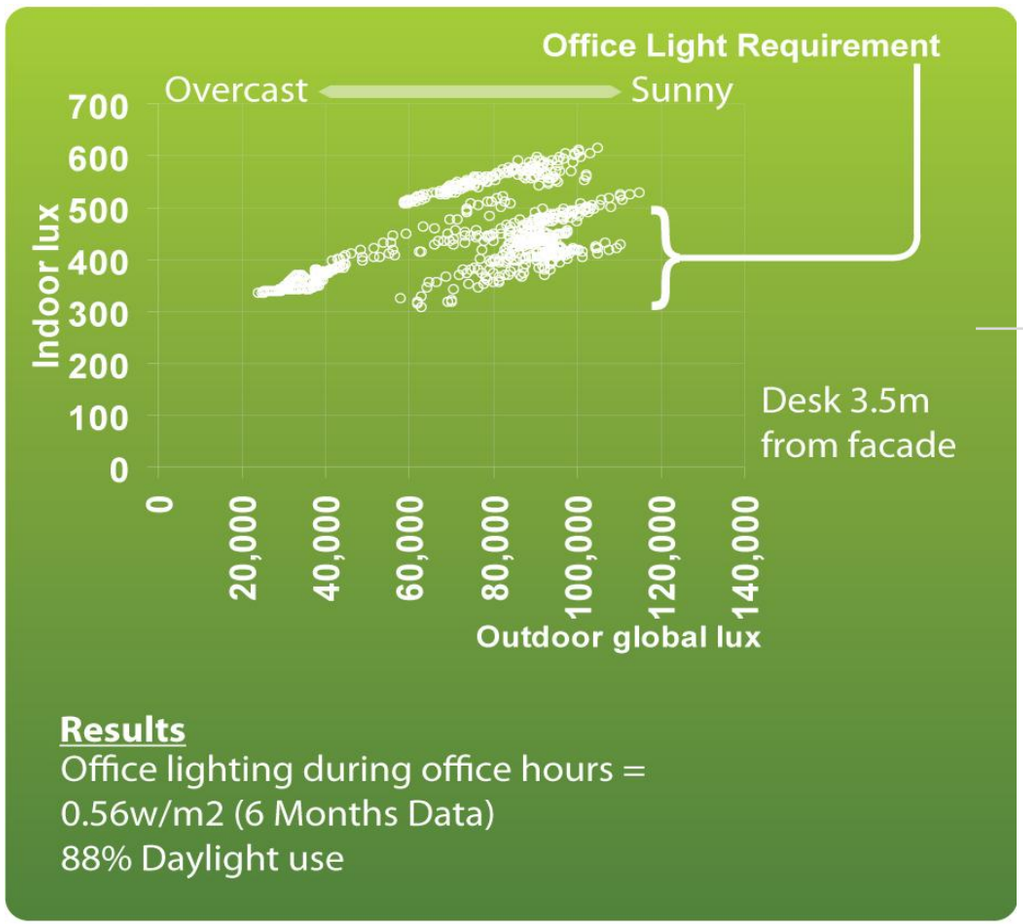
双层玻璃之间固定的采光反光百叶。百叶内侧表面是哑光白色，百叶外侧表面接近镜面反射



近零能耗办公楼GEO，采光与照明节能效果　Measured daylight levels



Measured Daylight levels



在工作时间（8am ~17pm），通常只有5%的人工照明。照明安装功率只 5W/m2 。而实测照明能耗只有0.56 W/m2，相比设计标准要求则是15 W/m2

Electric lighting needs only to be on 12% of the time during working hours 8.00 – 17.00, Installed lighting load is 5 W/m2 only.

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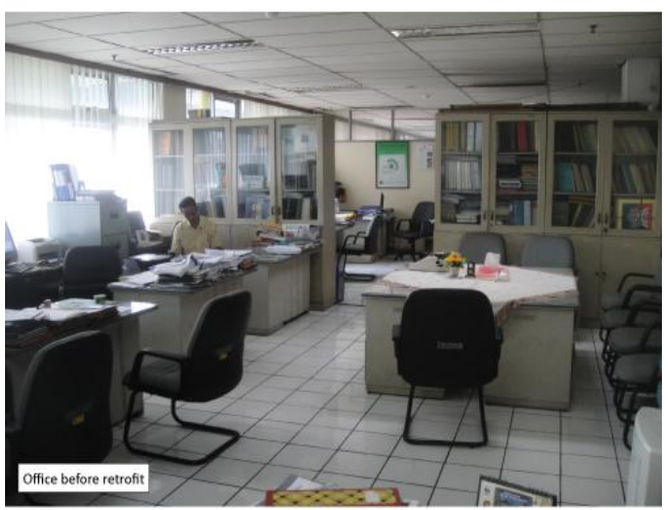
印尼既有办公楼，室内采光，热舒适与节能改造　Retrofitting



Energy	
170 kWh/m² yr	80 kWh/m² yr
Comfort	
26-31 temp (°C)	24-26 temp (°C)
75 RH (%)	55 RH (%)
Noise	
57 dB	53 dB
Daylight	
No	Yes
View out	

<u>改造前</u>

- 窗帘一直拉下
- 灯一直开着
- 低能效的中央空调
- 无新风控制
- 漏风的围护结构
- 单层玻璃

<u>改造后</u>

- 充沛的自然采光
- 灯关上
- 高能效的VRV空调系统
- 需求通风控制
- 气密性好的围护结构
- 双层玻璃

亚洲发展银行总部，中庭采光改造　Retrofitting

BEFORE

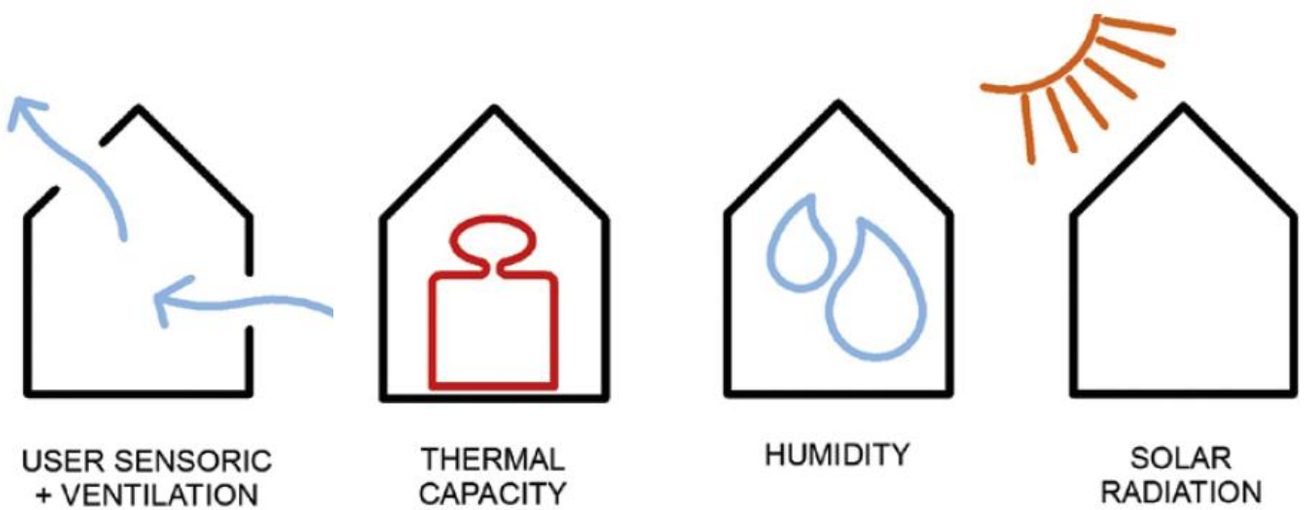
AFTER

BEFORE

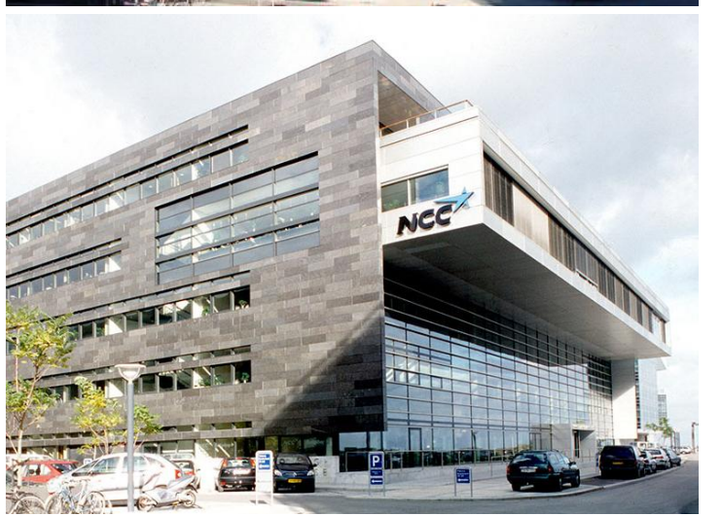
AFTER

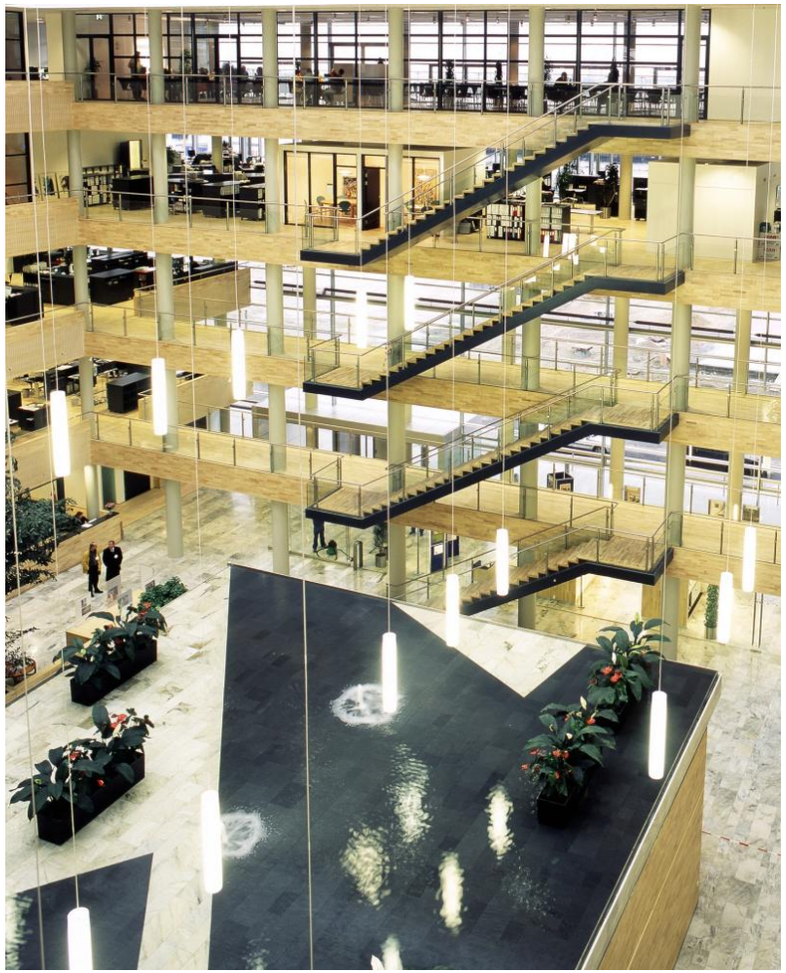
菲律宾亚行总部中庭改造项目，采光效果提升6倍

Comfort – Thermal



哥本哈根 NCC（丹麦），完全依靠自然通风的办公建筑　Natural ventilation





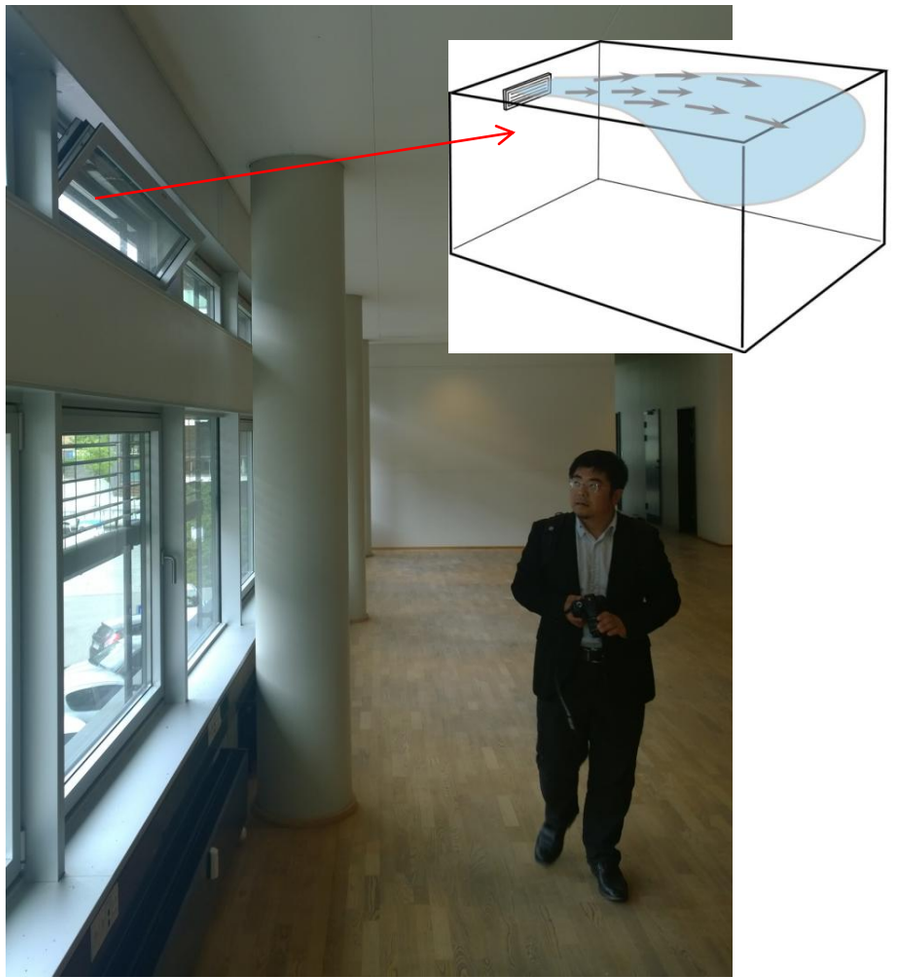


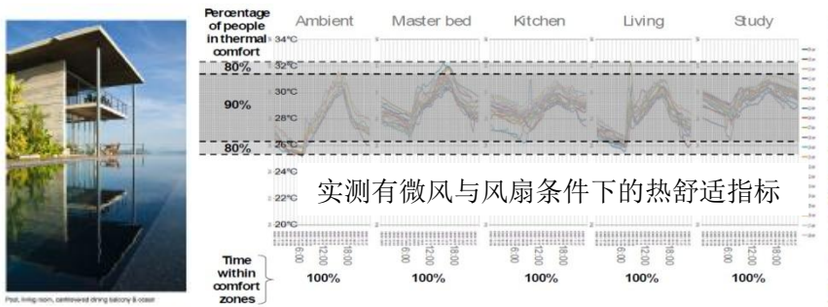
Image courtesy of SHL (architects for the project)

竹屋别墅（泰国），被动设计提高舒适度　Adaptive comfort & natural ventilation

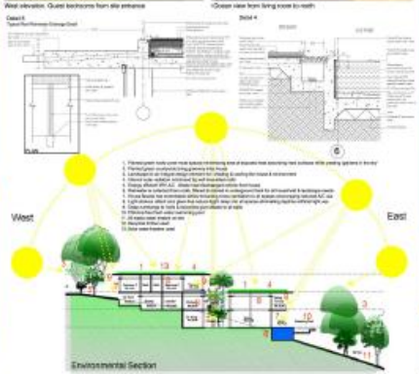
总建筑面积: 450 m^2
奖项: BCI 设计大奖
能耗数据对比:
< 51 kWh/m^2/年,节能31%相比参考建筑，一年依靠雨水的水资源自给自足的时间: 8 个月

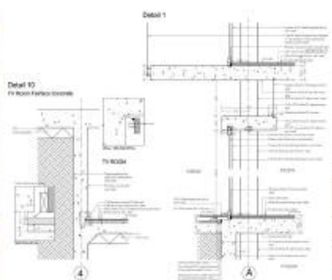
在房间实际使用过程中，超过30,000次的测量温度，湿度，采光强度。客户的观察与反馈意见:

- 白天在房子的任何地方不需要开灯
- 在淋浴喷头与用水器具上没有结水垢
- 在巨大多数的日子里，整座房子有充分的自然通风
- 这是我们住过的所有房子中，唯一一座不需要空调的房子，即使是在晚上睡觉时
- 房间里没有发霉放生
- 参观者经常评价说整个房子对他们而言是相当的舒适与凉爽。



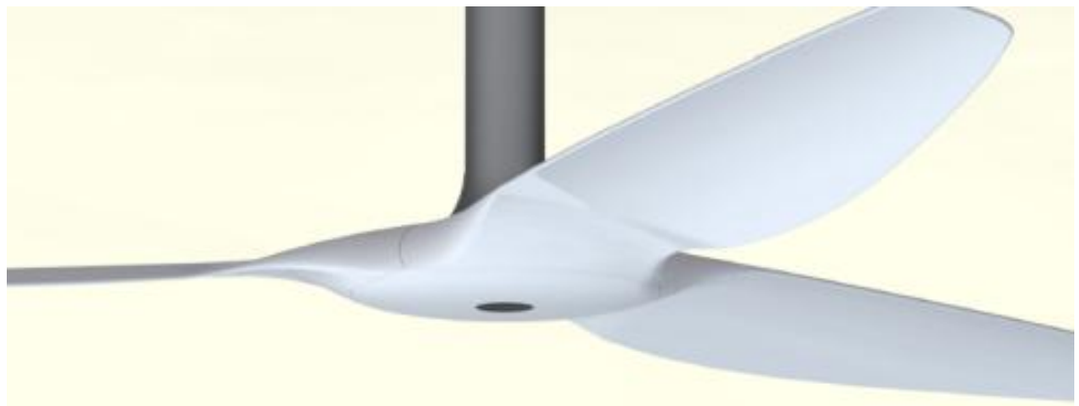
实测有微风与风扇条件下的热舒适指标





P_114076 Residential - Individual Houses

竹屋别墅，在每个房间都有良好的自然通风 Adaptive comfort & natural ventilation



吊扇降低体感温度2-3°C,世界上能效最好的吊扇Haiku，4W在低速。

Affordable

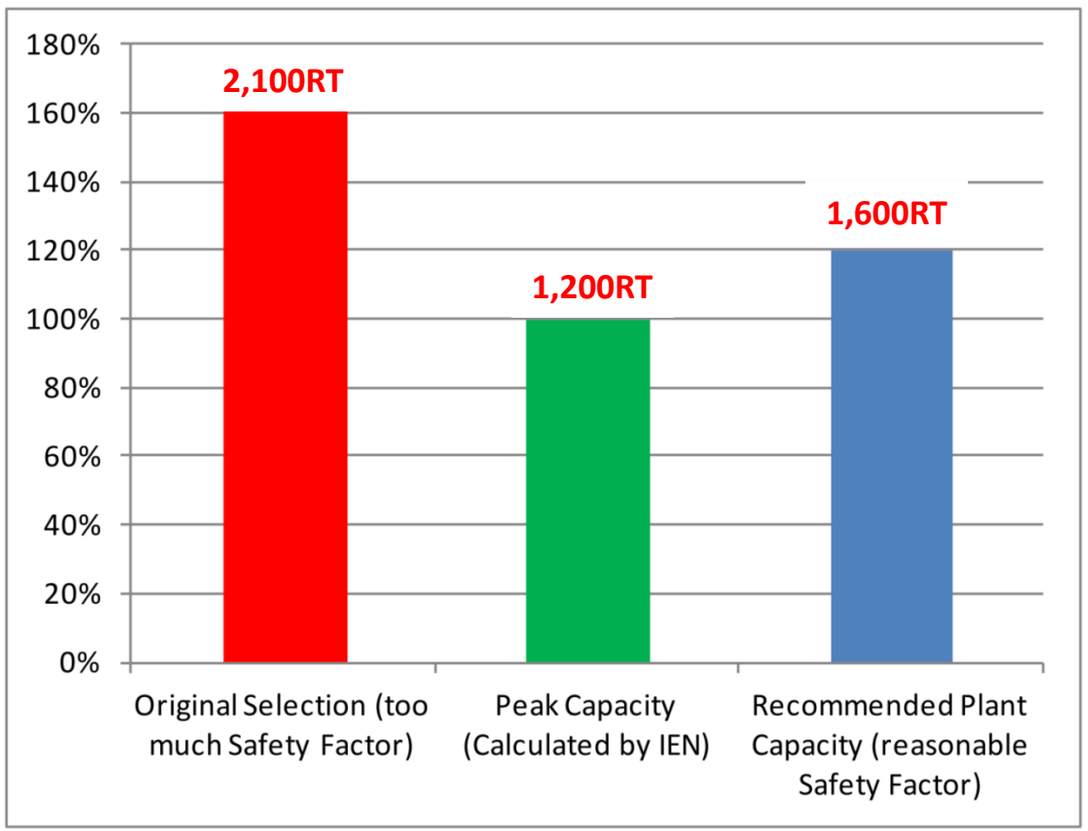
Expensive Not to Go Green

宜家商场，最佳的建筑成本控制　Avoiding overdesign!

降低23%建筑空调冷负荷，节省超过200万人民币的制冷机房初投资并降低30%~40%运行能耗！

GBI
Gold

LEED
Gold



制冷机房装机容量（冷吨RT）

宜家商场，最佳的建筑成本控制　Avoiding overdesign!

降低23%建筑空调冷负荷，节省超过200万人民币的制冷机房初投资并降低30%~40%运行能耗！

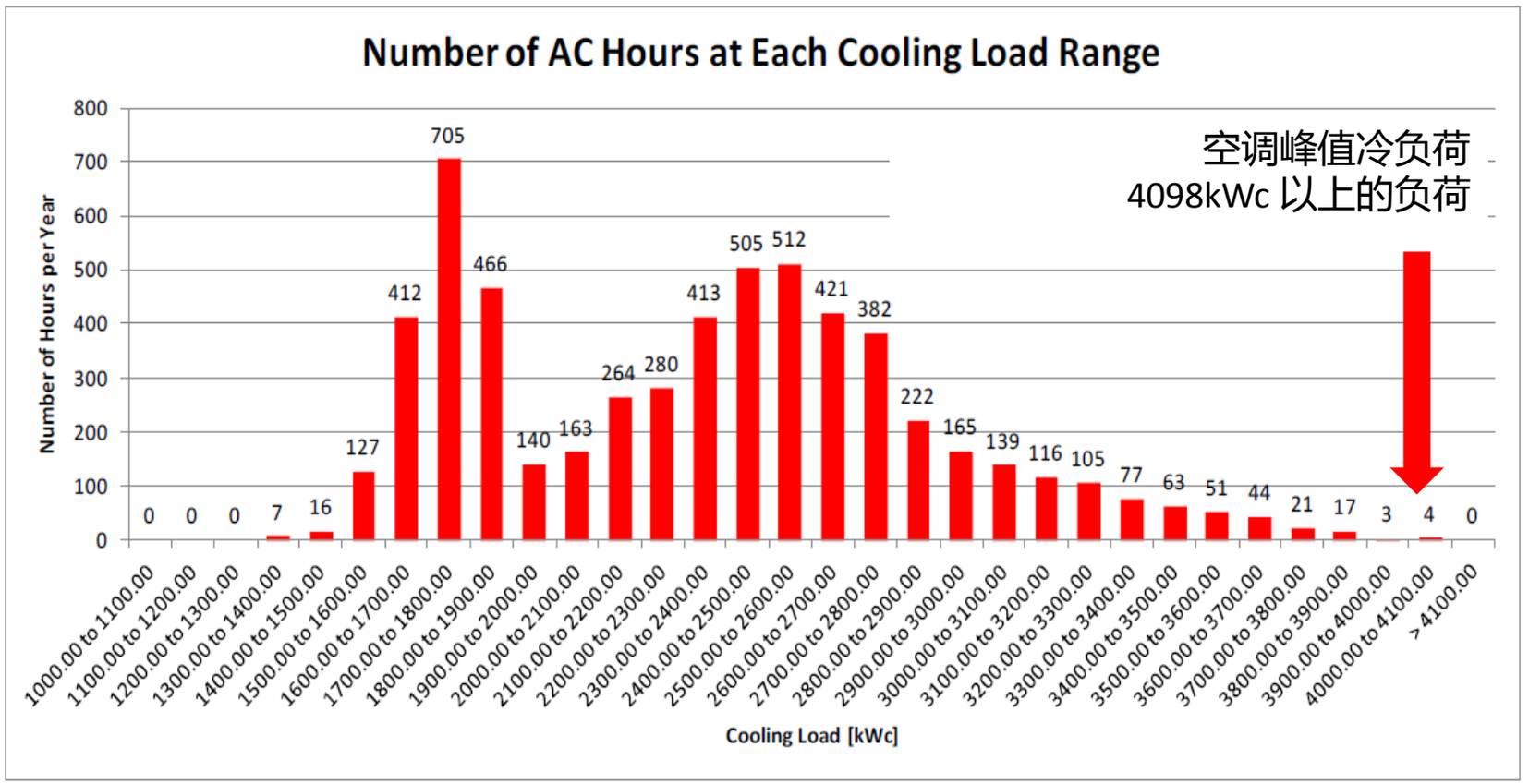


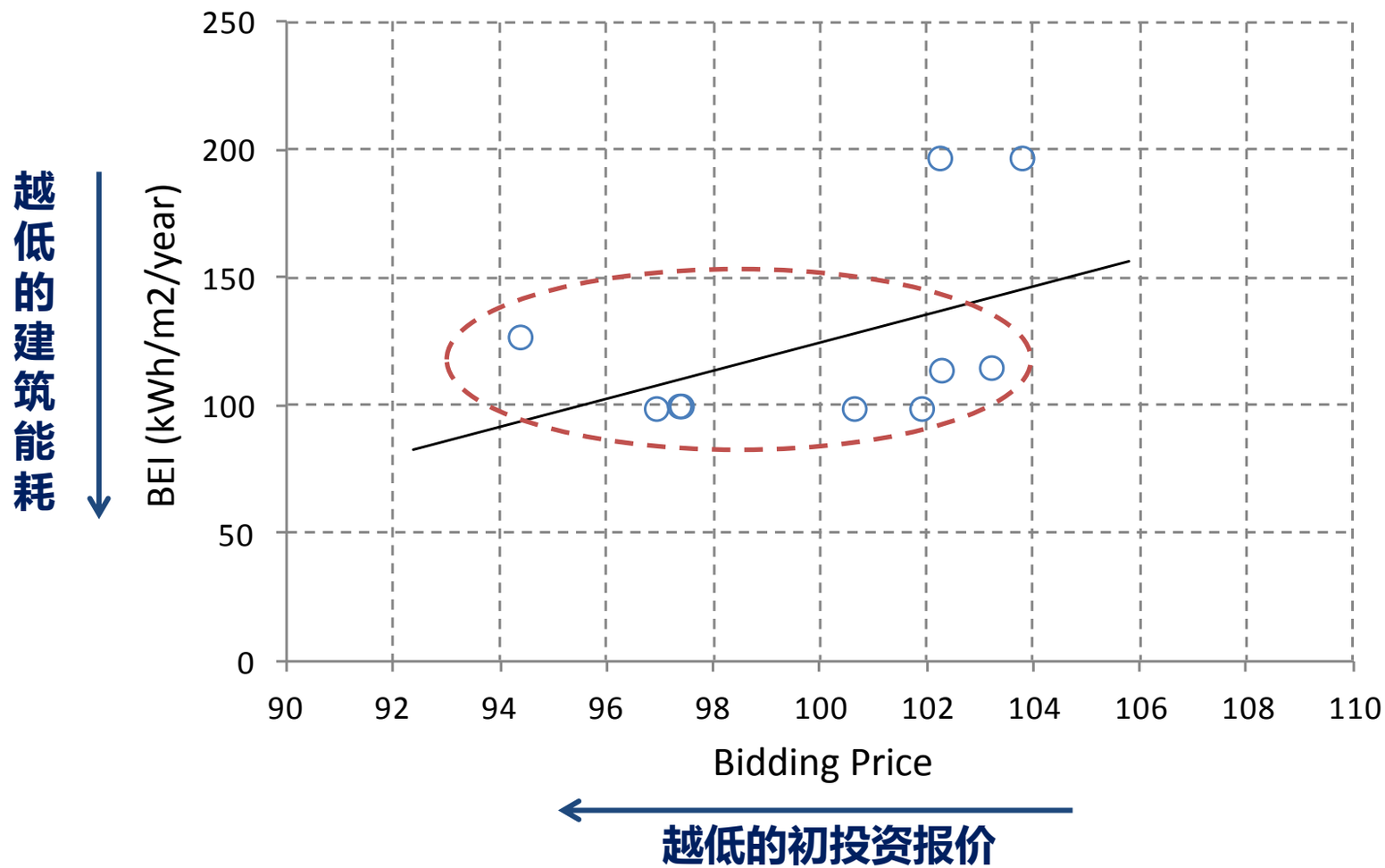
Figure 4.2 Chart showing the number of AC hours per year the store Total Cooling Demand will be between the specified range

大部分冷负荷出现在1600kWc 至3000kWc之间！

KKR2超高层办公楼，最佳的建筑成本控制　Avoiding overdesign!

1. 我们发展具有经济吸引力的解决方案，以最低的整体投资获得最佳的建筑能耗性能与环境品质
2. 开发商明确在施工招标文件中提出建筑能耗指标要求，100 kWh/m2/yr
3. 公开招标结果表明：通过 IEN Consultants 协助的更合理的节能设计同时也是投标方总报价成本最低的。

KKR2，超高层高级办公项目
（设计+施工）



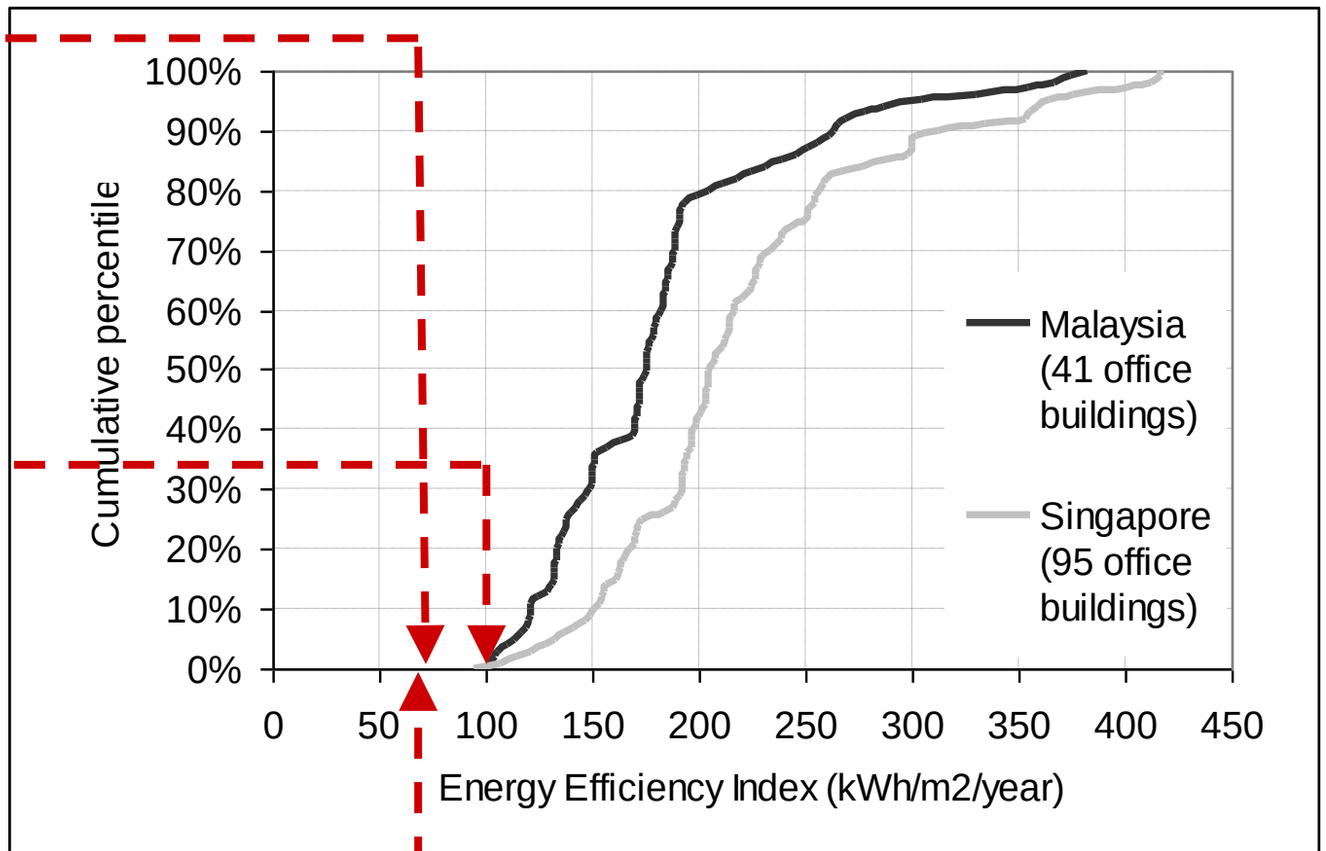
Energy & Monitoring

与同类型的建筑对比，出众的实测节能效果
Energy Benchmarking

项目名称：ST钻石大厦（ST Diamond Building）
获奖时间：2013年
授予单位：ASHRAE美国暖通工程师协会
东盟能源中心
奖项名称：ASHRAE Technology Award (第二名)
ASEAN Energy Award
实测能耗：65 kWh/m2/年 (不包括PV)
60 kWh/m2/年 (包括PV)

项目名称：LEO低能耗大厦（LEO Building）
获奖时间：2006年
授予单位：东盟能源中心
奖项名称：ASEAN Energy Award
实测能耗：100 kWh/m2/年

项目名称：GEO绿色能源大厦（Pusat Tenaga Malaysia, GEO Building,Greentech Malaysia）
获奖时间：2009年
授予单位：东盟能源中心
奖项名称：ASEAN Energy Award (Renewable Energy)
实测能耗：64 kWh/m2/年 (不包括PV)
35 kWh/m2/年, (包括PV)



***Source of chart:* EAEF Project 64**
Development of a Compreshensive Building Energy Benchmarking Database in ASEAN
Project leader: Energy Sustainabilty Unit, Singapore, 2006

I | E | N CONSULTANTS

建筑一体化可再生能源　Building Integrated Renewable Energy

总建筑面积: 5,000 m^2

能耗数据对比:

64 kWh/m2/year (不包括PV),

35 kWh/m^2/年, (包括PV),

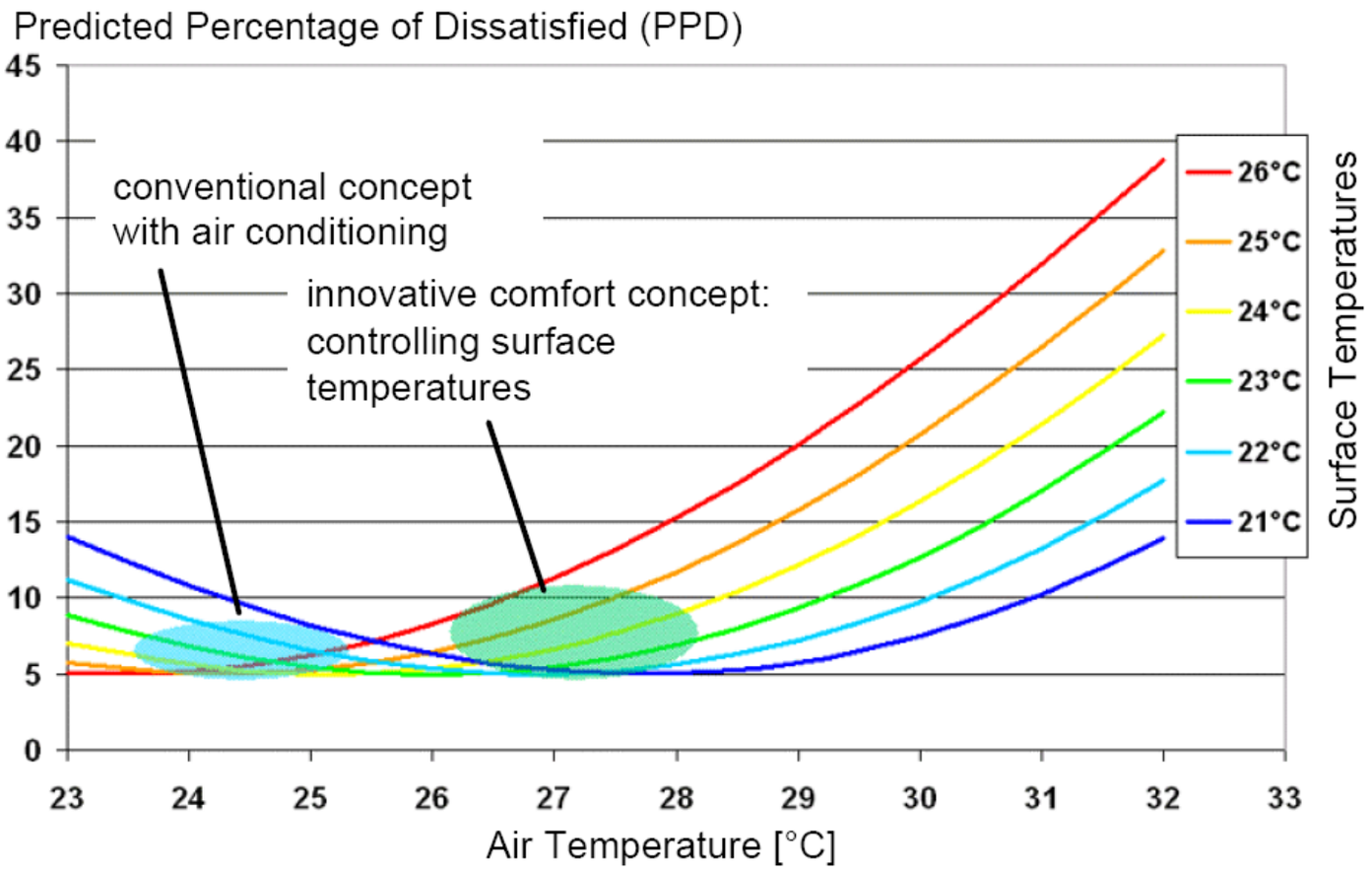
是典型办公建筑能耗的15%，

增量成本: 18% (不包括PV), 33% (包括PV)

EE Features:

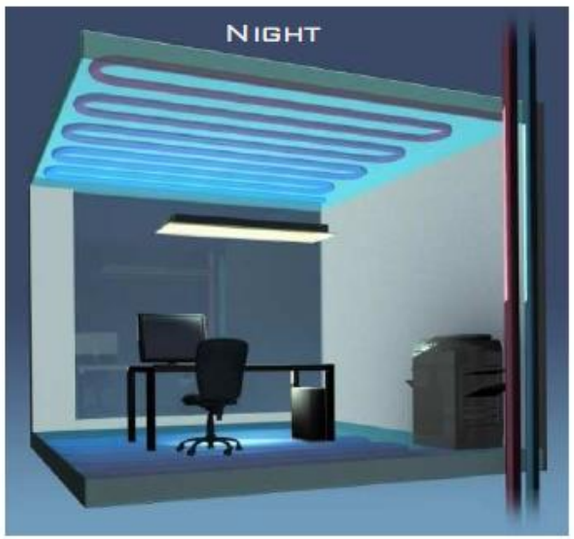
- Daylighting (88%)
- EE lighting + task lights
- EE office equipment
- EE server room
- Floor slab cooling
- EE ventilation
- Controls & Sensors
- Double glazing
- Insulation
- Air tightness

地板辐射制冷系统（TABS）　Radiant cooling allows higher air temperature



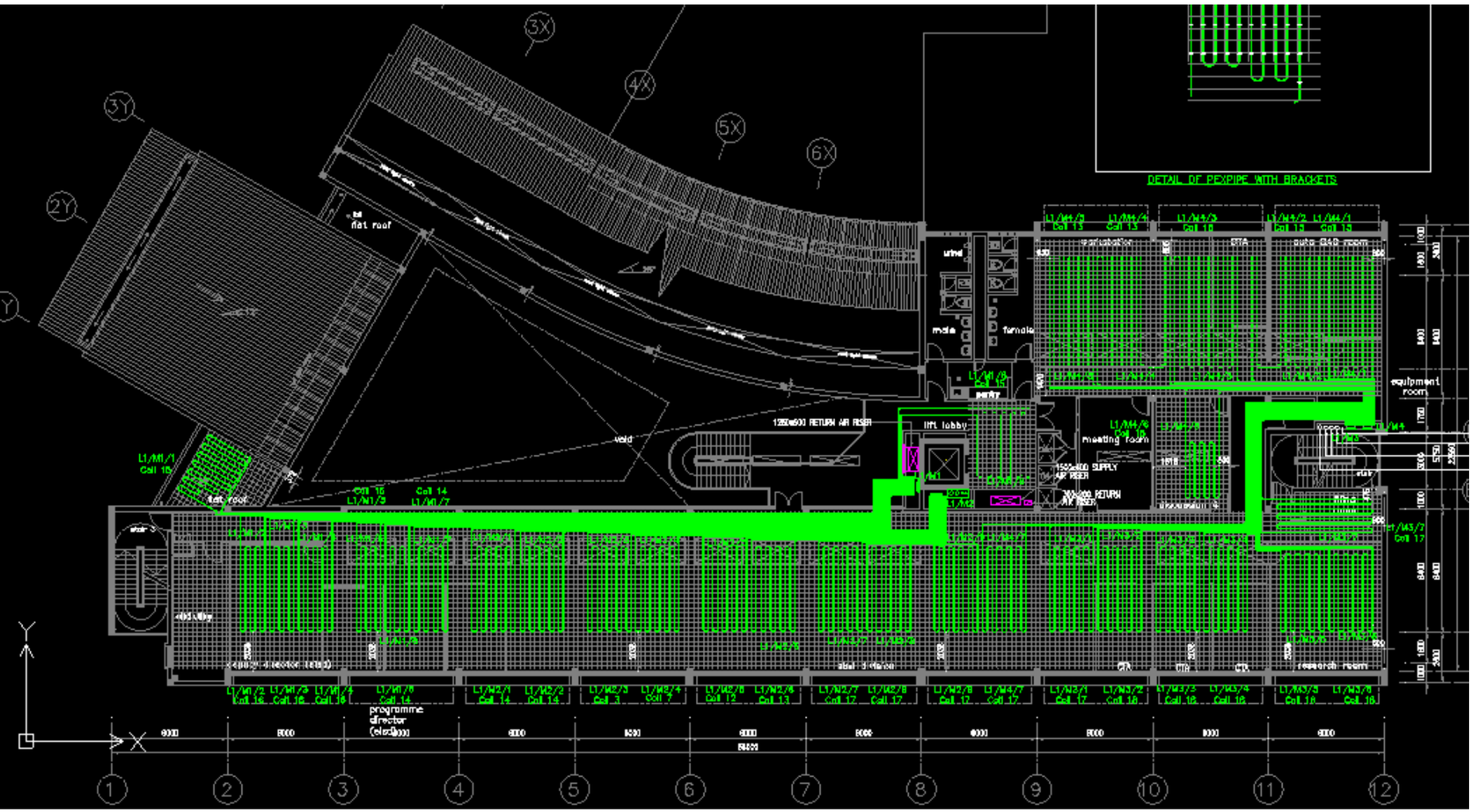
Predicted percentage of dissatisfied (PPD) according to Prof. O. Fanger
different surface temperatures; no direct radiation
office work, light clothing air velocity 0.15 m/s; humidity 11 g/kg

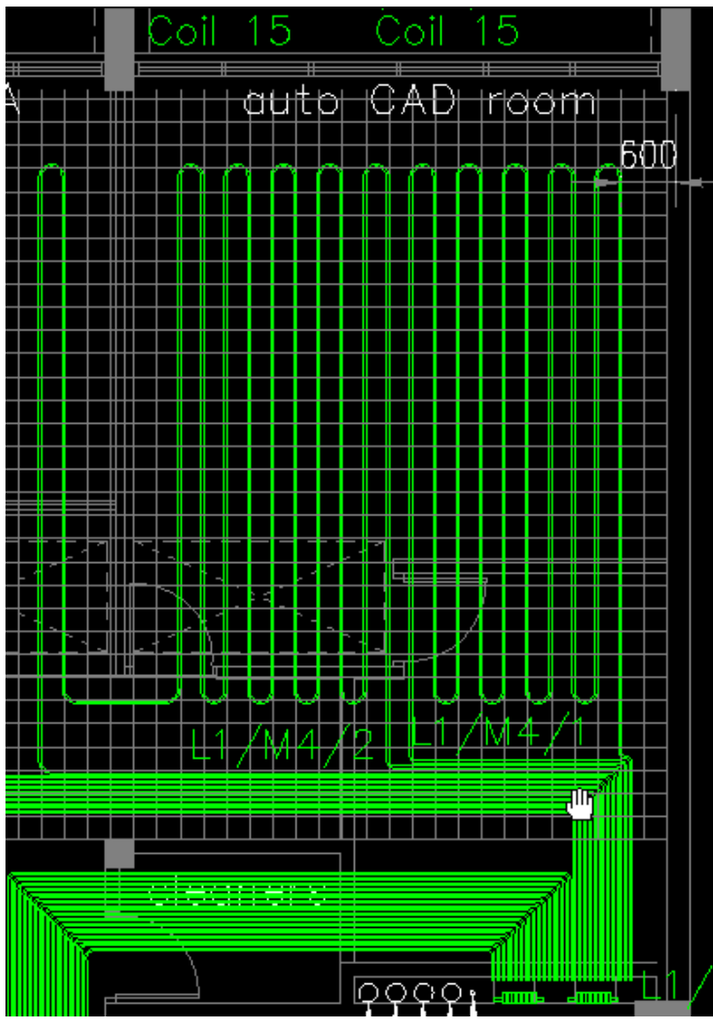
地板辐射制冷系统（TABS）热舒适与节能设计　Slab cooling



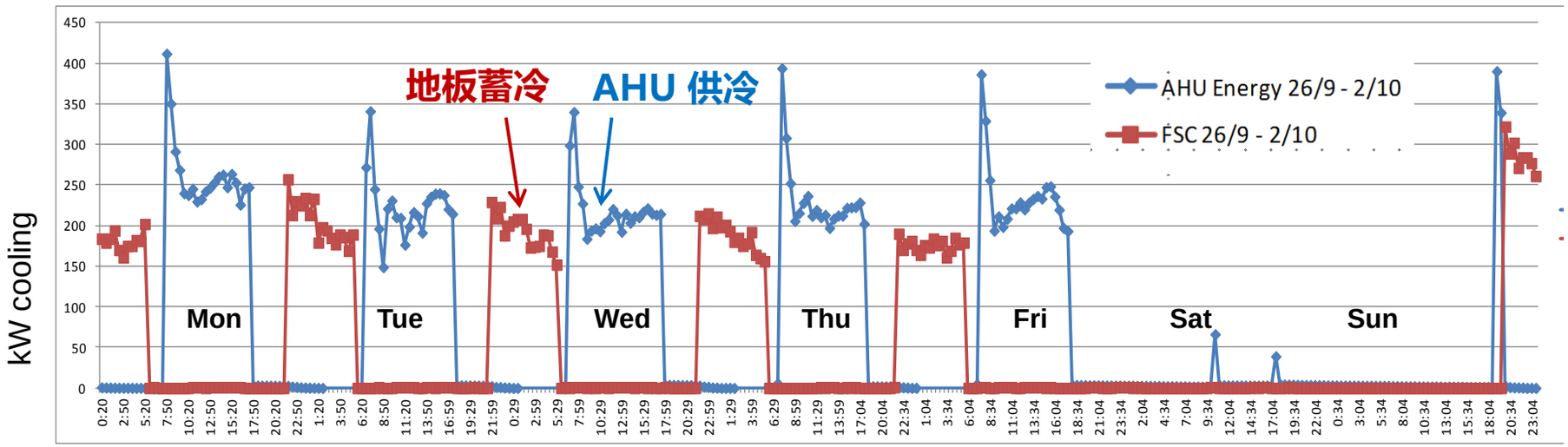
- PEX pipes
- Embedded in concrete slab
- Supply temperature: 18-20°C
- Return temperature: 22-24°C
- Night time operation only

地板辐射制冷系统（TABS）热舒适与节能设计　Slab cooling

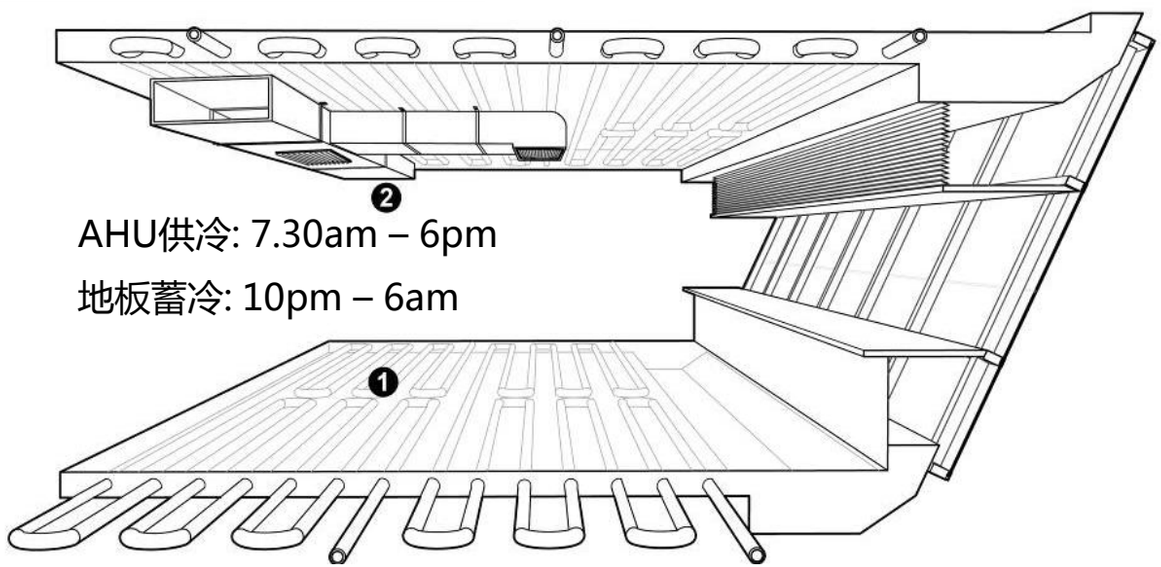




地板辐射制冷系统（TABS）热舒适与节能设计　Slab cooling



建筑体蓄能地板辐射制冷系统（TABS）
将能耗降低至普通建筑的1/3



谢 谢！
THANK YOU!

绿色建筑咨询 | 节能与环境设计及改造 | 可持续城镇规划 | 区域能源规划

Green Building Consultancy | Energy & Environment Design Retrofit |
Sustainable Urban Planning | District Energy Planning

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