HVAC CHALLENGES AHEAD, AN ARCHITECT'S PERSPECTIVE: ERADICATING REDUNDANCY OR ADDING COMPLEXITY

HVAC CHALLENGES AHEAD, AN ARCHITECT'S PERSPECTIVE: ERADICATING REDUNDANCY OR ADDING COMPLEXITY

OIL RIGS OR CAVES?

base

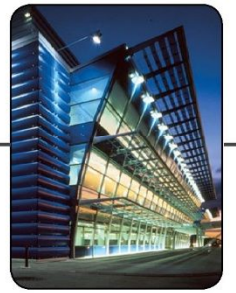
glazing

daily express
sir owen williams

air conditioning

1 canada sq.
césar pelli

shading

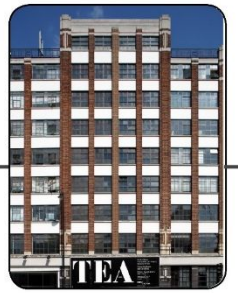


compass house
nicolas grimshaw

intelligent skins

plantation place
arup

morelands



tea

johnson

horseferry

base

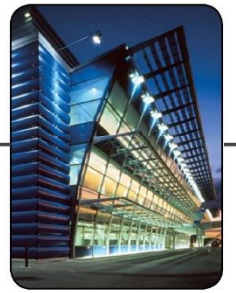
glazing

daily express
sir owen williams

air conditioning

1 canada sq.
césar pelli

shading

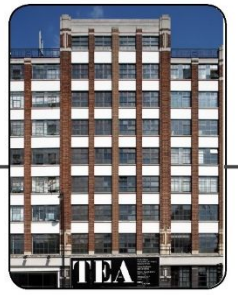


compass house
nicolas grimshaw

intelligent skins

plantation place
arup

morelands

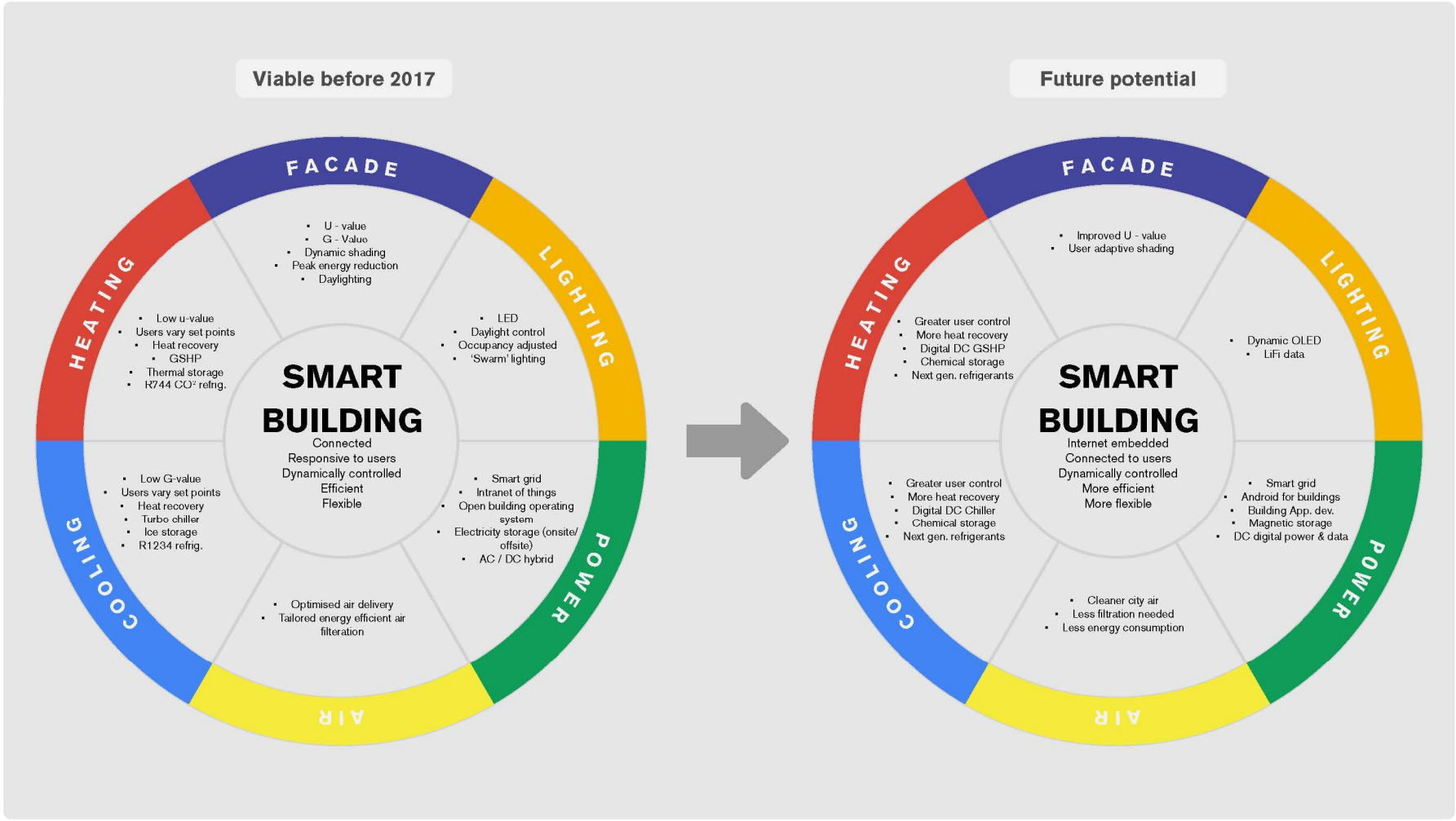


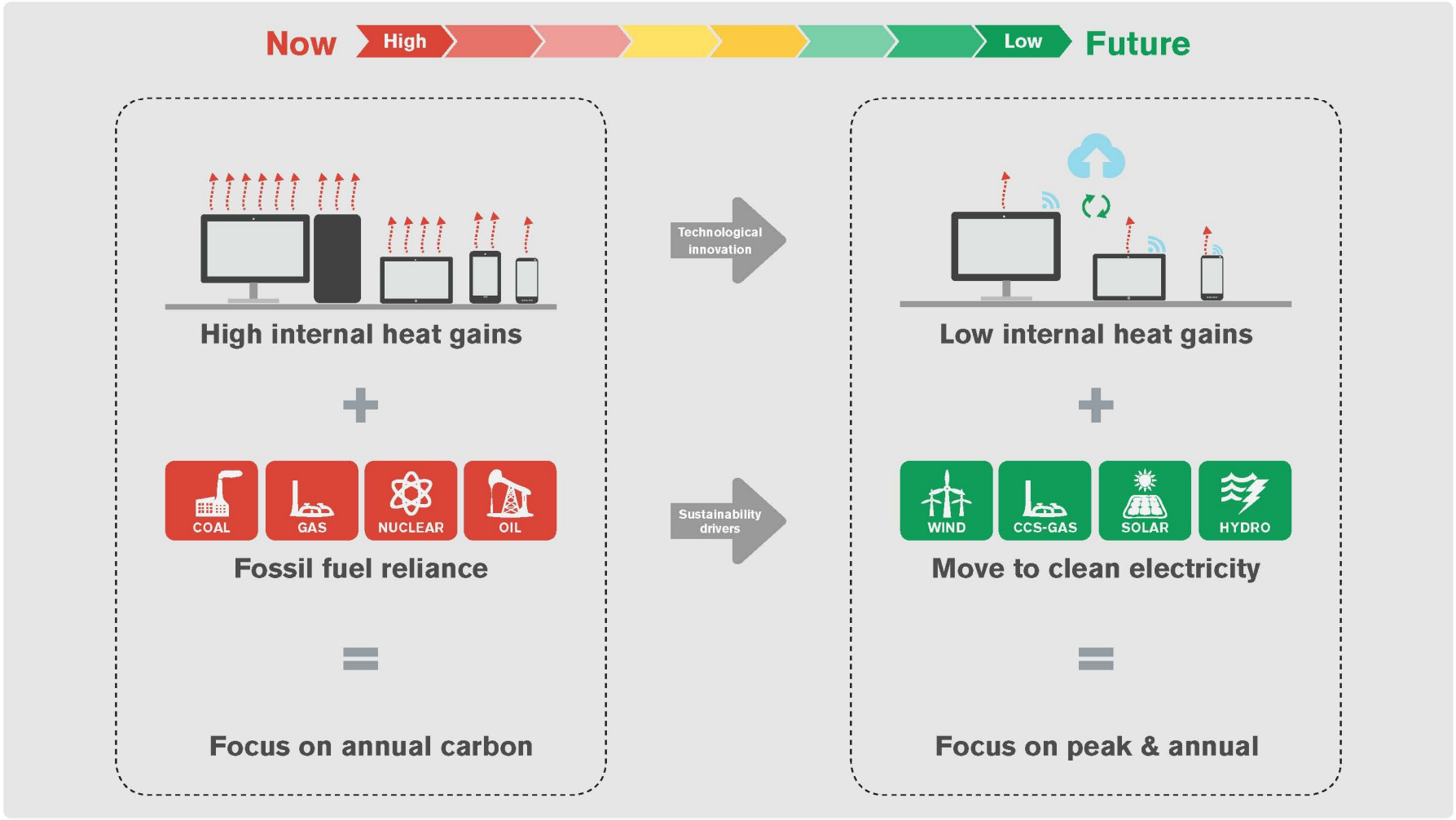
tea

johnson

horseferry

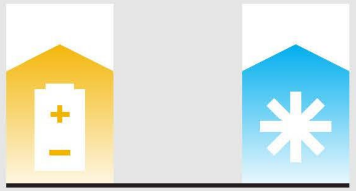
glazing / air conditioning / shading / intelligent skins


Viable before 2017
FACADE
LIGHTING
POWER
AIR
COOLING
HEATING
U - value
G - Value
Dynamic shading
Peak energy reduction
Daylighting
LED
Daylight control
Occupancy adjusted
'Swarm' lighting
Smart grid
Intranet of things
Open building operating system
Electricity storage (onsite/ offsite)
AC / DC hybrid
Optimised air delivery
Tailored energy efficient air filteration
Low G-value
Users vary set points
Heat recovery
Turbo chiller
Ice storage
R1234 refrig.
Low u-value
Users vary set points
Heat recovery
GSHP
Thermal storage
R744 CO² refrig.
SMART BUILDING
Connected
Responsive to users
Dynamically controlled
Efficient
Flexible
Future potential
FACADE
LIGHTING
POWER
AIR
COOLING
HEATING
Improved U - value
User adaptive shading
Dynamic OLED
LiFi data
Smart grid
Android for buildings
Building App. dev.
Magnetic storage
DC digital power & data
Cleaner city air
Less filtration needed
Less energy consumption
Greater user control
More heat recovery
Digital DC Chiller
Chemical storage
Next gen. refrigerants
Greater user control
More heat recovery
Digital DC GSHP
Chemical storage
Next gen. refrigerants
SMART BUILDING
Internet embedded
Connected to users
Dynamically controlled
More efficient
More flexible


Now
High
Low
Future
High internal heat gains
+
COAL
GAS
NUCLEAR
OIL
Fossil fuel reliance
=
Focus on annual carbon
Technological innovation
Sustainability drivers
Low internal heat gains
+
WIND
CCS-GAS
SOLAR
HYDRO
Move to clean electricity
=
Focus on peak & annual

Non peak London

North sea wind

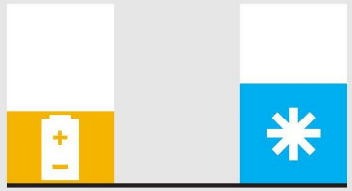


Charge

- Building charges batteries
- Building creates ice
- Building communicates carbon low
- Building cools with chillers

Non peak London

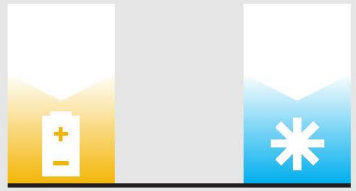
No north sea wind



Wait

Peak London

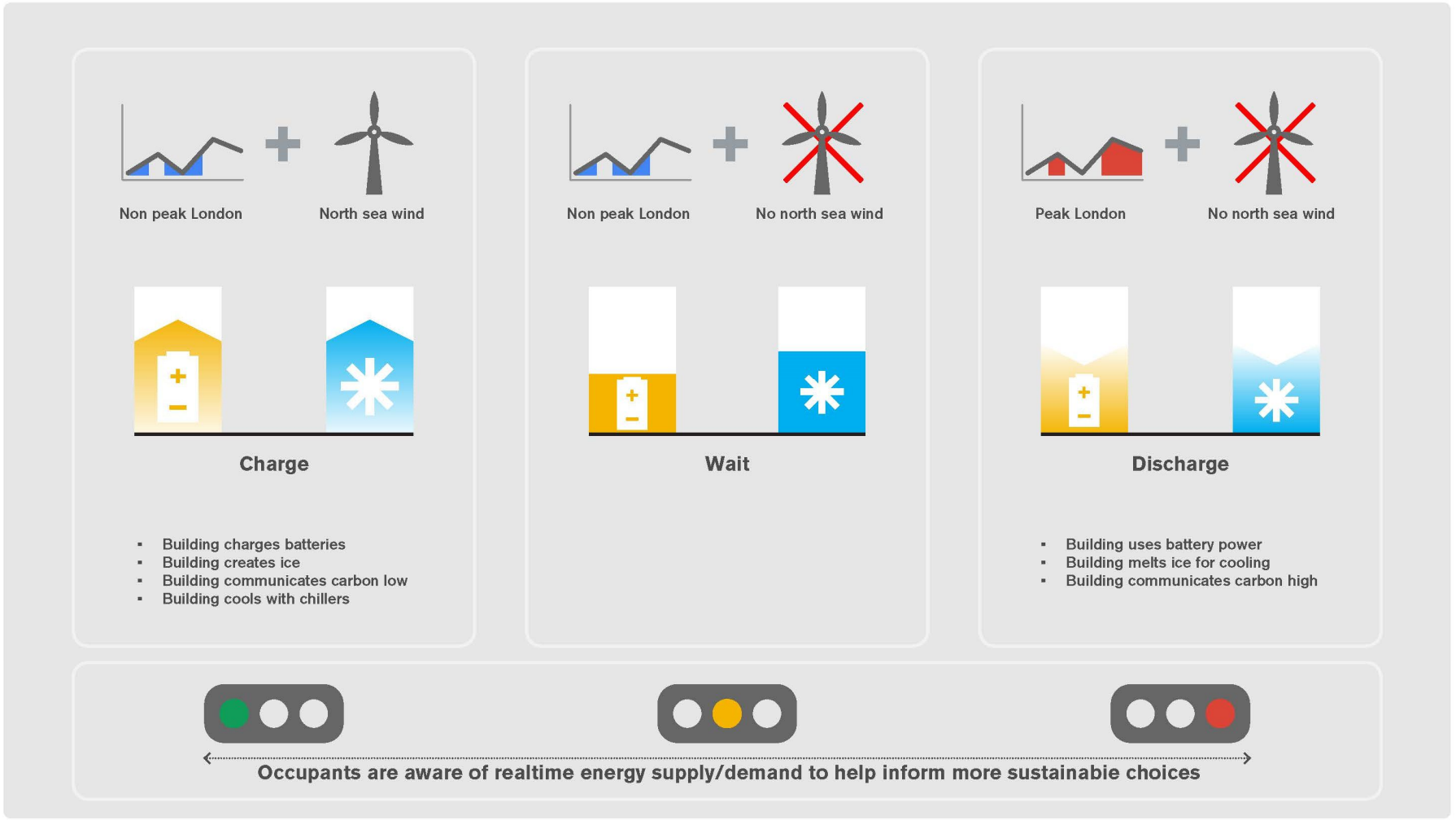
No north sea wind

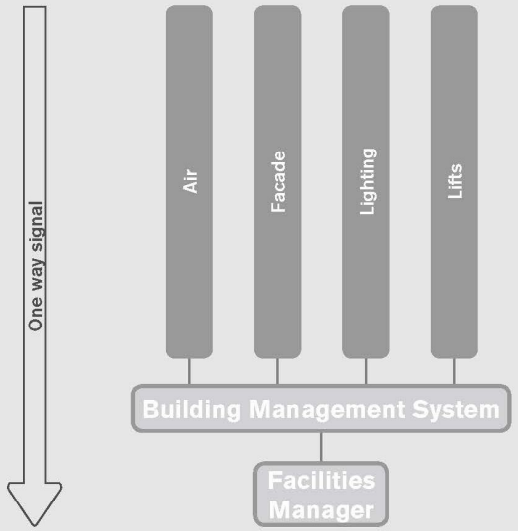


Discharge

- Building uses battery power
- Building melts ice for cooling
- Building communicates carbon high

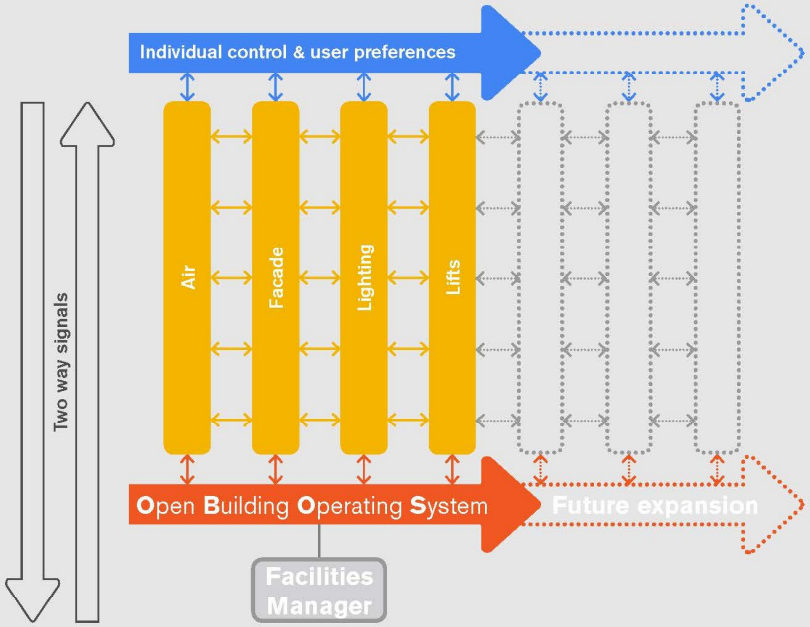
Occupants are aware of realtime energy supply/demand to help inform more sustainabie choices


Non peak London
North sea wind
Charge
Building charges batteries
Building creates ice
Building communicates carbon low
Building cools with chillers
Non peak London
No north sea wind
Wait
Peak London
No north sea wind
Discharge
Building uses battery power
Building melts ice for cooling
Building communicates carbon high
Occupants are aware of realtime energy supply/demand to help inform more sustainabie choices



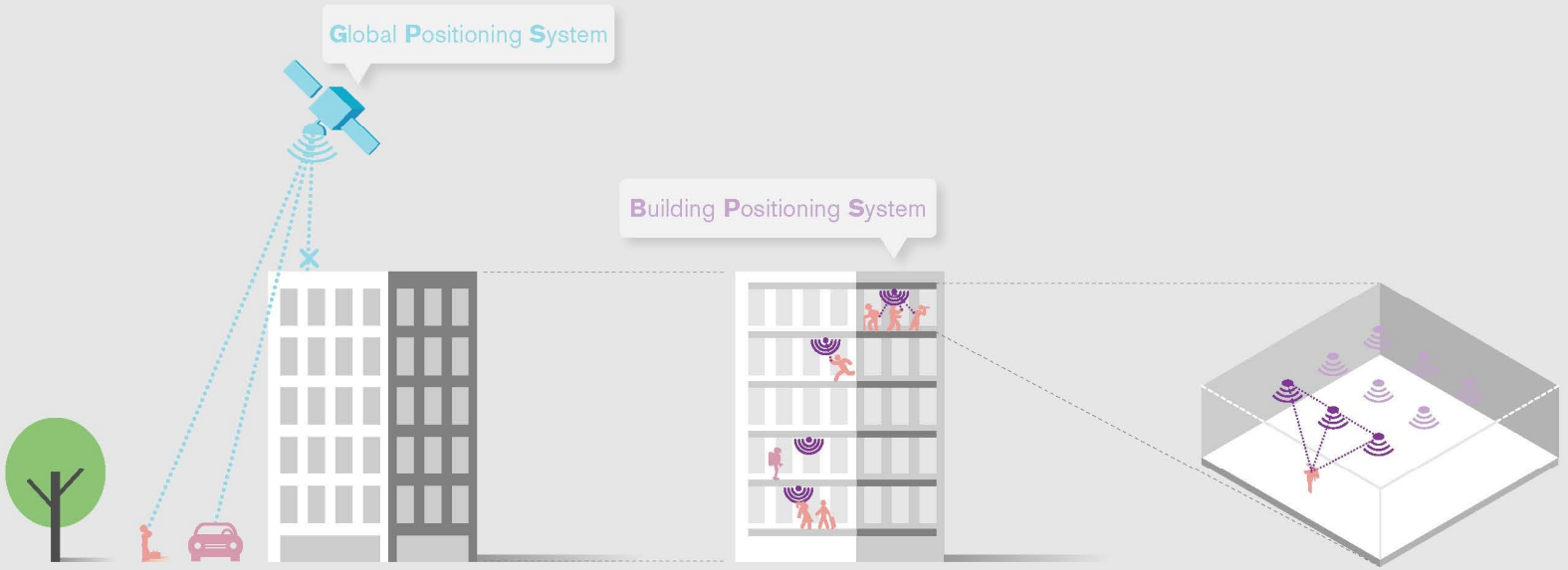
Now: Building Management System

- Typically vertical integration only
- Horizontal communication typically difficult to implement
- Closed approach equals slow evolution of functionality
- Little or no application programming interfaces



Future: Open Building Operating System

- Full interoperability of systems equal greater control, flexibility & communication
- Multiple sensors and actuators equal granular control
- Real time data capture and systems response
- Forecasting and learning capability
- Open approach equals fast evolution of functionality
- Ability to develop sophisticated, simple and user-friendly programming interfaces
- Enhanced user experience : comfort, control and informed decisions

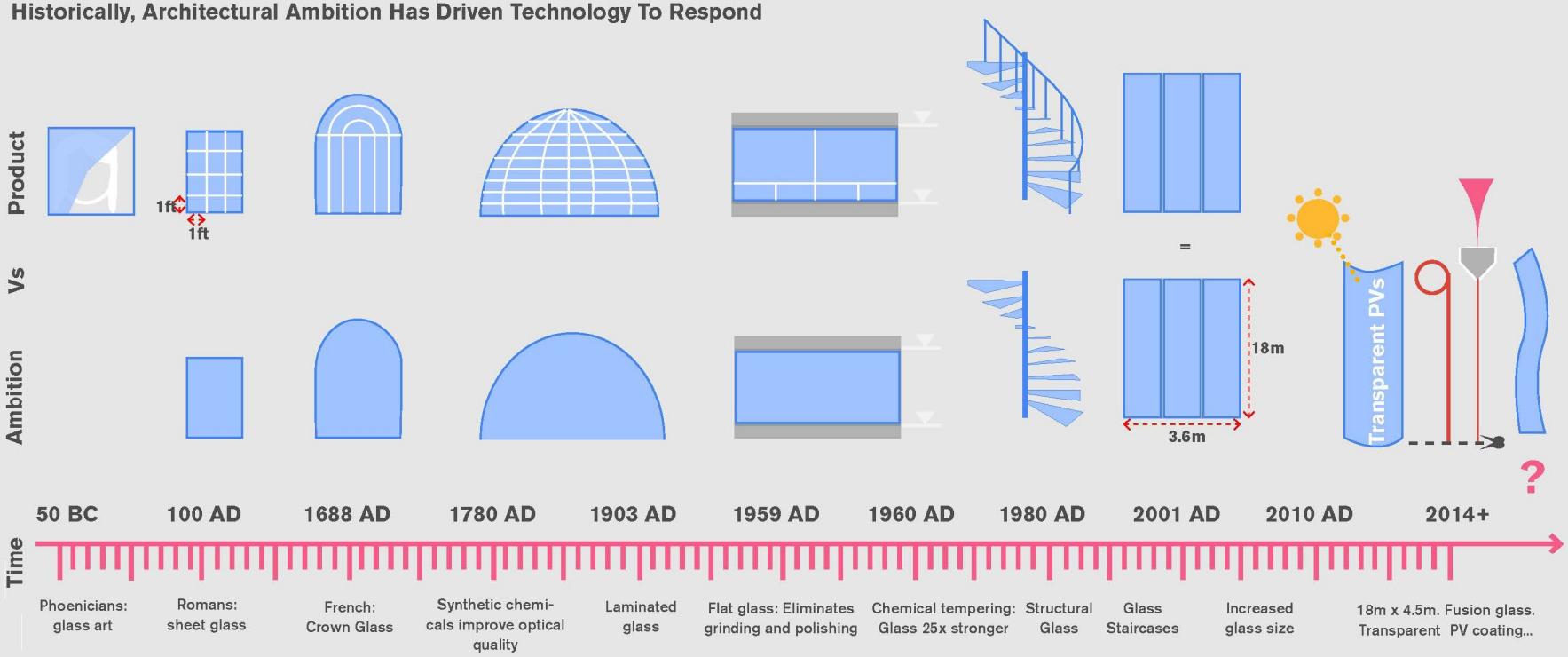


GPS not suitable for inside buildings

A BPS system tracks occupancy and user movements inside the building anonymously.

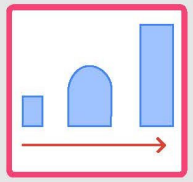
Fixed BPS sensors triangulate to anonymously to provide positions.

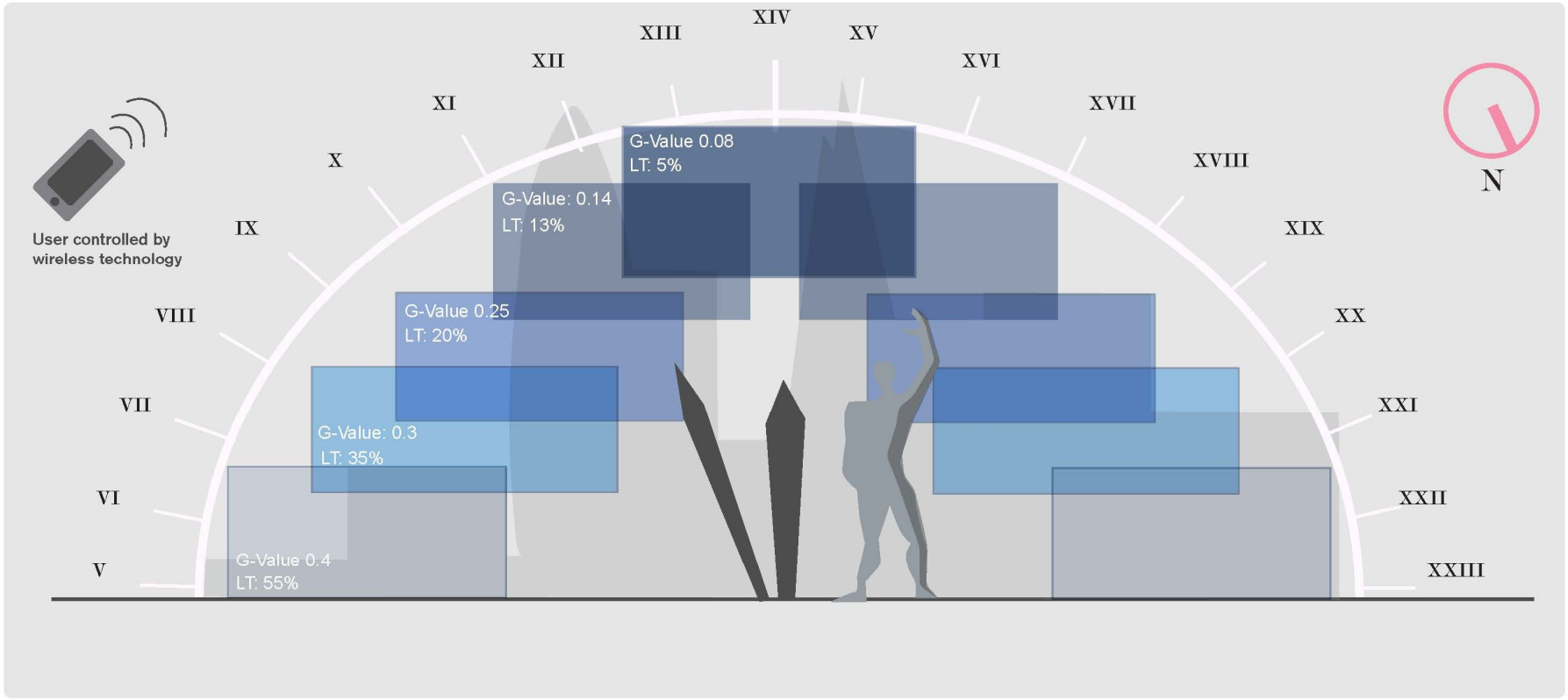
Historically, Architectural Ambition Has Driven Technology To Respond



Key Points

- Smaller panes were made to represent a larger opening
- Bigger and clearer sheets of glass have consistently been the ambition
- Post 2014 energy generating, flexible and clear sheets of glass may drive manufacturing developments.

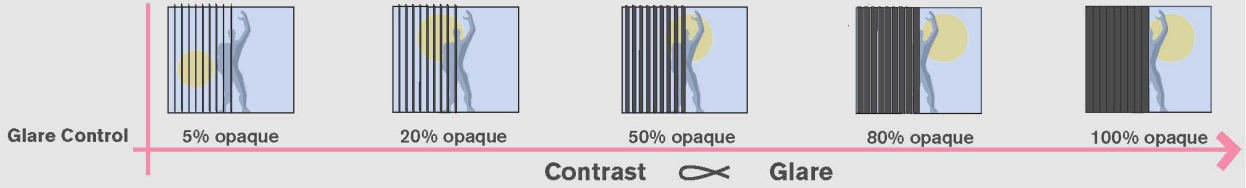


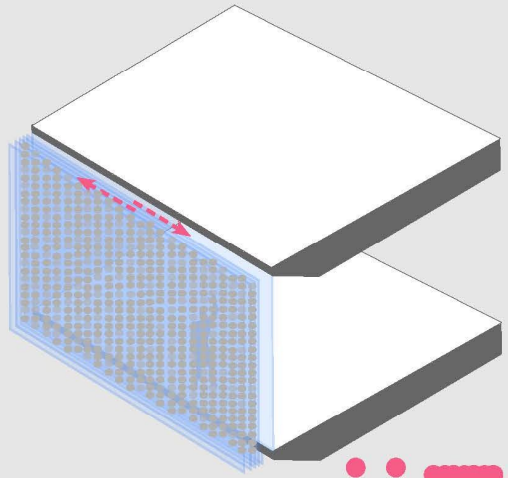


Key Points

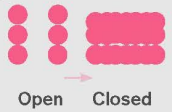
- Glass tints from pale to dark to shade the interior from intense sun
- Tint programmed to suit facade orientation, season and time
- Investment and research required to increase panel size
- Potential to be controlled by an app and linked to the OBOS (open building operating system)

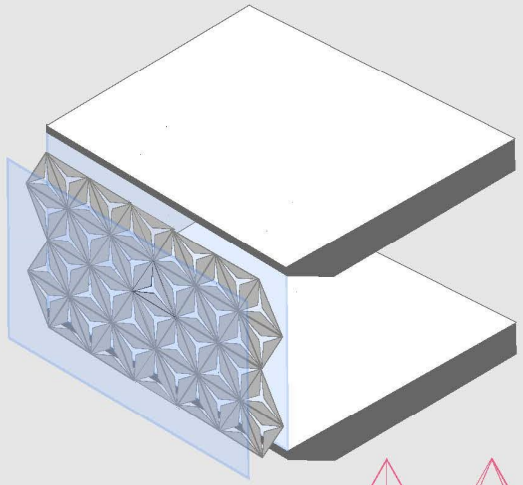
System Closed



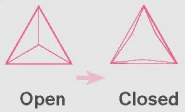


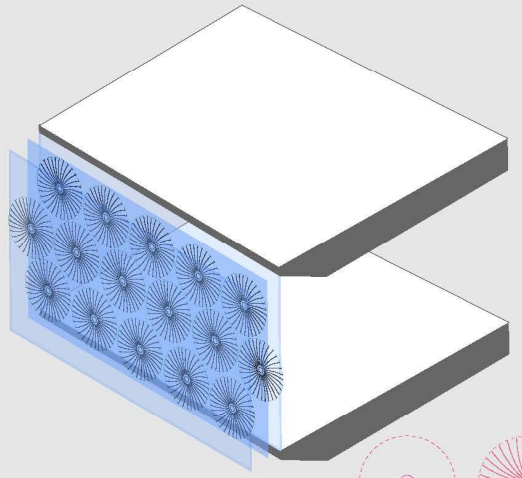
Adaptive Frit



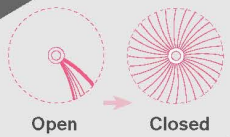


Shade Activated By Thermoresponsive Actuator



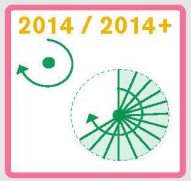


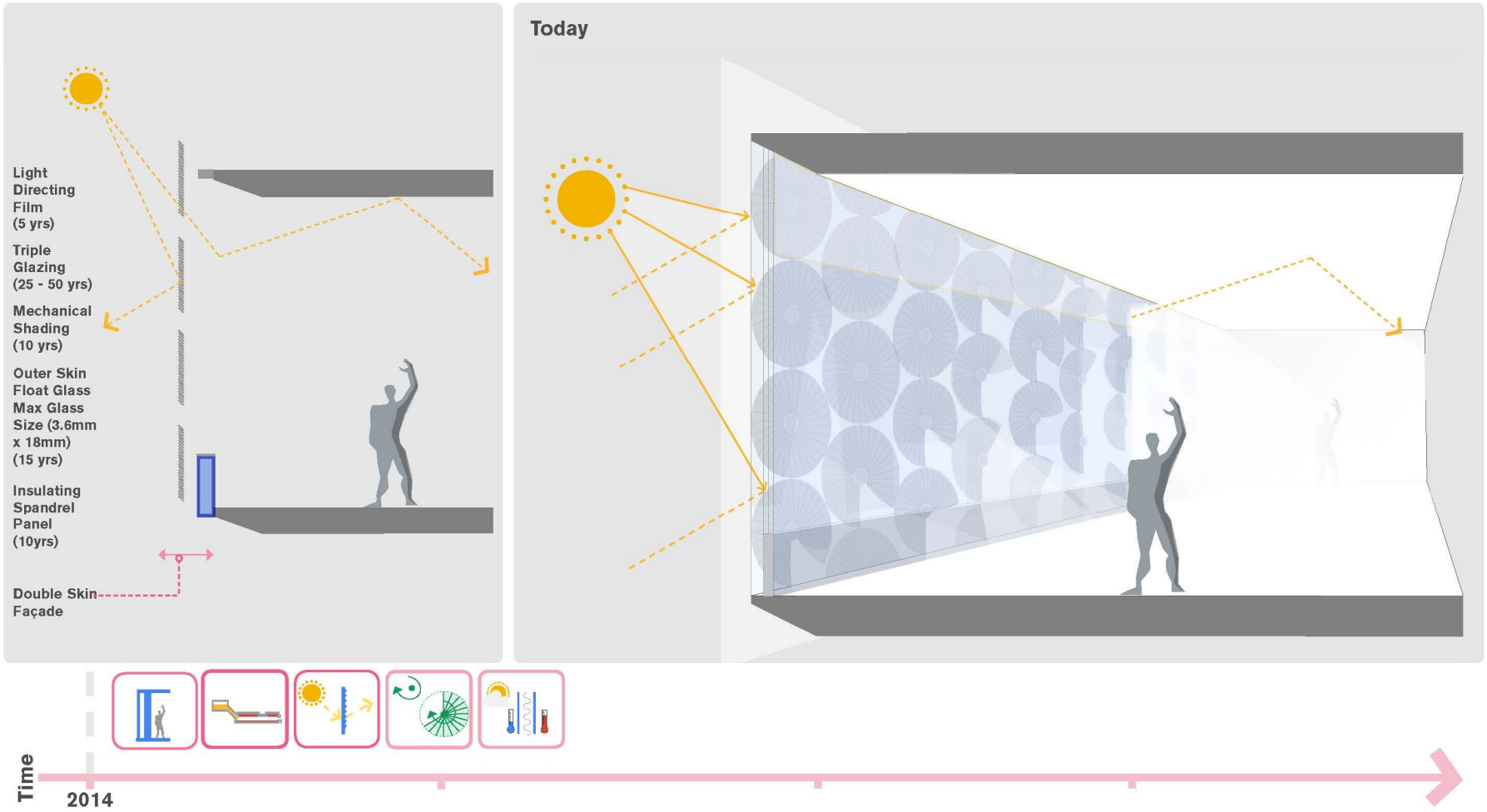
Satellite Deployable Devices

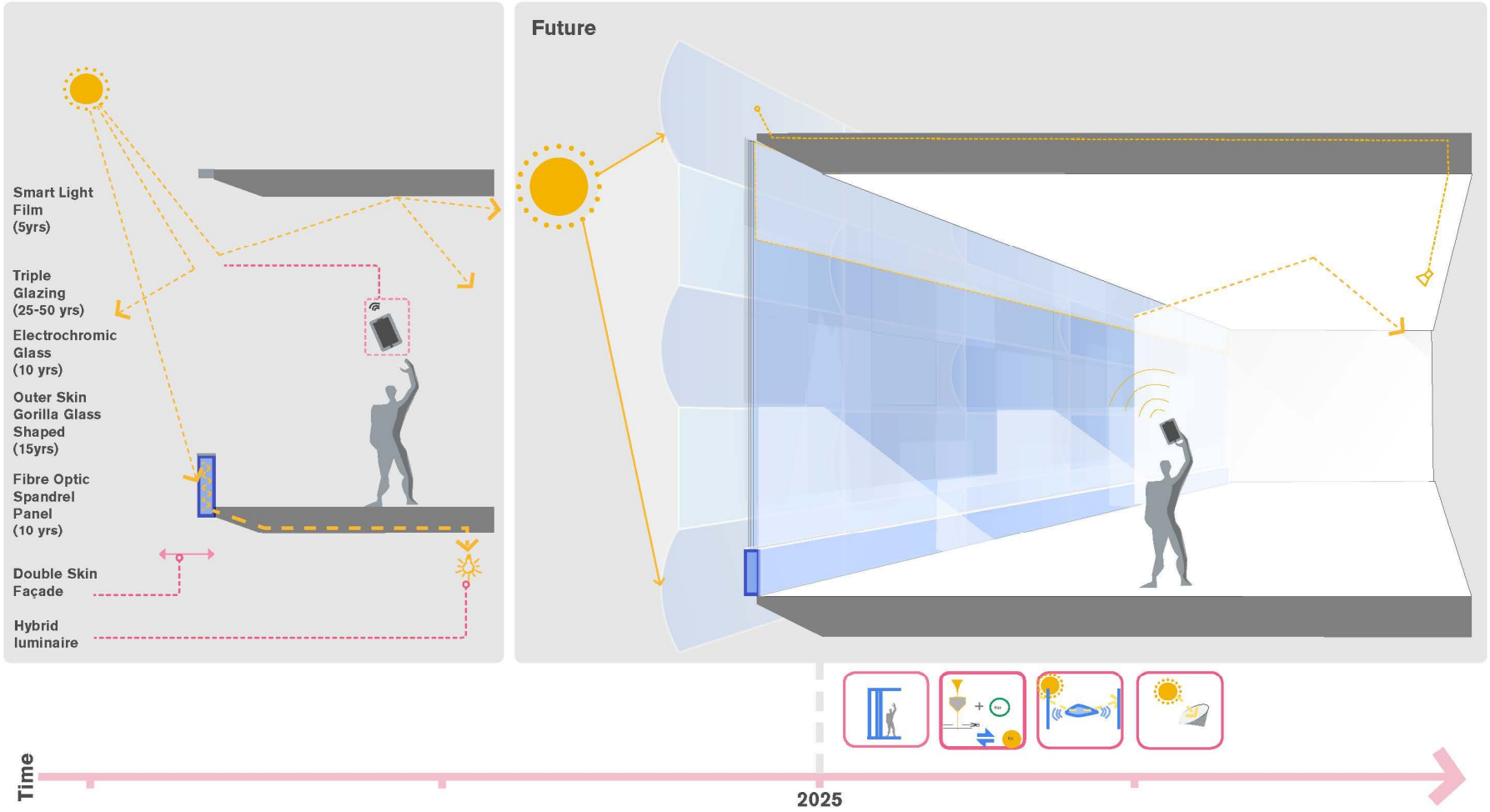


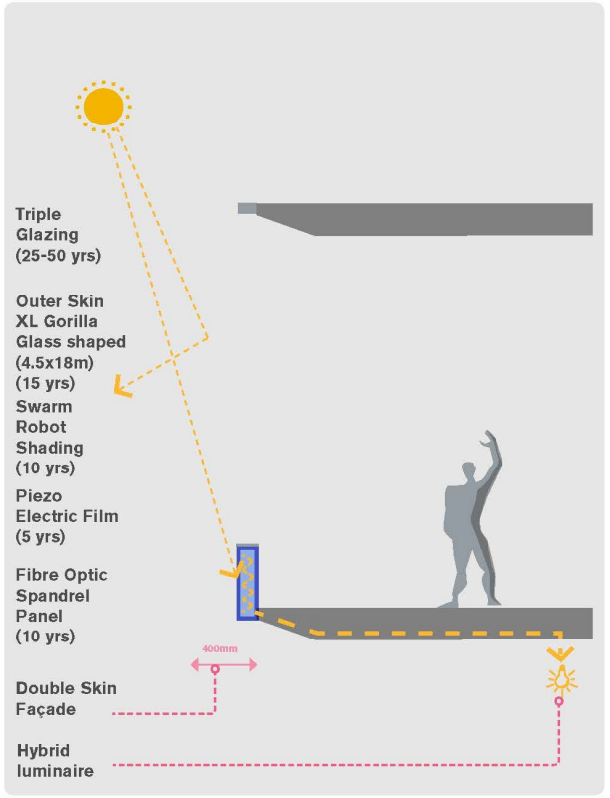
Key Points

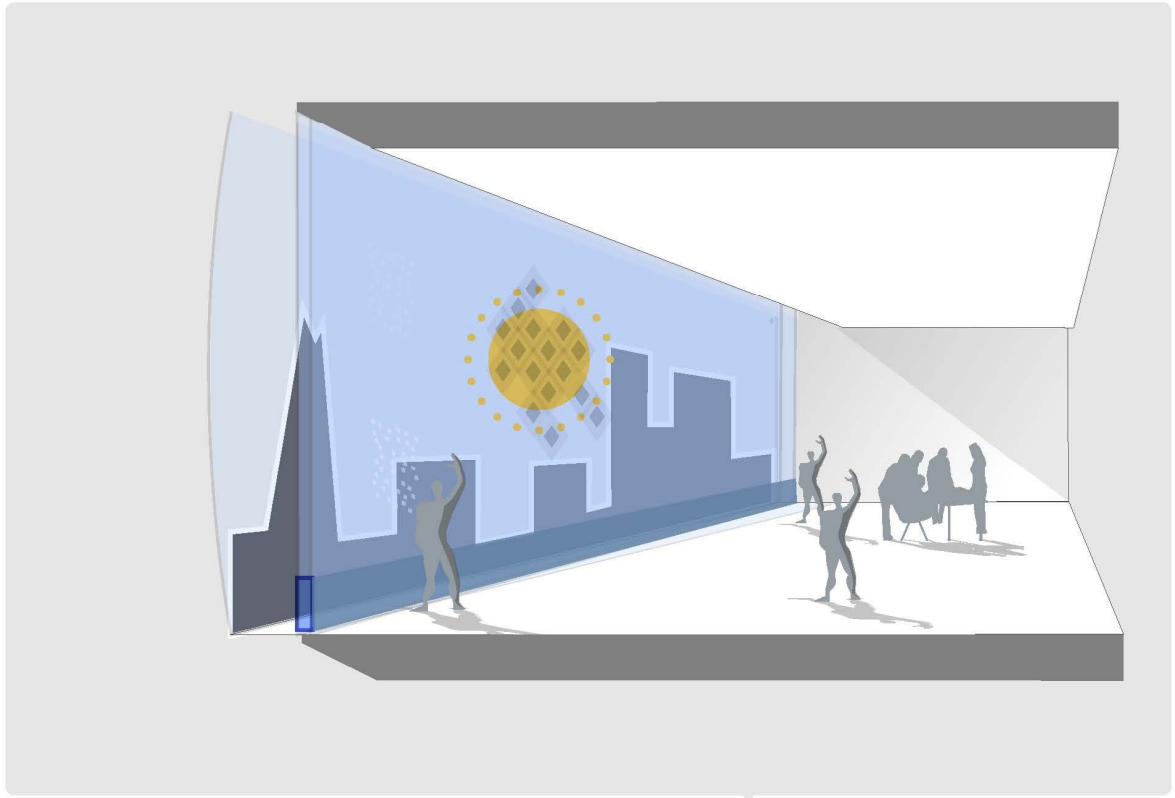
- User controlled or light activated shading currently available.
- A thermal actuator would offer an autonomous sytem without electric cables
- Satellite deployable devices are designed to be as light and small as possible in their open position

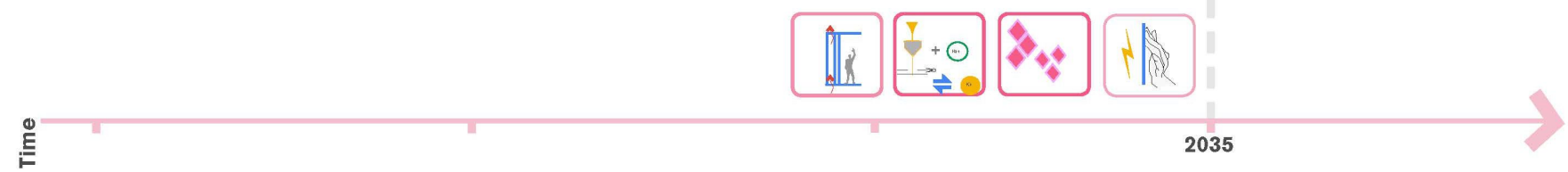



Light
Directing
Film
(5 yrs)
Triple
Glazing
(25 - 50 yrs)
Mechanical
Shading
(10 yrs)
Outer Skin
Float Glass
Max Glass
Size (3.6mm
x 18mm)
(15 yrs)
Insulating
Spandrel
Panel
(10yrs)
Double Skin
Façade
Today
Time
2014

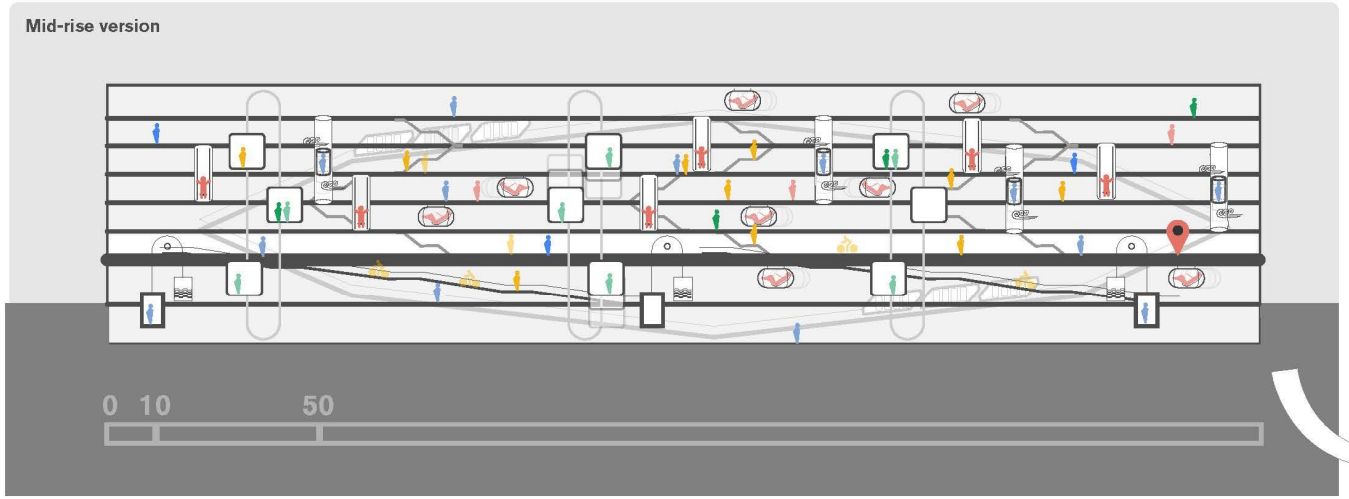

Smart Light Film (5yrs)
Triple Glazing (25-50 yrs)
Electrochromic Glass (10 yrs)
Outer Skin Gorilla Glass Shaped (15yrs)
Fibre Optic Spandrel Panel (10 yrs)
Double Skin Façade
Hybrid luminaire
Future
Time
2025


Triple
Glazing
(25-50 yrs)
Outer Skin
XL Gorilla
Glass shaped
(4.5x18m)
(15 yrs)
Swarm
Robot
Shading
(10 yrs)
Piezo
Electric Film
(5 yrs)
Fibre Optic
Spandrel
Panel
(10 yrs)
400mm
Double Skin
Façade
Hybrid
luminaire

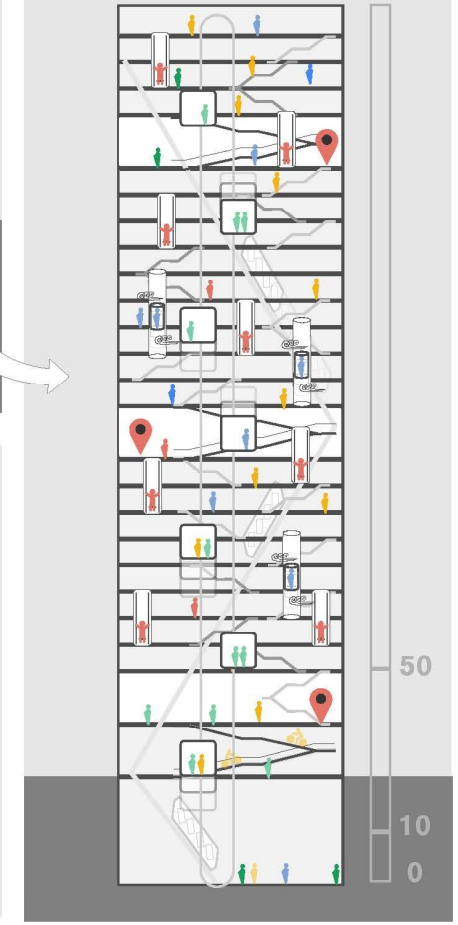



Time
2035

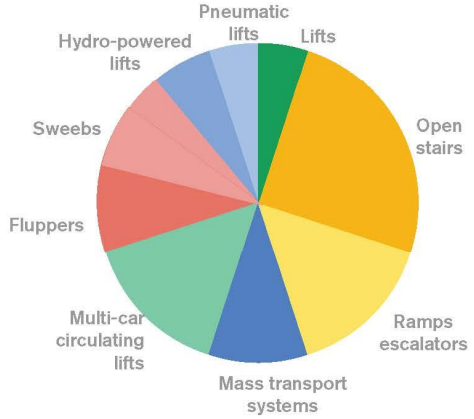
Mid-rise version



Tower version



Available technologies



Key points

The diverse network of movement can be further enriched in the future provided that sufficient investement goes into R&D.

Multicar circulating lifts, can have further benefits into opening floor plates particularly in tower typologies.

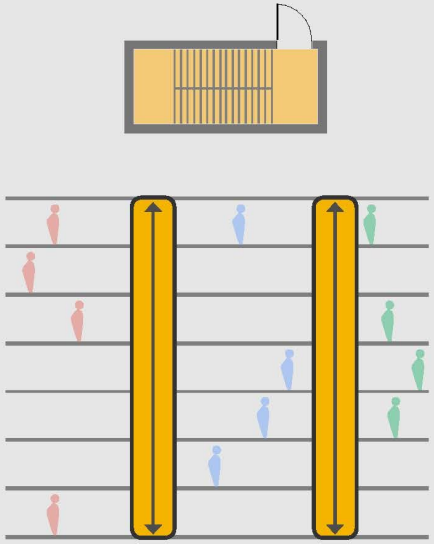
The development of other technologies such as pneumatic and hydro-powered lifts can result in further reduction of energy consumption of movement networks.

Open escape stairs

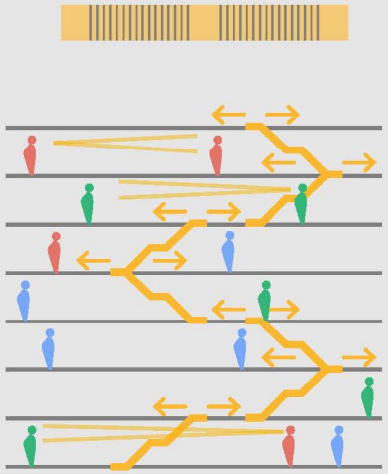
Stairs in buildings are usually enclosed due to:

- drive for efficiency which leads to combined communication and fire stairs
- compliance with building regulations

However there are many benefits to opening up stairs and making them visible to users.



Enclosed stairs
Result of repeatedly applied preconceptions
- Large cores
-Blocked views
- Do not promote its use
- Unpopular



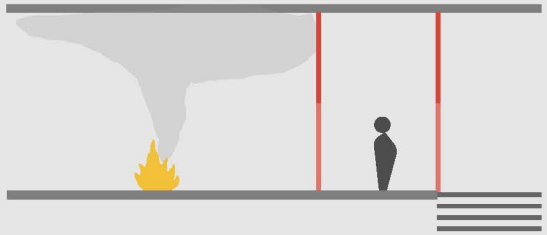
Open Stairs
Greater Interaction
- Positive friction
- Visual connectivity
- Healthy
- Dynamic relations

Alternative smoke control concept

Escape stairs are usually enclosed due to the need to control smoke. However, there are alternative ways of controlling smoke which could result in open stairs.

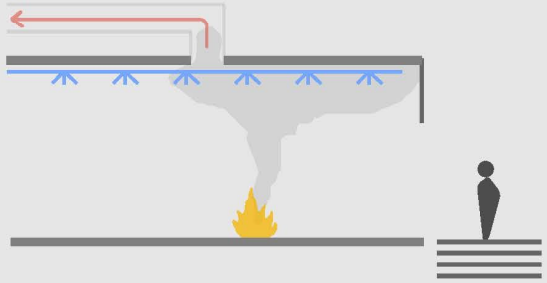
Current conventional way

-Smoke lobby

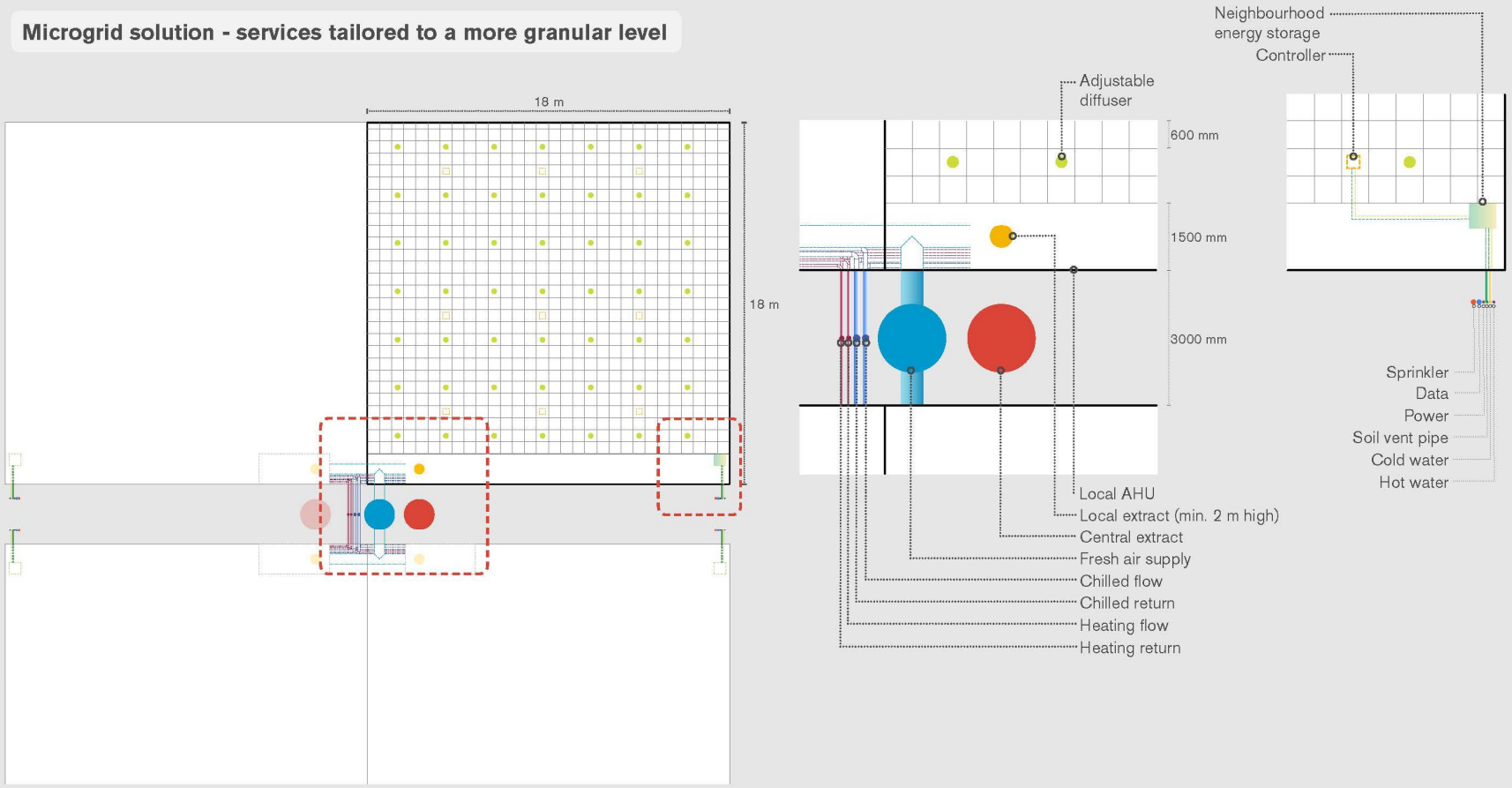


Alternative way

Controlling risk by distance and dilution:
- Sprinkler technology
- Controlled smoke: extracts, reservoirs,...



Microgrid solution - services tailored to a more granular level



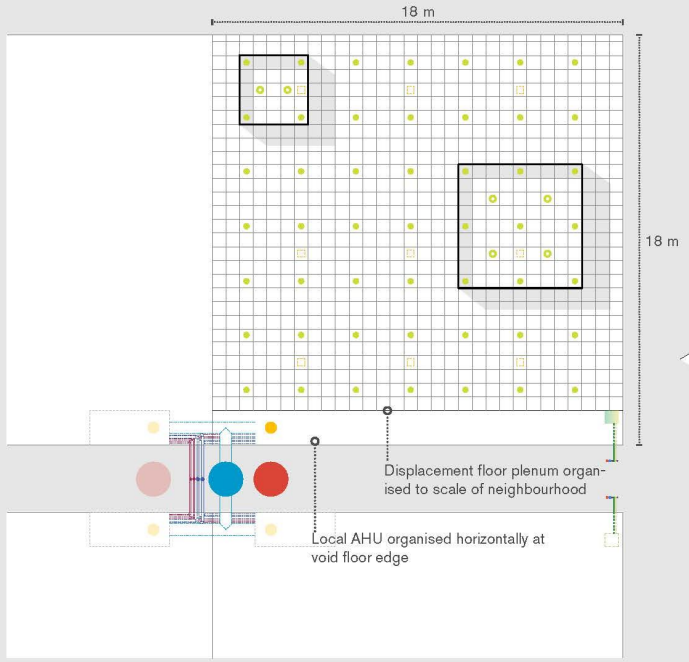
Adaptable building services to multiple use of space

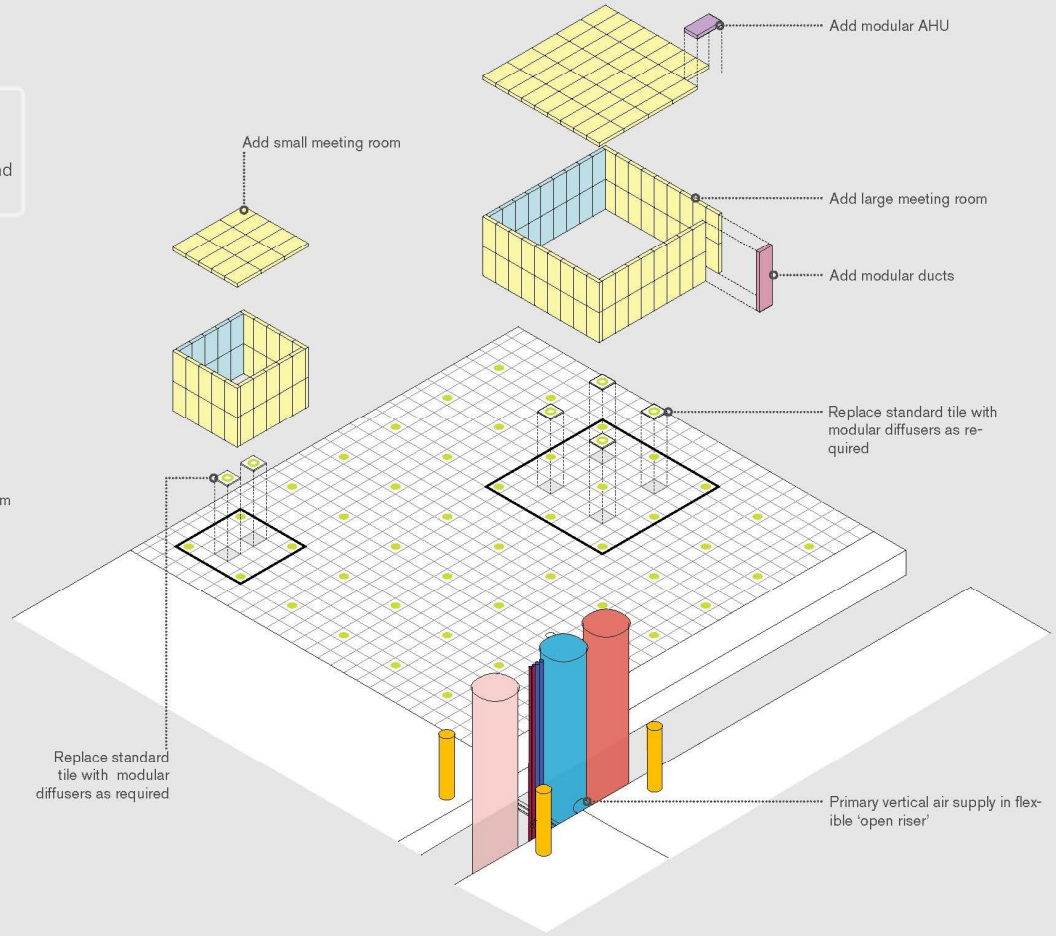
Small meeting room

- Plenum & air supply sized for flexibility e.g. To increase diffuser outlets by 25%.

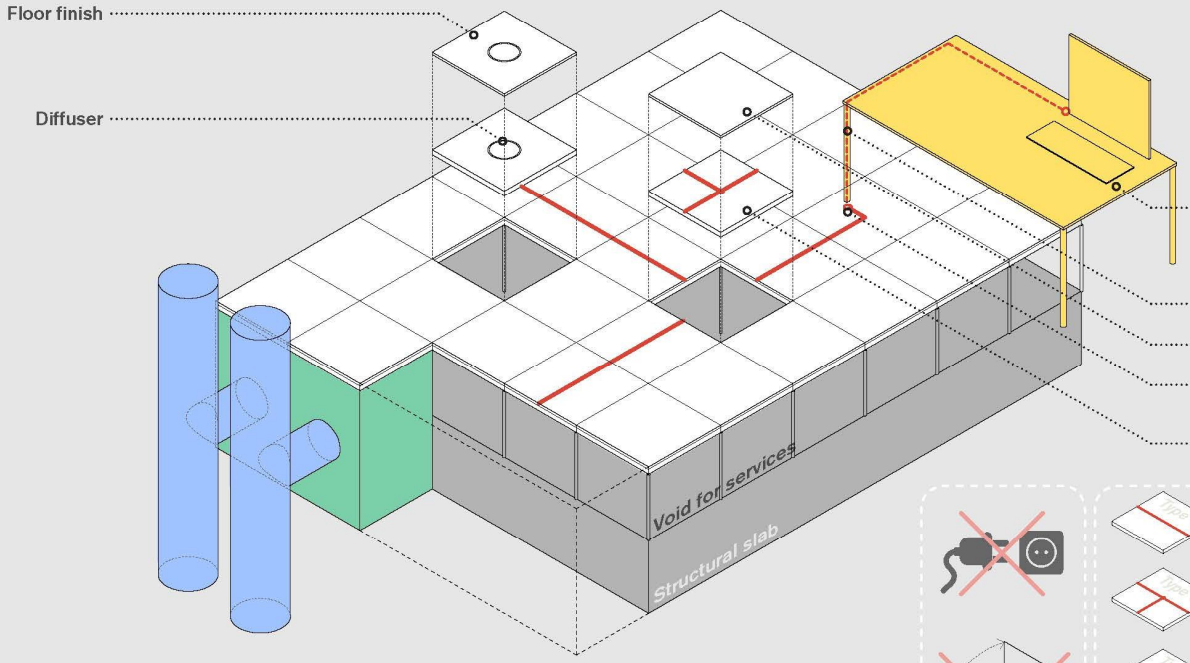
Large meeting room

- Beyond that design for local modular/bolt-on/off ducts and Air Handling Unit additions.





Integrated Raised Access Floor with induction charging



NFC (near field communication) enabled Inductive charger mat

Power-over-Ethernet

Floor finish

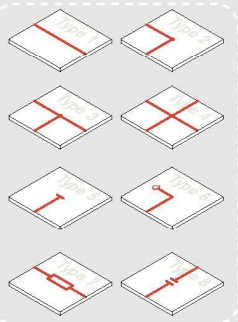
Docking points

Re configurative power integrated tiles

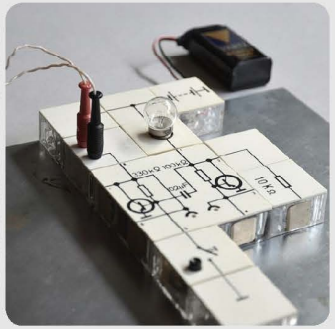
Why?

- Makes building flexible
- Enables occupants to interact with spaces

No plugs & floor box

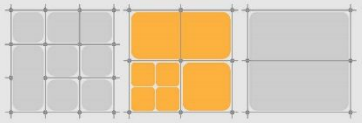


Re configurative tiles



e.g. The Braun Lectron System: Retro "Circuit Dominoes"
- 1960s built by a Dieter Rams for Brauns to help kids understand electronics

Large Span



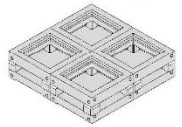
1 Steel Frame and Composite Metal Deck

2 Innovative approach

Light Weight PT Beams and PT Slabs

3 Proprietary System

Steel Frame and Sandwich Plate System



4 Innovative approach

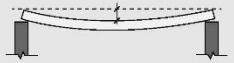
Smart Cassette Floor System

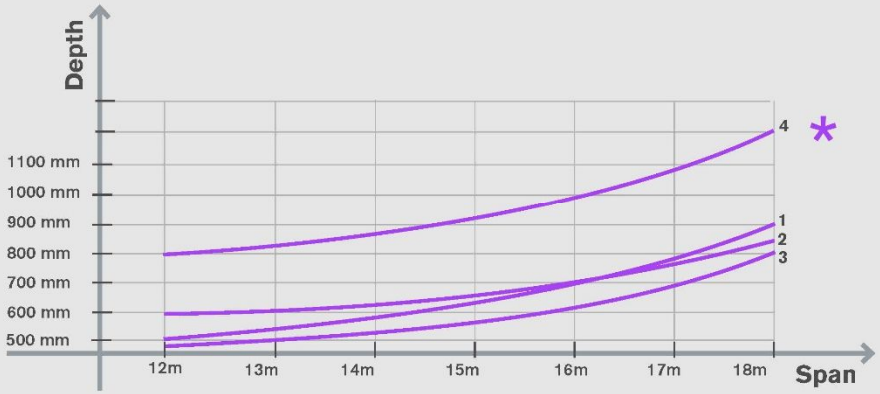
Span to depth ratio is based upon set limits

Live load

Vibration

Deflection





Comparative cost

1

2 TBD

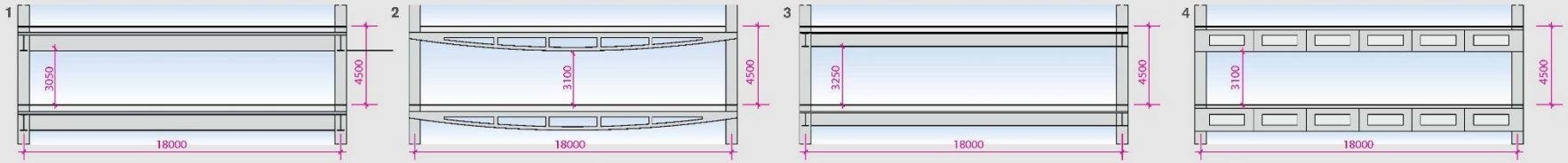
3

4

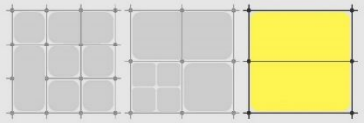
Key points

Large span can be achieved with traditional structural systems; innovative, proprietary or bespoke systems can also achieve large span with additional benefits.
Note - Option 4 requires no supplementary raised floor zone

Comparative sections



3D Printed Sandwich Plate

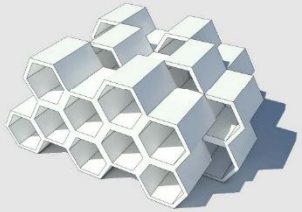


3 Innovative approach

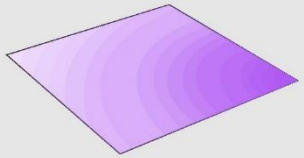
3D Printed Sandwich Plate

Geometry

Unique geometries enhance specific physical properties

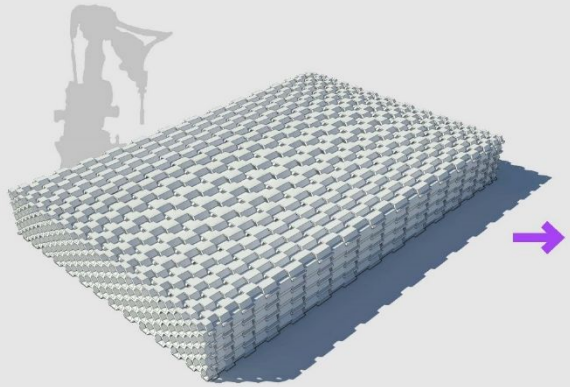


Stress Diagram



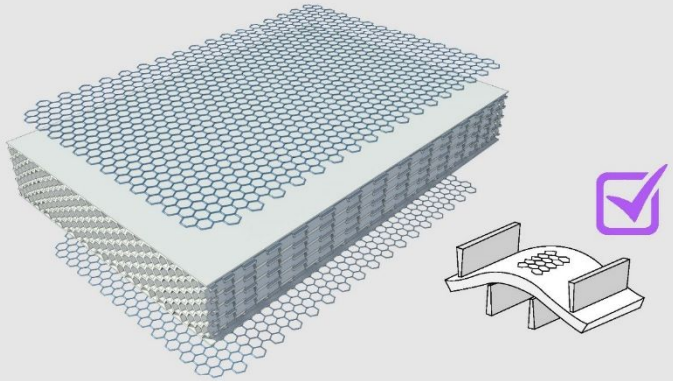
3D printed polymer matrix

The Geometry density varies according to the Stress Diagram



Graphene

Two layers of graphene are applied to the top and bottom of the plate; the polymer matrix transfer shear between each layer of graphene



Graphene

Graphene is a two dimensional material consisting of a single layer of carbon atoms arranged in a honeycomb or chicken wire structure. It is the thinnest material known and yet is also one of the strongest.
The material is not yet widely available.

Related Research

Graphene flakes could be used as to strengthen polymer matrix composites and to impart conductivity to such composite materials. This is currently an active area of research at Manchester University, particularly in the groups of Prof. Young and Dr. Kinloch.

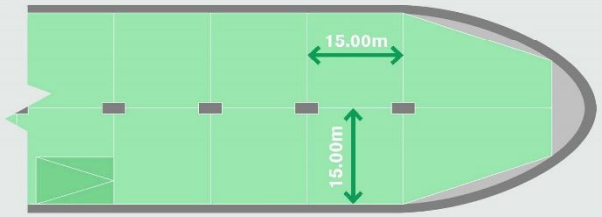
They have mapped the stress transfer between a polymer matrix and graphene flake in composites. And they have discovered the relationship between graphene loading, the number of layers in the graphene flake as well as its size to the extent of stress transfer.

Publication

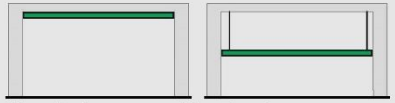
L. GONG, L. et al. (2010) Interfacial Stress Transfer in a Graphene Monolayer Nanocomposite. *Advanced Materials.* **22 (24). p. 2694-2697**

Hoist-able deck technology

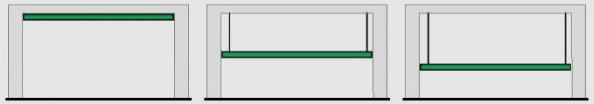
Hoist-able decks are used on RO-RO (roll-on/roll-off) car transport ships to accommodate different size vehicles.



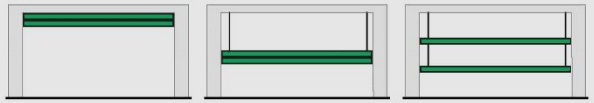
Working level options



One deck, one working level

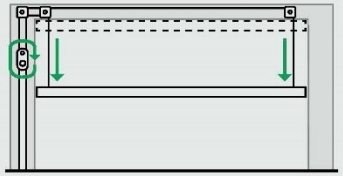


One deck, two working levels

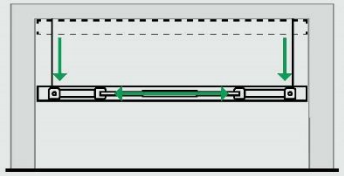


Two decks, three working levels

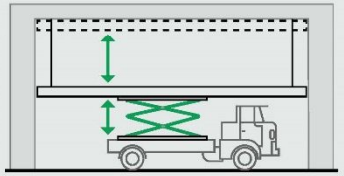
Operating options



Jigger-winch in the side shell structure



Pulling cylinder in the panel



Moveable deck lifter

Key Points

- Decks can be moved to alternative working levels and stowed when not in use.
- The system makes it possible to efficiently stow vehicles with different headroom requirements.

Refer to Cargotec Sweden AB Marine: www.macgregor-group.com

Rainfall

0.625 m^3/m^2
Of rainfall per year in London

5000 m^3
Will fall on the building every year

Blue Roof

Attenuation of water during storm surges by holding it on the roof and releasing it slowly.

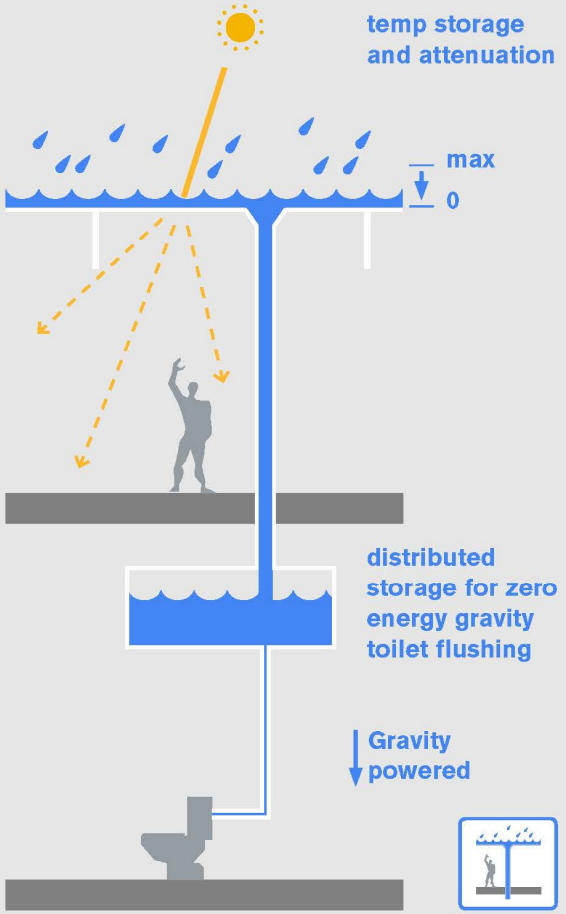
Ponding height 75 - 100

Roof could be designed in such a way that only certain areas will allow water to pond.

Rainwater runoff from the roof is filtered through specially designed outlet with filtration media.

Will contribute approximately 0.72 l/p/d which equals to 2664 l/p and 674000 litres per year water saving

674000 Litres
per year saving

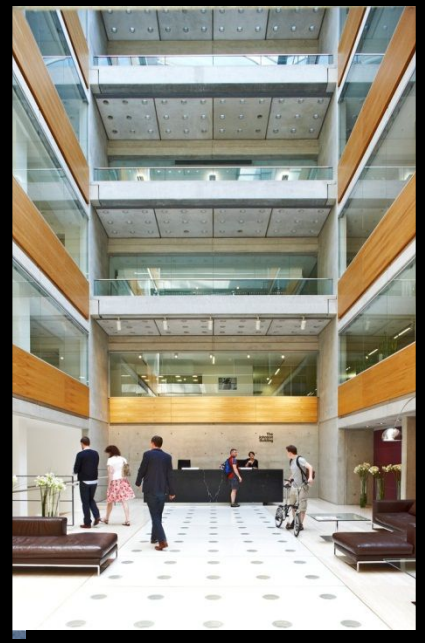


White Collar Factory….

…….the journey of an idea

How WCF came about





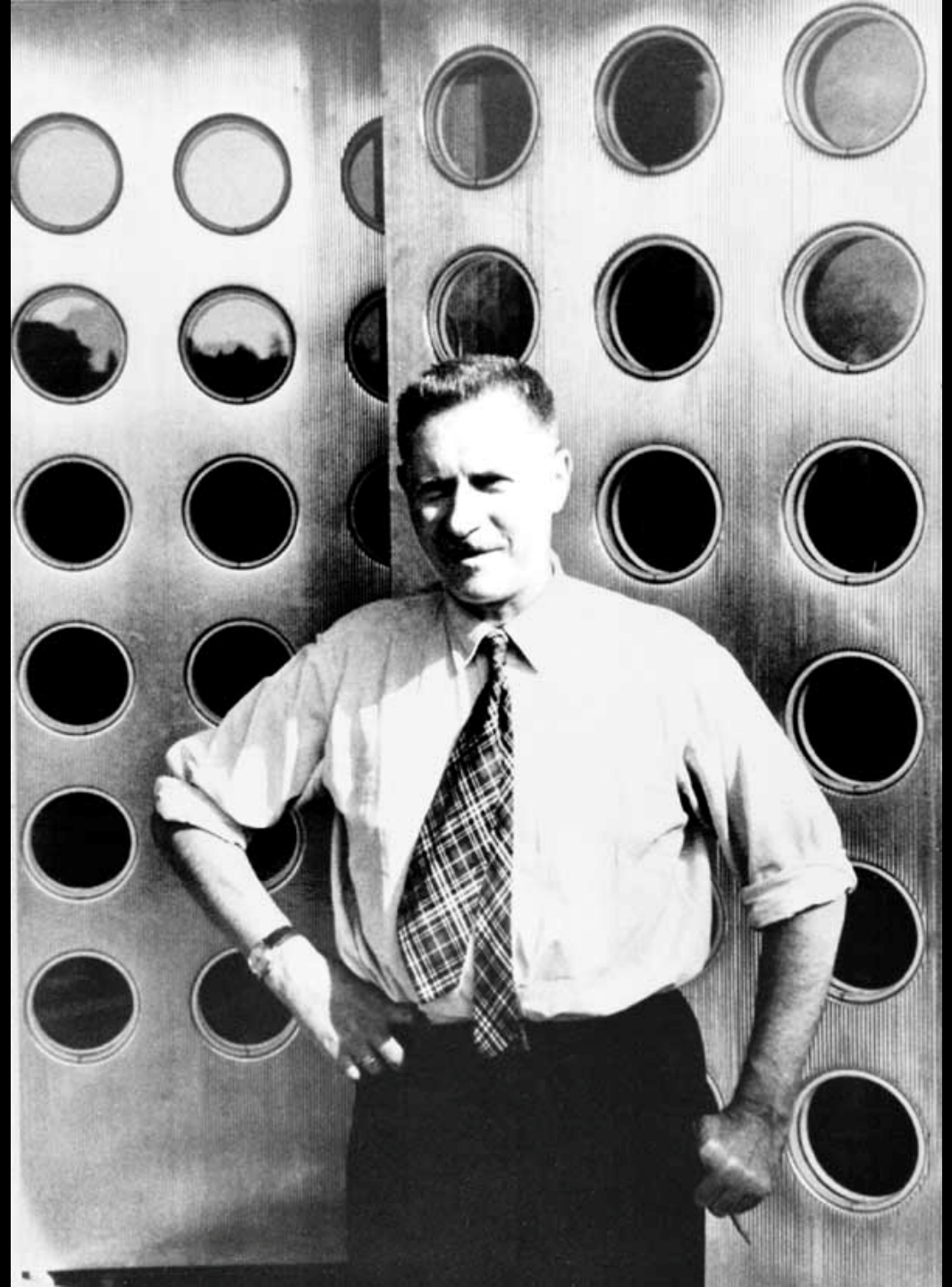
←LIFTS STAIRS→
5
←3.01-3.02


The
Johnson
Building


ANGEL BUILDING

HABS No. WI-284-22

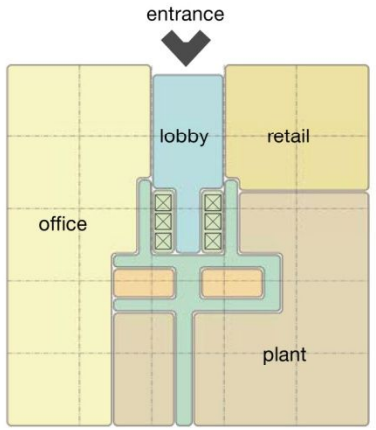

VAN
HELLE'S



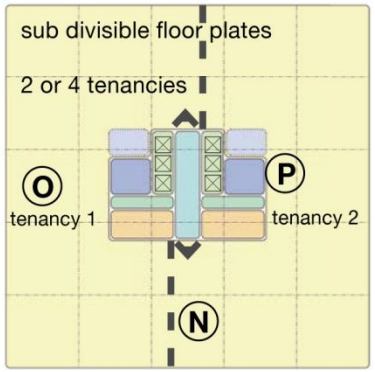
White Collar Factories: generic design

- (A) building height G(5m) + 5 storeys
- (B) 45 x 45 m floor plate
- (C) 4m floor to floor = tall ceilings
- (D) 9m x 9m insitu concrete frame
- (E) central core
- (F) GIA = 130,000 sqft
- (G) NIA = 105,300 sqft
- (H) overall NIA:GIA = 81%
- (I) typical floor NIA:GIA = 85-87%
- (J) Wall to floor ratio = 0.35
- (K) No basement, car park or transfer structure
- (L) Min. fresh air and radiant slabs
- (M) section 20 does not apply
- (N) limited sub divisible floors
- (O) 1 or 2 tenancies
- (P) 8 WC's per floor

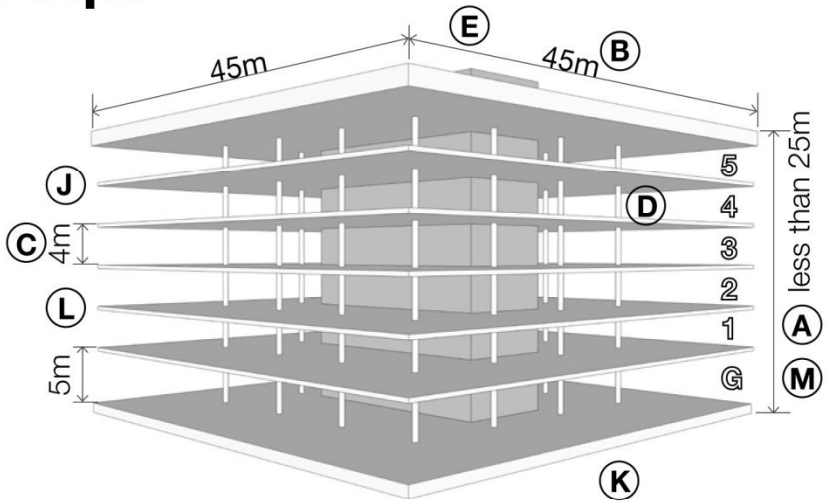
= £165 per sqft



ground floor plan



typical floor plan (I)

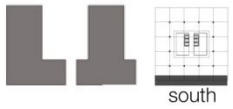


massing perspective (F) (G) (H)

key

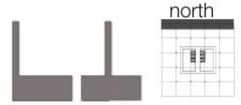
- Office
- retail
- lobby / reception
- lifts
- plant / servicing
- circulation
- stairs
- WC's
- optional extra WC's

facade modules



grande 30% glazing

regular 53% glazing



skinny 68% glazing

The White Collar Factory is built according to five key principles. Since much of the running cost of a typical office building is mechanical climate control, the WCF is optimised to reduce artificial heating, cooling and lighting.
This is how it does it:

1
TALL CEILINGS

2
SMART SERVICING

3
SIMPLE PASSIVE FACADE

4
FLEXIBLE FLOOR-PLATES

5
THERMAL-MASS STRUCTURE

1 TALL CEILINGS
- 1a 3500mm floor to ceiling heights
- 1b Exposed services – easy to maintain and adapt for particular uses

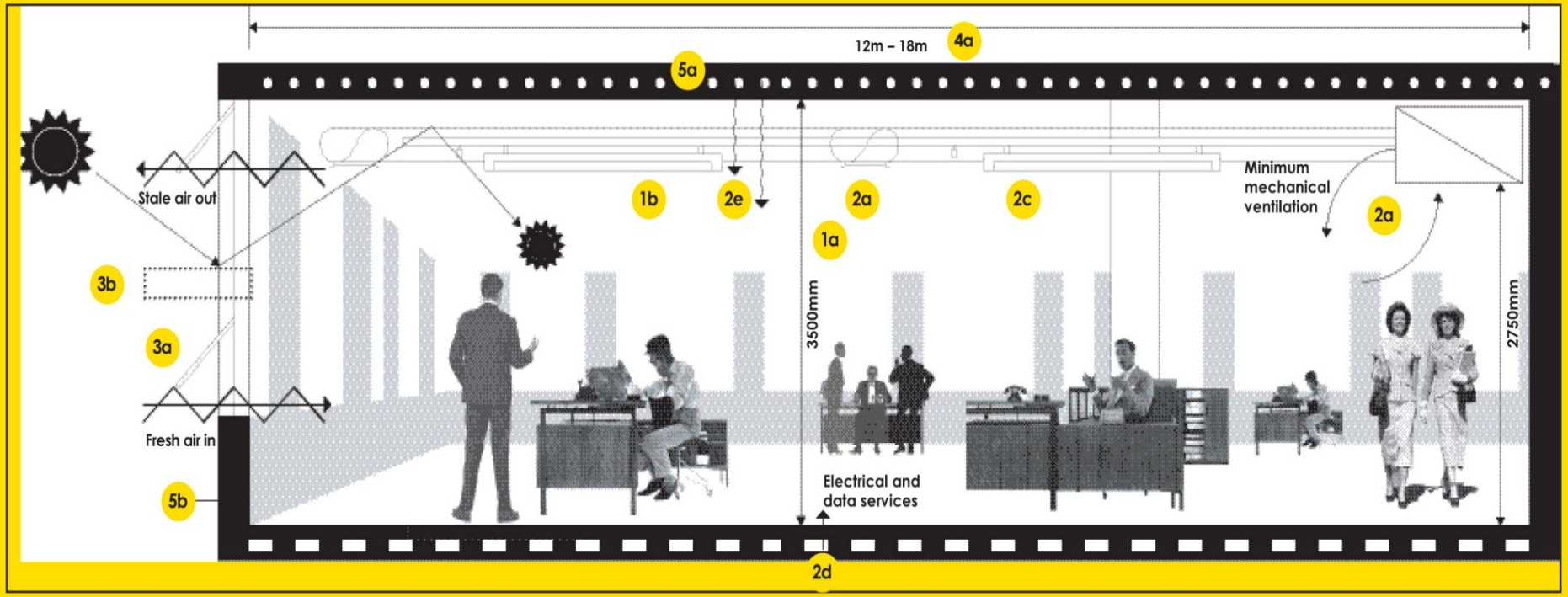
2 SMART SERVICING
- 2a Minimum fresh air mechanical vent with extract from bulkhead
- 2b Option for on floor plant
- 2c Light fittings included as basic product
- 2d Power and data in shallow raised access floor
- 2e Radiant slab for cooling & heating

3 PASSIVE LOW TECH FACADE
- 3a Opening windows
- 3b Windows adapt to suit solar conditions i.e small openings to south, larger to the north

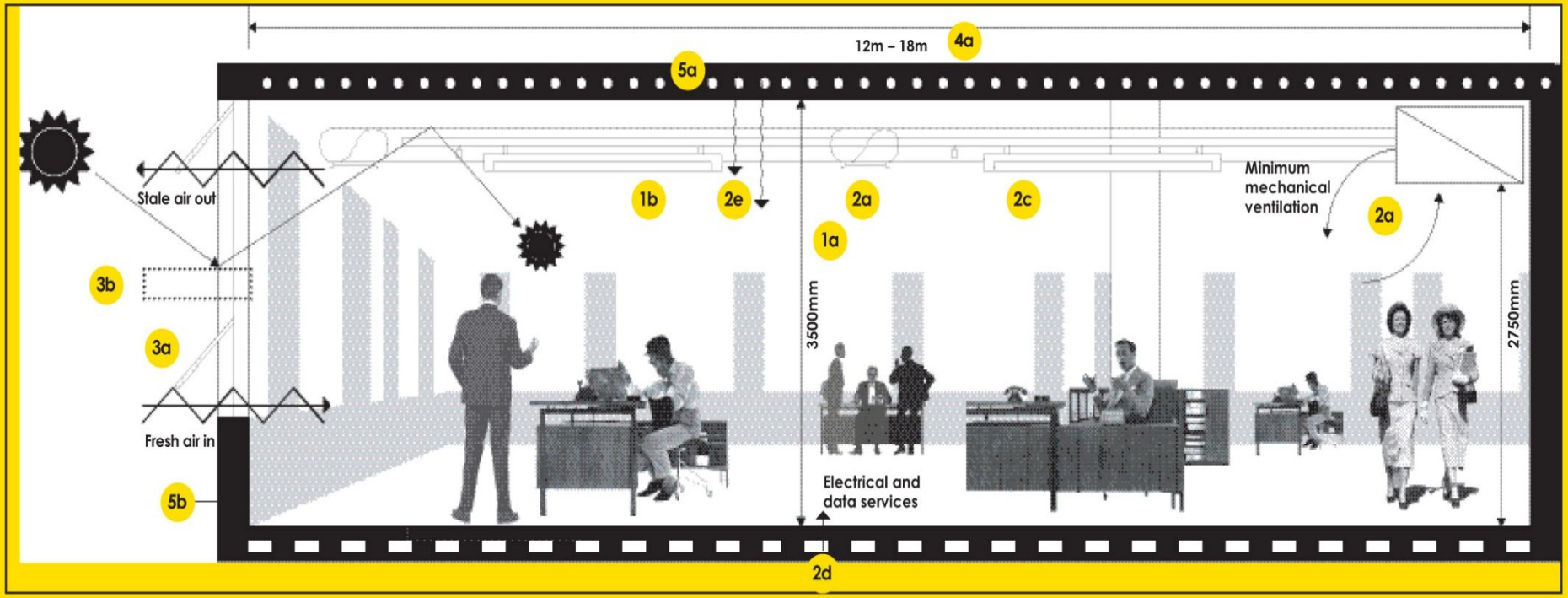
4 FLEXIBLE FLOORPLATES
- 4a Generous scale provides maximum flexibility to suit a wide range of users

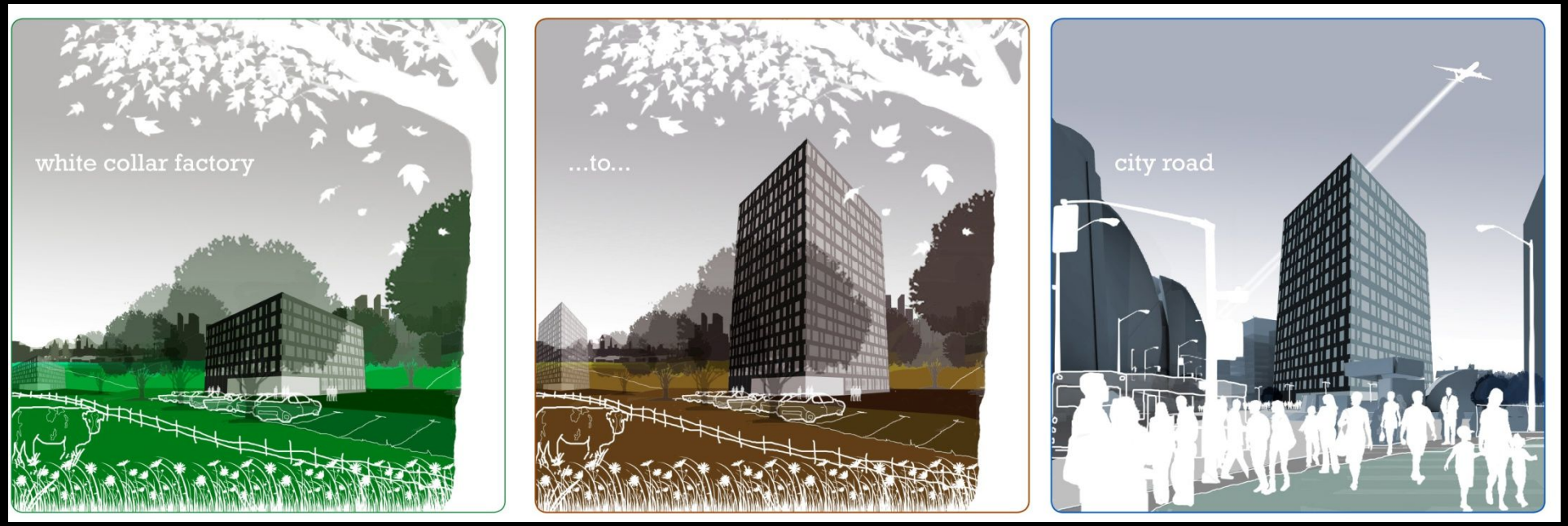
5 CONCRETE STRUCTURE
- 5a Exposed concrete soffit
- 5b Concrete perimeter upstand increases structural spans and eliminates perimeter columns
- 5c Robust self finished, activated for heating & cooling

Principle: one size does not fit all, but a generous shell provides best opportunity for greatest market share

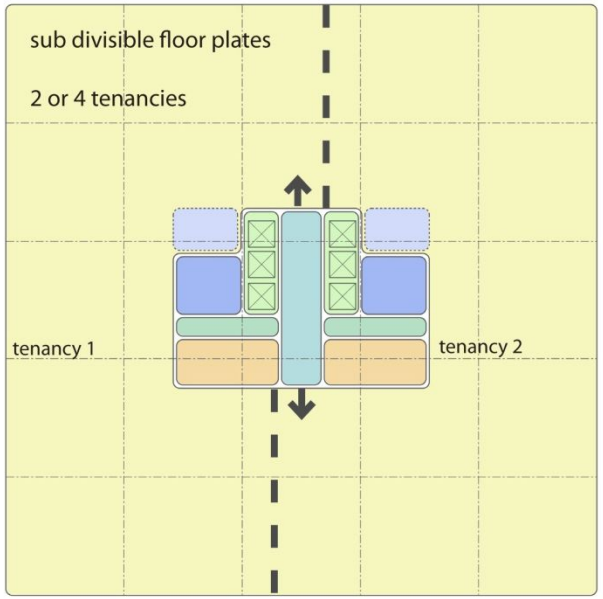


& upgradeable




white collar factory
...to...
city road

WCF: prototype plan

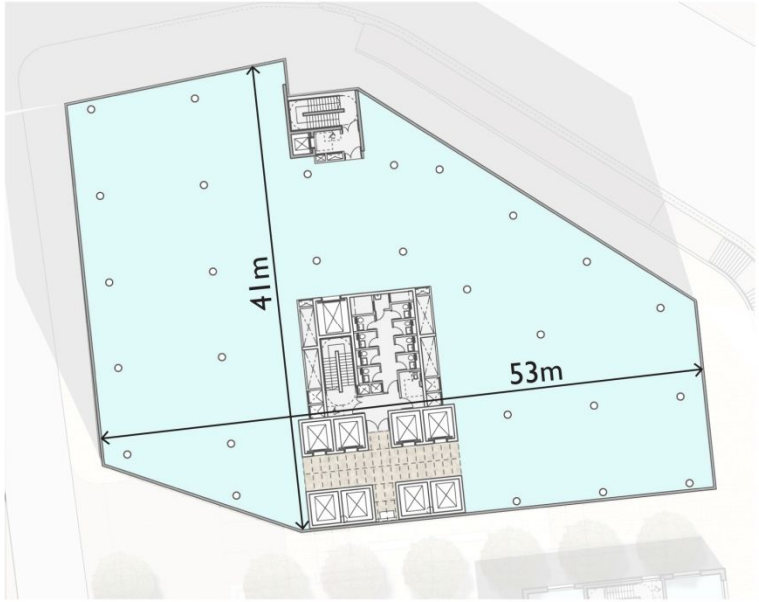


typical floor plan

- *building height G(5m) + 5 storeys*
- *45 x 45 m floor plate*
- *4m floor to floor = tall ceilings*

= £165 per sqft

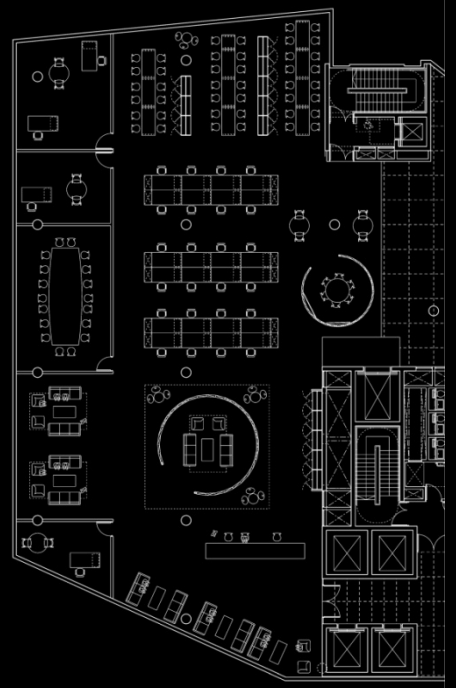
City Road: developed plan



typical floor plan

- *includes basement* **+ £10 per sqft**
- *increased building height G(6.5m) + 15 storeys & structure* **+ £8 per sqft**
- *increased services distribution* **+ £5 per sqft**
- *includes sprinklers (Section 20)* **+ £5 per sqft**

= £193 per sqft

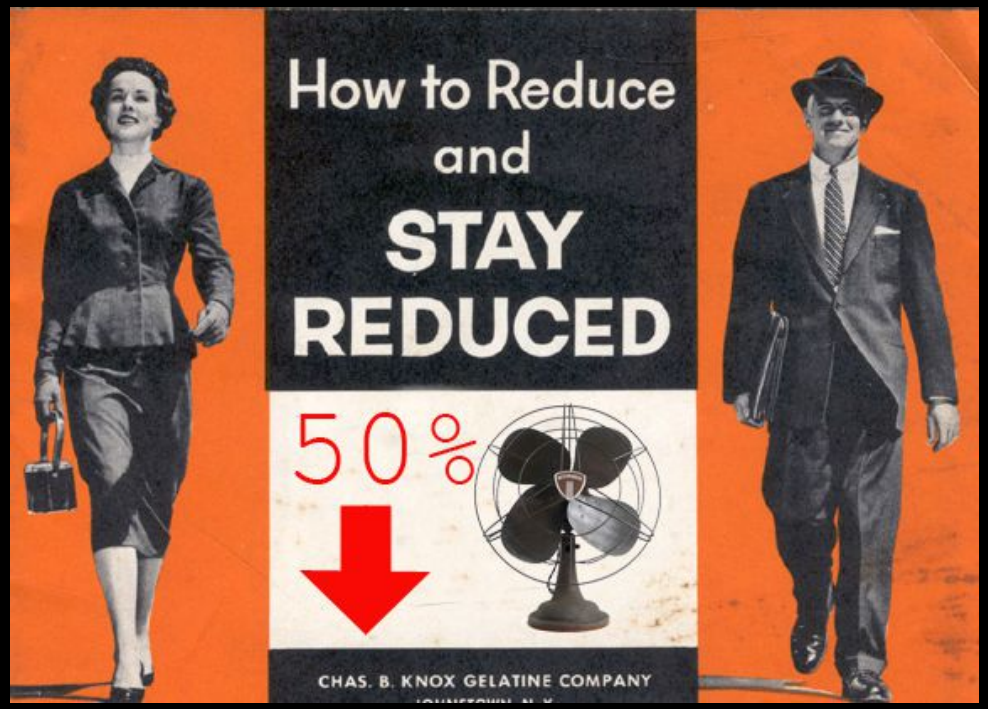


30% cellular:
"corporate" media


BALICREST
01753
STRICTLY
NO
PARKING
THIS
WAY
UP
LLAR FACTORY
WHITE CO

Ventilation strategy

1. open the window…

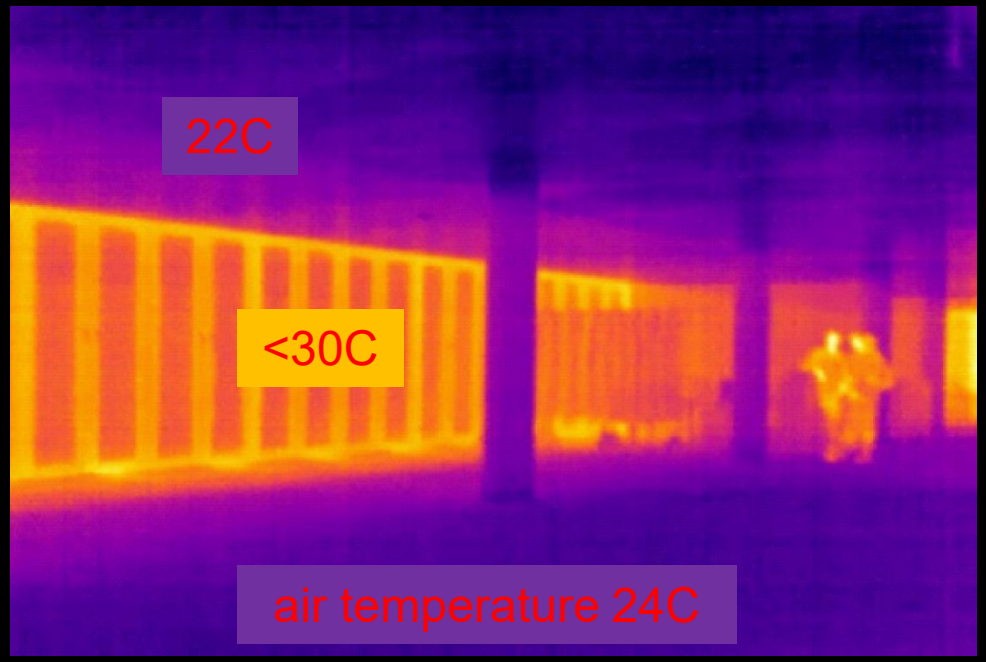


and therefore 2. reduce mechanical ventilation by 50%

Cooling strategy

1. lower surface temperatures

1. lower surface temperatures



…with radiant concrete slabs

1. lower surface temperatures

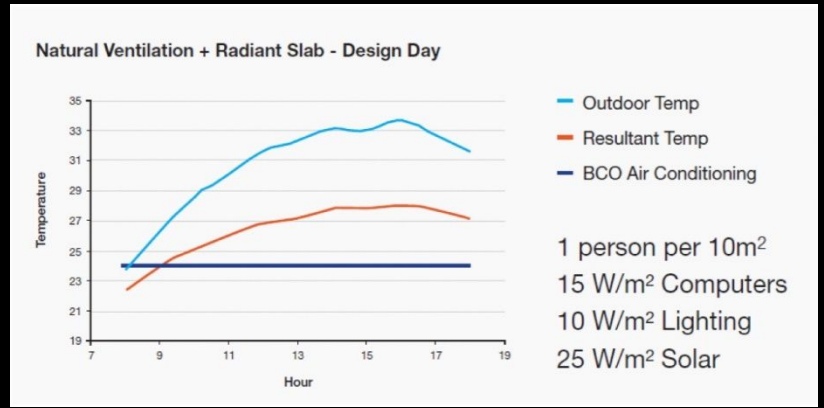
this is not a new concept

and 2. challenge the BCO notion of comfort…

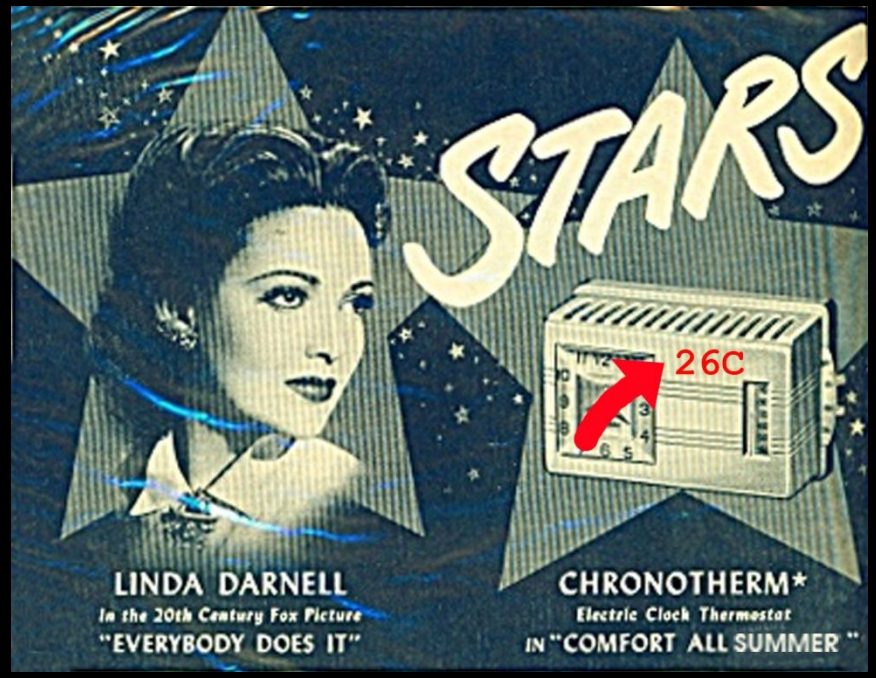
BCO a/c: 24C
WCF air temp: 22-28C

BCO a/c: 24C
WCF air temp: 22-28C

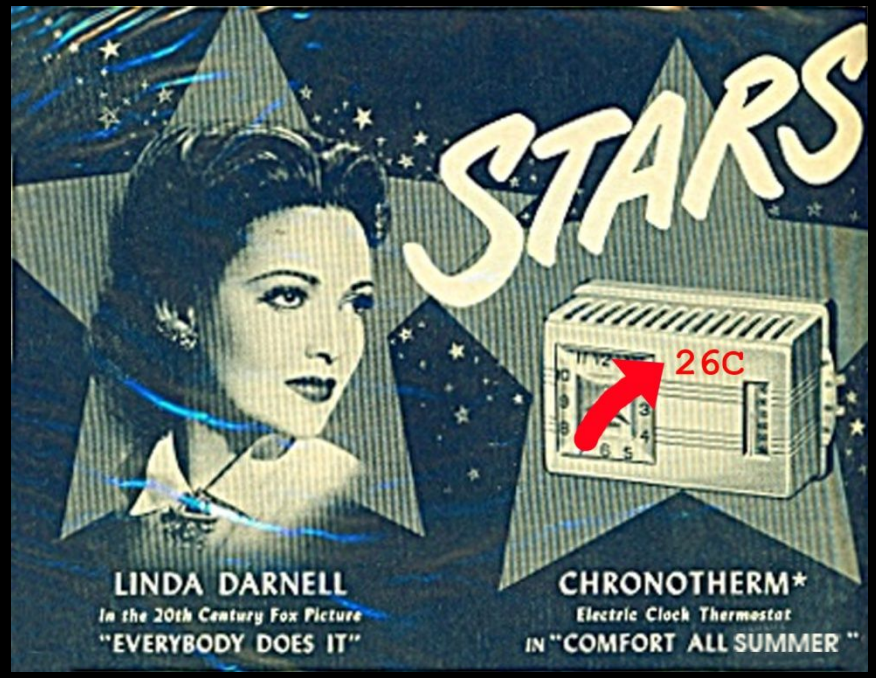
- 37 hours exceed 25C or <1% of annual working hours
- 0 hours exceed 28C

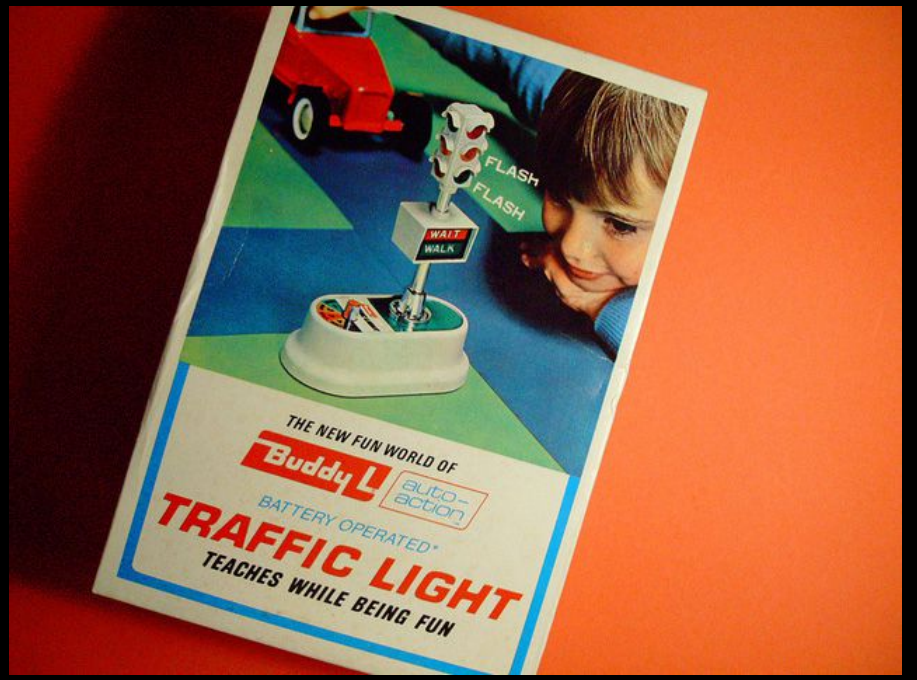


How to ‘operate’ this concept?

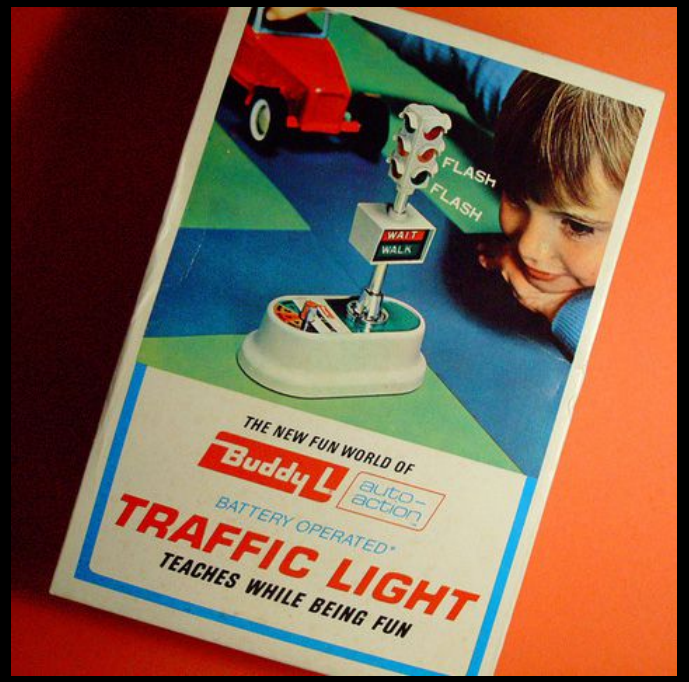


1. monitor energy useage…





with 2. attractive incentives…



to 3. achieve savings

City Road Jacket:

bespoke but affordable

elevations respond to site factors: orientation

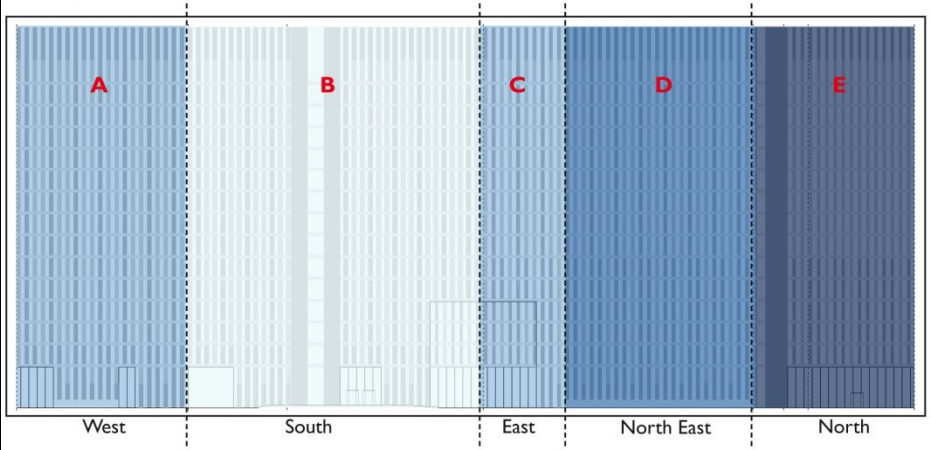
Building A: Facade Analysis & Treatment

The following pages are an explanation for the emerging strategy regarding the treatment for the facade.

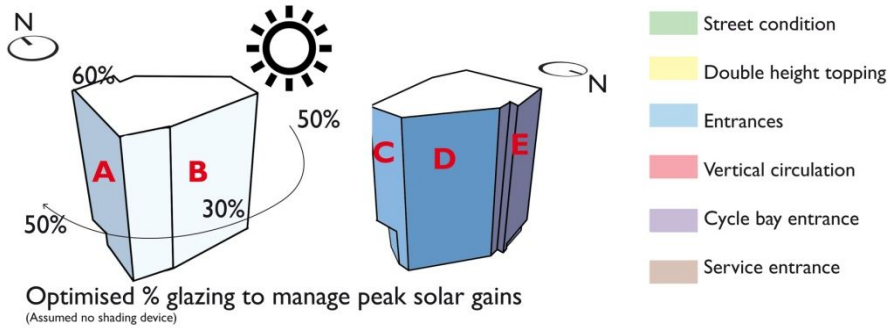
Identifying specific environmental and functional influences which have led us to respond to three separate conditions:

1/. Orientation of the site 2/. Air Quality 3/. Function

1. Response to Orientation



A graded system emerges as a response to the varying requirements each elevation has, regarding the reduction of peak solar gains.



Optimised % glazing to manage peak solar gains
(Assumed no shading device)

Diagrams highlighting the impact of the orientation of the site within initial facade studies

air & acoustic quality

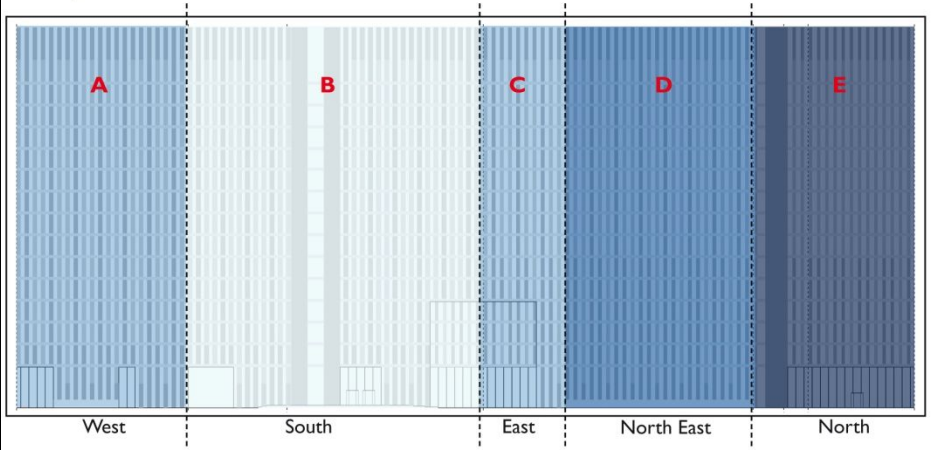
Building A: Facade Analysis & Treatment

The following pages are an explanation for the emerging strategy regarding the treatment for the facade.

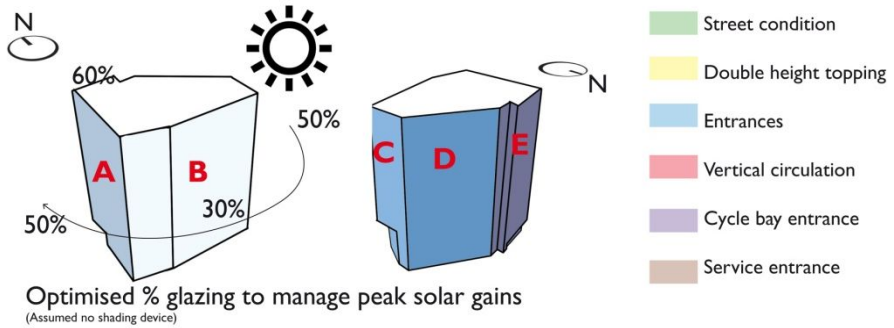
Identifying specific environmental and functional influences which have led us to respond to three separate conditions:

1/. Orientation of the site 2/. Air Quality 3/. Function

1. Response to Orientation



A graded system emerges as a response to the varying requirements each elevation has, regarding the reduction of peak solar gains.

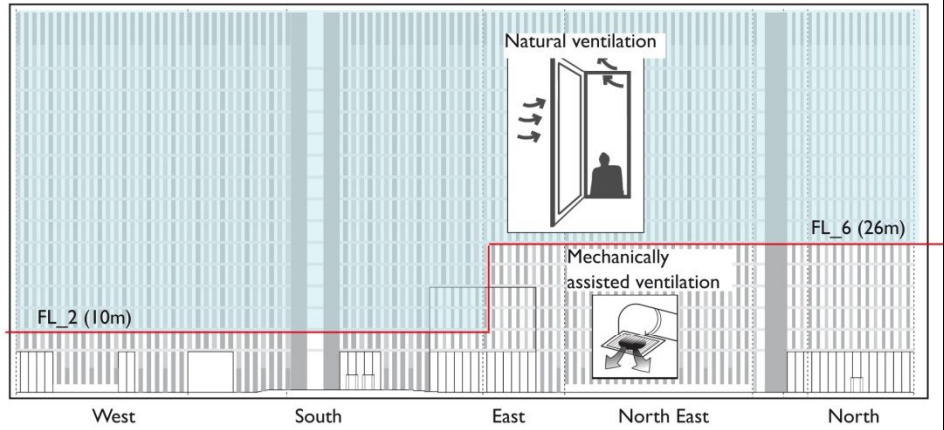


Optimised % glazing to manage peak solar gains
(Assumed no shading device)

Street condition
Double height topping
Entrances
Vertical circulation
Cycle bay entrance
Service entrance

Diagrams highlighting the impact of the orientation of the site within initial facade studies

2. Response to Air/Acoustic Quality



The amount of traffic and street pollution can have an enormous impact on the level of air quality. By identifying areas of high pollution (such as the North and East elevations as a result of Old Street and City Road junction), a threshold can be determined to establish exactly where full natural ventilation is beneficial and where it is not.

& programme

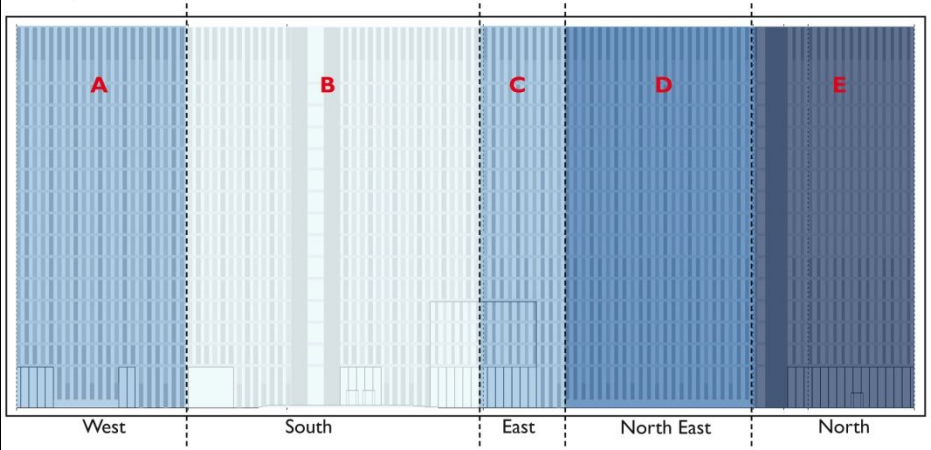
Building A: Facade Analysis & Treatment

The following pages are an explanation for the emerging strategy regarding the treatment for the facade.

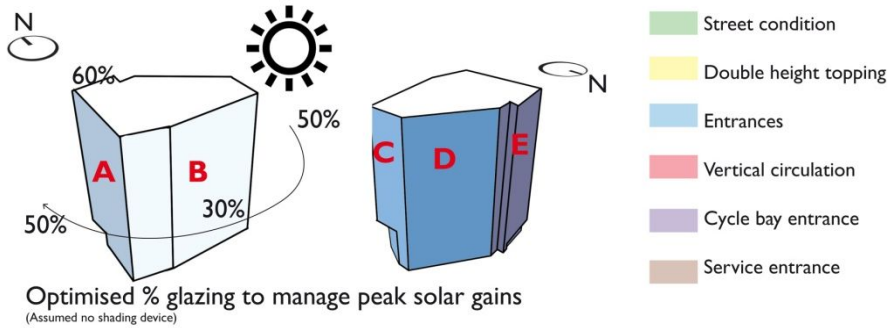
Identifying specific environmental and functional influences which have led us to respond to three separate conditions:

1/. Orientation of the site 2/. Air Quality 3/. Function

1. Response to Orientation

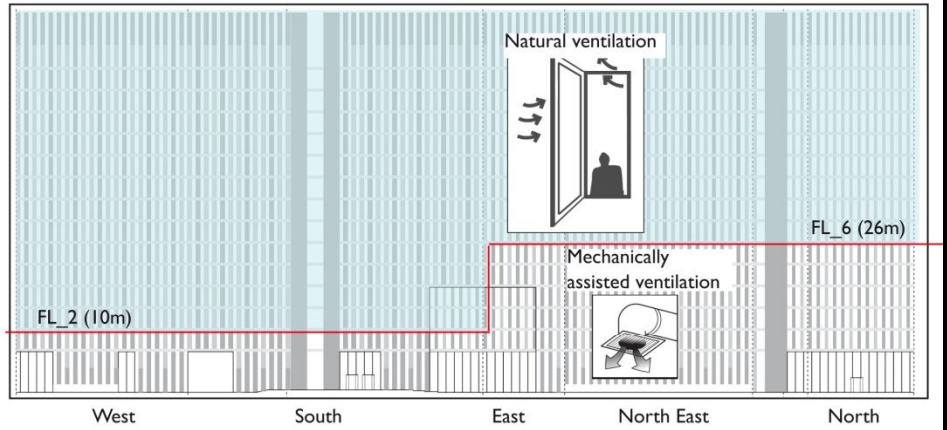


A graded system emerges as a response to the varying requirements each elevation has, regarding the reduction of peak solar gains.



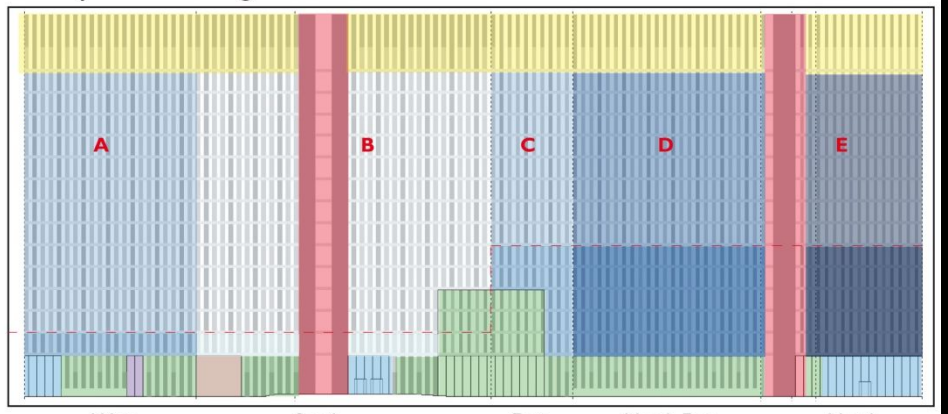
Diagrams highlighting the impact of the orientation of the site within initial facade studies

2. Response to Air/Acoustic Quality



The amount of traffic and street pollution can have an enormous impact on the level of air quality. By identifying areas of high pollution (such as the North and East elevations as a result of Old Street and City Road junction), a threshold can be determined to establish exactly where full natural ventilation is beneficial and where it is not.

3. Response to Programme



By identifying the different and specific functions within the building, it has generated possible areas of the facade that can be articulated in alternative ways.

1 TALL CEILINGS

1a 3500mm floor to ceiling heights

1b Exposed services – easy to maintain and adapt for particular uses

2 SMART SERVICING

2a Minimum fresh air mechanical vent with extract from bulkhead

2b Option for on floor plant

2c Light fittings included as basic product

2d Power and data in shallow raised access floor

2e Radiant slab for cooling & heating

3 PASSIVE LOW TECH FACADE

3a Opening windows

3b Windows adapt to suit solar conditions i.e small openings to south, larger to the north

4 FLEXIBLE FLOORPLATES

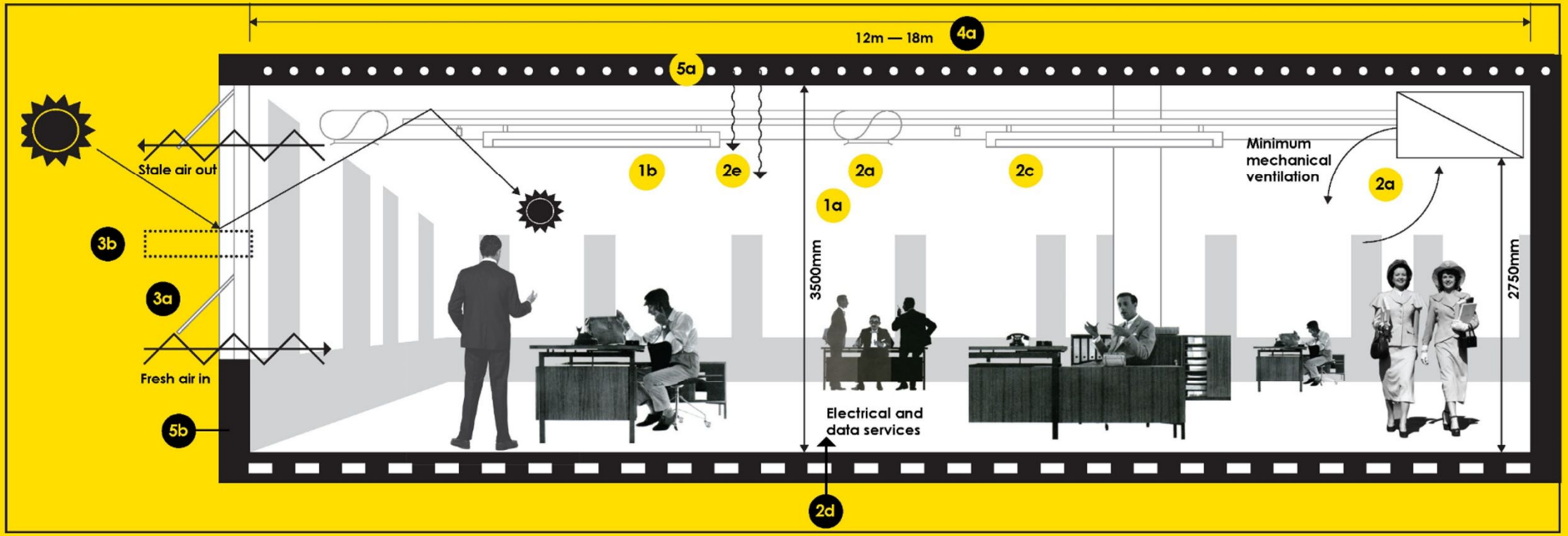
4a Generous scale provides maximum flexibility to suit a wide range of users

5 CONCRETE STRUCTURE

5a Exposed concrete soffit

5b Concrete perimeter upstand increases structural spans and eliminates perimeter columns

5c Robust self finished, activated for heating & cooling




Steady rain on the way...
13°

base

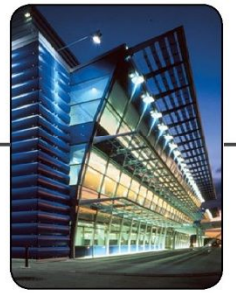
glazing

daily express
sir owen williams

air conditioning

1 canada sq.
césar pelli

shading

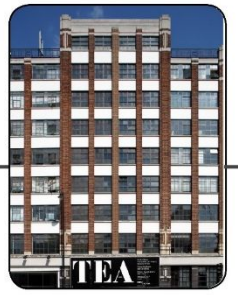


compass house
nicolas grimshaw

intelligent skins

plantation place
arup

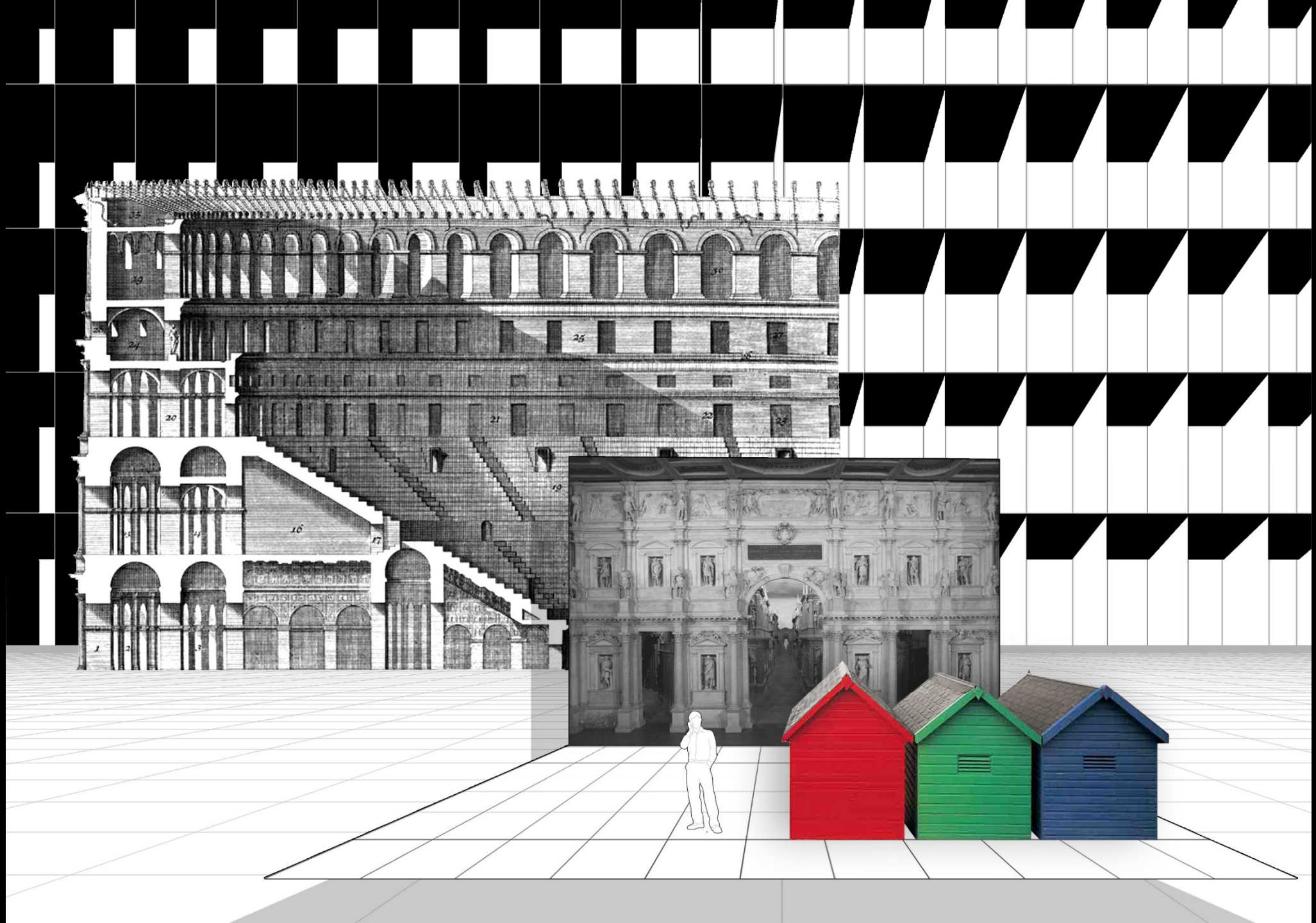
morelands



tea

johnson

horseferry



Project

Large scale speculative office in central Europe.

Challenge

Meet maximum solar gain criteria, provide views out, minimise maintenance.

Analysis

Comparison of active external blinds and fixed architectural shading.

Metrics

Cooling loads.
Proportion of working hours external blinds required.
Time glare occurs.

Outcome

Simple, fixed, architectural solution meets solar gains requirements and maintains year round views out.

Glare is limited by external shading and occurs significantly less than blinds needed for solar gains.

Glare therefore controlled internally via accessible, low cost, replaceable blinds.

External shading offers saving in maintenance, access etc. External shading offers saving in maintenance, access etc.

External shading offers saving in maintenance, access etc.

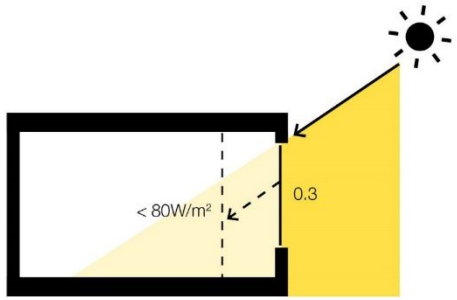
15049
1.0 External Blinds

Solar Gains in Internal Space limited to 80 W/m2

> 80W/m² - External blinds required

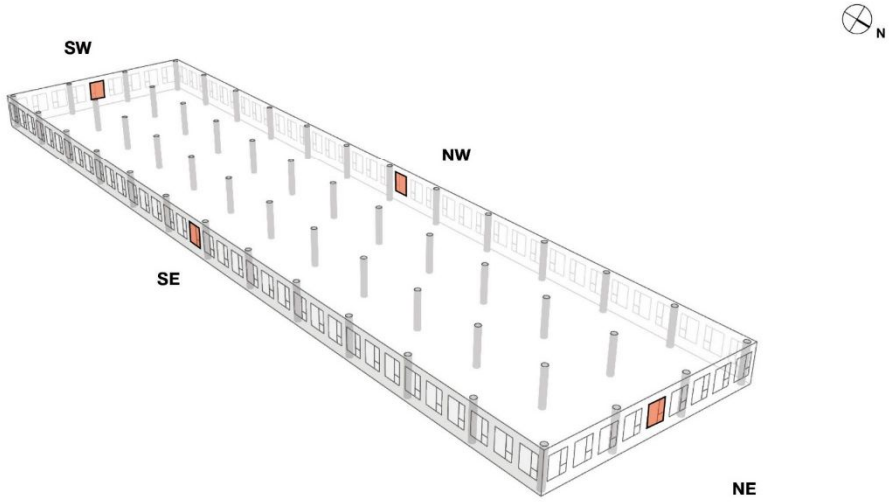
Glazing G-value - 0.3

Assumed Occupied Hours - 8am-7pm



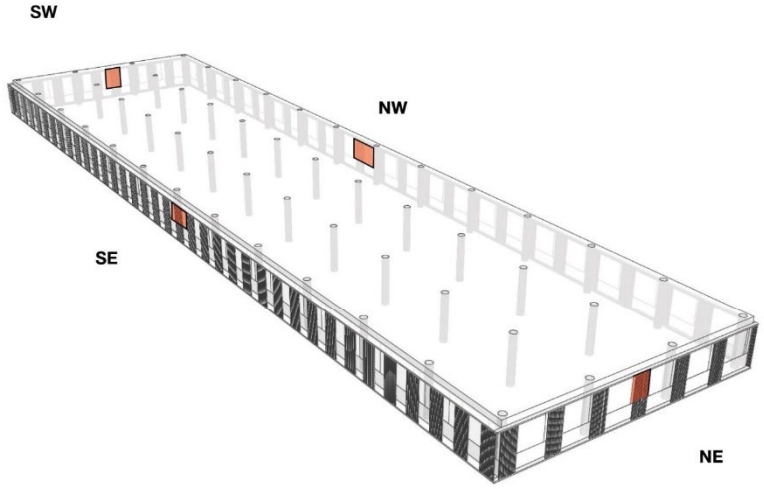
Plot A Approach - No External Shading

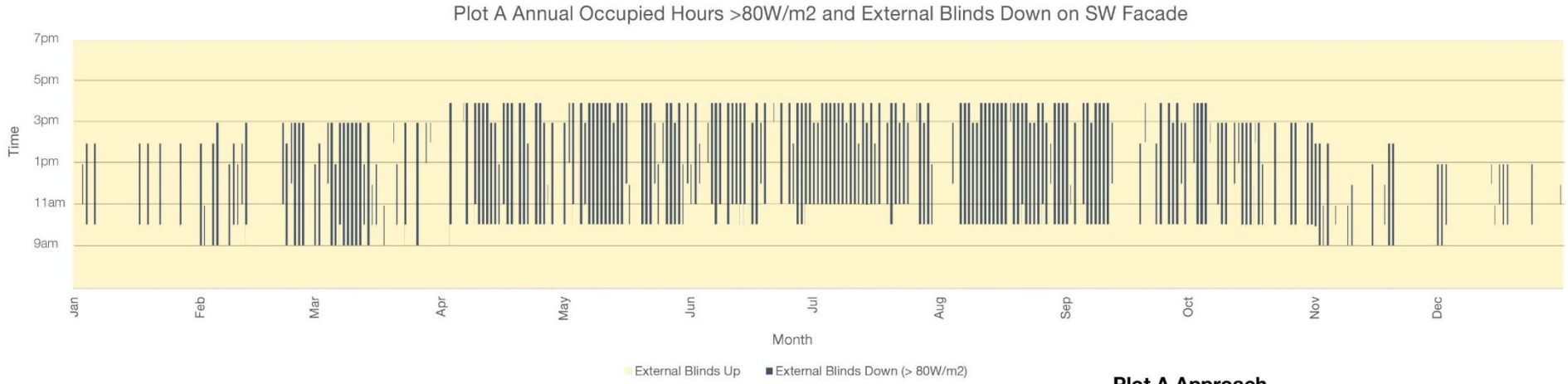
	No. of Annual Hours Solar Gain in Internal Space > 80W/m² and External Blinds Required	% of Annual Occupied Hours Solar Gain in Internal Space > 80W/m²
North East	1	0.02%
South East	838	19%
South West	1307	30%
North West	577	13%



AHMM Approach - Fixed External Shading

	No. of Annual Hours Solar Gain in Internal Space > 80W/m²	% of Annual Occupied Hours Solar Gain in Internal Space > 80W/m²
North East	1	0.02%
South East	1	0.02%
South West	11	0.25%
North West	1	0.02%

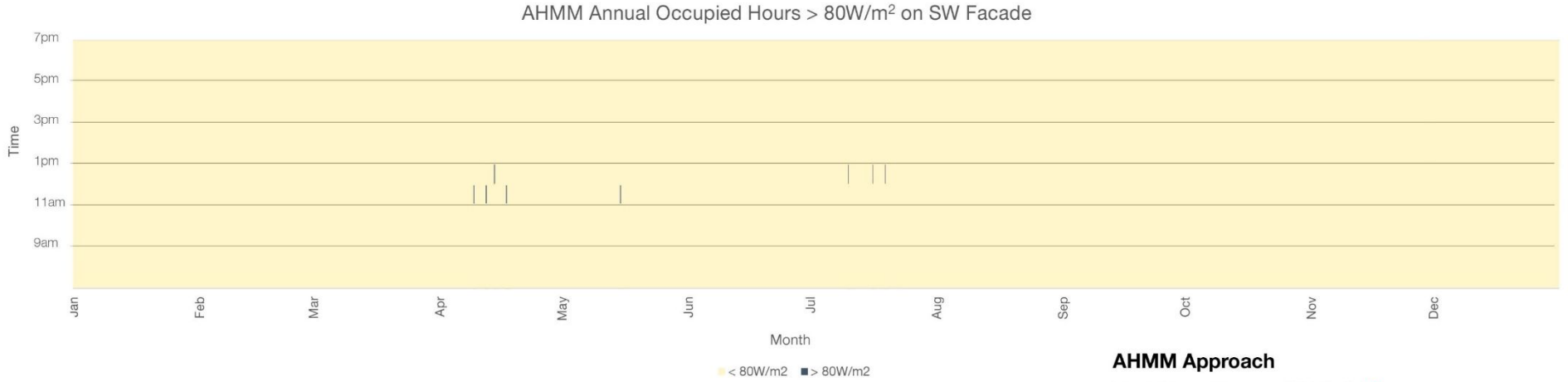




Plot A Approach

Total No. of Days Blinds Down - **245**

No. of Days Blinds Down for > 50% of the Day - **148**



AHMM Approach

Total No. of Days > 80W/m² - **8**

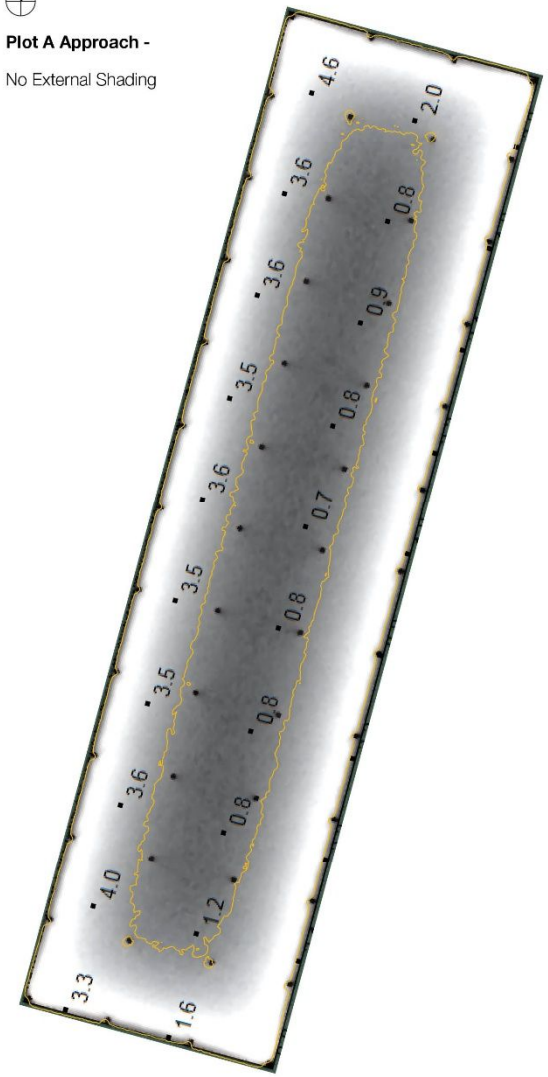
No. of Days > 80W/m² for > 50% of the Day - **0**

15049
2.0 Daylighting

N

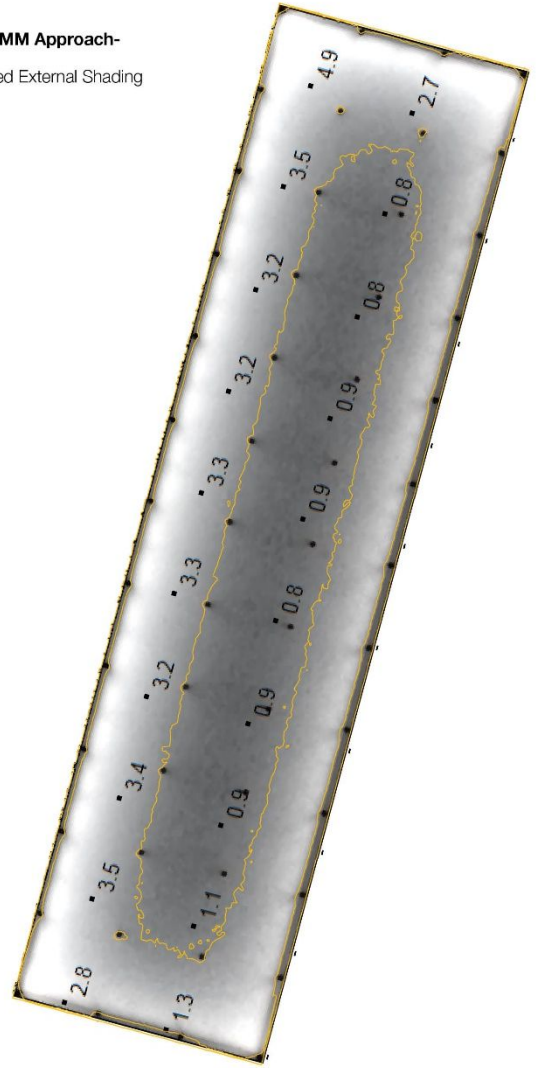
Plot A Approach -

No External Shading



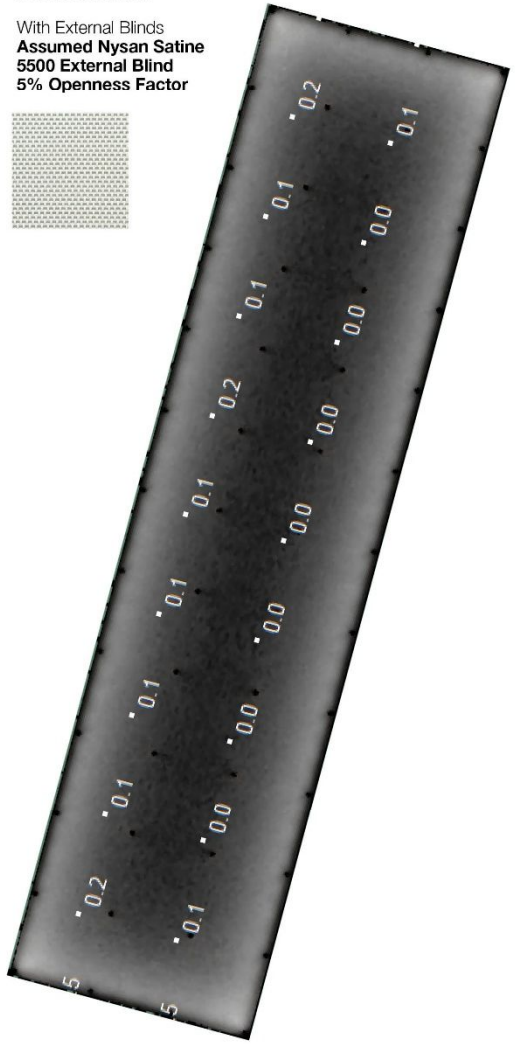
AHMM Approach-

Fixed External Shading



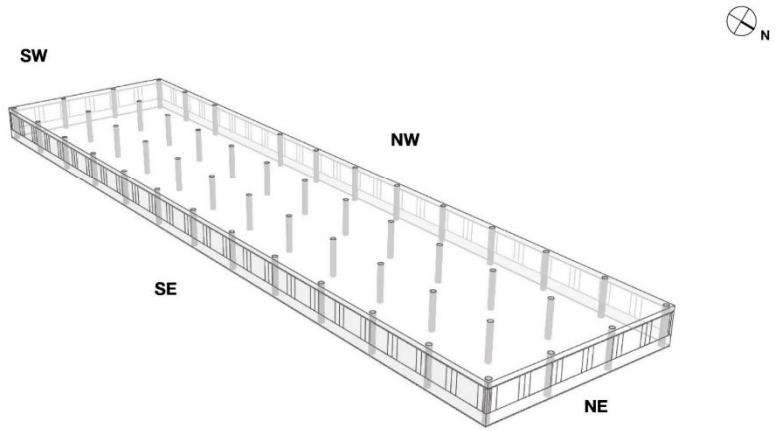
Plot A Approach -

With External Blinds
Assumed Nysan Satine
5500 External Blind
5% Openness Factor



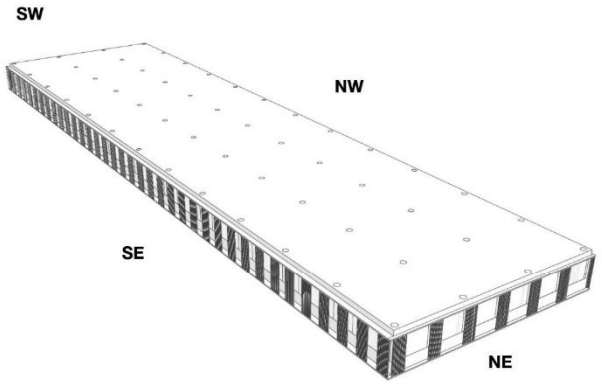
1.5% Daylight Factor Threshold

15049
0.0 Glare Study Inputs



Plot A Approach

No External Shading



AHMM Approach

Fixed External Shading

View Eye Position - 1.2m Above FFL

Sky File - Sunny Sky

Unified Glare Rating (UGR)

Max. Allowed UGR for Offices - 19, If UGR >19, internal blinds are needed

UGR Degree of Perceived Glare Scale -

<13 = Imperceptible

13-22 = Perceptible

22-28 = Disturbing

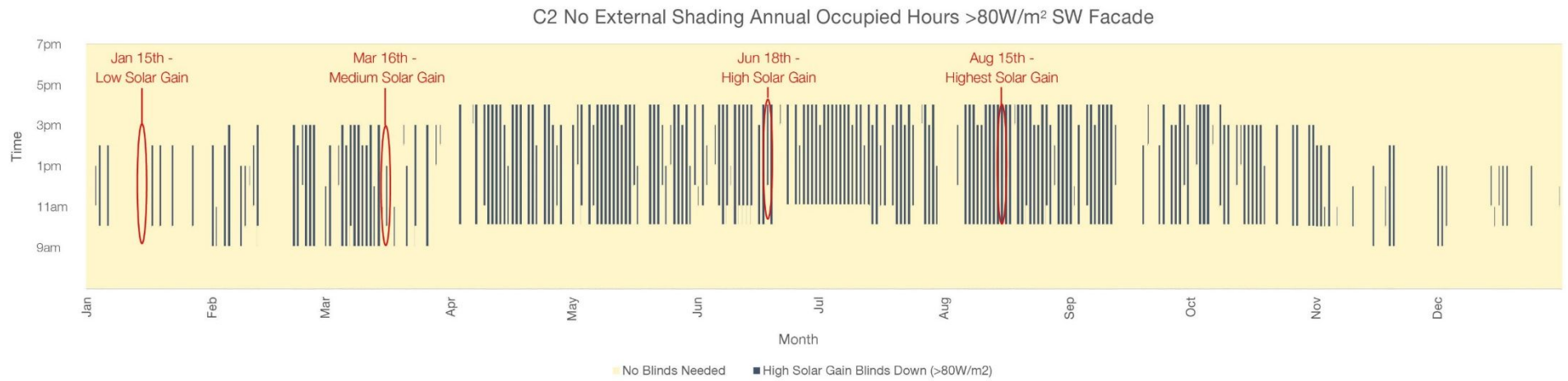
>28 = Intolerable

Solar Gain

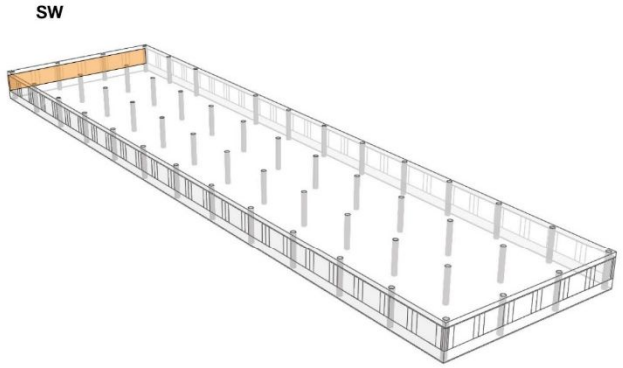
Solar Gain in Office Limited to - 80W/m², If solar gains > 80W/m², solar shading is needed

15049

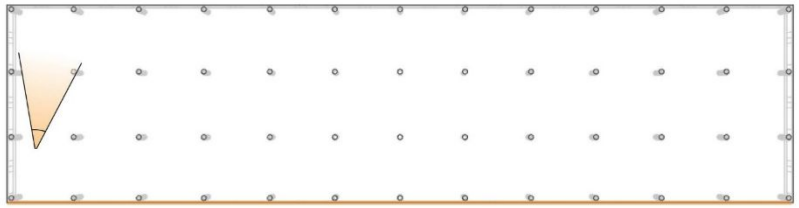
1.0 Plot A Approach - No External Shading SW Facade



Dates Used for Glare Analysis

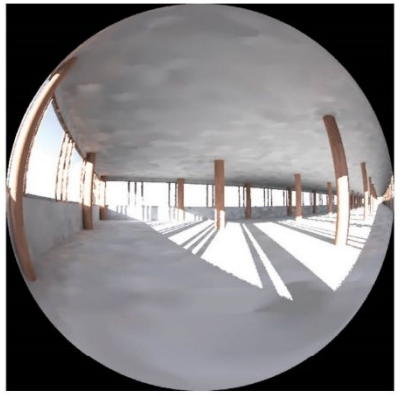


SW Facade and Blind Location



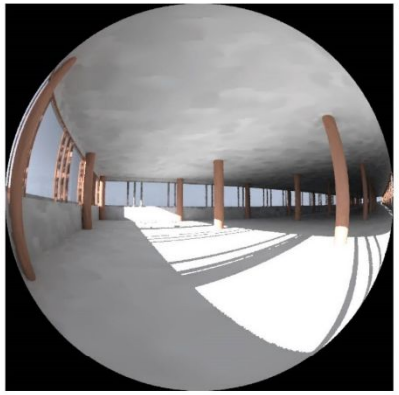
Glare View Location

15049
1.1 SW Facade - Jan 15th



9am

No Glare
Low Solar Gains

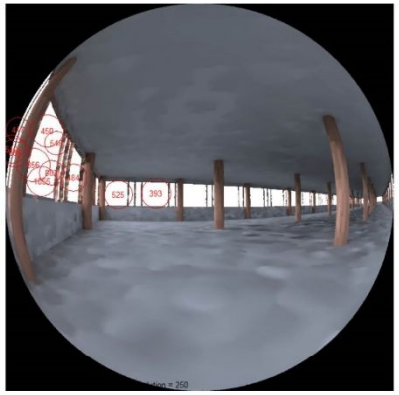


12pm

No Glare
Low Solar Gains

3pm

Glare
Low Solar Gains



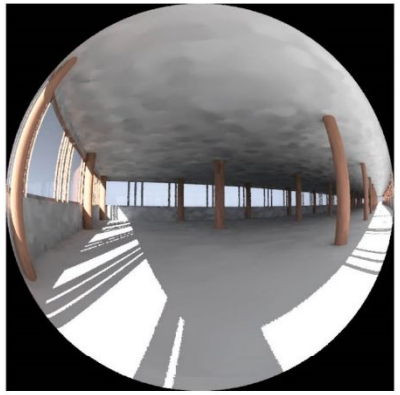
5pm

Glare
Low Solar Gains

Jan 15th

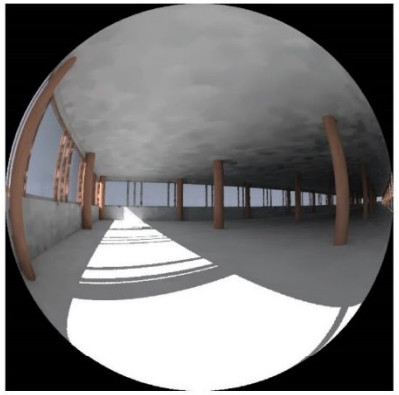
15049

1.2 SW Facade - Mar 13th



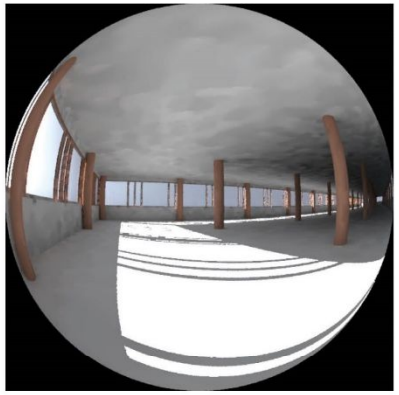
9am

No Glare
Low Solar Gains



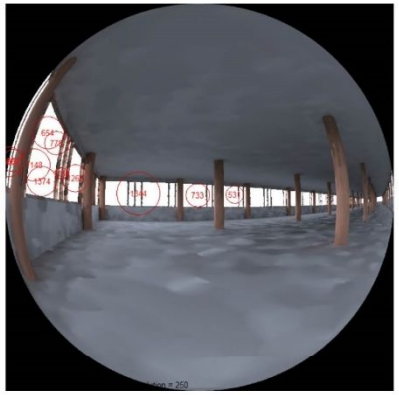
12pm

No Glare
High Solar Gains



3pm

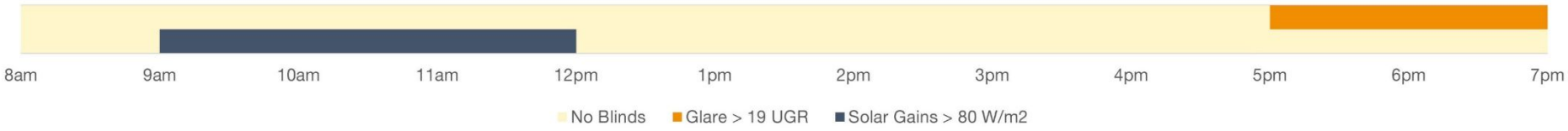
No Glare
Low Solar Gains



6pm

Glare
Low Solar Gains

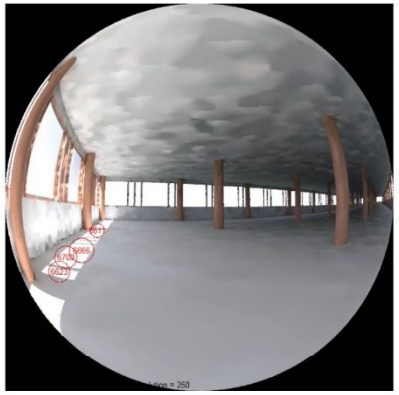
Mar 13th



15049
1.3 SW Facade - Jun 18th

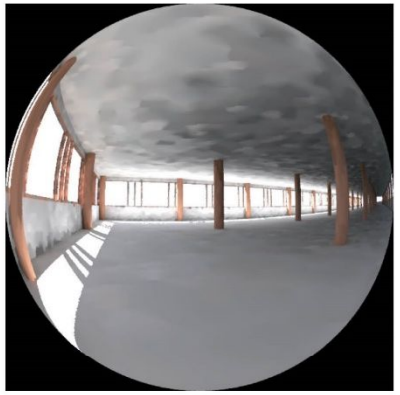
9am

No Glare
Low Solar Gains



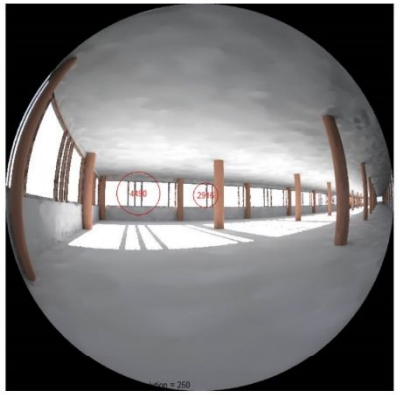
12pm

Glare
High Solar Gains



3pm

No Glare
High Solar Gains



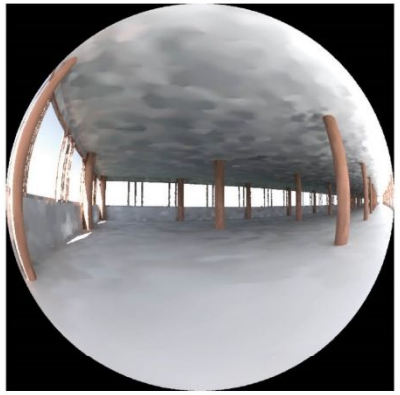
6pm

Glare
Low Solar Gains

Jun 18th

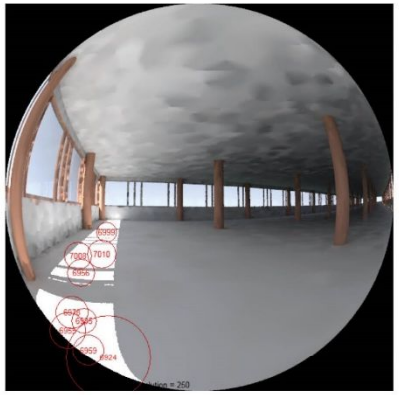
15049

1.4 SW Facade - Aug 15th



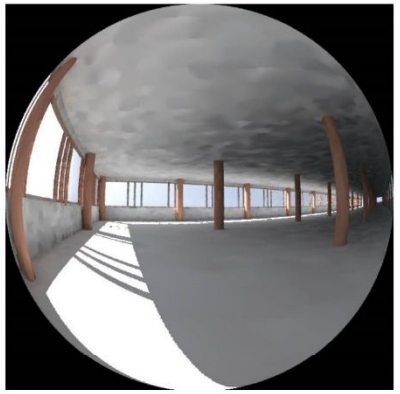
9am

No Glare
Low Solar Gains



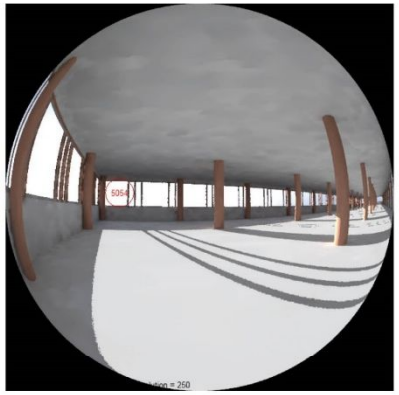
12pm

Glare
High Solar Gains



3pm

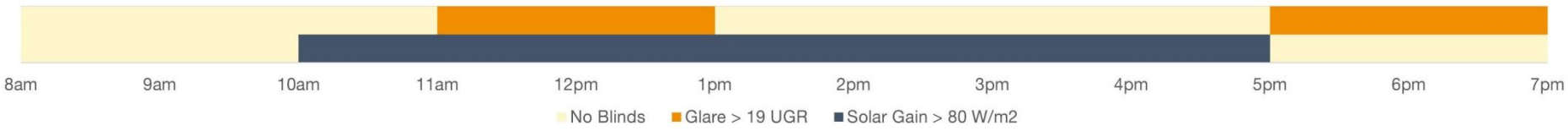
No Glare
High Solar Gains



6pm

Glare
Low Solar Gains

Aug 15th



Project

Mixed use building in central London.

Challenge

Interrogate proposed system design for actual operation, not compliance.

Analysis

Comparison of actual management strategies to SBEM based approach

Metrics

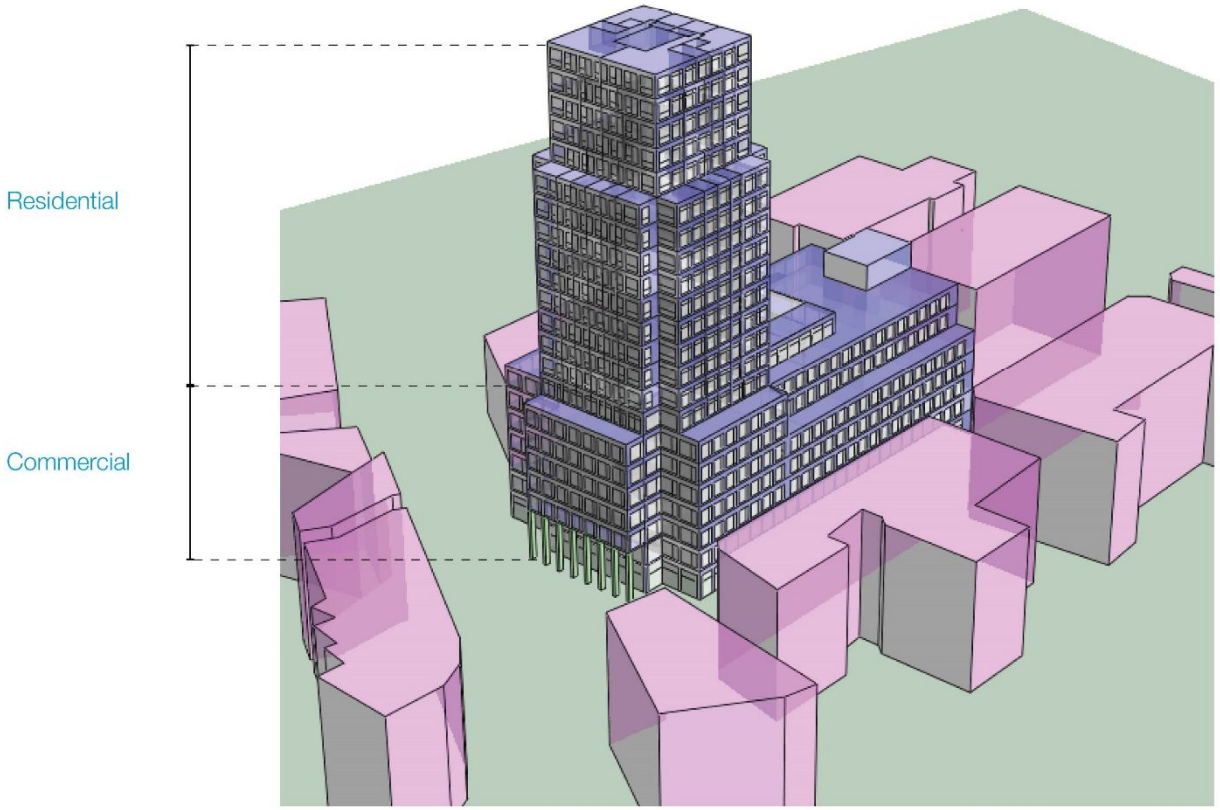
Thermal comfort
Cooling loads.
Heating Loads.
Solar gains.
Daylight.

Outcome

Comfort analysis for compliance not operation.
Operational modes could reduce CapEx on plant, energy consumption and CO_2.
Demonstrates that a simpler system with occupant control can improve comfort.
Challenge is to ensure this is built and programmed into BMS, not the compliance model!

13136

1.1 Commercial - Thermal Comfort



IES Model

Occupancy Profiles, Internal Gains, Heating and Cooling Profile

Commercial

NCM Office: Office
NCM: Office: Reception
NCM Office: Circulation Areas

Residential

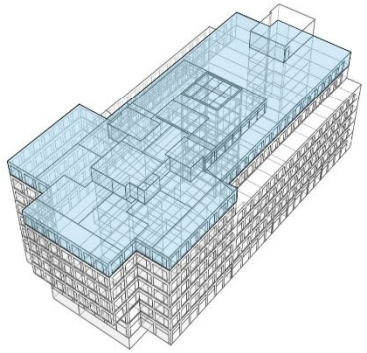
NCM Dwelling: Kitchen
NCM Dwelling: Bedroom
NCM Dwelling: Bathroom

Commercial Building Fabric	Residential Building Fabric
Walls - 0.18 W/m²k	**Walls -** 0.2 W/m²k
Roof - 0.15 W/m²k	**Roof -** 0.16 W/m²k
Floor - 0.2 W/m²k	**Windows -** 1.2 W/m²k G-Value - 0.55
Windows - 1.4 W/m²k G-Value - 0.34	

*Different values between DSA report and SBEM inputs

Weather File - 2030_Islington_a1b_10_percentile_DSY.epw

13136
1.1 Commercial - Thermal Comfort

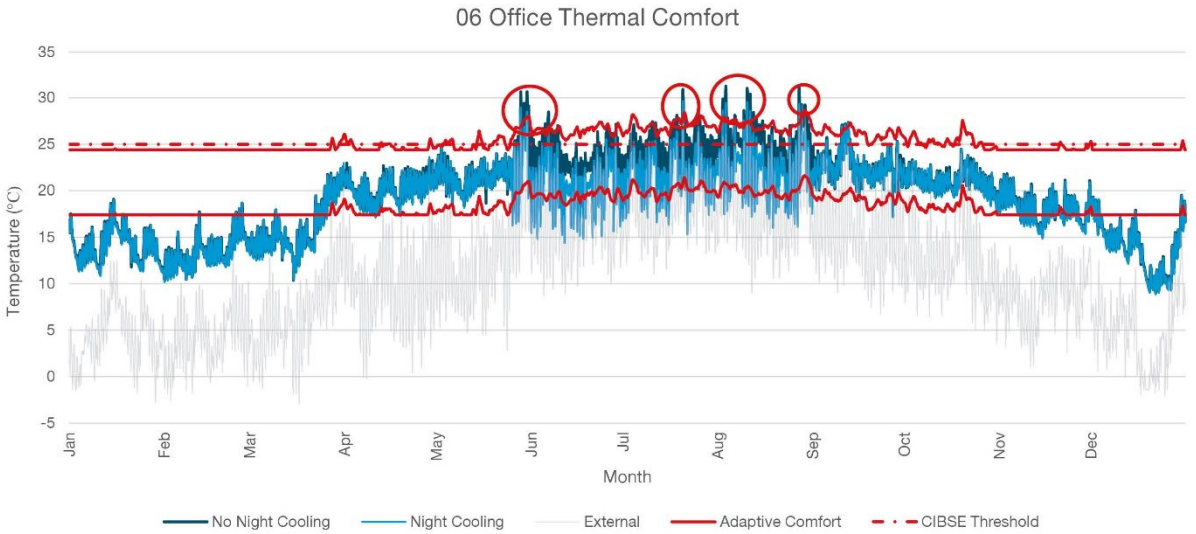


06 Office

Mode of Operation

Systems - None, free-running with night cooling

Window opening for night cooling -
19:00-08:00 open if to<ta
08:00-19:00 open if ta>22 & to<25
Where to = external temp. and ta = internal temp.



Thermal Comfort

- The 6th Floor office has highest solar gain of all office floors

- Without night cooling, the maximum temperatures within the office exceeds 30°C during the peak summer periods and 28°C 11% over the year

- Night cooling reduces the peak summer temperatures to under 30°C as well as the % of hours under 28°C to 3%

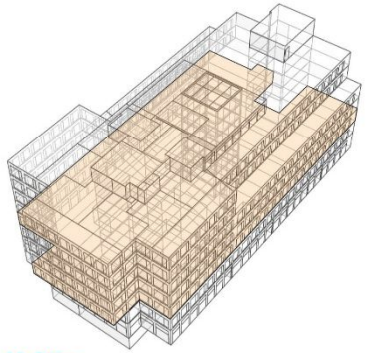
- If the adaptive comfort threshold were applied, the internal environment would lie within it for the majority of the year and therefore further decrease the cooling load

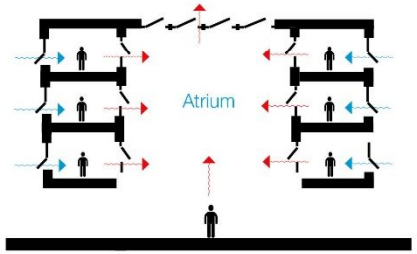
	No. of Hrs > 28°C	No. of Hrs > 25°C	No. of Hrs > Adaptive Comfort
No Night Cooling	956 (11%)	117 (1%)	235 (3%)
Night Cooling	256 (3%)	32 (0.4%)	52 (0.6%)

If operated as free-running, the building is within CIBSE guidance for overheating (1% of hours above 28°C and 5% of hours above 25°C)
Cooling load with the offices is therefore minimal

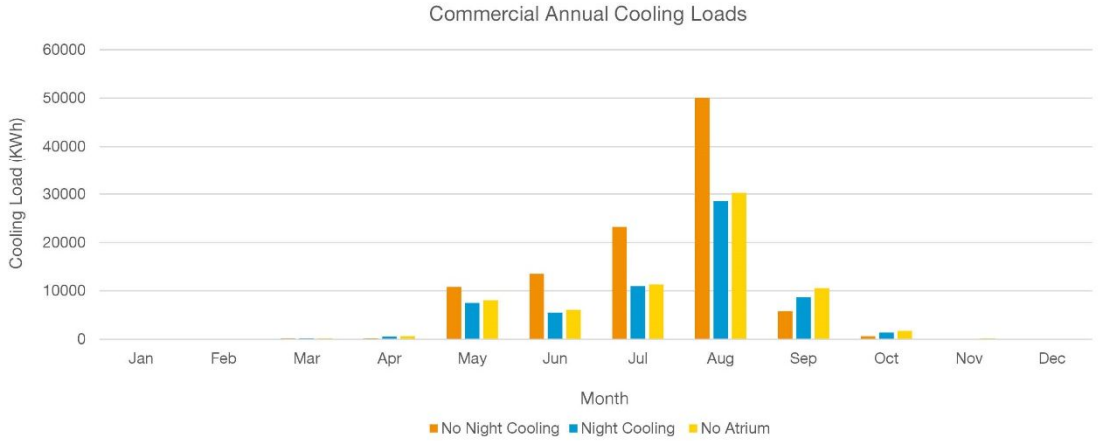
13136

1.2 Commercial - Cooling Load





02 Office

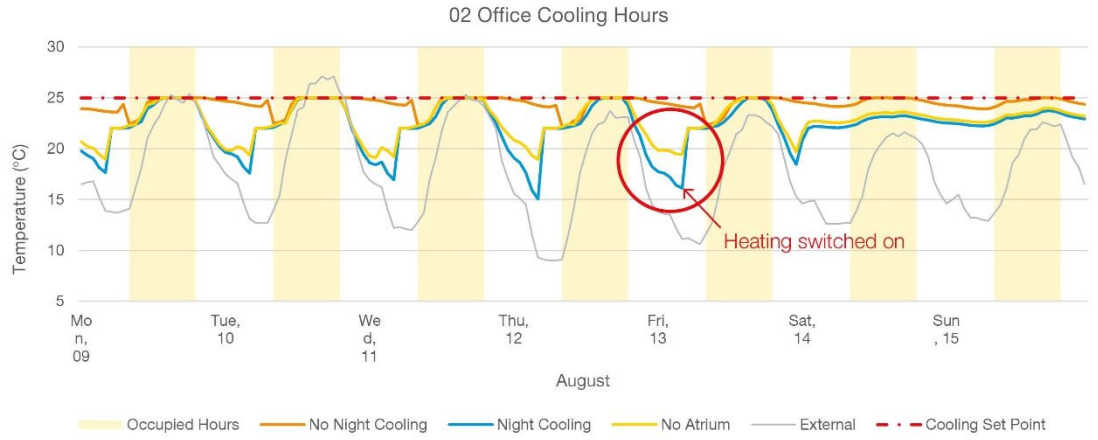


Mode of Operation

Systems - NCM Specification with night cooling, cooling set-point at 25°C

	Annual Cooling Load (KWh)	Annual Cooling Load (KWh/m²)	Difference
No Night Cooling	104387	4.9	-
Night Cooling	63669	2.9	-39%
No Atrium	69182	3.3	-34%

	Annual Heating Load (KWh)	Annual Heating Load (KWh/m²)	Difference
No Night Cooling	919519	43.1	-
Night Cooling	1180117	55.3	+28%
No Atrium	1074627	40.4	+17%

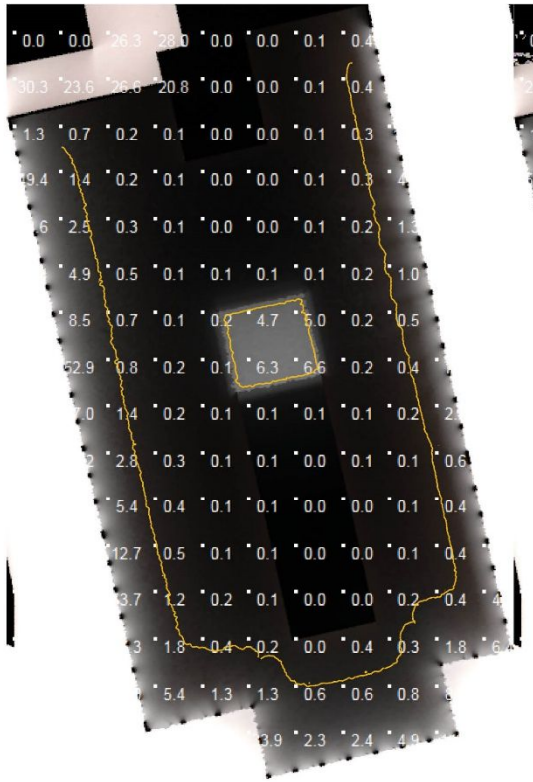


Cooling loads

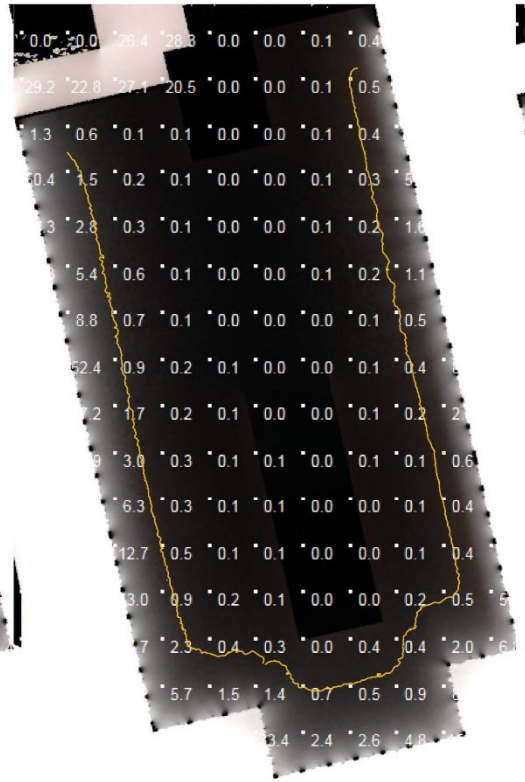
- Introducing night cooling to the commercial block results in a 39% reduction in overall annual cooling loads when using a 25°C set-point. The atrium linking the commercial spaces together, facilitate the stack effect and removing the atrium would result in only a 5% difference in cooling load

NCM heating profile

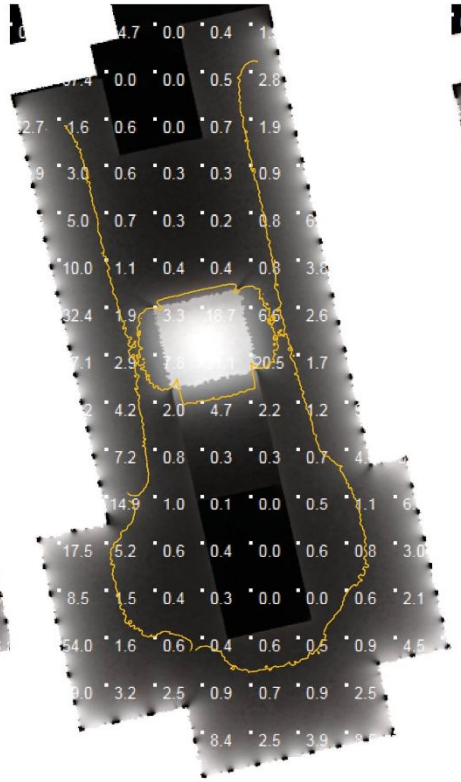
- Using the NCM heating profile causes an increase in heating loads as the heating is switched on in early hours of the morning when the night cooling is operating. **Therefore a more realistic heating profile should be used when night cooling is in operation**



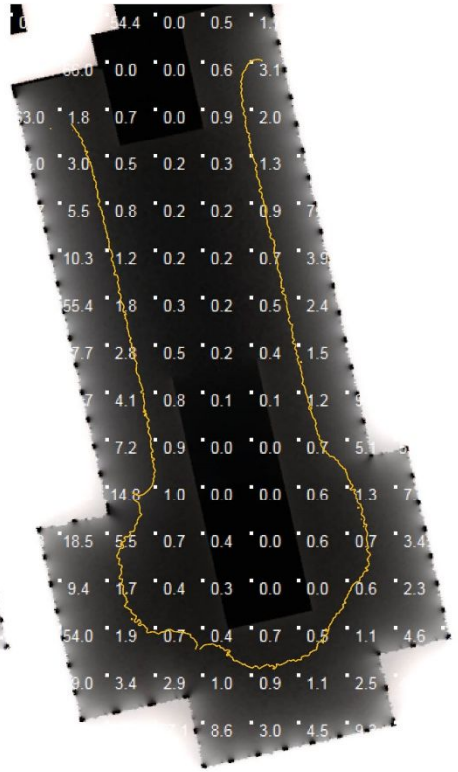
02 Office - With Atrium



02 Office - Without Atrium



06 Office - With Atrium



06 Office - Without Atrium

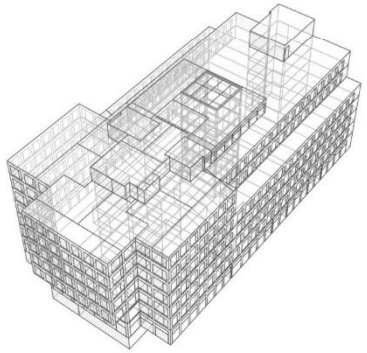
Daylight

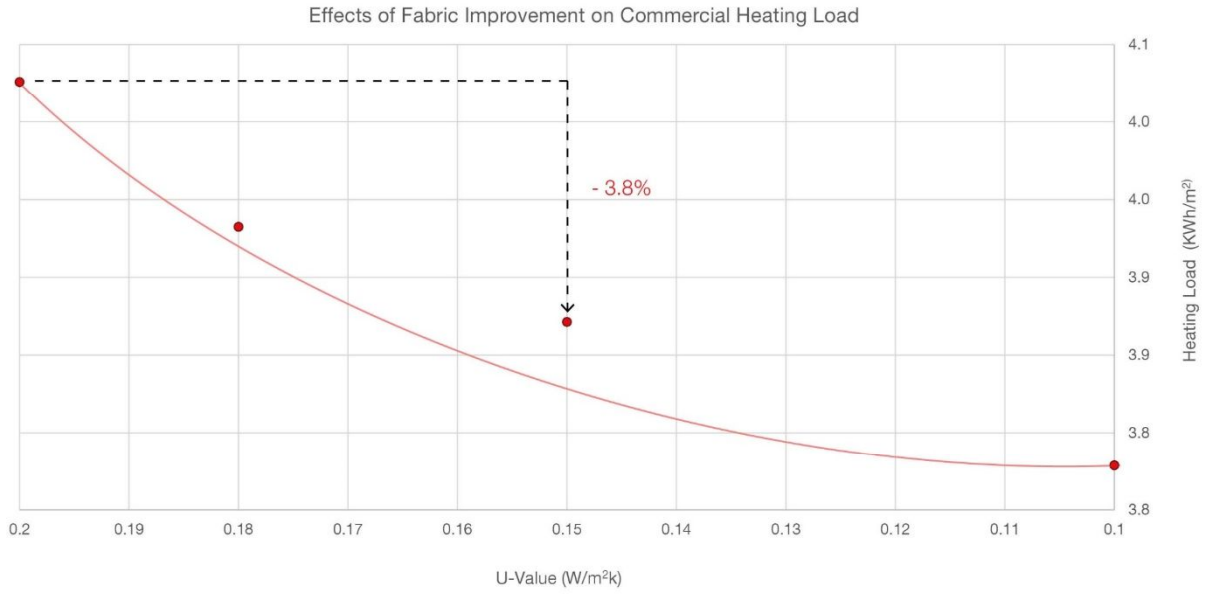
- The building is well shaded on the east and west orientations on the lower floors, this, along with the deep floor plates therefore reduces daylight penetration

- The atrium has very little impact on the lower office floors compared to the upper floors due to the deeper floor plates.

2% Daylight Factor Threshold
Daylight factors at 5x5m grid

13136
1.4 Commercial - Fabric Improvements





Mode of Operation

Systems - Adapted NCM Specification with night cooling

Adapted NCM Heating Profile - Heating during occupancy hours, set-point of 19°C

Fabric Improvements

- Reducing the annual heating loads would decrease the total carbon emissions and this can be achieved by improving the building fabric

- Although the U-values of the commercial block all surpass part L compliance, the U-value of the external walls could improve

- Improving the U-value from 0.2 W/m²k to 0.15 W/m²k could reduce the overal heating load by almost 4%

Fabric Performance

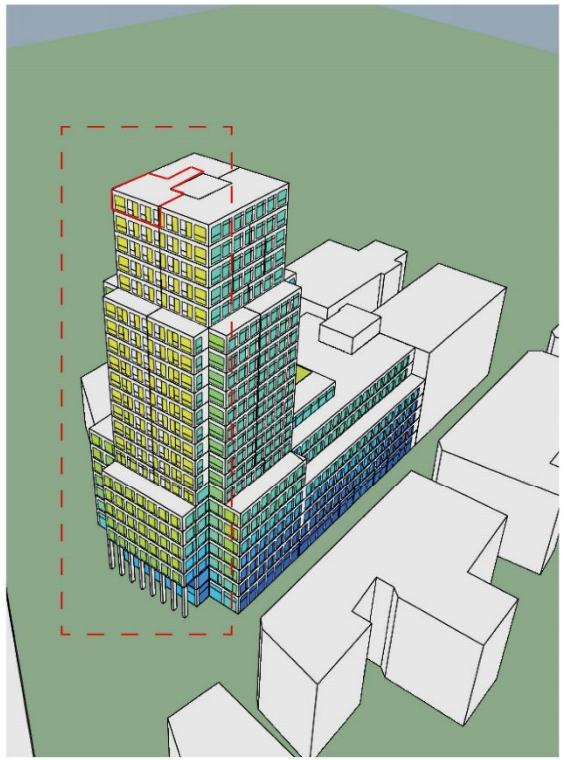
Walls - 0.2 W/m²k

Roof - 0.15 W/m²k

Floor - 0.2 W/m²k

Windows - 1.4 W/m²k

Wall U-Value (W/m²k)	0.2	0.18	0.15	0.1
Annual Heating Load (KWh)	85769	83777	82476	80504
Annual Heating Load (KWh/m²)	4.0	3.9	3.9	3.8
Difference	-	- 2.3%	- 3.8%	- 6.1%



Mode of Operation

Systems - None, free-running

Window opening profile for night cooling -
19:00-08:00 open if to<ta
08:00-19:00 open if ta>22 & to<25
Where to = external temp. and ta = internal temp.

Solar Gains and Thermal Comfort

- The residential block above has limited shading and therefore high solar gains, especially on the upper levels on the south facade

- The temperatures within these apartments are very high, exceeding the comfort threshold. However, after introducing thermal mass and night cooling into the kitchen and living spaces, they drop to a comfortable environment, with peak tempertures of 28°C.

- Internal blinds can be used to mitigate some gains but compromises the quality of space, therefore more architectural solutions could be used

13136
2.1 Residential - Overheating and Glazing Performance

21 Flat 3 Kitchen/Dining

Mode of Operation

Systems - NCM Specification with night cooling, cooling set-point at 25°C

	Solar Gain (KW)	Difference
G-Value 0.55	8447	-
G-Value 0.34	5100	-40%

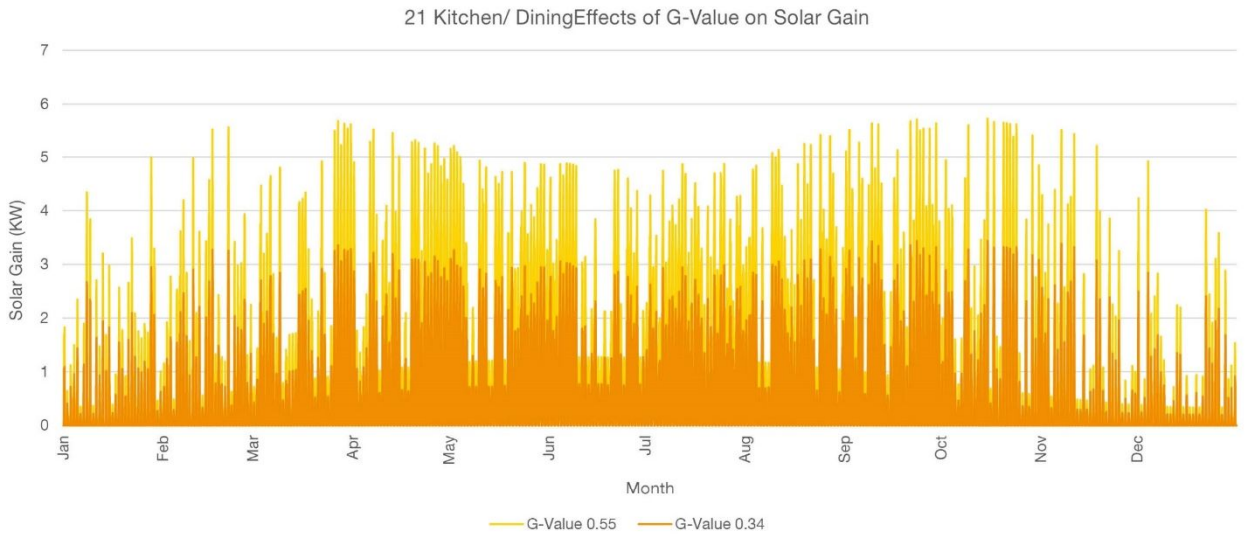
	Annual Cooling Load (KWh)	Annual Cooling Load (KWh/m²)	Difference
U-Value 1.2 G-Value 0.55	16573	1.83	-
U-Value 1.2 G-Value 0.34	7139	0.8	-57%

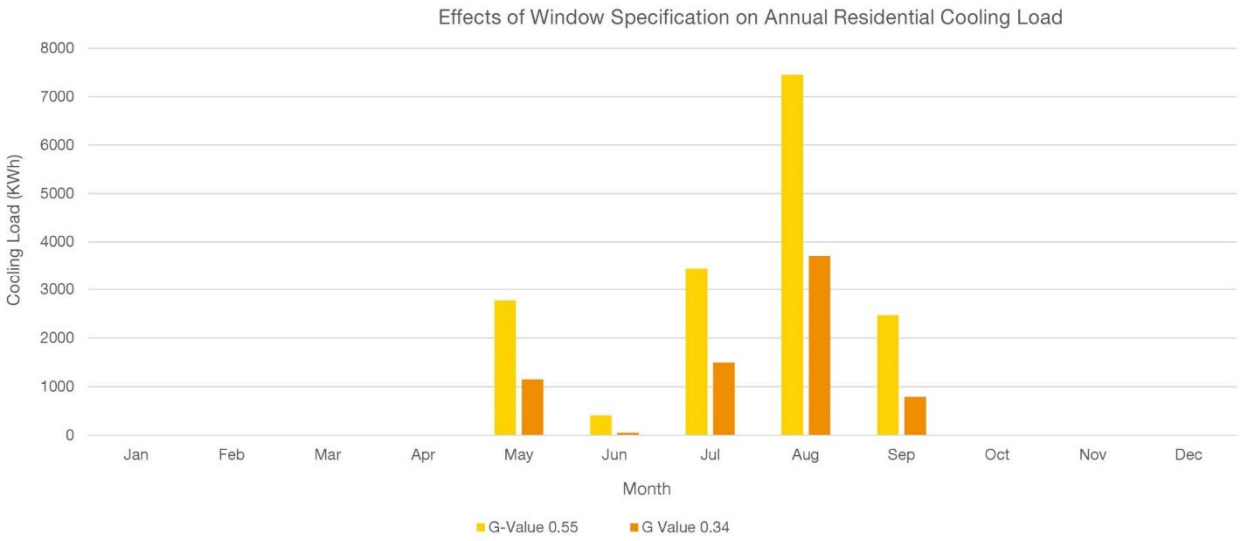
Glazing Specification

- The current residential windows have a G-Value of 0.55 compared to the commercial of 0.34, the residential block also has higher solar gains compared to the commercial block due to lack of shading

- Improving the G-Value to 0.34 reduces the solar gain by 40% in a 21st floor kitchen/dining space and annual cooling loads by 37%

- It is therefore recommended to improve the glazing specification of the residential units





13136

3.0 Summary

	Commercial (With Night Cooling)		Residential (With Night Cooling)	
	NCM Specification for SBEM	**Adjusted NCM Specification**	**NCM Specification for SAP**	**Adjusted NCM Specification**
Annual Heating Load (KWh/m²)	55.3	3.9	34.0	9.7
Annual Cooling Load (KWh/m²)	2.9	2.6	1.8	1.7

Commercial

Thermal Comfort

- If operated as **free-running**, the building is within **CIBSE guidance for overheating** (1% of hours above 28°C and 5% of hours above 25°C) and for the majority of the year sits **within the adaptive comfort thresholds**. Cooling load within the offices is therefore **minimal if night cooling is applied**.

NCM Profiles

- The NCM heating profile **doesn't correlate with realistic running** of the building, the **annual heating load** is therefore **much higher** than anticipated when night cooling is applied

Atrium

- The atrium is used to **facilitate the stack effect** and benefit the **overall cooling loads**. However, the results show that the inclusion of the atrium only provides a **5% decrease** in cooling load. In addition, the daylighting benefits of the atrium are also **very limited** espically in the lower office floors with the deeper floor plates

Fabric Performance

- The **heating load** of the commercial building can be further improved through the **fabric performance**. Changing the U-value of the external walls from **0.2 W/m²k to 0.15 W/m²k** results in a **4%** decrease in annual heating load

Residential

Solar Gains and Glazing Performance

- The highest solar gains occur in on the higher south facade due to lack of site shading. The glass in the residential portion of the building have a very low U-value of 1.2 W/m²k but a **high G-value of 0.55**. This therefore contributes greatly to the solar gain and d**ecreasing the G-value** of the glass will **improve comfort levels** and **reduce the times in which internal blinds** are in operation

Project

Speculative office in London business district.

Challenge

Brief preventing exploiting opportunities for energy reduction and comfort improvement inherent in architecture.

Analysis

Comparison of briefed system and proposed hybrid operational strategy.

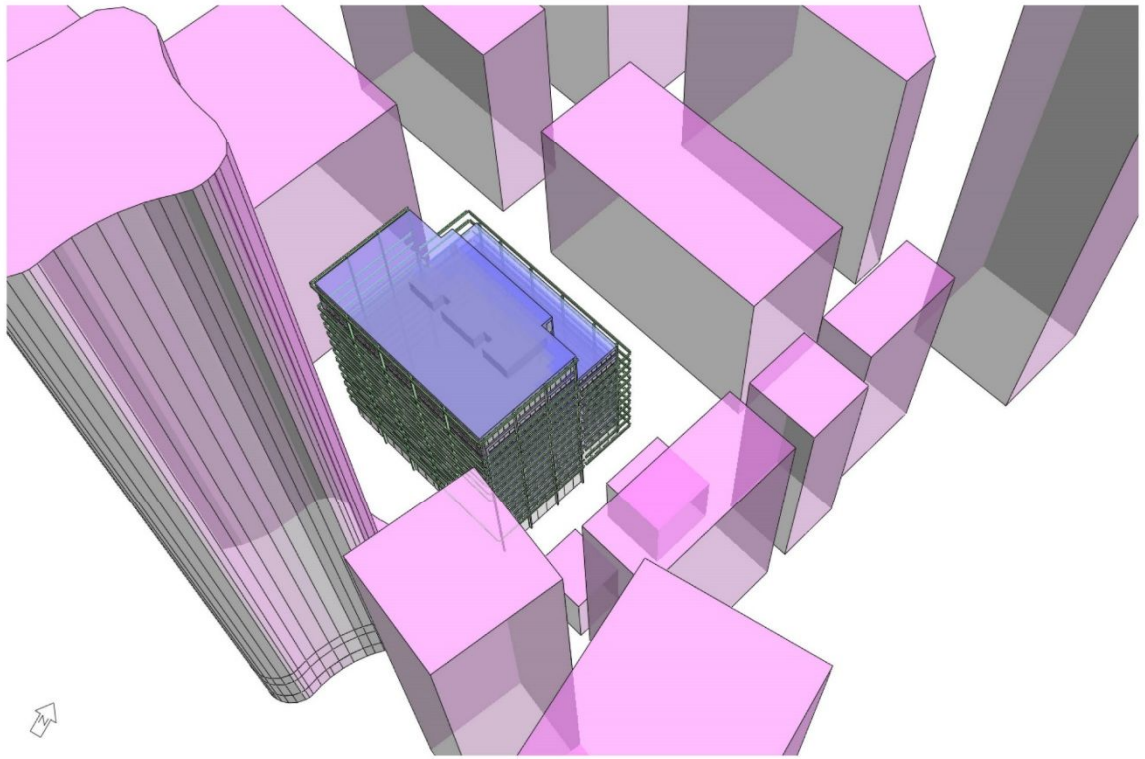
Metrics

Thermal comfort
Cooling loads.
Solar gains.

Outcome

90% energy saving through simple introduction of opening windows.
Hybrid operation gives control to occupants.
Reduced peak capacity (size and CapEx) of plant equipment.
Significant reductions in carbon emissions.

15119
0.0 Aims and Model Inputs



Present Weather File - cntr_Islington_DSY.epw

2030 Weather File - 2030_Islington_a1b_50_percentile_DSY.epw

Building Fabric

External Walls - 0.26 W/m²K

Roof - 0.18 W/m²K

Internal Ceiling/Floor - 1.5 W/m²K (Exposed Concrete Soffit)

Windows - 1.6 W/m²K

Internal Gains

People - 8 m²/ Person

Lighting - 6 W/m²

Equipment - 25 W/m²

Ventilation Rate - 1.6 litres per second per m²

Indoor Environmental Quality - CO_2 Levels < 1000ppm

Atmospheric CO_2 Levels - 400ppm

Summer Design Temperature - 22-26°C

Winter Heating Set Point - 22°C

Aims

1. To test the current office design specification of a sealed envelope with no opening windows

2. To investigate low energy passive or hybrid means of achieving the required design specifications

3. To test the impacts of low energy passive or hybrid means of achieving design specifications in future climate scenarios

15119

0.1 Tests Conducted and Testing Parameters

1. Site Shading

1.1 Solar Gains - Overshadowing of Context

2. Current Office Specification - No Opening Windows with Cooling

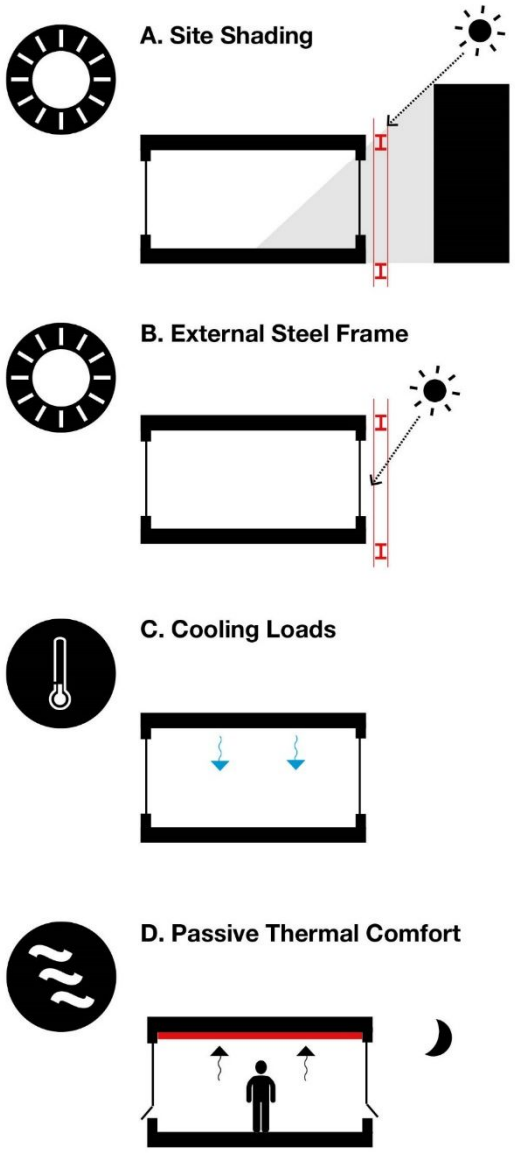
2.1 Cooling Load - Current Office with Context
2.2 Cooling Load - 2030 Current Office with Context
2.3 Cooling Load - Current Office with No Context
2.4 Cooling Load - Current Office with No Context and No Frame

3. Hybrid - Opening Windows, Night Cooling with Cooling

3.1 Cooling Load and CO_2 Levels - Hybrid with Context
3.2 Cooling Load and CO_2 Levels - 2030 Hybrid with Context
3.3 Cooling Load and CO_2 Levels - Hybrid with No Context

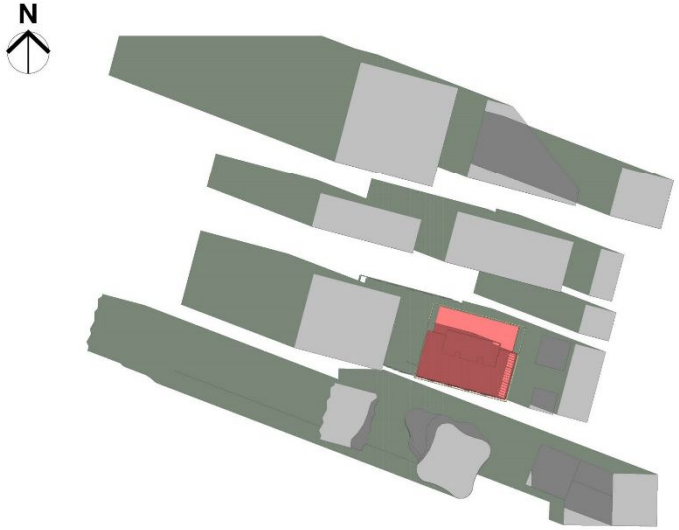
4. Free-running - Opening Windows, Night Cooling with No Cooling

4.1 Thermal Comfort - Free-running with Context
4.2 Thermal Comfort - 2030 Free-running with Context
4.3 Thermal Comfort - Free-running with No Context

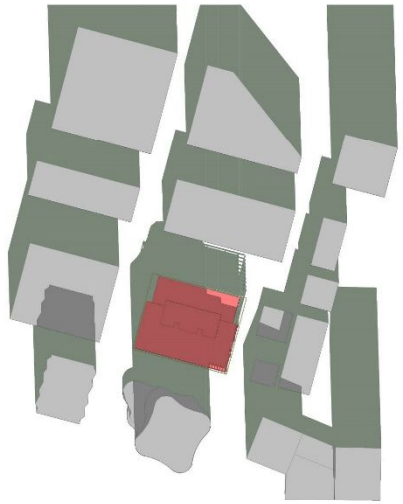


15119

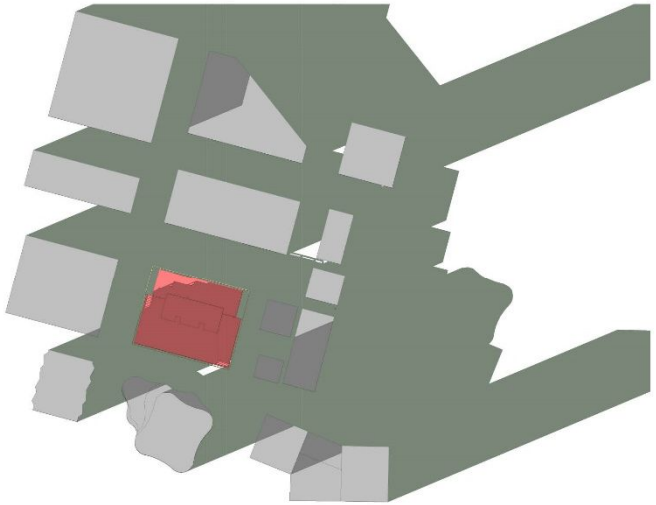
1.0 Site Shading and Solar Gains with Context



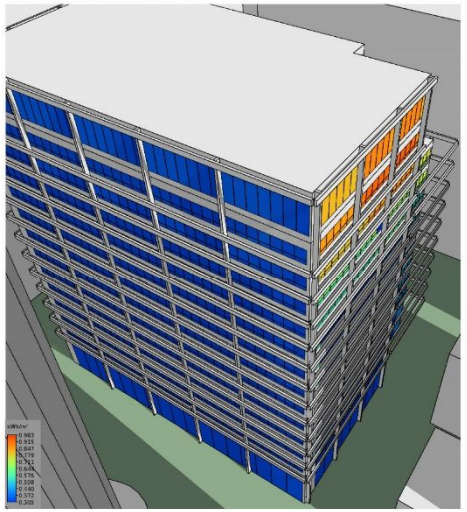
Site Shading 21st Jun 9am



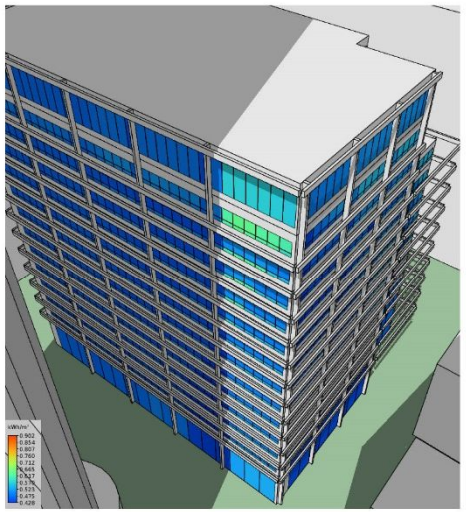
Site Shading 21st Jun 12pm



Site Shading 21st Jun 3pm



Solar Gains on South Facade 21st June 9am



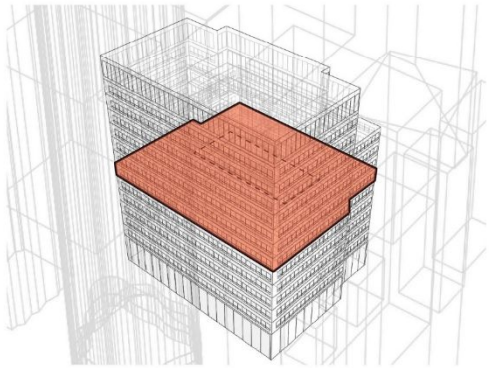
Solar Gains on South Facade 21st June 12pm

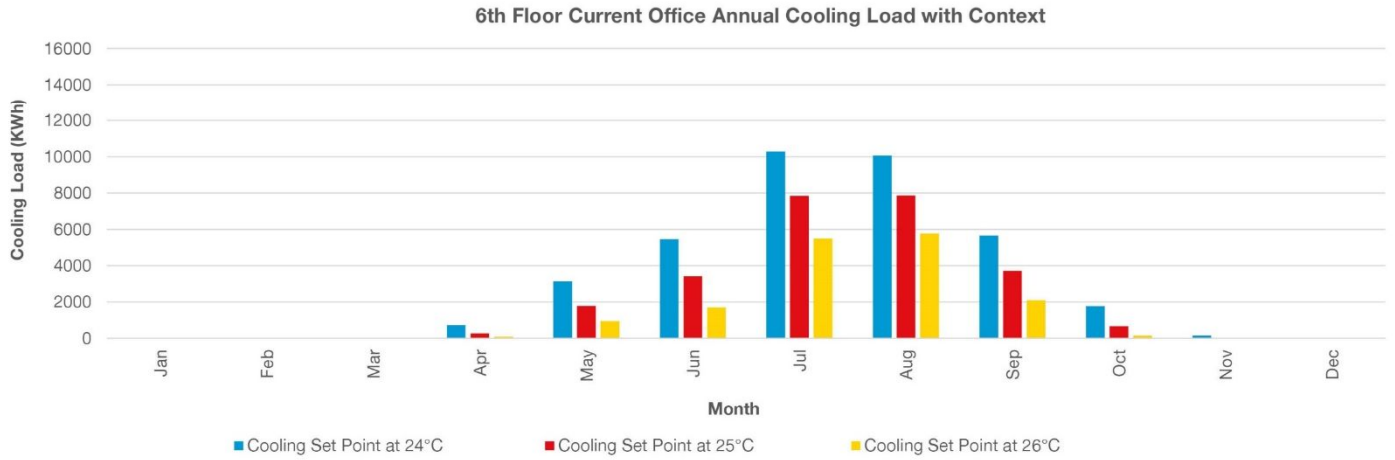
15119

2.0 6th Floor Cooling Load - Comparison of Current Office and Hybrid with Context

Heating Set Point - 22°C

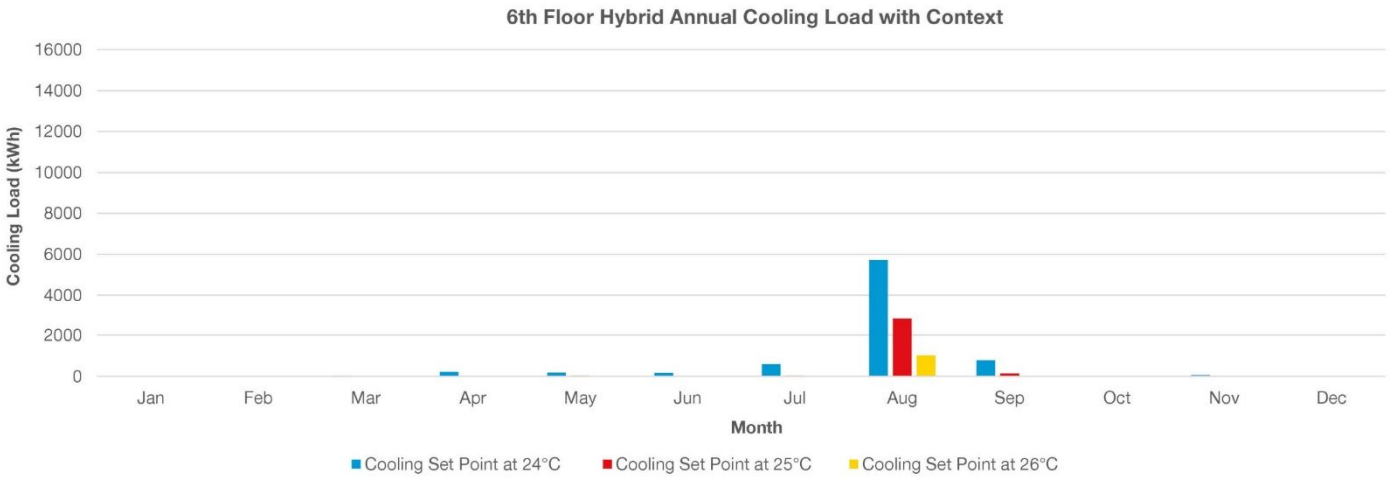
Cooling Set Point - 24,25,26°C





Comparison

	Annual Cooling Load (KWh) Setpoint at 26°C	Annual Cooling Load (KWh/m²)	% Difference
Current Office	16254.20	7.63	-
Hybrid	1013.40	0.48	**- 94%**

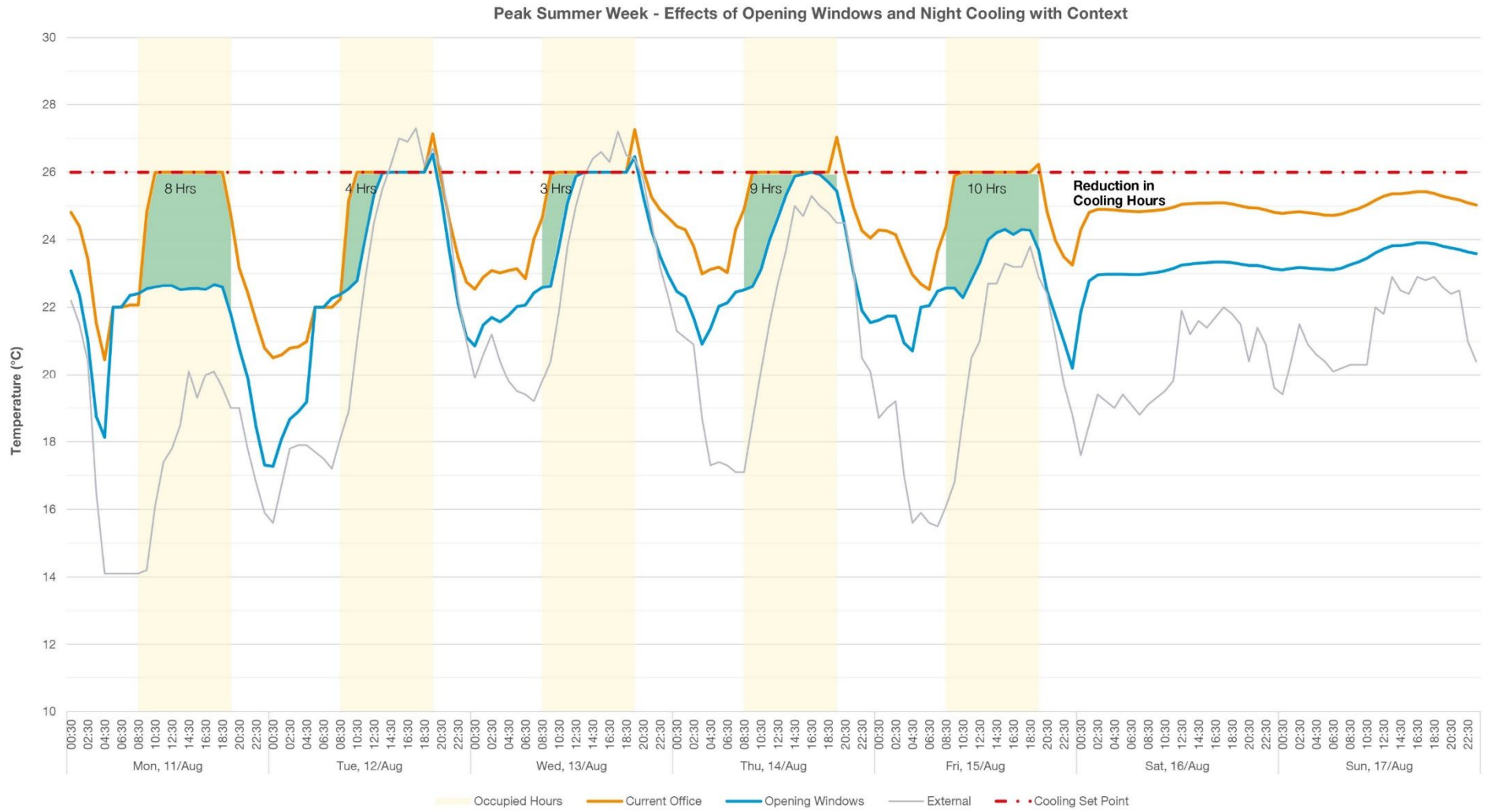


15119

2.1 6th Floor Peak Summer Week - Effects of Opening Windows and Night Cooling with Context

Heating Set Point - 22°C

Cooling Set Point - 26°C

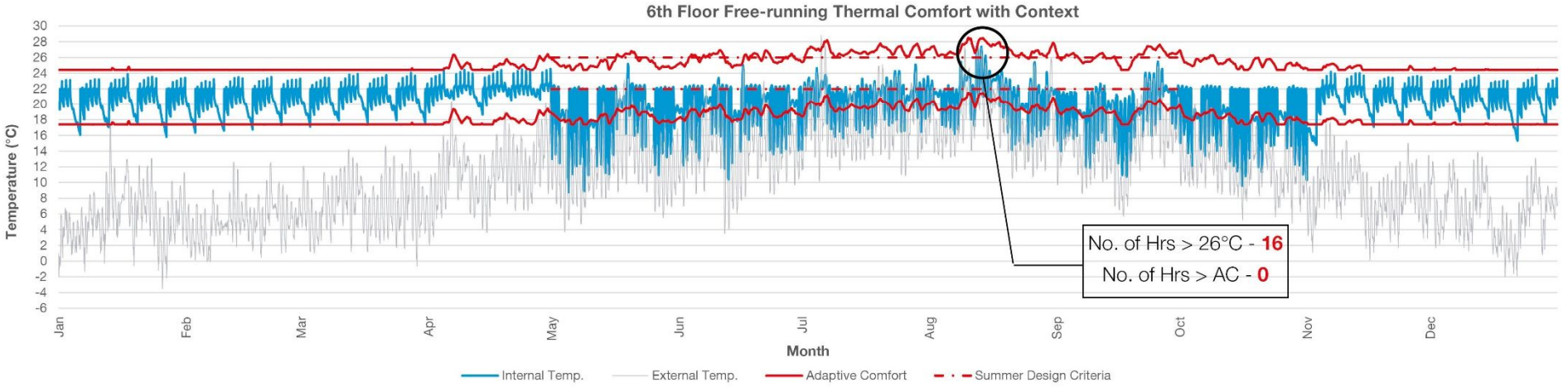


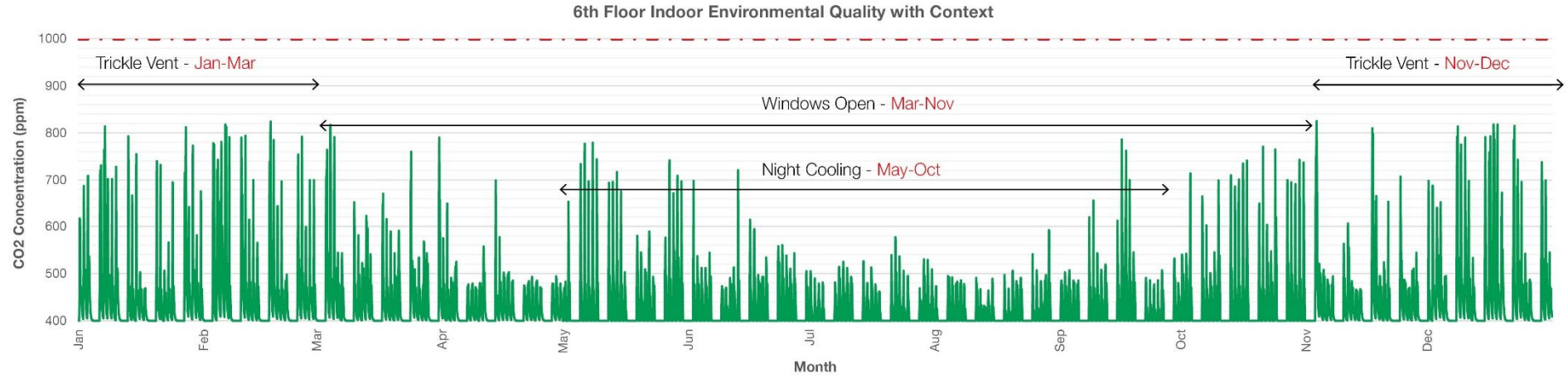
15119

2.2 6th Floor Thermal Comfort and Indoor Environmental Quality- Free-running with Context

Heating Set Point - 22°C

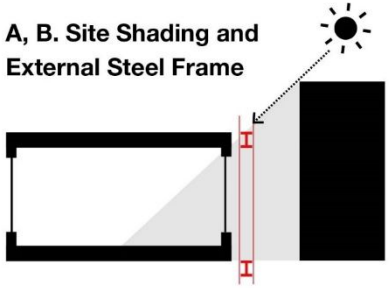
Cooling - Off





15119
Summary

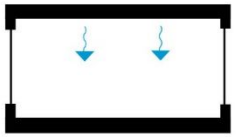
A, B. Site Shading and External Steel Frame



Solar Gains

- Site well shaded by surrounding buildings
- Increase in solar gains to the East at higher levels
- External steel frame shading provides a 10% decrease in cooling loads

C. Cooling Loads



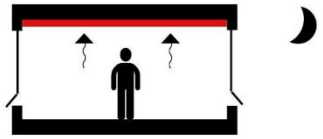
Energy Consumption

- 94% decrease in cooling load using hybrid solution compared to current office specification
- Utilising the opening windows with night cooling decreases number of cooling hours during occupancy

Comparison with the Better Buildings Partnership (BBP) 2015 Real Estate Environmental Benchmarks for Air Conditioned Buildings -

	Total Annual Electricity Load (KWh/m²/yr)
BBP Good Practice	179.00
Current Office with Context	96.91
Hybrid with Context	89.76

D. Passive Thermal Comfort



Climate Change and Adaption

- Application of 2030 weather data shows that although less effective, there is still a 51% decrease in cooling load from opening windows

Employee Well-Being

- Opening windows provide a comfortable indoor environmental air quality with CO_2 concentration below 1000ppm
- Allowing occupants to control their indoor environment results in higher tolerances to temperatures

Project

Residential masterplan in south London

Challenge

Demonstrate the comfort and energy benefits of an architectural aesthetic.

Analysis

Comparison of concrete soffit and lined ceilings as part of a operational strategy.

Metrics

Thermal comfort
Cooling loads.
Solar gains.

Outcome

Architectural approach verified with reductions in plant, applied finishes and improvements in comfort
However, market force change to spec that limits free cooling.
Sales up but resource use also up, energy consumption also up, but control and comfort down!

15112
1.0 Inputs and Solar Gains

Weather File - 2030_Islington_a1b_10_percentile_DSY.epw

Mode of Operation

Free-running, No heating or cooling

Window Profile

Open if ta > 22°C & to < 25°C
Where ta = internal temp. and to = external temp.

Building Fabric

Walls - 0.18 W/m²k

Roof - 0.18 W/m²k

Windows - 1.6 W/m²k

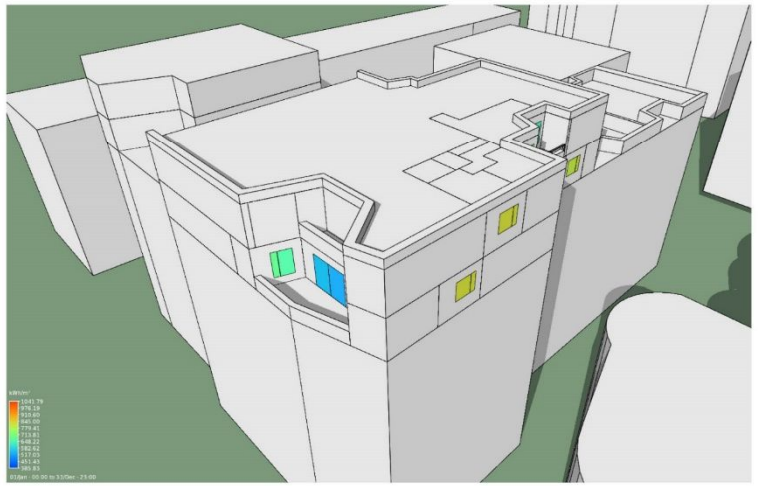
Occupancy

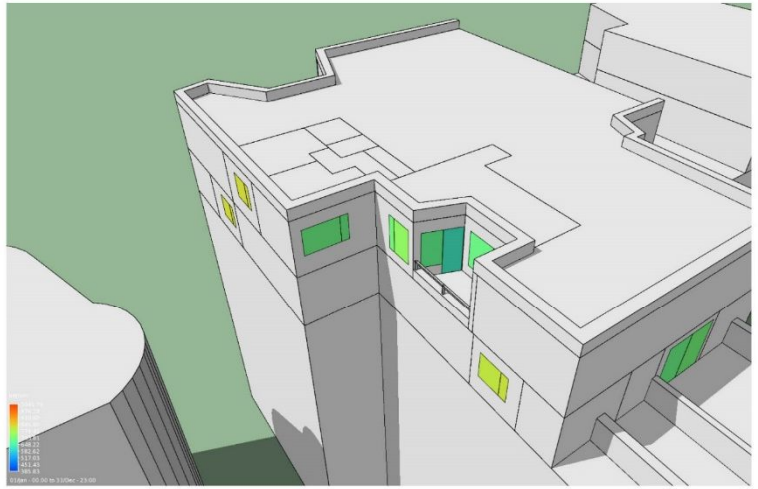
Adapted NCM dwelling occupancy profiles, up to 4 people per 2 bed flat

Solar Gain

Solar gains primarily on the **south facing bedrooms**.

The kitchen/living rooms are mostly **self shaded** which reduces solar gains into the high occupancy rooms.





15112
1.1 Overheating - Plasterboard Ceiling

Ceiling - Plasterboard
Windows - 1.6 W/m²k , G-Value - 0.38

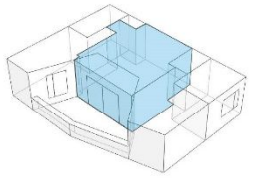
CIBSE Guide A Limit of Overheating

Living Rooms - > 1% hours > 28°C

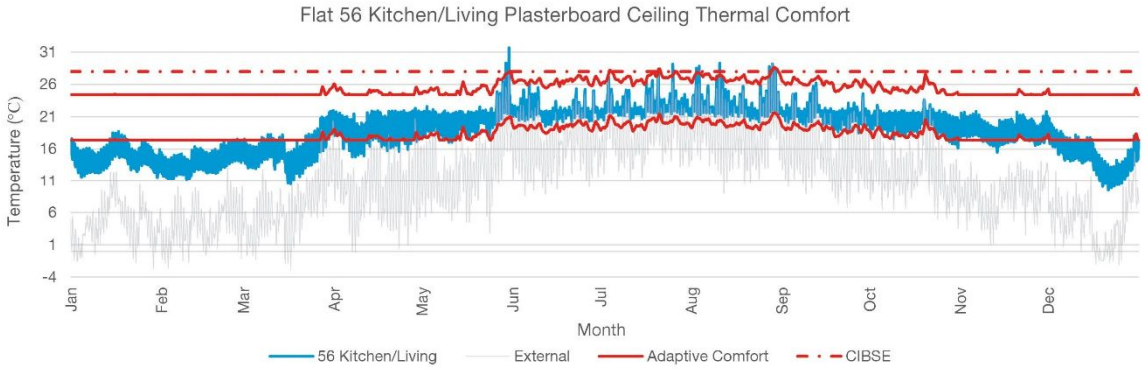
Bedrooms - > 1% hours > 26°C

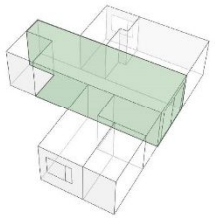
Using a U-value of **1.6 W/m²K** and a **G-value of 0.38**, the internal temperatures of the kitchen/livng rooms of the selected flats **comply** with the **CIBSE guidelines**. However, peak temperature in **Flat 56** is **31.6°C**

This is the same for the bedrooms which also **comply and minimal overheating,** with the majority **not exceeding the 26°C limit** at all.

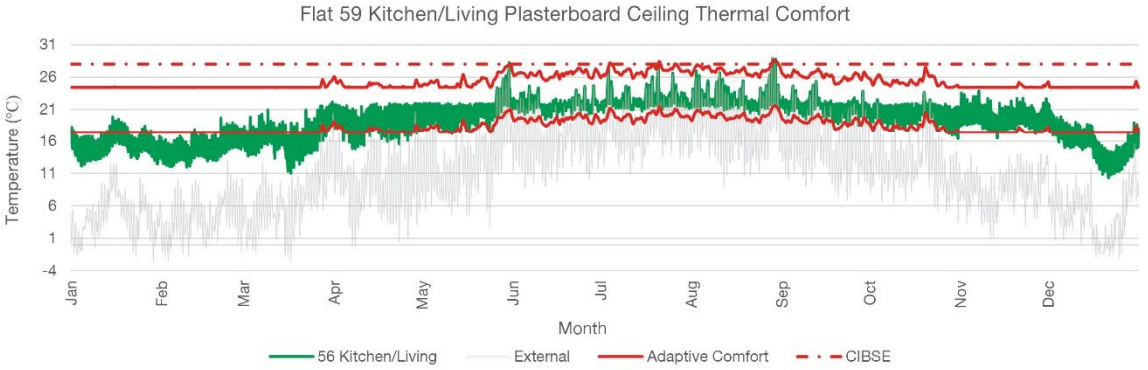


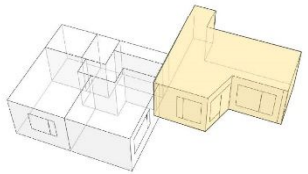
Flat 56 K/L
No. of Hrs > 28°C - 25 (0.7%)



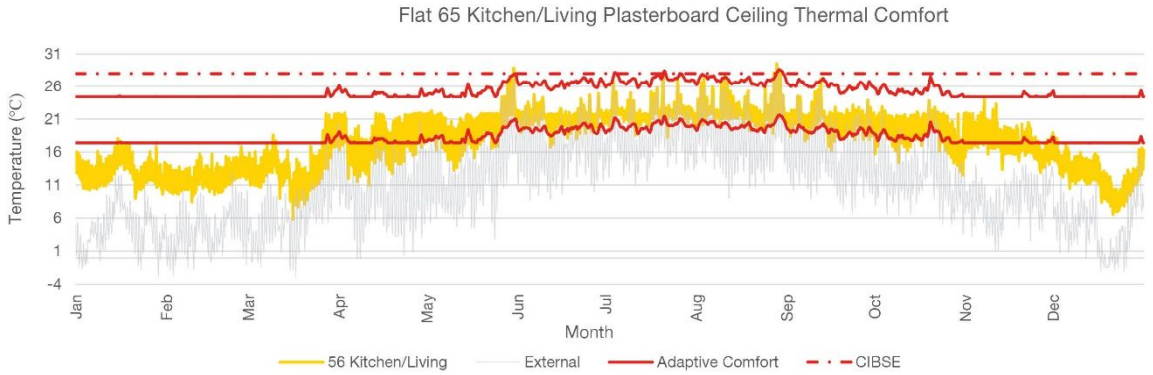


Flat 59 K/L
No. of Hrs > 28°C - 7 (0.2%)





Flat 65 K/L
No. of Hrs > 28°C - 11 (0.3%)



15112
1.1 Overheating - Concrete Soffit

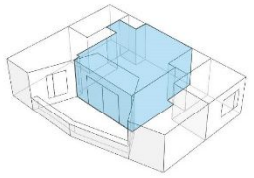
Ceiling - Concrete Soffit
Windows - 1.6 W/m²k , G-Value - 0.38

CIBSE Guide A Limit of Overheating

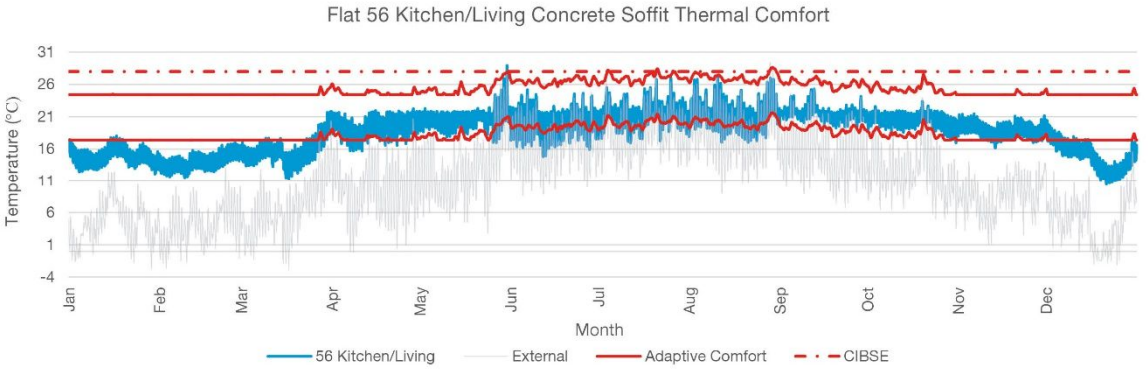
Living Rooms - > 1% hours > 28°C

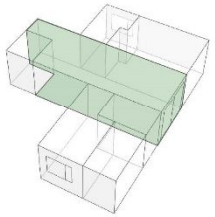
By using a **concrete soffit** and introducing night cooling instead of a plasterboard ceiling and **G-value of 0.38**, the internal temperatures of the kitchen/living rooms of the selected flats **comply** with the **CIBSE guidelines**.

Flats 59 and **65** both do not exceed the **28°C limit.** The **peak temperture** in **Flat 56** is **29°C, 3°C lower** than with a **plasterboard ceiling.**

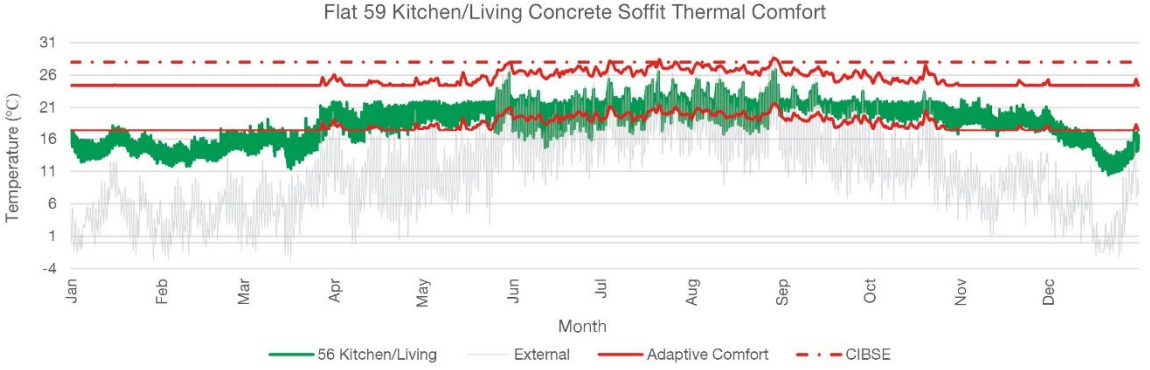


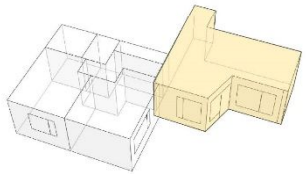
Flat 56 K/L
No. of Hrs > 28°C - 1 (0.02%)



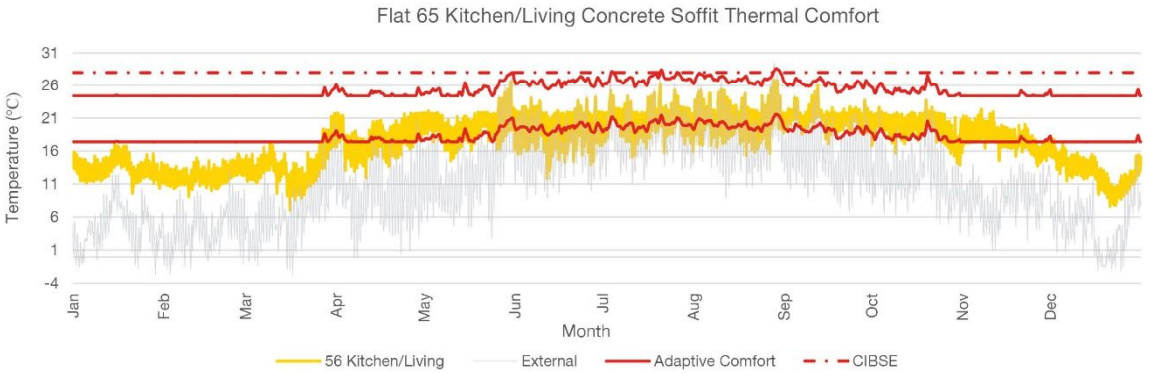


Flat 59 K/L
No. of Hrs > 28°C - 0 (0%)





Flat 65 K/L
No. of Hrs > 28°C - 0 (0%)



15112
1.2 Overheating Plasterboard Ceiling

Ceiling - Plasterboard
Windows - 1.6 W/m²k , G-Value - 0.45

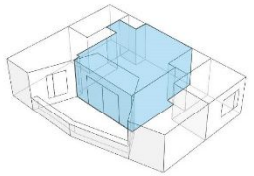
CIBSE Guide A Limit of Overheating

Living Rooms - > 1% hours > 28°C

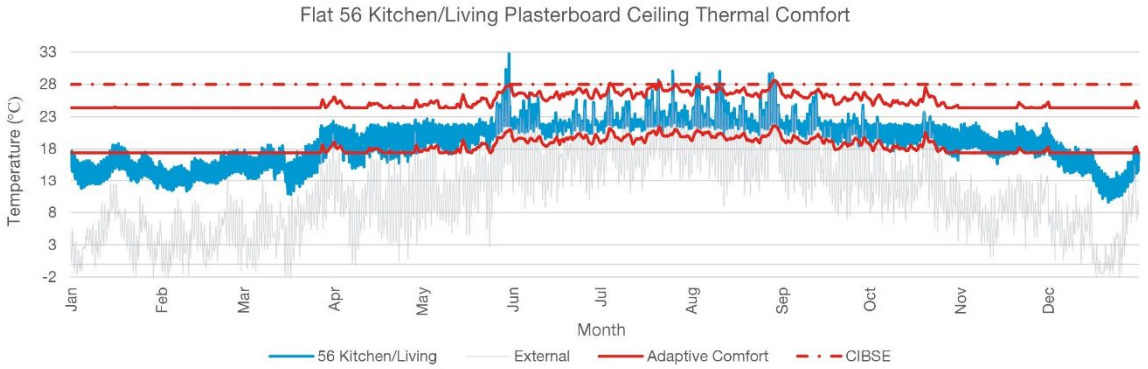
Bedrooms - > 1% hours > 26°C

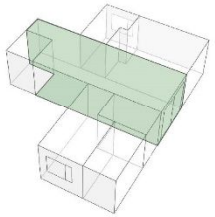
Using a U-value of **1.6 W/m²K** and a **G-value of 0.45**, the internal temperatures of the kitchen/living rooms of the selected flats **comply** with the **CIBSE guidelines**. However, the peak temperature in Flat 56 is **32.7°C** and may cause discomfort.

The bedrooms have limited **overheating**, with the worst performing south facing rooms only exceeding **26°C for 0.3%** of occupied hours.

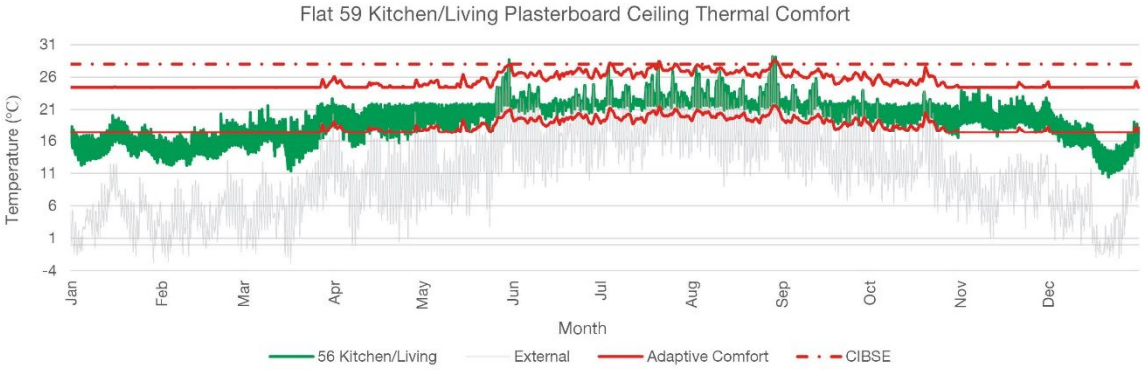


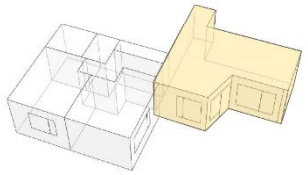
Flat 56 K/L
No. of Hrs > 28°C - 28 (0.8%)



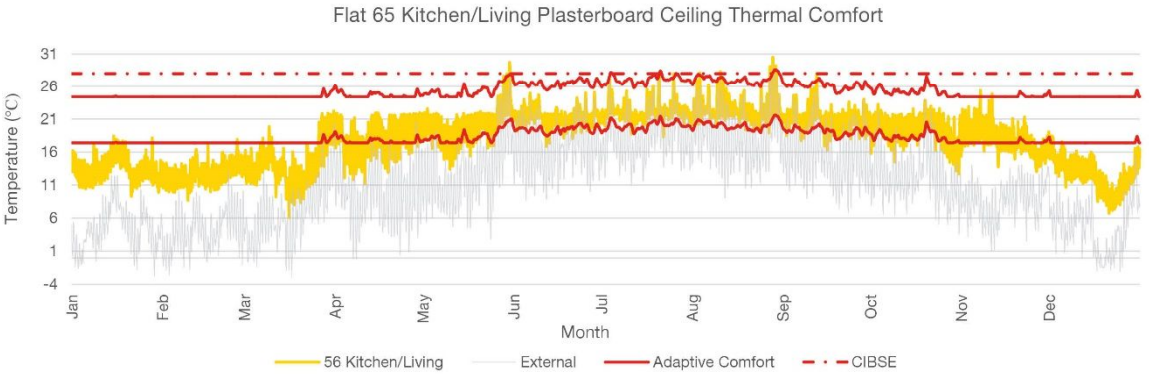


Flat 59 K/L
No. of Hrs > 28°C - 8 (0.2%)





Flat 65 K/L
No. of Hrs > 28°C - 19 (0.5%)



15112
1.2 Overheating - Concrete Soffit

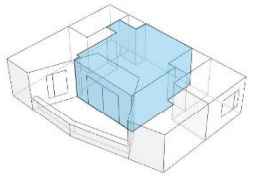
Ceiling - Concrete Soffit
Windows - 1.6 W/m²k , G-Value - 0.45

CIBSE Guide A Limit of Overheating

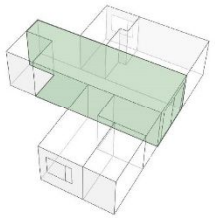
Living Rooms - > 1% hours > 28°C

By using a concrete soffit instead of a plasterboard ceiling and **G-value of 0.45**, the internal temperatures of the kitchen/living rooms of the selected flats **comply** with the **CIBSE guidelines**.

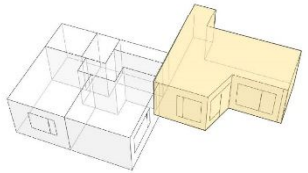
As with the 0.38 G-Value, **Flats 59** and **65** both do not exceed the **28°C limit.** The **peak temperture** in **Flat 56** is **29.5°C, 3°C lower** than with a **plasterboard ceiling.**



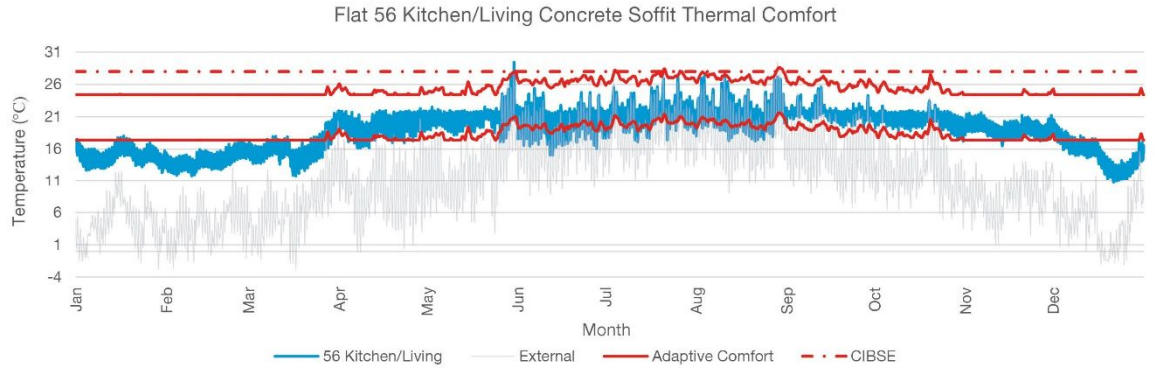
Flat 56 K/L
No. of Hrs > 28°C - 3 (0.1%)

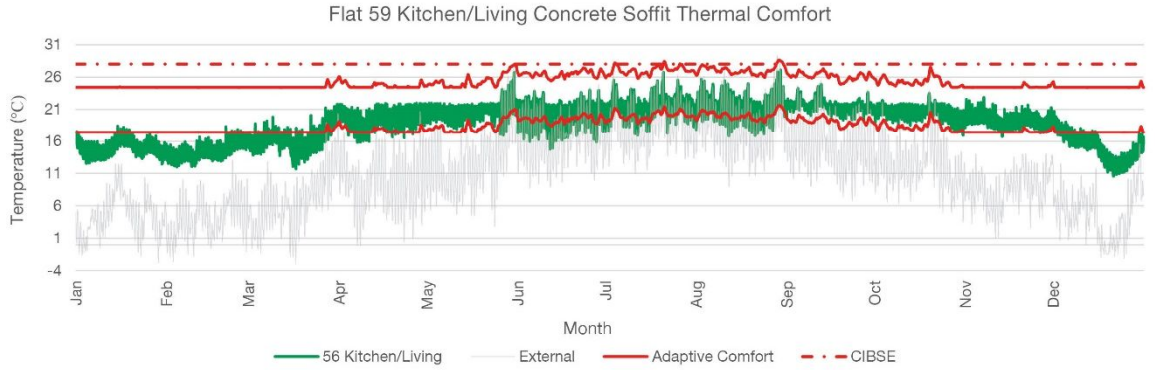


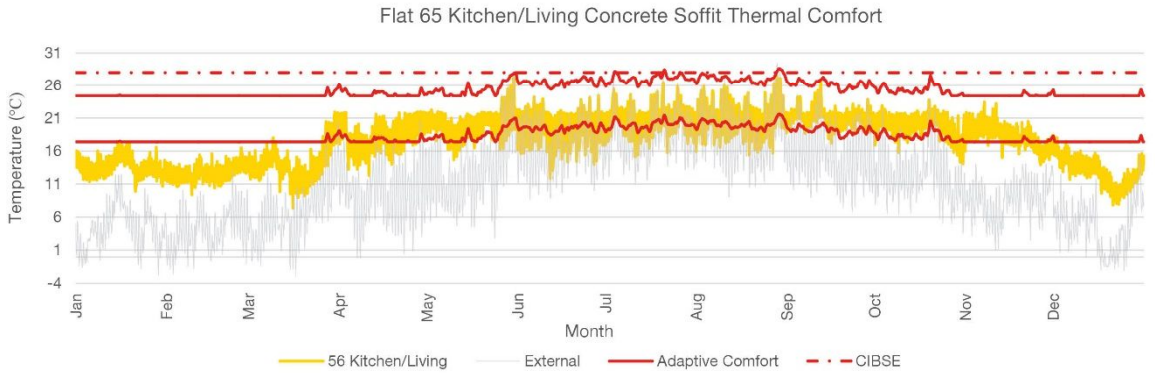
Flat 59 K/L
No. of Hrs > 28°C - 0 (0%)



Flat 65 K/L
No. of Hrs > 28°C - 0 (0%)







15112
1.3 Daylighting

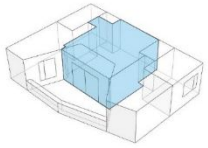
BS 8206-2 : 2008 Recommends

Living Rooms - > 1.5% ADF

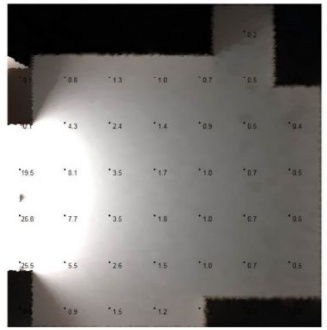
Bedrooms - > 1% ADF

Living rooms require a minimum of **1.5% average daylight factor**. In all the kitchen/living rooms of the selected flats, this is exceeded when the glazing has a **visible light transmittance** of **0.7.** Even when this is reduced to **0.6**, the rooms still **all comply** with the recommendations.

This is the same for the bedrooms, they all **comply with the 1% ADF for both light transmittances.**

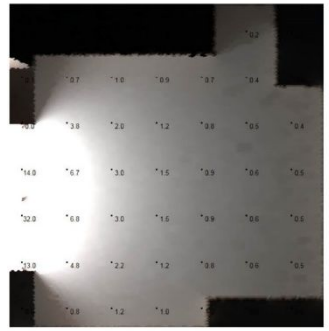


Windows - Visible Light Transmittance 0.7

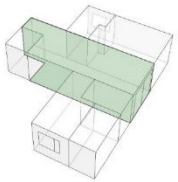


Flat 56 K/L
ADF = **1.9%**

Windows - Visible Light Transmittance 0.6

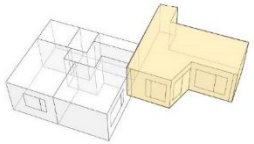


Flat 56 K/L
ADF = **1.7%**



Flat 59 K/L
ADF = **2.0%**

Flat 59 K/L
ADF = **1.8%**



Flat 65 K/L
ADF = **2.6%**

Flat 65 K/L
ADF = **2.2%**