# BDP.

ARCHITECTURE ▪ DESIGN ▪ ENGINEERING ▪ URBANISM ▪ SUSTAINABILITY ▪ LIGHTING ▪ ACOUSTICS

BDP.

# Making Spaces Better for People: Thermal Comfort, Lighting and Air Quality

Jon Hall, Sustainability Consultant

28th November 2019

# Agenda

1. Introductions
2. Context
3. Thermal Comfort
4. Lighting
5. Air Quality
6. Summary

# Who Am I?

- Sustainability Consultant with over 6 years' experience
- UWE Bristol
  - BSc (Hons) Geography (1st Class)
- University of Bristol
  - MSc Environmental Policy

# Who are BDP?

- Multi(inter)-disciplinary urban design practice
  - *Architecture*
  - *Design*
  - *Engineering*
  - *Masterplanning/Urban Design*
  - *Landscape Architecture*
  - *Town Planning*
  - *Sustainability*
  - *Lighting*
  - *Acoustics*

# Who are BDP?

- Founded in 1961
- Partnership work style
- Over 800 people across the UK in six design studios
- Collaborative design epitomises BDP's ethos

# Sustainability @ BDP

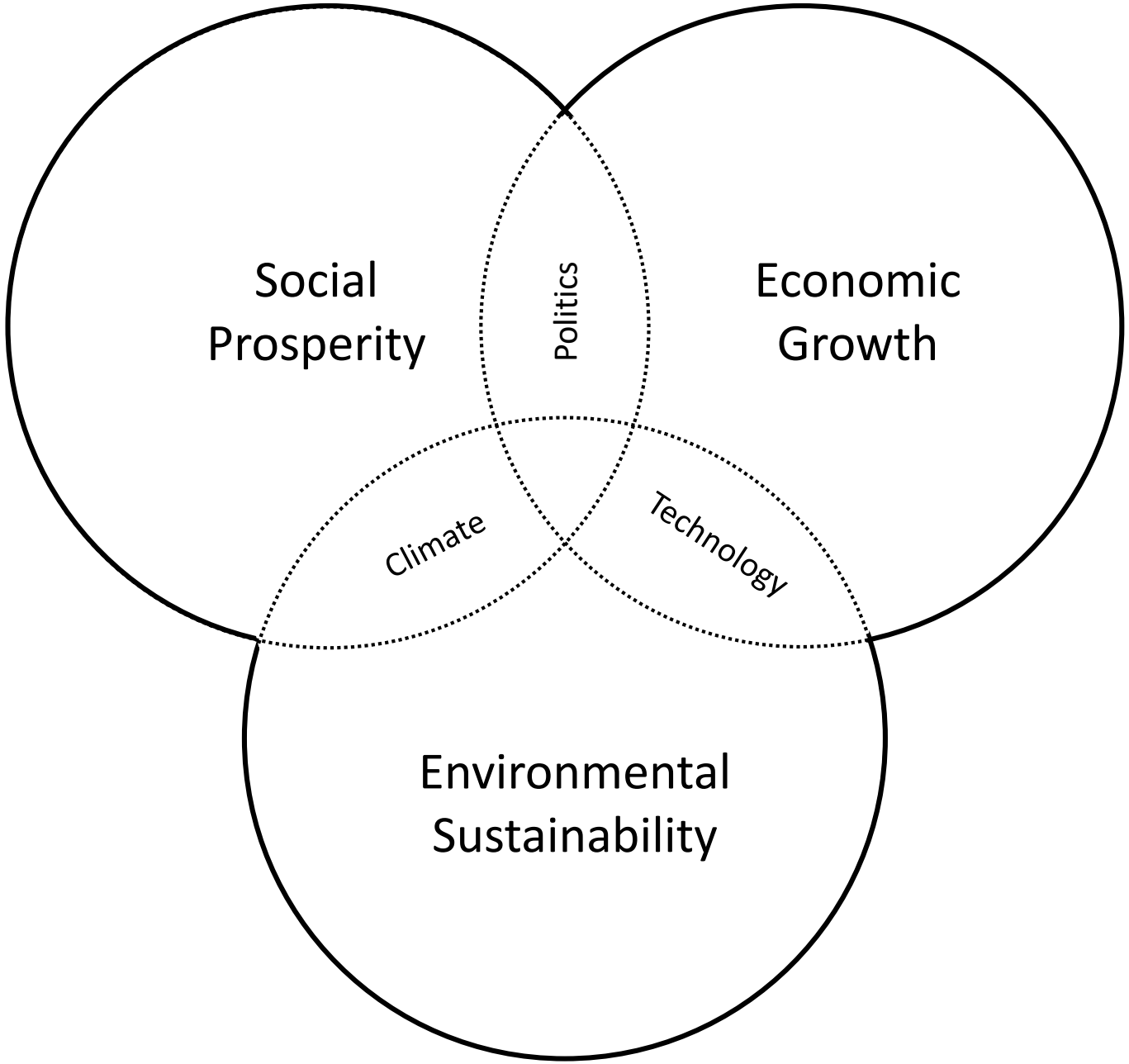
- Environmental Assessments
- Master Planning
- Environmental Management
- Energy Strategies
- EIA Chapters
- Surveys
- Research and Development
- Soft Landings Framework
- Post Occupancy Evaluation

# Sustainability @ BDP

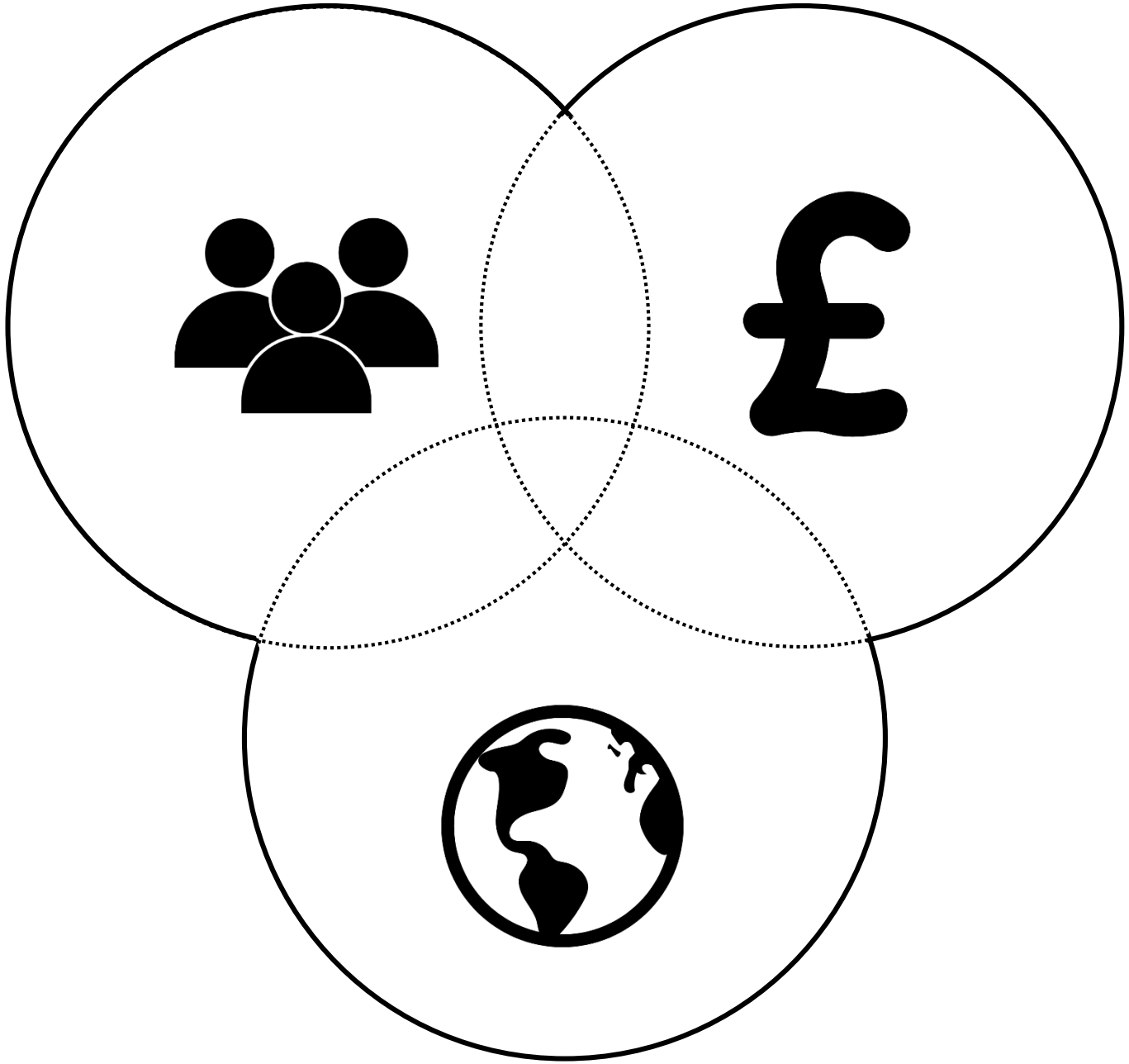
- Life cycle assessment
- Circular economy research and implementation
- Healthy material research
- Health and wellbeing research

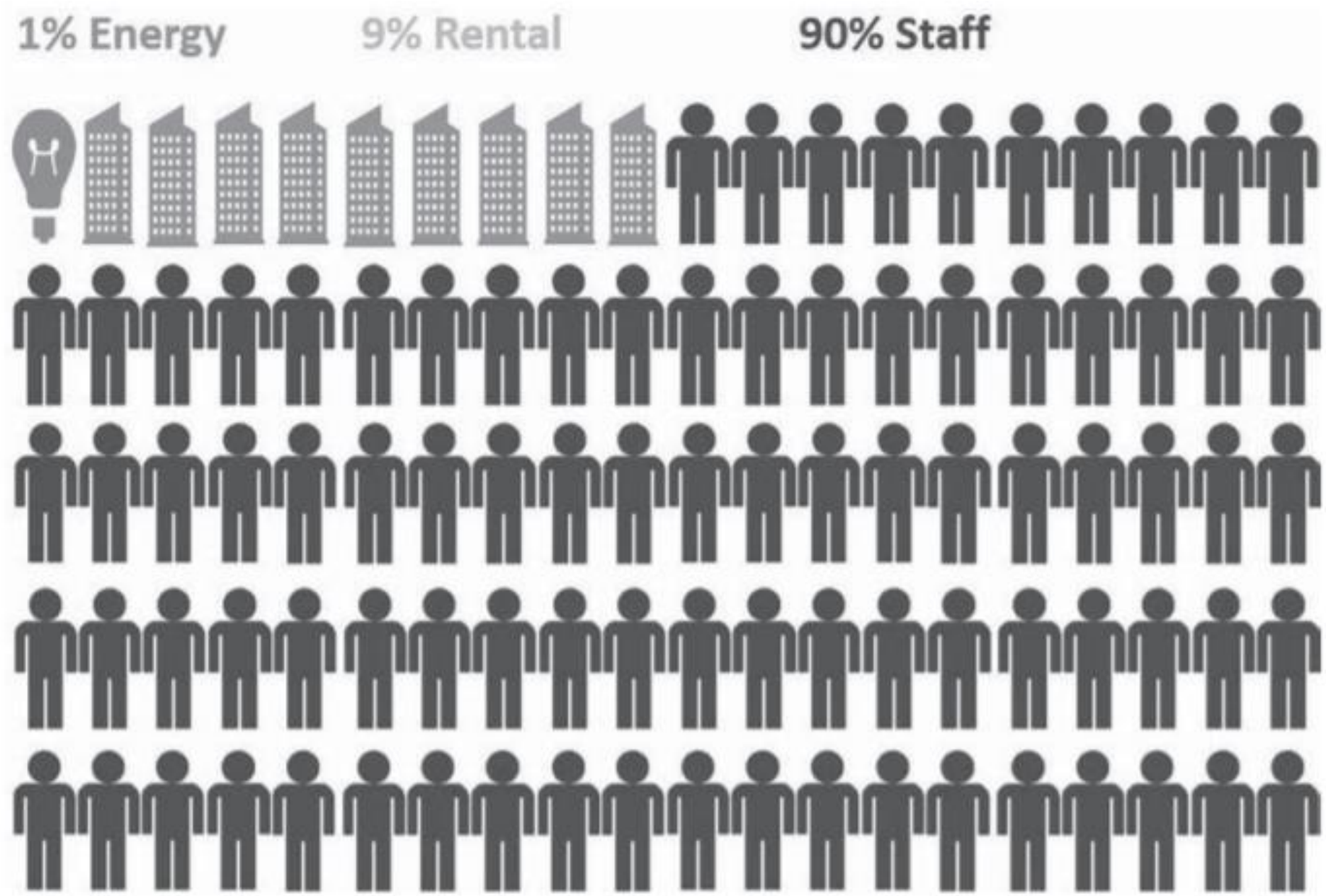
BDP.

# Context


Social
Prosperity
Politics
Economic
Growth
Climate
Technology
Environmental
Sustainability

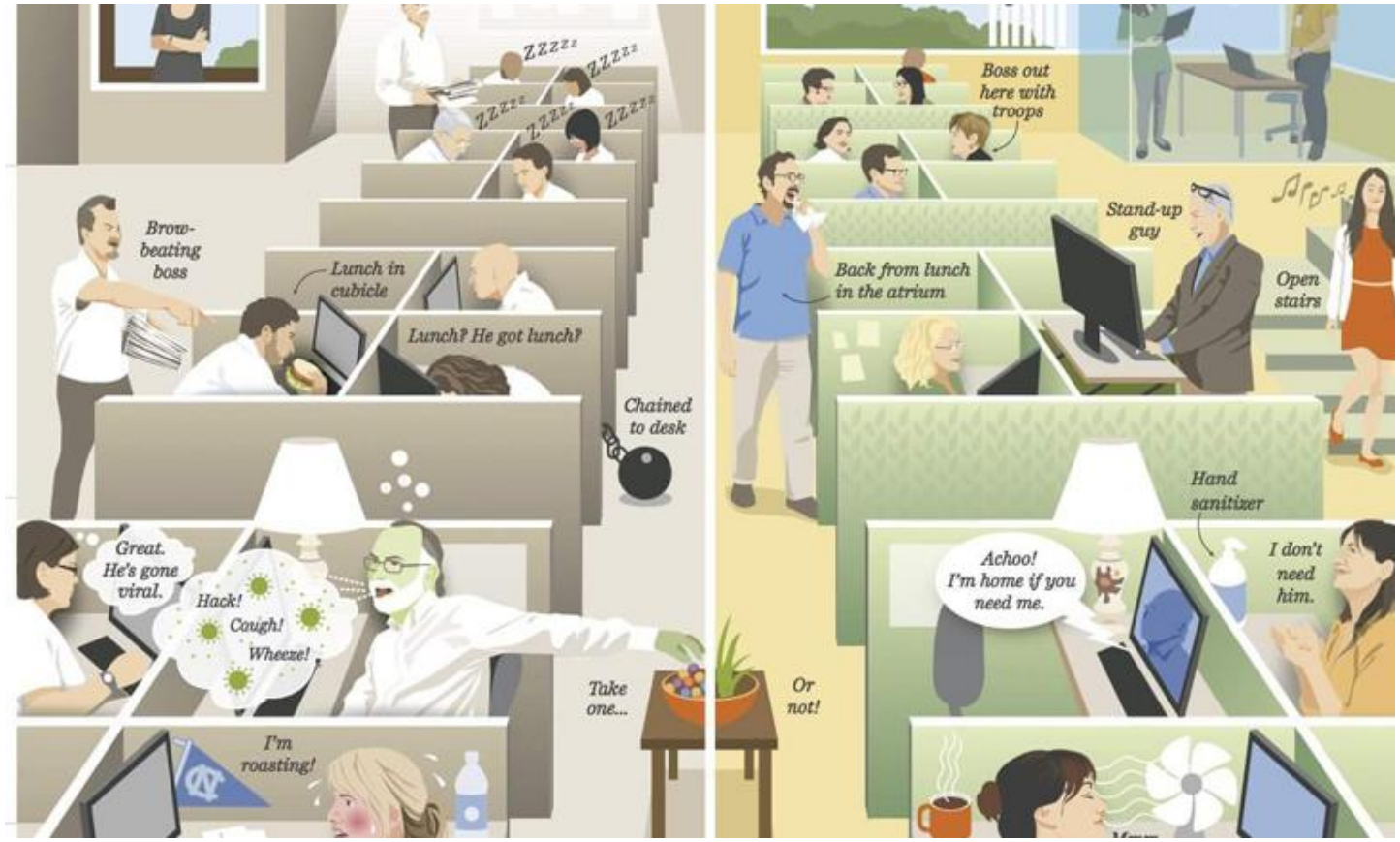
BDP.






Creating the Productive Workplace (Clements-Croome, 2006)

BDP.


ZZZZz
ZZZZz
ZZZZz
ZZZZz
ZZZZz
Brow-beating boss
Lunch in cubicle
Lunch? He got lunch?
Chained to desk
Great. He's gone viral.
Hack!
Cough!
Wheeze!
Take one...
I'm roasting!
Boss out here with troops
Stand-up guy
Back from lunch in the atrium
Open stairs
Hand sanitizer
Achoo! I'm home if you need me.
I don't need him.
Or not!

# 90%

BDP.


AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR
LIGHT LIGHT LIGHT LIGHT LIGHT LIGHT
NOURISHMENT NOURISHMENT
FITNESS FITNESS
MIND MIND
MIND
INTERNATIONAL
WELL
BUILDING
INSTITUTE
COMFORT
FITNESS FITNESS
NOURISHMENT NOURISHMENT
WATER WATER WATER WATER
AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR AIR

BDP.

## AIR

14 FEATURES
4 preconditions
10 optimizations

## WATER

8 FEATURES
3 preconditions
5 optimizations

## NOURISHMENT

13 FEATURES
2 preconditions
11 optimizations

## LIGHT

8 FEATURES
2 preconditions
6 optimizations

## MOVEMENT

12 FEATURES
2 preconditions
10 optimizations

## THERMAL COMFORT

7 FEATURES
1 precondition
6 optimizations

## SOUND

5 FEATURES
1 precondition
4 optimizations

## MATERIALS

14 FEATURES
3 preconditions
11 optimizations

## MIND

15 FEATURES
2 preconditions
13 optimizations

## COMMUNITY

16 FEATURES
3 preconditions
13 optimizations

BDP.

## AIR

14 FEATURES
4 preconditions
10 optimizations

## WATER

8 FEATURES
3 preconditions
5 optimizations

## NOURISHMENT

13 FEATURES
2 preconditions
11 optimizations

## LIGHT

8 FEATURES
2 preconditions
6 optimizations

## MOVEMENT

12 FEATURES
2 preconditions
10 optimizations

## THERMAL COMFORT

7 FEATURES
1 precondition
6 optimizations

## SOUND

5 FEATURES
1 precondition
4 optimizations

## MATERIALS

14 FEATURES
3 preconditions
11 optimizations

## MIND

15 FEATURES
2 preconditions
13 optimizations

## COMMUNITY

16 FEATURES
3 preconditions
13 optimizations

BDP.

## AIR

14 FEATURES
4 preconditions
10 optimizations

## WATER

8 FEATURES
3 preconditions
5 optimizations

## NOURISHMENT

13 FEATURES
2 preconditions
11 optimizations

## LIGHT

8 FEATURES
2 preconditions
6 optimizations

## MOVEMENT

12 FEATURES
2 preconditions
10 optimizations

## THERMAL COMFORT

7 FEATURES
1 precondition
6 optimizations

## SOUND

5 FEATURES
1 precondition
4 optimizations

## MATERIALS

14 FEATURES
3 preconditions
11 optimizations

## MIND

15 FEATURES
2 preconditions
13 optimizations

## COMMUNITY

16 FEATURES
3 preconditions
13 optimizations

BDP.

## AIR

14 FEATURES
4 preconditions
10 optimizations

## WATER

8 FEATURES
3 preconditions
5 optimizations

## NOURISHMENT

13 FEATURES
2 preconditions
11 optimizations

## LIGHT

8 FEATURES
2 preconditions
6 optimizations

## MOVEMENT

12 FEATURES
2 preconditions
10 optimizations

## THERMAL COMFORT

7 FEATURES
1 precondition
6 optimizations

## SOUND

5 FEATURES
1 precondition
4 optimizations

## MATERIALS

14 FEATURES
3 preconditions
11 optimizations

## MIND

15 FEATURES
2 preconditions
13 optimizations

## COMMUNITY

16 FEATURES
3 preconditions
13 optimizations

# Thermal Comfort

BDP.

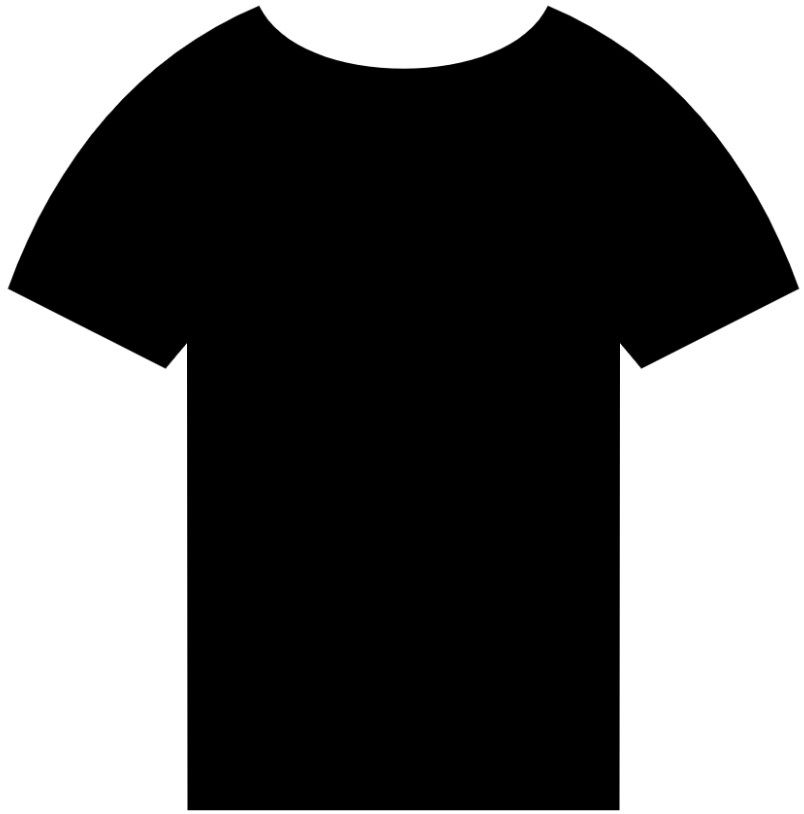
- Between **30%** and **50%** of excess winter deaths can be attributable to **cold indoor temperatures** (WHO, 2010)

- Excess heat **negatively** affects the health of people suffering from cardiovascular, Parkinson's and Alzheimer's diseases, as well as diabetes and epilepsy (Ormandy, 2012)

- Excess **cold** and **mould** in homes lead to asthma/respiratory illness and affects **negatively** the **mental health** of the occupants (BPIE, 2015)

- Children's educational **attainment** and emotional **wellbeing** can be affected by thermal discomfort (WHO, 2012)

BDP.



BDP.

## Environmental Factors

- Air temperature
- Air velocity
- Radiant temperature
- Relative humidity

## Personal Factors

- Clothing
- Metabolic heat
- Wellbeing and sickness

BDP.

ASHRAE

STANDARD

**ANSI/ASHRAE Standard 55-2017**
(Supersedes ANSI/ASHRAE Standard 55-2013)
Includes ANSI/ASHRAE addenda listed in Appendix N

# Thermal Environmental Conditions for Human Occupancy

See Appendix N for approval dates.

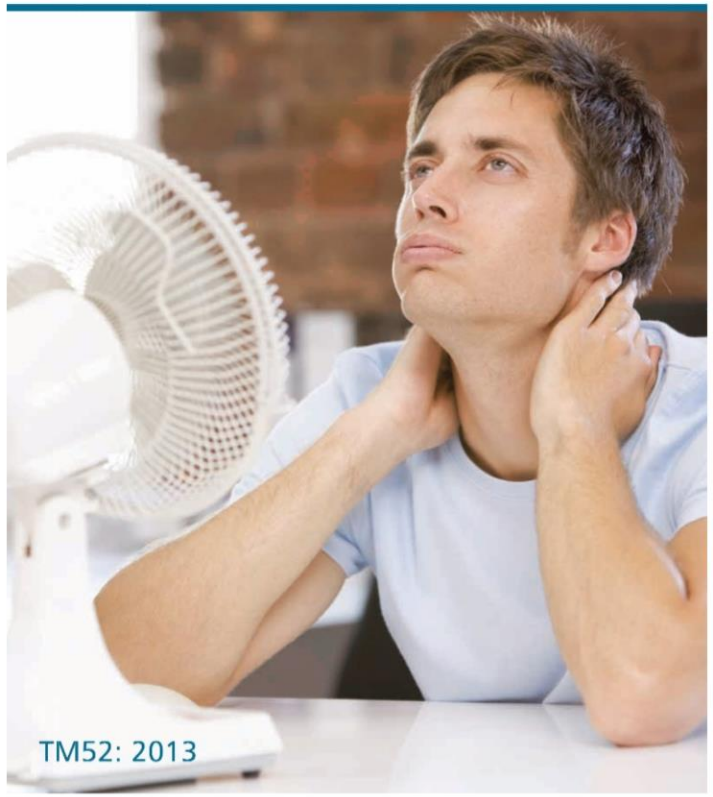
This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336

ANSI

The limits of thermal comfort: avoiding overheating in European buildings

CIBSE



TM52: 2013

BRITISH STANDARD

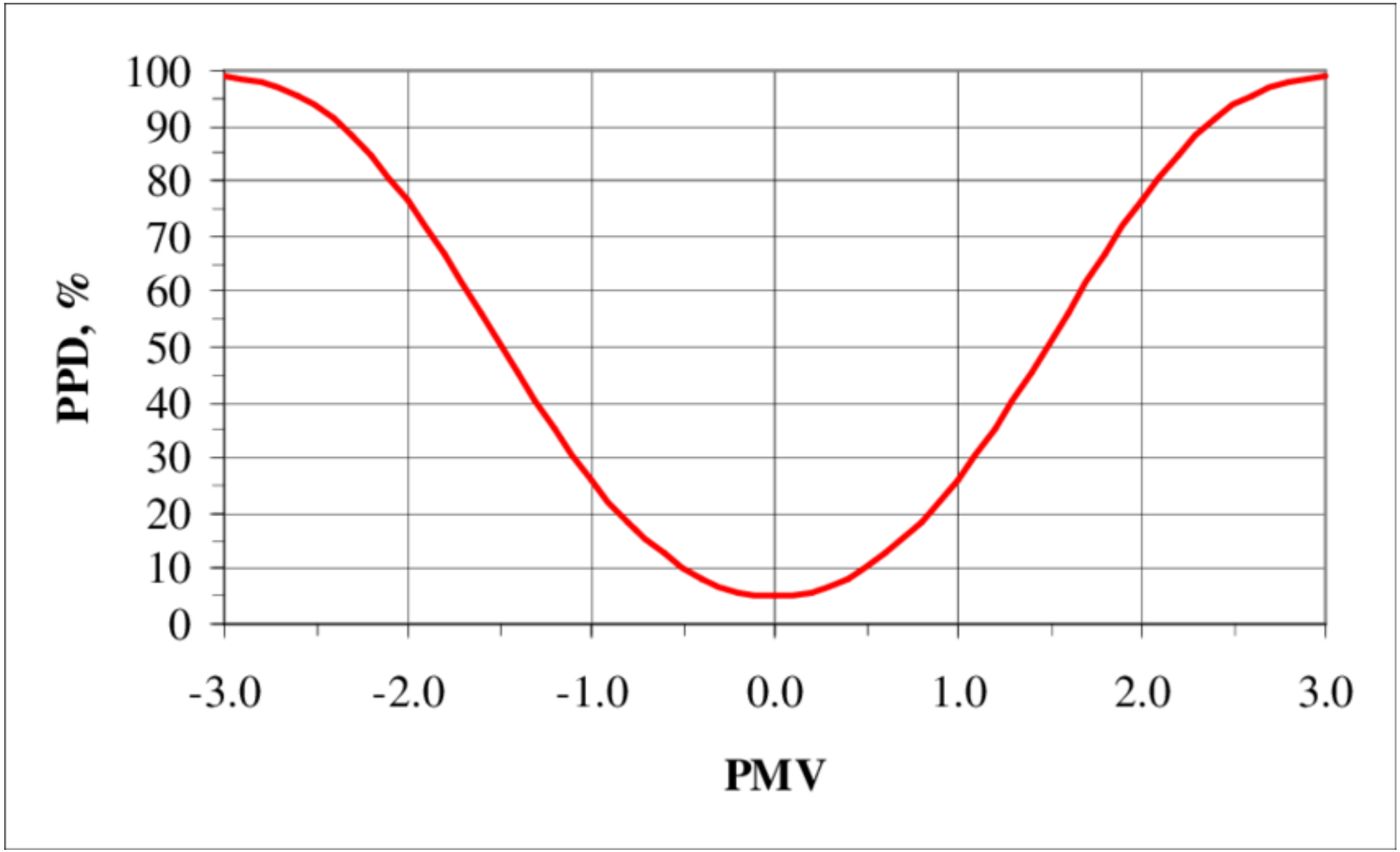
7730:2005

# Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria

The European Standard EN ISO 7730:2005 has the status of a British Standard

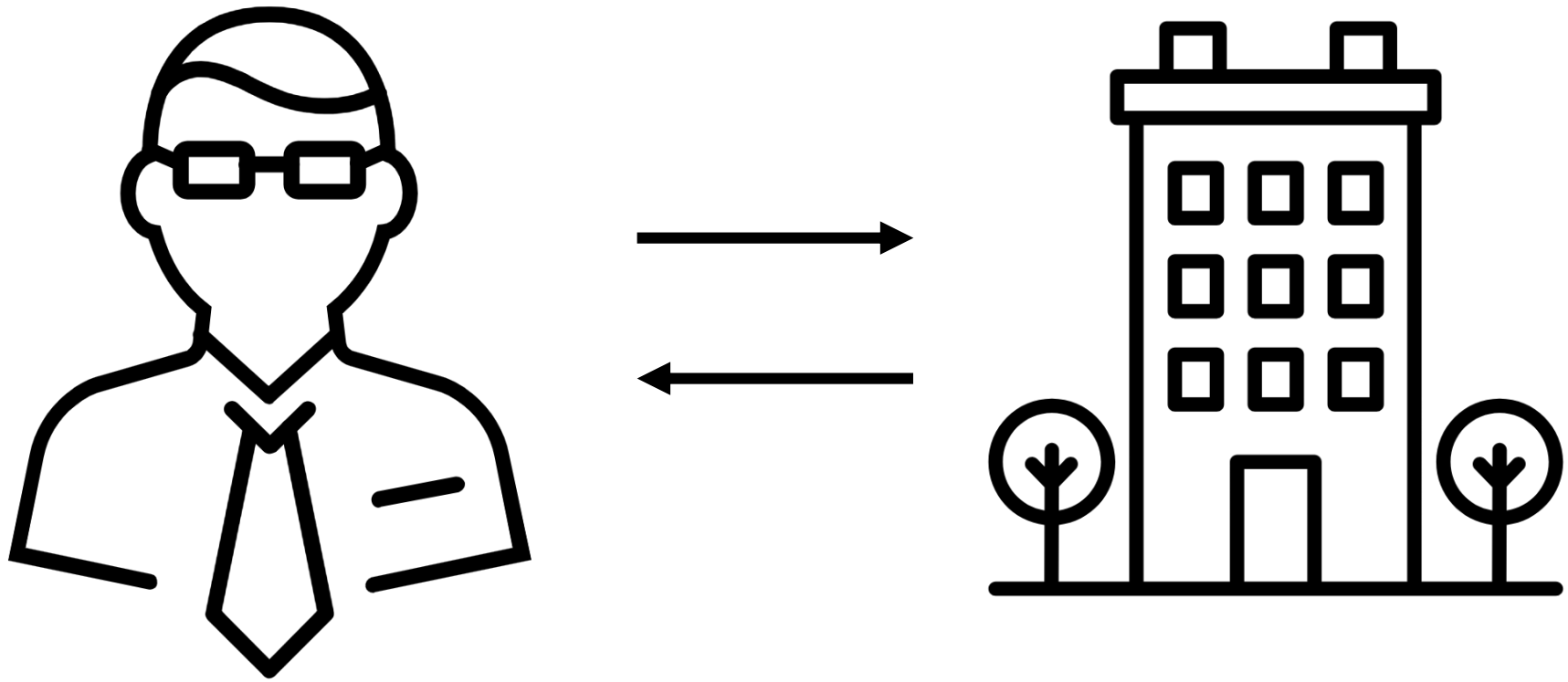
ICS 13.180

BSI




Practical evaluation of the thermal comfort parameters (Markov, 2002)

BDP.



The Enterprise Centre, UEA, Norwich

BREEAM Outstanding

The Enterprise Centre, UEA, Norwich


Project Angel, Northampton BREEAM Excellent


Project Angel, Northampton

# Lighting

BDP.

- **63%** of the people rated **natural light** as the most **important** aspect of a home (survey: HOMEWISE, “Without space + light”).
- Daylight improves **visual** and **psychological** comfort, and has a **positive** effect on people’s performance, attentiveness, satisfaction and capacity to learn.
- Daylight **alleviates** Seasonal Affective Disorder (a form of **depression**).
- **Daylight** through windows is the key source to provide high levels of light, required to **sustain** the operation of the **circadian system**.

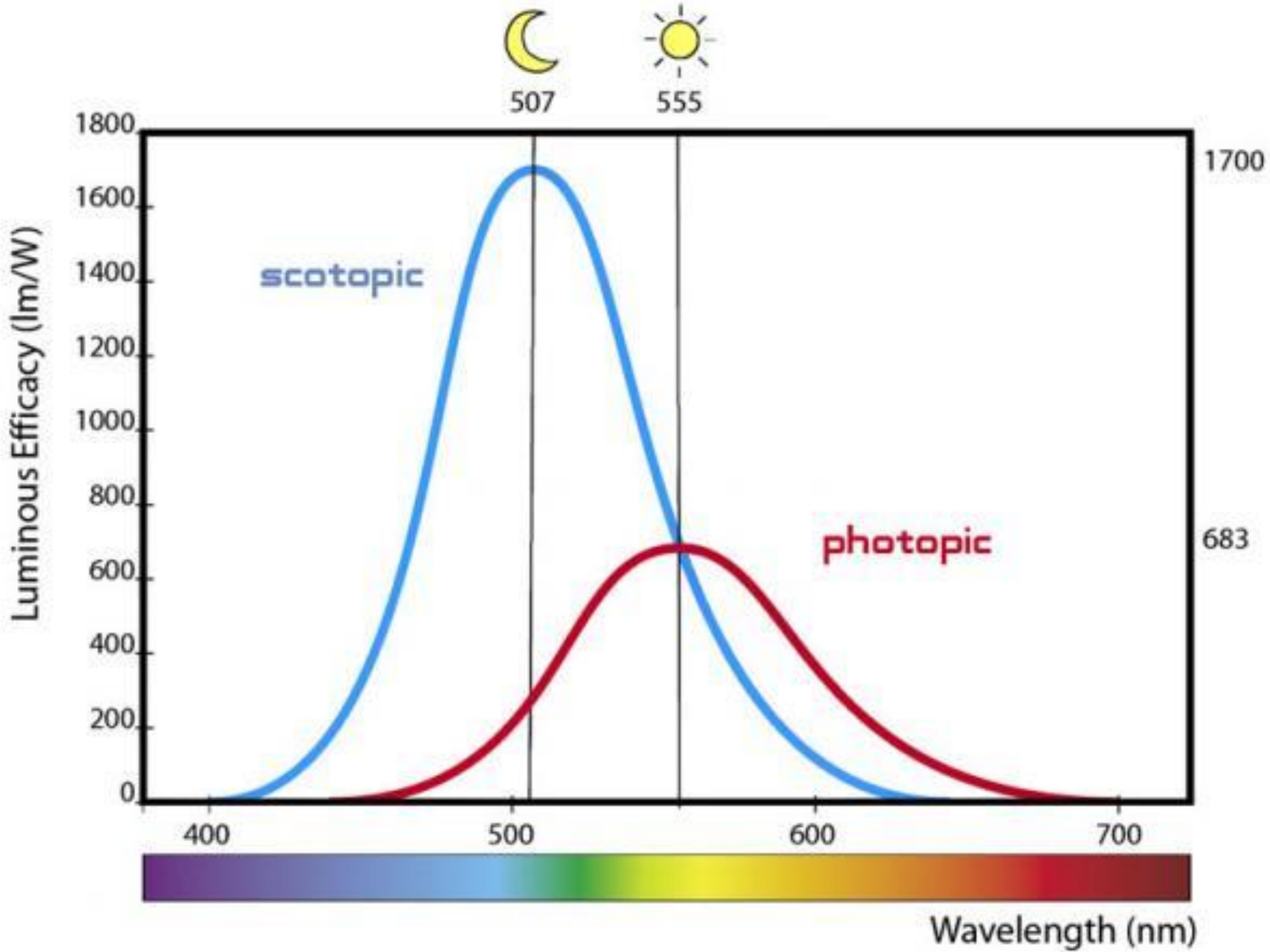
Source: http://www.lrc.rpi.edu/programs/daylighting/dr_health.asp

BDP.

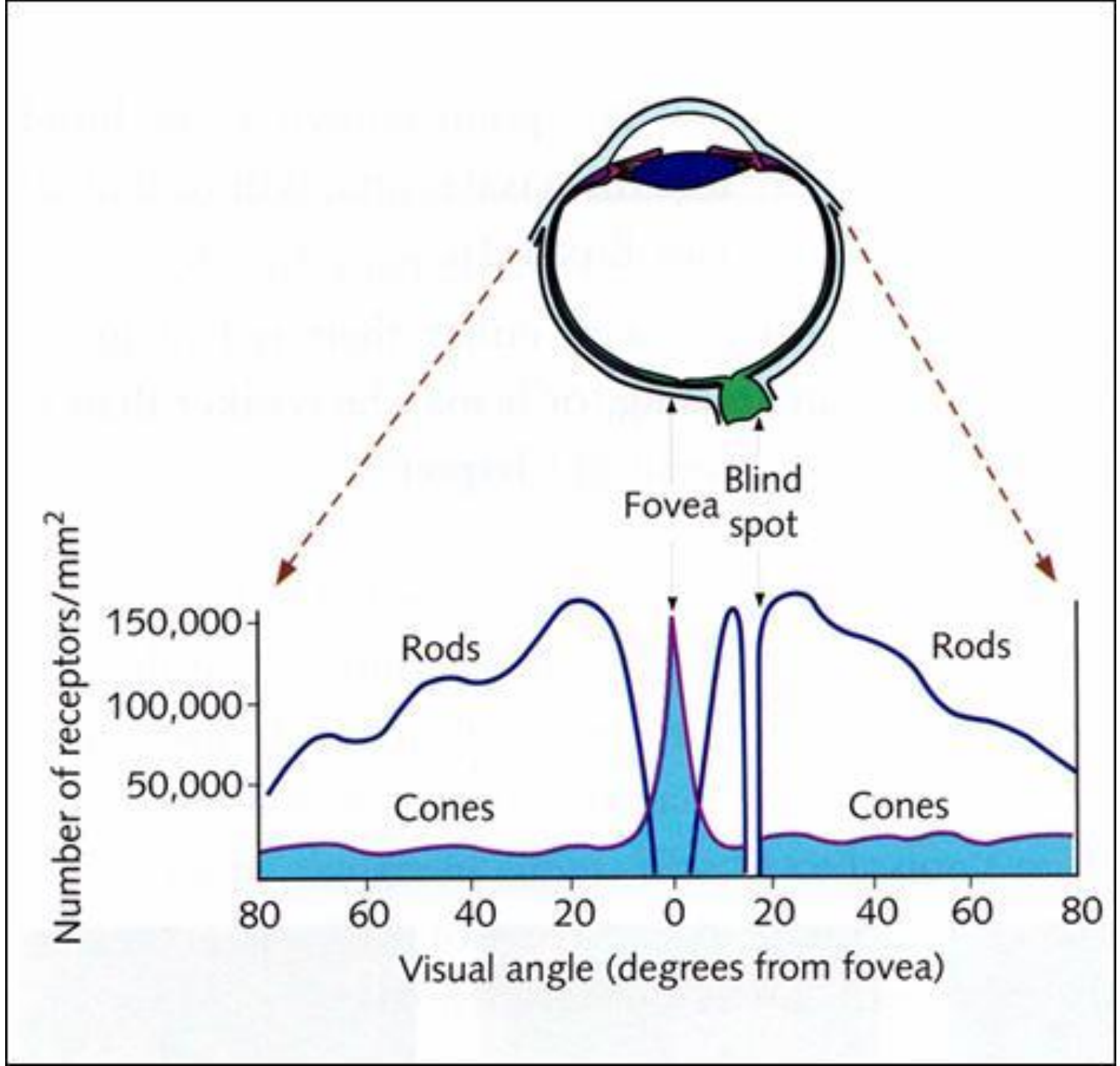
# How do we achieve good lighting conditions?

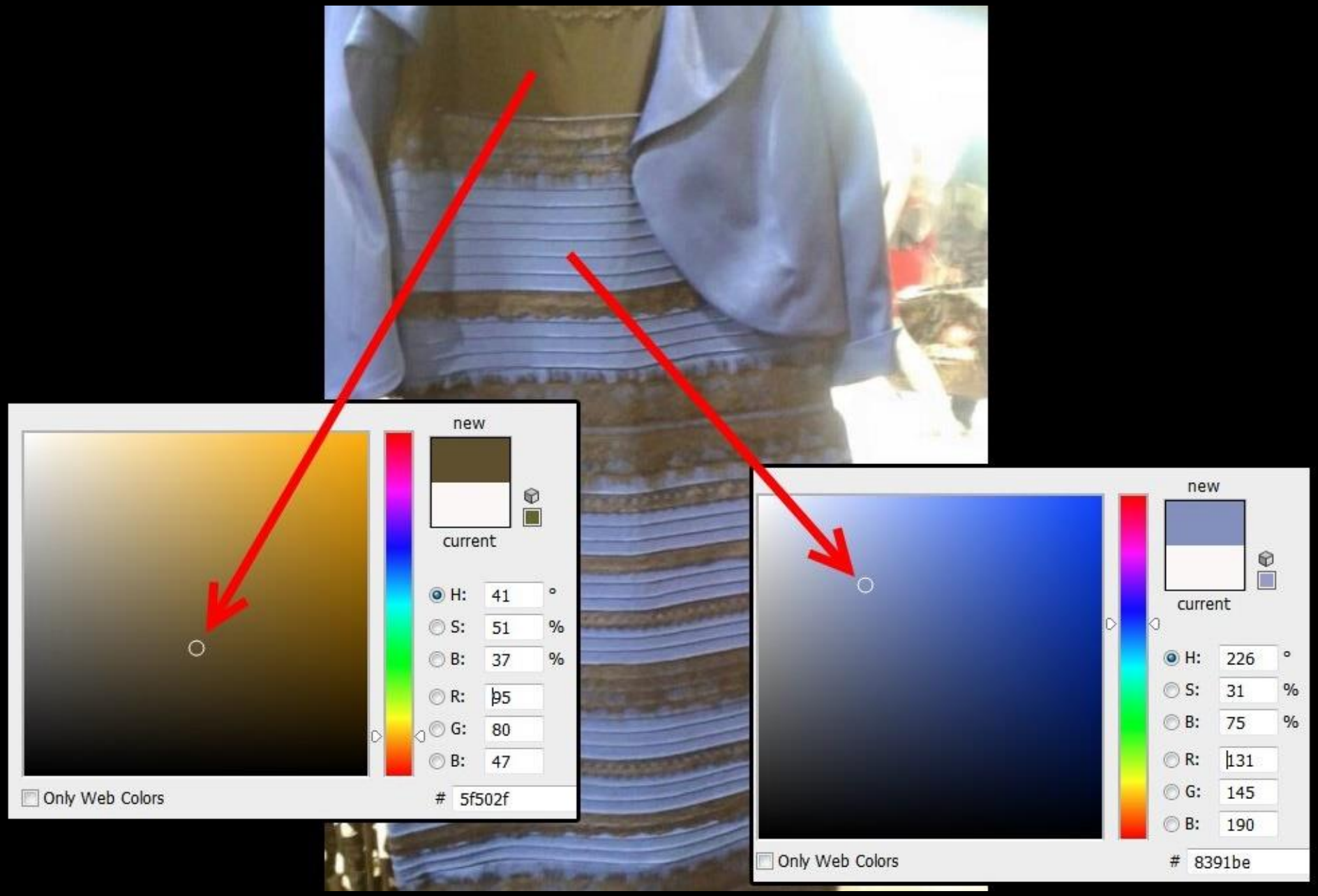
1. Perception
2. Circadian rhythms

BDP.


507
555
1800
1600
1400
1200
1000
800
600
400
200
0
Luminous Efficacy (lm/W)
scotopic
photopic
1700
683
400
500
600
700
Wavelength (nm)

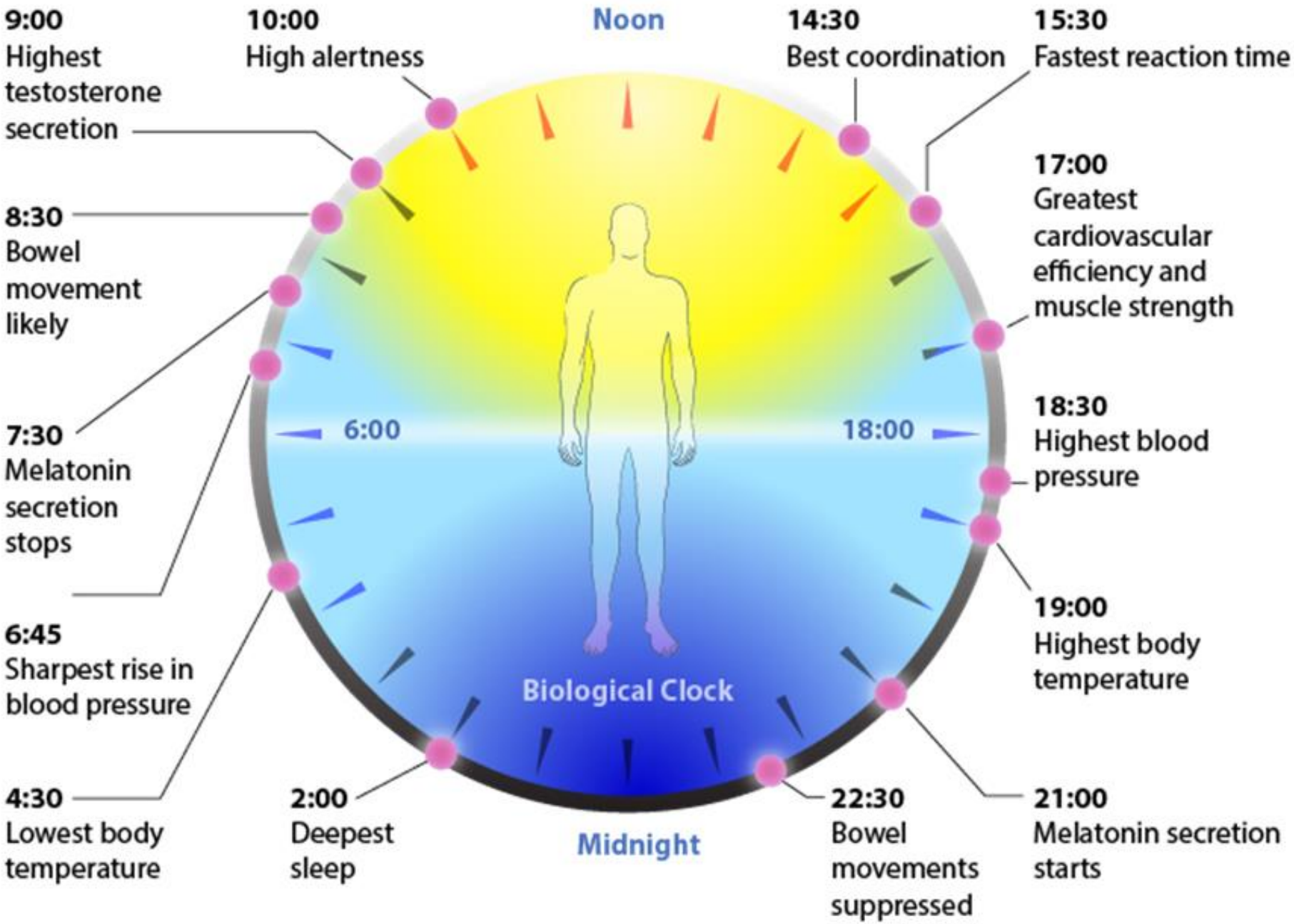
BDP.


Fovea
Blind spot
Number of receptors/mm²
150,000
100,000
50,000
Rods
Rods
Cones
Cones
80
60
40
20
0
20
40
60
80
Visual angle (degrees from fovea)

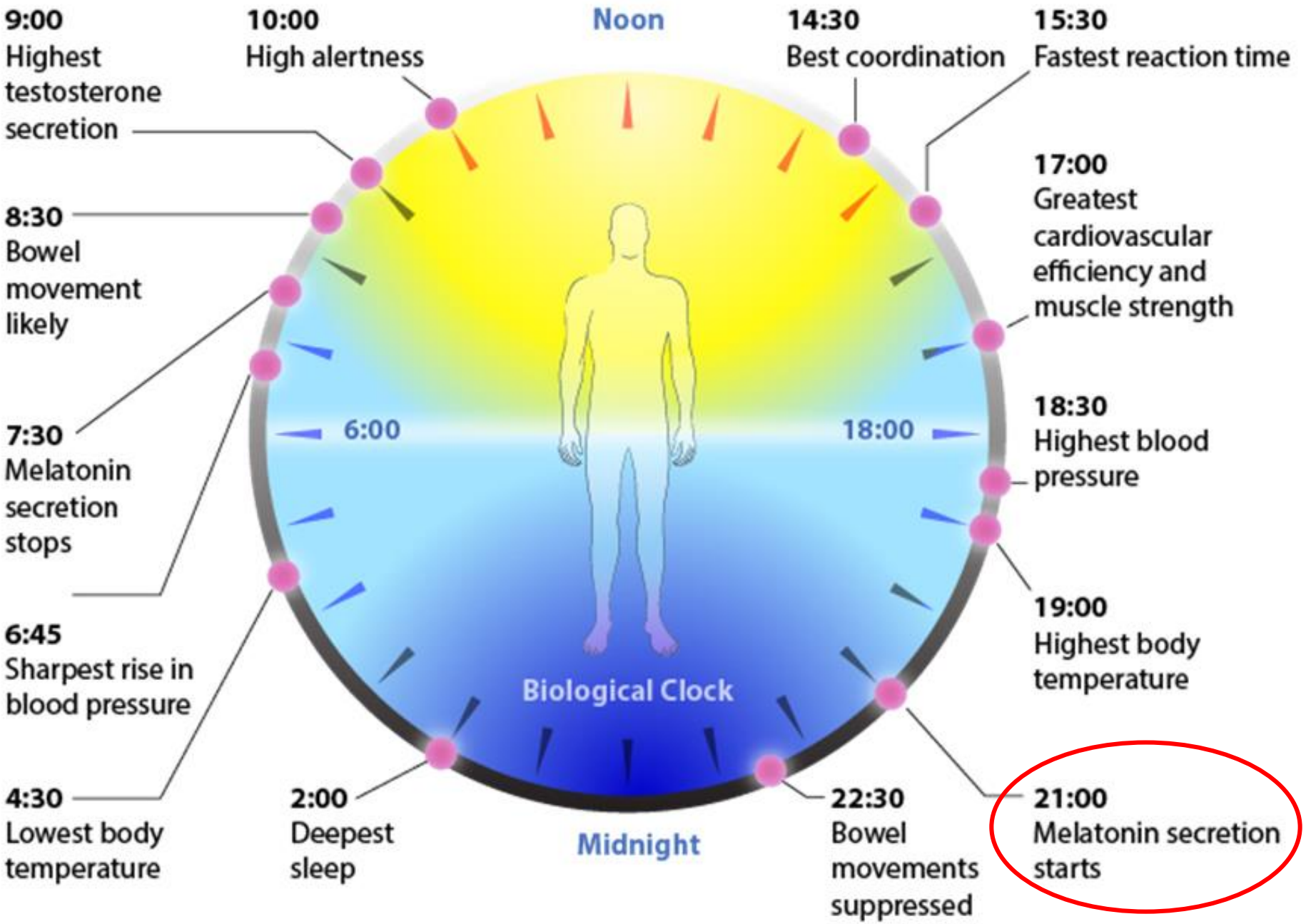

new
current
H: 41 °
S: 51 %
B: 37 %
R: 95
G: 80
B: 47
Only Web Colors
# 5f502f
new
current
H: 226 °
S: 31 %
B: 75 %
R: 131
G: 145
B: 190
Only Web Colors
# 8391be

BDP.

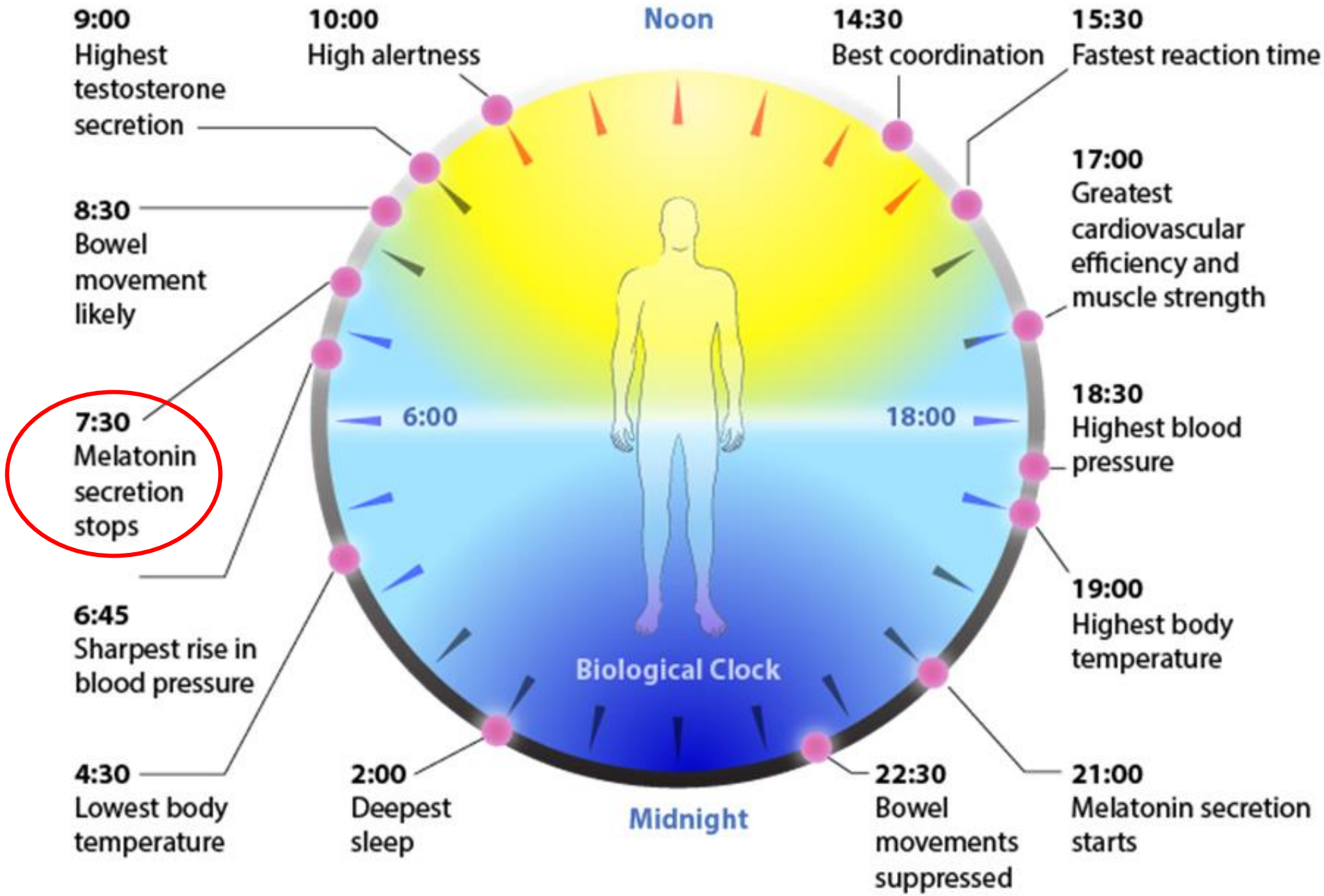
BDP.


9:00
Highest testosterone secretion
10:00
High alertness
Noon
14:30
Best coordination
15:30
Fastest reaction time
8:30
Bowel movement likely
17:00
Greatest cardiovascular efficiency and muscle strength
7:30
Melatonin secretion stops
6:00
18:00
18:30
Highest blood pressure
6:45
Sharpest rise in blood pressure
19:00
Highest body temperature
Biological Clock
4:30
Lowest body temperature
2:00
Deepest sleep
Midnight
22:30
Bowel movements suppressed
21:00
Melatonin secretion starts

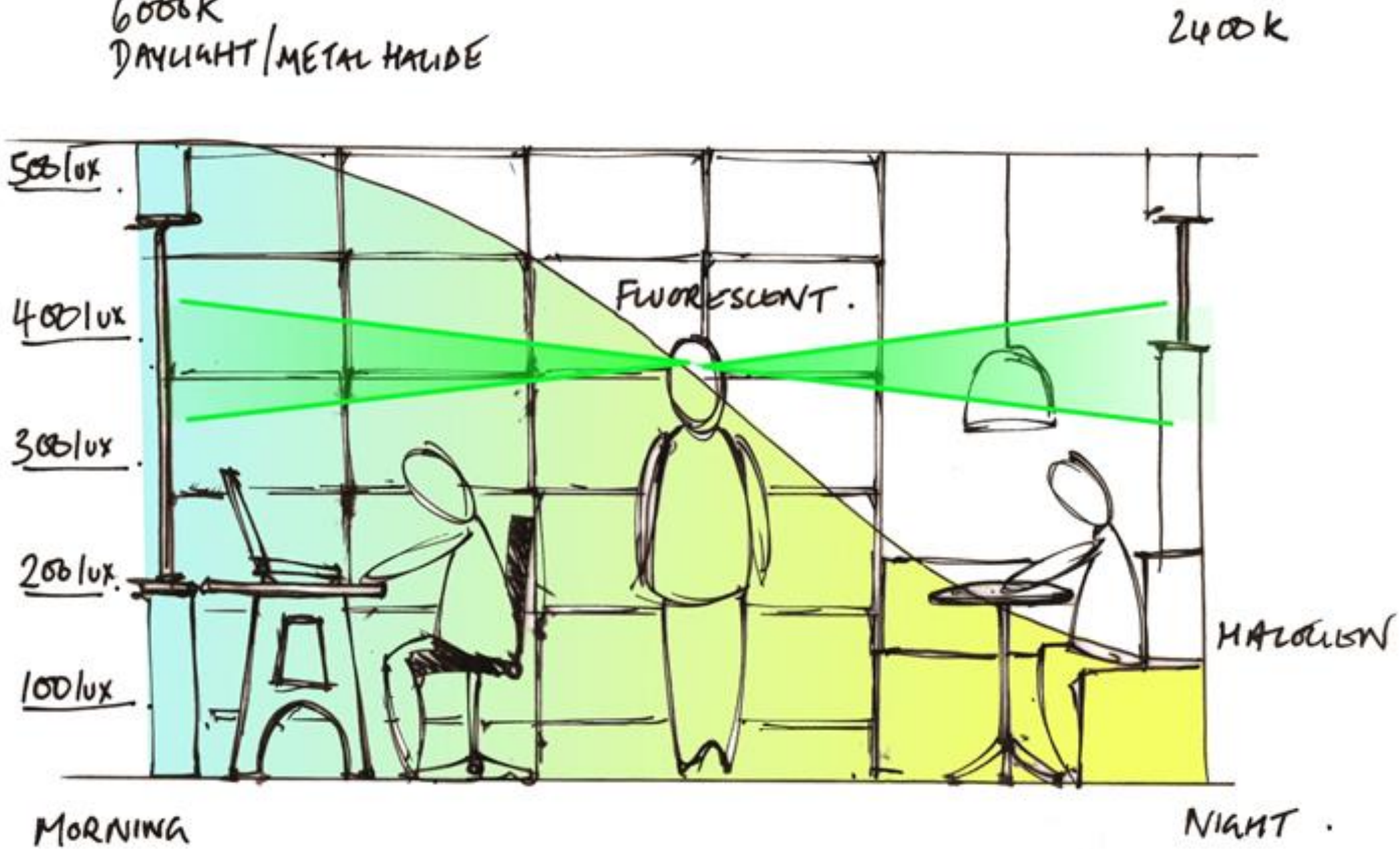
BDP.

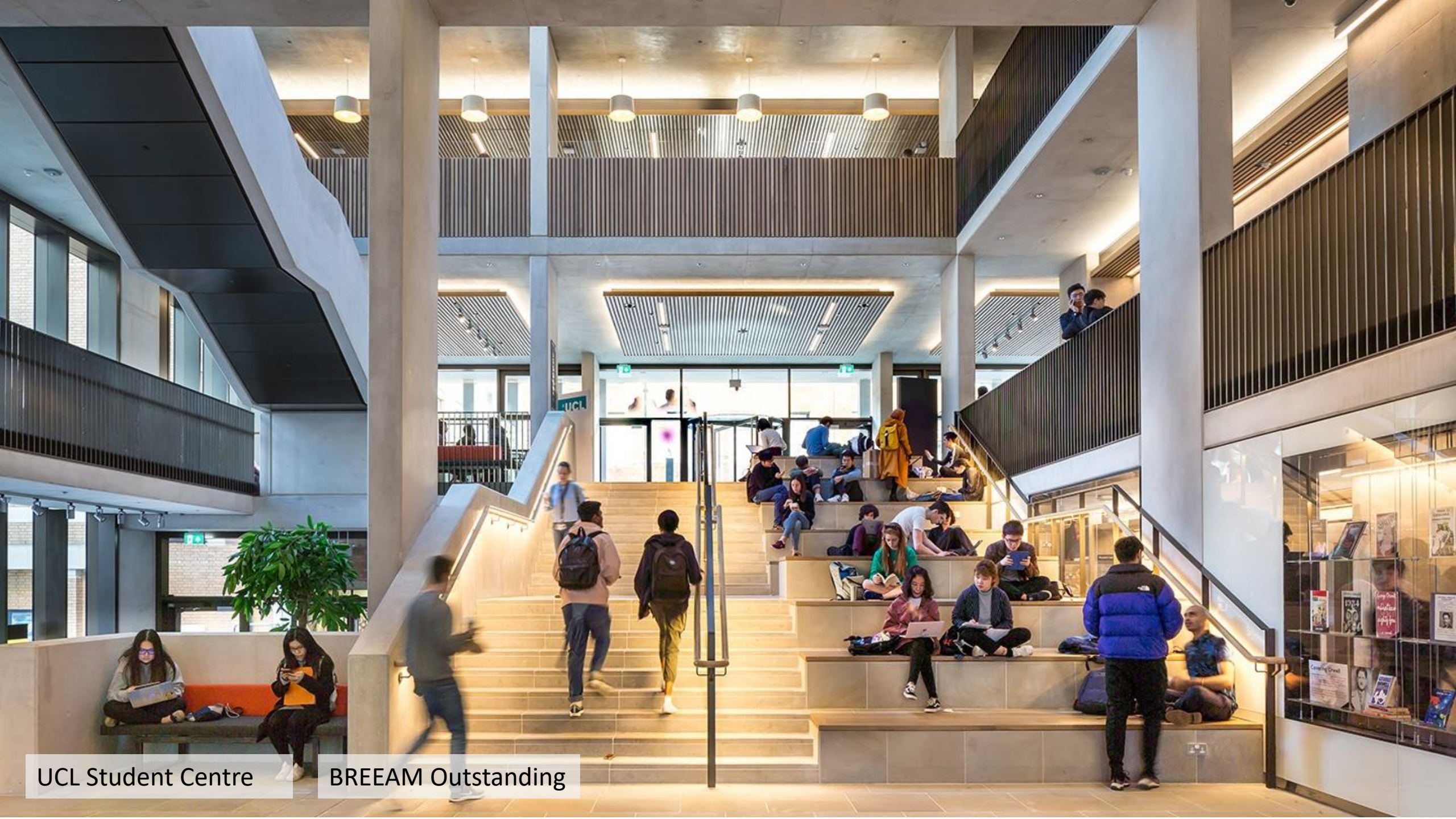

9:00
Highest testosterone secretion
10:00
High alertness
Noon
14:30
Best coordination
15:30
Fastest reaction time
8:30
Bowel movement likely
17:00
Greatest cardiovascular efficiency and muscle strength
7:30
Melatonin secretion stops
6:00
18:00
18:30
Highest blood pressure
6:45
Sharpest rise in blood pressure
19:00
Highest body temperature
Biological Clock
4:30
Lowest body temperature
2:00
Deepest sleep
Midnight
22:30
Bowel movements suppressed
21:00
Melatonin secretion starts

BDP.


9:00
Highest testosterone secretion
10:00
High alertness
Noon
14:30
Best coordination
15:30
Fastest reaction time
8:30
Bowel movement likely
17:00
Greatest cardiovascular efficiency and muscle strength
7:30
Melatonin secretion stops
6:00
18:00
18:30
Highest blood pressure
6:45
Sharpest rise in blood pressure
19:00
Highest body temperature
Biological Clock
4:30
Lowest body temperature
2:00
Deepest sleep
Midnight
22:30
Bowel movements suppressed
21:00
Melatonin secretion starts

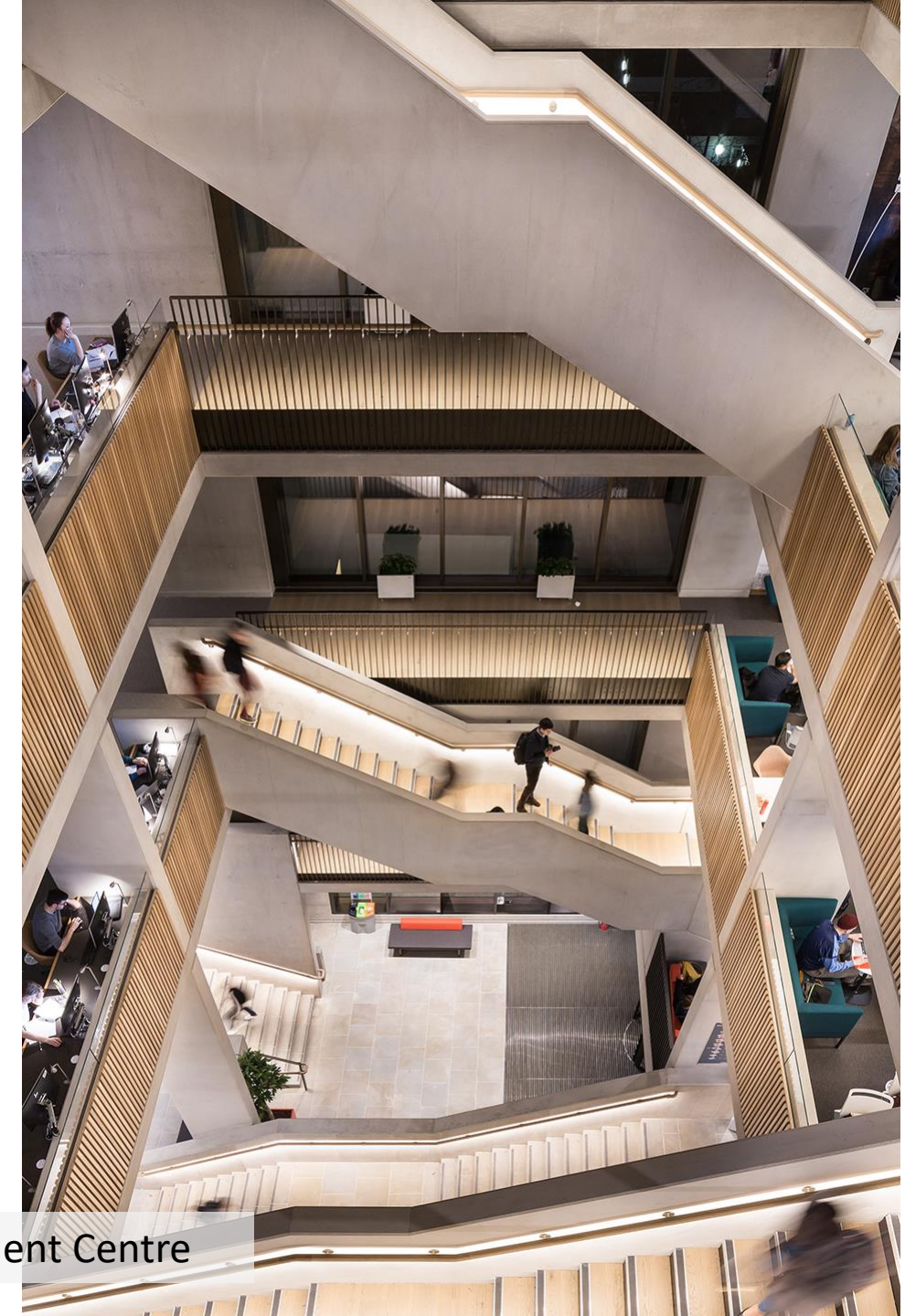
BDP.


6000K
DAYLIGHT/METAL HALIDE
2400K
500lux
400lux
300lux
200lux
100lux
FLUORESCENT.
HALOGEN
MORNING
NIGHT.



UCL Student Centre

BREEAM Outstanding



UCL Student Centre


# Office, Education and Healthcare Lighting Project of the Year

UCL Student Centre

The Enterprise Centre, UEA, Norwich

BREEAM Outstanding

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

The Enterprise Centre, UEA, Norwich

# Air Quality

# Over 80% of urban residents are exposed to air quality levels that exceed WHO limits

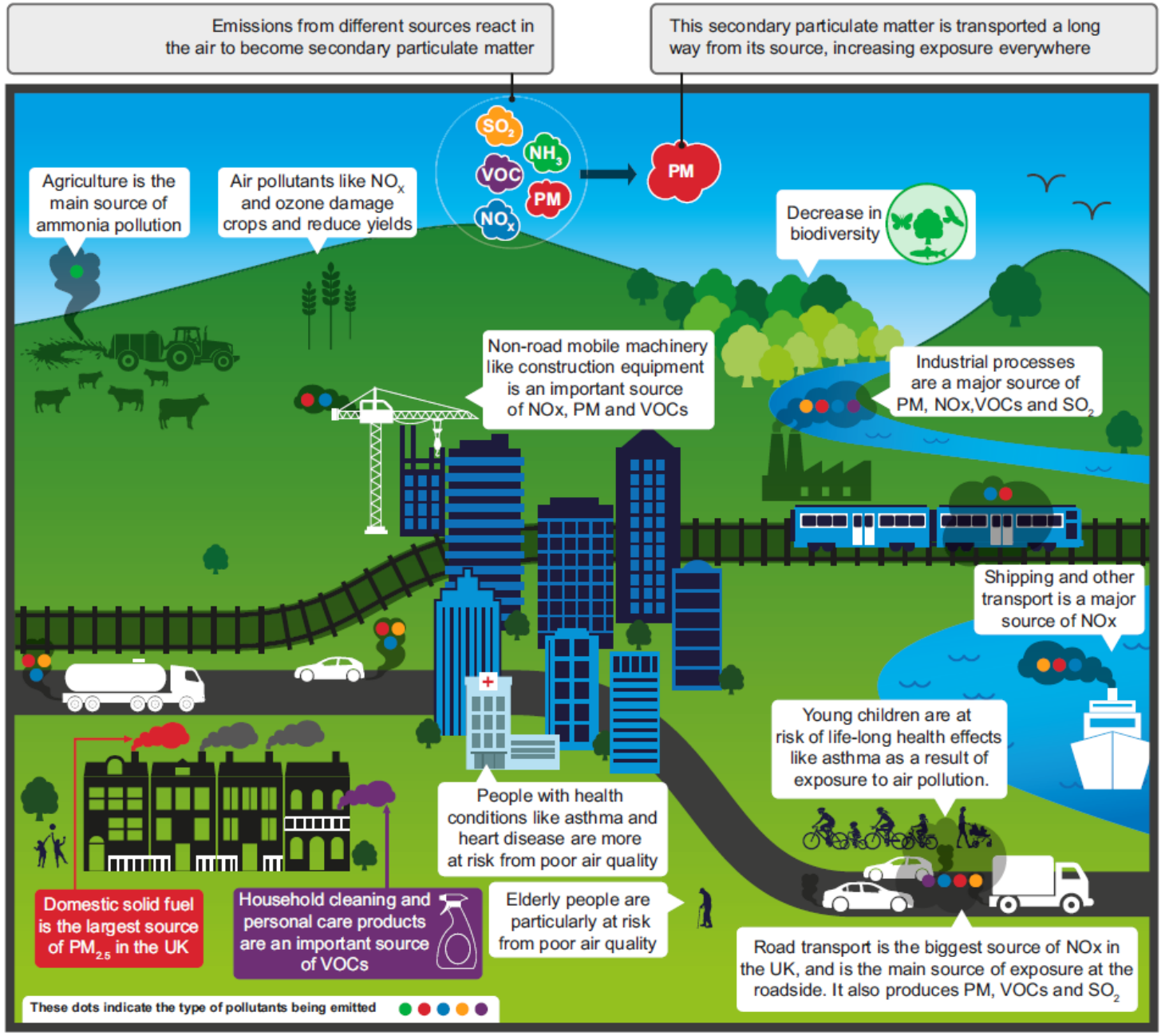

WHO, 2018

BDP.

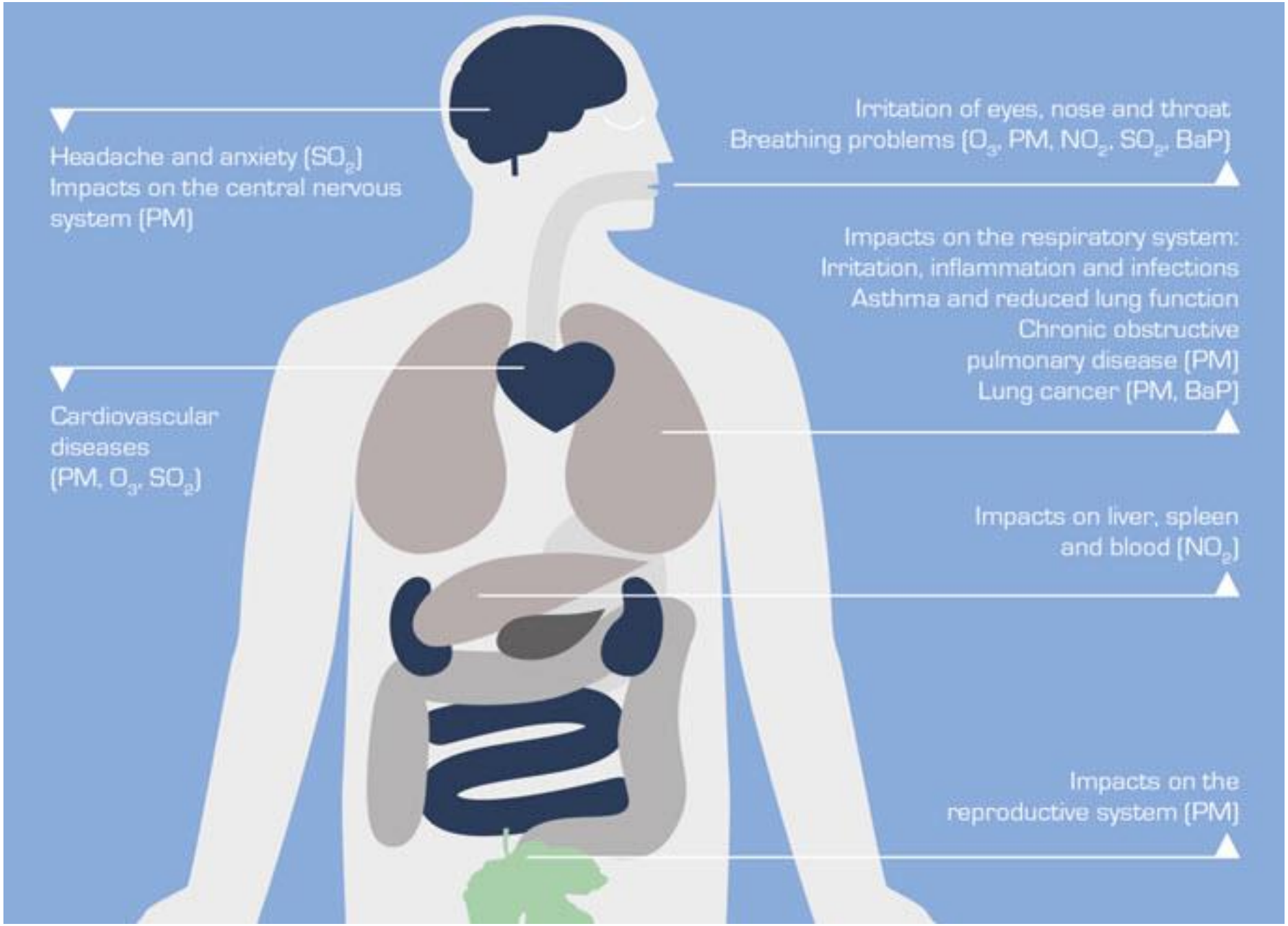
- In 2012, **99,000** deaths in Europe and **19,000** in non-European high income countries were attributable to household (indoor) **air pollution** (WHO, 2012).

- **Indoor** air pollution can be **2-5 times higher** than in outside air (EPA, 2019)

- Targeting the reduction of their **energy demand**, buildings are becoming more **airtight** and **IAQ** should be carefully considered (BPIE, 2015)



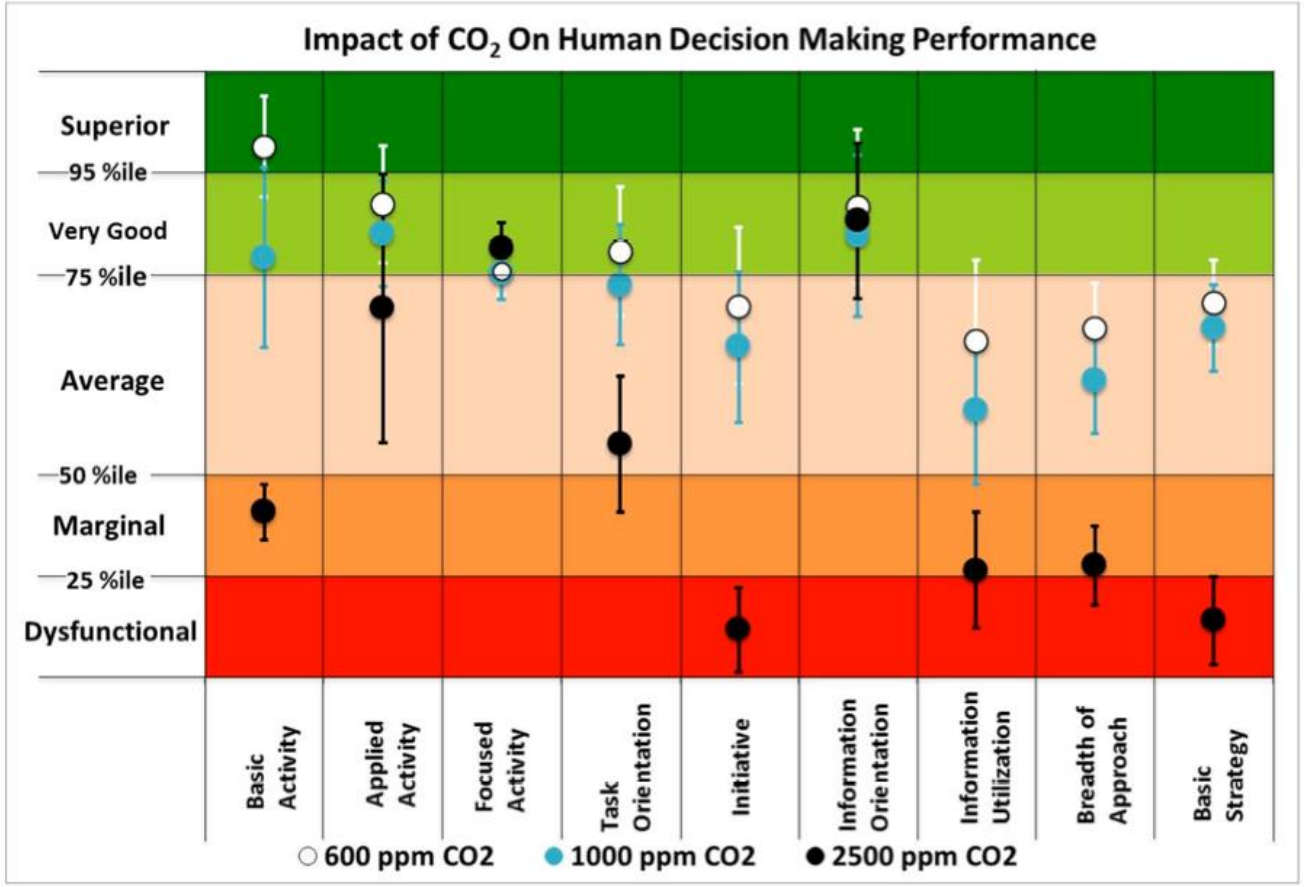

UK Clean Air Strategy, 2018 (draft)


Headache and anxiety ($SO_2$)
Impacts on the central nervous system (PM)
Irritation of eyes, nose and throat
Breathing problems ($O_3$, PM, $NO_2$, $SO_2$, BaP)
Impacts on the respiratory system:
Irritation, inflammation and infections
Asthma and reduced lung function
Chronic obstructive pulmonary disease (PM)
Lung cancer (PM, BaP)
Cardiovascular diseases (PM, $O_3$, $SO_2$)
Impacts on liver, spleen and blood ($NO_2$)
Impacts on the reproductive system (PM)

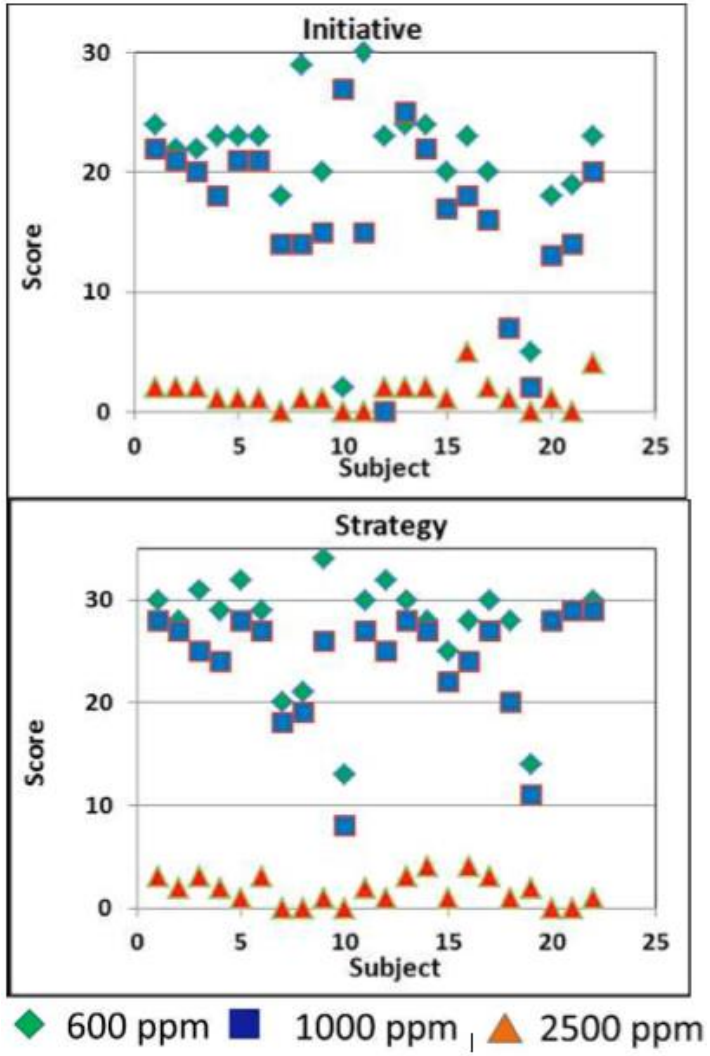
BDP.

| Pollutant | Health Impacts |
|---|---|
| Nitrous Oxide ($No_x$) | Respiratory symptoms |
| Sulphur Dioxide ($SO_2$) | Respiratory symptoms |
| Carbon Monoxide (CO) | Death at high levels |
| Particulate Matter (PM) | Reduced lung function and risk of heart disease |
| Radon | Lung cancer |
| Allergens (dust, pollen etc.) | Worsened asthma |
| Volatile Organic Compounds (VOCs) | Respiratory tract irritation |

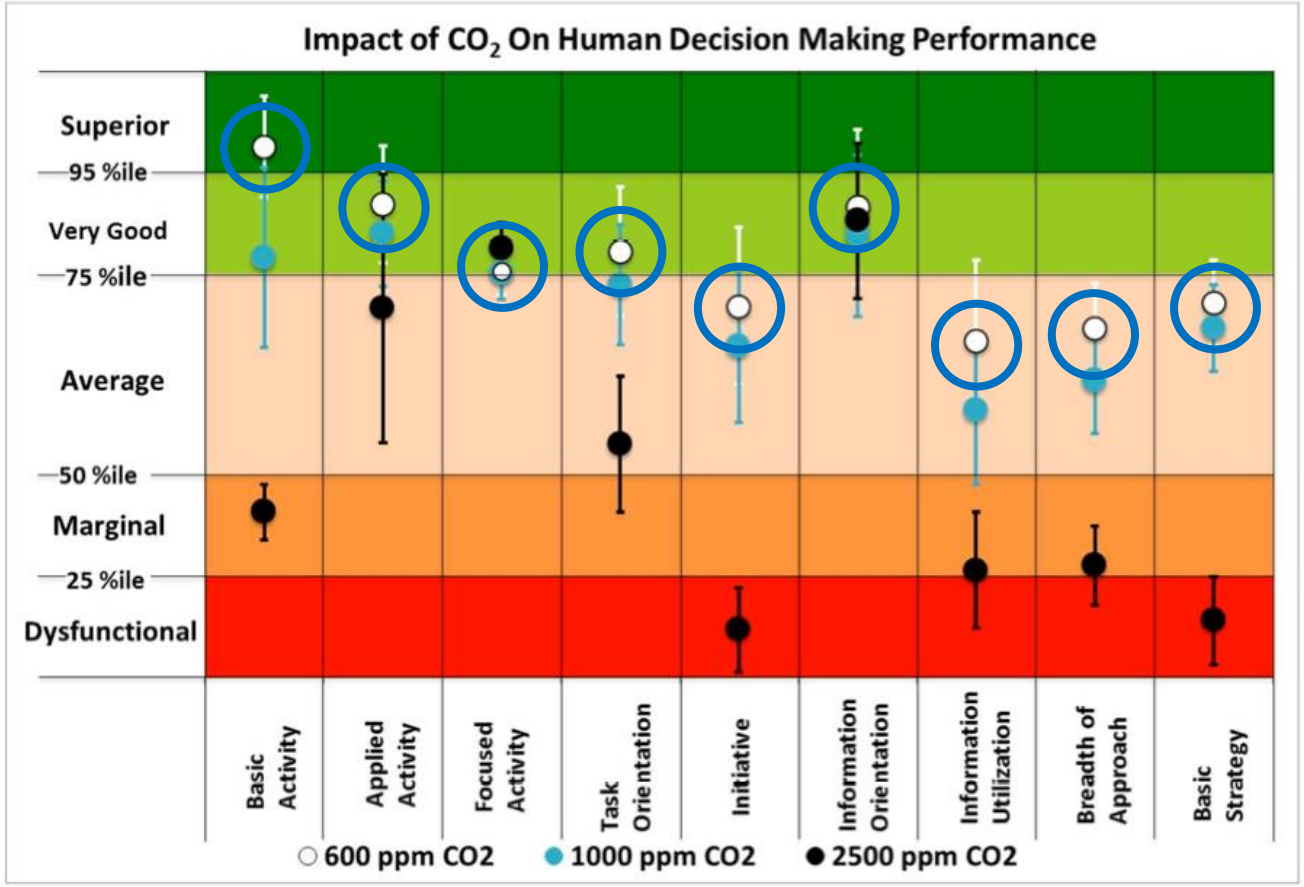
BDP.



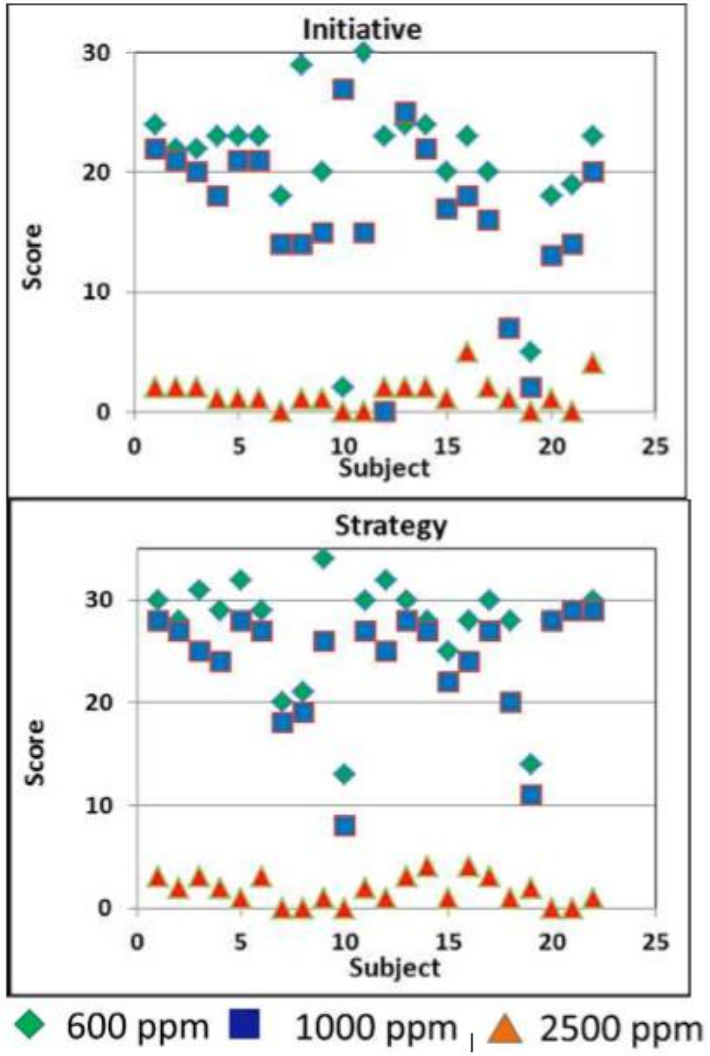

Lawrence Berkeley National Laboratory (Berkeley Lab), 2017



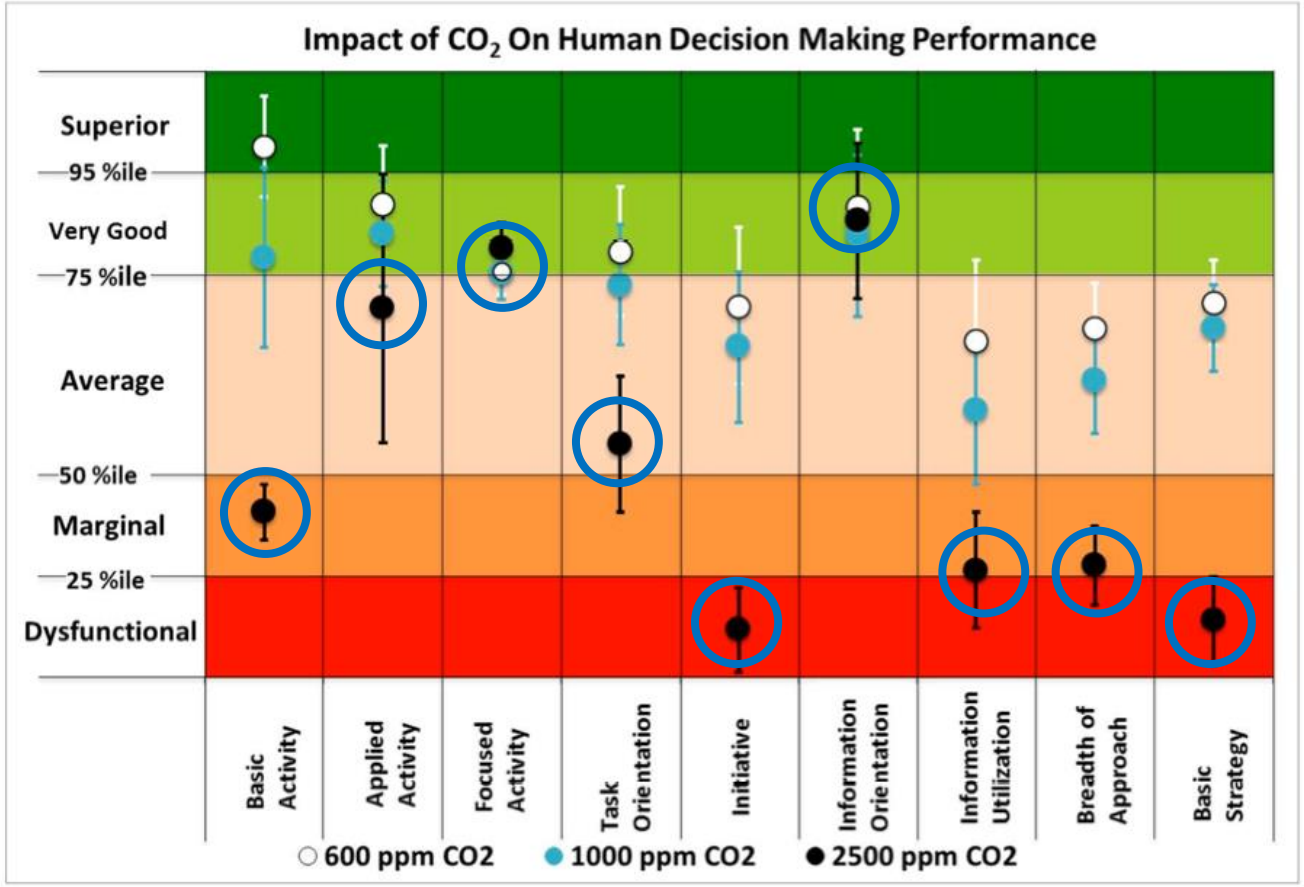
BDP.



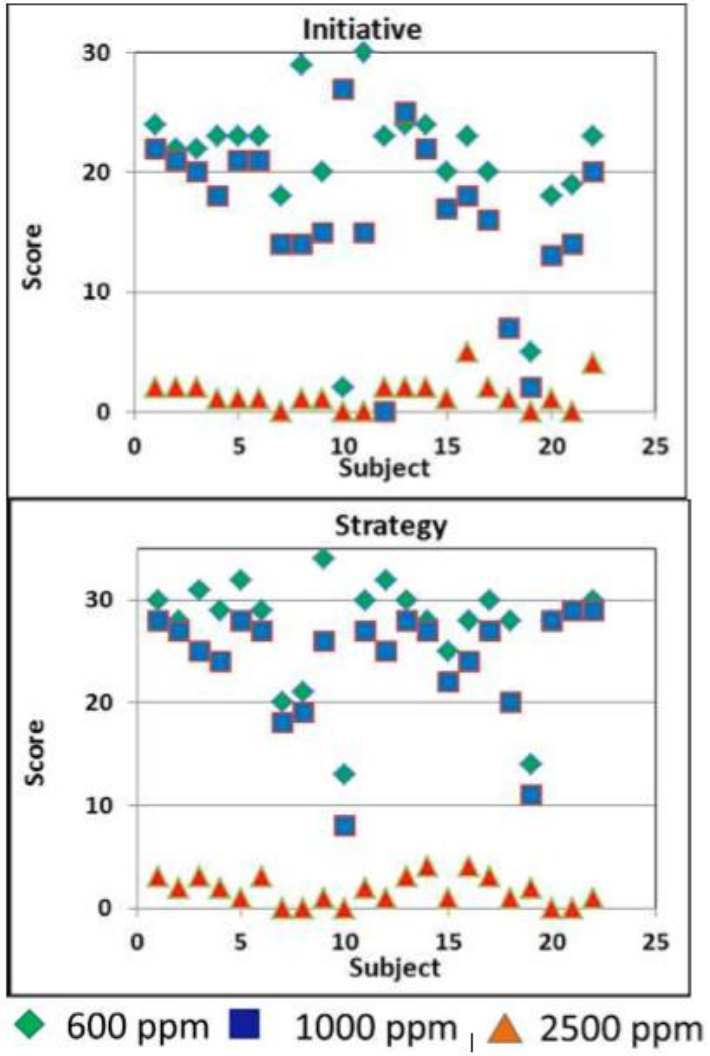

Lawrence Berkeley National Laboratory (Berkeley Lab), 2017



BDP.




Lawrence Berkeley National Laboratory (Berkeley Lab), 2017



# How do we achieve good IAQ?

1. Clean air supply
2. Internal pollutant control

# 1. Clean air supply

BDP.

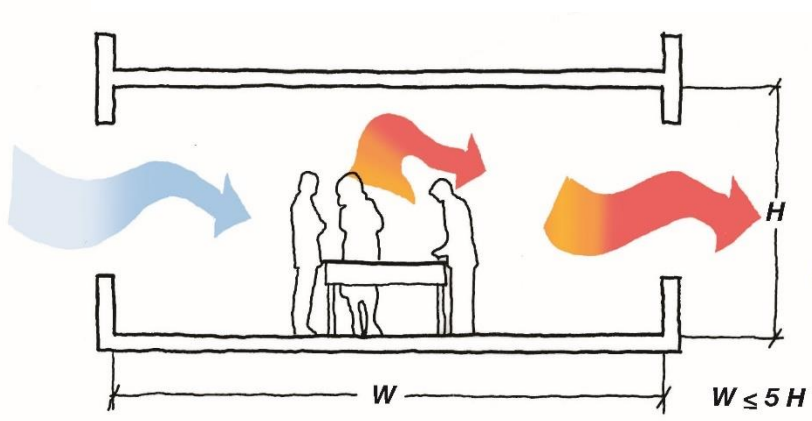
# Function

# Location

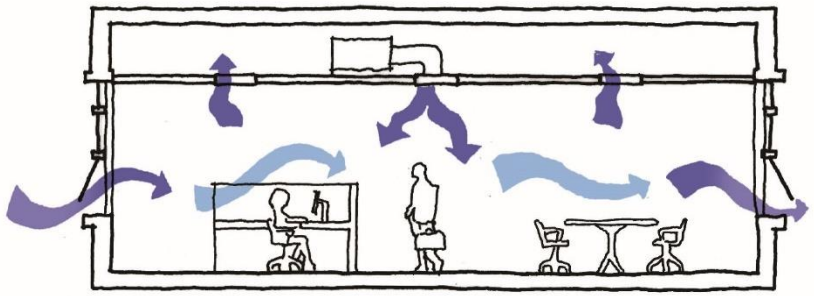

# Occupancy

BDP.

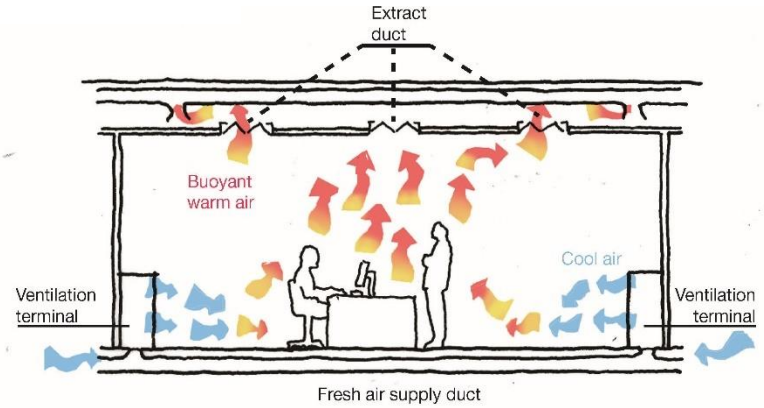
# Natural




# Mixed Mode



# Mechanical



BDP.

| | Natural | Mixed Mode | Mechanical |
|---|---|---|---|
| Pros | • User control<br>• Connection with outdoors<br>• Energy efficient | • User control<br>• Connection with outdoors<br>• Energy efficiency<br>• Maximised Comfort<br>• Flexibility<br>• Operational resilience | • User control<br>• Maximised Comfort<br>• Flexibility in function<br>• Air filtration |
| Cons | • Difficult to control<br>• Lack of flexibility<br>• No resilience<br>• Balancing openings with glare control<br>• Limits floor plan<br>• Noise | • Capital cost – provision of two strategies<br>• Challenge in training users to user building effectively | • Energy hungry<br>• No connection with outdoors<br>• Maintenance<br>• No resilience if systems fail<br>• Limited by design criteria |

BDP.

| | Natural | Mixed Mode | Mechanical |
|---|---|---|---|
| Pros | • User control<br>• Connection with outdoors<br>• Energy efficient | • User control<br>• Connection with outdoors<br>• Energy efficiency<br>• Maximised Comfort<br>• Flexibility<br>• Operational resilience | • User control<br>• Maximised Comfort<br>• Flexibility in function<br>• Air filtration |
| Cons | • Difficult to control<br>• Lack of flexibility<br>• No resilience<br>• Balancing openings with glare control<br>• Limits floor plan<br>• Noise | • Capital cost – provision of two strategies<br>• Challenge in training users to user building effectively | • Energy hungry<br>• No connection with outdoors<br>• Maintenance<br>• No resilience if systems fail<br>• Limited by design criteria |

# 2. Internal pollutant control

BDP.

# Material Selection

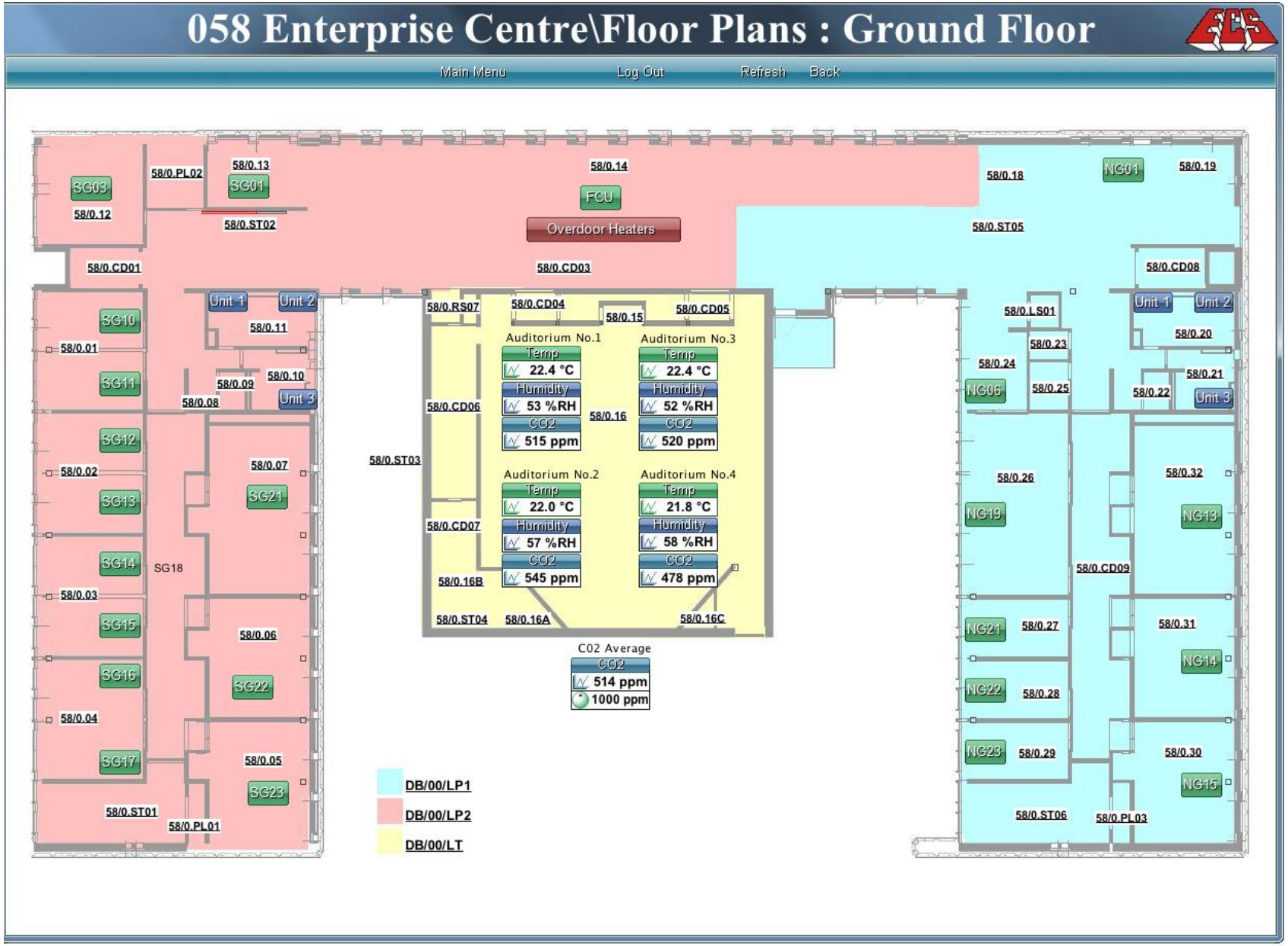
# Maintenance Regime

# Active Monitoring

The Enterprise Centre, UEA, Norwich

BREEAM Outstanding

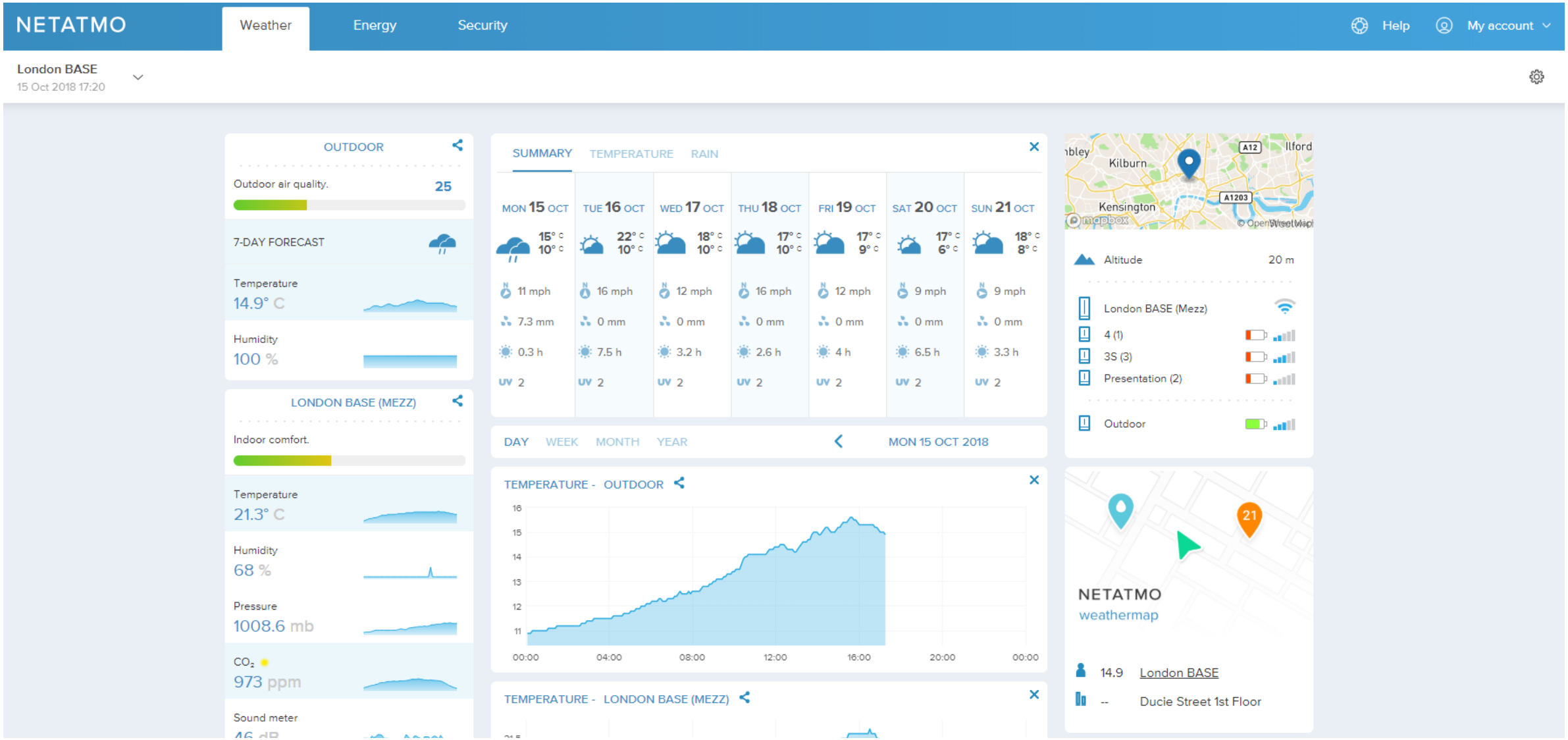
BDP.

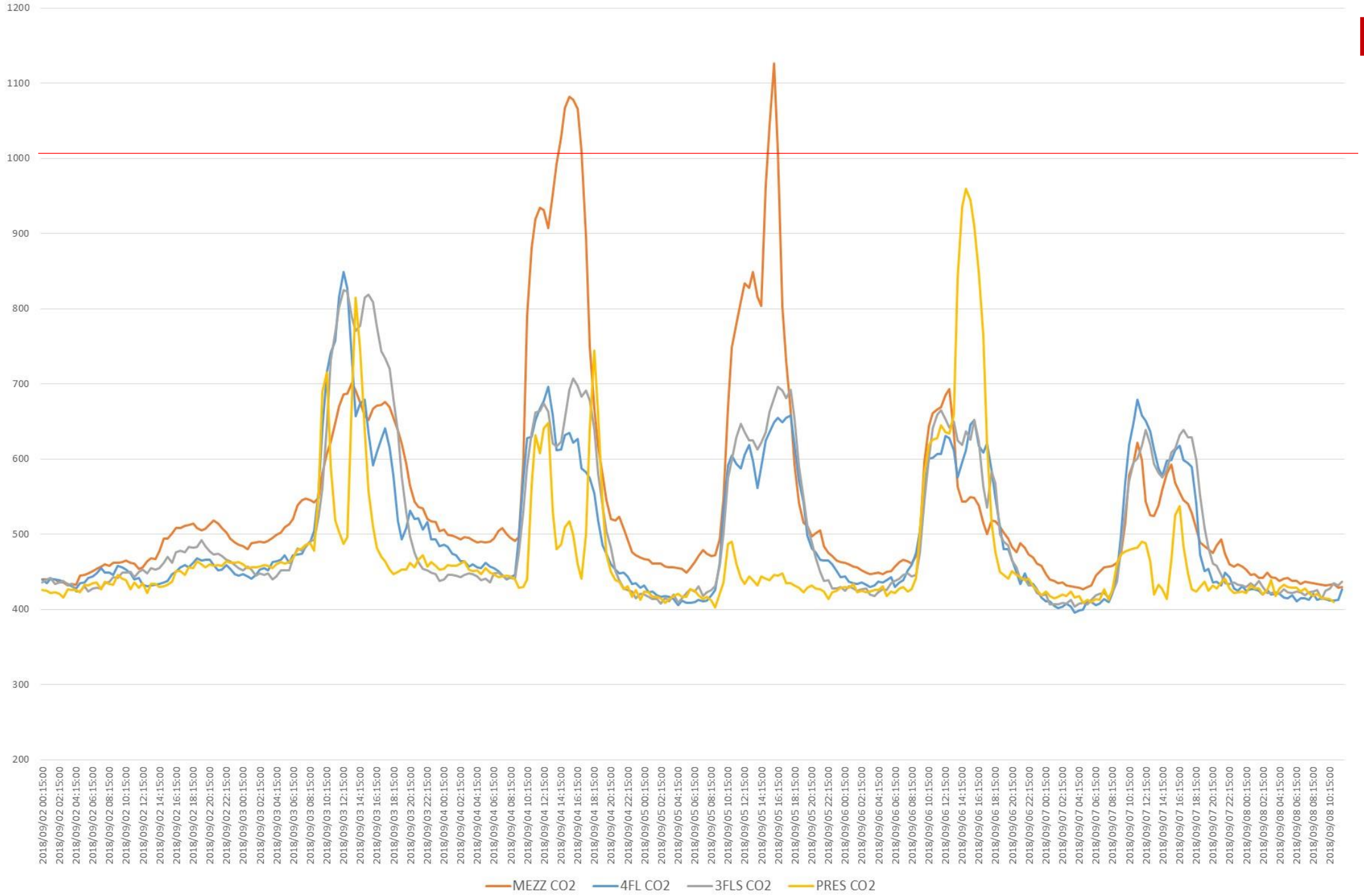

058 Enterprise Centre\Floor Plans : Ground Floor
Main Menu
Log Out
Refresh
Back
SG03
58/0.PL02
58/0.13
SG01
58/0.12
58/0.ST02
58/0.14
FCU
Overdoor Heaters
58/0.18
NG01
58/0.19
58/0.ST05
58/0.CD01
58/0.CD03
58/0.CD08
Unit 1
Unit 2
58/0.RS07
58/0.CD04
58/0.15
58/0.CD05
58/0.LS01
58/0.20
SG10
58/0.11
58/0.01
58/0.23
58/0.24
SG11
58/0.09
58/0.10
58/0.08
Unit 3
58/0.CD06
58/0.16
NG06
58/0.25
58/0.22
58/0.21
Unit 3
Auditorium No.1
Temp
22.4 °C
Humidity
53 %RH
CO2
515 ppm
Auditorium No.3
Temp
22.4 °C
Humidity
52 %RH
CO2
520 ppm
SG12
58/0.02
58/0.07
58/0.ST03
58/0.26
58/0.32
SG13
SG21
SG18
Auditorium No.2
Temp
22.0 °C
Humidity
57 %RH
CO2
545 ppm
Auditorium No.4
Temp
21.8 °C
Humidity
58 %RH
CO2
478 ppm
NG19
NG13
58/0.CD07
SG14
58/0.16B
58/0.CD09
58/0.03
58/0.ST04
58/0.16A
58/0.16C
SG15
58/0.06
NG21
58/0.27
58/0.31
C02 Average
CO2
514 ppm
1000 ppm
NG14
SG16
SG22
NG22
58/0.28
58/0.04
SG17
58/0.05
NG23
58/0.29
58/0.30
NG15
SG23
58/0.ST01
58/0.PL01
58/0.ST06
58/0.PL03
DB/00/LP1
DB/00/LP2
DB/00/LT

BDP.


BDP Brewhouse Yard, London

BDP.


NETATMO
Weather
Energy
Security
Help
My account
London BASE
15 Oct 2018 17:20
OUTDOOR
Outdoor air quality. 25
7-DAY FORECAST
Temperature 14.9° C
Humidity 100 %
LONDON BASE (MEZZ)
Indoor comfort.
Temperature 21.3° C
Humidity 68 %
Pressure 1008.6 mb
CO2 973 ppm
Sound meter
SUMMARY
TEMPERATURE
RAIN
MON 15 OCT 15° C 10° C 11 mph 7.3 mm 0.3 h UV 2
TUE 16 OCT 22° C 10° C 16 mph 0 mm 7.5 h UV 2
WED 17 OCT 18° C 10° C 12 mph 0 mm 3.2 h UV 2
THU 18 OCT 17° C 10° C 16 mph 0 mm 2.6 h UV 2
FRI 19 OCT 17° C 9° C 12 mph 0 mm 4 h UV 2
SAT 20 OCT 17° C 6° C 9 mph 0 mm 6.5 h UV 2
SUN 21 OCT 18° C 8° C 9 mph 0 mm 3.3 h UV 2
DAY
WEEK
MONTH
YEAR
MON 15 OCT 2018
TEMPERATURE - OUTDOOR
16
15
14
13
12
11
00:00
04:00
08:00
12:00
16:00
20:00
00:00
TEMPERATURE - LONDON BASE (MEZZ)
Kilburn
Ilford
Kensington
A12
A1203
Altitude 20 m
London BASE (Mezz)
4 (1)
3S (3)
Presentation (2)
Outdoor
21
NETATMO
weathermap
14.9 London BASE
-- Ducie Street 1st Floor


1200
1100
1000
900
800
700
600
500
400
300
200
2018/09/02 00:15:00
2018/09/02 02:15:00
2018/09/02 04:15:00
2018/09/02 06:15:00
2018/09/02 08:15:00
2018/09/02 10:15:00
2018/09/02 12:15:00
2018/09/02 14:15:00
2018/09/02 16:15:00
2018/09/02 18:15:00
2018/09/02 20:15:00
2018/09/02 22:15:00
2018/09/03 00:15:00
2018/09/03 02:15:00
2018/09/03 04:15:00
2018/09/03 06:15:00
2018/09/03 08:15:00
2018/09/03 10:15:00
2018/09/03 12:15:00
2018/09/03 14:15:00
2018/09/03 16:15:00
2018/09/03 18:15:00
2018/09/03 20:15:00
2018/09/03 22:15:00
2018/09/04 00:15:00
2018/09/04 02:15:00
2018/09/04 04:15:00
2018/09/04 06:15:00
2018/09/04 08:15:00
2018/09/04 10:15:00
2018/09/04 12:15:00
2018/09/04 14:15:00
2018/09/04 16:15:00
2018/09/04 18:15:00
2018/09/04 20:15:00
2018/09/04 22:15:00
2018/09/05 00:15:00
2018/09/05 02:15:00
2018/09/05 04:15:00
2018/09/05 06:15:00
2018/09/05 08:15:00
2018/09/05 10:15:00
2018/09/05 12:15:00
2018/09/05 14:15:00
2018/09/05 16:15:00
2018/09/05 18:15:00
2018/09/05 20:15:00
2018/09/05 22:15:00
2018/09/06 00:15:00
2018/09/06 02:15:00
2018/09/06 04:15:00
2018/09/06 06:15:00
2018/09/06 08:15:00
2018/09/06 10:15:00
2018/09/06 12:15:00
2018/09/06 14:15:00
2018/09/06 16:15:00
2018/09/06 18:15:00
2018/09/06 20:15:00
2018/09/06 22:15:00
2018/09/07 00:15:00
2018/09/07 02:15:00
2018/09/07 04:15:00
2018/09/07 06:15:00
2018/09/07 08:15:00
2018/09/07 10:15:00
2018/09/07 12:15:00
2018/09/07 14:15:00
2018/09/07 16:15:00
2018/09/07 18:15:00
2018/09/07 20:15:00
2018/09/07 22:15:00
2018/09/08 00:15:00
2018/09/08 02:15:00
2018/09/08 04:15:00
2018/09/08 06:15:00
2018/09/08 08:15:00
2018/09/08 10:15:00
MEZZ CO2
4FL CO2
3FLS CO2
PRES CO2

BDP.

# Summary

1. Thermal comfort is unique to individuals and allowing users to actively adapt is beneficial.
2. Consider perception and circadian rhythms when designing for good lighting.
3. Location, ventilation supply and material specification all contribute to a good air quality.

BDP.

# Thank you.

Jon.hall@bdp.com

@BDP_com