

Using daylight modelling to verify compliance with the WELL Building Standard

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WELL Building Standard

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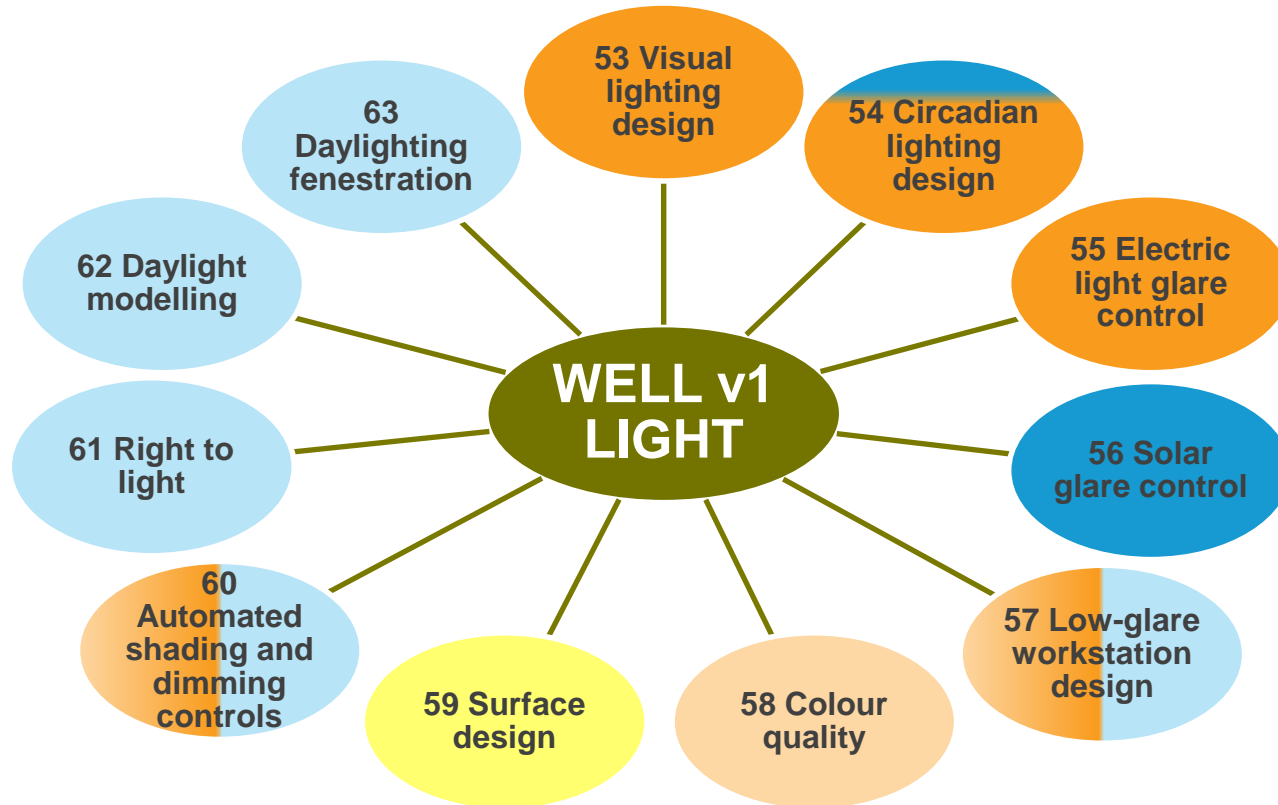
The WELL Building Standard



<http://standard.wellcertified.com>



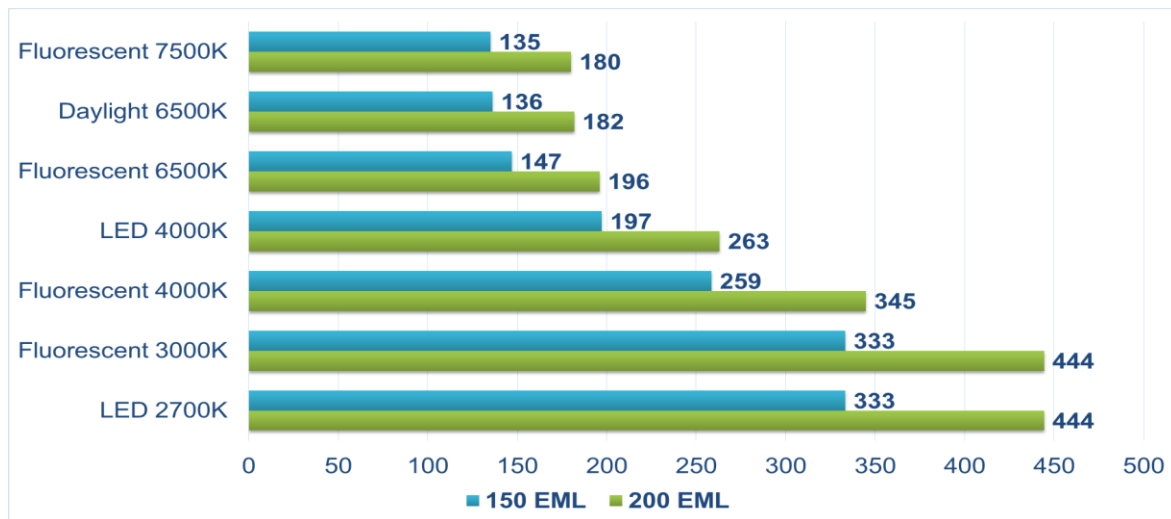
<https://v2.wellcertified.com>



Feature 54 Circadian lighting design

PRECONDITION

- At least 200 EML from **electric lighting** + **daylight** (9am – 1pm, 75% of workstations)
- At least 150 EML from **electric lighting** alone (all workstations)


$$\text{EML} = \text{Lux} \times \text{R}$$

Equivalent visual
lux levels for typical
light sources

Feature 56 Solar glare control

PRECONDITION

Options for windows	View window shading	Daylight management
Blinds / internal shading – manual / timed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
External shading	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Glazing with variable transmission	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Light shelves / sunlight redirecting films		<input checked="" type="checkbox"/>

Atria: glare reducing film with solar transmittance $\leq 10\%$; workstations set back from atria by ≥ 7 feet; building orientation

Feature 57 Low glare workstation design

OPTIMISATION

- Computer screens orientation relative to nearest windows
- Overhead luminaires vs computer screens



Feature 60 Automated shading and dimming controls

- Automatically controlled shading for windows $\geq 0.55 \text{ m}^2$
- Dimming of electric lighting (except decorative)
 - Continuous dimming in response to daylight
 - Unoccupied areas: automatic dimming to 20% or less or switch off

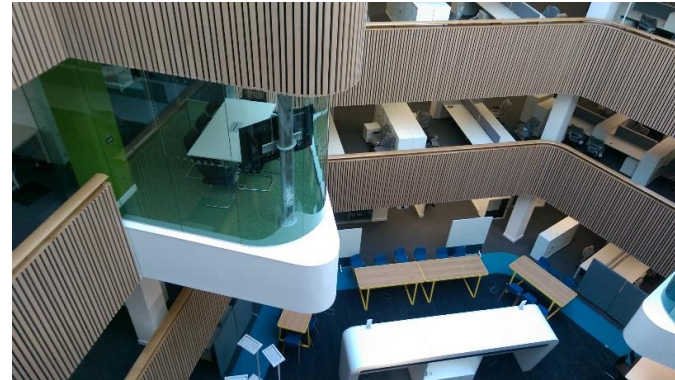
OPTIMISATION



Feature 61 Right to light

OPTIMISATION

- 75% of regularly occupied area within 7.5m of view windows
- 75% of workstations within 7.5m of atria / view windows
- 95% of workstations within 12.5m of atria / view windows



Feature 62 Daylight modelling

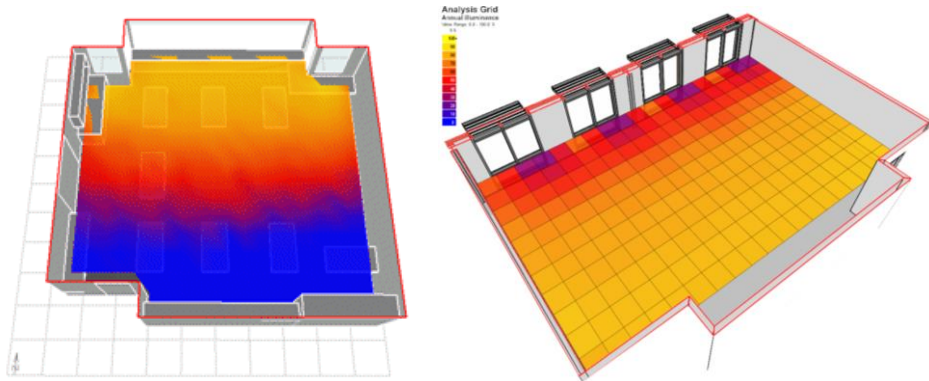
- $sDA_{300,50\%} \geq 55\%$ (of regularly occupied space)
- $ASE_{1000,250} \leq 10\%$ (of regularly occupied space)
- Alternative: LEED v4 BD+C EQ Daylight Credit

OPTIMISATION

sDA = percentage of floor area that exceeds a specified illuminance for a specified percentage of the analysis period

ASE = percentage of the horizontal work plane that exceeds a specified direct sunlight illuminance level more than a specified number of hours per year over a specified daily schedule with all operable shading devices retracted

Source: IES LM-83-12

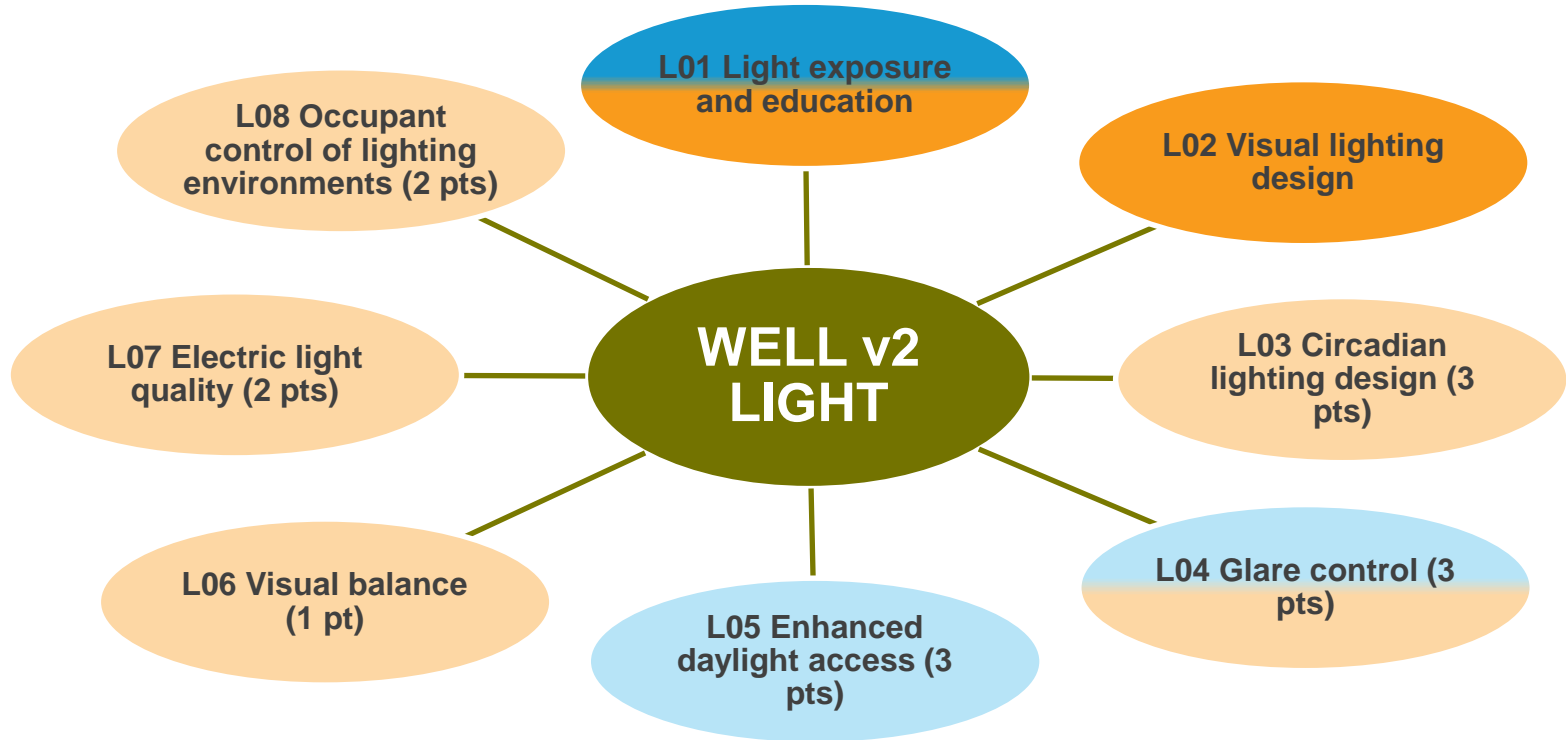


Feature 63 Daylighting fenestration

- Window to wall ratios: 20-60%
 - External shading or adjustable opacity glazing if > 40%
- 40-60% of window area > 2.1m above floor
- Minimum transmittance
 - ≥ 0.6 for windows > 2.1m above floor (excluding skylights)
 - ≥ 0.5 for windows < 2.1m above floor
- Uniform colour transmittance (400-650nm)

OPTIMISATION





Feature L01 Light exposure and education

PRECONDITION

Part 1: Ensure indoor light exposure

– All spaces except dwellings

Daylight in regularly occupied spaces	Daylight in common spaces
$sDA_{200,40\%} \geq 30\%$	$sDA_{300,50\%} \geq 70\%$
30% of workstations within 6m of transparent envelope glazing; VLT > 0.4	70% of seating space within 5m of transparent envelope glazing; VLT > 0.4
Transparent envelope glazing area no less than 7% of floor area for each floor level; VLT > 0.4	Transparent envelope glazing area no less than 10% of gross internal floor area of space; VLT > 0.4

- **Electric lighting** in regularly occupied spaces: Achieve Feature L03 (circadian light)

Feature L01 Light exposure and education

PRECONDITION

Part 1: Ensure indoor light exposure

– Dwellings

$sDA_{200,40\%} \geq 30\%$

Transparent envelope glazing area no less than 7% of floor area; VLT > 0.4

Electric lighting: Achieve Feature L03 (circadian lighting)

Feature L01 Light exposure and education

PRECONDITION

Part 2: Promote lighting education

- Educational resources on:
 - Circadian rhythms
 - Sleep hygiene
 - Age-related increase in light requirements
 - Importance of **daylight exposure** on circadian and mental health

Feature L04 Glare control

OPTIMISATION

Part 1: Control solar glare (2 points)

Window shading	Glare calculation
<ul style="list-style-type: none">• Interior or exterior shading to all spaces (atria/lobbies may be excluded)• Shading controllable by occupants or set to automatically prevent glare• Occupant-controlled shading:<ul style="list-style-type: none">▪ All shades are raised or retracted either manually or automatically at least twice a week	<ul style="list-style-type: none">• Regularly occupied space:<ul style="list-style-type: none">▪ $ASE_{1000,250} \leq 10\%$

Feature L05 Enhanced daylight access

OPTIMISATION

Part 1: Implement enhanced daylight plan (1 point)

All spaces except dwellings	Dwellings
70% of workstations within 7.5m of transparent envelope glazing or atria; VLT > 0.4	Window area no less than 10% of floor area; VLT > 0.4
Window area no less than 10% of regularly occupied floor area; VLT > 0.4	

Feature L05 Enhanced daylight access

OPTIMISATION

Part 2: Implement enhanced daylight simulation (2 points)

- $sDA_{300,50\%}$
 - > 55% of regularly occupied floor area: 1 point
 - > 75% of regularly occupied floor area: 2 points
- All spaces except dwellings: area on each floor
- Dwellings: area in each dwelling unit

Feature L05 Enhanced daylight access

OPTIMISATION

Part 3: Ensure views (1 point)

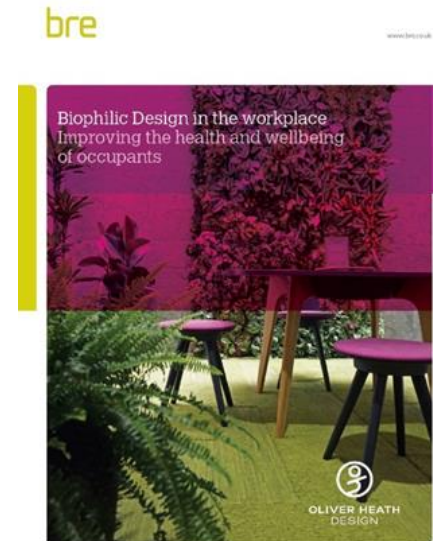
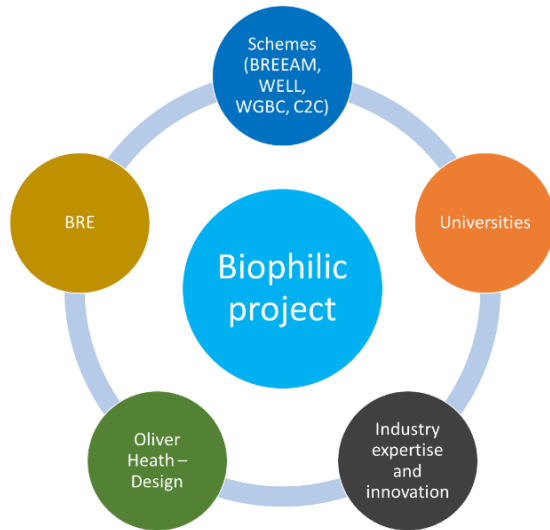
- At least 50% of occupants have access to views through transparent envelope glazing:
 - Ground floor: distance from fenestration to roadway at least 7.5m
 - View factor of 3 or greater
 - Views with a vertical view angle of at least 30 degrees from occupant facing forward or sideways provide a direct line of sight to the ground or sky

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BRE Biophilic Office

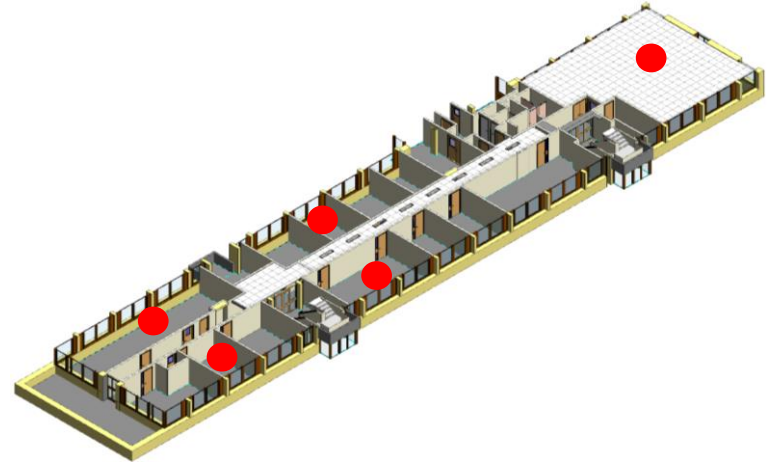
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- Two-year multidisciplinary research and demonstration project investigating:
 - How office refurbishment measures inspired by biophilic design principles can improve occupant productivity, health and wellbeing



Computer modelling of daylight:

- Daylight distribution across office space
- Annual profiles of daylight illuminance at eye level, and working plane level



Daylight monitoring:

- Outdoor levels
- Indoor levels



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CBDM Results

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DIVA-for-Rhino

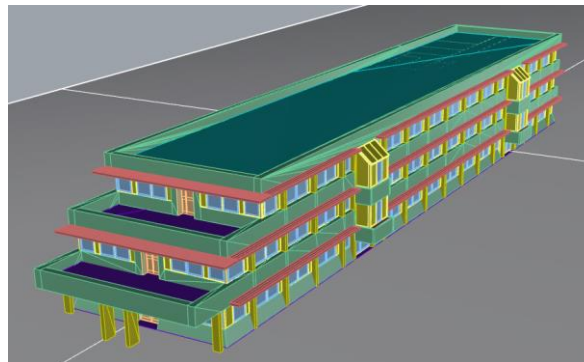
-ab 5 -ad 1000 -as 32 -ar 1000 -aa 0.1

Occupancy: 0800-1800 weekdays

Empty spaces

Working plane

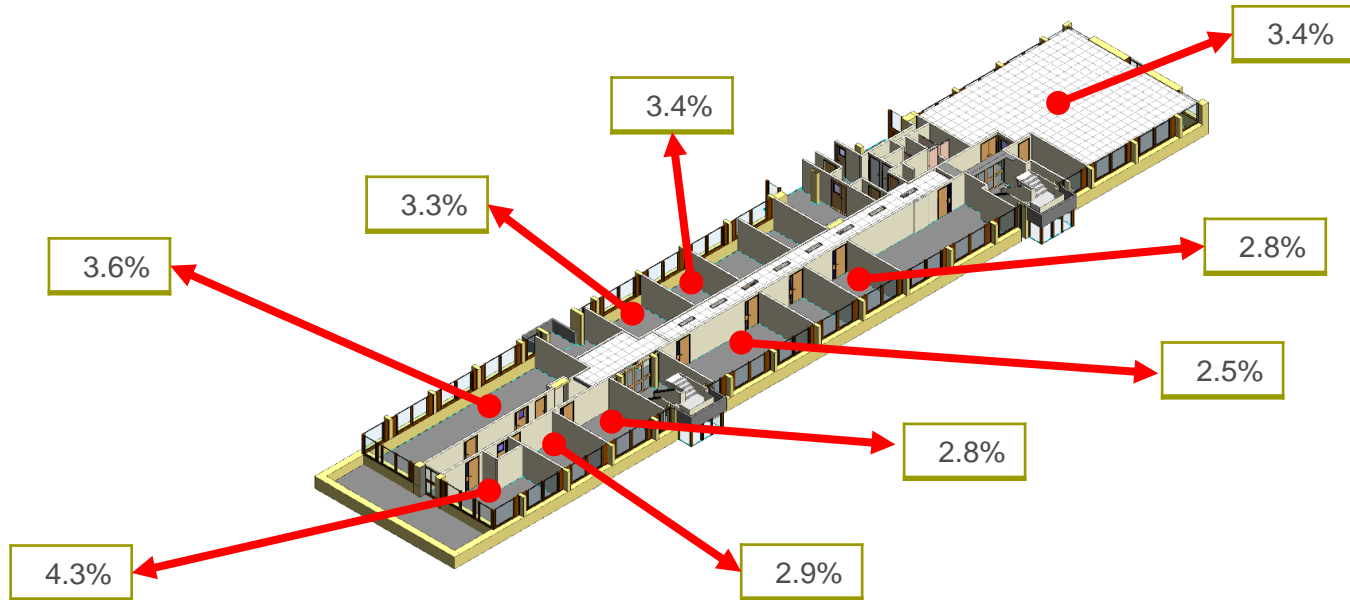
Reflectances as measured in situ



Scenario	Description
NB	No blinds
CDS	Conceptual dynamic shading (idealised blinds)
DDS1	Detailed dynamic shading v1 (2 states: down & open; down & closed)
DDS2	Detailed dynamic shading v2 (3 states: up; down & open; down & closed)

Overall

3.3%



Overall

NB	97%
CDS	30%
DDS1	11%
DDS2	12%

NB	98%
CDS	18%
DDS1	3%
DDS2	9%

NB	100%
CDS	34%
DDS1	40%
DDS2	36%

NB	100%
CDS	34%
DDS1	0%
DDS2	3%

NB	100%
CDS	50%
DDS1	0%
DDS2	5%

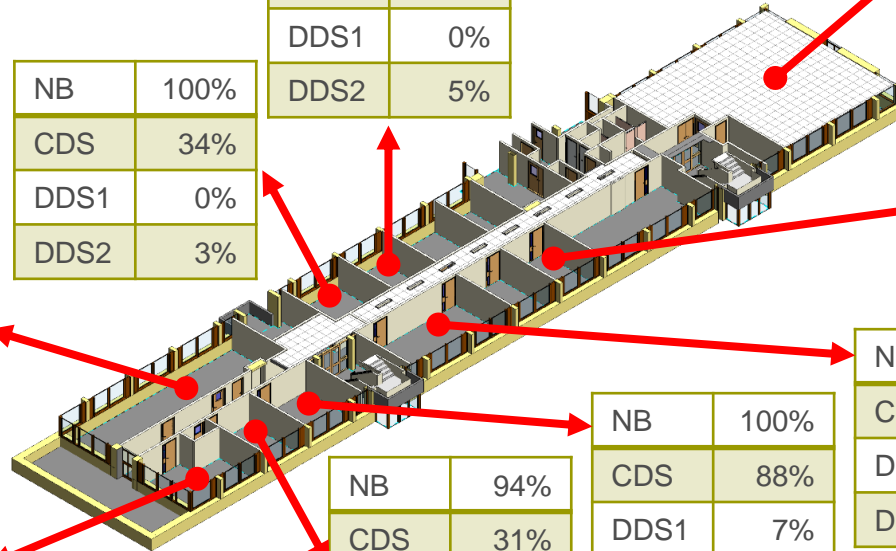
NB	94%
CDS	31%
DDS1	10%
DDS2	9%

NB	100%
CDS	88%
DDS1	7%
DDS2	8%

NB	99%
CDS	32%
DDS1	4%
DDS2	4%

NB	100%
CDS	28%
DDS1	8%
DDS2	9%

NB	94%
CDS	21%
DDS1	16%
DDS2	17%



Overall

NB	100%
CDS	71%
DDS1	48%
DDS2	72%

NB	100%
CDS	51%
DDS1	29%
DDS2	70%

NB	100%
CDS	94%
DDS1	96%
DDS2	100%

NB	100%
CDS	90%
DDS1	16%
DDS2	53%

NB	100%
CDS	98%
DDS1	20%
DDS2	55%

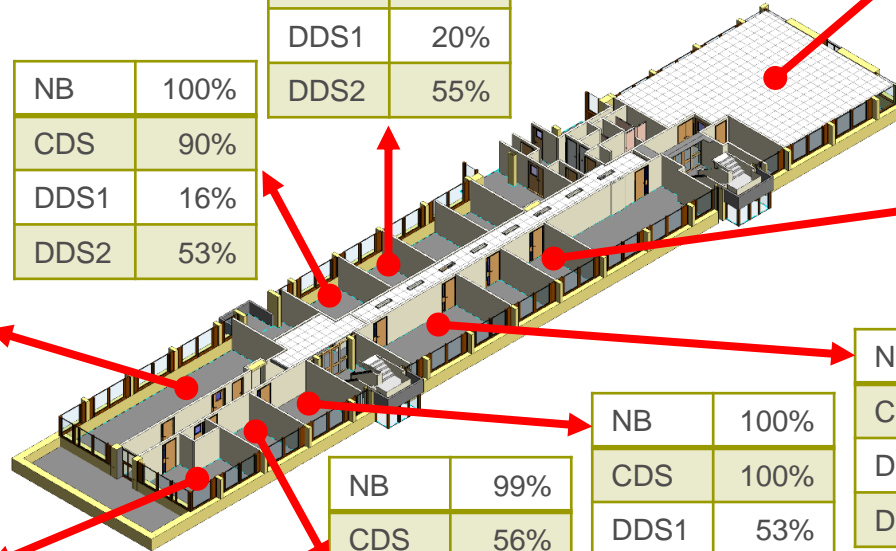
NB	99%
CDS	56%
DDS1	54%
DDS2	71%

NB	100%
CDS	100%
DDS1	53%
DDS2	79%

NB	100%
CDS	89%
DDS1	47%
DDS2	67%

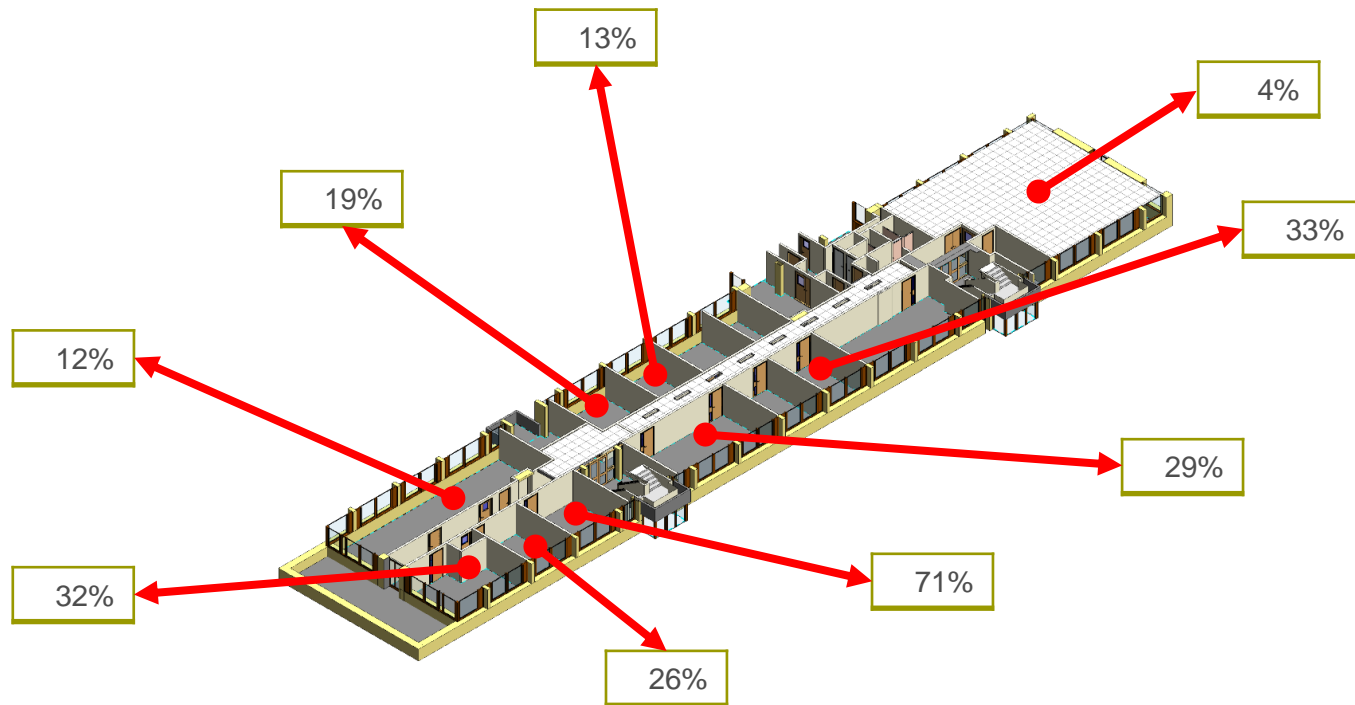
NB	100%
CDS	84%
DDS1	50%
DDS2	70%

NB	100%
CDS	55%
DDS1	55%
DDS2	73%



Overall

20%



Overall

NB	20%
CDS	20%
DDS1	20%
DDS2	20%

NB	12%
CDS	12%
DDS1	1%
DDS2	1%

NB	32%
CDS	32%
DDS1	68%
DDS2	68%

NB	19%
CDS	19%
DDS1	0%
DDS2	0%

NB	13%
CDS	13%
DDS1	0%
DDS2	0%

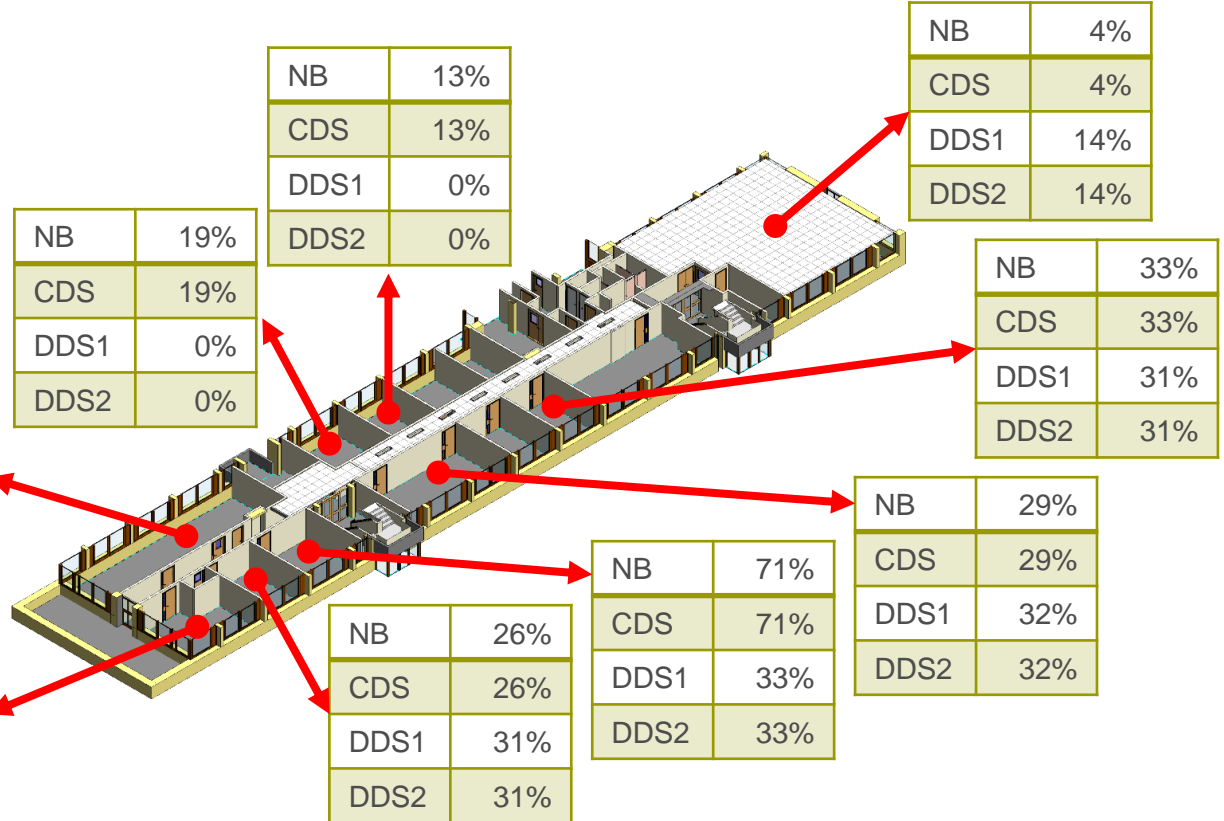
NB	26%
CDS	26%
DDS1	31%
DDS2	31%

NB	71%
CDS	71%
DDS1	33%
DDS2	33%

NB	29%
CDS	29%
DDS1	32%
DDS2	32%

NB	33%
CDS	33%
DDS1	31%
DDS2	31%

NB	4%
CDS	4%
DDS1	14%
DDS2	14%



WELL v1

Feature 62 Daylight modelling (optimisation)

Scenario	sDA _{300,50%}	≥ 55%	ASE _{1000,250}	≤ 10%	Overall
NB	97%	Yes	20%	No	No
CDS	30%	No	20%	No	No
DDS1	11%	No	20%	No	No
DDS2	12%	No	20%	No	No

WELL v2

Feature L01 Light exposure and education (precondition)

Part 1: Ensure indoor light exposure

Scenario	sDA _{200,40%}	≥ 30%
NB	100%	Yes
CDS	71%	Yes
DDS1	48%	Yes
DDS2	72%	Yes

WELL v2

Feature L04 Glare control (optimisation)

Part 1: Control solar glare (2 points)

Scenario	ASE _{1000,250}	≤ 10%
NB	20%	No
CDS	20%	No
DDS1	20%	No
DDS2	20%	No

WELL v2

Feature L05 Enhanced daylight access (optimisation)

Part 2: Implement enhanced daylight simulation

Scenario	sDA _{300,50%}	> 55%	> 75%
NB	97%	Yes	Yes
CDS	30%	No	No
DDS1	11%	No	No
DDS2	12%	No	No

DIVA-for-Rhino

-ab 5 -ad 1000 -as 32 -ar 1000 -aa 0.1

Empty spaces

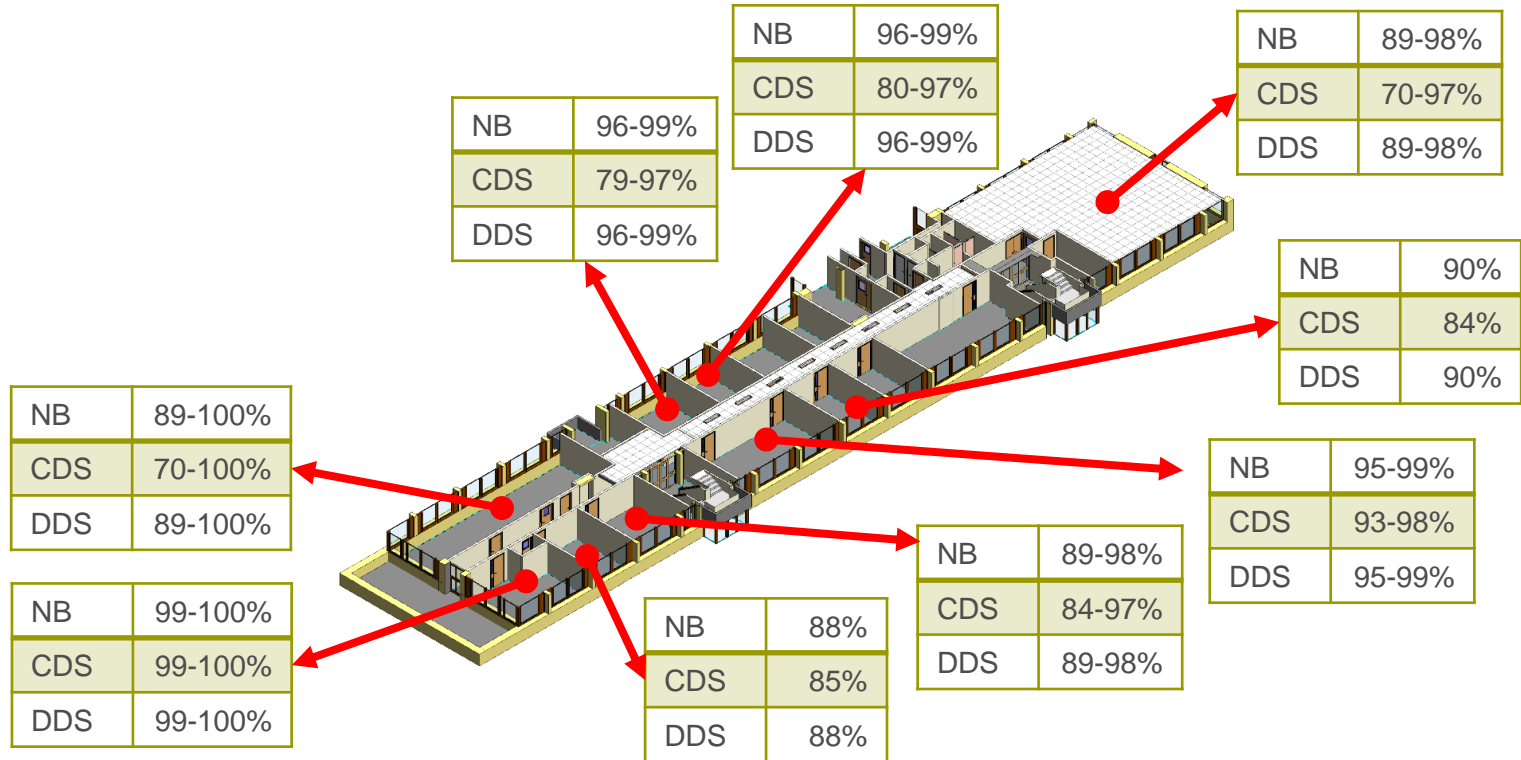
Occupancy: 0900-1300 weekdays

Reflectances as measured in situ

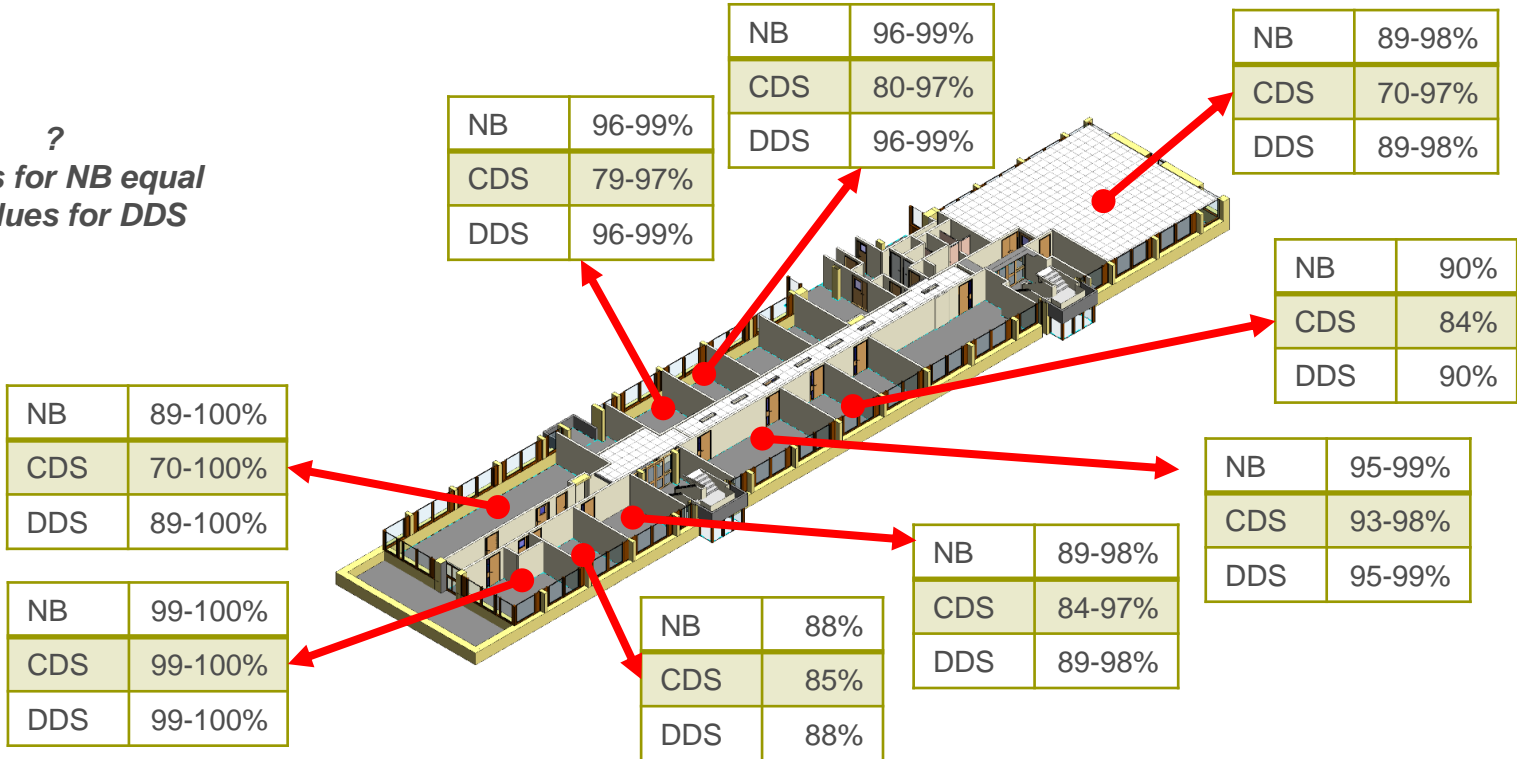
Eye level

Scenario	Description
NB	No blinds
CDS	Conceptual dynamic shading (idealised blinds)
DDS	Detailed dynamic shading v2 (3 states: up; down & open; down & closed)

Required	200 EML
Provided by electric lighting	61 EML (124 lux) 3000K & 4000K T8
Target for daylight	139 EML (164 lux) ~5100K from windows



?
 Values for NB equal
 to values for DDS



WELL v1

Feature 54 Circadian lighting design (precondition)

Required	200 EML
Provided by electric lighting	61 EML (124 lux) from 3000K & 4000K T8
Target for daylight	139 EML (164 lux) from ~5100K from windows

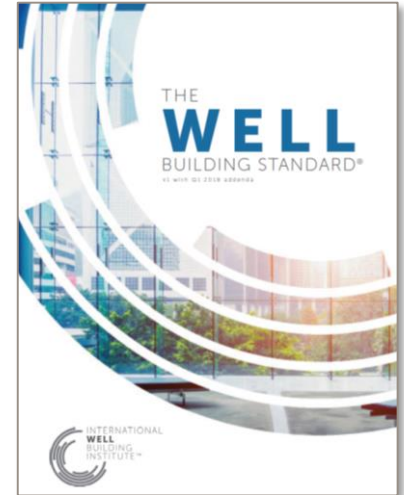
Scenario	Proportion of workstations with $DA_{164}=100\%$	$\geq 75\%$
NB	9%	No
CDS	12%	No
DDS	9%	No

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Conclusions

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- Taking forward building design
- Tangible advice and rating system for measuring and verifying building design & performance
- Some features easy to evaluate
- Others require more complex testing and/or modelling protocols
- WELL v2 provides more flexibility in meeting the mandatory 'Light' criteria compared to WELL v1
- Modelling outcomes strongly dependent on assumptions and algorithms
- In practice, it may be difficult to comply and/or demonstrate compliance



Thank you

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