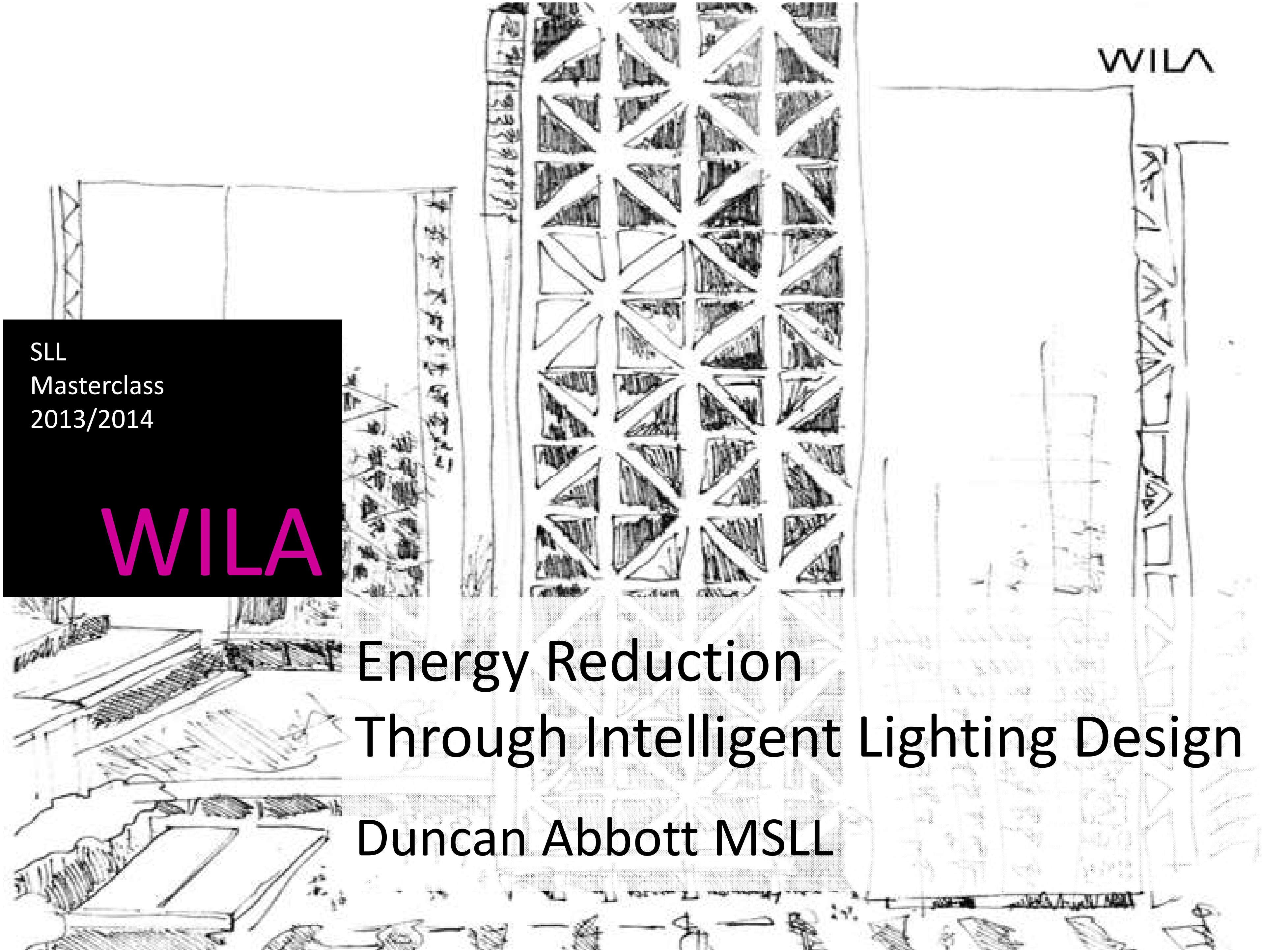


WILA

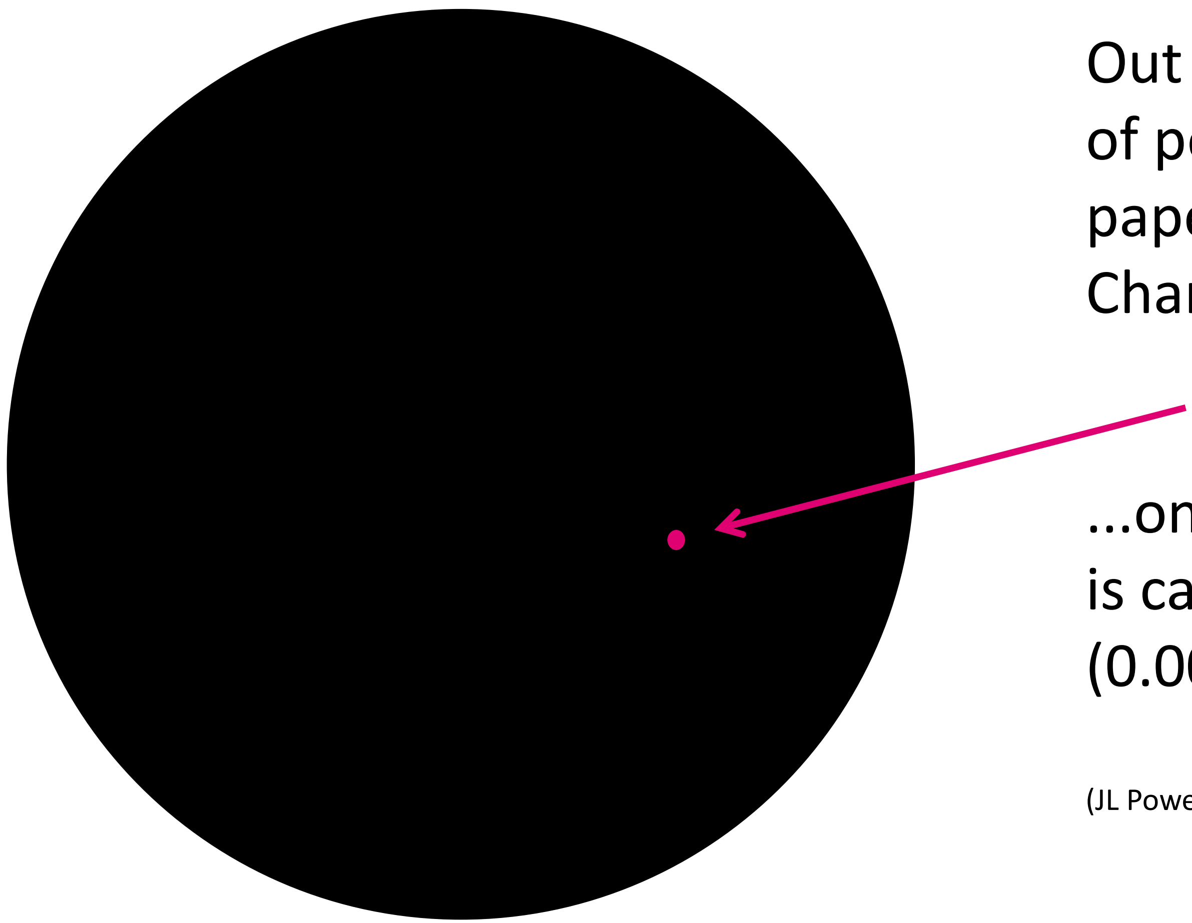
SLL
Masterclass
2013/2014

WILA

Energy Reduction Through Intelligent Lighting Design

Duncan Abbott MSLL

Climate change is real but are humans causing it?



Out of 33,700 authors of peer reviewed papers on Climate Change ....

...only 34 reject that it is caused by humans (0.001%)

(JL Powell – between 1991 and 2011)

Why Reduce Energy?

- Lighting accounts for 20% of global electricity consumption
- Global target of 50% reduction in CO_2 required by 2050
- UK committed to 80% reduction in CO_2 by 2050 (based on 2005 targets)

Energy Reduction through Intelligent Lighting Design

1. The importance of good scheme design utilising daylight
2. Selection of efficient luminaires without compromising light quality
3. Use of controls to deliver the right light to the right place at the right time
4. Post occupancy evaluation to verify energy reduction

WILA

1.

The importance of good scheme design utilising daylight

No daylight – worst case

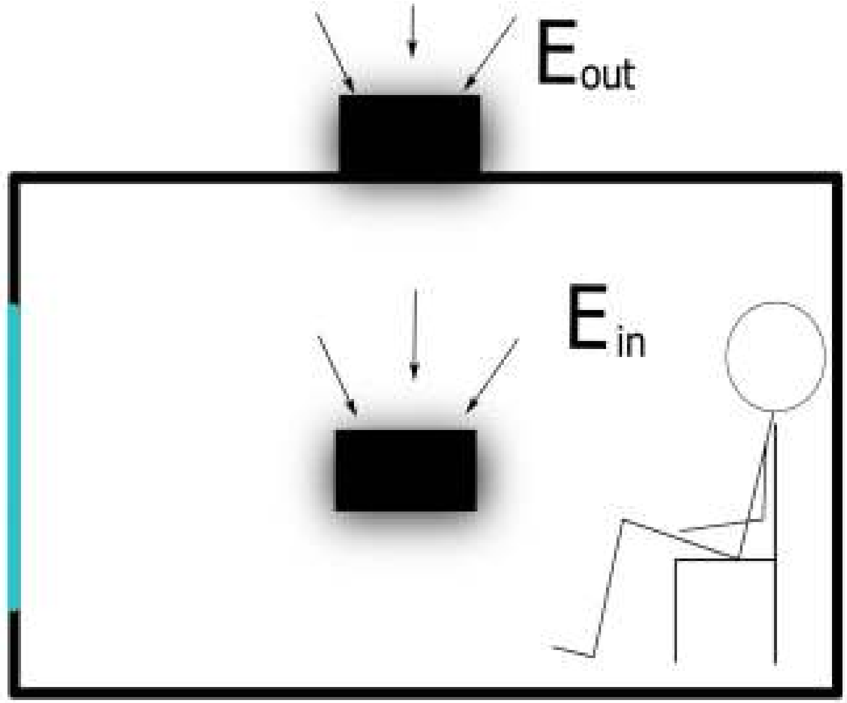
10,000 lux

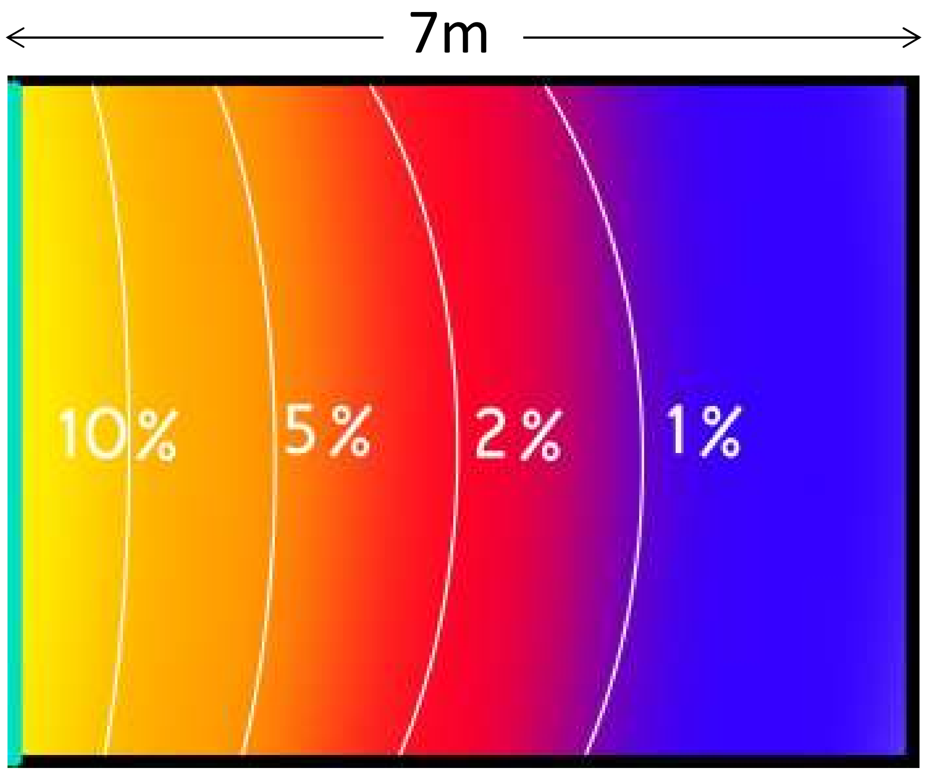

120,000 lux

The Importance of Good Daylighting in Buildings

- Energy reduction possibilities
- Statistically preferred by occupants
- Positive health, wellbeing and productivity benefits
- Non visual effects of daylight

Daylight Factor





DF = $100 * E_{in}/E_{out}$ (using the CIE overcast sky)

Daylight Factor

- According to BS8206 the average DF should be at least 2%. If the average daylight factor in a space is at least 5% then electric lighting is not normally needed during the daytime.
- Carbon Trust recommends 4% DF, preferably 6%
- Where 80% of occupied space has a DF of 2% BREEAM will award - 1 credit
- Where all space has a DF of at least 4% in single story and 3% in multi story BREEAM will award - 2 credits

WILA

Daylight Factor

$DF = 100*E_{in}/E_{out}$

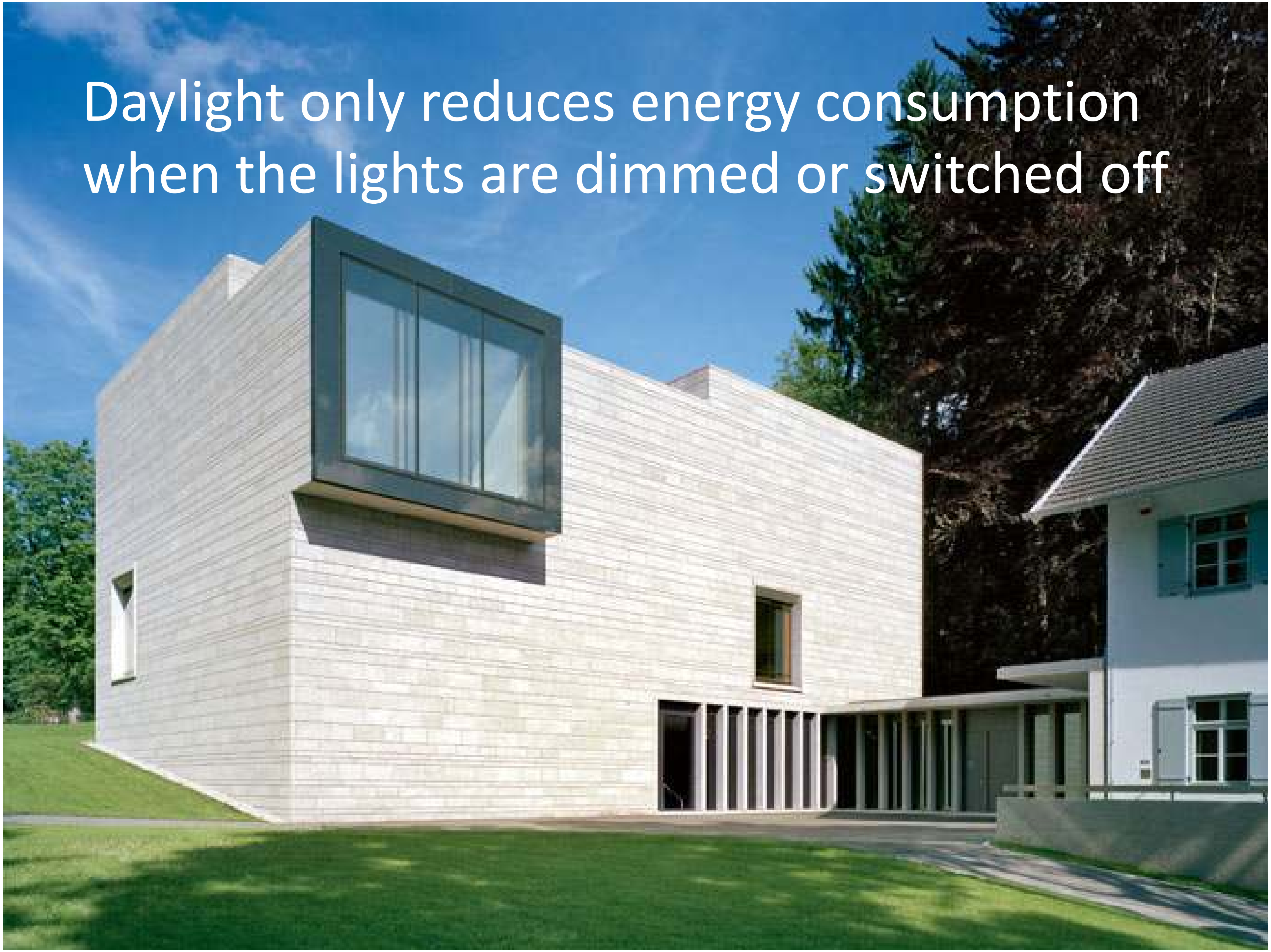
$E_{in} = E_{out}*DF/100$

Using DF = 5% average

$E_{in} = 10{,}000*5/100$

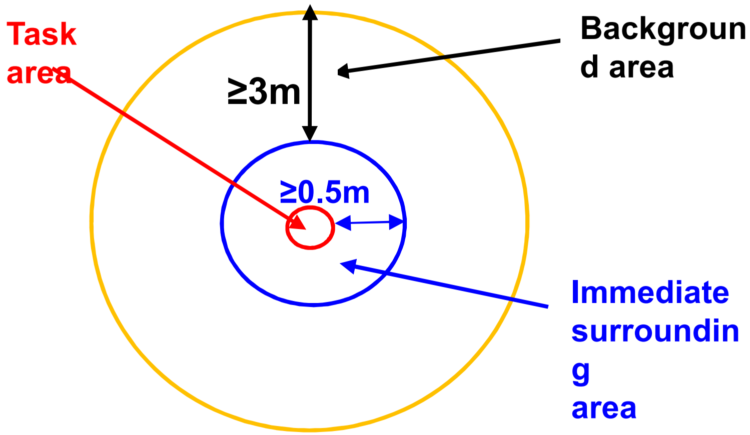
$E_{in} = 500$ lx average

CIE overcast sky

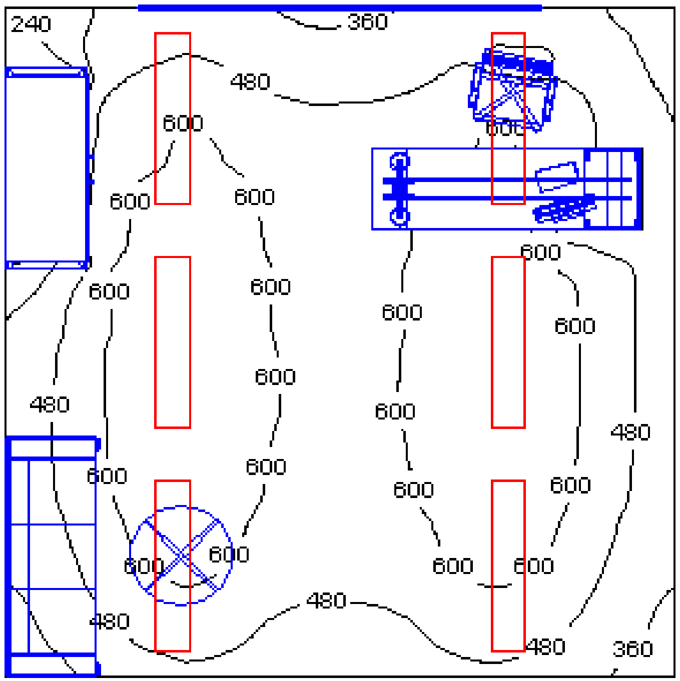

Daylight only reduces energy consumption
when the lights are dimmed or switched off

Put the Light where it is required

- Lighting the task
  - The SLL Code
  - EN12464-1
- Horizontal or vertical task

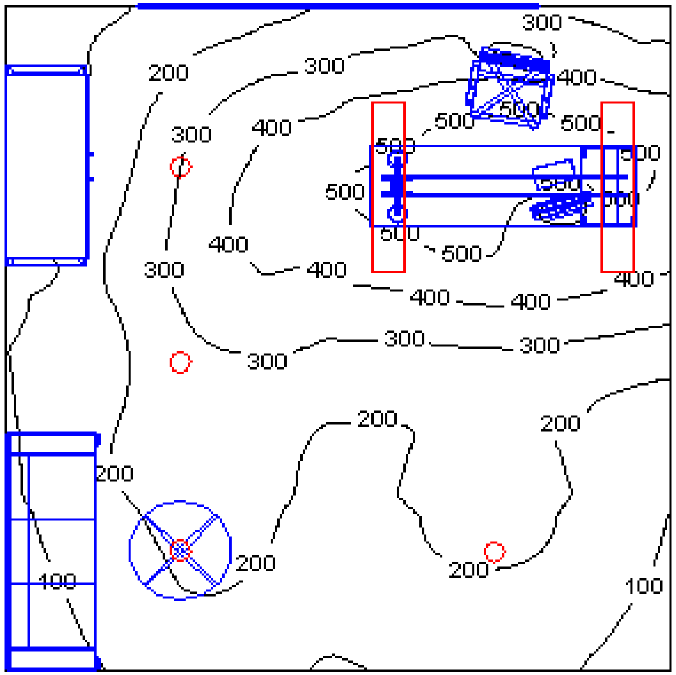


Lighting the working plane



- 500 lux on desk – task, surround and background
- Illuminated walls and ceiling
- 14.6 W/m²

Lighting the task



- 500 lux on desk (250 lux average)
- Illuminated surround and background
- Illuminated walls and ceiling
- 7.1 W/m^2

2.

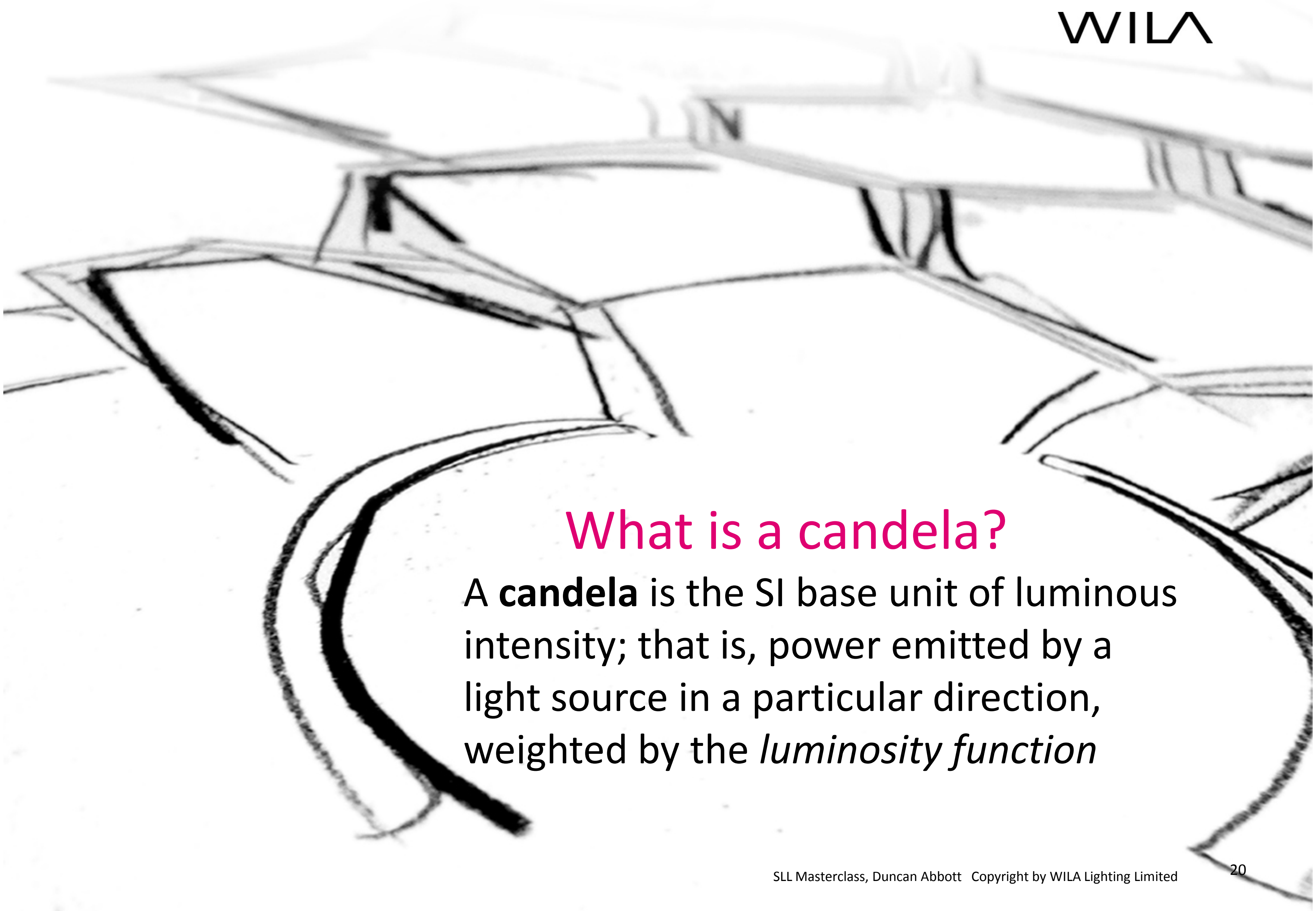
Selection of efficient luminaires without compromising light quality

Luminaire Efficiency

- Building Regulations
  - Part L (2010) 55 Llm/Wc
  - Part L (2013) 60 Llm/Wc
- Enhanced Capital Allowance
- Light source + luminaire
- Efficiency vs Efficacy?

What is a lumen?

A **lumen** is the derived SI unit of luminous flux; the flux emitted in a solid angle of 1 steradian by a point source having a uniform intensity of 1 *candela*



What is a candela?

A **candela** is the SI base unit of luminous intensity; that is, power emitted by a light source in a particular direction, weighted by the *luminosity function*

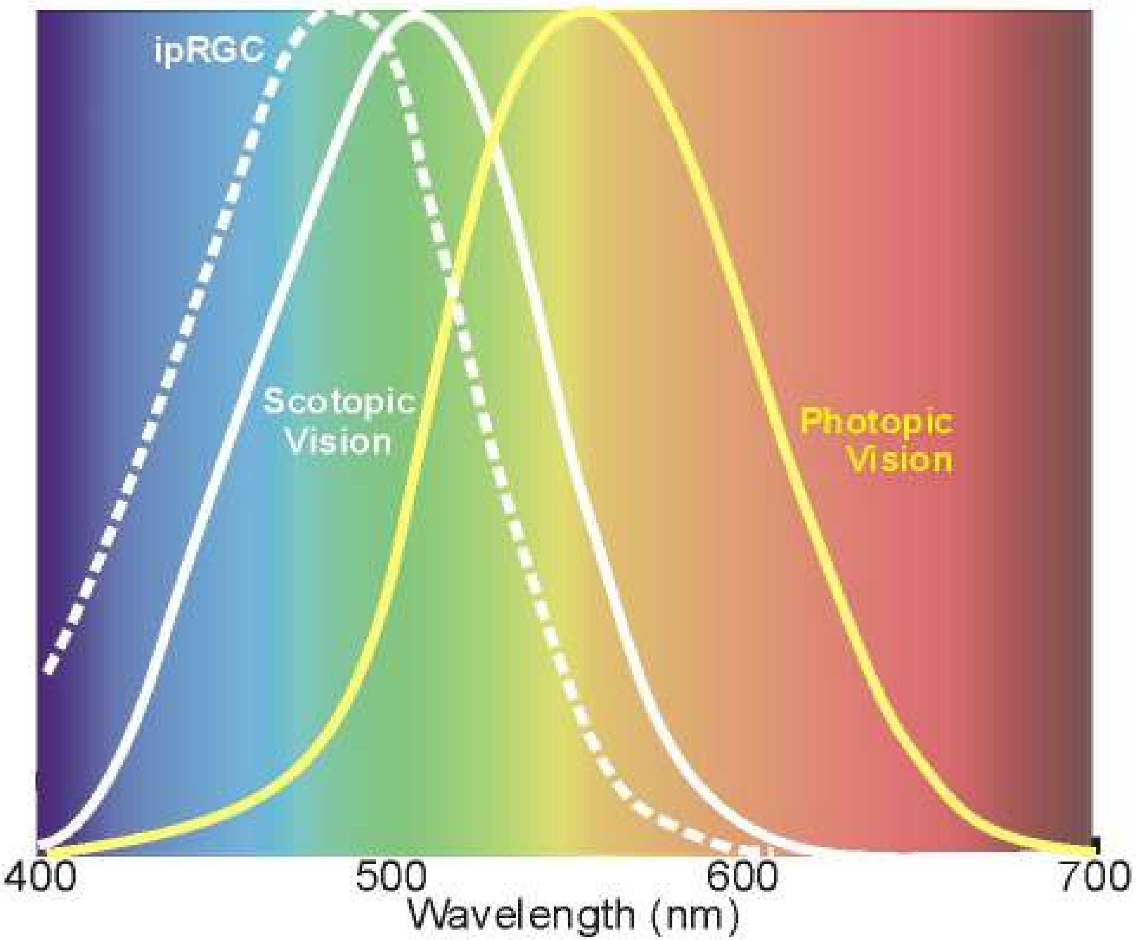
WILA

What is the luminosity function?

The **luminosity function,** or luminous efficiency function describes the average spectral sensitivity of human visual perception of brightness

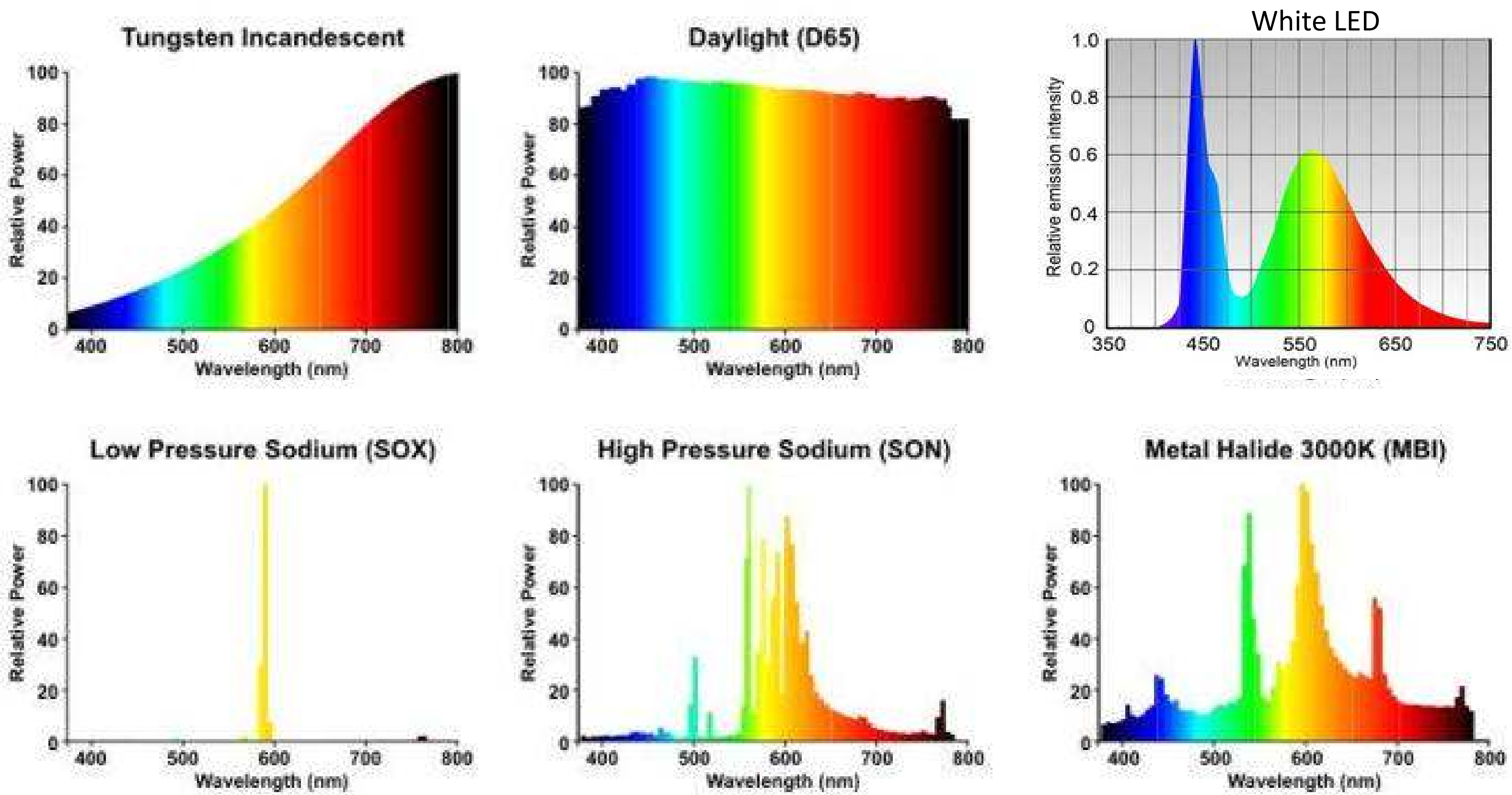
WILA

What is the Luminosity Function?



WILA

Spectral Distribution



- Efficacy is dependant on the effect on the average human eye

Efficient Light Sources – Caution

- Efficient light sources do not necessarily provide good quality light
  - Low pressure sodium
- LED is not necessarily better!
- Do not neglect:
  - Colour rendering index (CRI)
  - Correlated colour temperature (CCT)
  - Standard deviation of colour matching (SDCM)

Luminaire Lumens per Circuit Watt

Ingenic

Micro Prism | Opal Cover | Parabolic Louvre

Ingenic ®
Pendant Luminaires
with Micro Prismatic Cover
Fluorescent Lamps

$$\frac{\text{Lamp lumens x LOR}}{\text{Circuit Watts}}$$

Lamp, Wattage T16	L mm	L1 mm	W mm	H mm	H1 mm	kg	$\gamma \geq 65°$ cd/m²	η %	UGR	LZ	Lm/W	Article number	DALI
2 x 28 W	1277	1000	249	45	1500	5,6	<3000	89	14	0,04	76	IG2205-53	-DD
2 x 35 W	1577	1300	249	45	1500	6,8	<3000	97	14	0,03	85	IG2206-53	-DD
2 x 49 W	1577	1300	249	45	1500	6,8	<3000	83	15	0,03	70	IG2207-53	-DD
2 x 54 W	1277	1000	249	45	1500	5,6	-	85	16	0,02	67	IG2208-53	-DD
2 x 80 W	1577	1300	249	45	1500	6,8	-	70	16	0,02	52	IG2209-53	-DD

Luminaire Lumens per Circuit Watt

WILA

LED Tentec

Downlights | with Liteoptic

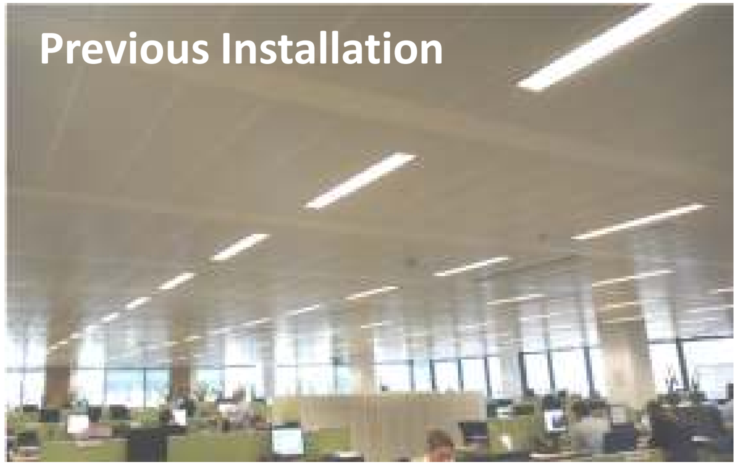
Luminaire module + Liteoptic
TL1101002-03-40+81001R18

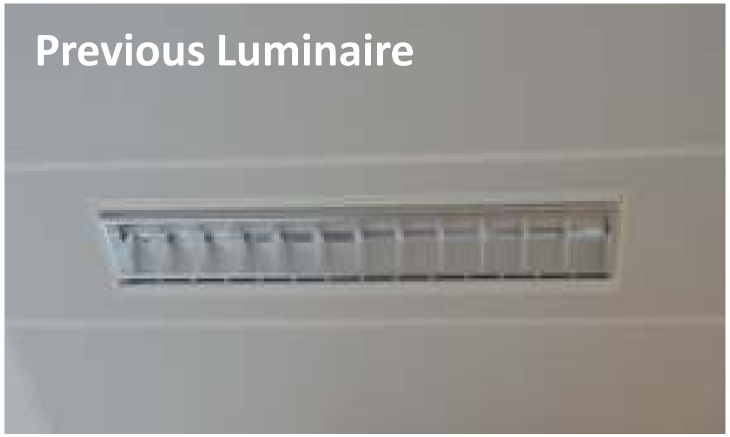
Lamp, Wattage:	LED(4000K)
Colour Rendering Index CRI:	80
Electrical power:	23 W
Reflector size:	R18
Height H:	5 mm
Ceiling cut-out CO:	195 mm
Diameter D:	210 mm
Installation depth RD:	160 mm
Weight:	1,1 kg
Average luminance:	<1000 cd/m^2
Unified Glare Rating UGR:	17
Number of Luminaires:	0,06
System-Luminaire lumens:	2050 LIm
System-Lumen per watt:	79 LIm/W

- Not all manufacturers publish luminaire lumens

Case Study - Cat A office fit out

Case Study – Previous Installation





- Recessed 1x21W T5 luminaire with aluminium louvre and HF ballast
- Recessed 1x32W CFL downlights with HF
- 414 lux average at desk height
- 1.77 $W/m^2/100$ lux
- 143 lux cylindrical illumination (at 1.6m)

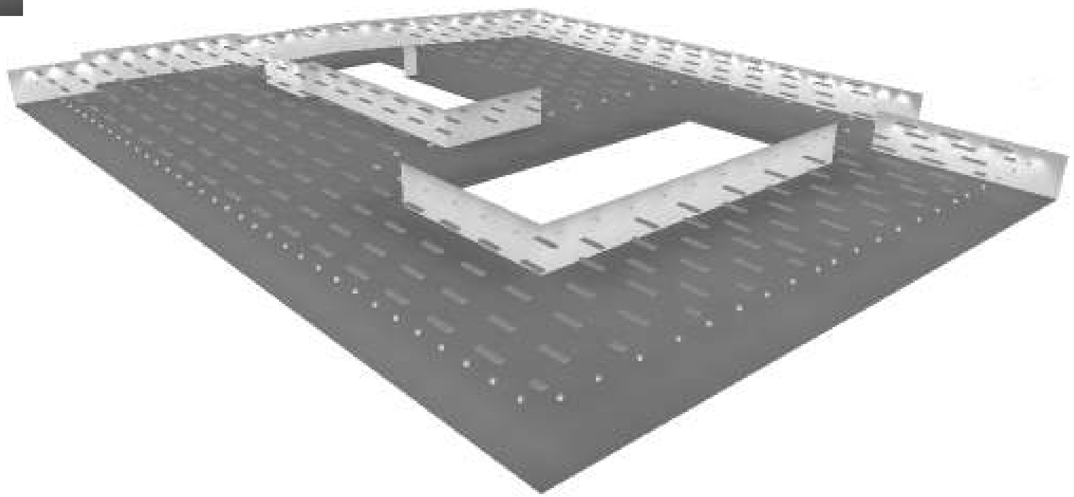
The client required new lighting to modernise the space and create a brighter feel, achieving 500 lux on the desk

Case Study – New Installation

- Recessed 2x28W T5 luminaire with micro prismatic optic and DALI ballast
- Recessed 30W LED downlight with DALI ballast
- 537 lux average at desk height (**+30%**)
- 1.66 $W/m^2/100$ lux (**-7%**)
- 294 lux cylindrical illumination (**+106%**)
- Dimming ballast provides further energy saving possibilities
- Half the number of luminaires

Case Study – What could be achieved with LED?

- 524 lux at desk height (**+27%**)
- 243 lux Ec (**+70%**)
- 1.24 W/m²/100 lx (**-30%**)
- Cost generally depends on quality of LEDs used



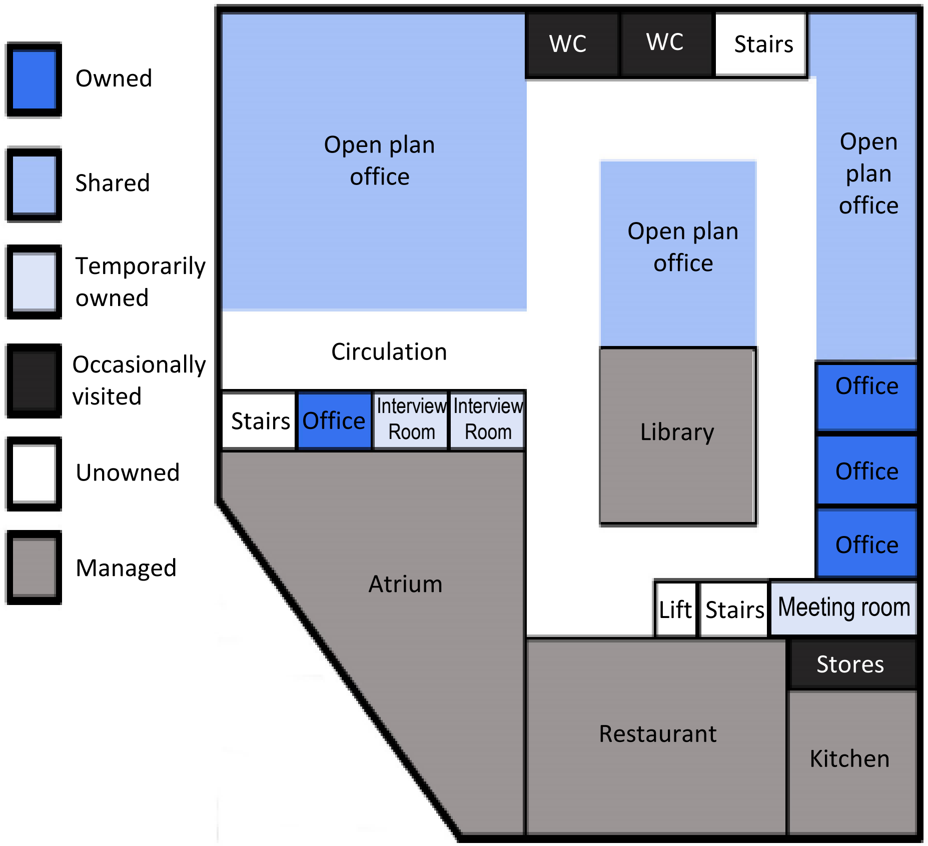
WILA

3.

Use of controls to deliver the right light to the right place at the right time

Lighting Controls and Energy Saving

- Part L (2013) specifies that lighting controls are to be fitted to new and refurbished buildings
- Appropriate control methods should be utilised in different zones of the building
- Zoning is also required for LENI calculations



Manual Operation

- The cheapest form of control and provides direct user control
- Lights only come on if required
- Manual dimming gives the user the option to select less than 100% power if preferred.
- Relies on the user to switch off

WILA

Time Control

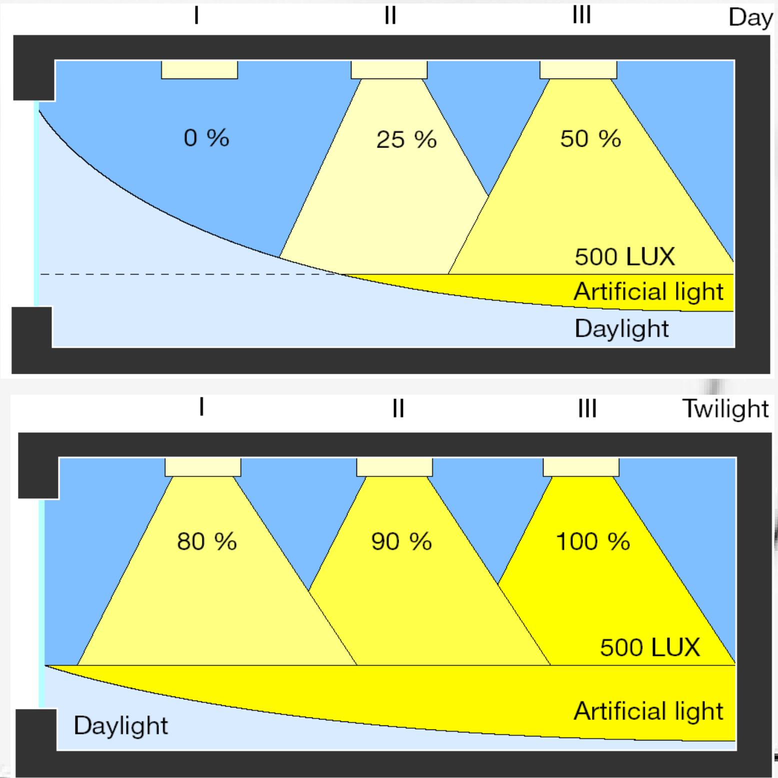
- Time control is a form of occupancy control based on predicted patterns of usage
- Can be set to opening times of buildings or sunrise and sunset
- Can be used to change the mode of operation.

Occupancy Control

- You don’t need to light an empty office
- People generally don’t switch lights off if they are not paying the electricity bill
- Absence detection – request on and auto off
- Subtle dimming can be more effective in an open plan office than switching

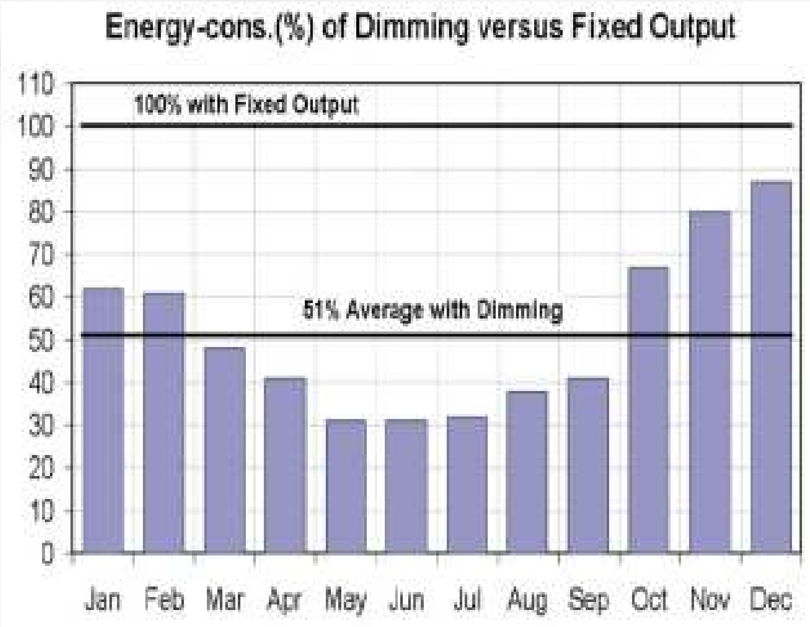
WILA

Daylight Linked Control



- Energy saving from daylight only happens when the lights are dimmed or switched off
- Typical daylight penetration into a room with single sided glazing is only meaningful up to 7 metres
- Subtle dimming is more effective than on/off switching which can be distracting

Daylight Linked Control



- Real life data from installation with dimming by ambient light sensor
- With occupancy sensors a decrease from 51% to 30% is realistic.

Constant Illuminance

- Due to maintenance factor (MF) rooms are over lit from day 1
- Using a 0.7 MF means that there is a 20% energy saving to be had
- Achieved by photo cells or intelligent ballasts

WILA

Lighting Controls and Energy Saving

WILA

4.

Post occupancy evaluation to verify energy reduction

Lighting Energy Numeric Indicator (LENI)

- LENI methodology calculates energy usage per m^2 and compares it to a Part L allowance

- Divide building into zones according to:
  - Task type / required illuminance
  - Daylight availability
  - Annual usage
- Occupancy Factor (F_o)
- Daylight Factor (F_d)
- Constant illuminance factor (F_c)

$$LENI = \frac{E_p + E_d + E_n}{A}$$

WILA

Lighting Energy Numeric Indicator (LENI)

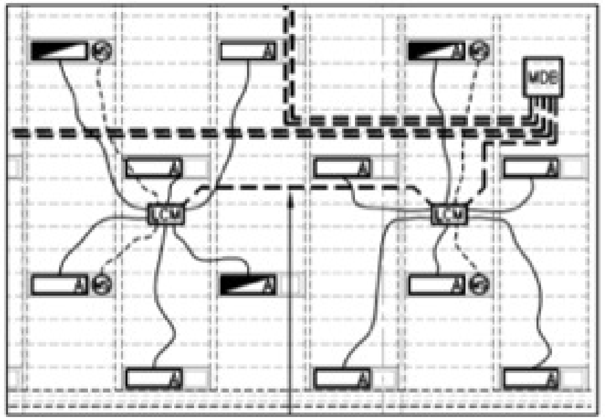
Using the example of a classroom - look up the LENI allowance for 300 lux and 1500 hours use:

Hours			Illuminance								Display Lighting	
Total	**Day**	**Night**	**50**	**100**	**150**	**200**	**300**	**500**	**750**	**1000**	**Normal**	Shop Window
1000	821	179	1,11	1.92	2.73	3.54	5.17	8.41	12.47	15.52	10.00	
1500	1277	223	1.66	2.87	4.07	5.28	7.70	12.53	'8.57	24.62	15.00	
2000	1726	274	2.21	3.81	5.42	7.03	10.24	16.67	24.70	32.7.3	20.00	
2500	2164	336	2.76	4.76	6.77	8.78	12.79	20.82	30.86	40.89	25.00	
3000	2585	415	3.31	5.72	8.13	10.54	15.37	25.01	37.06	49.12	30.00	
3700	3133	567	4.09	7.08	10.06	13.04	19.01	30.95	45.67	50,78	37.00	
4400	3621	779	4.89	8.46	12.02	15.59	22.73	37.00	54.84	72.68	44.00	96.80
5400	4184	1216	6.05	10.47	14.90	19.33	28.18	45.89	68.03	90.17	54.00	
6400	4547	1853	7.24	12.57	17.89	23.22	33.87	55.16	81.79	108.41	64.00	
8760	4380	4380	'0.26	17.89	25.53	33.16	48.43	78.96	117.12	155.29	87.60	192.72

$$KWh / m^2 a$$

Metering of Lighting Power Consumption

Recommended minimum standards for metering of lighting	
	Standard
Metering for general or display lighting	a. KWh meters on dedicated lighting circuits in the electrical distribution, or b. Local power meter coupled to or integrated in the lighting controllers of a lighting or building management system, or c. A lighting management system that can calculate the consumed energy and make the information available to a building management system or in an exportable file



- Of these options the use of KWh meters is generally the most expensive
- You can no longer run extractor fans or fan coil units from the lighting circuit

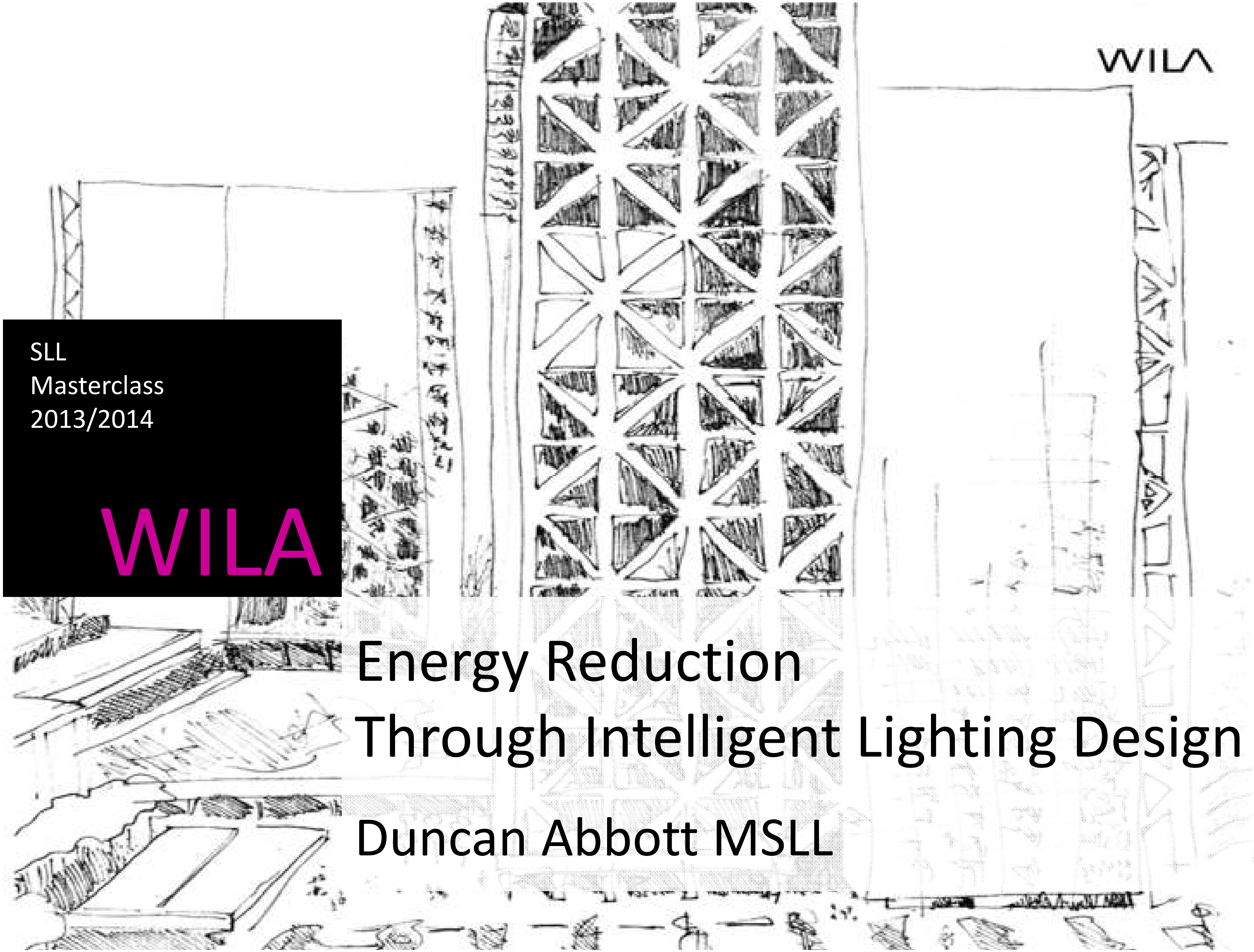
WILA

Metering Analysis of Usage

- Measure and analyse energy use
- An important piece of information available from the lighting control system is the actual building usage - provided by presence detectors
- Make changes to the control regime as suggested by the analysis
- Measure again and compare results

Energy Reduction through Intelligent Lighting Design

1. The importance of good scheme design utilising daylight
2. Selection of efficient luminaires without compromising light quality
3. Use of controls to deliver the right light to the right place at the right time
4. Post occupancy evaluation to verify energy reduction



WILA

SLL
Masterclass
2013/2014

WILA

Energy Reduction
Through Intelligent Lighting Design

Duncan Abbott MSLL