Seminar 1 - Planning a Lighting Retrofit

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Who I am

- Steven Beletich
  - Phase out of incandescent lamps (Australia, China, Middle East)
  - NSW ESS architect (+VEET)
  - CBD tenancy lighting methodology
  - etc.

Learning Objectives of this Session

- By the end of this session, you should:
  - Have a basic understanding of lighting technologies and efficiency
  - Be able to determine if your building has efficient lighting
  - Be engaged !!
  - Be empowered !!

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Contents

- Lighting in context
- The basics of lighting
- What makes lighting efficient?
- Does your building have efficient lighting?
- Interactive exercise – benchmarking your lighting
- After benchmarking?
- Context = primarily office space

Lighting in Context

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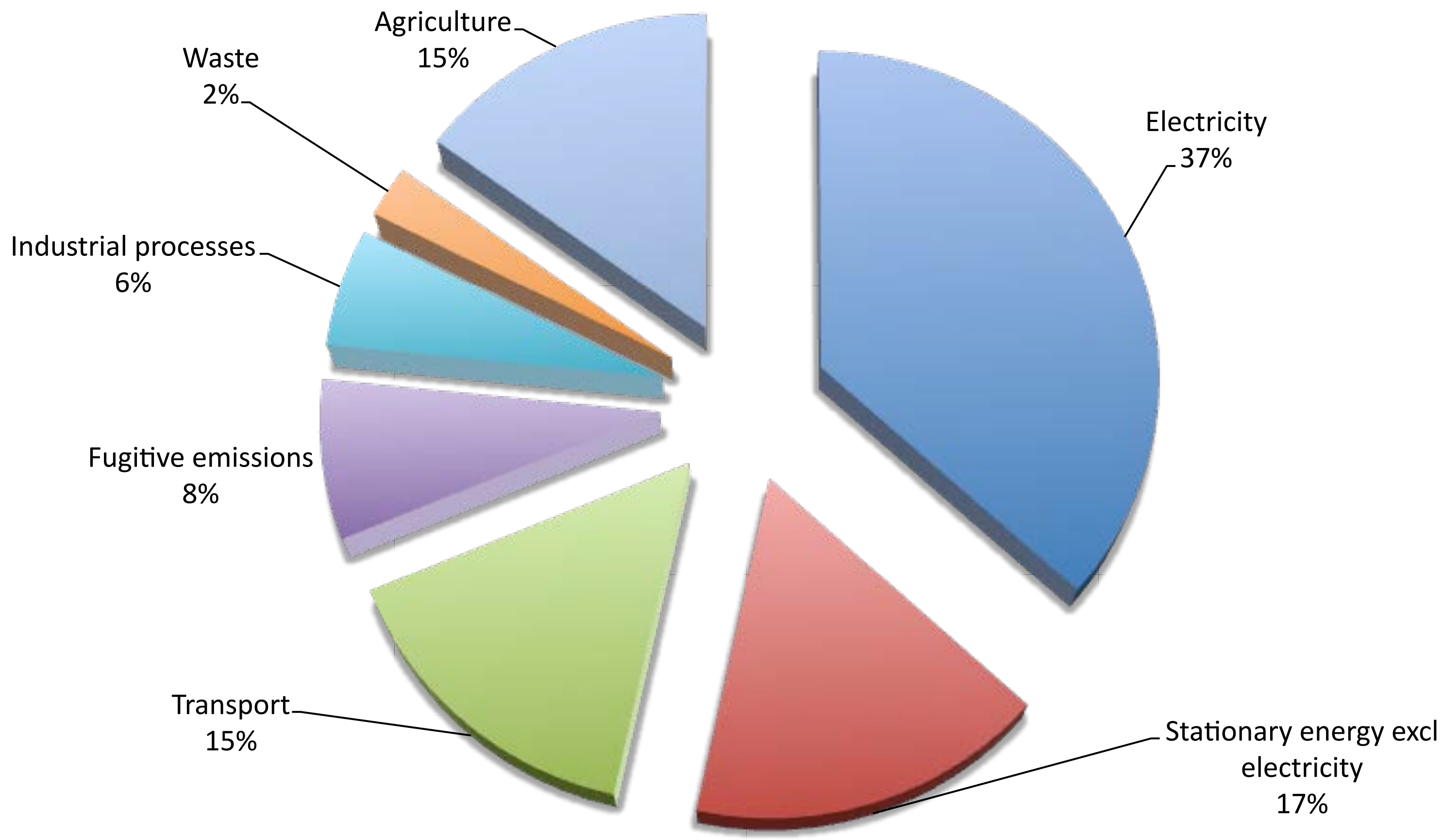
Australia's Greenhouse Gas Emissions



Source: DCCEE, Quarterly Update of Australia's National Greenhouse Gas Inventory (annual emissions), September Quarter 2010

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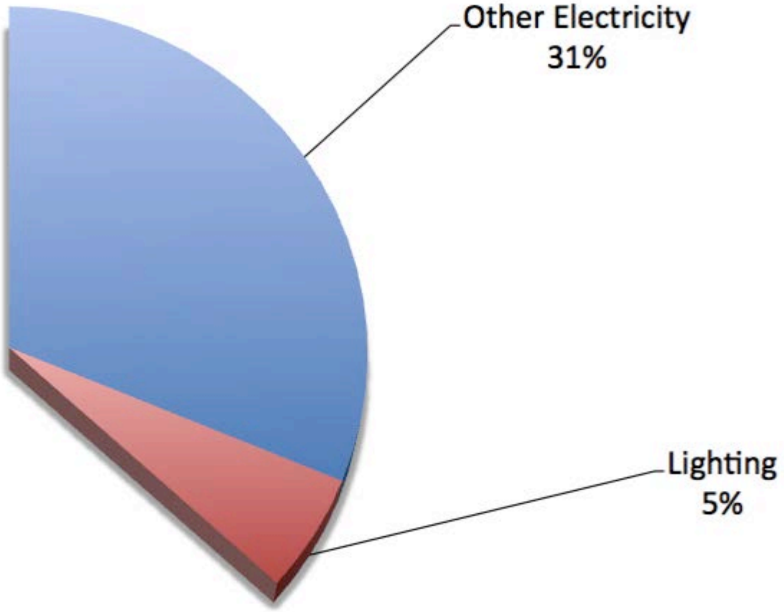
Australia's Greenhouse Gas Emissions (cont)

- Lighting ~ 25% of office energy
- Simplest to upgrade



Source: Greenlight Australia Strategy 2004

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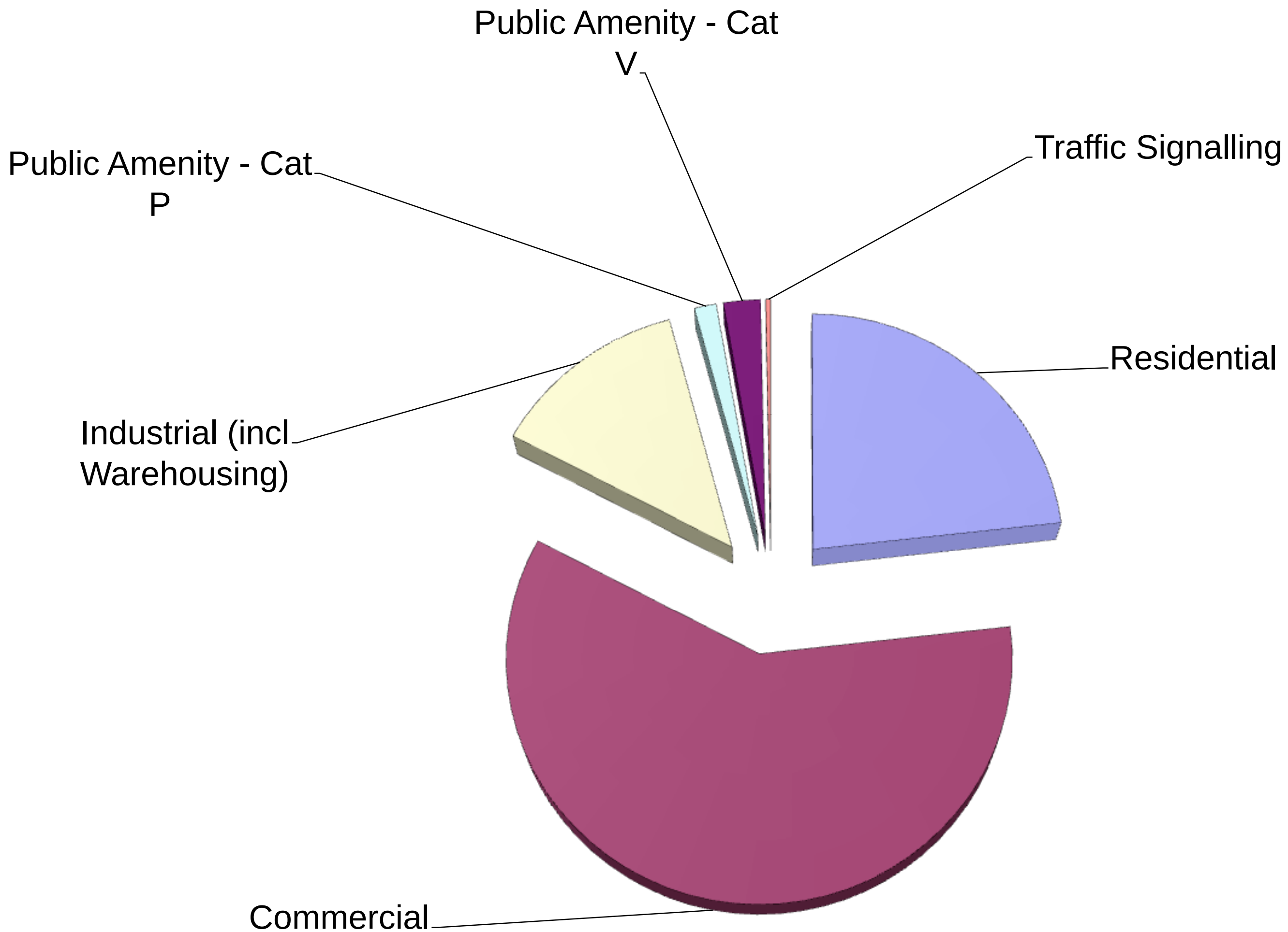
Lighting Sectoral Energy



Source: Greenlight Australia Strategy 2004

The Basics of Lighting

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Terminology

Luminaire	Entire light fitting
Lamp	   
Ballast / Transformer	
Power (Watts)	Energy per second

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Lamp Types

Incandescent	
Halogen	 
Fluorescent T8	
Fluorescent T5	
LED	

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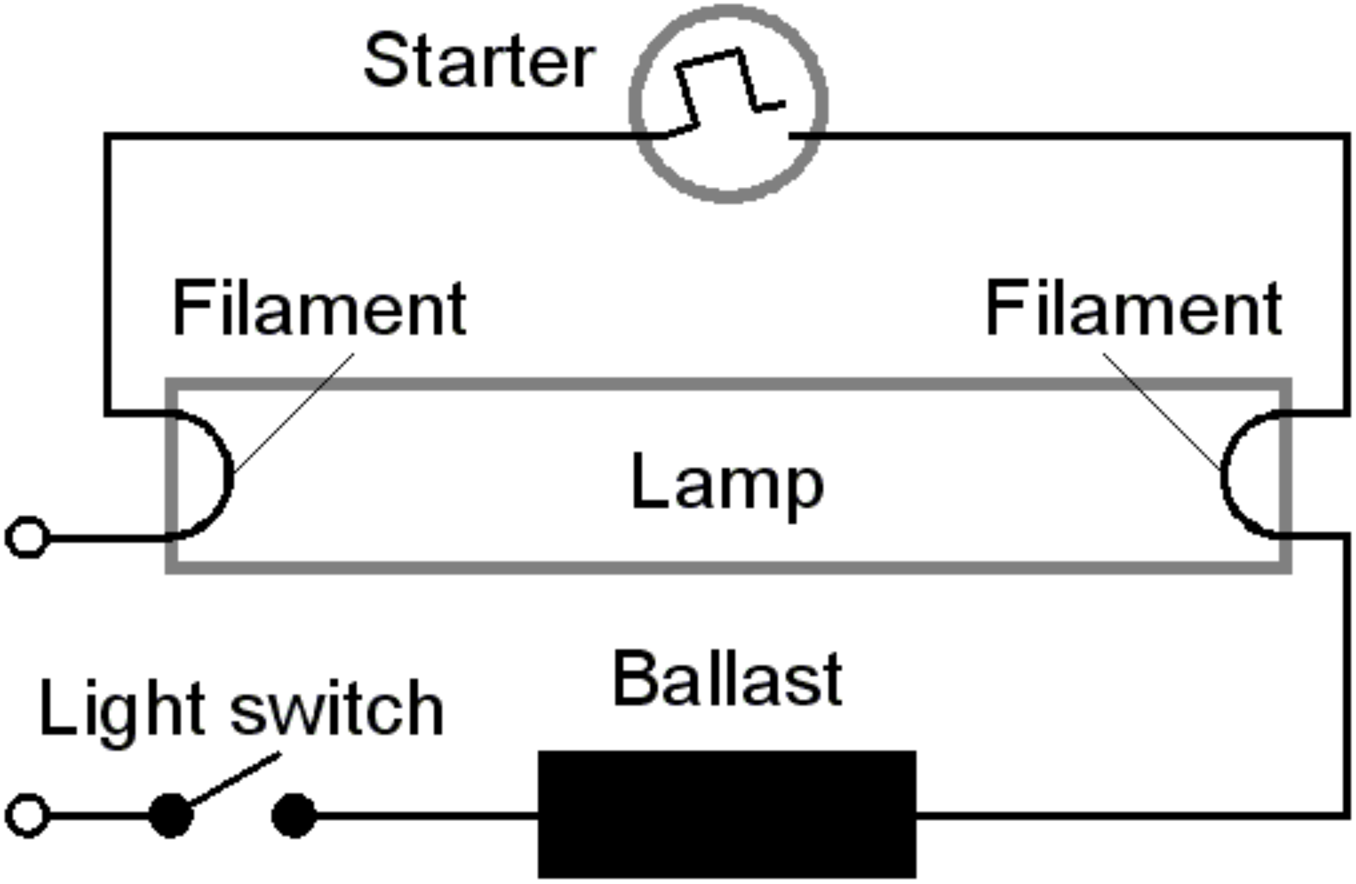
Anatomy of a Fluorescent Light



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Impacts on HVAC Loads

- Waste heat from lights extracted by HVAC system
- If HVAC system has CoP of 3
  - Each kWh of heat requires 0.33kWh of HVAC (electrical)
  - Thus lights use 1.33 x their power
- Office buildings run HVAC cooling for a high percentage of the year
  - Due to solar ingress

What Makes Lighting Efficient?

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Aspects of Lighting Efficiency

- Lamp type
- Ballast / transformer technology
- Luminaire photometric performance

- Control systems
- Lighting Layout

Lamp Type (Efficiency)

Best

- Fluorescent (electronic T8/T5)
- Very good LED

- Fluorescent (magnetic T8, CFL)

- 12V halogen IRC

- 12V Halogen

- 240V Halogen

Worst

- 240V Incandescent

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Ballast Technology

- Magnetic
  - Typically have starter
  - Lights typically flicker on startup
  - Ballast losses ~8W per lamp
- Electronic
  - No starter
  - No flicker – fast ramp up
  - Losses ~1W per lamp
  - Will actually drive the lamp to produce ~10% more light

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Transformer Technology (Halogen Downlights)

- Magnetic
  - Transformer losses ~12W
  - 50Hz output

- Electronic
  - Transformer losses ~3W
  - kHz output

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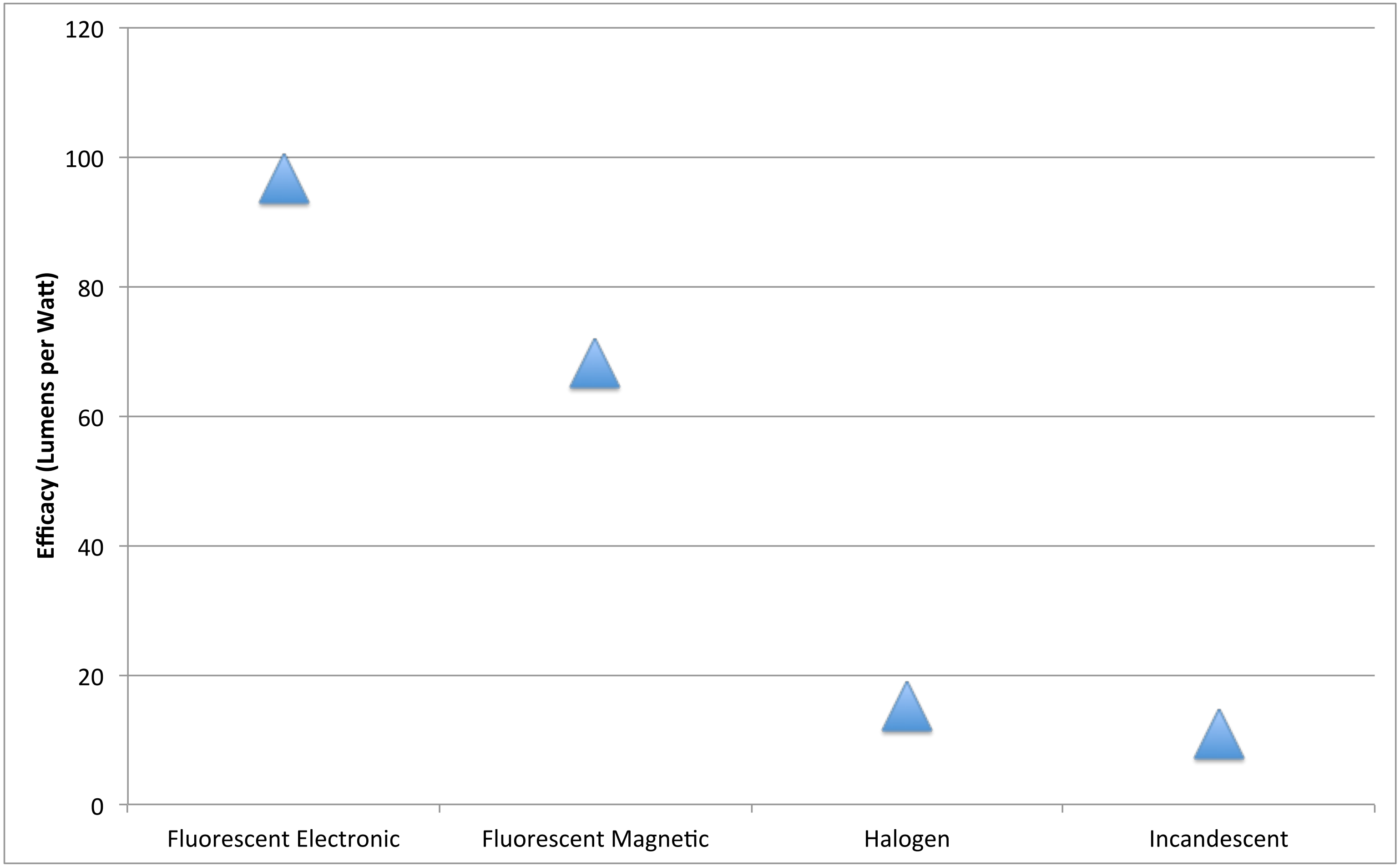
Fluorescent Lamp + Ballast Combined Efficiency



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Luminaire Photometric Performance

- Want high "Light output ratio"
  - Amount of useful light escaping luminaire
- High performance reflector
- High performance diffuser
  - E.g. louvred
  - Not prismatic

Control Systems

- Timers / BMS
- Presence detection
- Daylight dimming
- Must be well commissioned !
- Must work !
- Must be liked by occupants !

Lighting Layout

- Luminaire placement
  - Typical spacing 2.4 x 1.8m
- Lighting should meet AS/NZS 1680
  - Av maintained lux
  - Uniformity of lux
  - Cut-off angle for luminaires (glare)
  - Glare index
  - Colour temperature
  - Colour rendering

Demonstration of Lighting Power

- Physical demonstration of light fitting power
  - Twin T8 magnetic vs single T5 electronic
  - 50W 12V halogen magnetic vs LED

Does Your Building Have Efficient Lighting?

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Qualitative Method

- What is the lamp type?
- What is the ballast / transformer technology?
- High performance luminaire?
  - High light output ratio

- Are the lights on too long?
- Are there control systems?
- Are light levels too high?

Quantitative Method - Lighting Power Density

- Lighting power density =
  - Total luminaire power ÷ floor area

- Best practice is <7 Watts/m^2
- Any lower may cause light levels to suffer
- Does not take into account control systems (i.e. operating hours)

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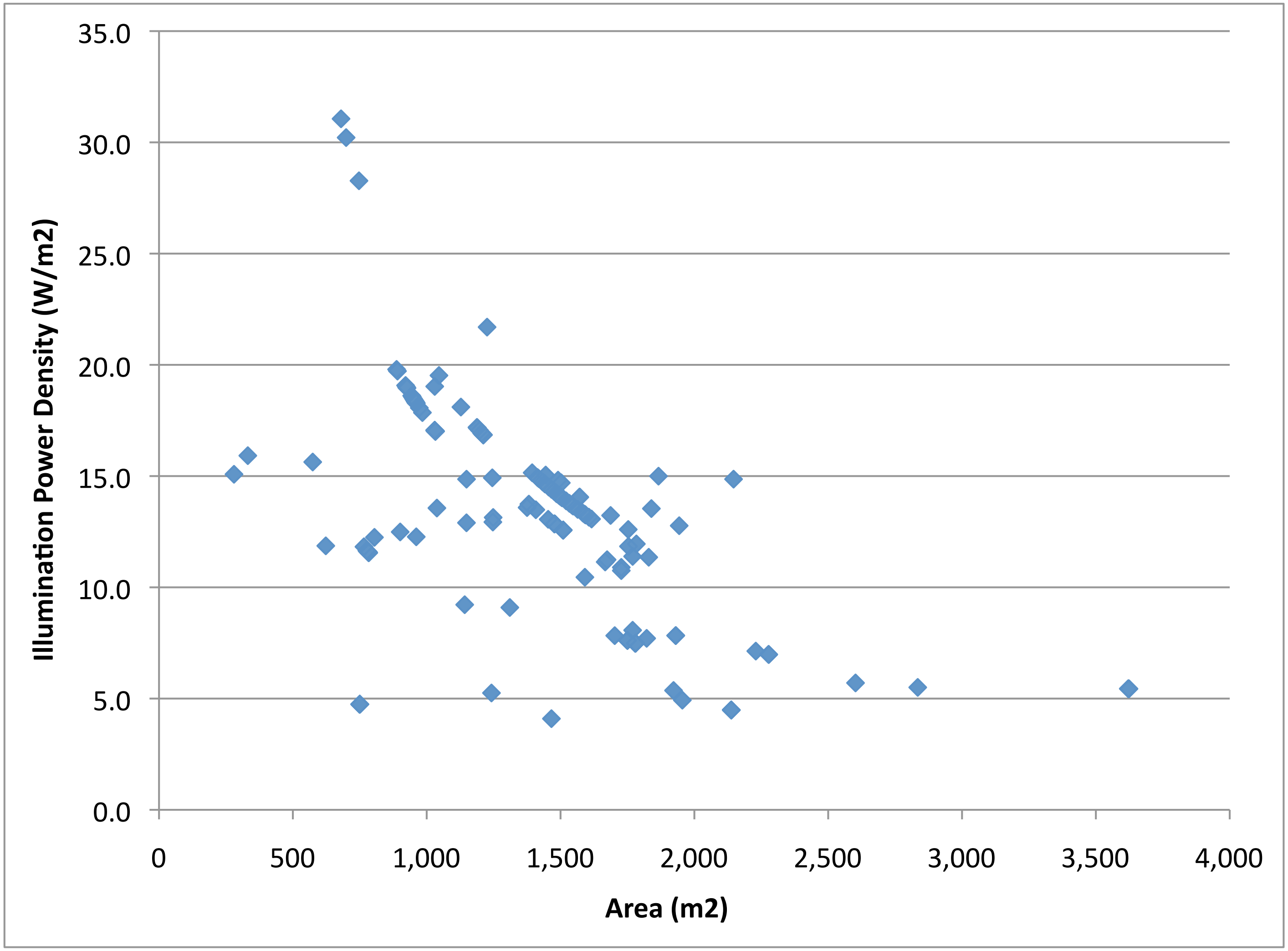
Lighting Power Density (cont)



What is your Lighting Power Density?

- Luminaire power =
  - (lamp power + ballast loss)
  - x no. lamps in luminaire
- Total luminaire power =
  - Σ luminaire power
- Lighting power density =
  - Total luminaire power ÷ floor area

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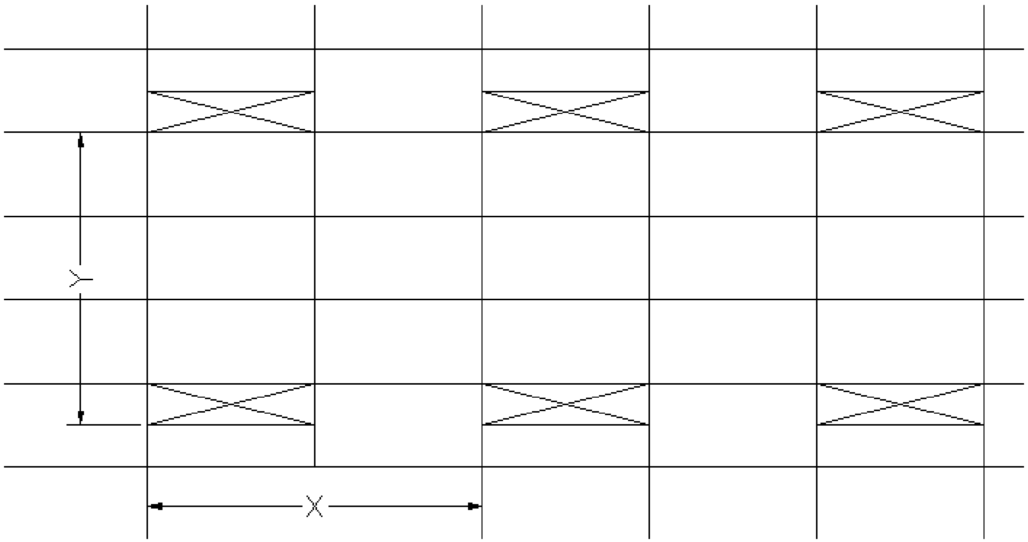
CBD Grid Method

- Area per luminaire = X*Y (spacings)
- Lighting power density=
  - Luminaire power
  - divided by area per luminaire



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Example of CBD Grid Method

- Typical grid spacing 2.4 x 1.8m
- Twin T8 (4’) magnetic luminaire:
  - Luminaire power =
    - 2 x (lamp power + ballast losses)
    - = 2 x (36W + 8W)
    - 88W
- Lighting power density =
  - 88 / (2.4 x 1.8)
  - = 20.4 W/m^2

Interactive Exercise - Benchmarking Your Lighting

With prizes !

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Lighting Case Study - QUESTION

Assume floor area of 1500 square metres, fitted with:

- 275 fluorescent luminaries (twin 36W lamp and magnetic ballast)
- 50 halogen downlights (50W lamp and magnetic transformer)

Data	Cell Ref	Formula	Answer
Energy cost per kWh	G10	Given	$0.22
Lighting hours per annum	G11	Given	3,000
1. Existing Lighting			
Total floor area (m^2)	G14	Given	
a) Fluorescent Luminaires			
Number of fluorescent luminaires	G16	Given	
Lamp power per lamp (Watts)	G17	Given	
Number of lamps per luminaire	G18	Given	
Ballast technology	G19	Given	Magnetic
Ballast losses (Watts)	G20	Magnetic=8, Electronic=1	
Total power per luminaire (Watts)	G21	(G17+G20) * G18	
Total power fluorescent luminiares (Watts)	G22	G21*G16	
b) Halogen Downlights			
Number of halogen downlights	G25	Given	
Lamp power per lamp (Watts)	G26	Given	
Number of lamps per luminaire	G27	Given	
Transformer technology	G28	Given	Magnetic
Transformer losses (Watts)	G29	Magnetic=12, Electronic=3	
Total power per luminaire (Watts)	G30	(G26+G29) * G27	
Total power for all halogen luminiares (Watts)	G31	G30*G25	
Total lighting power for this space (Watts)	G33	G22 + G31	
Energy cost p.a.	G34	G10*G11*G33/1000	
Lighting power density for this space (Watts/m^2)	G35	G33/G14	

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Solution

1. Existing Lighting

Total floor area (m^2)	G14	Given	1,500
a) Fluorescent Luminaires			
Number of fluorescent luminaires	G16	Given	275
Lamp power per lamp (Watts)	G17	Given	36
Number of lamps per luminaire	G18	Given	2
Ballast technology	G19	Given	Magnetic
Ballast losses (Watts)	G20	Magnetic=8, Electronic=1	8
Total power per luminaire (Watts)	G21	(G17+G20) * G18	88
Total power fluorescent luminiares (Watts)	G22	G21*G16	24,200
b) Halogen Downlights			
Number of halogen downlights	G25	Given	50
Lamp power per lamp (Watts)	G26	Given	50
Number of lamps per luminaire	G27	Given	1
Transformer technology	G28	Given	Magnetic
Transformer losses (Watts)	G29	Magnetic=12, Electronic=3	12
Total power per luminaire (Watts)	G30	(G26+G29) * G27	62
Total power for all halogen luminiares (Watts)	G31	G30*G25	3,100
Total lighting power for this space (Watts)	G33	G22 + G31	**27,300**
Energy cost p.a.	G34	G10*G11*G33/1000	**$18,018**
Lighting power density for this space (Watts/m^2)	G35	G33/G14	**18.2**

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Next Session

- Business case to upgrade this building
  - Capital costs
  - Energy savings
  - VEECs
  - Cashflow analysis
  - Quantifying return on investment

After Benchmarking?

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Benchmarking

- Is your lighting efficient?
  - What is lighting power density?
  - If more than say $10W/m^2$ then not efficient
- Can get lighting power density easily to $7W/m^2$, cost effectively
- Then add control systems

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Business Case for Upgrading

- Using previous exercise:
- Upgrade costs ~$40K
- Savings ~$13K p.a.
- Internal rate of return ~37% typical
- More next session

Learning Objectives of this Session

- By the end of this session, you should:
  - Have a basic understanding of lighting technologies and efficiency
  - Be able to determine if your building has efficient lighting
    - Lighting power density
    - Control system present
  - Be engaged !!
  - Be empowered !!

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Next Session:
Delivering Positive Outcomes

- Best practice
- Overview of lighting design
- LED lighting
- Case studies
- Economics of lighting upgrades
- Building a successful business case

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Homework for Next Session NABERS Rating

- Calculate a NABERS office tenancy (energy) star rating
  - http://www.nabers.gov.au/public/WebPages/RatingCalculator.aspx?module=40
- Building is located in Melbourne 3000
- Area = 1500 m^2
- Occupancy = 58 hours/week
- 105 staff members with a computer

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Homework for Next Session NABERS Rating (cont)

- Only electricity is used
  - Lighting = 81,900 kWh p.a.
  - Power = 100,000 kWh p.a.
  - Total electricity = 181,900 kWh p.a.
    - Note to save this entry using disk icon
    - No GreenPower
- What is the NABERS star rating?
- Answer next week
- Copy on Twitter: @beletich

Questions and Discussion

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