

# Energy efficient and biological aspects in renovation of auditorium – dynamic lighting

Eino Tetri

Helsinki University of Technology  
Lighting Laboratory



HELSINKI UNIVERSITY OF TECHNOLOGY  
Lighting Laboratory



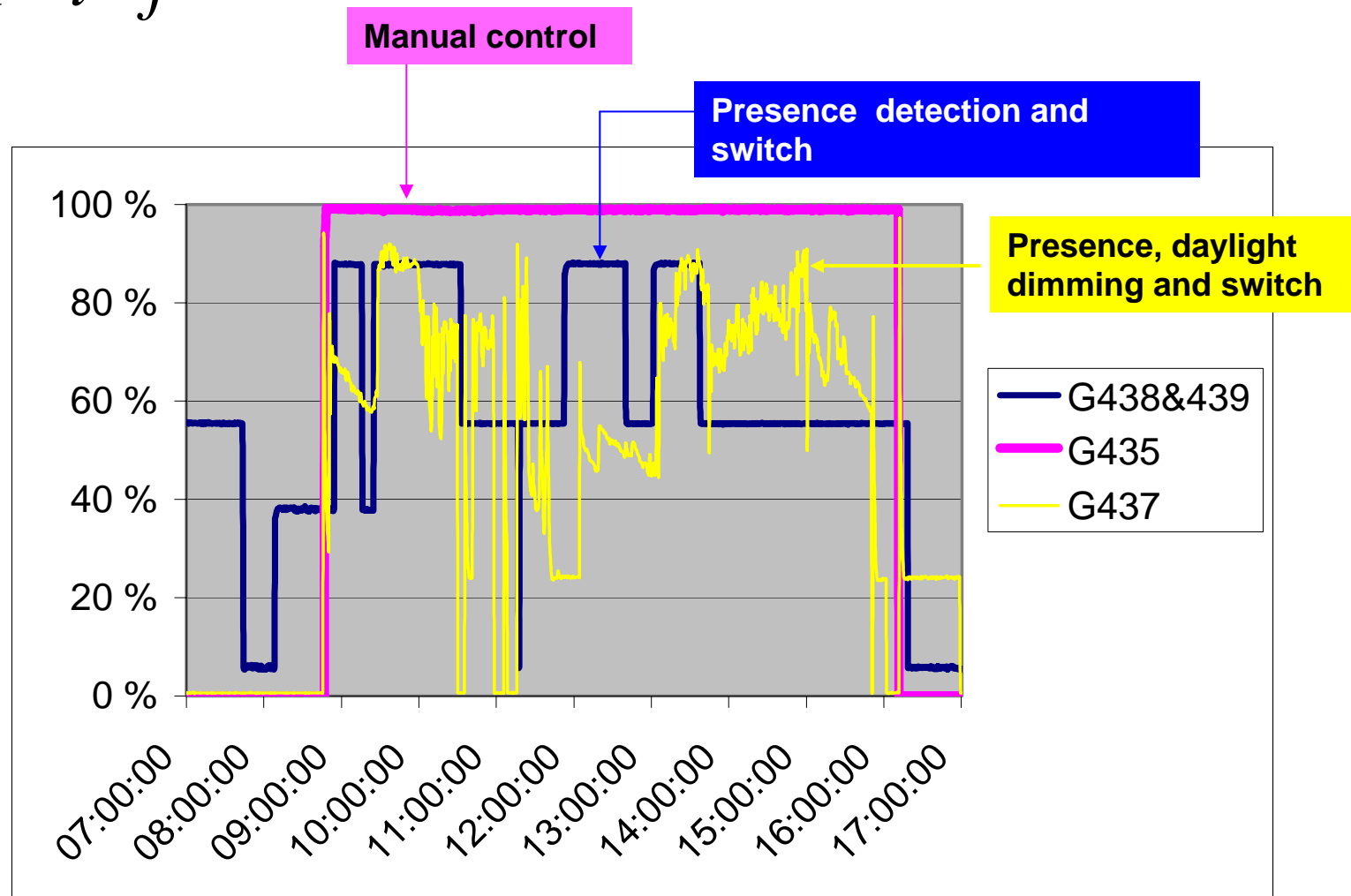
*International Energy Agency*  
**Energy Conservation in  
Buildings and Community  
Systems Programme**

# Content

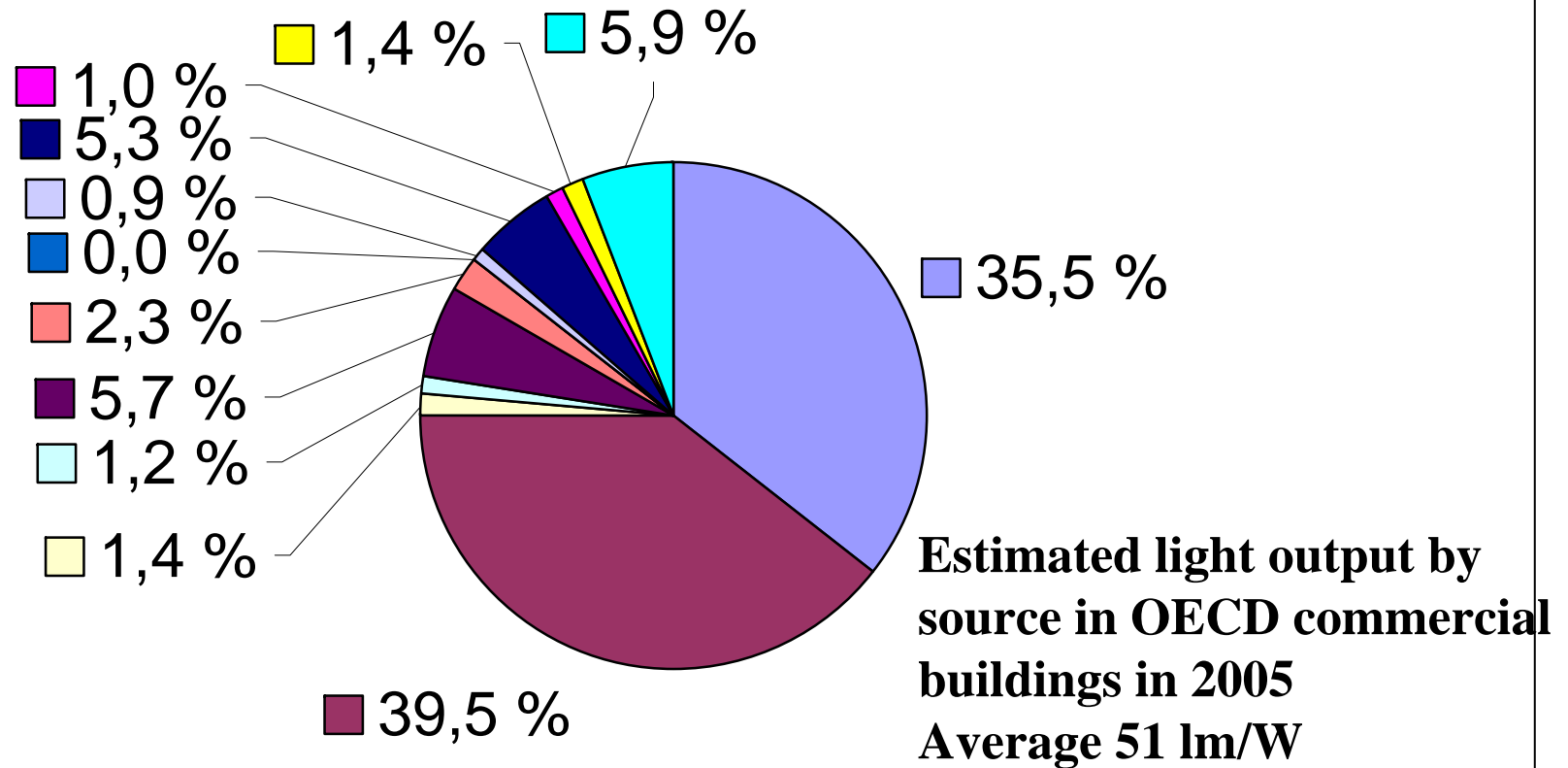
- Introduction
  - Benefits of lighting control
  - Non-visual effects of lighting
- Renovation
- Measurements
- Results
- Conclusions

# Power curve: dependent on control system applied

$$W = P \cdot t \cdot f$$



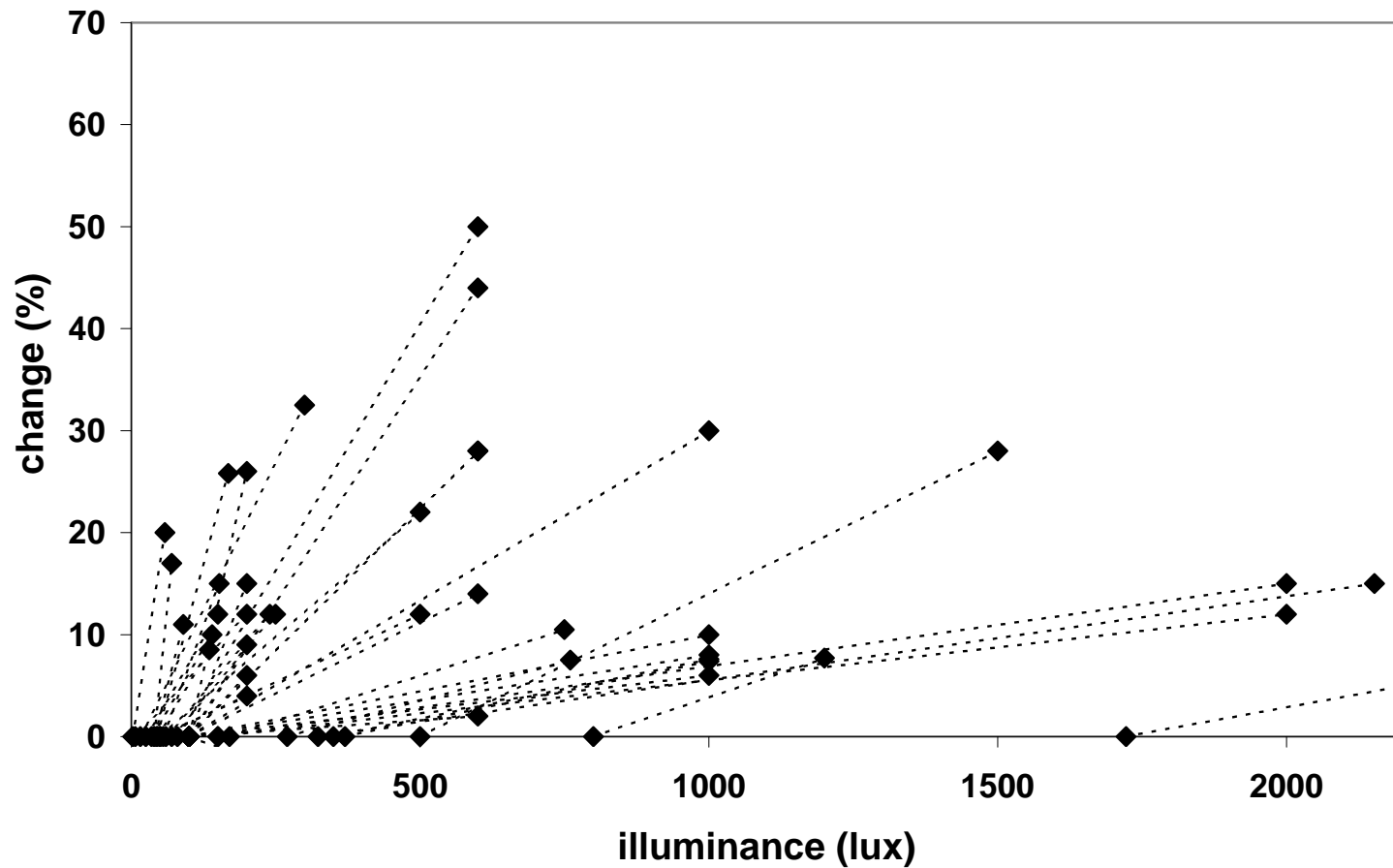
# Barriers



T12	T8	T5
CFL, self ballasted	CFL, external ballast	Halogen
LED	High pressure sodium	Metal halide
Mercury vapour	Incandescent reflector	Incandescent

# Lighting and productivity

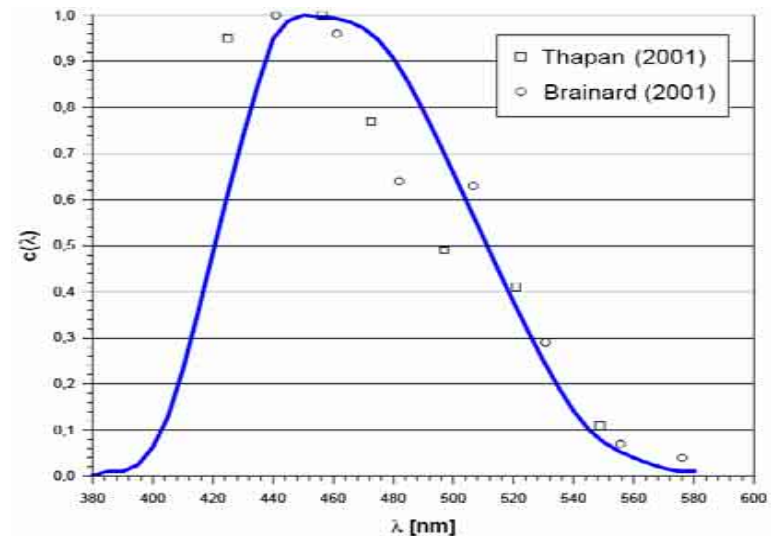
Increase in output



# Biological effects

## 2002 David Berson et al.:

- **Third photoreceptor ipRGC** 'intrinsically photosensitive Retinal Ganglion Cell',
- Light has visual and non-visual effects
- Biological effects mean that lighting has a positive influence on health, well-being, alertness
- Spectral biological action curve based on melatonin suppression



# Renovation



# Renovation



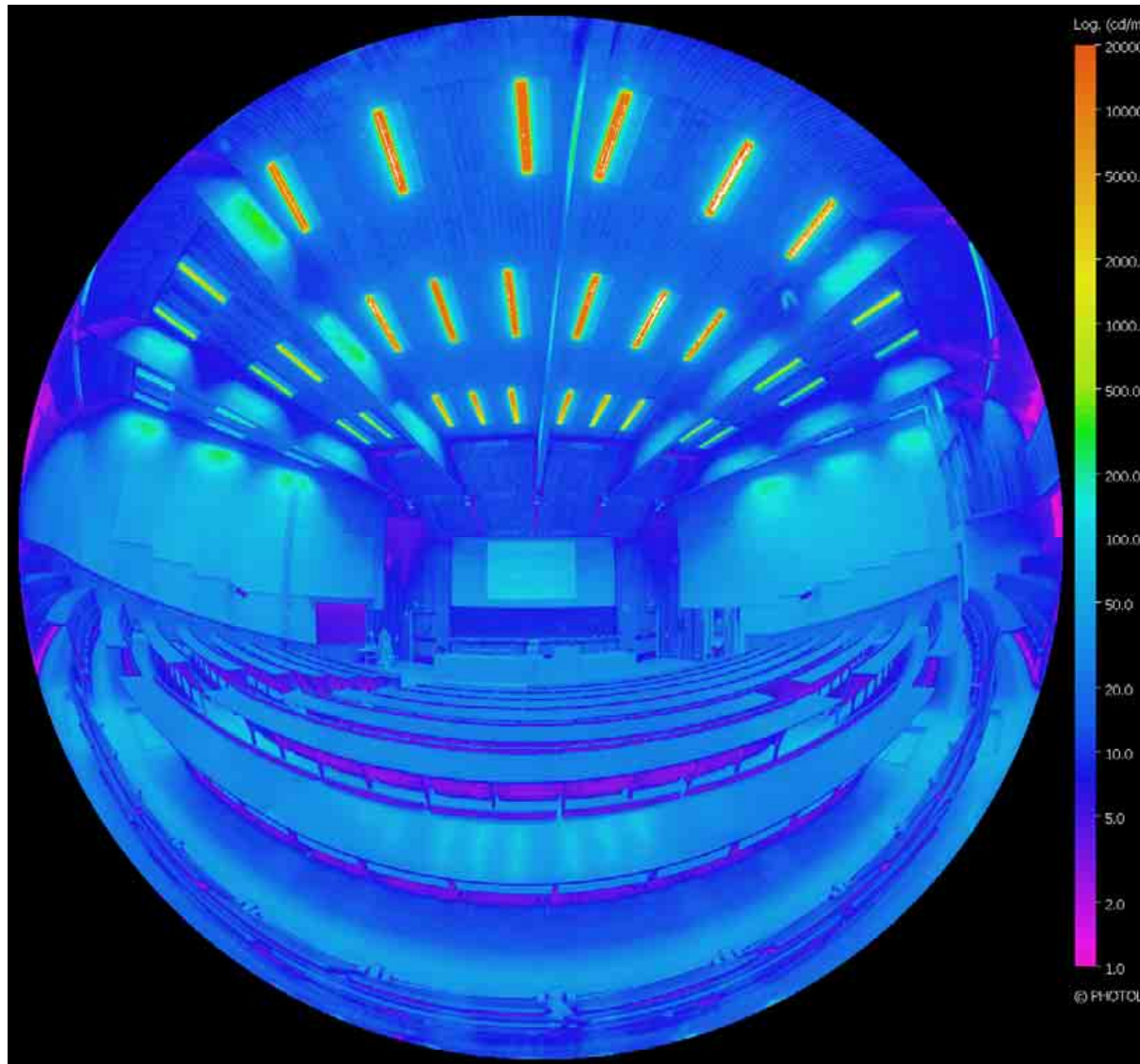
# Luminaires

- 40 years old luminaires
  - 87 luminaires, lamps 2 x 40 W
  - T12 fluorescent lamps
  - Nominal voltage of the ballast 220 V
  - Dimming with variable voltage, separate cathode heating transformers
  
- New luminaires
  - 69 luminaires, lamps 2 x 49 W
  - T5 lamps
  - Dimmable electronic ballasts
  - DALI control system
  - Double lighting, 4200 K or 17 000 K

# Measurements

- Photometric measurements in auditorium
  - Illuminance
  - Luminance
  - Glare, UGR
  - Spectral power distribution
- Integrating sphere
  - Luminous flux of lamps with and without luminaire
- Electrical measurements
  - Power

# Results



**Luminance map of  
the auditorium  
after the renovation.  
Data processed with  
Photolux**

# Results

	Before	After	%
Photometric values			
Illuminance lx	428	974	228 %
Average luminance cd/m <sup>2</sup>	45	103	229 %
UGR	14	21	
Electrical values			
Power W	10 571	7 383	70 %
Luminaire output ratio	0,39	0,74	191 %

# Results

- Power of a old luminaire (2 x 40 W)
  - 220 V: 111 W,  $\Phi$  2062 lm
  - 230 V: 121 W,  $\Phi$  2142 lm
- Old lamps, CCT 4000 K, CRI 63
- New lamps, CCT 4200 K or 17 000 K, CRI > 80

# Conclusions

- Old lighting installations should be renovated
- Benefits are:
  - Energy savings
  - Lighting quality improvements
  - Dynamic lighting

# Future work

- Questionnaire before and after lecture
  - How alert do you feel
  - Could you concentrate on the lecture, was the lecture interesting, was the lecture too long,...
  - Also questions about temperature, air quality
  
- Any differences between 4200 K and 17 000 K

