CALIFORNIA LIGHTING TECHNOLOGY CENTER

UCDAVIS
UNIVERSITY OF CALIFORNIA

2015 DOE Solid-State Lighting R&D Workshop

January 27-29, 2015, San Francisco, CA

Adaptive Lighting

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The Fundamental Lighting Design Strategy

Provide

Right Light→ *Spectral Power Distribution*

Where→ *Candle Power Distribution*

& When→ *Environmental Conditions*

Needed

Adaptive Electric Lighting Systems

- **Automatically adjust their light output…**
  - Candle Power Distribution (CPD) - *total flux & spatial distribution*
  - Spectral Power Distribution (SPD) - *CCT & CRI*
  - …
- **…based on environmental conditions…**
  - Occupancy / Vacancy
  - Daylight Availability
  - Demand Response Signals
  - …
- **…to optimize space & building performance**
  - Maximize Comfort
  - Minimize Energy Requirements
  - Minimize Peak Electricity Demand
  - …

Adaptive Outdoor Lighting – Circa 2005

- **Amber LED** (2W) & **CFL** Light Sources
- Controlled based on **Photo** sensor & **Occupancy** sensor signals

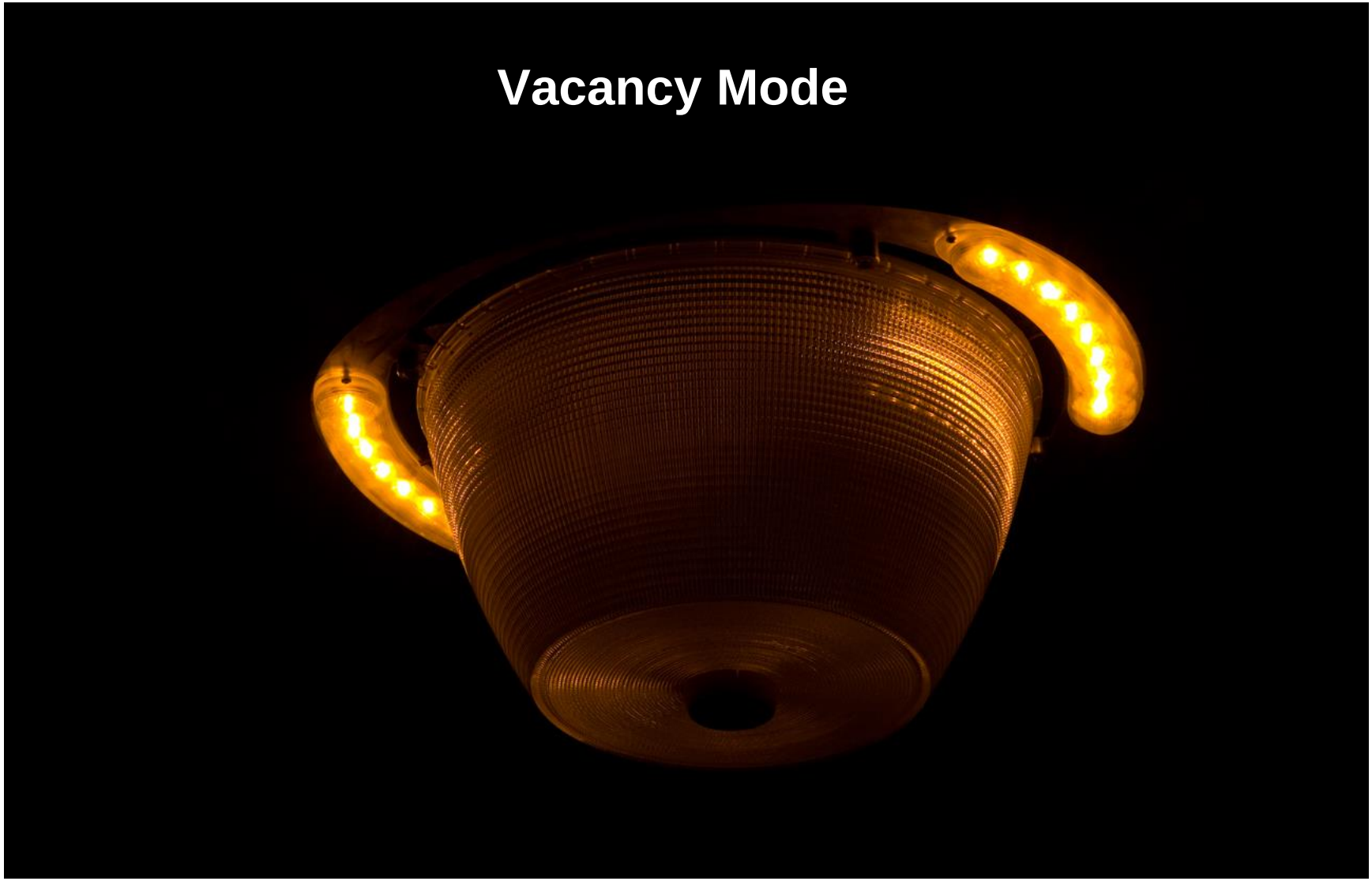
CLTC Adaptive Lighting Control Strategy

During Occupancy
Focus on Comfort

During Vacancy
Focus on Energy Efficiency

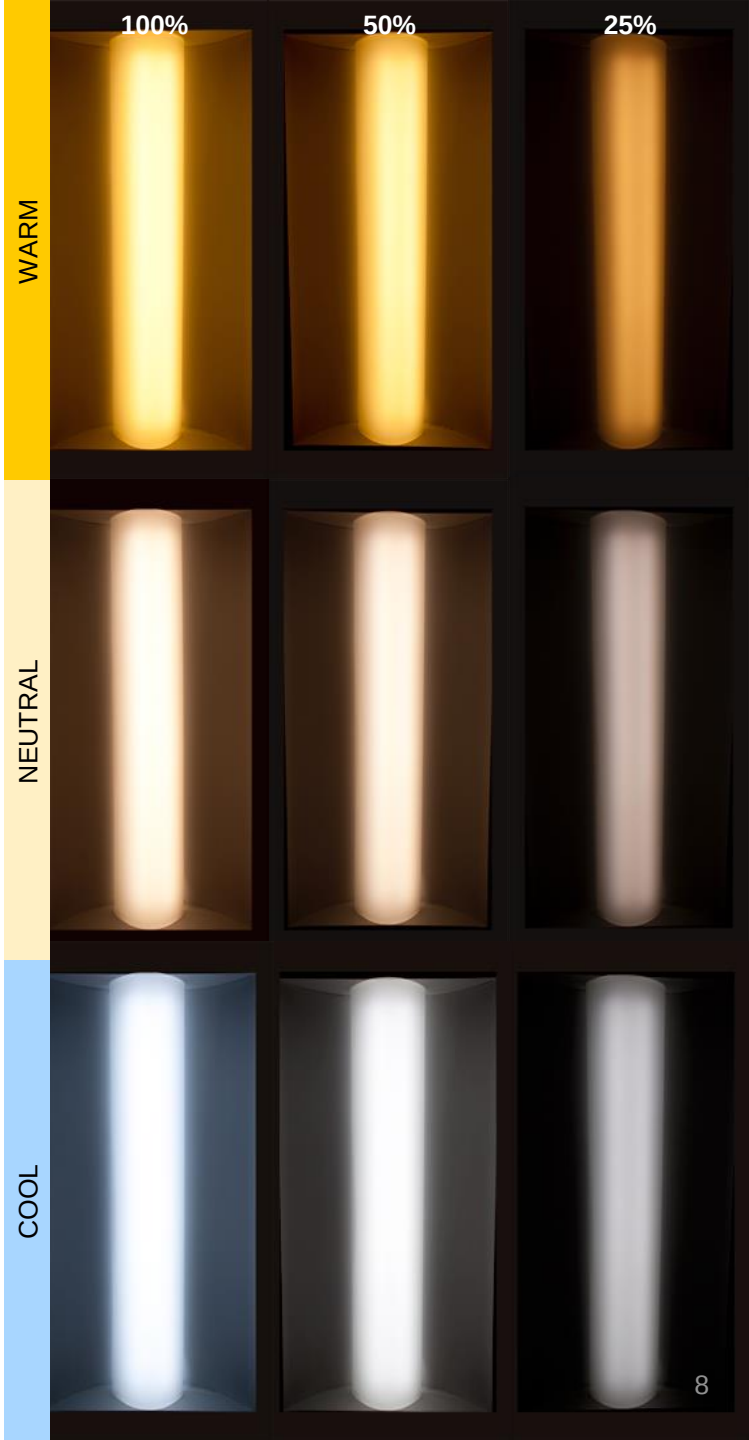
Dual Source Bi-level Luminaire

Dual Source Bi-level Luminaire



Spectrally Tunable Lighting

- **Independent control of Intensity & CCT**
  - Change CCT maintaining Intensity
  - Change intensity maintaining CCT
- **Emerging commercial technologies**
  - Residential
  - Educational
  - Medical
  - Hospitality
  - …
  - Outdoor
  - Retail
  - Industrial
  - …



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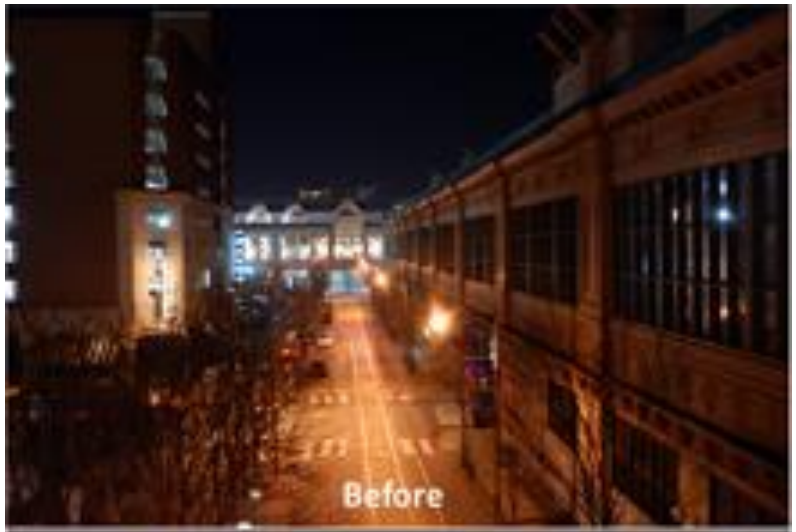
Needed

Right SPD? Right CPD?
Where would like to go for a walk?



Right SPD? Right CPD?

American Medical Association - June 2012

Light Pollution: Adverse Health Effects of Nighttime Lighting

Report 4 of the Council on Science and Public Health (A-12) of the ***American Medical Association***

Biological adaptation to the sun has evolved over billions of years.

The **power to artificially override the natural cycle** of light and dark is a **recent event** and represents a **man-made self-experiment on the effects of exposure to increasingly bright light during the night** as human societies acquire technology and expand industry.

Among the latter (health effects) are potential **carcinogenic effects** related to melatonin suppression, especially **breast cancer**. Other diseases that may be exacerbated by circadian disruption include **obesity, diabetes, depression** and **mood disorders**, and **reproductive problems.**

Due to the nearly ubiquitous exposure to light at inappropriate times relative to endogenous circadian rhythms, a need exists for further multidisciplinary research on occupational and environmental exposure to light -at-night, the risk of cancer, and effects on various chronic diseases.

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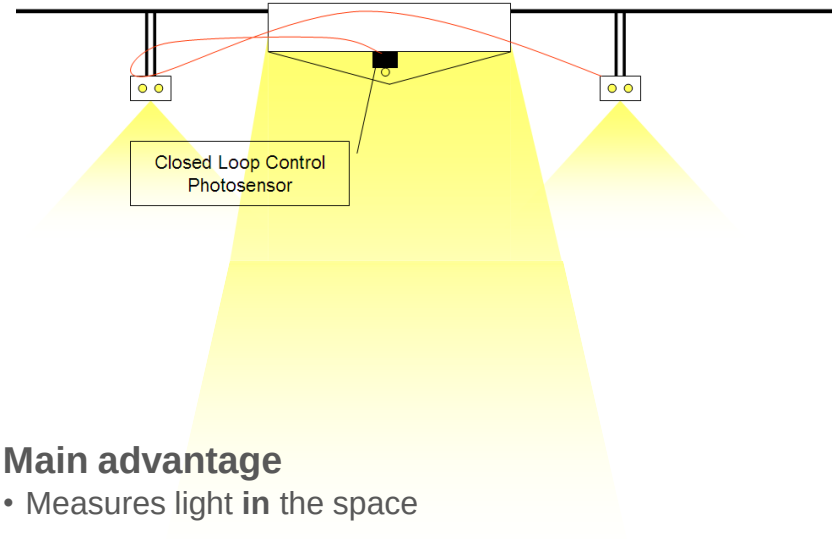
Key Electric Lighting Control Strategies

- High-end Tuning
- **Occupancy/Vacancy!**
- **Daylight Harvesting!**
- **Scheduling**
- **Demand Response!**
- Manual Control

Automated Controls	Key Challenges
	**Determine What Is Happening**
	
	**No Challenge**
	**Determine What To Do**

Traditional Daylight Sensing Strategies

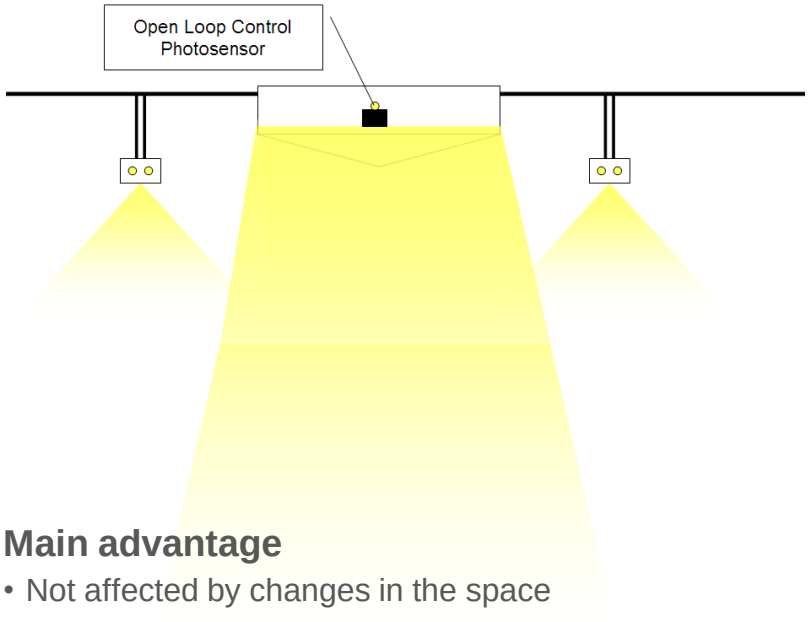
Closed Loop Sensing
Affected by electric lighting



Main advantage
- Measures light **in** the space

Main disadvantage
- Signal is affected by changes in the space
  - Geometry & reflectance of interior surfaces
  - Occupants moving through the space

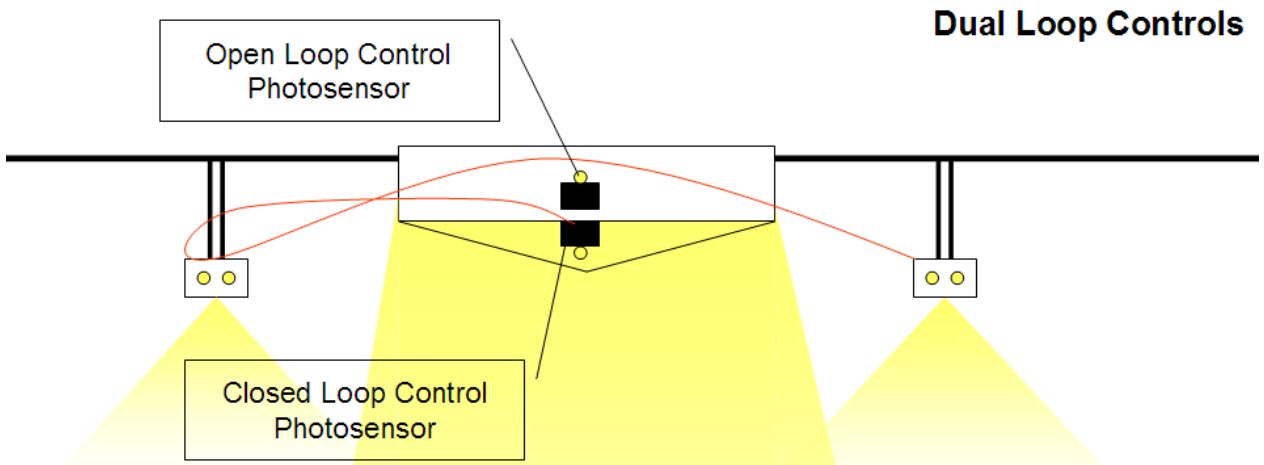
Closed Loop Sensing
Not affected by electric lighting



Main advantage
- Not affected by changes in the space

Main disadvantage
- Not an accurate indicator of daylight levels in the space

Dual Loop Daylight Sensing



Advantages

- Measures light **in** the space
- Can differentiate between true daylight changes and change in geometry and reflectance of interior surfaces
- Automatically & continuously accounts for changes in geometry & reflectance of interior surfaces

Disadvantages

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Thank You!

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