



Lighting Energy Management

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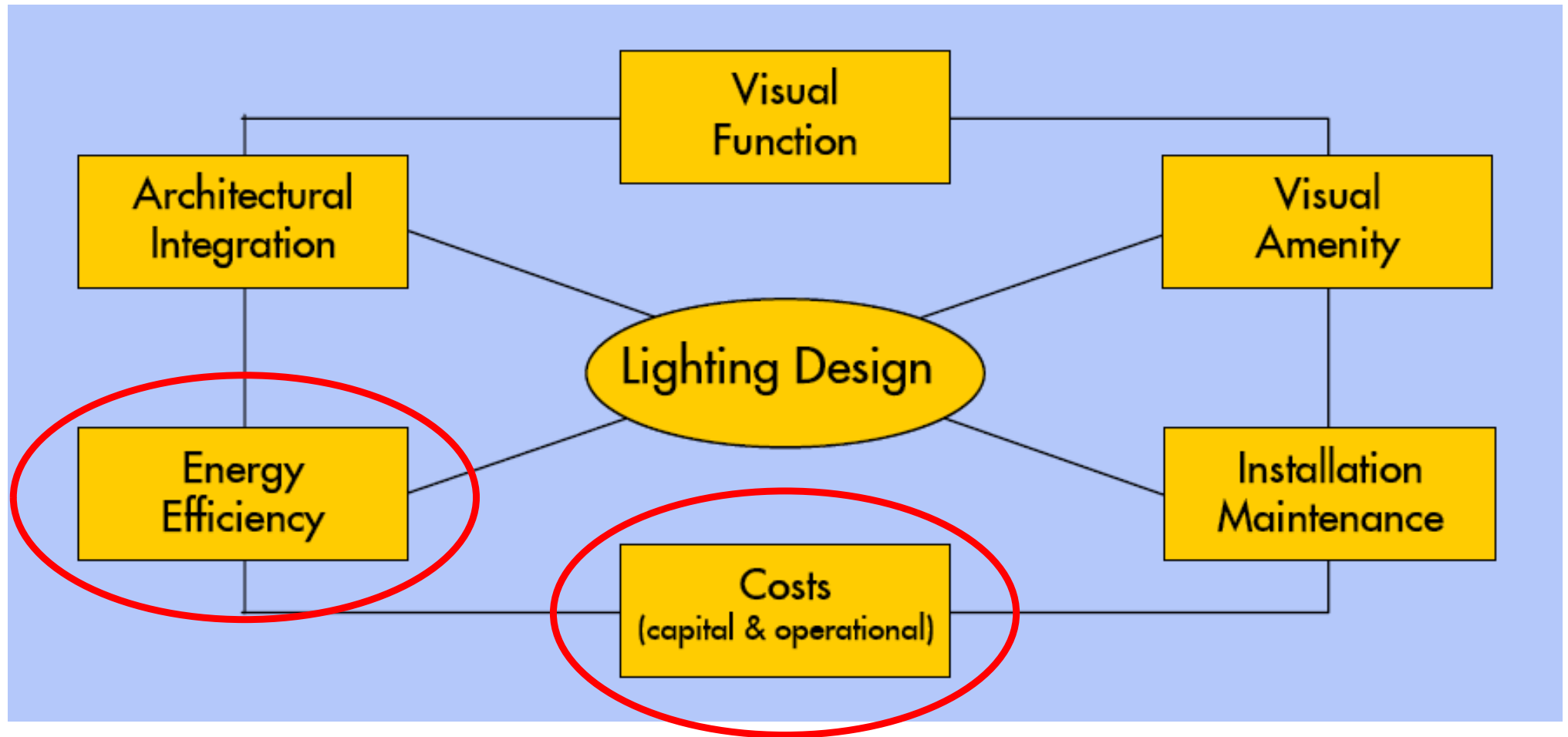
<http://ibse.hk/cmhui/>

Content



- Lighting energy use
- Energy efficient lighting
- Lighting economics
- Existing buildings
- Lighting surveys & audits

Energy efficiency & costs are two important criteria for lighting design



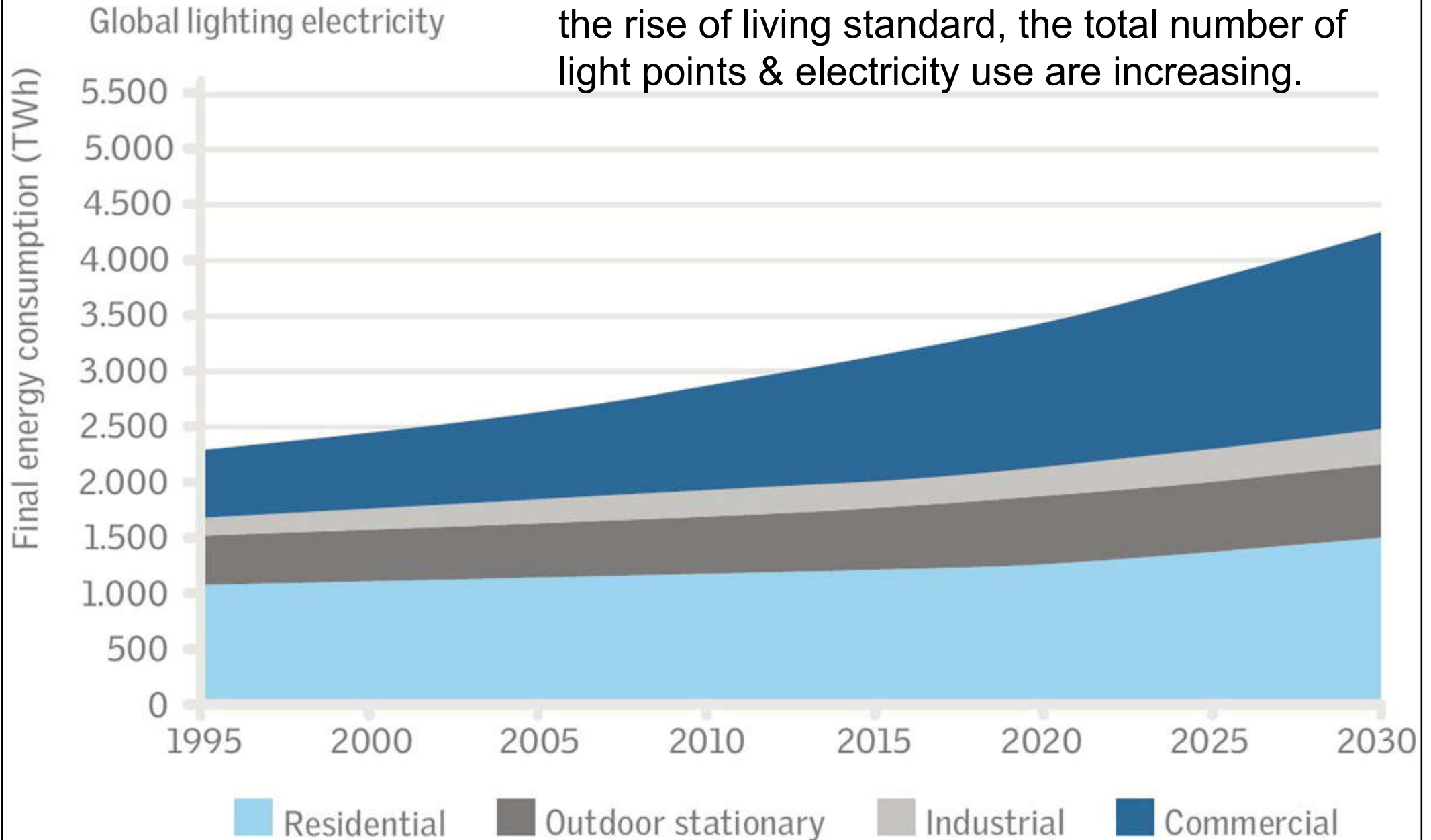


Lighting energy use

- **Lighting** consumes a great share of energy use in buildings & facilities
 - Direct consumption of electricity
 - Indirectly affect the cooling systems (due to **heat**)
 - Operation & maintenance issues
- The need to manage the lighting energy
 - Prevent energy wastage & reduce running costs
 - Ensure good quality visual environment
 - Reduce greenhouse gas or CO₂ emissions

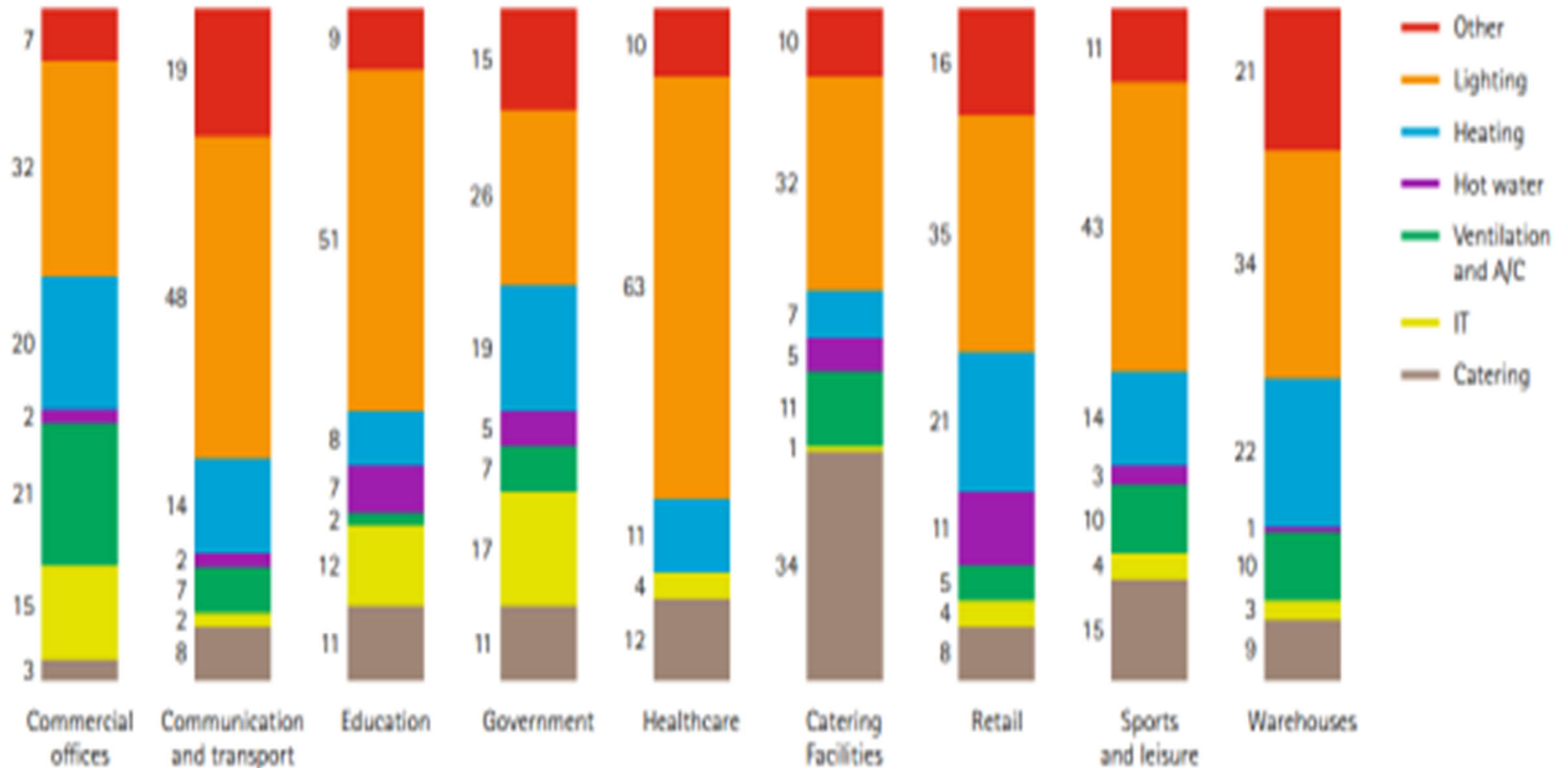
Global electricity consumption for lighting

Due to population growth, urbanization, and the rise of living standard, the total number of light points & electricity use are increasing.



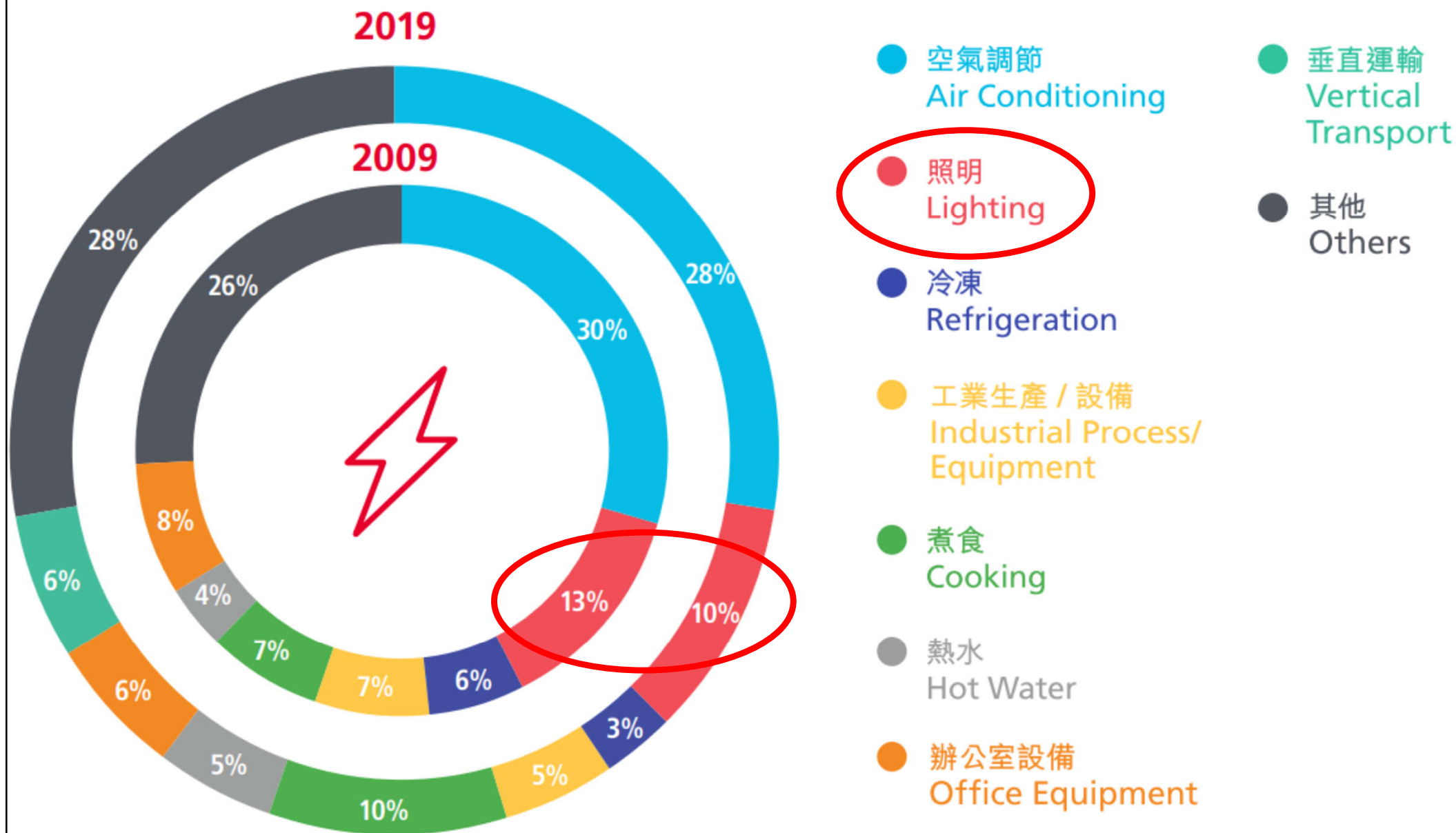
Energy end-use for different types of buildings

Energy use per type of building

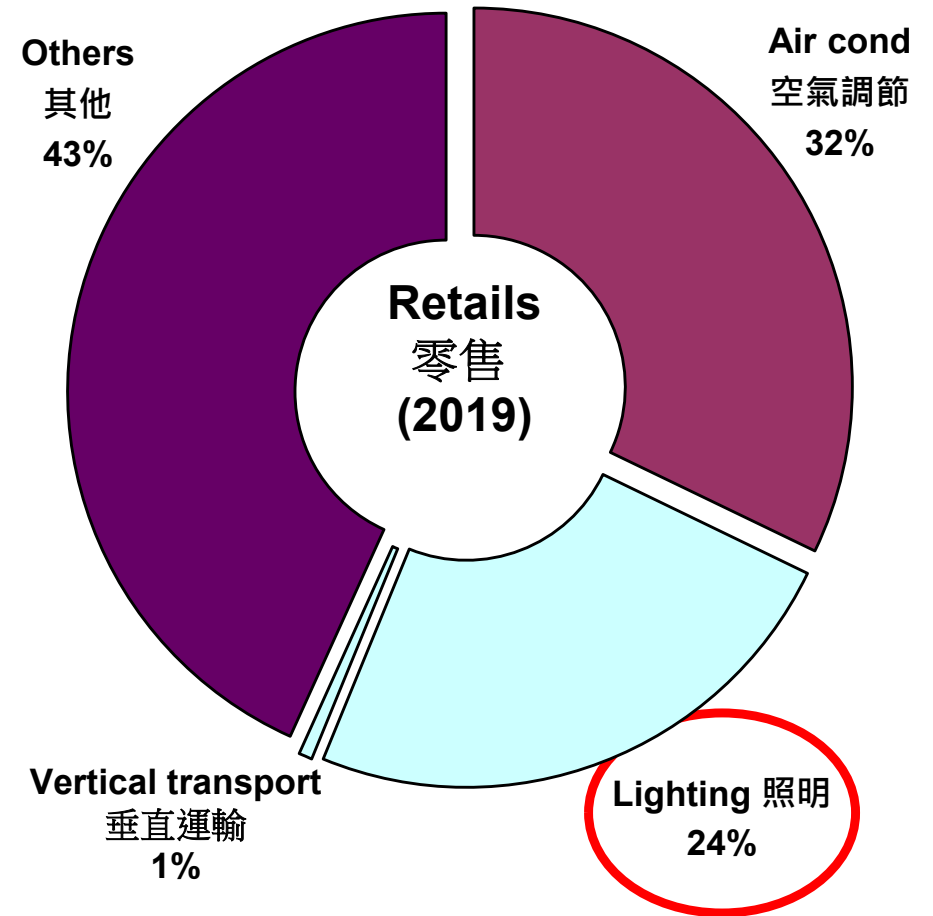
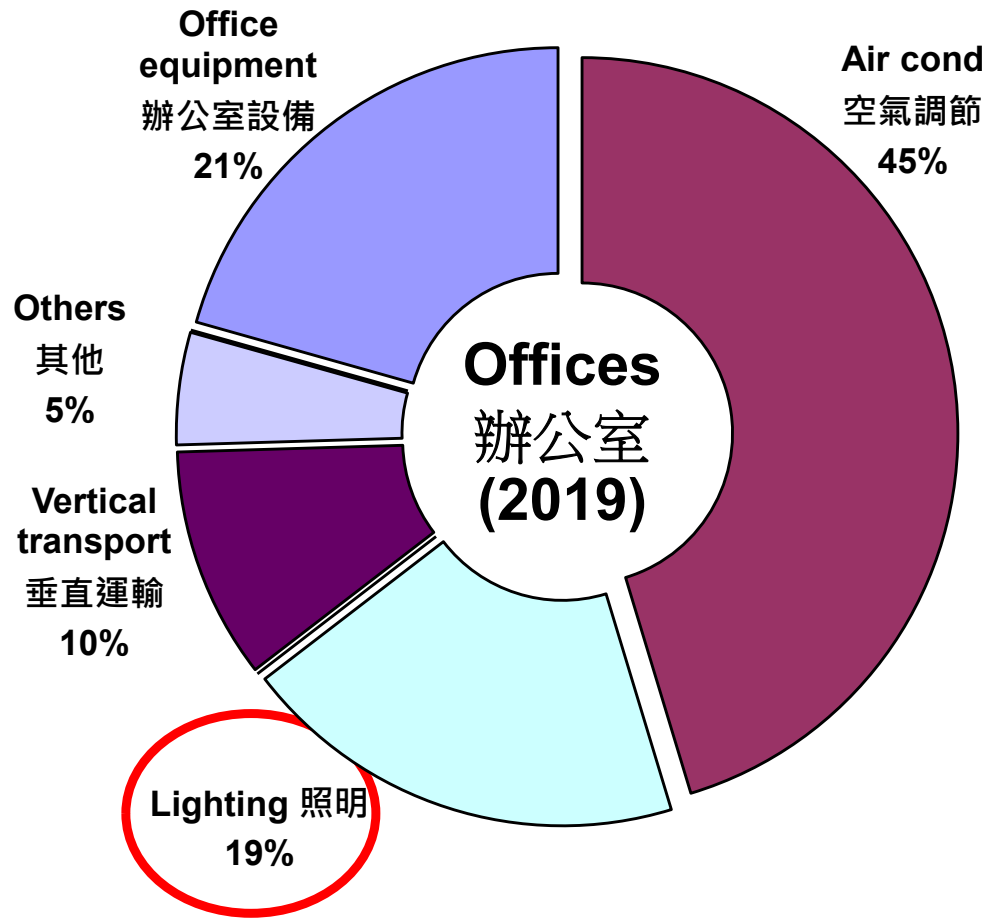


Source: Pike Research Report 1Q 2011: Intelligent Lighting Controls for Commercial Buildings

Electricity consumption by end-use in Hong Kong

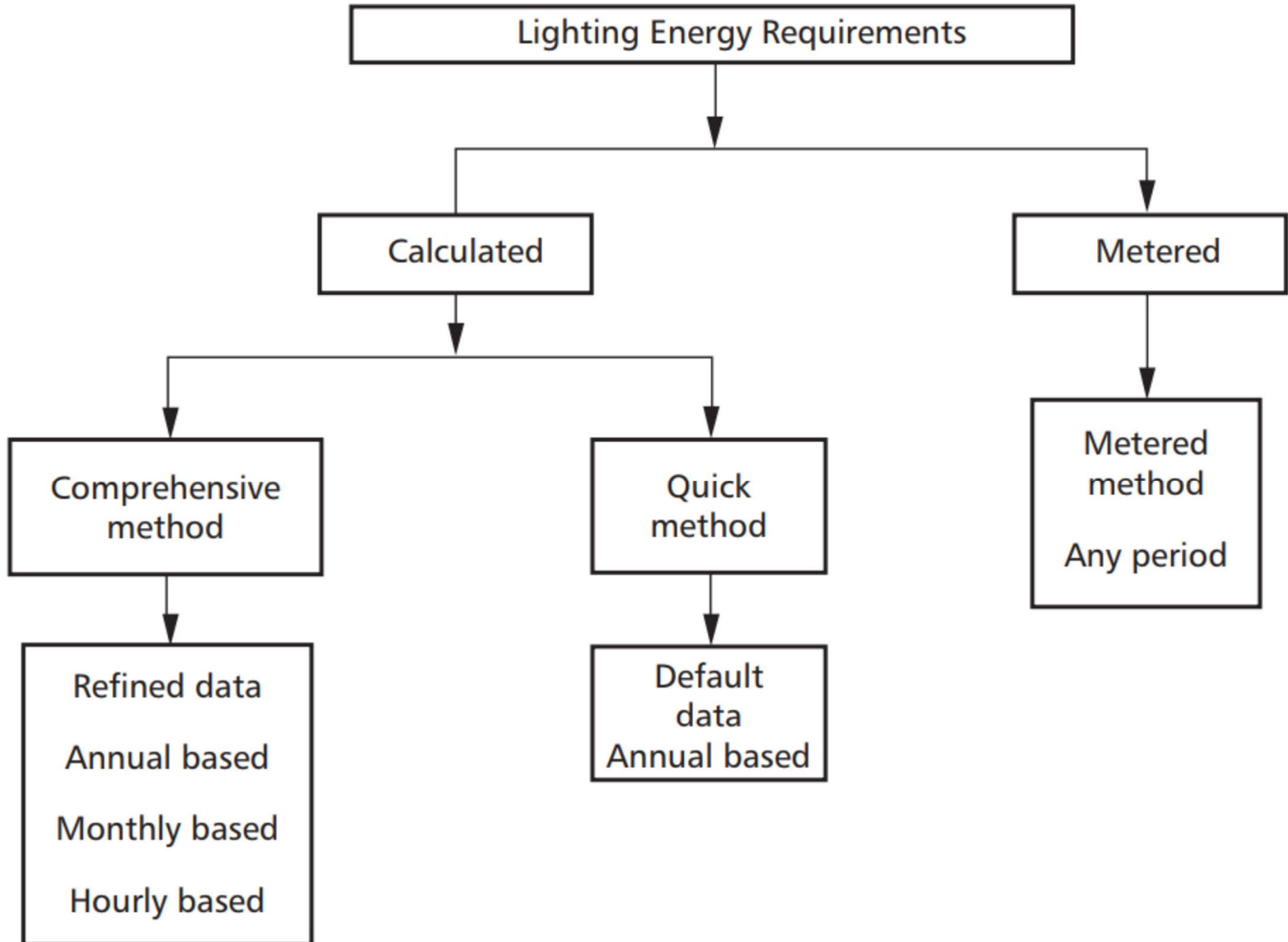


Energy consumption patterns in offices & retails in Hong Kong (2019)



Do you know what are the direct and indirect energy consumption of lighting?

Methods for determining lighting energy use



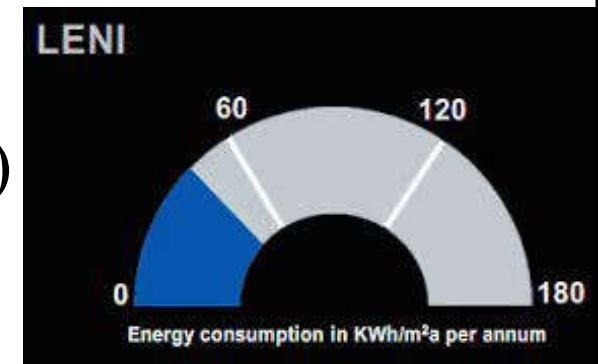
Lighting Energy Numeric Indicator (LENI)

(based on EN 15193 standard)

$$\text{LENI} = W / A \quad [\text{kWh per m}^2 \text{ per year}]$$

where W = annual estimate of energy use (kWh)

A = useful floor area assessed (m²)



$$\text{LENI} = \sum (P_n \times F_C) \times \{(t_D \times F_O \times F_D) + (t_N \times F_O)\} / A$$

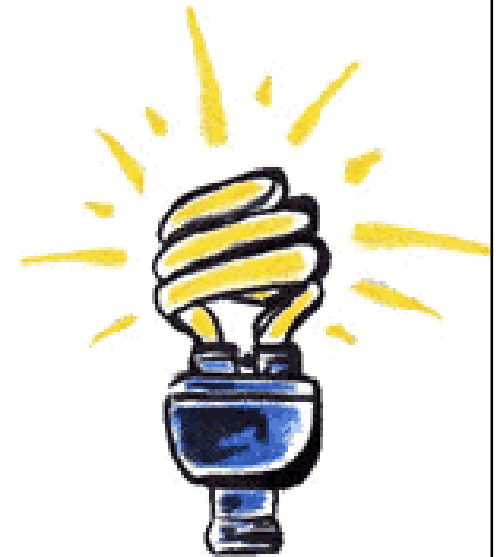
- The installed load (P_n)
 - Multiplied by the annual hours of use by day (t_D) & at night (t_N)
 - Reduced by the factors (≤ 1) for daylight-based control (F_D), presence-based control (F_O) & a constant lighting control system (F_C) (e.g. maintenance control)
- (LENI also takes charging energy for emergency lighting & standby energy into account)

* Further information on LENI: <https://eeabs.co.uk/leni-lighting-energy-numerical-indicator/>



Lighting energy use

- Energy management for lighting
 - 1. Design considerations
 - Codes & legislation, design practice
 - 2. Equipment considerations
 - Light sources, ballasts, luminaires, controls
 - 3. System maintenance
- Lighting economics
 - Cost & financial analysis
- Lighting audit (evaluate & identify savings)

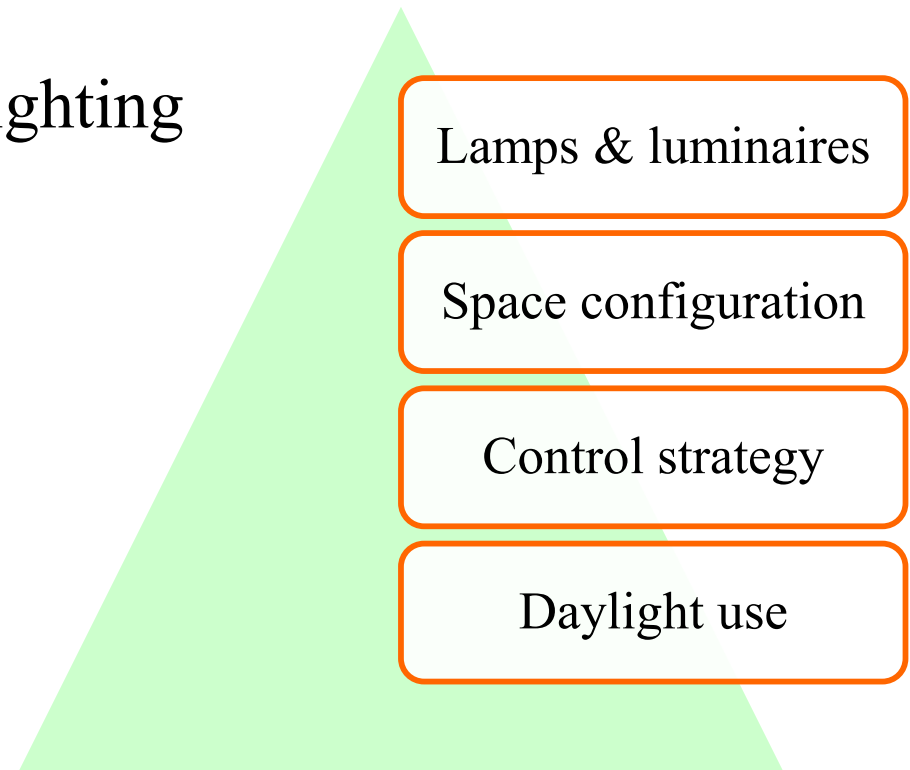


Basic strategies for lighting energy management

New Construction	Existing Buildings (System Upgrades)
<ul style="list-style-type: none">• Designing for daylighting• Electric lighting equipment• Lighting controls• Space design & material selection• Lighting system maintenance	<ul style="list-style-type: none">• Lamps• Ballasts• Luminaires• Lighting controls• Exist sign upgrades• Disposal

Simple guidance for energy efficient lighting

- The right amount of light
- Light in the right place
- Light at the right time
- The right lighting equipment





Lighting energy use

- Lighting system efficiency principles:
 - 1. Lighting hardware efficiency
 - Includes light source, control gear, optical system, luminaire housing, etc.
 - 2. Lighting installation efficiency
 - Largely dependent on the choice, location & setting up (e.g. aiming) of the lighting hardware
 - 3. Usage efficiency
 - Depends largely on the type of lighting controls & space design



Lighting energy use

- Video: **Energy 101: Light Bulbs** (4:47)



- <http://youtu.be/Pk60-D61h34>

- Our animated correspondent, ‘Little Lee Patrick Sullivan,’ kicks off our “Energy 101” series with an inside look -- literally -- at light bulb technology. He goes inside an incandescent, a compact fluorescent and an LED bulb to see what makes them work, and their potential drawbacks.

Evolution of light bulbs



Edison
lamp

Incandescent
lamp

Compact
fluorescent
lamp

LED lamp

Traditional incandescent

Halogen incandescent

Compact fluorescent (CFL)

Light-emitting diode (LED)

Approximate wattage needed to produce 1,600 lumens

100 watts

77* watts

23 watts

20 watts

Energy input

INPUT
OUTPUT

Wasted energy

1,600 lumens

1,600 lumens

1,600 lumens

1,600 lumens

Electric current heats an incandescent bulb's tungsten filament until it glows.



LIFE SPAN: 750 hours



PRICE: \$0.37 per bulb



Halogen gas such as iodine inside the bulb prevents wear on the filament, allowing it to glow brighter.



1,000 hours



\$1.59 per bulb



Excited gas in a CFL tube emits ultraviolet photons, which coax the bulb's coating to emit visible light.



10,000 hours



\$2.23 per bulb



An LED bulb contains many small semiconductor units; each emits light when a voltage is applied.



20,000 hours



\$45 per bulb



Life span

Comparison of capital cost & electricity cost among different lamps

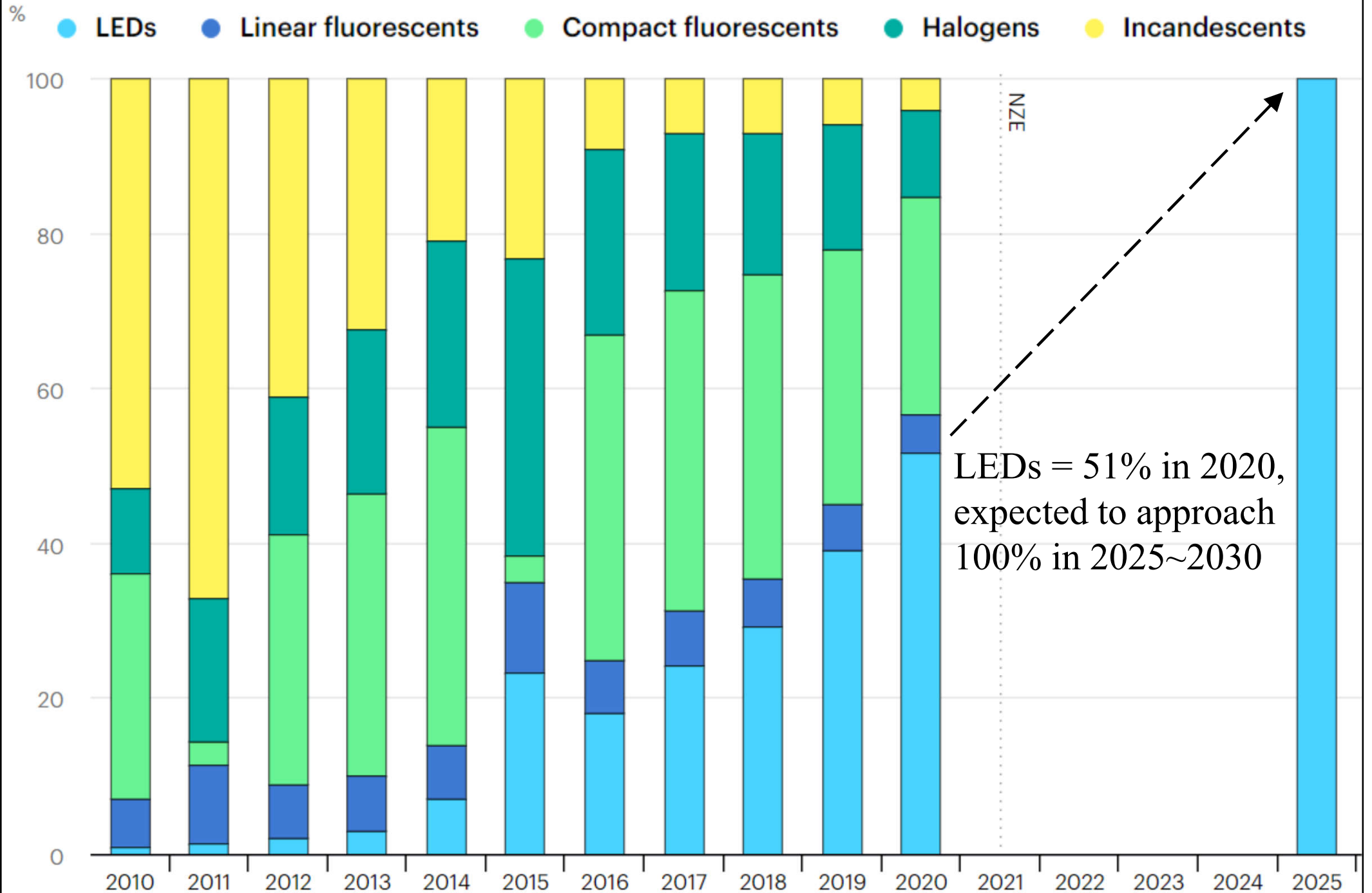
	Incandescent Bulb	Compact Fluorescent Lamp	LED Lamp
Wattage (W)	60	12	7
Lumen Output (lm)	710	700	600
Luminous Efficacy (lm/W)	12	58	86
Average Life Expectancy (hrs.)	1,000	8,000	15,000
Annual Electricity Consumption for Each Bulb (kWh) ^{1.3}	131	26	15
Annual Electricity Cost for Each Bulb ^{1.4}	HK\$158	HK\$32	HK\$18
Retail Price for Each Bulb	HK\$18	HK\$40	HK\$52
Number of Bulb Required for Operating 15,000 Hours (No.)	15	2	1
Total Capital Cost and Electricity Cost for Operating 15,000 Hours	HK\$1,350	HK\$291	HK\$178
Photo			

(Source: <https://www.emsd.gov.hk/energyland/en/appAndEquip/equipment/lighting/example.html>)

Comparison of capital cost & electricity cost for decorative lamps

	Halogen Lamp	LED Lamp
Wattage (W)	50	5.5
Centre Beam Luminous Intensity (cd)	1200	1030
Average Life Expectancy (hrs.)	2,000	25,000
Annual Electricity Consumption for Each Lamp (kWh) ^{2.3}	110	12
Annual Electricity Cost for Each Lamp ^{2.4}	HK\$131	HK\$14
Retail Price for Each Lamp	HK\$10	HK\$102
Number of Lamp Required for Operating 25,000 Hours (No.)	13	1
Total Capital Cost and Electricity Cost for Operating 25,000 Hours	HK\$1,625	HK\$267
Photo		

Global lighting sales, historical & in the net-zero energy (NZE) scenario



LEDs = 51% in 2020, expected to approach 100% in 2025~2030

Classifications of LED lighting products & examples of application

Type of LED lighting products	Application category
<ul style="list-style-type: none">• Directional lamp• Non-directional lamp• Strip light• Integrated LED luminaire• Integrated downlight• Planar (or Panel) LED luminaire• Linear batten LED luminaire• Troffer LED luminaire• High/Low bay LED luminaire• Outdoor (Floodlight) integrated luminaire• Roadway integrated luminaire	<ol style="list-style-type: none">1. Residential lighting products<ul style="list-style-type: none">• Non-directional & directional lamps for general lighting service• Linear strip light (flexible or rigid)• Integrated LED downlight luminaires2. Commercial & industrial lamps (typical retrofit lamps for linear fluorescent & HID Lamps)<ul style="list-style-type: none">• Linear double-capped LED lamps• Single-capped high luminous flux LED lamps3. Commercial & industrial indoor luminaires<ul style="list-style-type: none">• Integrated LED luminaires (planar/panel, linear batten, troffer)• Retrofit kits for fluorescent troffer luminaires• High/Low bay LED luminaires4. Outdoor luminaires<ul style="list-style-type: none">• Roadway/street lighting integrated luminaires• Outdoor integrated luminaires

(See also: <https://www.ledlightsinindia.com/information/types-of-led-lights-available-applications>)

(Source: <https://www.iea-4e.org/ssl/news/quality-and-performance-requirements-for-led-lighting-products-public-review-draft/>)

Energy efficient lighting



- **HK Building Energy Code (BEC)***
 - Code of Practice for Energy Efficiency of Building Services Installations
 - 2018 Edition, 2015 Edition & 2012 Edition
 - Requirements for lighting installation
 - Technical Guidelines on Building Energy Code
 - 2018 Edition, 2015 Edition & 2012 Edition
- **Energy Efficiency Labelling Scheme (HK)***
 - Compact fluorescent lamps (CFLs), LEDs

Buildings Energy Efficiency Ordinance (BEEO)

<https://www.emsd.gov.hk/beeo/>



空調裝置
Air-conditioning
installation

BUILDINGS ENERGY EFFICIENCY ORDINANCE (CAP. 610) 《建築物能源效益條例》第610章



照明裝置
Lighting installation



電力裝置
Electrical installation



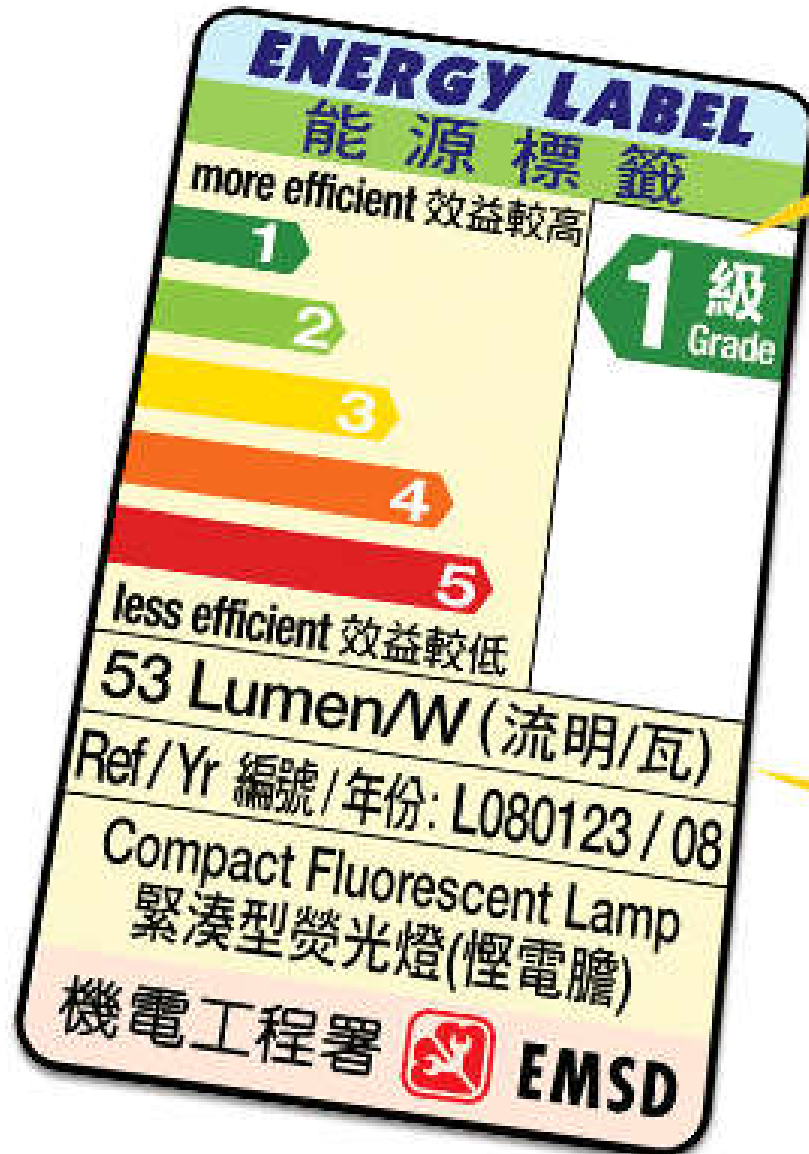
升降機及自動梯裝置
Lift and escalator
installation

Energy Efficiency Labelling Scheme

<https://www.emsd.gov.hk/energylabel/>

UNDERSTANDING THE LABEL

Compact Fluorescent Lamps (CFLs)



This indicates the energy efficiency grading of the model. Grade 1 products are most efficient (green) and have an average lamp life of 8,000 hours or above. Grade 5 products have an average lamp life of below 6,000 hours (red).

PERCENTAGE OF ENERGY SAVING
Compact Fluorescent Lamps (CFLs)

Grade 1 vs Grade 5
18%

TIPS
Switch off lights that are not in use.

Lamp luminous efficacy of the model. A higher number indicates that the product is more efficient.

Energy efficient lighting



- HK Building Energy Code: energy efficiency requirements for lighting installation
 - 1. Lighting power density (LPD)
 - Reduce lighting power
 - 2. Lighting control point
 - Facilitate effective operation; reduce energy use
 - 3. Automatic lighting control
 - Such as daylight responsive control, occupant sensor, time scheduling, dimmer control system

HK Building Energy Code (BEC): Lighting power density (LPD)

LPD for office spaces:

	LPD (W/m ²)
BEC 2012	15
BEC 2015*	13 / 12
BEC 2018**	12 / 10 / 9

* For enclosed office $\leq 15 \text{ m}^2$ & open plan office $> 15 \text{ m}^2$.

** For enclosed office $\leq 15 \text{ m}^2$, office with area between 15 to 200 m² & office $> 200 \text{ m}^2$.

(Source: BEC 2018)

Table 5.4 : Lighting Power Density and Automatic Lighting Control for Various Types of Space

Type of Space	Maximum Allowable LPD (W/m ²)	Automatic Lighting Control Required (Yes / No)
Atrium / Foyer with headroom over 5m	17	Yes
Bar / Lounge	13	No
Banquet Room / Function Room / Ball Room	17	No
Canteen	11	No
Car Park	5	Yes, at parking spaces only
Changing Room/ Locker Room	10	Yes
Classroom / Training Room	12	Yes
Clinic	15	No
Common Room/ Break Room	8	Yes
Computer Room / Data Centre	15	Yes
Conference / Seminar Room	14	Yes
Confinement Cell	12	No
Copy/ Printing Room, Photocopy Machine Room	10	Yes
Corridor	8	Yes
Court Room	15	Yes
Covered Playground (underneath building)/ Sky Garden	12	Yes
Dormitory	8	Yes
Entrance Lobby	13	Yes
Exhibition Hall / Gallery	15	No
Fast Food / Food Court	14	No
Guest room in Hotel or Guesthouse	13	No
Gymnasium / Exercise Room	11	Yes
Indoor Swimming Pool, for recreational or leisure purposes	15	No
Kitchen	13	No
Laboratory	15	No
Lecture Theatre	13	Yes
Library – Reading Area or Audio Visual Centre	12	No
Library – Stack Area	15	No
Lift Car	11	Yes
Lift Lobby	10	Yes
Loading & Unloading Area	8	Yes
Long Stay Ward for elderly	15	No
Nurse Station	13	No
Office, enclosed (Internal floor area at or below 15m ²)	12	Yes
Office, Internal floor area above 15m ² and of or below 200m ²	10	Yes
Office, Internal floor area above 200m ²	9	Yes

Sample calculation for lighting power density (LPD)

Table 5.7 : LPD Calculation for Multi-functional Space

<u>Space</u>	<u>Function-specific Luminaires</u>			<u>LPD (W/m²)</u>	
	<u>Luminaire Designation</u>	<u>Quantity</u>	<u>Total Circuit Wattage (W)</u>	<u>Calculated</u>	<u>Max Allowable</u>
Banquet room	LT1	96	480	[480 + 2880 + 1104] / 264 = 16.9	17
	LT2	90	2880		
	LT3	8	1104		
	LT4	Excluded in LPD			
Ball room	LT2	90	2880	[2880 + 1104] / 264 = 15.1	17
	LT3	8	1104		
	LT4	Excluded in LPD			
Seminar room	LT1	96	480	[480 + 2016] / 264 = 9.5	14
	LT5	112	2016		

(Source: Technical Guidelines on Building Energy Code 2018)

Energy efficient lighting



- Typical lighting requirements

- Minimum allowable luminous efficacy
 - Choose appropriate type of lamps
- Maximum allowable lamp controlgear loss
 - Energy efficient ballast for fluorescent lamps
- Maximum allowable lighting power density (LPD)
 - Design suitable amount and type of lighting systems
- Interior lighting controls (switching)
 - Number of control points (to facilitate effective operation)

Energy efficient lighting

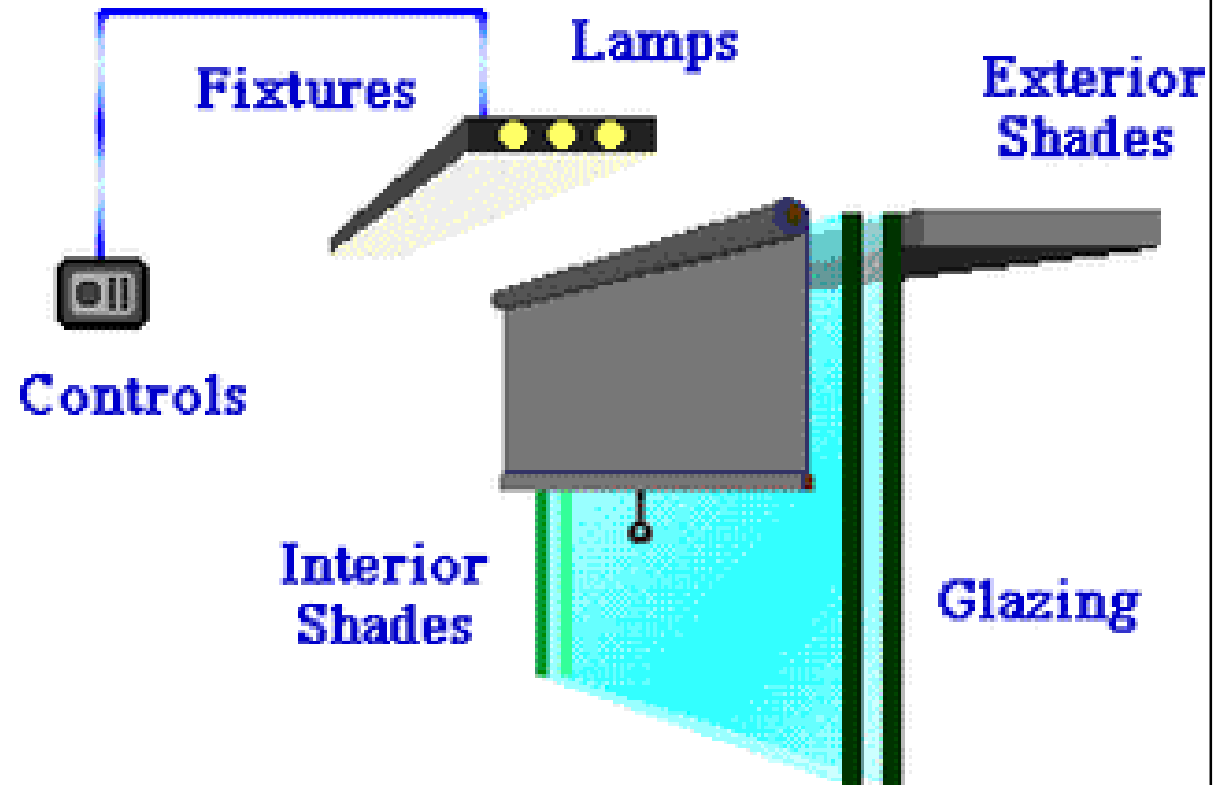


- Principles of efficient lighting design
 - Meet target light levels
 - Efficiently produce light
 - Use natural light or efficient light sources
 - Efficiently deliver light
 - Balance efficiency with aesthetics, lighting quality, visual comfort
 - Automatically control lighting operation
 - Switch off or dim unnecessary lighting equipment

Energy efficient lighting design strategies



Energy efficient fittings (e.g. compact fluorescent lamps, LED)



Lighting controls and interactions with windows

Example: Integrated controls for lighting luminaires

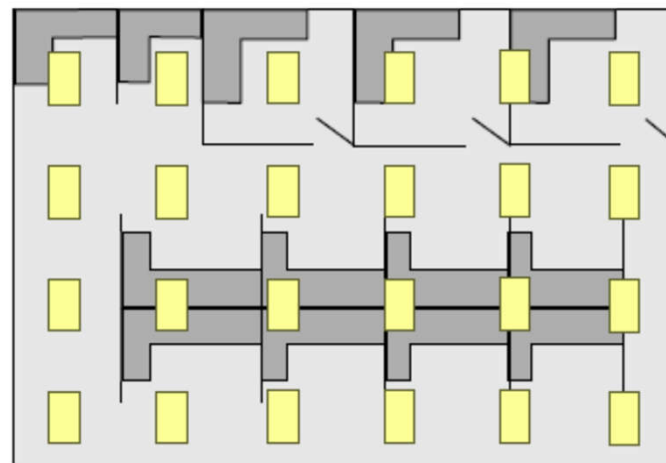
Vertically Integrated Design

Personal Control Features:

- Direct/ Indirect Pendant Luminaire
- Task light: 2T8-PS Dimmable EB (64W)/ 100%-5%
- Ambient light: 1T8-PS EB (31W)/ ON/OFF only
- Photocell Sensor built in
- Occupancy Sensor built in

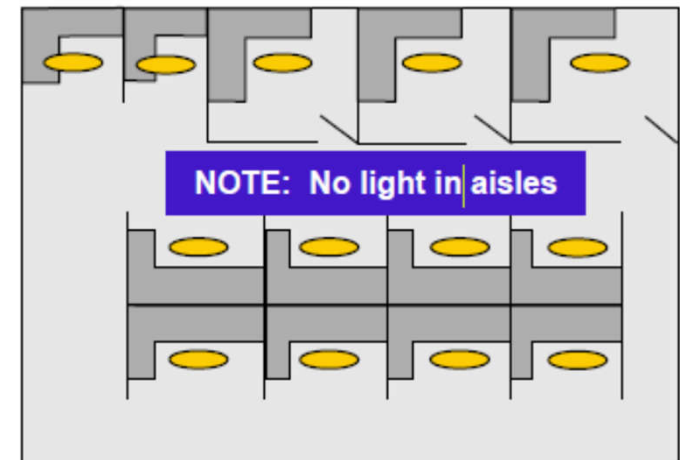


Comparison to a Standard Troffer Layout:



- 2x4 Parabolics
- **24 Luminaires**
- 72 lamps
- ~2300 watts

- Direct Indirect
- **13 Luminaires**
- 39 lamps
- ~1250 watts



Energy efficient lighting



- The key is to understand lighting needs & operation
 - Space design & utilisation
 - Daylighting potential
 - Light sources
 - Luminaires
 - Lighting controls
 - Operation & maintenance



Energy efficient lighting



- Recommendations by IESNA
 - Design lighting for expected activity (higher light levels for "working", lower levels for "walking")
 - Design with more effective fixtures & fenestration
 - Use efficient light sources (higher lumen per watt output)
 - Use more efficient fixtures
 - Use thermal controlled fixtures
 - Use lighter finish on ceilings, walls, floor & furnishings

Energy efficient lighting



- Recommendations by IESNA (cont'd)
 - Use efficient incandescent lamps
 - Turn off lights when not needed
 - Control window brightness
 - Use daylighting as practicable
 - Keep lighting equipment clean and in good working condition
 - Post instructions covering operation & maintenance

Checklist for lighting energy-saving guidelines

Lighting needs

- Visual tasks: specification
- Safety & aesthetics
- Overlighted application
- Groupings: similar visual tasks
- Task lighting

Space design & utilization

- Space plan & activities
- Room surfaces
- Space utilization: flexibility & operation periods

Daylighting

- Use daylight in suitable spaces
- Daylight compensation
- Daylight sensing & control

Light sources: lamps & ballasts

- Source efficacy
- Control compatibility
- System change

Luminaires

- Direct/indirect lighting
- Luminaire efficiency
- Heat removal
- Maintained efficiency
- Lamp replacement schedule

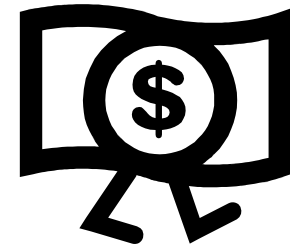
Lighting controls

- Local control & selective switching
- Master control system
- Multipurpose spaces
- Tuning, dimming & scheduling
- Occupant & motion sensors
- Lumen maintenance
- Ballast switching

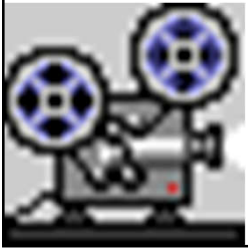
Operation & maintenance

- Cleaning & relamping schedule
- Regular system checks
- Renovation of luminaires
- Education & promotion

Lighting economics

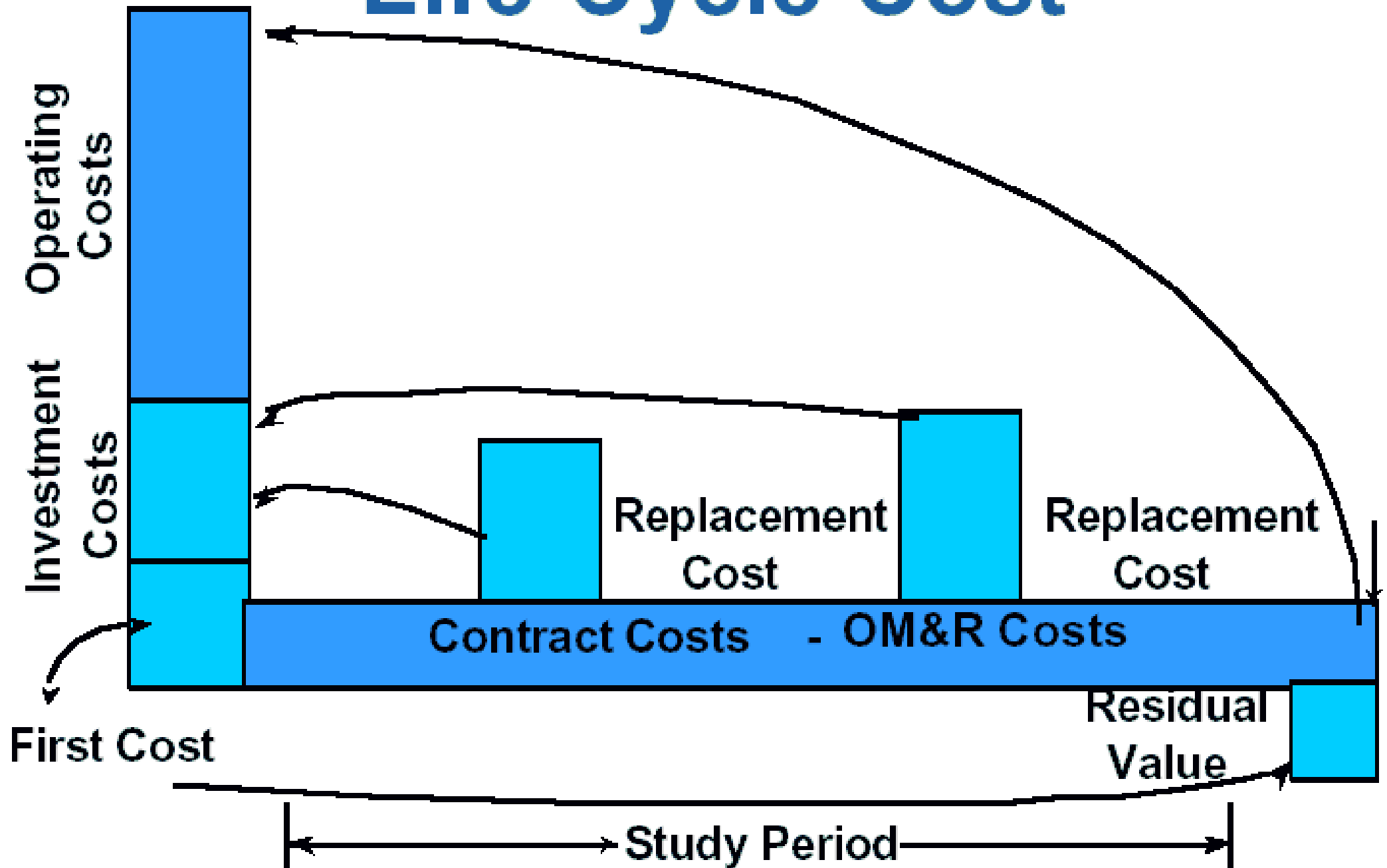


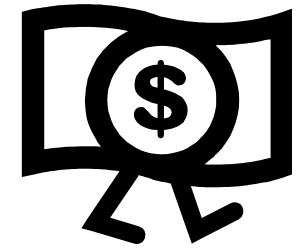
- Lighting costs
 - Financial costs
 - Lamps, luminaires, control systems & installation
 - Operating & maintenance costs
 - Disposal costs
 - Environmental costs
 - Electricity consumption & greenhouse gas emissions
 - Chemical pollution (lamps & control gear are scrapped)
 - Light pollution (light trespass & sky glow)



(Video: What does lighting cost (4:30) <https://youtu.be/wflEn2mWCcI>)

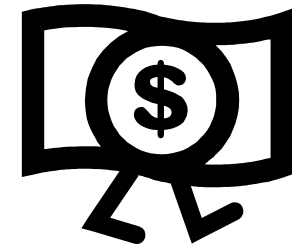
Life-Cycle Cost





Lighting economics

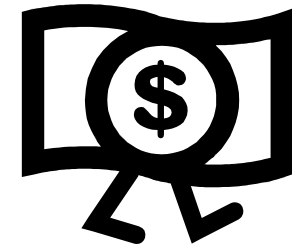
- Lighting systems --- **Life Cycle Costs (LCC)**
 - Initial costs
 - Equipment, installation, wiring, HVAC
 - Energy costs
 - Direct lighting costs
 - Energy use (kWh) = lighting power (kW) x operating time (hr)
 - Lighting-related HVAC (indirect) costs
 - Lighting heats up the space & require cooling
 - Total cost savings = energy costs + demand costs
 - Maintenance costs



Lighting economics

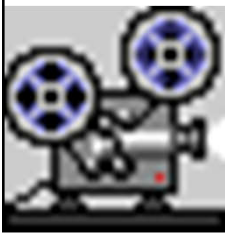
- Lighting maintenance
 - Relamping
 - Reballasting
 - Cleaning
 - Miscellaneous maintenance
 - e.g. replace lenses or louvers, damaged parts
- Other related costs:
 - Working at height
 - Insurance, property taxes, depreciation





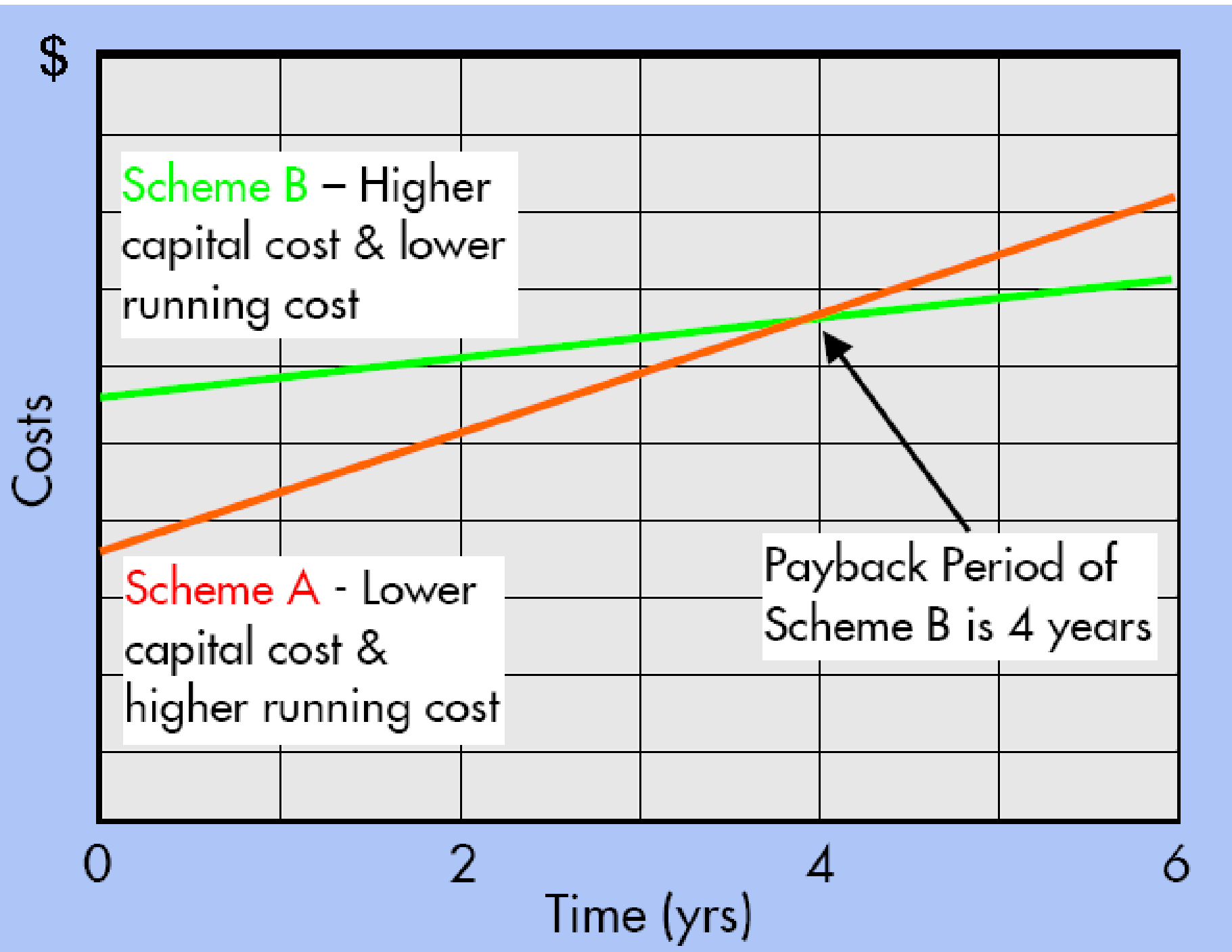
Lighting economics

- Investment costs
 - Luminaire, including control gear (where applicable)
 - Lighting control systems (e.g. dimmers)
 - Mounting accessories
 - Electrical wiring
 - Installation costs
- Running costs
 - Energy
 - Lamp replacement
 - Maintenance
 - Amortization (disposal)



(Video: Economics of Light (3:22) https://youtu.be/QzSAKWR_zv4)

Payback period of lighting scheme

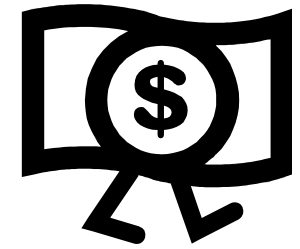


Example: comparison of two lighting systems (1/2)

Parameters	2x4 Lamp Parabolic ES lamps and Ballast	2x4 Lamp Parabolic T8 Electronic System
Number of Fixtures	100	100
Initial Cost Luminaire and Lamps	80	90
Total	\$ 8,000	\$ 9,000
Maintenance & Operating Cost/Year	\$ 2,616	\$ 2,040
Total (5 years)	\$13,080	\$ 10,200
Total Cost	\$ 21,080	\$ 19,200

Example: comparison of two lighting systems (2/2)

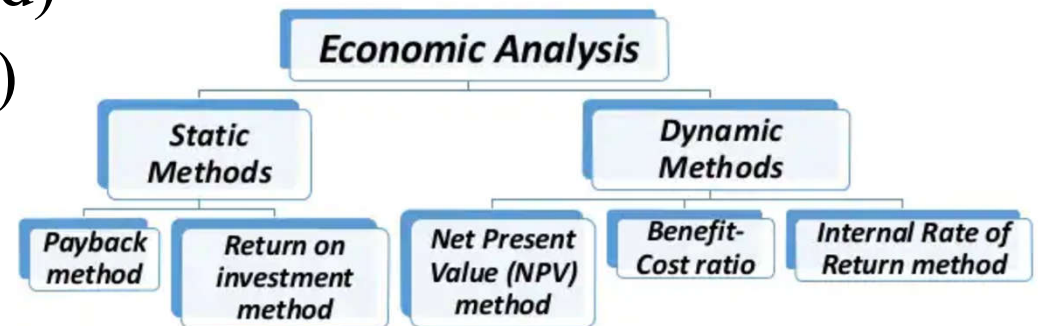
Parameters	2x4 Lamp Parabolic ES lamps and Ballast	2x4 Lamp Parabolic T8 Electronic System
Delivered Lumens		
-Lumens/Lamp	2650	2950
-Number of Lamps	3	3
-Coefficient of Utilization	0.69	0.79
-Light Loss Factor	0.85	0.85
Total Delivered Lumens	4,663	5,943
Operating Hours		
Operating Hours per Year	4,000	4,000
Number of Years	5	5
Total Operating Hours	20,000	20,000
Total Cost per Million Lumen Hours	\$ 226 (21,080 x 1,000,000) /(4663 x 20,000)	\$ 161 (19,000 x 1,000,000) /(5943 x 20,000)



Lighting economics

- Economic analysis techniques:

- Payback (simple, discounted)
- Return on investment (ROI)
- Net present value (NPV)
- Benefit-cost ratio (BCR)
- Internal rate of return (IRR)
- Total life cycle cost (TLCC)

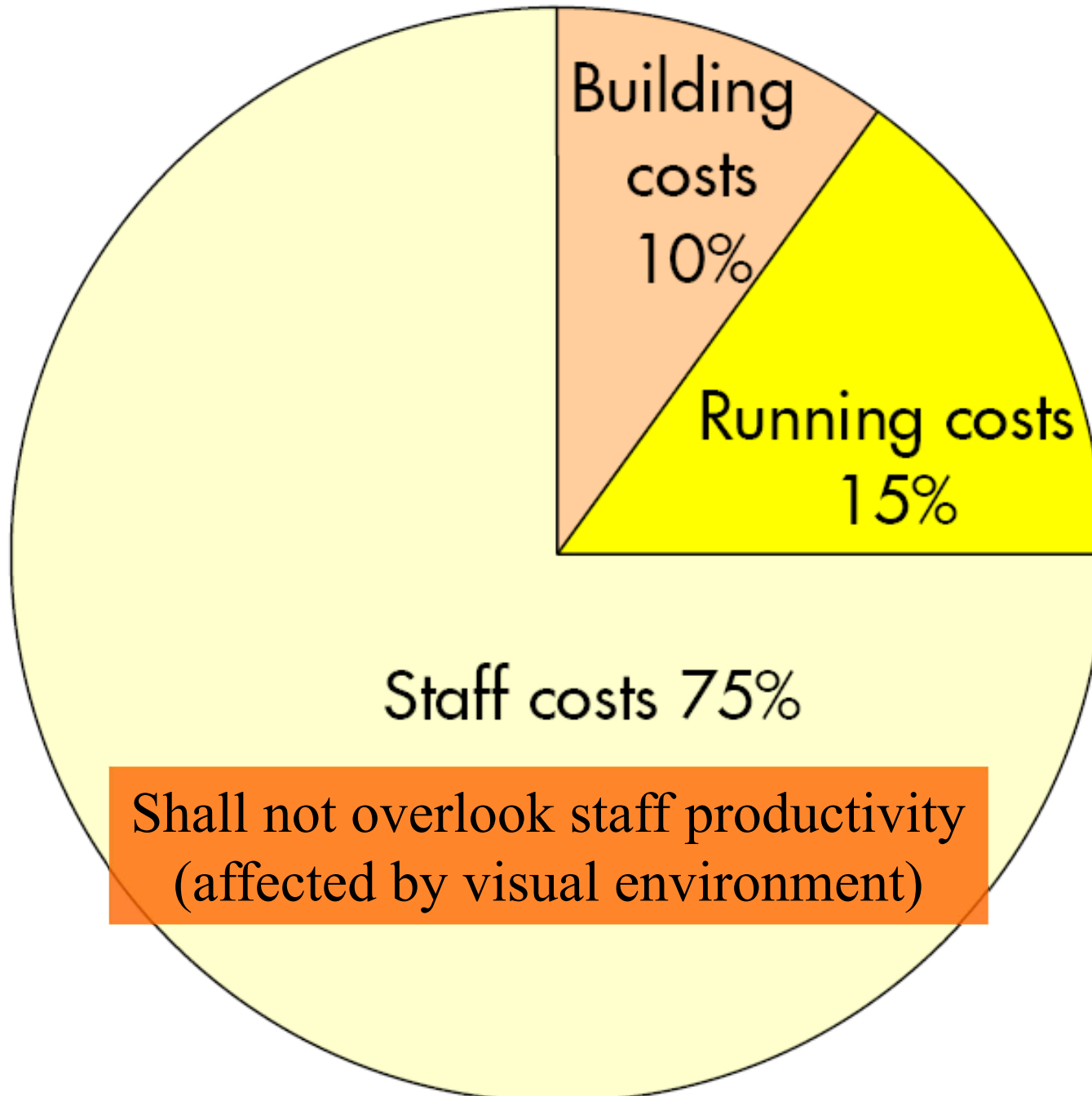


- Lighting economic analysis tools:

- Simple Economic Tool <https://www.visual-3d.com/tools/payback/>
- Visual Economic Tool <https://www.visual-3d.com/tools/economicpro/>



Building, running & staff costs



Shall not overlook staff productivity
(affected by visual environment)

Existing buildings



- Energy management for existing buildings
 - Building survey
 - Power budget & limit determination
 - Energy limit determination
 - Energy limit analysis
- Critical issues to consider
 - Maintenance of lighting systems
 - Lighting upgrade strategies
 - Environmental aspects



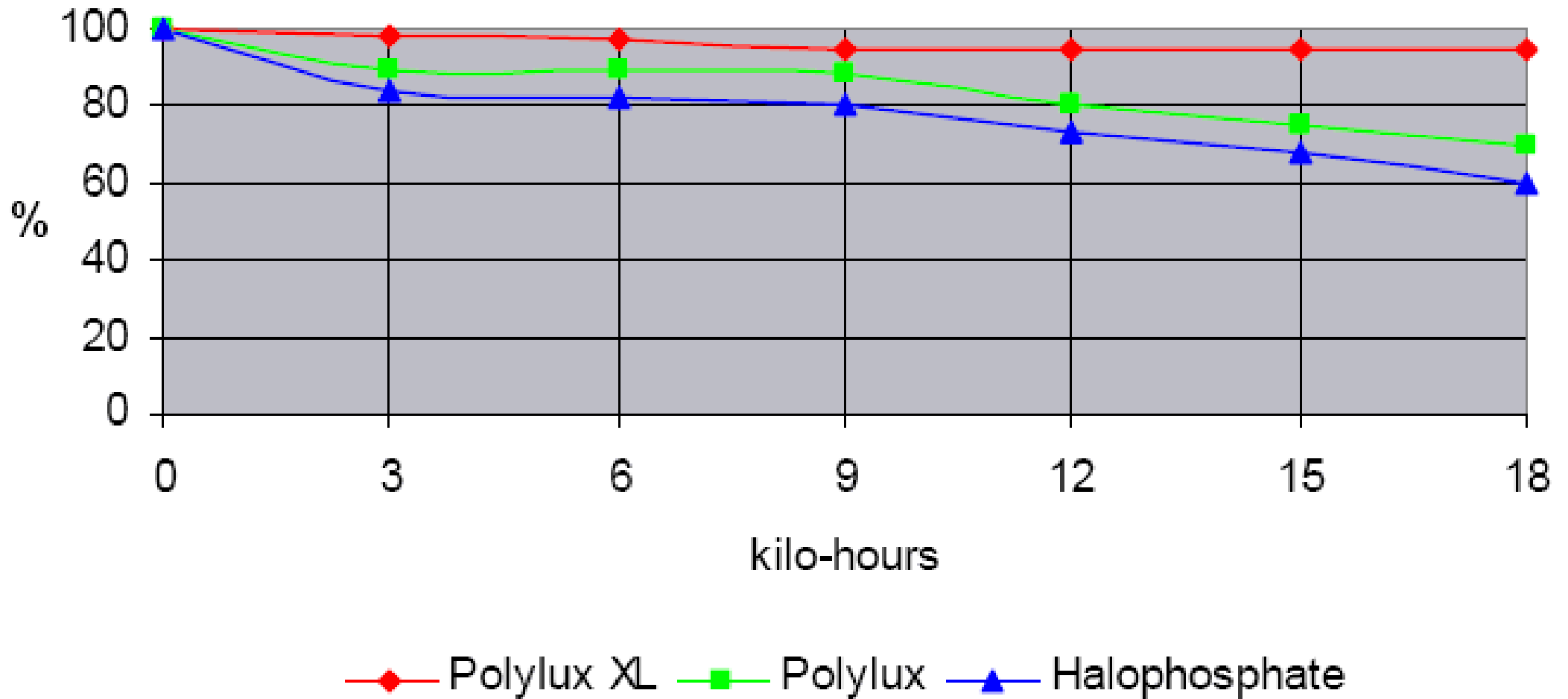
Existing buildings



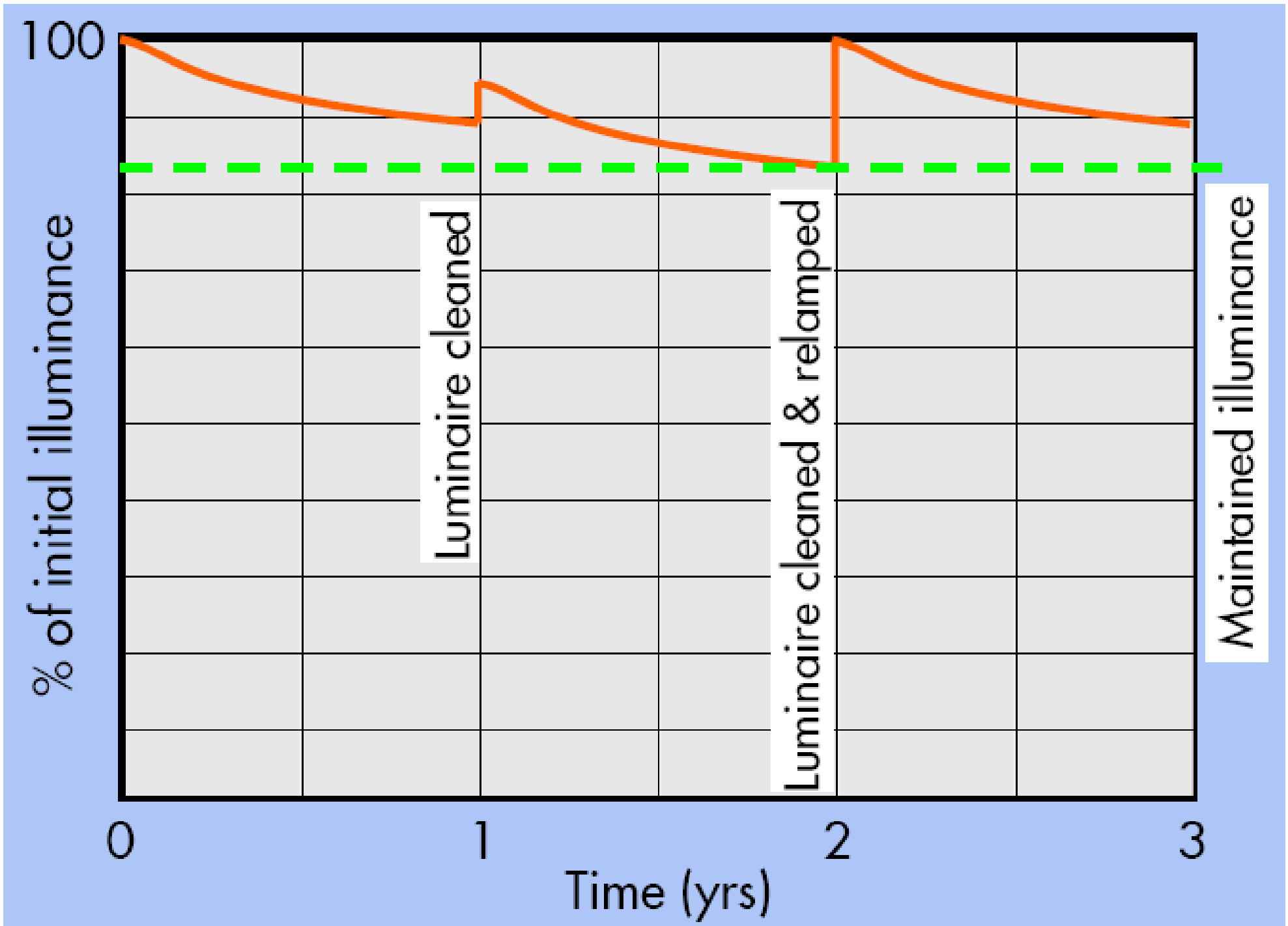
- Maintenance of lighting system
 - Periodic cleaning of lighting fixtures & lamps
 - Decreases light loss & improve light levels
 - Spot or group replacement of lamps based on the economics of the system
 - Periodic repainting or cleaning of the room surfaces (ceiling, walls, and floor) to maintain optimum light reflection characteristics
- **“Lumen maintenance”** & lamp life/failure

Examples of lumen depreciation for different luminaires
(Lumen maintenance = ratio of the light output at a particular time relative to the initial output)

(Lamps with high lumen maintenance levels can contribute to energy savings)

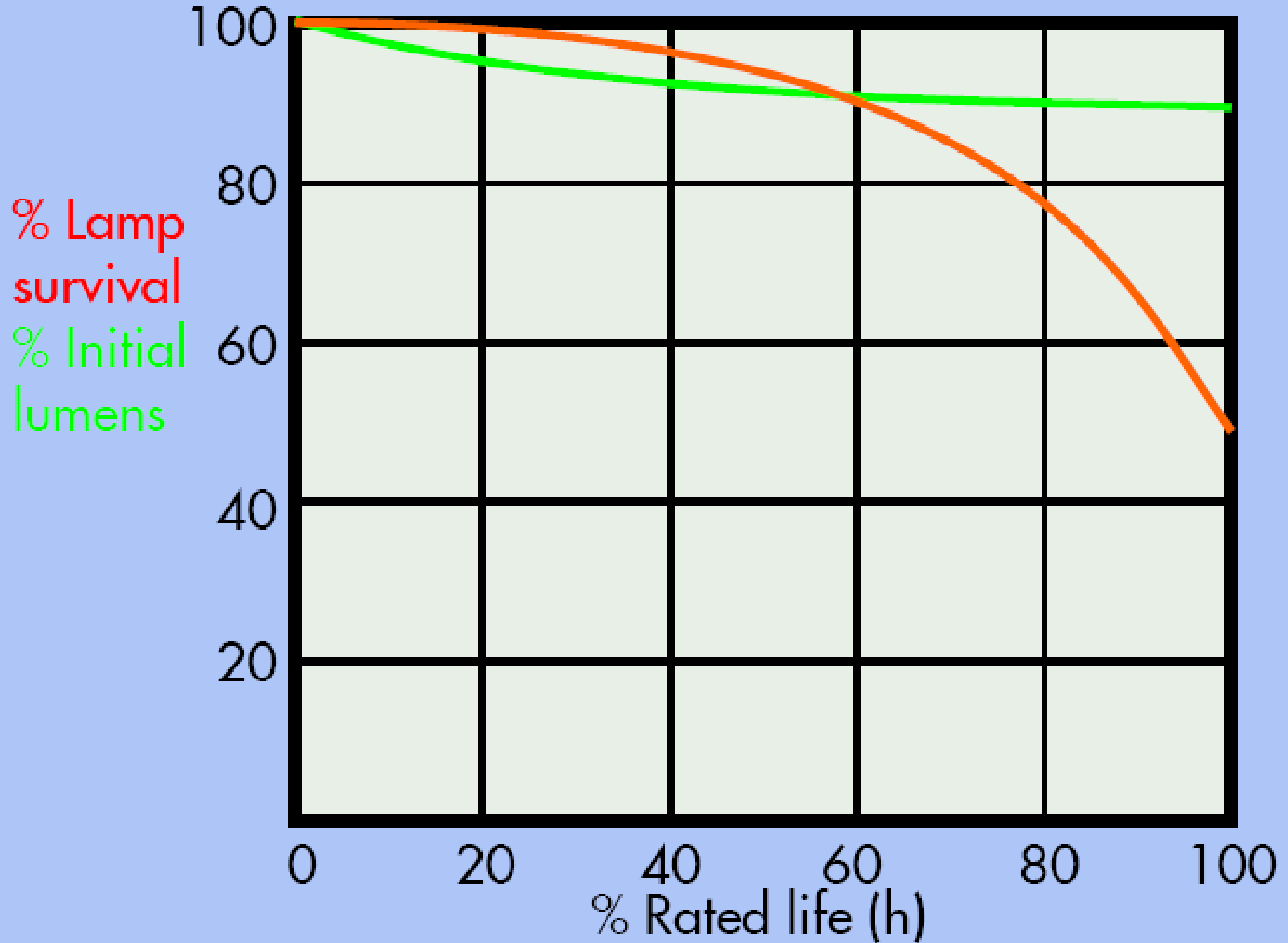


Lamp maintenance effect & maintained illuminance



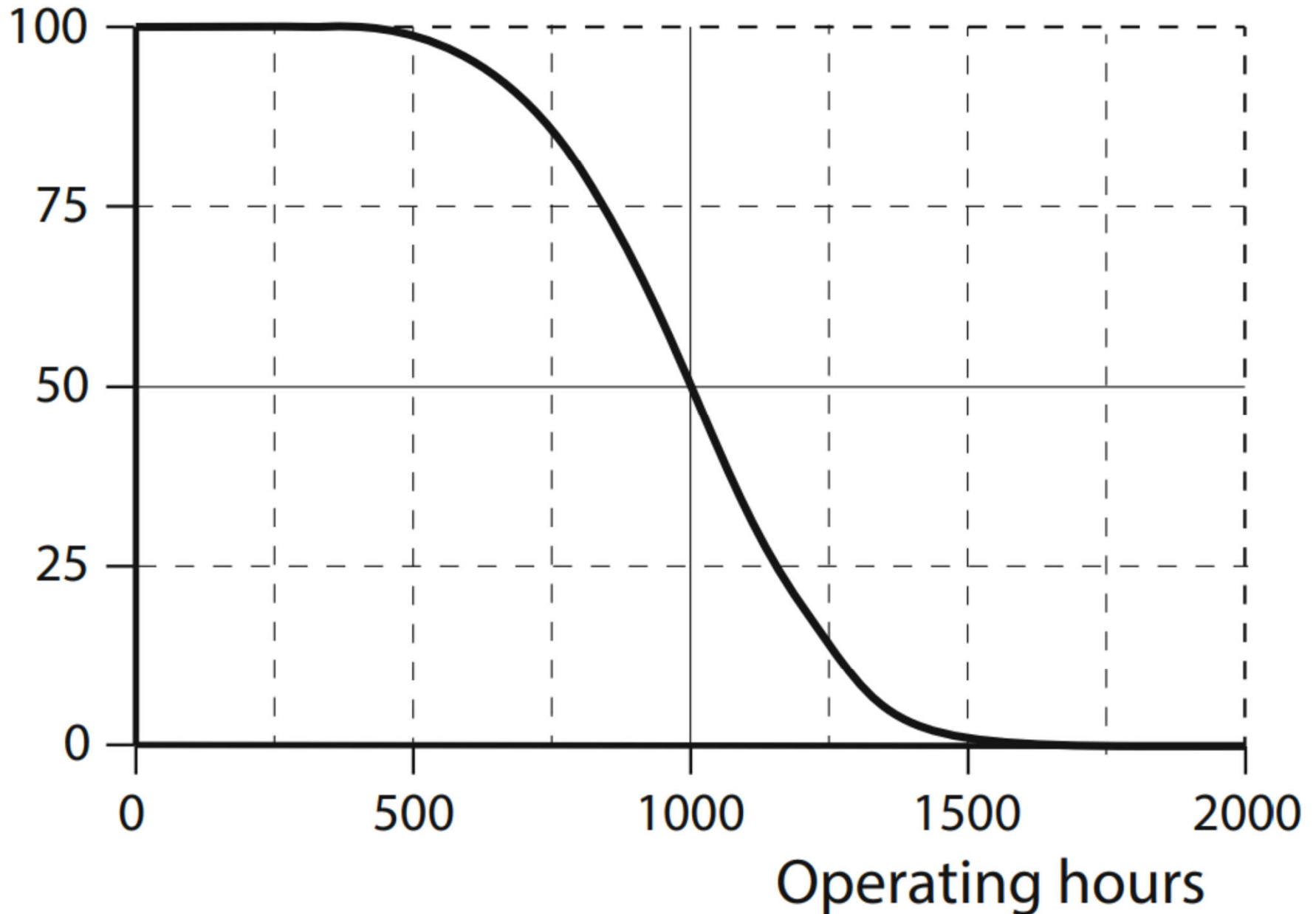
Lamp survival & rated life

Rated life 28500h

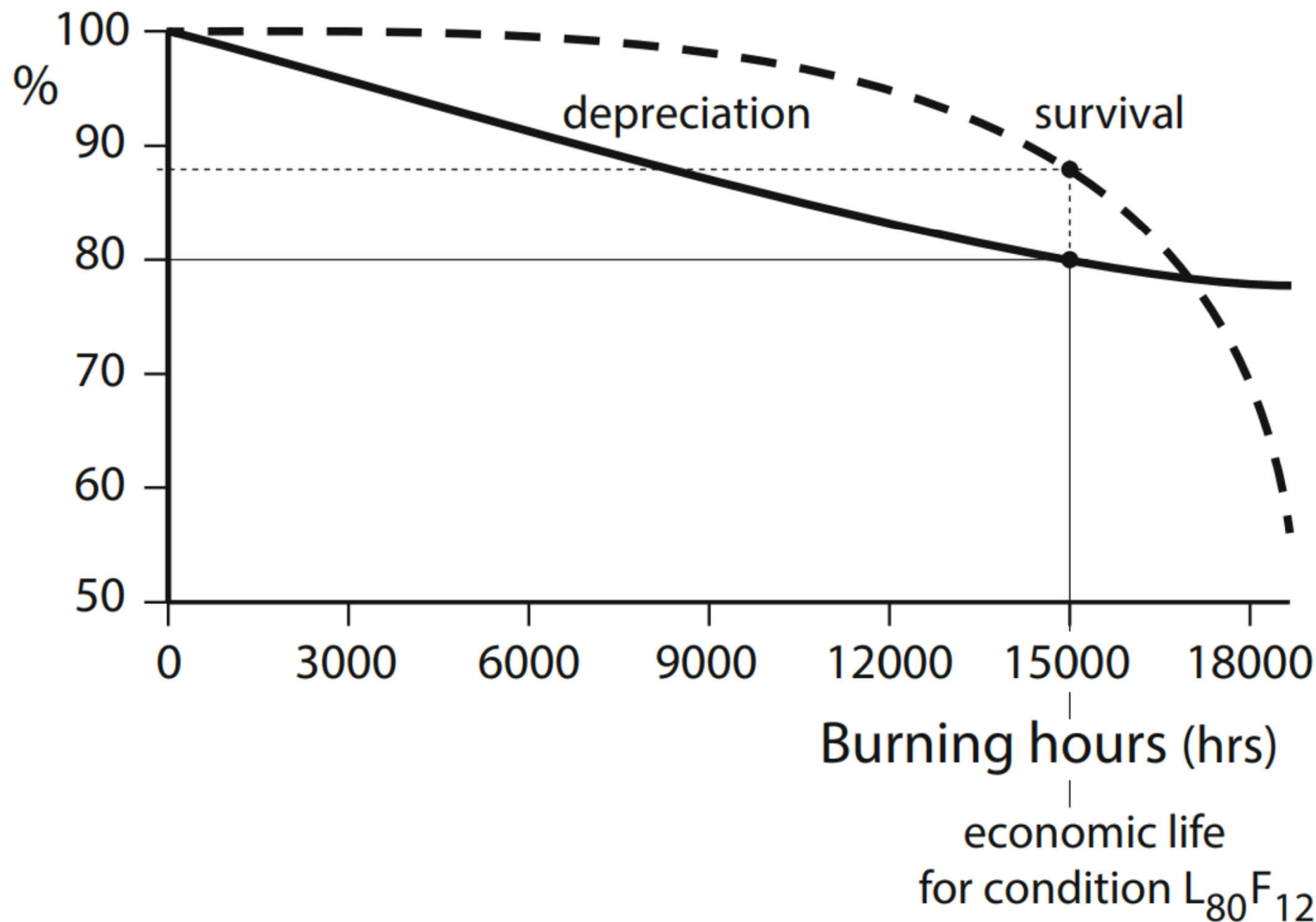


Typical life survival curve of an incandescent lamp for general lighting

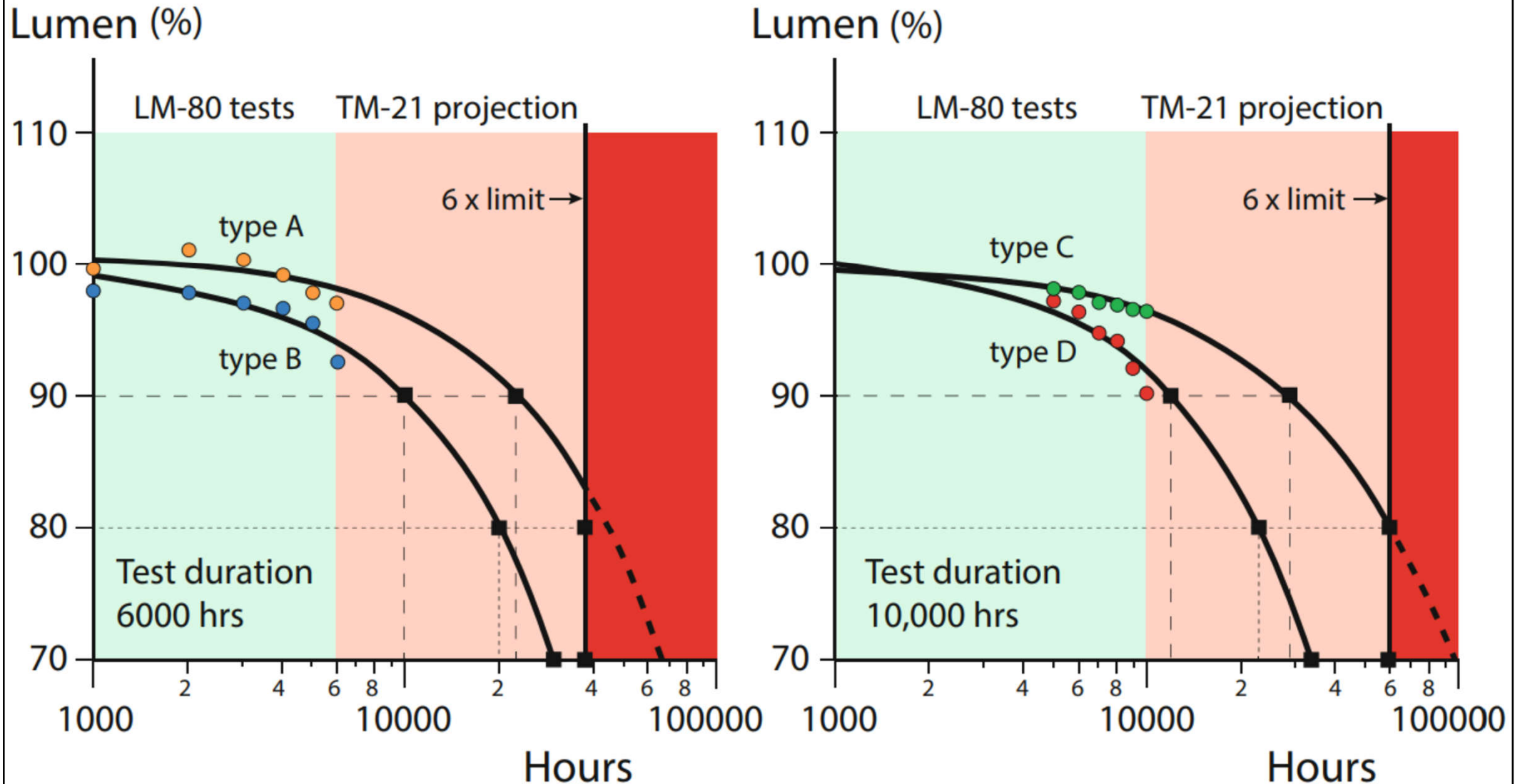
Survivals (%)



Example of a lamp survival & a lamp lumen depreciation curve of a typical gas-discharge lamp



Examples of lumen maintenance interpolated curves for four different LED types. The coloured circles are measuring points; the black squares represent the projected lifetime for the conditions L_{90} , L_{80} and L_{70}



Existing buildings



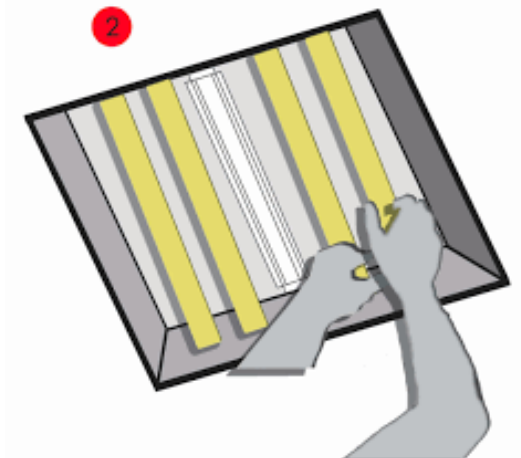
- Common lighting upgrade strategies
 - Upgrade with reduction in light levels
 - If original design is excessive
 - Increase light levels
 - Maintain light levels
 - Focus light levels
 - Task lights or accent lighting
 - Reduce hours of use
 - Add time schedule or automatic controls



Existing buildings



- Upgrade fluorescent fixtures
 - Improved fluorescent lamps
 - T-8, T-10. T-12 tri-phosphor lamps
 - New T-5 lamps
 - New induction lamps (long life)
 - Electronic ballasts
 - Standard non-dimmable
 - Consider dimming ballasts
 - New programmable ballasts
 - Reflectors



Existing buildings



- Typical fluorescent fixture upgrades

- T8 lamp/ballast system
- T5 twin-tube lamp/ballast system
- Specular reflectors/delamping
- Current limiters
- Daylight-dimming systems
- 25W T12 lamps/T8 ballasts
- Premium magnetic, cathode cut-out (hybrid), electronic ballasts (full output, dimmable, light-level switching and low-wattage)
- Lens/Louvre upgrades
- Indirect lighting w/task lighting
- Task lighting w/reduced ambient lighting
- New fixtures



Existing buildings



- LED lighting upgrade
 - Retrofits using tubular LEDs or LED retrofit kits
 - Minimal impact to the architecture or other systems
 - Existing layouts may not be optimized for the LEDs
 - Replace fixtures with integrated LED luminaires
 - Opportunity for customization & optimization
 - May require a more substantial space renovation
 - Upgrade of controls (occupant/daylight sensors)
 - Also, new requirements of building energy codes



Existing buildings



- Typical exit sign upgrades
 - Compact fluorescent lamps
 - Low-wattage incandescent lamps
 - LEDs
 - Electroluminescent panels
 - New exit signs
- Typical control upgrades
 - Lighting management systems
 - Dimmable fluorescent & HID ballasts
 - Daylight- & lumen maintenance-dimming systems
 - Electronic timeclocks
 - Occupancy sensors (many options available)
 - Manual, step-level & panel-level dimming systems
 - Current limiters
 - Capacitive-switching HID systems



Existing buildings



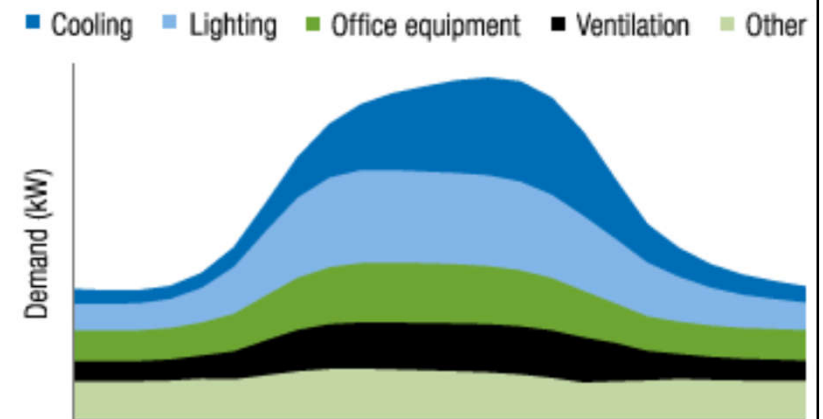
- Lighting retrofit economics (\$\$\$)
 - Must understand current energy consumption
 - Payback & return on investment (ROI)
 - Simple payback usually
 - Life cycle cost (LCC) analysis
- Impact of lighting on building HVAC
 - Lighting & HVAC interactions
 - Cooling energy savings



Existing buildings



- Other considerations:
 - Calculate energy usage & costs
 - Power quality: power factor & harmonic distortion
 - Daylighting
 - Lighting vs. HVAC
 - Energy audit & lighting studies
 - Economic analysis
 - Load shape impacts



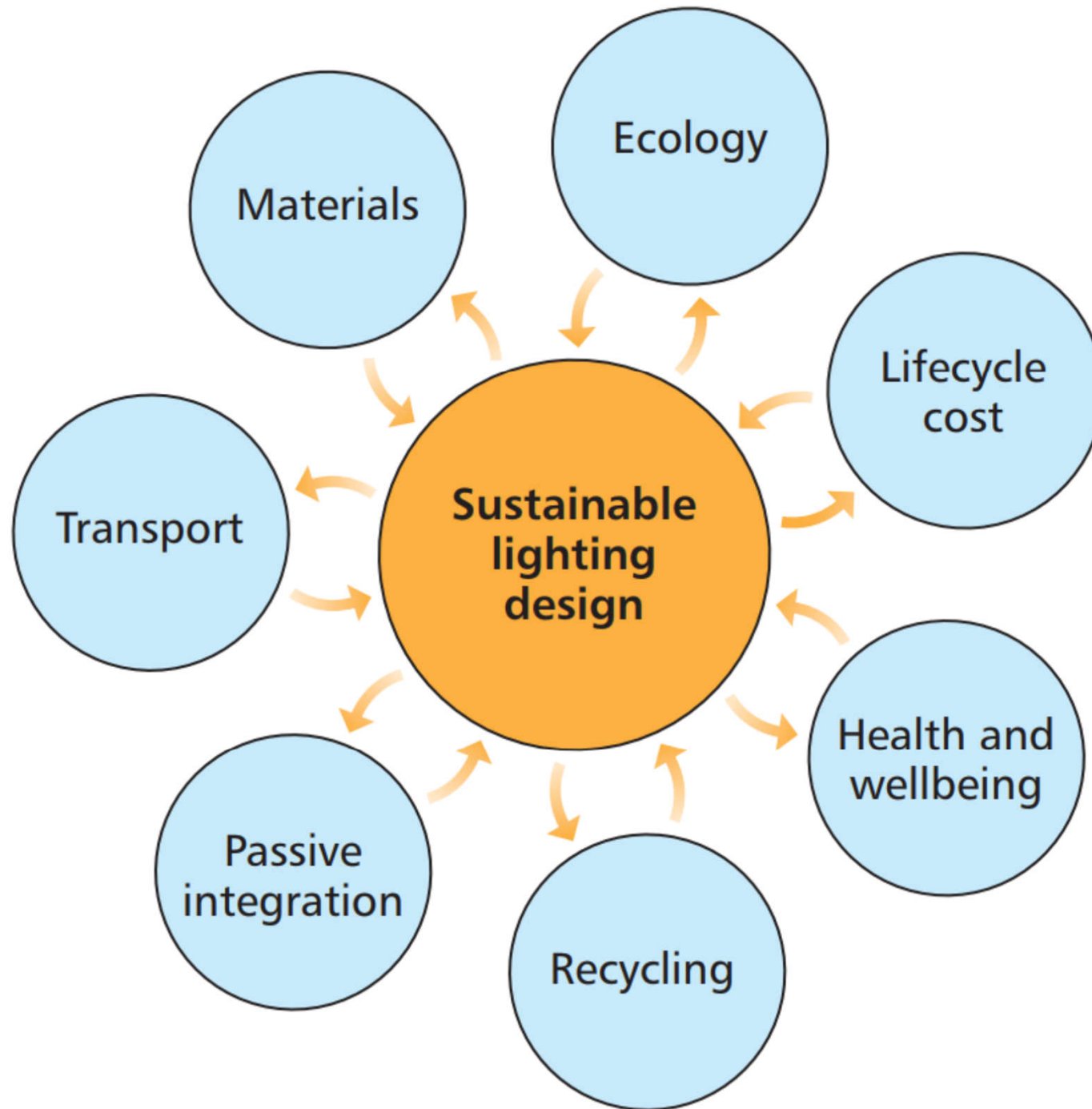
Existing buildings



- Environmental aspects of lighting
 - Disposal & recycling
 - Lighting waste disposal (e.g. lamp & ballast)
 - Green lights
 - Minimum efficacy standards for lamps
 - Emissions (e.g. mercury)
 - During manufacturing
 - During operation



Considerations for sustainable lighting design



Lighting surveys & audits



- Lighting audit
 - A detailed, systematic evaluation of the existing conditions of lighted spaces & the performance of lighting systems
 - Data collection, measurements & in-depth analysis of the data
 - To identify & quantify the potential energy/cost savings & benefits for the owner/occupants
 - To determine if lighting upgrade is possible within the constraints (time & budget)

Lighting surveys & audits



- Types of audit
 - Walk-through audit (simplest)
 - Intermediate or preliminary audit
 - Comprehensive or detailed audit
- Evaluating lighting system
 - 1. Perform a lighting audit
 - 2. Identify opportunities for improvements
 - 3. Calculate the potential savings (using simple payback or life cycle costing)



Lighting surveys & audits



- Major tasks:
 - Collect financial information
 - Utility rate & tariff structure, average charges for energy (kWh) and demand (kW), rebates or subsidies
 - Collect general information
 - Floor plans, reflected ceiling plan, room dimensions
 - Operating conditions/hours, maintenance practice
 - Collect occupant information
 - How they feel about the lighting system



Lighting surveys & audits



- Major tasks: (cont'd)
 - Collect lighting information
 - Hours of operation
 - Type, size & nos. of fixtures
 - Nos. of lamps per fixture, no. of lamps per ballast
 - Type of lamps, type of ballasts, specular reflectors (if any)
 - Fixture condition, whether fixtures are air-handlers
 - Availability of daylight
 - Tasks performed in the space
 - Use of partitions
 - Unique fixture types or physical features
 - Area dimensions, height of the tasks, fixture mounting height
 - Surface reflectances, colours of major objects & room surfaces



Lighting surveys & audits



- Instrumentation
 - Illuminance measuring equipment
 - Luminance measuring equipment
 - Daylight factor meters
 - Electrical measuring tools
- Survey methods
 - Number of measuring points
 - Presentation of information
 - Method of evaluating daylight & artificial lighting
 - Calculation using lumen method



Lighting measuring equipment



Minolta Illuminance Meter
T-10 (luxmeter)

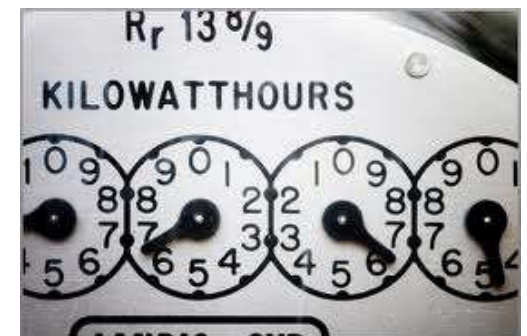


Minolta Luminance Meter
LS-110

Lighting surveys & audits



- What to look for?
 - Lighting equipment inventory
 - Lighting loads
 - Room dimensions
 - Illumination levels
 - Hours of use
 - Lighting circuit voltage & control



Lighting surveys & audits



- Potential lighting energy saving measures
 - Fluorescent upgrades
 - Delamping
 - Incandescent upgrades
 - HID upgrades
 - Control upgrades
 - Daylight compensation
- Three major areas of lighting improvement
 - Replace incandescent lamps with fluorescent or CFL/LED
 - Upgrade fluorescent fixtures with improved components
 - Install lighting controls to minimise energy costs



Electromagnetic vs. Electronic Ballasts



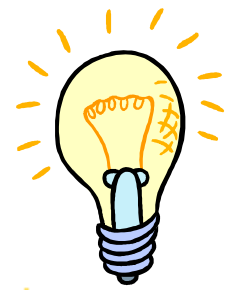
	Electromagnetic Ballast	Electronic Ballast
Heat	Generates about 30 deg. C more heat than electronic	Internal losses are less than 8 watts
Light Flicker	60 Hz frequency causes light flicker levels of 30% or higher	20,000-25,000Hz frequency produces virtually no detectable flicker
Noise	Vibrations induced by electromagnetic field causes humming noise	No audible noise
Weight	Heavy components coated in heavy protective material	Weighs about half as much as electro-magnetic type

Lighting surveys & audits



- Lighting audit report
 - Overview of the area audited (existing lighting systems) & the main energy end-users
 - Details of the scope of the audit including the areas, systems & activities assessed
 - The status of the energy management system
 - The current energy performance of the site and of each of the energy systems assessed
 - Recommendations & feasibility (with energy savings & payback period)





Further reading

- HK EE Net: Lighting
https://ee.emsd.gov.hk/english/lighting/light_intro/light_intro.html
- Energy Efficient Equipment - Lighting
<https://www.emsd.gov.hk/energyland/en/appAndEquip/equipment/lighting/>
- Performance Assessment of Lighting Systems
<https://pdhonline.com/courses/e153/e153content.pdf>