Electric Lighting

“We are striking it big in the electric light, better than my vivid imagination first conceived. Where this thing is going to stop Lord only knows.”

Thomas Alva Edison
Is this where Edison’s “thing” stopped?

... because there was no more room on the ceiling?

Daylighting vs. Electric Lighting

**Daylighting**  
Passive system  
Architects design  
Uses renewable resource  
Source is exterior  
Involves building elements  
Done in schematic design

**Electric lighting**  
Active system  
Consultants design  
Uses non-renewable resource  
Source is interior  
Involves specialty products  
Done in design development

these are typical patterns in current design processes
Recap: Electric Lighting Design Process

- Establish issues; define intents; set criteria
- Select likely implementation approach (concept first and then products)
- Using appropriate design methods, validate that the proposed approach can actually work (that it can meet your criteria)
- Refine your first workable design solution using judgment and further analysis; validate final solution
- Prepare construction drawings/specifications and engage the commissioning process

*Then construct, occupy, validate-in-use, learn lessons*

Electric Lighting System Elements

- **Source** — lamp and luminaire (fixture)
- **Path** — space geometry and reflectances
- **Receiver** — observer / user / occupant
- **Controls** — manual / automatic
System Elements: **Source**

**Luminaire (fixture)**
- Holds lamp
- Shapes light distribution
- Should control glare
- Potential aesthetic element

**Lamp**
- Produces light
- Consumes energy

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System Elements: **Path**

- Defines volume light must fill
- Establishes limits of light distribution
- Redirects/absorbs light

*the space being illuminated is an important part of the lighting system*
System Elements: **Receiver**

visual situations will vary, as will eyes

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System Elements: **Controls**

- Manual or automatic
- On-off or dimming
- Several purposes
  - Activation/deactivation
  - Daylight compensation
  - Lumen maintenance
  - Energy use reduction
  - Scene changes

conceptually straightforward, but automatic controls (especially with daylighting) should be commissioned to ensure proper functioning
Lighting System Design Considerations

• Basic Approach
  – Establish a sense of how light will relate to the space and its bounding surfaces

• Illuminance Distribution
  – Develop an idea of how and why illuminance will be used in the space

• Luminaire Selection
  – Select a fixture from among several broad categories
  – This selection will be influenced by lamp choice and basic approach

these considerations will be addressed in more detail in the following slides

Basic Electric Lighting Approaches

• Toplighting
  – By far the most common approach
  – Many, many luminaires are available
  – Several specific distribution patterns

• Sidelighting
  – Not uncommon in smaller spaces or for surface emphasis, ambience
  – Many luminaires available

• Hybrids and combinations of the above

• Bottomlighting (pretty rare/unusual)
Illuminance Patterns

• **Uniform** illuminance
  – This approach provides essentially equal illuminance across all portions of the task plane

• **Local** illuminance
  – This approach provides illuminance for a very specific (and typically small) task area within a larger space

• **Supplemental** illuminance
  – This approach provides general illuminance across a broad area with additional (supplemental) illuminance for a more restricted area

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Illuminance Patterns

• **Localized uniform** illuminance
  – This approach provides two or more distinct areas (zones) with different uniform illuminances *within a larger single space*

• “**Task-ambient**”
  – This is an ambiguous term; sometimes used as a synonym for supplemental illuminance (avoid this), sometimes used to describe bi-directional lighting that is integrated into furniture (a distinct approach with interesting architectural and tax implications)
Example: Uniform Illuminance

luminaire pattern is independent of what's happening at task level

Example: Local Illuminance

only the area of the task is illuminated; a serious potential for glare (and stubbed toes) limits this approach (even if it can reduce energy use)
Example: Supplemental Illuminance

Additional light is provided at more difficult visual tasks; as opposed to circulation task (requiring little light).

Example: Localized-Uniform Illuminance

System provides for two illuminance zones: one for reading, one for circulation.
Example: Task-Ambient Illuminance

note very different “feel” to ceiling plane with furniture-mounted luminaires

Luminaire Classifications

Direct luminaire
- Preponderance (90%+) of light output goes toward task
- Most commonly ceiling mounted (flush or recessed)
- Wall sconces also possible
Luminaire Classifications

**Semi-direct luminaire**
- Majority (60%+) of light goes toward task
- Fixture is suspended (typically)
- Wall sconce possible

![Diagram of semi-direct luminaire]

**Indirect luminaire**
- 90%+ of light initially goes away from task
- “Suspended” fixture a necessity
- Ceiling or wall location

![Diagram of indirect luminaire]
Luminaire Classifications

**Semi-indirect luminaire**
- 60%+ of light initially goes away from task
- “Suspended” fixture a necessity
- Ceiling or wall location

**Direct-indirect luminaire**
- apx. 50% / 50% with no horizontal component
- “Suspended” fixture a necessity
- Ceiling or wall location
Luminaire Classifications

**General diffuse luminaire**
- 360 deg (spherical) light distribution
- Fixture is a suspended object or lollipop

Examples of Direct Luminaires

*note that luminaire distribution approach is independent of lamp type*
Examples of Indirect Luminaires

<< a rare, but interesting, example of "bottom-lighting"

Examples of Direct/Indirect Luminaires
Examples of General Diffuse Luminaires

often used as much for its value as a lighted object as its utility as a light source

Lighting Design/Analysis Methods

- **Rules, patterns, or precedents**
  - Simple to use, little information is required as input, not commonly used for electric lighting; when used, *precedents* are the most common; some manufacturers provide look-up design tables for their products

- **Correlation methods**
  - Although potentially complex, still fairly simple to use, moderately detailed information is required as input (the correlating parameters), fair accuracy; historically the most common method for electric lighting design; the *zonal cavity* method is most commonly used
Lighting Design/Analysis Methods

- **Simulation methods**
  - *Computer software*: may use correlations or first principles, lots of information typically required for input, accuracy can be exceptional (or not—garbage-in, garbage-out); often used both as a preliminary design and a design refinement tool; fastest growing approach to analysis

- **Analog methods**
  - *Scale models*: lots of information required for input, accuracy can be great; not commonly used for electric lighting design (it is hard to obtain scale-model luminaires); fixture mock-ups not uncommon

- **First Principles**
  - *Point-to-point calculations*: using fundamental physics relationships/equations

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A Correlational Method: the Zonal Cavity Method

**a first look**

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note: CU and LLF →
Zonal Cavity Method Variables

**CU** = coefficient of utilization

→ represents the efficiency (lumens/lumens) of a luminaire in a particular space as it delivers light from lamps to task

→ a dimensionless value (decimal)
  0.65 means 65% of light (lumens) from lamp reaches task (the rest of the light is absorbed before reaching the task)

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**LLF** = light loss factor

→ represents factors (there are several) that will result in a difference between *initial* and *maintained* illuminance values

→ dimensionless value (decimal)
  0.75 means a 25% loss over time as the system operates, ages, and deteriorates

→ total LLF = product of individual LLFs
Reminder: Effective versus Efficient

effective lighting
efficient lighting


two of the thousands of available luminaires

mocoloco.com/archives/001246.php