Daylighting and Daylighting Controls

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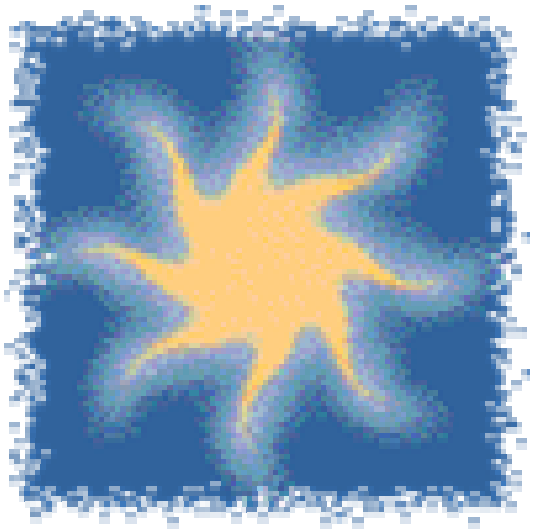
Attempt to answer the following:

- What is Daylight? What is Daylighting?
- Why are we discussing Daylighting?
- What are attributes of effective daylighting design?
- How do controls contribute to daylighting success?



What is daylight?

- **Daylight** is the diffuse light of the overcast sky. It is similar in all orientations, is soft and is cool in both temperature and color.
- **Sunlight** is the direct rays of the sun. It is directional, warmer in color and temperature, piercing and very strong.

What does Google say about Daylighting?

- The use of natural sunlight in a building through windows, skylights, etc. in order to reduce the amount of artificial lighting and electricity that is needed, as well as to create a more nature and enjoyable interior.
- The means by which daylight is brought into a building to either supplement or replace electrical lighting in order to allow the occupants to perform their tasks.
- The use of direct, diffuse, or reflected sunlight to provide supplemental lighting for building interiors.
- The reorientation of daylight by means of systems incorporating reflective and adjustable surfaces or grilles. Daylighting systems re-direct natural light, distributing diffused light in a room space and prevent strong areas of glare.

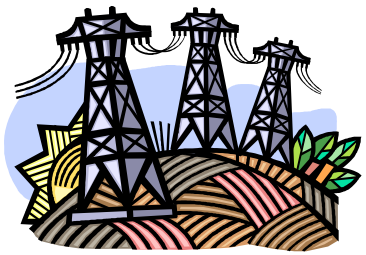
What do these definitions all have in common?

Daylighting – a Simple Definition

The intentional delivery and use of daylight in interior spaces in order to provide a variety of benefits

The Values of Daylighting

- Human Performance



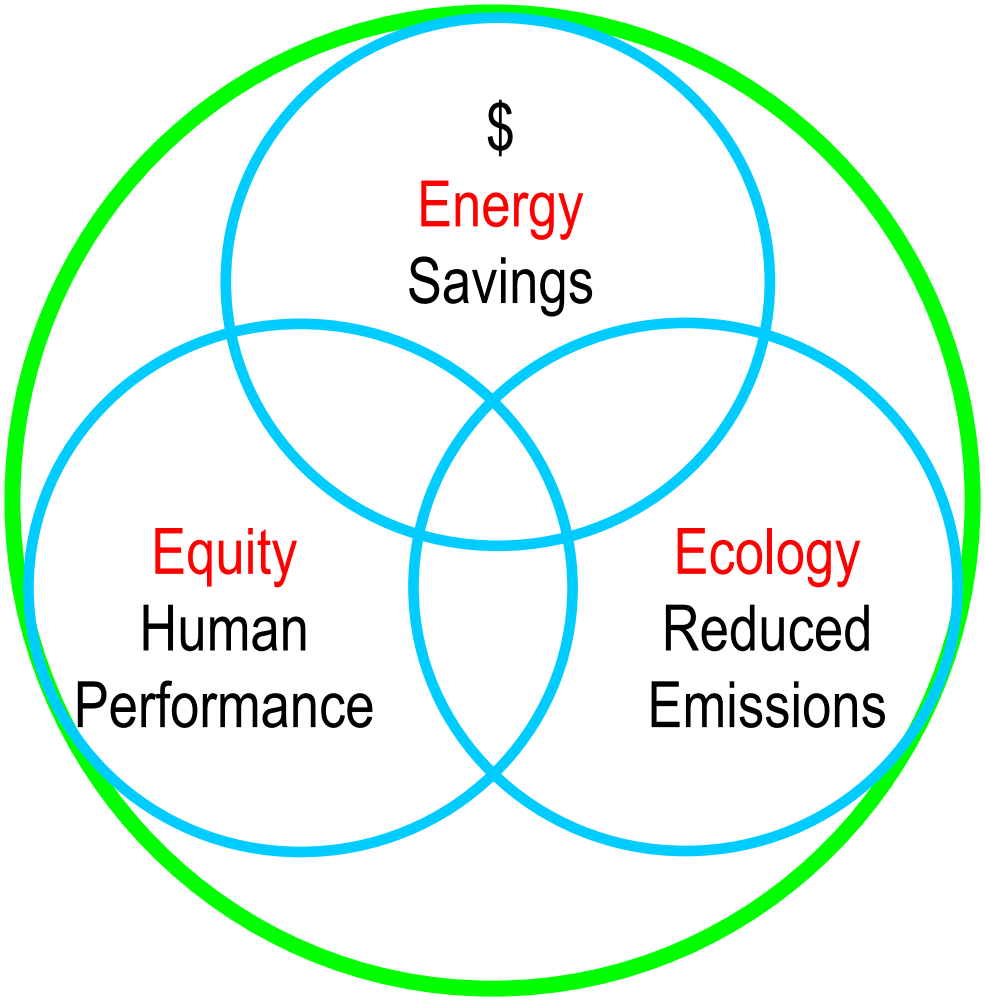
- Energy Savings

- Environmental Benefits

What might be additional benefits of delivering daylight into interior spaces?

The three E's of value

Helpful to look at daylighting from an integrated value perspective



Human Performance

- Bright Daylight contributes to our well-being
  - “Feel better” / more comfortable
  - Circadian Rhythms
  - Sleep Quality
  - Seasonal Affective Disorder (SAD)

- Research continues to improve our understanding of how light impacts human physiology
  - Humans need bright days and dark nights for health
  - Daylight provides important “blue wavelength” light – trigger for the body’s clock
  - Light is not just for vision!

Human Performance

- Daylight increases:
  - Sales
    - The value of the energy savings from the daylighting is far overshadowed by the value of the predicted increase in sales due to daylighting. By the most conservative estimate, **the profit from increased sales associated with daylight is worth at least 19 times more than the energy savings, and more likely, may be worth 45-100 times more than the energy savings**. (Heschong Mahone Group)
  - Academic performance
    - In San Juan Capistrano, California, where the study was able to examine the improvement between fall and spring test scores, **we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% faster on reading tests in one year than in those with the least**. (Heschong Mahone Group)

Energy Savings - $$$

- Consider construction costs and life-cycle costs
  - 50 to 100 year life-cycle of High Performance Building
- Proper sizing of HVAC Systems
  - Reduction in lighting heat may result in HVAC savings
- Operational savings
  - Reduced use of artificial lighting
  - Lower electricity bills
  - Lower cooling loads in the summer

Calculating Lighting Savings

- Energy Savings – Consumption
  - Measured in kWh = power saved in kW X hours X $ per kWh
- Energy Savings – Demand
  - Measured in kW saved at Peak times X $ per kW charged on tariff
- Rough math:
  - Lighting is 35-40% of a buildings energy load
  - Office buildings spend $2.00/sq.ft./year on energy
  - Therefore, lighting costs $0.80 per year
  - Daylighting can save 20-50% of lighting energy consumption
  - Daylighting saves $0.16 - $0.40 per square foot per year

Estimate Savings Accurately

- Calculate illuminance of work space:
  - March 21, June 21, Sept 21 and Dec 21
  - Radiance and other software modeling tools
  - Direct observation is existing buildings
  - Estimate amount of dimming hours by looking at the difference between target light levels and expected daylighting contribution

Ecology

- Daylighting reduces the use of fossil fuels
- Daylighting reduces CO2 and other greenhouse gases
- Daylighting is a renewable resource

Designing for Daylight

- Control of incoming Light
  - Goal: No direct beams of sunlight in eyes or on work surfaces
  - Goal: Eliminate potential of overheating spaces

Good Daylighting is ALL about design

Good Design Considerations

- Orientation / Placement of Building on site
  - **Southern** orientation provides the most daylighting opportunity, but requires passive control to prevent problems
  - **Northern** orientation provides great light, but no free thermal energy
  - **Western** and **Eastern** orientations should be AVOIDED
    - Excessive thermal gains

Elements of Good Design

- Use overhangs, light shelves, louvers etc. on south-facing walls
- High windows allow deeper light penetration into building
- Skylights, light tubes, others
- Window glazing

Challenges with Daylighting

- Increased Design and Construction costs
- Direct Glare and Reflected Glare
- Brightness Adaptation
  - 2% to 4% daylighting factor
- Direct Sunlight on occupants and work surfaces
  - Hot, bright, uncomfortable

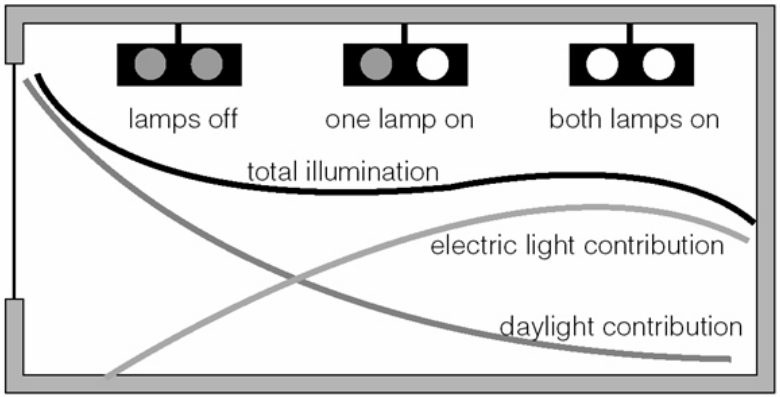
Good Daylighting Design yields…

- Significant opportunity for energy savings
- More productive occupants
- Reduced environmental impact
  - Especially over the life-cycle of the building

Daylighting Controls – enabling energy savings

Daylighting Controls – a definition

- An **active** system that provides the right amount of light to a work space
  - Delivers only enough artificial light to ensure target overall light level
  - Continuously adapting to a changing environment
    - Time of Day
    - Sky Conditions
    - Occupant needs – a look to the future?

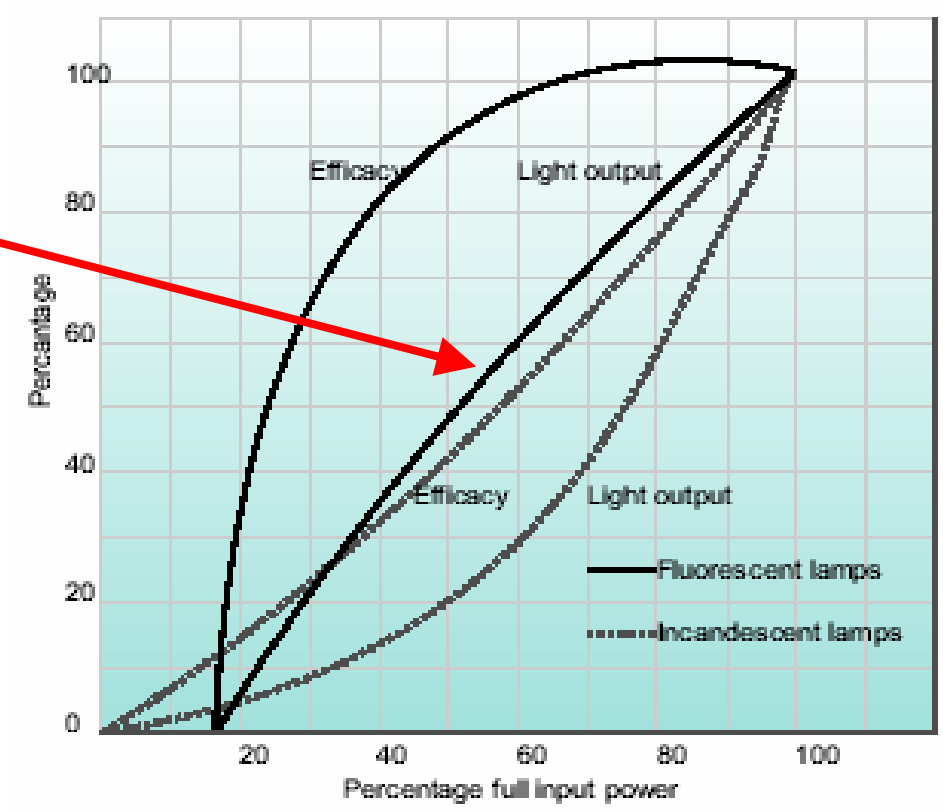


Elements of Daylighting Control systems

- Lamps
- Dimming Ballasts
  - Fluorescent and HID lamps
  - Stepped versus continuous dimming
- Photosensors
- Controls Architecture
  - Hard-wired versus “soft-wired”

Dimming **SAVES** Energy !!

A linear relationship exists between dimming fluorescent lamps and energy savings



Goals for Daylighting Control systems

- Transparent to Occupants
- Maximized Energy Savings
- Balance of first-costs and life-cycle flexibility

One size does **Not** fit all

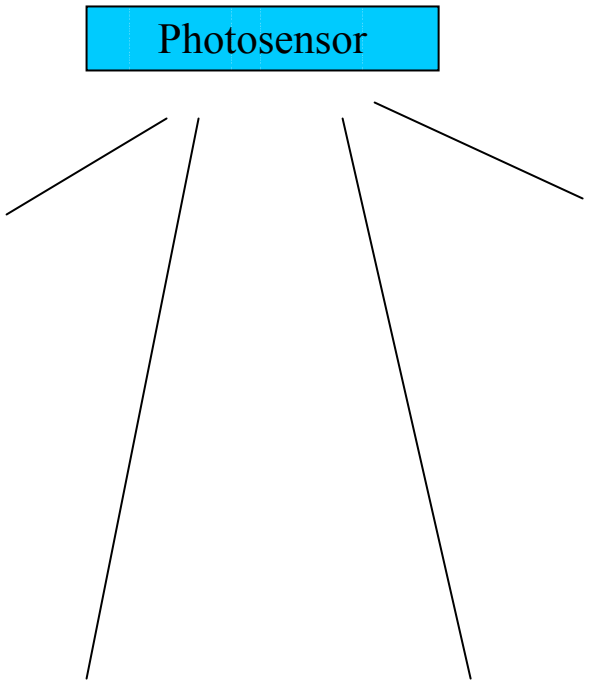
- Understanding basic variables
  - Closed-Loop versus Open-Loop
  - Photosensors
    - Placement
    - Specification

Closed-Loop versus Open-Loop

- Closed-Loop
  - Photosensor looks into space being controlled
  - Continuous feedback
- Open-Loop
  - Photosensor looks “outside”, out window

Placement and Selection of Photosensors

- Photosensors measure illuminance at their location (i.e. ceiling), not directly in the work space
  - Requires a “tuning” of the photosensor to deliver the correct amount of total light to the space
- Photosensors are spatially sensitive
  - Proper choice of narrow or wide beam for application



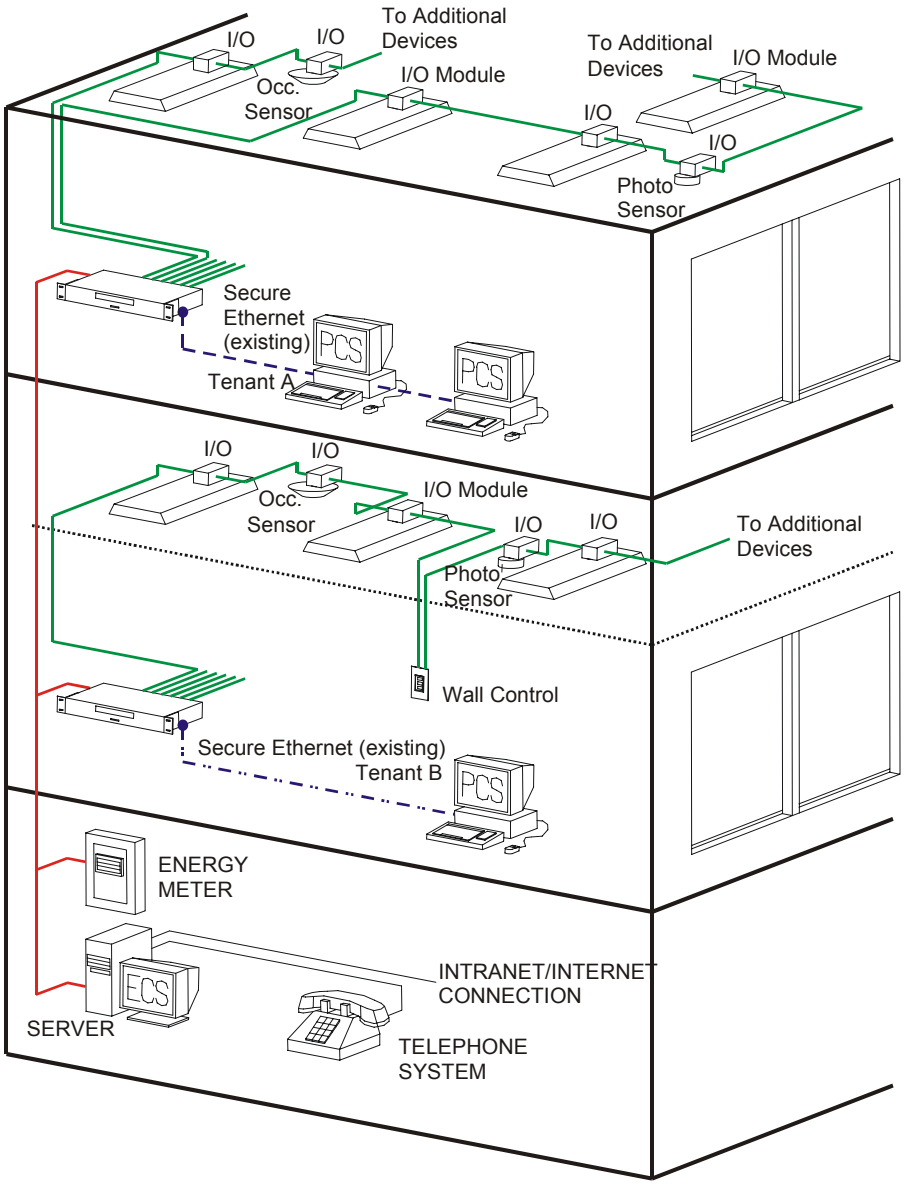
Daylighting Systems

- Conventional “hard-wired” approach
  - Photosensors are wired to dimming fixtures
    - Directly or thru a “controller”
  - Controls are “local”, lack flexibility
  - Control is delivered at the **Zone** level
    - All fixtures in zone respond identically to control signal

Daylighting Systems

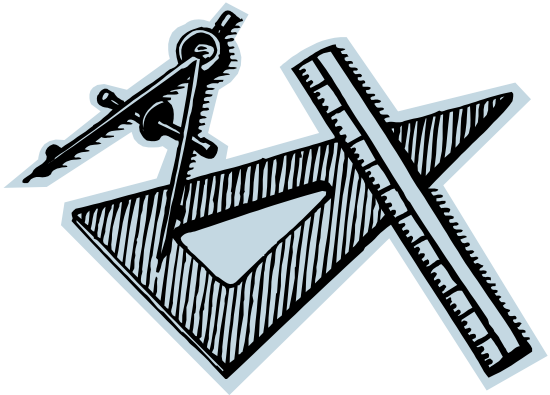
- New Generation "soft-wired" approach
  - Daylighting control architecture is software based
    - The fixture-photosensor association is not hard-wired
    - Adaptations and commissioning done thru software
  - Control is delivered at the **Fixture** level
    - Enhanced opportunity for energy savings
    - Each fixture can have unique response to photosensor output

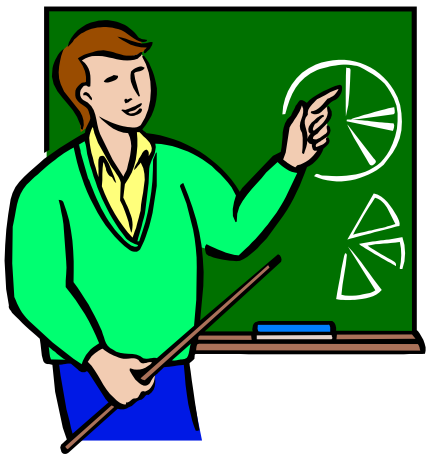
"Long Life – Loose Fit"



Lessons Learned…

- Commissioning of Daylighting Systems vital to success of project
  - Achieve transparency with maximum energy savings
  - Challenge assertions that “one size fits all”
  - Embrace systems that provide flexibility and adaptability
  - Anticipate and plan for modifications
- Education of Occupants is a requirement
  - Communicate, Communicate, Communicate
  - Automated lighting is new, requires knowledge sharing
  - Ensure education is acknowledged during project planning





Summary

- Daylighting delivers a variety of significant and measurable values to a building and its occupants
- Daylighting success hinges on good design – takes an integrated perspective and process
- Daylighting controls enable value to be captures
- **Education** of building owners, designers and occupants needed for successful daylighting