

# Lighting Design with Efficiency

**TOMORROW IS TODAY**

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A special presentation of the Energy Center of Wisconsin

# Credits and Contributions

A decorative graphic in the top right corner showing a glowing yellow lightbulb attached to a green stem with two leaves, set against a blue sky background.

Assistance including example product literature and/or AIA-qualified educational materials have been provided by

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- Osram Sylvania
- Lutron Electronics
- Visa Lighting

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*Background and title graphics courtesy Light Congress*

A decorative graphic in the bottom right corner showing a glowing yellow lightbulb attached to a green stem with two leaves, set against a blue sky background.

# About the Speaker



- Principal, Benya Lighting Design
    - Members of the Light Collaborative, the International Lighting Alliance, the US Green Buildings Council, IESNA Sustaining Member, Fellow of IESNA, Fellow of IALD
    - 35 years in architectural lighting design
  - Professional Engineer, California
  - Professor, University of California at Davis
  - Editor at Large, ***Architectural Lighting*** Magazine
  - Member of the Board, International Dark Sky Association
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**Thank you!**



# Goals




This material is designed to teach you how to:

- Evaluate lighting designs in existing buildings for quality, power and energy efficiency
  - Analyze daylighting strategies to meet LEED standards
  - Incorporate the latest lighting technologies into your lighting designs
  - Utilize the latest lighting technology to ensure energy efficient design
  - Integrate daylighting principles in future projects
  - Select from a toolbox of design strategies and lighting technologies to meet building standards and occupant needs
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# Benefits



We hope you will:

- Learn how to produce better projects by correctly designing and implementing sophisticated lighting for commercial, retail and institutional spaces
  - Find out how low you can go – use the lowest amount of light for the job
  - Understand why daylighting is key – for healthy buildings and healthy people
  - All in the context of good lighting design
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# Regulatory Environment

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# Regulatory Framework



- Wisconsin Energy Code
  - ASHRAE/IESNA 90.1-2004 and upcoming
  - IECC-2006
  - Federal Energy Independence Act of 2007
  - Federal Energy Policy Act of 2005
  - LEED NC 2.2 and other LEED documents
  - National Electric Code
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# Principal Energy Codes



- National : ASHRAE/IESNA 90.1-2004
  - 2007 Updates now being reviewed
- National: International Energy Conservation Code IECC-2006
- California: California Code of Regulations Title 24-2005 (new effective 10/1/05) 2008 version in 15 day language
- Wisconsin: IECC-2006 with Wisconsin Amendments

# International Energy Conservation Code (IECC)



- International Energy Conservation Code (IECC) is an Simplified 90.1 to which it is essentially equivalent
    - Dumbed down to make it “easier”
    - But according to IECC, you should always have the option of using 90.1. Don’t forget this!!!!
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# Code Quality

- Highly variable
- Worst codes are generally state-specific codes (except Title 24)
- Many problems and issues not addressed by codes, especially IECC

# Got the Latest Code?

- Purchase Codes
  - 90.1 from ASHRAE
  - IECC from ICC
- Download Codes
  - Some state codes, including Title 24, are public domain and downloadable
  - Download Wisconsin Amendments Only

# Code Compliance Software

- Use ComCheck for all IECC and 90.1 projects
- Free download from DOE
- Will Demo later
- Has a lot of code information built in

# Wisconsin Amendments

## (1) DAYLIT AREAS.

These are department rules in addition to the requirements in IECC section 505: Luminaires providing general lighting that are in or are partially in daylit areas described in pars. (a) or (b) shall be controlled according to the applicable requirements in sub. (2).

### (a) *Determining daylit areas.*

1. Except as determined under par. (b), the horizontal daylit area under skylights shall be the rough opening of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 60-inch or high permanent partition, or one half the horizontal distance to the edge of the closest skylight or vertical glazing.
2. Except as determined under par. (b), the daylit area illuminated by vertical glazing shall be the daylit depth multiplied by the daylit width, where the daylit depth is 15 feet, or the distance on the floor, perpendicular to the glazing, to the nearest 60-inch or higher permanent partition, whichever is less; and the daylit width is the width of the window plus, on each side, either 2 feet, the distance to a permanent partition, or one half the distance to the closest skylight or vertical glazing, whichever, is least.

(b) *Alternative.* The daylit area shall be as calculated using a method acceptable to the department.

# Wisconsin Amendments




## (2) CONTROLS.

These are department rules in addition to the requirements in IECC section 505:

(a) *General.* Except as provided in par. (b), daylit areas in any interior enclosed space greater than 250 square feet and a lighting density more than 0.8 W/ft<sup>2</sup> shall have at least one control that meets all of the following requirements:

1. Controls only luminaires in the daylit areas.
2. Controls at least 50% of the lamps or luminaires in the daylit area, in a manner described in IECC section 505.2.2.1.
3. Controls luminaires in vertically daylit areas separately from horizontally daylit area.

(b) *Exceptions.* The requirements of this subsection do not apply to any of the following:


1. Daylit areas where the effective aperture of glazing is equal or less than 0.1 for vertical glazing and 0.01 for horizontal glazing.
  2. Daylit areas where existing adjacent structures or natural objects obstruct daylight to the extent that effective use of daylighting is not feasible.
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# Wisconsin Amendments



## **(3) LIGHTING POWER EXCEPTIONS.**

These are department exceptions to the requirements in IECC 505.5.1:

- (a) Lighting for theatrical purposes, including performance, stage, film production and video production.
  - (b) Lighting for photographic processes.
  - (c) Lighting integral to equipment or instrumentation and is installed by the manufacturer.
  - (d) Task lighting for plant growth or maintenance.
  - (e) Advertising signage or directional signage.
  - (f) In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
  - (g) Lighting equipment that is for sale.
  - (h) Lighting demonstration equipment in lighting education facilities.
  - (i) Lighting approved because of safety or emergency considerations, inclusive of exit lights.
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# Wisconsin Amendments



## **(4) LINE-VOLTAGE LIGHTING TRACK AND PLUG-IN BUSWAY.**

Substitute the following for the requirements in IECC section

505.5.1.4: The wattage of line voltage lighting track and plug-in busway which allows the addition or relocation of luminaires without altering the wiring of the system shall be the volt-ampere rating of the branch circuit feeding the luminaires or an integral current limiter controlling the luminaires, or the higher of the maximum relamping rated wattage of all of the luminaires included in the system, listed on a permanent factory installed label, or 30 W/linear foot.



# Current Energy Code Structures



## Non-residential lighting

- Mandatory requirements for Interior Lighting
- Mandatory requirements for Exterior Lighting
- Daylighting requirements (CA)
- Interior lighting power density allowance
  - For whole buildings
  - Space by space
- Exterior lighting power allowance


## Residential lighting

- Mandatory requirements for Interior Lighting (CA)
- Mandatory requirements for exterior lighting (CA)
- Mandatory high efficacy lighting requirements (CA)



# Mandatory Requirements



- Controls in every space
  - Automatic shut off controls (buildings >5KSF)
  - Automatic daylight zone controls
  - Automatic outdoor lighting controls
  - Separate control zones for display lighting
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# Indoor Power Density



## Whole building

- Easiest
- Fastest
- Least complicated
- No wiggle room

## Space by Space

- More complex
  - More work
  - More wiggle room
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# Example: JEWELRY STORE

## Space by Space

- 2400 sf (60 x 40)
- Three separate areas with at least three walls (800 sf each) 12' ceiling
- 360 sf of display cases
- 320 lf of full height walls with 4 shelves 16" deep
- 1706 sf of display shelves



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# 90.1-2004

- General Lighting  $1.7\text{w/sf} \times 2400\text{sf} = 4080\text{ w}$
- Fine Allowance cabinets  $3.9\text{w/sf} \times 360\text{sf} = 1404\text{ w}$
- Fine allowance shelves  $3.9\text{w/sf} \times 1706\text{sf} = 6653\text{ w}$
- Chandelier allowance  $1.0\text{w/sf} \times 2400\text{sf} = 2400\text{ w}$

**TOTAL ALLOWED      14,537 w      6.1w/sf**

**Note use it or lose it allowances**

# 90.1-2007

## Major change is to define 4 classes of store

- Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4.
- Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics.
- Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork.
- Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.

## For Jewelry

- General  $2400\text{sf} * 1.7 \text{ w/sf} = 4080 \text{ w}$
- Display allowance  $1000\text{w} + 2400\text{sf} * 4.2\text{w/sf} = 11,080 \text{ w}$
- Chandelier allowance  $1.0\text{w/sf} * 2400\text{sf} = 2400 \text{ w}$

**TOTAL ALLOWED            16,560 w            6.9 w/sf**

**Note use it or lose it allowances**

# Summary of Example Jewelry Store Allowances



## Major Codes

California T24-2005	7.5 w/sf
90.1-2004	6.1 w/f
90.1-2007	6.9 w/sf

## State specific codes

Oregon	5.2 w/sf
Washington	3.0 w/sf



# Example: DESIGN CLOTHING STORE

- 4,800 sf (80 x 60)
- 12' high ceiling spaces divided into 600 sf areas with full height partitions
- 480 lf of full height walls with average 3 shelves 18" deep = 2160sf of display shelves – 120 sf of cases



# 90.1-2004

- General  $1.7 \text{ w/sf} \times 4800 \text{ w} = 8160 \text{ w}$
- Fine Allowance cabinets  $3.9 \text{ w/sf} \times 120 \text{ sf} = 468 \text{ w}$
- Fine allowance shelves  $3.9 \text{ w/sf} \times 2160 \text{ sf} = 8,424 \text{ w}$
- Decorative Allowance  $4800 \text{ sf} \times 1.0 \text{ w/sf} = 4800 \text{ w}$

**TOTAL ALLOWED                      21,852w                      4.6 w/sf**

**Note use it or lose it allowances**

# 90.1-2007

- General 4800 sf \* 1.7 w/sf = 8160 w
- Category 3 display 1000 +(2.6w/sf \* 4800 sf)= 13,480 w
- Decorative Allowance 4800 sf\*1.0 w/sf = 4800 w

**TOTAL ALLOWED 26,440 w 5.5 w/sf**

**Note use it or lose it allowances**

# Summary of Designer Clothing Store Allowances



## Major Codes

California T24-2005 6.0 w/sf

90.1-2007 5.5 w/sf

90.1-2004 4.6 w/sf


Oregon 3.75 w/sf

Washington 3.0 w/sf



# What We Need to Know




1. Lighting energy codes are becoming increasingly enforced.
  2. Code developing bodies are constantly increasing stringency.
  3. There is a public process for code development in which there is very little participation by the public and we are poorly represented.
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# Special Issue: Track Power



The wattage of line voltage lighting track and plug-in busway which allows the addition or relocation of luminaires without altering the wiring of the system shall be **the volt-ampere rating of the branch circuit feeding the luminaires or an integral current limiter controlling the luminaires,** or the higher of the maximum relamping rated wattage of all of the luminaires included in the system, listed on a permanent factory installed label, or 30 W/linear foot.



# Related Issue: Track Circuit Requirements (NEC)



## Through 1993

- Article 410-103 required track be rated at 90 watts/foot
- A new branch circuit every 21' 4"
- No special arrangement for Low Voltage

## Starting in 1996

- 1996: 410-103 added FPN indicating 90 w/ft was for feeders only
  - 1999: Removed article 410-103
  - 1999: Reduced feeder calculations to 75 w/ft
  - 1996 Added Article 411 on low voltage
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# Track Power Methods



For a 20 foot track with (8) 39 watt metal halide luminaires

## Method 1

Actual Load

$$8 \times 45 \text{ w} = \mathbf{360 \text{ w}}$$

## Method 2

Watts per foot

$$20 \times 30 = \mathbf{600 \text{ w}}$$

(ASHRAE/IECC)

$$20 \times 45 = \mathbf{900 \text{ w}}$$

(California)

## Method 3

Branch Circuit Capacity

$$20\text{A} \times 120 \text{ volts} =$$
$$\mathbf{2400 \text{ w}}$$

## Method 4

Inline Current limiter

$$3\text{A} \times 120 \text{ volts} =$$
$$\mathbf{360 \text{ watts}}$$

# EPACT 2005

- New ballast efficiency standards
- Other product efficiency standards
- Set criteria for up to 60¢ per SF tax deduction for efficient buildings (extended and increased recently?)

# EPIA 2007

- Established program to make general lighting more efficient by 2020
- Additional standards for metal halide and fluorescent lamps and ballasts
- Requirements for Federal Energy Efficiency programs at all levels



# And Now....LEED

- Leadership in Energy Efficiency and Environmental Design
- Product of US Green Buildings Council
- Increasingly important on commercial and institutional projects
- Points based system



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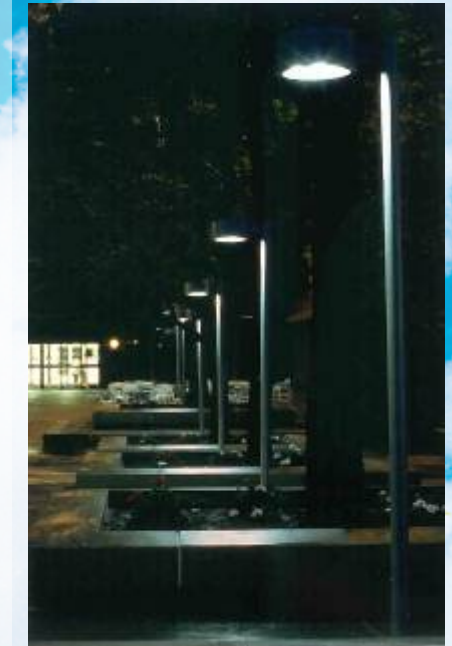
# The LEED Family



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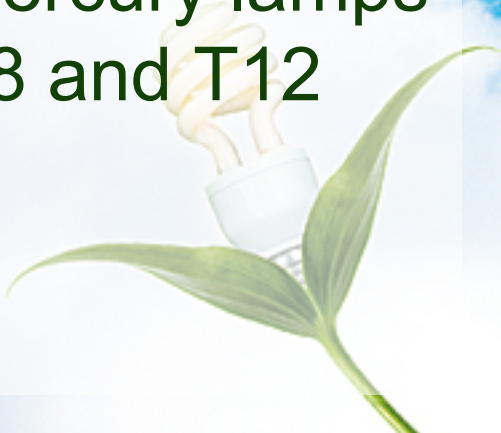
# How To Get LEED Credits

- Up to 10 points for energy efficiency
  - Must be at least 14% less than ASHRAE/IESNA 90.1-04 (2 points)
  - 1 point for each additional 3.5% reduction to a maximum of 10 points
- 1 or 2 points for daylighting
- 1 point for views
- 1 point for lighting controls
- 1 point for dark sky preservation



# LEED Issues



- LEED-NC 2.2 may not permit display lighting allowances, decorative lighting allowances, etc.
  - LEED-CI only awards points for beating 90.1-2004 by at least 15% (1 point) to a maximum of 3 points for 35% less
  - LEED-EB requires the use of low mercury lamps effectively requiring a lot of linear T8 and T12 fluorescent lighting
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# Demonstration



**COMcheck™**

**DOE's Building Energy Codes Program**  
*Internet Address: [www.energycodes.gov](http://www.energycodes.gov)*  
*Technical Support: [techsupport@becp.pnl.gov](mailto:techsupport@becp.pnl.gov)*



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