

Maneuvering Lighting Design Within Title 24, IECC, and ASHRAE/IES 90.1

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BENYA LIGHTING DESIGN



About the Speaker

James R Benya

- Principal, Benya Lighting Design, West Linn, OR
 - Former Principal and CEO, Luminae Souter Lighting Design, San Francisco
 - 36 years in architectural lighting design
- Professional Engineer, California
- Fellow IES
- Fellow IALD
- Member ASHRAE SPC 189
- Editor at Large, ***Architectural Lighting*** Magazine
- Treasurer of the Board, International Dark Sky Association



Energy Code Background

Maneuvering
Lighting
Design
Within Title
24, IECC, and
ASHRAE 90.1

90.1

- Past member SSPC 90.1, helped develop the 1999 and 2001 codes

189.1

- Member of the Committee

Title 24

- Consultant to the CEC since 1975
- Principal Consultant for 1993, 2005, 2008 and 2011 editions

IECC

- Just another everyday critic

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Thank you!



Goals

This material is designed to teach you:

- Understand the basic theory of energy codes
- Know the key points common to all codes
- Know the key differences among the major codes
- Learn the codes' tight spots
- Learn the codes' loose areas
- Learn design strategies that meet codes
- Learn how to do use the codes to the best advantage for the project

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
- Know enough about codes to get your design out of a jam
- All in the context of good lighting design

Agenda

Maneuvering
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9:00-9:30 Regulatory Structure

9:30-10:00 Lighting Code Theory

10:00-10:30 Residential Lighting Codes

10:30-10:50 BREAK

10:50-11:30 Non-Residential Lighting Codes

11:30-Noon Fixture Ratings and Track

BREAK FOR LUNCH

1:00-1:20 Controls

1:20-1:50 Using Title 24 Forms (group exercise)

1:50-2:20 Using ComCheck (group demonstration exercise)

2:20-2:40 Strategies for Schools & Higher Ed

2:40-3:00 BREAK

3:00-3:15 Strategies for Offices

3:15-3:45 Strategies for Retail

3:45-4:00 Strategies for Hospitality

3:00-4:15 Strategies for Outdoor Lighting

4:15-4:30 Wrap Up

Lighting's Regulatory Environment



US Regulatory Framework

Energy Codes

- California Title 24-2008
- ASHRAE/IES 90.1-2007
- International Energy Conservation Code-2009

Federal Regulations

- Federal Energy Independence and Security Act of 2007
- Federal Energy Policy Act of 1992 and 2005

US Regulatory Framework

Construction Codes and Standards

- National Electric Code
- UL Listing Standards

Sustainability Codes and Standards

- LEED NC 3 (2009) and other LEED documents
- ASHRAE/IES/USGBC 189.1
- IGCC 2010

EPACT EISA

FEDERAL ENERGY POLICY



EPACT 2005

- New ballast efficiency standards
- Other product efficiency standards
- Set criteria for up to 1.80¢ per SF tax deduction for efficient buildings (extended to 2013 in 2008)

EPACT 2005 Incentives

- Tax deduction of \$0.60 per SF for lighting systems that are 40% better than 90.1-2001 and has dual level switching
- Deduction available to designers of government-owned projects such as schools

EISA 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

Tougher than Code

LEED

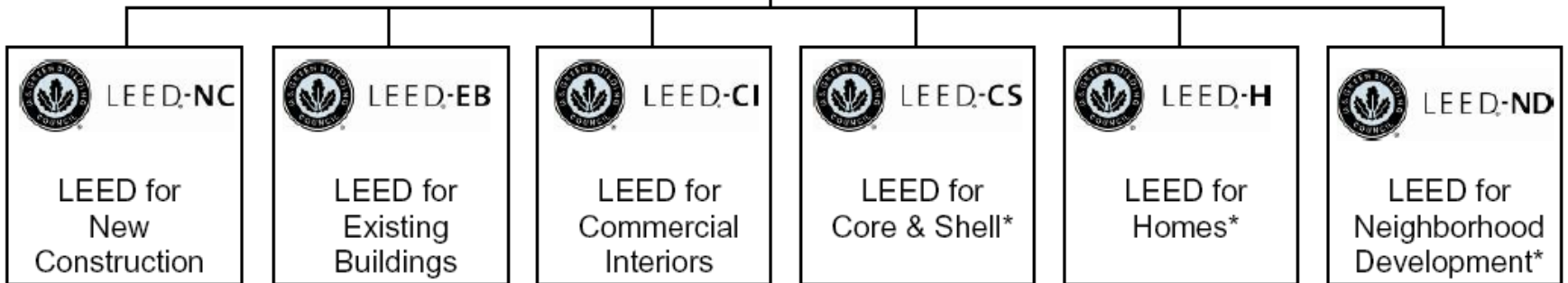




- Leadership in Energy Efficiency and Environmental Design
- Product of US Green Buildings Council
- Increasingly important on commercial and institutional projects
- Points based system

Why is LEED Important

- Has the net effect of code for many projects
- Requires compliance with energy code and in new construction, a minimum of 5% better than code
- Is more carefully checked than permit applications



And many others go to www.usgbc.org



Significant LEED Standards

- LEED NC 2009 (LEED 3)
- LEED for Schools
- LEED CI (commercial interiors)
- LEED EB (existing buildings)
- LEED for Retail
- LEED for Homes and others
- DOWNLOAD at [www/usgbc.org](http://www.usgbc.org)

LEED 2009 Point System for Lighting and Daylighting

- (EApr2): Energy Efficiency 10% better than ASHRAE/IES 90.1-2007
- (EApr1): commissioning
- (EAc1) 1 point for 12%, up to 19 points for 48% better than 90.1-2007
- (EQc8.1) 1 point for daylighting
- (EQc8.2) 1 point for views
- (EQc6.1) 1 point for lighting controls
- (SSc8) 1 point for dark sky preservation



23 points
related
directly to
lighting

Current LEED Notes

- LEED-2009
 - You can use Advanced Energy Design Guides for EAPr2 for small buildings
 - Title 24 2008 = 90.1 2007
- LEED-CI awards points for beating 90.1 by at least 15% (1 point) to a maximum of 3 points for 35% better
- LEED for Retail awards up to 5 pts for lighting efficiency 35% better than 90.1-2007 and 3 points for controls, plus 1 point for lighting controls for office areas.
- LEED for Schools awards 1 point for the PIER 4.5 classroom lighting system

Summary of LEED Considerations

- Meet LEED, meet code
- A high LEED rating may be required by the Client
- Lighting affects both almost more than any other discipline

Available from all California utilities and many others

UTILITY INCENTIVES



Incentive Programs

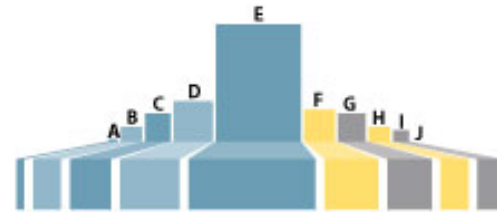
- Nation wide program offerings
- Several possible program types
 - Unit by unit rebate
 - Energy savings based rebate
 - Custom rebate
 - Design assistance or reward

Example: SCE

Find out what areas of your office building are using the most electricity, then read the tips below to learn how to conserve.

Office

A	Water Heating	1%	F	Other	13%
B	Space Heating	5%	G	Computers	10%
C	Ventilation	9%	H	Refrigeration	5%
D	Cooling	14%	I	Office Equipment	4%
E	Lighting	39%	J	Cooking	0%



- Existing building lighting retrofits 10¢/watt plus \$0.05 for each lighting kWh saved
- Specific retrofit unit payments per ballast or lamp
- DR payments of \$100/kW (\$300/kW if automatic)

There's free money and opportunity if you

LAY THE GROUNDWORK



Quintuple Dipping

Design a super-efficient building (25% better than 90.1-2004 and Title 24-2005) and dip into these!

1. Easily meet code
2. Achieve high LEED rating
3. Get 60¢/sf tax deduction for someone
4. Get 20-50¢/sf owner incentive from SCE
5. Get 8.3¢/sf design incentive from Savings by Design

Energy codes

Watts are not energy!!!



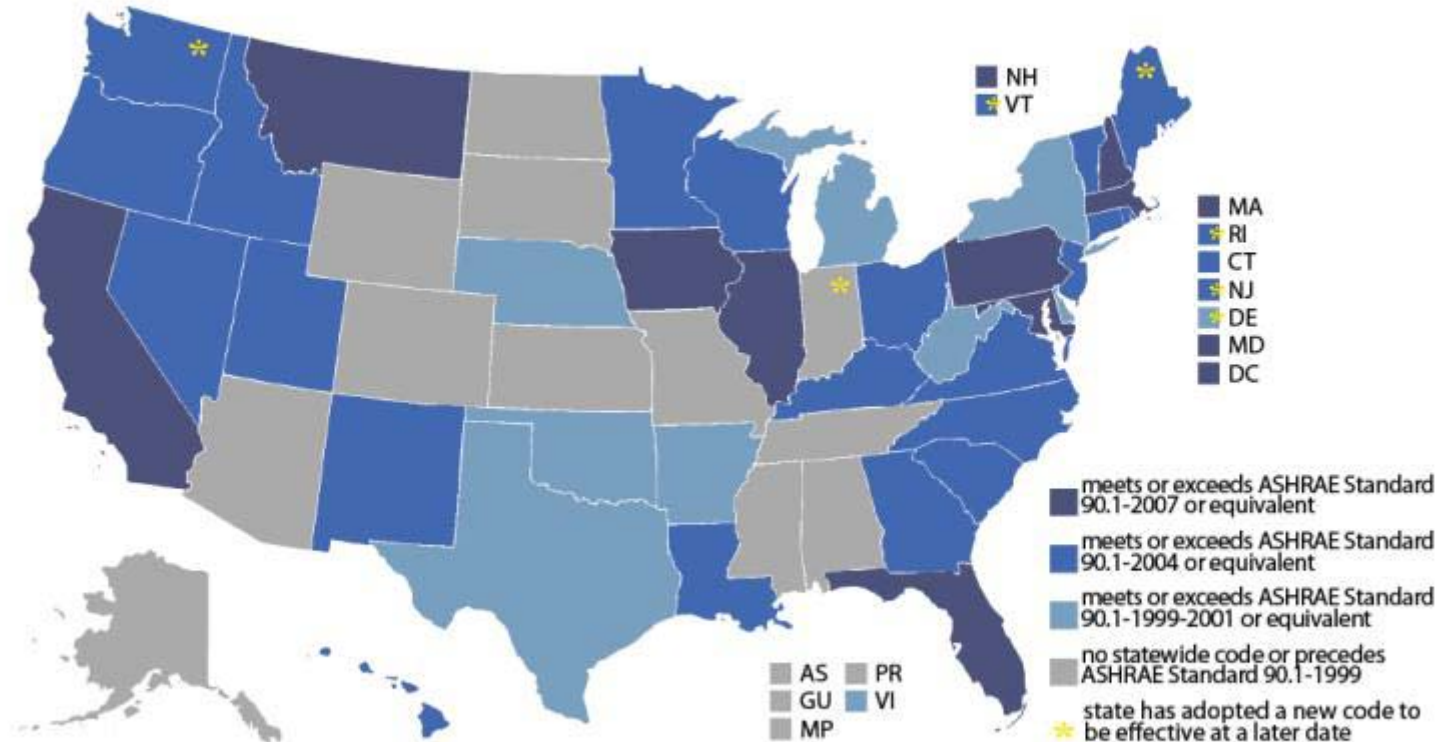
What Are Energy Codes?

- Cause: Oil Embargo of 1973-1974
- First code ASHRAE 90-75
- California Warren-Alquist Act 1974 and first Building Energy Efficiency Standards (Title 24 Part 6) in 1978
- States required to have an energy code by Energy Policy Act of 1992
- IECC introduced 2000
- Many states use either IECC or 90.1 as a base for state specific amendments
- Some states have unique codes including Washington and Oregon

Commercial State Energy Code Status

AS OF APRIL 1, 2010

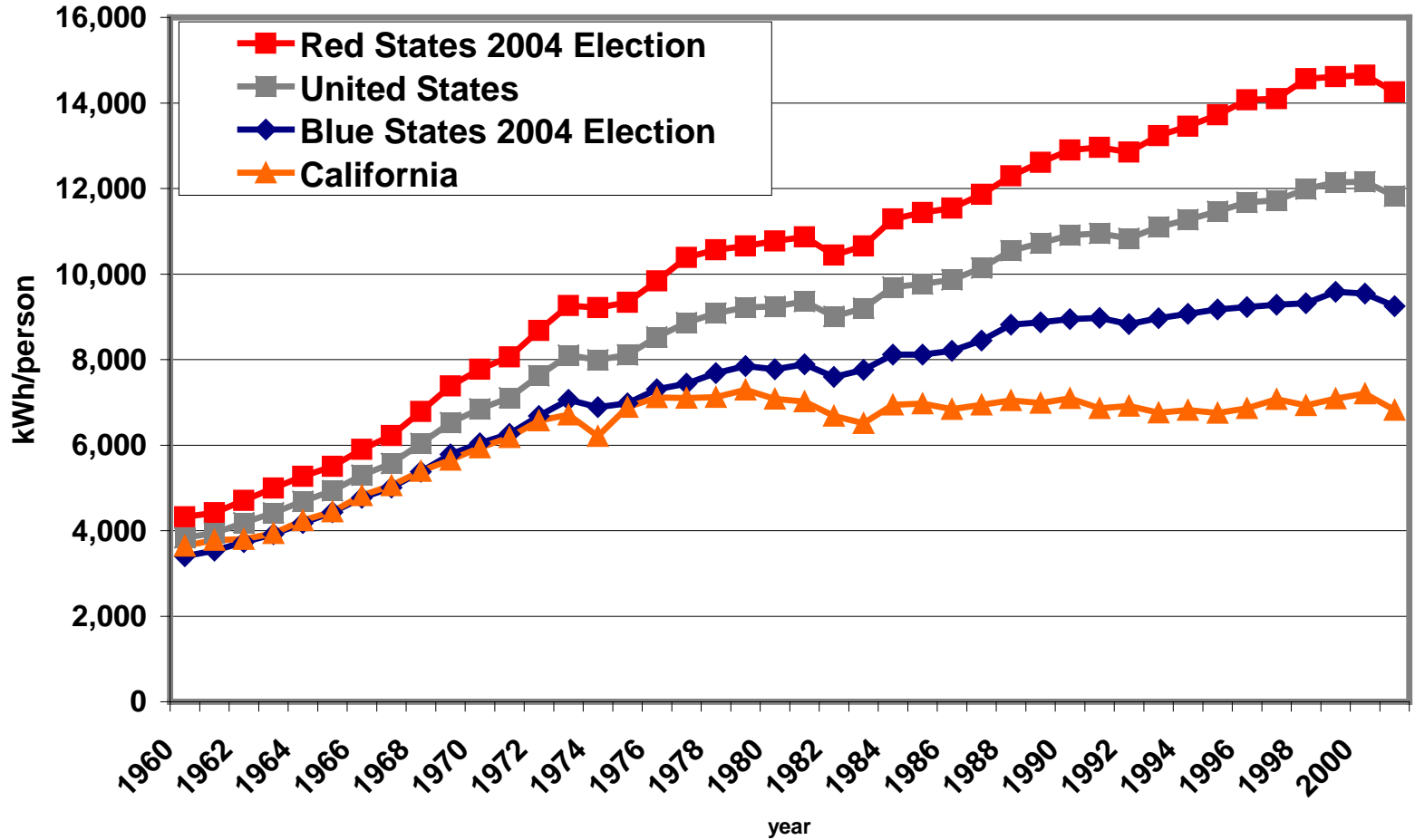
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 **BCAP** Dedicated to the adoption, implementation, and advancement of building energy codes
Get all the most up-to-date code status maps and other valuable resources at www.bcap-ocean.org

NOTE:
These maps reflect only mandatory statewide codes currently in effect.

Per Capita Electricity Consumption



Got Code?

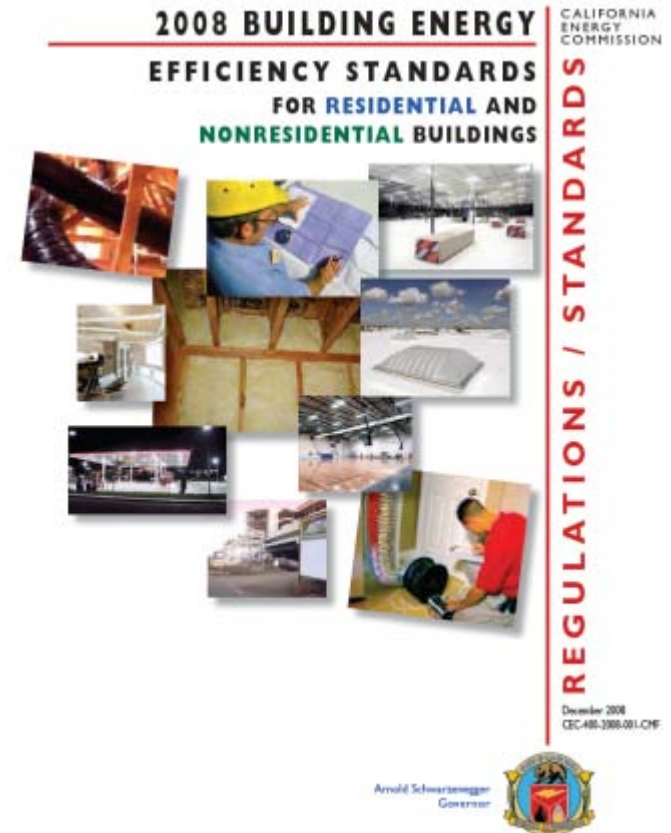
- Purchase Codes
 - 90.1 from ASHRAE
 - IECC from ICC
- Download Codes
 - Some state codes, including Title 24, are public domain and downloadable (Oregon, Washington)

Versions of Codes

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Title 24 (Free PDF download)

- 2008 Version effective 1/1/2010
- Former version 2005
- Former version 2001

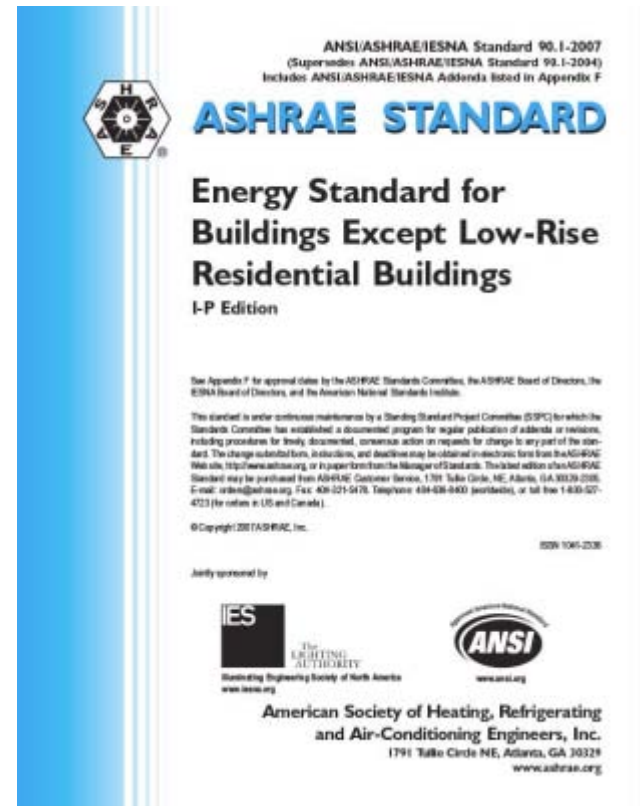


Versions of Codes

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90.1 Browse for Free;
\$119 to buy

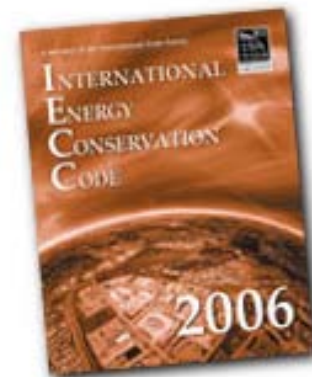
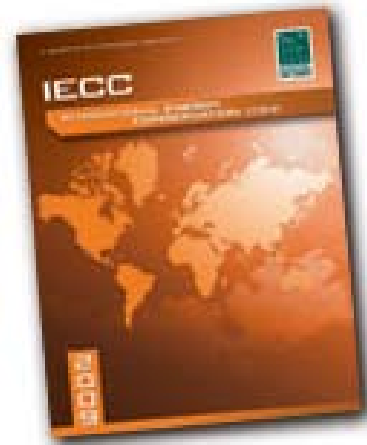
- Current version
2007
- Most use 2004 or
2001
- A few use 1999 or
earlier



Versions of Codes

IECC \$32.50 to buy

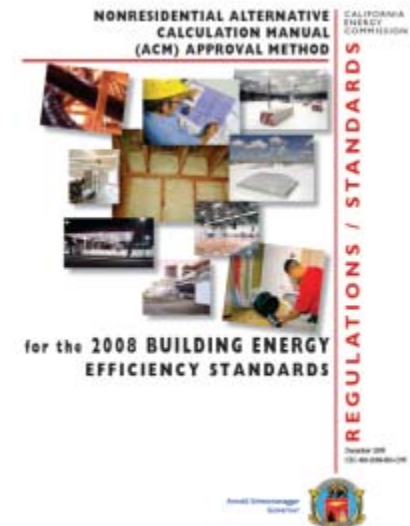
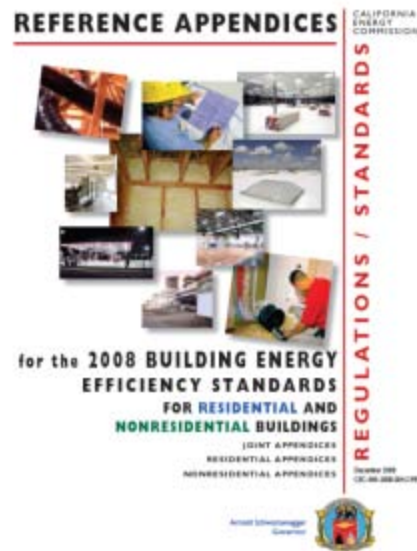
- Current version 2009
- Most use 2006 or 2003
- Generally follows 90.1 by 2 years



Code Support

Title 24 (all free download PDF)

- The Manual (Title 24 forms are Excel spreadsheets)
- The Reference Appendices
- The ACM Manual

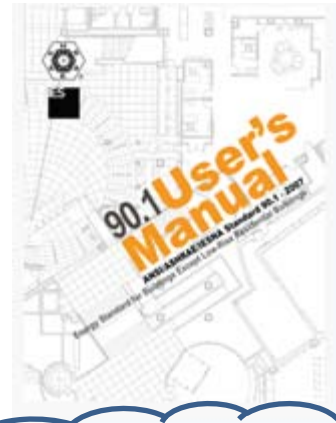


Forms here!

Code Support

90.1

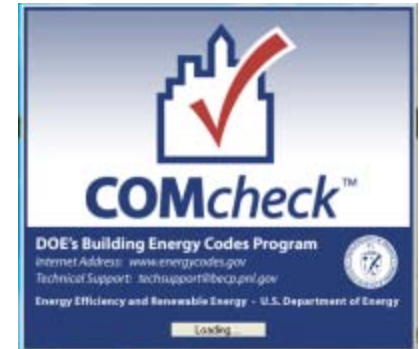
- User's Manual (purchase \$93)
- Official Interpretations on-line
- Errata on-line
- Addenda and continuous maintenance on-line



Forms here!

Code Compliance Software

- Use ComCheck for all IECC and 90.1 projects thru 90.1-2007 and IECC-2006
- Version 3.7 now available
- Free download from energycodes.gov/comcheck



Forms here!

COMCheck

Download Screen 4-14-2010

Download COMcheck™ Software

[Windows](#) | [Mac](#) | [Linux](#) | [Support Documents](#)

COMcheck™ for Windows®

Download Now!

[>>> Download COMcheck for Windows® version 3.7.1<<<<](#) (20MB)
runs on 2000, XP, Vista, Windows 7 in either single, multiuser, or network environment



Supported Codes:

IECC: 1998, 2000, 2001, 2003, 2004, 2006 and 2009.
ASHRAE/IES Standard 90.1: 1998, 1999, 2001, 2004 and 2007, and various state-developed energy codes.

State-Specific Versions

The generic COMcheck software includes the following state-specific energy codes: Georgia, New Hampshire, New York, Vermont and Pima County, Arizona. **Standalone state-specific versions of COMcheck are no longer provided.**

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There is a method to all of this

ENERGY CODE STRUCTURE



Common Sections

- Definitions
- Applicability
- Residential Lighting Regulations
- Non-residential lighting
 - Prescriptive path
 - Performance path

Learning the Code

- Read the code
- Learn to read between the lines
- Read the Manual

Definitions

The definitions are essential reading. Do
Not Skip!

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Definition Example

Title 24 -2008

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- LIGHT EMITTING DIODE (LED)** is a *pn junction semiconductor device that emits incoherent optical radiation when* biased in the forward direction. The acronym “LED” typically refers to an LED Component, LED Device, or LED Package.
- Hybrid LED Luminaire** is a **complete lighting unit consisting of a light source and driver together with parts** to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light sources in the Hybrid LED Luminaire contain both LED Source Systems, or LED Lamps, as well as other types of light sources such as incandescent or fluorescent lamps. The Hybrid LED Luminaire is intended to be connected directly to a branch circuit.
- LED Array** is an **assembly of LED Components, LED Devices or LED Packages on a printed circuit board or** substrate, possibly with optical elements and additional thermal, mechanical, and electrical (LED Control Circuitry) interfaces that are connected to the load side of LED Driver (Power Source). LED Array does not contain an LED Driver (Power Source) and is not connected directly to the branch circuit.
- LED Component (or LED Device, or LED Package)** is a **semiconductor die that contains wire bond** connections, possibly with an optical element, or a thermal, mechanical, or electrical interface. LED Component, LED Device, or LED Package does not contain an LED Driver (Power Source) and is not connected directly to the branch circuit.
- LED Control Circuitry** is **electronic components located between the Power Source (LED Driver) and the LED Component, or LED Device, or LED Package** designed to limit voltage and current, to dim, to switch or otherwise control the electrical energy to the LED. The circuitry does not include a Power Source.
- LED Driver** is a **power source with integral LED control circuitry designed to meet the specific requirements of** an LED Lamp, an LED Array, or an LED Module. Typically LED Driver (Power Source) contains the LED Control Circuitry.
- LED Lamp** is an **LED Component, LED Device, or LED Package and other optical, thermal, mechanical and** electrical (LED Control Circuitry) components with an integrated LED Driver (Power Source) and a standardized base that is designed to connect to the branch circuit via a standardized base, lamp-holder, or socket. In North America, “a standardized base” refers to an ANSI standard base. In the U.S. “branch circuit” is used to describe the “mains voltage” in IEC documents. Note: Non-integrated type of LED Lamp should not be defined, it is a LED Module.
- LED Light Engine with Integral Heat Sink (or LED Light Source System)** is a **subsystem of an LED Luminaire** that includes one or more LED Components, LED Devices or LED Packages, an LED Array, or LED Module; an LED Driver (Power Source); electrical and mechanical interfaces; and an integral heat sink to provide thermal dissipation. An LED Source System may be designed to accept additional components that provide aesthetic, optical, and environmental control (other than thermal dissipation). An LED Source System with standardized base is an LED Lamp.
- LED Luminaire** is a **complete LED lighting unit consisting of a light source and driver together with parts** to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED Components, LED Packages or LED Devices, LED Array, an LED Module, an LED Source System, or an LED Lamp. The LED Luminaire is intended to be connected directly to a branch circuit.
- LED Module** is a **component part of an LED Source System that includes one or more LED Components, LED Devices or LED Packages,** possibly with optical elements and additional thermal, mechanical, and electrical (LED Control Circuitry) interfaces that are connected to the load side of LED Drive (Power Source). The LED Module does not contain a power source. An LED Array is equivalent to an LED Module.

Exempt and Exceptions

- EXEMPT lighting has been carefully identified to ignore lighting issues of little or no significant impact
- EXCEPTIONS have been developed to address special situations

Loopholes

- Intentional
- Unintentional

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Small but not insignificant

RESIDENTIAL LIGHTING



Residential Energy Codes

Exempt, Excepted and Special

Title 24

- High efficacy sources
 - LED
 - GU24
 - Other
- No blank covers
 - No cheating
- Electronic ballasts >13 w
- Night lights <5 w
- Ignore swimming pool lights
- No other exemptions

IECC 2009 and others

- Nothing special

Residential Energy Codes

Interior

Title 24

- *Kitchen* At least 50% of all lighting must be high efficacy. No screw-based lamps.
- *Lighting in Bathrooms, Garages, Laundry Rooms, Closets, and Utility Rooms.* High efficacy lighting or motion sensors.
- *Lighting other than in Kitchens, Bathrooms, Garages, Laundry Rooms, Closets, and Utility Rooms.* High efficacy, dimmer switches or motion sensors.

IECC 2009 and others

- *Whole house* at least 50% of the lamps must be high efficacy.

Residential Energy Codes

Exterior

Title 24

- *Luminaires providing outdoor lighting, including outdoor lighting for private patios on low-rise residential buildings with four or more dwelling units, entrances, balconies, and porches, and which are permanently mounted to a residential building or to other buildings on the same lot.* High efficacy lighting, photoelectrically controlled lighting, astronomical time devices, energy management or motion/daylight sensors .

IECC 2009 and others

- *Whole house* at least 50% of the lamps must be high efficacy.

Design Planning for Homes

Title 24

- Micromanaging code
- Most loopholes closed
- Knowledgeable code officials
- Sophisticated solutions will be needed

IECC and Other Codes

- Loopholes big enough to drive a Hummer through
- Moderate need for sophisticated solutions

Residential Design for T24

Basic Approach

- A. Use high efficacy lamps wherever they can be used or tolerated.
- B. Learn to manage fluorescent color to keep homeowners, architects and designers happy.
- C. Load up on kitchen watts using high efficacy sources. So you can use low efficacy sources where they are most needed.
- D. Use dimmers a lot.
- E. Learn to love the 37MR16 IR lamp.
- F. Learn to love the 55 watt HIR PAR38 WFL lamp.
- G. Learn to specify maximum wattage labeling.

What is “high efficacy”?

TABLE 150-C HIGH EFFICACY LUMINAIRE REQUIREMENTS

Lamp Power Rating for Non-LED Lighting (see Note 1), or System Power Rating for LED Lighting (see Notes 2, 3, and 4)	Minimum Lamp Efficacy for Non-LED Lighting, or Minimum System Efficacy for LED Lighting
5 watts or less	30 lumens per watt
over 5 watts to 15 watts	40 lumens per watt
over 15 watts to 40 watts	50 lumens per watt
over 40 watts	60 lumens per watt

Notes:

- ¹ Determine minimum lamp efficacy category for lighting systems which are not LED using the initial rated lumens divided by the rated watts of the lamp (not including the ballast).
- ² To qualify as high efficacy, an LED luminaire shall meet the minimum system efficacy requirements in Table 150-C when determined according to Reference Joint Appendix JA8, and be certified to comply with Section 119(m), and input power shall be determined according to Section 130(d)5.
- ³ For a Hybrid LED Luminaire to qualify as a high efficacy luminaire, all lighting systems in the luminaire shall qualify as high efficacy according to Section 150(k)1, and the LED Light Engine with Integral Heat Sink shall comply with Note 4, below.
- ⁴ To qualify as high efficacy, an LED Light Engine with Integral Heat Sink shall meet the minimum system efficacy requirements in Table 150-C when determined according to Reference Joint Appendix JA8, shall be certified to comply with Section 119(m), and input power shall be determined according to Section 130(d)5.

Residential Design for T24

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Basic Technologies

Linear fluorescent lighting

- Undercabinet lights
- Kitchen cove lights
- Laundry rooms
- Garage luminaires
- Closet lights

Residential Design for T24

Basic Technologies

Compact fluorescent lighting

- Undercabinet lights (short)
- Kitchen cove lights (curving)
- Laundry rooms (ceiling lights)
- Garage luminaires (twin tubes)
- Outdoor luminaires
- Closet lights

Residential Design for T24

Basic Technologies

LED Lighting

- Undercabinet lights
- Kitchen cove lights (curving)
- Downlights

Residential Lighting for T24

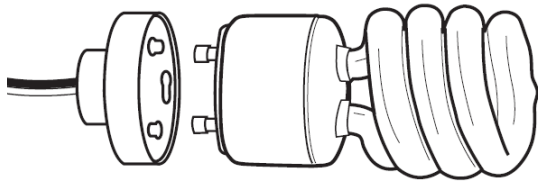
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“Secret” Weapons ****=high efficacy***

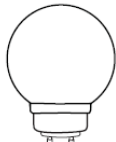
- 2700K T-8 lamps
- GU-24 lamps*
- Two-wire dimming ballast*
- Programmable astronomical wall switch
- Motion sensor dimmer
- Motion sensor night light
- LED cove system*

Secret Weapons

GU-24



A-Lamp



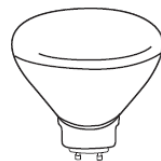
Globe



R20 Flood



R30 Flood



R40 Flood

Sensors and Switches



Example

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LED Cove



Example



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Example

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Challenging in any Code

NON-RESIDENTIAL LIGHTING

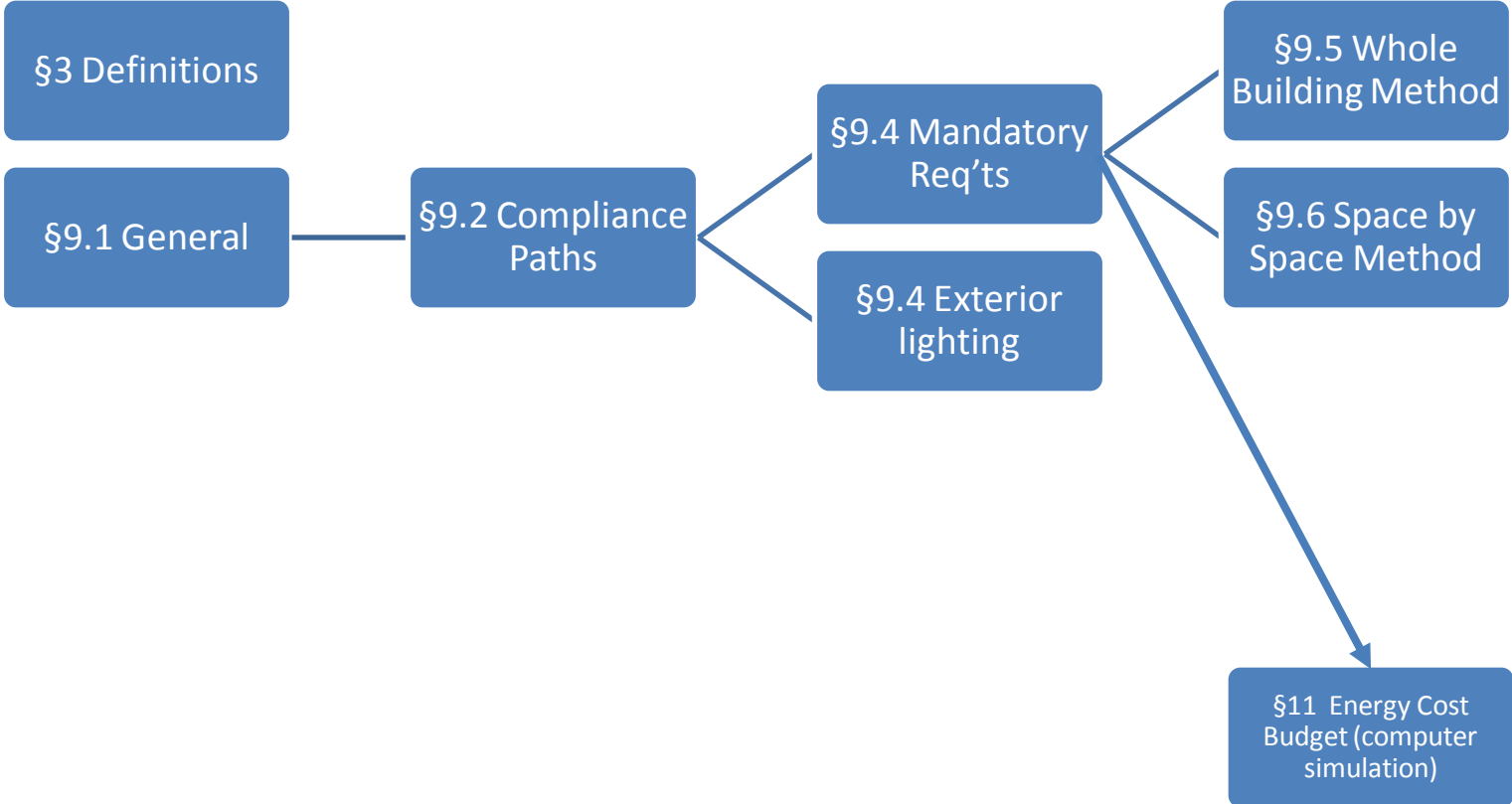


Non-residential Codes are the brunt of lighting energy code emphasis

CODE STRUCTURE

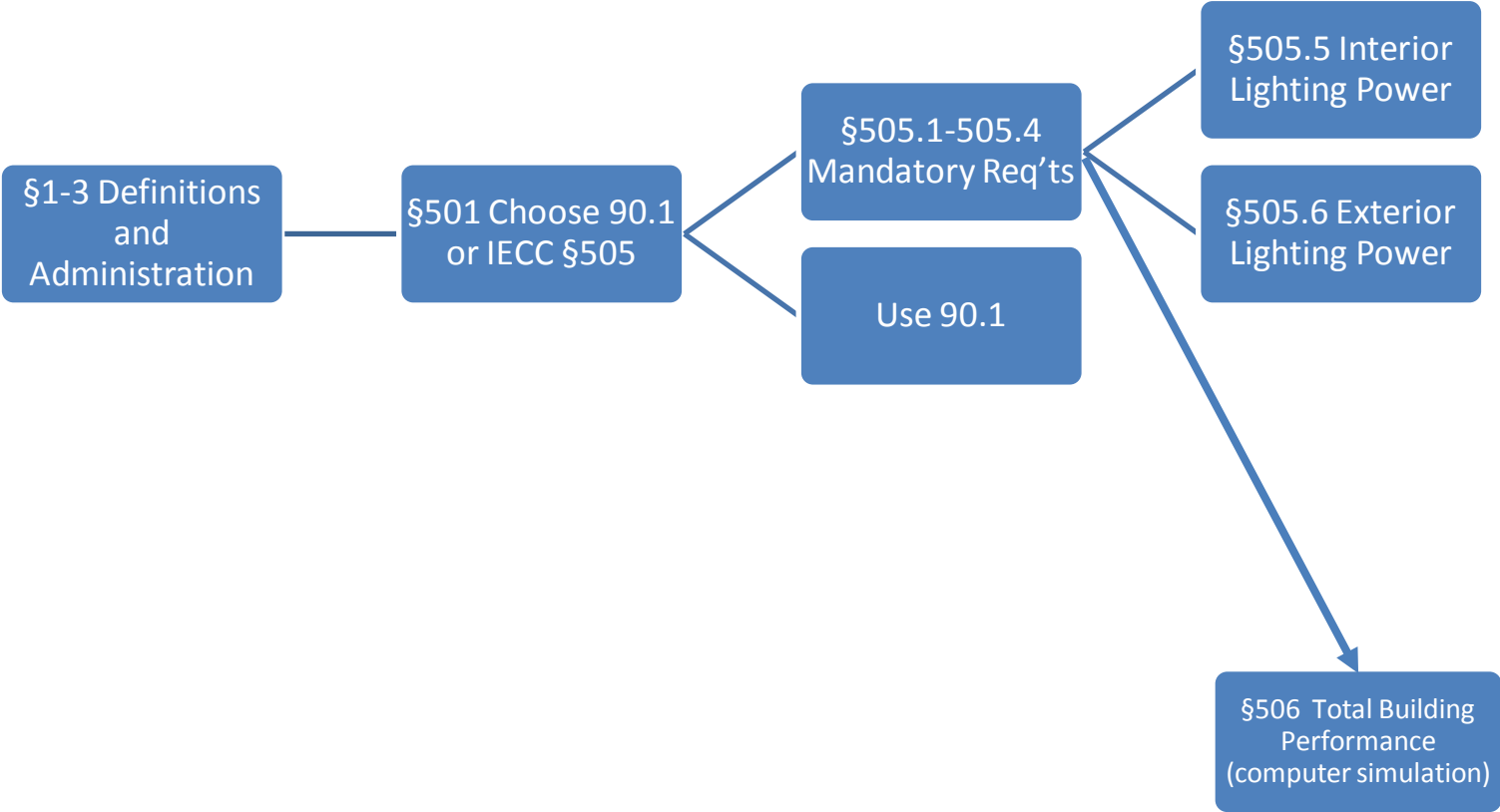


90.1 Structure



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IECC Structure



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Revision System

California

- Revised every 3 years

ASHRAE/IES (90.1, 189.1)

- Revised every 3 years
- Continuous maintenance in between

International Codes Council (IECC, IGCC)

- Revised every 3 years

ASHRAE Addenda

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ANSI/ASHRAE/IESNA Addenda a, b, c, g, h, i, j, k, l,
m, n, p, q, s, t, u, w, y, ad, and aw to
ANSI/ASHRAE/IESNA Standard 90.1-2007

ASHRAE ADDENDA

2008 SUPPLEMENT

Energy Standard for Buildings Except Low-Rise Residential Buildings

ANSI/ASHRAE/IESNA Addenda a, b, c, g, h, i, j, k, l,
m, n, p, q, s, t, u, w, y, ad, and aw to
ANSI/ASHRAE/IESNA Standard 90.1-2007

See Appendix for approval dates.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-521-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-427-4723 (for orders in US and Canada).

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Current Issues

- **Addendum bp to ANSI/ASHRAE/IESNA Standard 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings**
- This proposed change allows the use of control that provides automatic 50% auto on with the capability to manually activate the remaining 50% and has full auto-off.

Addendum bq to ANSI/ASHRAE/IESNA Standard 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings
- This proposed language changes the requirements for retail space lighting which will make use of more recent lamp technology that is readily available.

Mandatory Requirements

- Wiring
- Controls
- Other provisions

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Demonstrating Compliance

The allowed lighting power is equal to or
MORE than the actual lighting power

Allowed watts = 5508

Actual watts = 5411

DESIGN PASSES

Calculating Allowed Watts

$$\begin{aligned} \text{Allowed power} &= \Sigma(\text{individual areas} \times \text{lighting} \\ &\quad \text{power density}) \\ &+ \\ &\quad \Sigma(\text{use it or lose it allowances}) \end{aligned}$$

Use it or lose it is the smaller of each allowance or the actual lighting installed to meet it.

Use it or lose it allowances include

- Retail and display lighting
- Decorative lighting
- Exterior non-trade-able lighting

Calculating Actual Watts

$$\begin{aligned} \text{Actual power} = & \Sigma(\text{all actual non track lighting watts}) \\ & + \\ & \Sigma(\text{track lighting power}) \\ & - \\ & \text{Controls credits} \end{aligned}$$

NOT INCLUDING EXEMPT LIGHTING

Comparing Codes

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ASHRAE 90.1

Major Issues	T24-2008	90.1-2007	IECC-2009
Scope	Does NOT include dwellings, emergency egress lighting, street lighting, or health care	Does NOT include dwellings, emergency egress lighting, street lighting, or industrial	Does NOT include dwellings, emergency egress lighting, street lighting, or industrial
Exempt Interior Lighting	Theme park (theme only), film and studio, theatrical and dance, temp exhibits, refrig. cases, equipment, medical and exam, plant, for sale or teaching, egress, guestrooms, temporary, historic, small agricultural, exit	Museum display, film and studio, theatrical, refrig. cases, equipment, medical and exam, plant, for sale or teaching, egress, casino, historic, exit, visually impaired, food, retail windows	Museum display, guestrooms, sports, medical and exam, plant, egress, exit

Comparing Codes

Major Issues	T24-2008	90.1-2007	IECC-2009
Interior Whole Building Method	Yes	Yes	Yes
Interior Area Category Method	Yes	No	No
Interior Tailored Method	Yes	No	No
Interior Space by Space Method	No	Yes	No
Exterior trade-able plus not trade-able method	Yes	Yes	Yes
Number of exterior lighting zones	4	1	1
Automatic lighting shutoff control threshold	All buildings	All classrooms, offices, break rooms conference rooms; 5,000 sf otherwise	5,000 sf

Maneuvering
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Comparing Codes

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Important Issues	T24-2008	90.1-2007	IECC-2009
Dual level lighting threshold	100sf + 0.8 w/sf	Not required	0.6 w/sf
Separate daylight zone switching	Yes	No	No
Automatic daylighting controls	Required in spaces >2500 sf with skylights	Not required	Not required
Display Lighting Circuit	Separate	Separate	Not required
Acceptance Testing Required	Yes	No	No
Controls Credits	Yes	No	No
Comprehensively addresses LED	Yes	No	No

Comparing Codes

Outdoor Lighting Issues	T24-2008	90.1-2007	IECC-2009
Automatic control required	Yes	Yes	Yes
Lighting Cutoff Requirement	Yes	No	No
Exempt lighting	Roadway, temporary, signs*, monuments, historic, sports, landscape, industrial, underwater, tunnels, bridges, stairs and ramps, ATM	Marker, temporary, signs, monuments, sports, theatrical, industrial, theme elements, historic	Marker, temporary, signs, monuments, sports, theatrical, industrial, theme elements, historic
Trade-able allowance	Hardscape, entrances, sales	Hardscape, entrances, canopies, sales, frontage	Hardscape, entrances, canopies, sales, frontage
Not trade-able allowance (use it or lose it)	Facades, frontage, canopies, service stations, ornamental, guarded, drive-up, dining	ATM, facades, guarded, drive-ups, 24 hour facilities, law/emergency areas	ATM, facades, guarded, drive-ups, 24 hour facilities, law/emergency areas

Maneuvering
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Comparing Codes

Other Lighting Issues	T24-2008	90.1-2007	IECC-2009
Retail categories	Layers of general, wall and key display	Two types: fine merchandise and general merchandise **	Two types: fine merchandise and general merchandise **
Additional Allowances for non-retail display lighting	Yes, both area category and tailored	Yes	Museums and galleries only
Decorative indoor allowance	Yes, both area category and tailored	Yes 1 w/sf	No
Hotel rooms regulated	Treated as residential, 10% exempt	Yes, must have master switch, 1.1 w/sf	Yes, must have master switch, 1.0 w/sf

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Title 24

Best Features

- Versatile
- Adapts to spacial geometry
- Most detailed
- Most thorough

Worst Problems

- Most complicated
- Too many forms
- A lot of work

Changes coming for 2011: major overhaul

IECC

Best Features

- Simple
- Goes fast
- Least work

Worst Problems

- Most restrictive
- Not versatile
- Simple code for simple buildings

Changes coming for 2012: unclear

90.1

Best Features

- A compromise

Worst Problems

- It's a compromise

Changes in 2010: reduced lighting power allowances, IECC 2009 retail allowances

Luminaire Ratings



A Secret to Success

NON-TRACK LIGHTING



Important Energy Code Ratings

- Air tight
- Luminaire rated watts
- Luminaire rated efficacy
 - Standard lamps and ballasts
 - LEDs

Luminaire Rated Watts

6" A-lamp downlight

- Design uses 60A19 lamp
- Housing rated to 200 watt A21
- T24: per label but 50 w min if <11'; 60 w 11-15'; 75 w min if >15'
- 90.1/IECC: per label

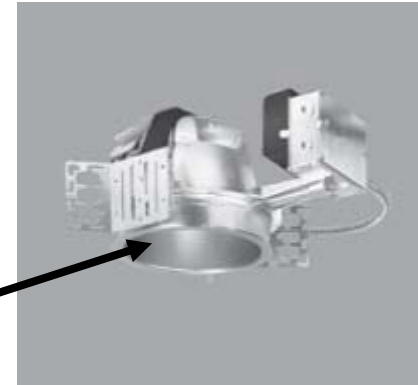
CF downlight

- Design uses CF26 triple
- Ballast and housing rated to 42 watt triple
- T24: larger of specified watts or ballast average (35)
- 90.1/IECC: maximum (45)



Warning: use only 60 watt lamp

Warning: use only 26 watt lamp



A lot of work has gone into this

TRACK LIGHTING



Track Watts?

- Applies to track and busway (“heavy duty track”)
- They are designed to have lights installed, uninstalled and moved
- Codes don’t like this



Related Issue: NEC Art. 410

Article 410-100 through-105

- Until 1996, Article 410-103 implied that track was to be counted as a load of 90 watts per foot; new branch circuit required for every 21' 4" of track.
- In 1996, a fine print note indicated that 90 w/foot was for feeders only, and Article 411 was added for low voltage lighting systems including 12 volt track and monorails
- In 1999, article 410-103 disappeared
- In 2002, Article 410-103 reappeared covering heavy duty track

What Happened?



CAUSE OF DEATH: MURDERED BY ENERGY CODES
Title 24 – 45 w/ft 90.1/IECC 30 w/ft

Maneuvering
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Track Revival: Limits on Power

- A. Branch circuit method – all track on circuit is 2400 watts
- B. Current limiter method – all track beyond a current limiter is the VA of the voltage and limiter amps
- C. Low voltage method – all track beyond a transformer is the transformer VA
- D. Watts per foot method – the original method

Comparing Codes on Track

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Major Issues	T24-2008	90.1-2007	IECC-2009
Watts per foot of 20A track	45	30	30
Watts per foot of busway	Circuit VA	30	30
Current limiter allowed	Yes min 12.5 w/ft	Yes	Yes
Low voltage track	Transformer VA	Transformer VA	Transformer VA
Whole circuit method	Yes	Yes	YES

Track Power Methods

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

Actual Load

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

Branch Circuit Method

$$20\text{A} \times 120 \text{ volts} =$$

$$\mathbf{2400 \text{ w}}$$

Watts per foot method

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

(ASHRAE/IECC)

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

(California)

Current limiter method

Inline Current limiter

$$3\text{A} \times 120 \text{ volts} =$$

$$\mathbf{360 \text{ watts}}$$

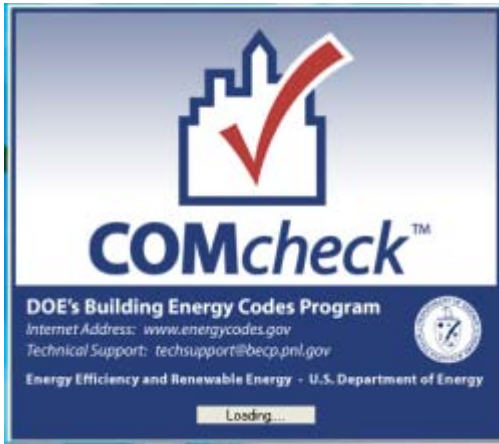
Compliance documentation



Group Exercise

TITLE 24 FORMS





Live Demonstration

COMCHECK



Mostly Title 24 and LEED

CONTROLS STRATEGIES



Title 24 Controls Credits

Similar credits being considered by 90.1 Addendum bp

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TYPE OF CONTROL		TYPE OF SPACE	FACTOR
Multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D		Any space \leq 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room.	0.20
Multi-level occupant sensor (see Note 2) that reduces lighting power at least 50% when no persons are present. May be a switching or dimming (see Note 3) system.		Hallways of hotels/motels , multi-family, dormitory, and senior housing	0.25
		Commercial and Industrial Storage stack areas (max. 2 aisles per sensor)	0.15
		Library Stacks (maximum 2 aisles per sensor)	0.15
Dimming system	Manual	Hotels/motels, restaurants, auditoriums, theaters	0.10
	Multiscene programmable	Hotels/motels, restaurants, auditoriums, theaters	0.20
Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal. (See Note 1)		All building types	0.05

NOTES FOR TABLE 146-C:

1. PAFs shall not be available for lighting controls required by Title 24, Part 6.
2. To qualify for the PAF the multi-level occupant sensor shall comply with the applicable requirements of Section 119.
3. To qualify for the PAF all dimming ballasts for T5 and T8 linear fluorescent lamps shall be electronic and shall be certified to the Commission with a minimum RSE in accordance with Table 146-D.
4. If the primary sidelit daylight area and the secondary sidelit daylight area are controlled together, the PAF is determined based on the secondary sidelit effective aperture for both the primary sidelit daylight area and the secondary sidelit daylight area.

Title 24 Controls Credits

	Manual dimming of dimmable electronic ballasts. (see Note 3)	All building types	0.10
	Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal when used in combination with manual dimming of dimmable electronic ballasts (see Note 1 and 3).	All building types	0.15
Combined controls	Multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D combined with automatic multi-level daylighting controls	Any space \leq 250 square feet within a daylit area and enclosed by floor-to-ceiling partitions, any size classroom, corridor, conference or waiting room. The PAF may be added to the daylighting control credit	0.10
	Manual dimming of dimmable electronic ballasts (see Note 3) when used in combination with a multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D.	Any space \leq 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room	0.25

NOTES FOR TABLE 146-C:

1. PAFs shall not be available for lighting controls required by Title 24, Part 6.
2. To qualify for the PAF the multi-level occupant sensor shall comply with the applicable requirements of Section 119.
3. To qualify for the PAF all dimming ballasts for T5 and T8 linear fluorescent lamps shall be electronic and shall be certified to the Commission with a minimum RSE in accordance with Table 146-D.
4. If the primary sidelit daylight area and the secondary sidelit daylight area are controlled together, the PAF is determined based on the secondary sidelit effective aperture for both the primary sidelit daylight area and the secondary sidelit daylight area.

Title 24 Controls Credits

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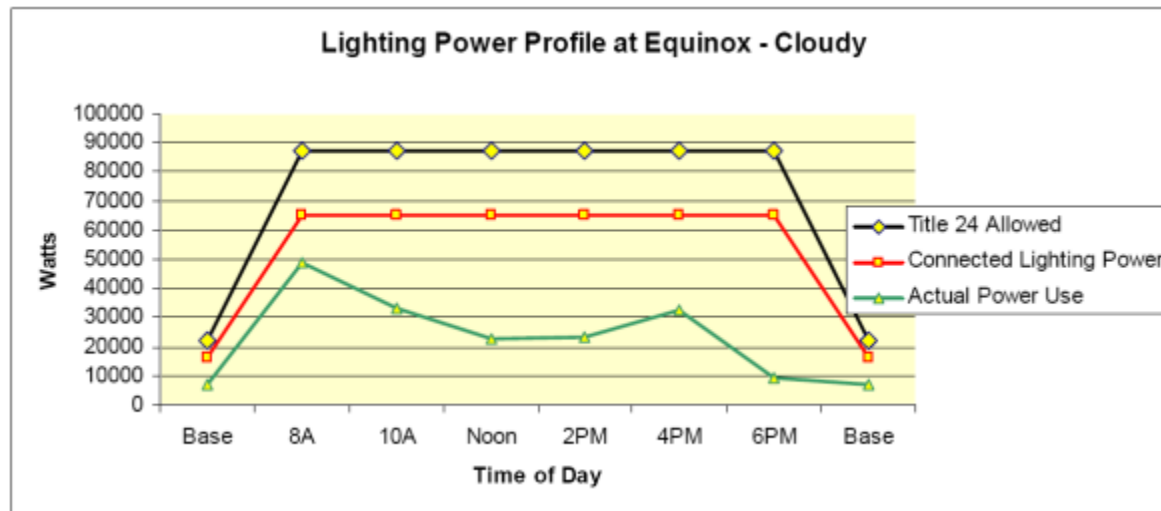
Automatic multi-level daylighting controls (See Note 1)	Total primary sidelit daylight areas less than 2,500 ft ² in an enclosed space and all secondary sidelit areas. (see Note 4)		Effective Aperture			
		General Lighting Power Density (W/ft ²)	>10% and ≤20%	>20% and ≤35%	>35% and ≤65%	> 65%
		All	0.12	0.20	0.25	0.30
Automatic multi-level daylighting controls (See Note 1)	Total skylit daylight areas in an enclosed space less than 2,500 square feet, and where glazing material or diffuser has ASTM D1003 haze measurement greater than 90%		Effective Aperture			
		General Lighting Power Density (W/ft ²)	0.6% ≤ EA < 1%	1% ≤ EA < 1.4%	1.4% ≤ EA < 1.8%	1.8% ≤ EA
		LPD < 0.7	0.24	0.30	0.32	0.34
		0.7 ≤ LPD < 1.0	0.18	0.26	0.30	0.32
		1.0 ≤ LPD < 1.4	0.12	0.22	0.26	0.28
		1.4 ≤ LPD	0.08	0.20	0.24	0.28

NOTES FOR TABLE 146-C:

1. PAFs shall not be available for lighting controls required by Title 24, Part 6.
2. To qualify for the PAF the multi-level occupant sensor shall comply with the applicable requirements of Section 119.
3. To qualify for the PAF all dimming ballasts for T5 and T8 linear fluorescent lamps shall be electronic and shall be certified to the Commission with a minimum RSE in accordance with Table 146-D.
4. If the primary sidelit daylight area and the secondary sidelit daylight area are controlled together, the PAF is determined based on the secondary sidelit effective aperture for both the primary sidelit daylight area and the secondary sidelit daylight area.

Controls in 90.1 and IECC

- Through computer simulation
- Requires considerable oversight (even with Title 24)



LEED Controls Strategies

LEED Controls Point

- In general requires providing users with individual control of lights
- In Schools, requires the providing of separate general lighting and AV lighting scenes

Maneuvering
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Group study rooms, Tuck School of Business, Dartmouth College

About Controls

- Next generation standards will change from w/sf to kWh per SF
- Controls will be everything

The Stimulus Should Affect This

STRATEGIES FOR SCHOOLS & HIGHER ED



Power Densities

Maneuvering
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Building Area/Whole Building	T24-2008 Whole Building	90.1-2007 Building Area	IECC-2009
Classroom Building	1.1	School	School
Auditorium/Perf Arts	1.5	1.6	1.6
Office	0.85	1.0	1.0
Library	1.3	1.3	1.3
School	1.0	1.2	1.2

Power Densities

Area Category/Space-by space	T24-2008 Area Category	Title 24 Tailored Worth it?	90.1-2007 Space by Space
Classroom	1.2	<input checked="" type="checkbox"/>	1.4
Gym	1.0		Play 1.4 Exercise 0.9
Office	1.1 <250 sf 0.9 >250 sf		1.1 open 1.1 private
Hallway	0.6		0.5
Multipurpose Room	1.4	<input checked="" type="checkbox"/>	1.3 + decorative
Parking Lot Hardscape	LZ1 .036 LZ2 .045 LZ3 .092 LZ4 .115		.15
Library	Reading 1.1 Stacks 1.5		Reading 1.2 Stacks 1.7+ decorative

Maneuvering
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School Design Strategy

Overarching Considerations

- Assume < 1 w/sf of connected load for the whole school
- Use T5 and Super T8 technology as much as possible
- Mix in a few CF and HID lamps
- A very small amount of tungsten load is tolerable

Easiest Energy Problems

- Classrooms
 - Recessed high efficiency T5
 - Pendant high efficiency T8 or T5
 - General light
 - White Board light
- Gyms
 - High bay T5HO
- Shops/industrial and fine arts
 - T8 or T5

Toughest Energy Problems

- Corridors
- Locker Rooms
- Multipurpose Rooms

Maneuvering
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Additional Resources

- ASHRAE Advanced Energy Design Guide (AEDG) for Schools www.ashrae.com
- California Collaborative for High Performance Schools (CHPS) and related groups www.chps.net

Great opportunities for savings

STRATEGIES FOR OFFICES



Power Densities

Maneuvering
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Building Area/Whole Building	T24-2008 Whole Building	90.1-2007 Building Area	IECC-2009
Office	0.85	1.0	1.0
Parking Lot Hardscape	See next slide	.15	.15

Power Densities

Maneuvering
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Area Category/Space-by space	T24-2008 Area Category	90.1-2009 Space by Space
Meeting Room	1.4	1.3 + decorative
Office	1.1 <250 sf 0.9 >250 sf	1.1 open 1.1 private
Lobby	1.5 + decorative	1.3 + decorative
Corridor	0.6	0.5
Parking Lot Hardscape	LZ1 .036 LZ2 .045 LZ3 .092 LZ4 .115	.15

Office Design Strategy

Overarching Considerations

- Assume < 0.9 w/sf of connected load for the whole building
- Use T5 and Super T8 technology as much as possible
- Mix in a few CF and HID lamps
- No tungsten load is tolerable

Easiest Energy Problems

- Open office
 - Recessed high efficiency T5
 - Pendant high efficiency T8 or T5
 - Ambient 35 fc – with task lights
- Private office (except executive)
 - Sim. open office

Toughest Energy Problems

- Corridors
- Meeting Rooms and Multipurpose Rooms
- Training Rooms
- Executive Rooms
- Spaces with dark finishes

Additional Resources

- ASHRAE Advanced Energy Design Guide (AEDG) www.ashrae.com
- Most office lighting manufacturers have educational material and are tuned into the issues

The toughest project type

STRATEGIES FOR RETAIL



Power Densities

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Building Area/Whole Building	T24-2008 Whole Building	90.1-2007 Building Area	IECC-2009
Retail	1.1	1.5	1.5 + display allowance*
Grocery Store	1.5	N/A	N/A

Power Densities

Area Category/Space-by space	T24-2008 Area Category	Title 24 Tailored	90.1-2007 Space by Space
Retail General	1.6	0.9 to 1.4	1.7
Retail Display	None	Wall display 17w/LF Floor display 1.5 w/sf	R4 4.2 w/sf R3 2.6 w/sf R2 1.7 w/sf R1 1.0 w/sf
Decorative allowance	None	0.7 w/sf	1 w/sf
Fine merchandise in case	None	1 w/sf	None
Storage	0.6	Use Area Category	0.8
Dressing	0.8	Use Area Category	0.6

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Retail Design Strategy

Overarching Considerations

- Determine the display lighting environment
 - Track
 - Recessed
 - Case-mounted/other
 - None
- Lay-out to fully use the display lighting allowance
- Lay-in general and ornamental lighting

Display lighting dilemma

- Halogen HIR/IR is fairly efficient
- CMH and fluorescent still use 50% of the power for the same number of mean lumens and/or center beam candlepower
- Title 24-2008 and 90.1-2007 are based on using HIR/IR
- IECC-2009 is based on using CMH and CF
- LED is not ready to step in to most display lighting applications

General lighting dilemma

- Linear lighting is most efficient
- CMH and CF look more “incandescent” but not exactly
- Title 24-2008 and 90.1-2007 are based on using HIR/IR
- IECC-2009 is based on using CMH and CF

Easiest Energy Problems

- General lighting for general merchandise
 - Recessed high efficiency T5
 - Pendant high efficiency T8 or T5
- Big box
 - High bay CMH, T5HO and T8

Toughest Energy Problems

- High end non-jewelry display lighting
- General lighting in better spaces
- Dressing rooms

Additional Resources

- ASHRAE Advanced Energy Design Guide (AEDG) for Small Retail
www.ashrae.com

Example: JEWELRY STORE

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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



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 T24-2008	6.5 w/sf
90.1-2004	6.1 w/f
90.1-2007	6.9 w/sf
90.1-2007 add. <i>br</i>	4.5 w/sf

Some state specific codes

Oregon	5.2 w/sf
Washington	3.0 w/sf**

Example: DESIGN CLOTHING STORE

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- 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 T24-2008	5.5 w/sf
90.1-2007	5.5 w/sf
90.1-2004	4.6 w/sf
90.1-2007 add. <i>br</i>	3.1 w/sf
Oregon	3.75 w/sf
Washington	3.0 w/sf**

**The State of Washington Retail Lighting Shuffle

Unlimited amount of lighting wattage if:

- Fluorescent and CF 1 and 2 lamp luminaires
- No track
- Aimable lighting all CMH or fluorescent

Residential Issues Re-appear

STRATEGIES FOR HOSPITALITY



Power Densities

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Building Area/Whole Building	T24-2008 Whole Building	90.1-2007 Building Area	IECC-2006
Hotel	N/A	1.0	1.0
Motel	N/A	1.0	1.0
Dining Fast Food	1.2	1.4	1.4
Dining Bar/leisure	1.2	1.3	1.3
Dining/family	1.2	1.7	1.7

Power Densities

Area Category/Space-by space	T24-2008 Area Category	90.1-2007 Space by Space
Lobby	1.1*	1.1*
Function Area	1.5*	1.3*
Other Public Areas	Waiting area 1.1* Corridors 0.6	Restroom 0.9* Corridors 0.5*
Guest Rooms	Not regulated	1.1*
Ballroom/Multipurpose Room	1.4*	1.3*
Dining Room	1.1* Lounge 1.1	Hotel 1.3* Motel 1.2* Bar/lounge 1.4* Family dining 2.1*
Kitchen	1.6	1.2*
Back of House	0.6	0.5*

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Hospitality Design Strategy

Overarching Considerations

- Use T5 and Super T8 technology as much as possible back of house
- HID and CF downlights and wallwashers
- A very small amount of tungsten load is tolerable, especially in ballrooms.
- Remember that lighting for temporary use (ballrooms, exhibit rooms) is generally *exempt*

Easiest Energy Problems

- Corridors
 - Good use for CF
- Guest rooms
 - Portable usually does not count
- Conference/meeting rooms

Toughest Energy Problems

- Ballrooms
- Lobbies
- Restaurants

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New in 2005 for Title 24 – Evolving Standards

STRATEGIES FOR OUTDOOR LIGHTING



Title 24 2008

- Outdoor lighting language rewritten for clarity
- Repackaged for simplification of compliance forms and enforcement
- No longer break site into many puzzle pieces
 - First layer = illuminated hardscape lighting power allowance for entire site
 - May trade off hardscape allowance within the site—provided entire hardscape remains illuminated
 - Must reduce total square feet of site hardscape if luminaires removed
- Other Specific Application “layers” available where appropriate
 - Each additional lighting power allowance is layered on the appropriate portion of site

Title 24 2008

The general hardscape area of a site includes:

- Parking lots, roadways, driveways, sidewalks, walkways, bikeways, plazas, and other improved areas that are illuminated
 - No longer differentiate between pedestrian and automotive hardscape
 - No longer have methods 'i' and 'ii'
- New Method allows base watts + perimeter watts + area watts

90.1-2007

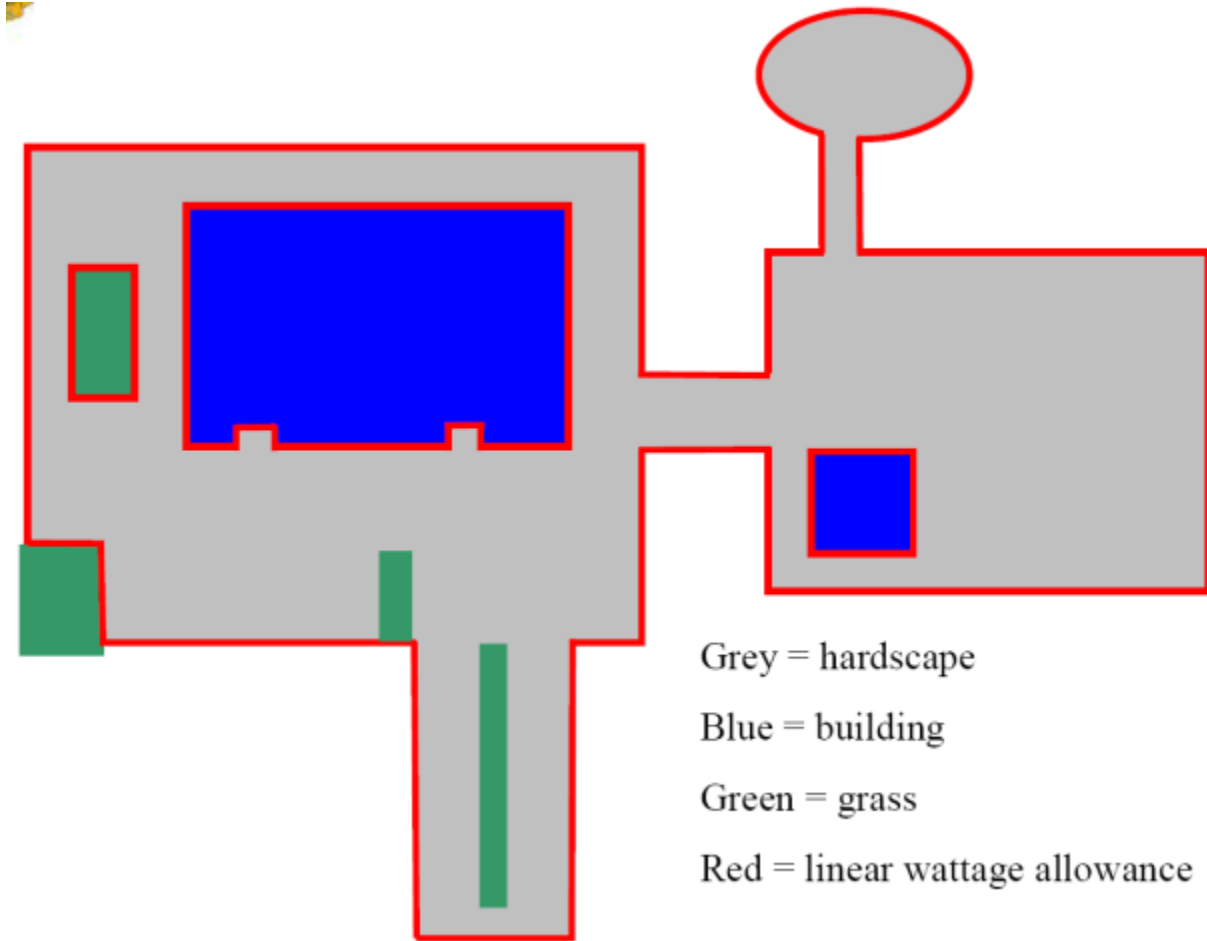
- Original code: single zone (sim. 90.1-2004)
- Appendix “i” changed to 4 zone system similar to Title 24

Title 24 2008

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Type of Power Allowance	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Area Wattage Allowance (AWA)	0.036 W/ft ²	0.045 W/ft ²	0.092 W/ft ²	0.115 W/ft ²
Linear Wattage Allowance (LWA)	0.36 W/lf	0.45 W/lf	0.92 W/lf	1.15 W/lf
Initial Wattage Allowance (IWA)	340 W	510 W	770 W	1030 W

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ASHRAE 90.1



Use it or Lose it Applications

Maneuvering
Lighting
Design
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Lighting Application	Lighting Zone 3
Building Entrances or Exits.	100 W
Primary Entrances to Senior Care Facilities, Police Stations, Hospitals, Fire Stations, and Emergency Vehicle Facilities.	120 W
Drive Up Windows.	125 W
Vehicle Service Station Uncovered Fuel Dispenser	185 W
Outdoor Sales Frontage	36 W/linear ft
Ornamental Lighting (based on ft ² of site hardscape)	0.04 W/ft ²
Building Facades	0.35 W/ft ²
Outdoor Sales Lots	0.758 W/ft ²

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Lighting Application	Lighting Zone 3
Vehicle Service Station Hardscape	0.308 W/ft ²
Vehicle Service Station Canopies	1.358 W/ft ²
Sales Canopies	0.908 W/ft ²
Non-sales Canopies	0.408 W/ft ²
Guard Stations	0.708 W/ft ²
Student Pick-up/Drop-off zone	0.45 W/ft ²
Outdoor Dining	0.258 W/ft ²
Special Security Lighting for Retail Parking and Pedestrian Hardscape.	0.019 W/ft ²

Design Strategy

Overarching Considerations

- Use high efficacy sources
- Meet IES recommended light levels
- Use good design practices
- The more “extra” you want to do, the more efficient your basic lighting should be

Easiest Energy Problems

- Parking lots
 - HID or LED
 - Sometimes CF
- Walkways
- Building entrances and exits

Toughest Energy Problems

- Themed facilities
- Facilities wanting excessive lighting

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Additional Resources

- Model Lighting Ordinance
www.darksky.org

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Final points and questions jbenya@benyalighting.com

WRAP UP

