



U.S. Department of Energy
Energy Efficiency and Renewable Energy



Building Energy Codes

Can You Have Good Lighting Design and Still Meet Code?

Commercial Lighting Energy Codes: Requirements, Application and Compliance

Eric Richman, PNNL

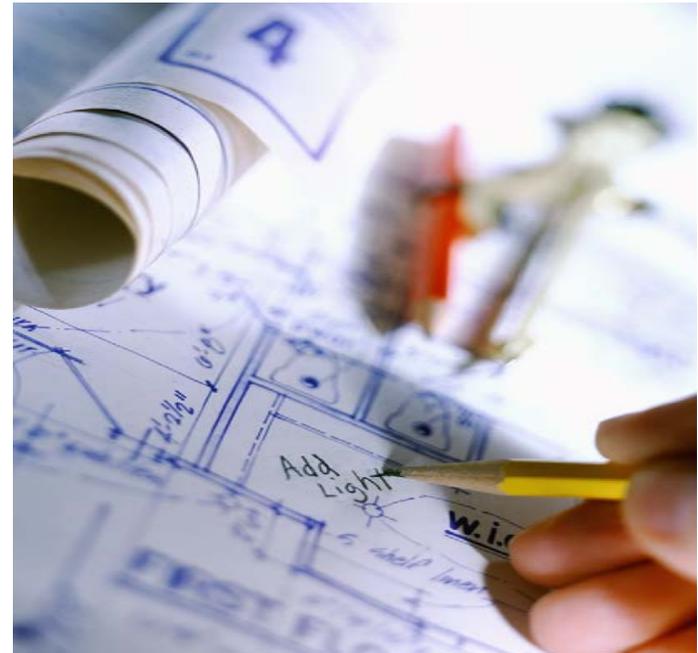
Nancy Clanton, Clanton & Associates, Inc.

What we plan to cover.....

- The requirements....of common National energy codes
 - Why we have them....some history
 - Specific details of the lighting code requirements
 - The Intent of the requirements

- Project Application
 - What the requirements mean in practice
 - Interpretations and practical application

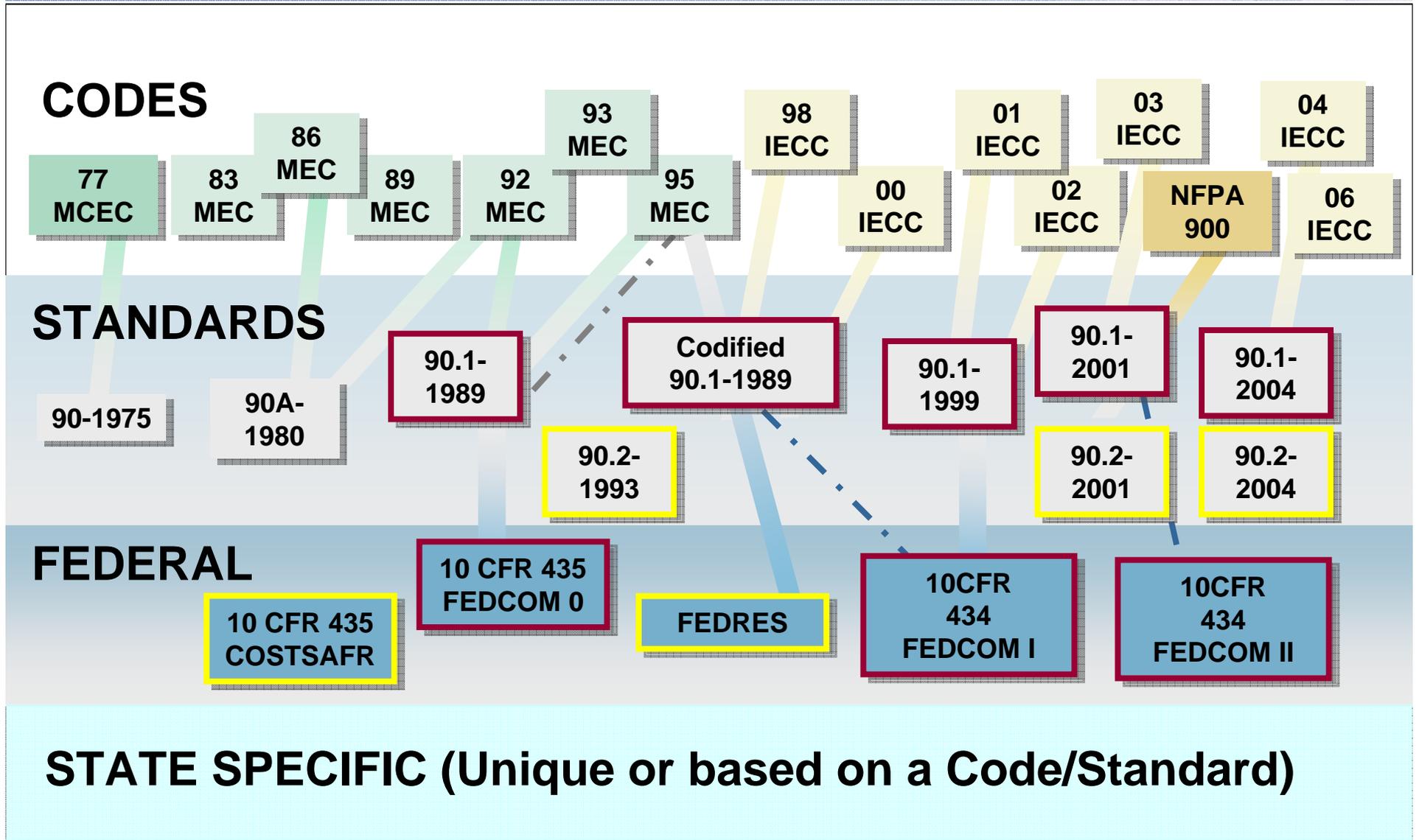
- Complying....with good design
 - Project compliance demonstration
 - Special cases



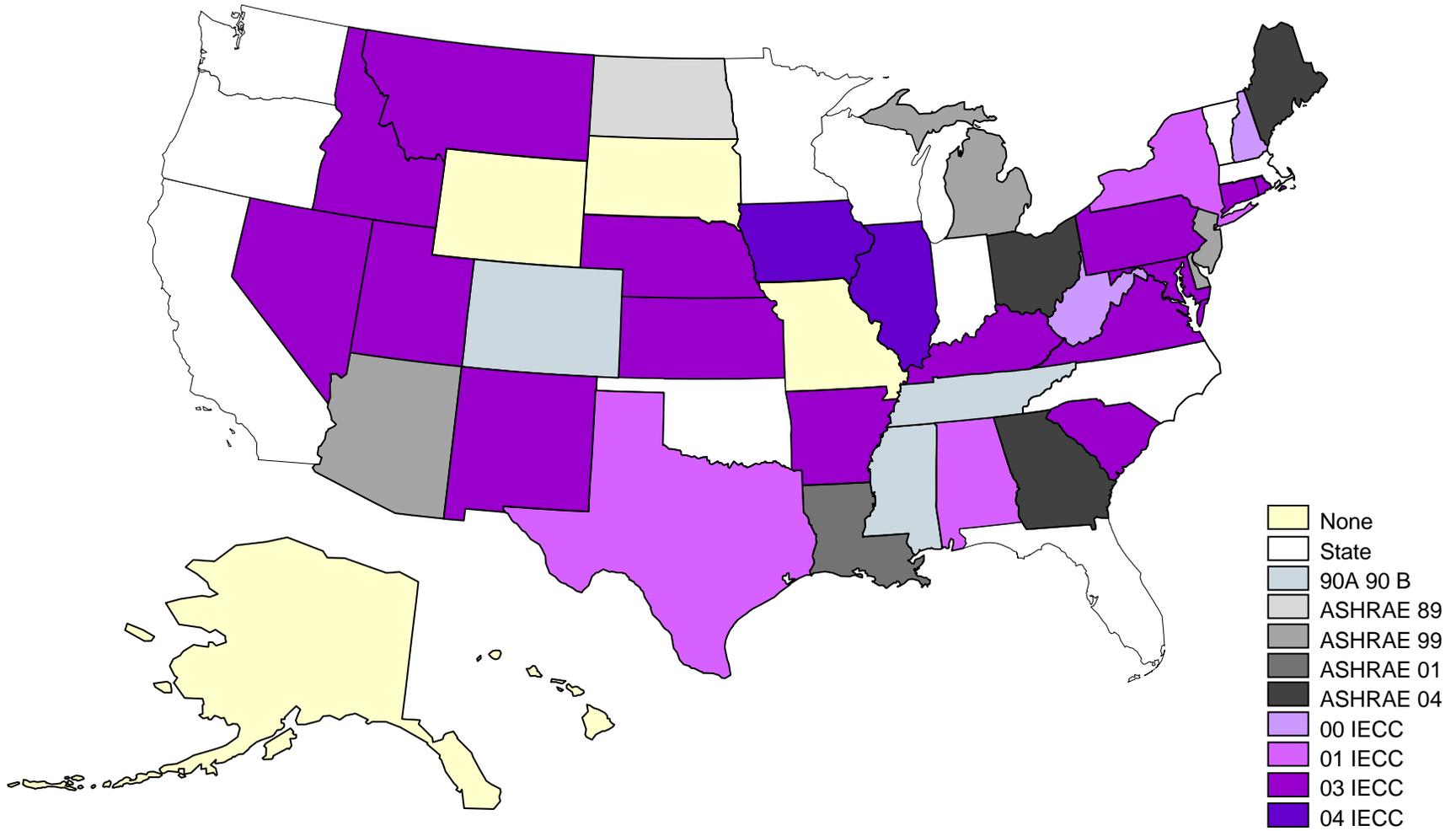
The Basis for Energy Requirements

- Energy Conservation and Production Act, as amended, requires States to adopt a commercial energy code
.....This drives state adoption of energy codes
- DOE determines the effective stringency level to meet or exceed – currently set at ASHRAE/IESNA 90.1-1999
- Many code/standard versions available and currently adopted – varies by state:
 - Some adopt nationally available codes/standards
 - Some develop state-specific codes
 - Some have no code!

Energy Codes/Standards History



Commercial Codes



ASHRAE 90.1 and IECC Code Basics

- Both provide minimum requirements for building efficiency
- Many State specific codes based on these same requirements
- Current published versions: ASHRAE/IESNA 90.1-2004, IECC 2006....but both have previous versions adopted by various states and local jurisdictions
- The IECC code references ASHRAE/IESNA 90.1 as an alternate compliance option.

.....we will focus on the specific requirements of ASHRAE/IESNA 90.1-2004 and IECC 2003 but will note major differences in other versions.



ASHRAE 90.1 and IECC Lighting Scope

➤ New Construction and Additions

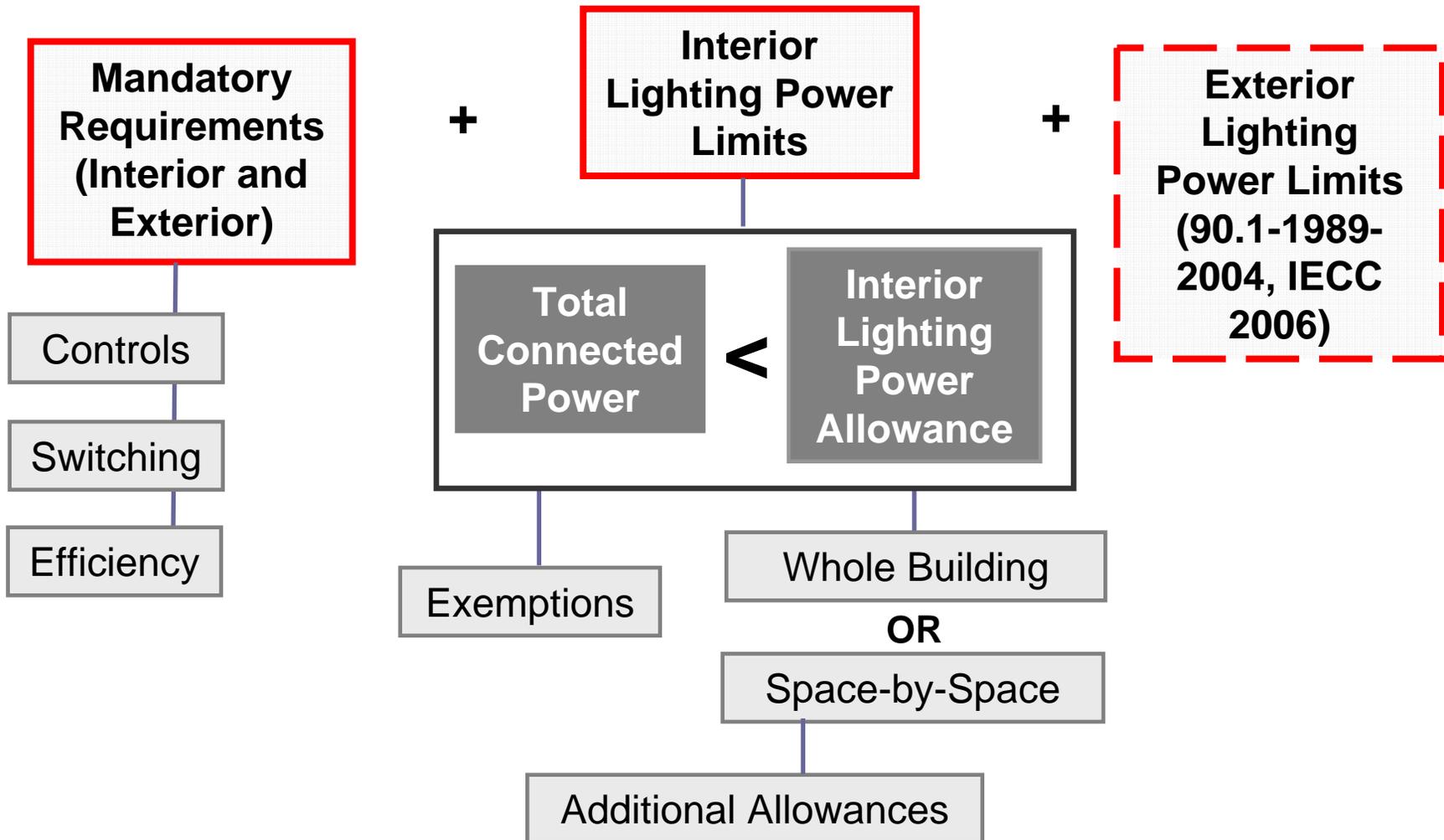
- All commercial type buildings including residential structures of 4 or more stories above grade
- Interior and exterior lighting
- Some exceptions to all requirements:
 - Lighting in dwelling units
 - Emergency lighting that is normally off (90.1-1989-2004)
 - Lighting required by life, health, safety statute (90.1-1989-2004)
 - Historic buildings (whole code exemption)

➤ Alterations/Renovations

- Generally treated as new construction
- Some exemptions apply



Basic Lighting Requirements

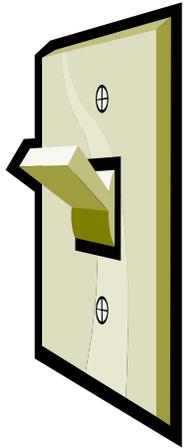


A few Words about Alterations/Renovations

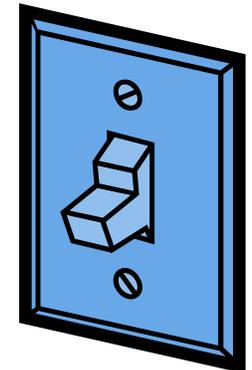
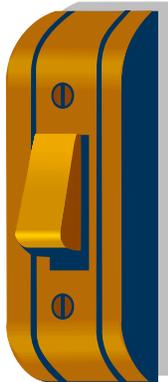
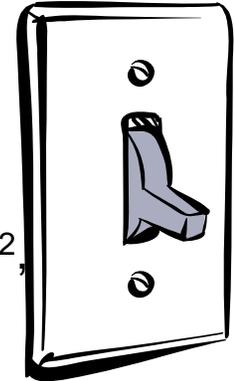
- The requirements are effectively the same as for new construction or additions:
 - The replacement of lighting systems in building spaces must comply.
 - Any new or replacement control devices must comply.
- 90.1-1999-2004 Exception: Replacement of less than 50% of the luminaires in a space need not comply (if no increase in power density).



Mandatory: Individual Space Control



- At least one for each room or space enclosed by ceiling-height partitions
 - 90.1-1999-2004 specifies that in spaces $<$ or $=$ 10,000 ft², each control serves 2500 ft² maximum and in spaces $>$ 10,000 ft², serves 10,000 ft² maximum
- Readily accessible to occupants
- Remote location is allowed to accommodate areas where safety or security is a concern
- IECC 1998-2006 specifically exempts: security/emergency areas with 24 hour lighting and egress stairways/corridors



Intent: Allow occupants to control unneeded lighting!

Mandatory: Additional Space Controls

- Hotel/motel guest room lighting must be controlled at room entry
 - IECC 1998-2006 exempts bathroom lighting and allows individual suite room control

Intent: Allow occupant to turn off lights at exit point!



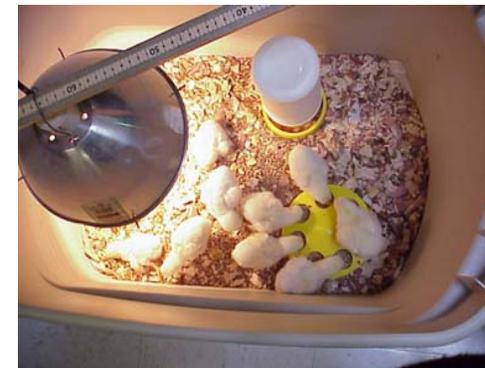
- 90.1-2004 requires occupancy sensors in:
 - Classrooms (except shop,lab,K-12)
 - Conference/meeting rooms
 - Employee lunch/break rooms

Intent: Capture major business hours wasted light.



Mandatory: More Individual Space Control

- 90.1-1999-2004 requires additional control for:
 - Display/accent lighting
 - Case lighting
 - Task lighting
 - Nonvisual lighting
 - Demonstration lighting



➤ IECC 1998-2006 requires “bi-level” switching in all spaces

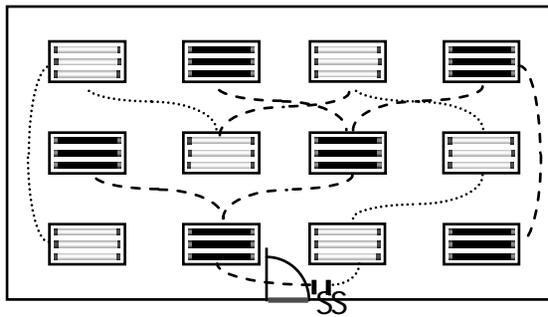
- Capability to reduce connected load by 50%
- Must be done in a uniform manner

➤ Exceptions:

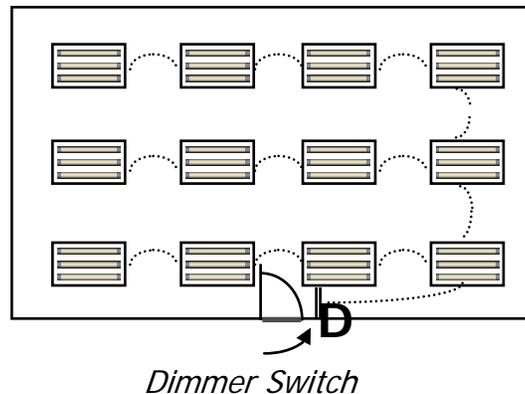
- Single fixture spaces
- Spaces with occupancy sensors
- Corridors, storerooms, restroom, public lobbies, guestrooms
- IECC 2003-2006 also exempts Low energy areas (<0.6 W/sqft)

Intent: Allow occupants to moderate light levels to save energy!

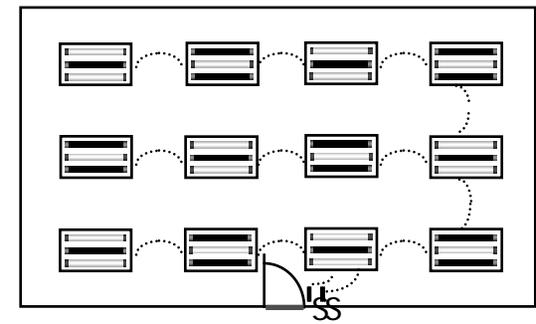
Alternating Luminaires



Dimming



Alternating lamps



Mandatory: Automatic Shutoff

Automatic lighting shutoff control device required in all buildings larger than 5,000 ft²

➤ Building Defined:

- “Any structure used or intended for supporting or sheltering any use or occupancy”
- Building area surrounded by exterior walls and fire walls

➤ Not required in 90.1-1989, or IECC 1998-2000

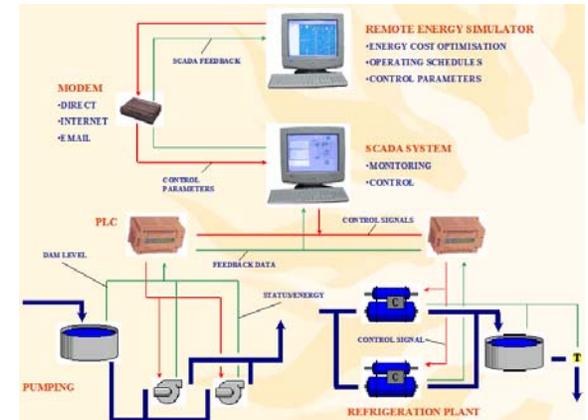
➤ IECC 2001 only requires in spaces >250 sq.ft.

Intent: Eliminate after hours lighting waste!

Mandatory: Automatic Shutoff

➤ Compliance options:

1. Control lights on a scheduled basis (automatic time switch)
 - Time-of-day controller
 - Controls $\leq 25,000$ ft² and not more than one floor,
2. Occupant sensor (intended in IECC)
 - Turn lights off within 30 minutes of occupant leaving the space
3. Signal from another control or alarm that indicates the area is unoccupied (intended in IECC)



NOTE: 90.1-1999 and IECC 2001-through 2004 include faulty “occupant intervention” phrase

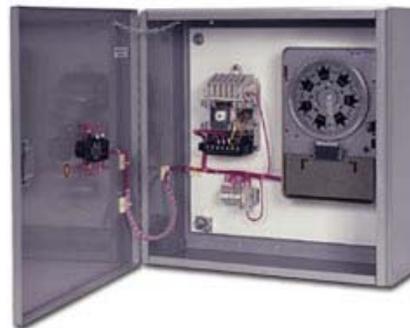


Mandatory: More Automatic Shutoff

- **Override of automatic shutoff required:**
 - IECC 2003-2006: for not more than 2 hours (exceptions apply)
 - 90.1-1999-2004: for not more than 4 hours
- **IECC 2003-2006 requires Holiday schedule capability**
 - Except in: retail stores and associated malls, restaurants, grocery stores, churches and theaters
- **Exceptions to automatic shutoff:**
 - 90.1-1999-2001: Lighting for 24 hour operation
 - 90.1-2004: 24 hour lighting, patient care spaces, areas with safety or security concerns
 - IECC 2004:
 - Areas with 1 fixture or occupancy sensor control,
 - Corridors, storerooms, restrooms, public lobbies, guestrooms

Mandatory: Exterior Lighting Control

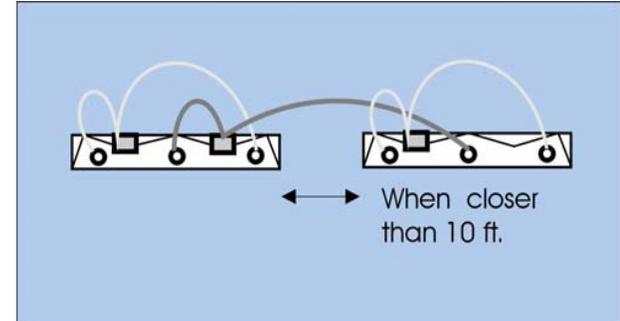
- Photocell (for dawn-to-dusk lighting) **OR**
- Seven-day/seasonal programmable with astronomic correction and 4 hour battery backup
- 90.1-1989-2004 Exceptions:
 - Covered vehicle entrances
 - Exits from buildings or parking structures(where required for safety, security, or eye adaptation)



Mandatory: Tandem Wiring/Exit Signs

- Tandem wiring: eliminate use of single lamp ballast where possible

Intent: Eliminate use of magnetic ballasts driving single lamps!



- Exit signs:

- IECC 2003-2006 and 90.1-2004 limit to 5 watts per face maximum
- 90.1-1999-2001 specifies 35 lumen/Watt if over 20 watts

Intent: Control extended use applications where practical.



Prescriptive: Interior Lighting Power

➤ Prescriptive Option

- Whole Building or Space-by-space method
- Compare actual **Installed Power** (wattage) to **Lighting Power Allowance** (lighting power density LPD) limits
- Additional power allowances and exemptions available

A few words about the Performance Option

- 90.1: “Energy Cost Budget”, IECC: “Total Building Performance”
- Whole building energy use modeling
- Compare prescriptively compliant base building with proposed building
- Can provide flexibility but requires detailed modeling inputs



Intent: Eliminate waste by promoting thoughtful design and application!

Prescriptive: Determine Installed Power

- Calculate installed lighting wattage for entire lighted space(s)
- Include all permanent and portable interior lighting designed for general, ambient, or task illumination
 - Exception: for 2 or more mutually exclusive lighting systems only count the system with highest wattage
- Wattage “Rules”
 - Standard incandescent = labeled wattage of the luminaire
 - Luminaires with ballasts = wattage of the lamp/ballast combination – not just nominal lamp wattage! (90.1-2007 will add option of labeled wattage)
 - Line voltage track = actual wattage with minimum 30 W per foot (90.1-2007 will add option of circuit breaker/permanent limiter)
 - Low voltage track = transformer wattage
 - All others as specified on equipment



Prescriptive: 90.1 Wattage Exemptions

- For 90.1-1999-2004, lighting for the following can be excluded:
 - Theatrical, stage, film, and video production
 - Used only during medical and dental procedures
 - Display/accent in exhibits/displays for museums monuments, and galleries
 - Plant growth or maintenance
 - Integral to equipment or instrumentation installed by manufacturer
 - Integral to both open and glass-enclosed refrigerator and freezer cases
 - Food warming and food prep equipment
 - In retail display windows when the display is enclosed by ceiling-height partitions
 - For use in areas specifically designed for the visually impaired
 - In spaces specifically designated as registered interior historic landmarks
 - Integral part of advertising or directional signage
 - Exit signs
 - Sale or lighting educational demonstration systems
 - For television broadcasting of sporting activities
 - Casino gaming areas
 - (90.1-2007 will add task lights that are occupancy sensor controlled)

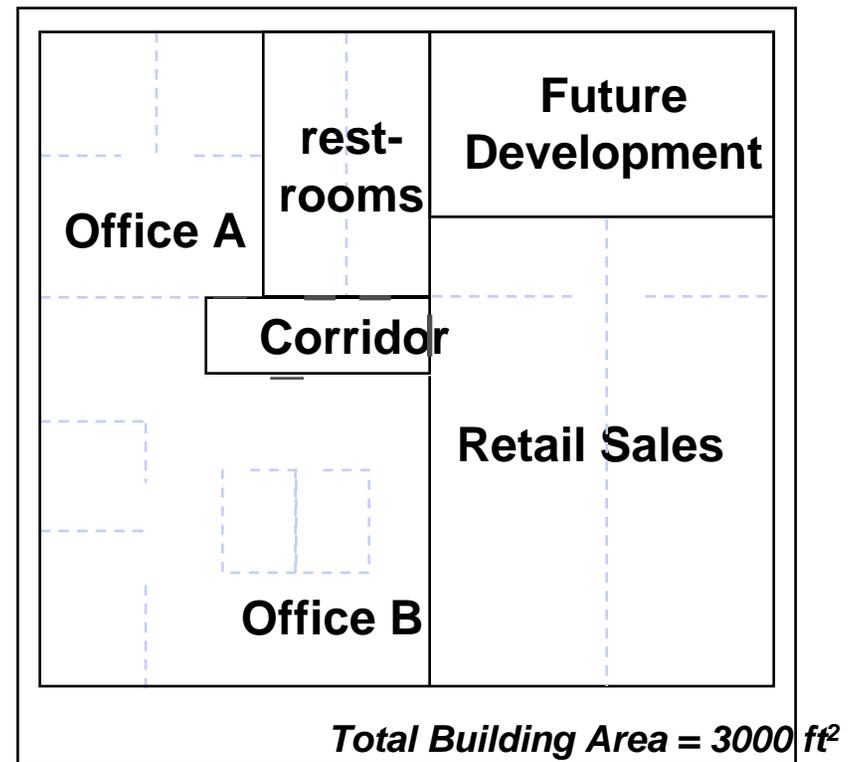
Prescriptive: IECC Wattage Exemptions

- IECC 1998 exemptions:
 - Specialized medical, dental, and research lighting
 - For display/accent in exhibits/displays for museums monuments, and galleries
- IECC 2000-2006 also exempts:
 - Professional sports arena playing field lighting
 - Guest room lighting
 - Emergency lighting that is normally off

Prescriptive: Lighting Power Allowance

- Choose appropriate Lighting Power Density (LPD)
 - Whole Building Path
 - Easier
 - Less flexibility
 - Space-by-Space Path
 - More math
 - Often higher potential total allowance

- Multiply LPD by square footage
 - Whole building LPD times total building area
 - Space-by-space LPD times space area(s) and sum values



Space LPDs

- 90.1-2004 Space type LPD sample
- IECC 2003-2004 has similar values but shorter list
- IECC 1998-2001 and 90.1-1999-2001 have looser sets of values
- IECC 2006 does not provide space type LPDs – must use whole building or use 90.1 alternate option

90.1-2004 Space Type (LPD) Allowance - Partial List		
Building Type	Space Type description	Watts/sqft
Common Space Type	Corridor/Transition	0.5
Common Space Type	Classroom/Lecture/Training	1.4
Common Space Type	Electrical/Mechanical	1.4
Common Space Type	Dining Area	0.9
Common Space Type	Food Preparation	1.2
Common Space Type	Lounge/Recreation	1.2
Common Space Type	Stairs - Inactive	0.4
Common Space Type	Stairway	0.6
Common Space Type	Restrooms	0.9
Common Space Type	Lobby	1.3
Common Space Type	Atrium - first three floors	0.6
Common Space Type	Atrium - each additional floor	0.2
Common Space Type	Office - enclosed	1.1
Common Space Type	Office - open plan	1.1
Common Space Type	Conference Meeting/Multipurpose	1.3
Common Space Type	Inactive storage	0.3
Common Space Type	Active storage	0.8
Auditorium	Lobby	1.0
Convention Center	Exhibit space	1.3
Court House	Courtroom	1.9
Exercise Center	Dressing/Locker/Fitting Room	0.6
Hospital/Healthcare	Exam/Treatment	1.5
Hospital/Healthcare	Emergency	2.7
Hospital/Healthcare	Recovery	0.8
Library	Stacks	1.7
Library	Reading Area	1.2
Manufacturing Facility	General Low Bay	1.2
Manufacturing Facility	General High Bay	1.7
Museum	General exhibition	1.0
Parking Garage	Parking Area - Pedestrian	0.2
Performing Arts Theatre	Audience/Seating Area	2.6
Police/Fire Station	Fire Station Engine room	0.7
Post Office	Sorting Area	1.2
Transportation	Airport - Concourse	0.6
Transportation	Terminal - Ticket counter	1.5

Whole Building LPDs

- 90.1-2004 whole building LPD values as shown
- IECC 2003-2006 values similar – but with some different type names
- IECC 1998-2001 and 90.1-1999-2001 have looser sets of values

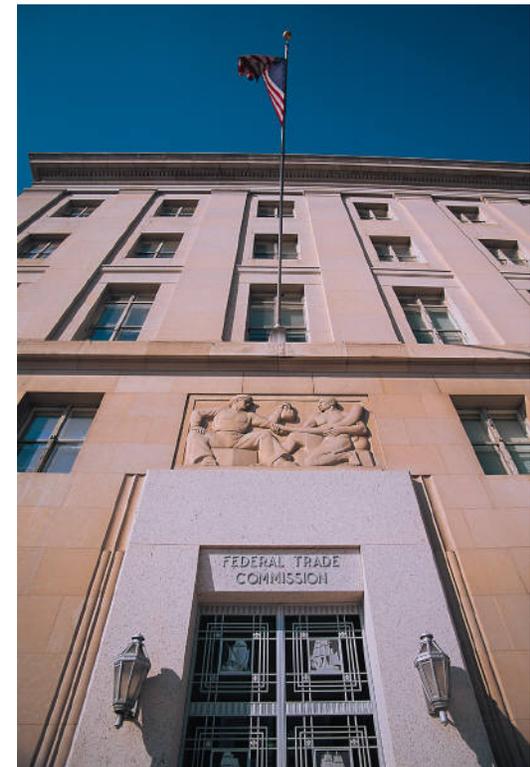
90.1-2004, IECC 2003-2006 Whole Building (LPD) Allowance	
Building Type	Watts per Square Foot
RETAIL	1.5
OFFICE	1
POST OFFICE	1.1
DINING: BAR LOUNGE/LEISURE	1.3
CONVENTION CENTER	1.2
MUSEUM	1.1
PARKING GARAGE	0.3
COURTHOUSE	1.2
POLICE STATIONS	1
Healthcare/Clinic	1
Hospital	1.2
MANUFACTURING	1.3
PERFORMING ARTS THEATER	1.6
SCHOOL/UNIVERSITY	1.2
SCHOOL/UNIVERSITY	1.2
SCHOOL/UNIVERSITY	1.2
TOWN HALL	1.1
PENITENTIARY	1
TRANSPORTATION	1
WORKSHOP	1.4
FIRE STATIONS	1
LIBRARY	1.3
HOTEL	1
MOTEL	1
MOTION PICTURE THEATRE	1.2
DINING: CAFETERIA/FAST FOOD	1.4
DORMITORY	1
MULTI-FAMILY	0.7
EXCERCISE CENTER	1
SPORTS ARENA	1.1
DINING: FAMILY	1.6
GYMNASIUM	1.1
AUTOMOTIVE FACILITY	0.9
RELIGIOUS BUILDINGS	1.3
WAREHOUSE	0.8

How were the Space Type LPDs developed?

- Developed within the ASHRAE/IESNA 90.1 Lighting subcommittee with IESNA committee support
- Similar general process for 90.1-1999, 2001, 2004
- Apply:
 - Current lighting product performance data
 - Current lamp/ballast efficacy and light loss factors
 - Latest IES recommended light levels
 - Professional consensus of quality lighted environments
- Combine these elements into building space models to calculate lighting power densities

...and Whole Building LPDs?

- Develop detailed space-by-space data for commercial buildings
 - Source: DODGE Construction data plans sets - best available current, multiple commercial building data
 - Perform space type area takeoffs for detailed square footage by space type
 - Current set at 246 buildings for 31 building types
- Assign applicable space type model LPD for each space
- Calculate whole building LPD



....Graphically:

POST OFFICE Whole Building								
Building and Space Description	Space Appl. Factor	Model #	Model LPD	Space Wtd LPD	LPD Sum	Bldg Appl %	Bldg Wtd LPD	Bldg Type Wtd Avg LPD
A	B	C	D	E	F	G	H	I
17,342 ft²					1.56	0.25	0.39	1.55
Conference	0.013	31.00	1.50	0.019				
Corridor	0.009	2.00	0.73	0.006				
Locker Room	0.070	24.00	0.81	0.057				
Elec/Mech	0.009	4.00	1.29	0.011				
Recreation	0.048	9.00	1.40	0.068				
Office - encl.	0.024	25.00	1.54	0.037				
Office - open	0.020	27.00	1.28	0.026				
Locker Room	0.069	20.10	1.75	0.121				
Reception	0.003	12.00	0.97	0.003				
Stair	0.006	11.00	0.94	0.006				
Acoustic	0.042	41.00	1.13	0.048				
Workshop	0.021	35.00	2.47	0.051				
Lobby	0.115	88.00	1.52	0.176				
Sorting Area	0.551	34.00	1.70	0.934				
	1.000							
13,971 ft²					1.53	0.25	0.38	
Active storage	0.058	41.00	0.97	0.036				
Workshop	0.022	35.00	0.97	0.036				
Dining Area	0.025	6.00	0.97	0.036				
Restrooms	0.012	12.00	0.97	0.012				
Locker Room	0.046	24.00	0.81	0.037				

Data from bldg plans

Space model & LPD

B x D

F x G

Sum of column E for bldg

Sum of column H for bldg type

Process Detail Available at IESNA

- Interactive version of the process is available at IESNA at:
<http://12.109.133.232/cgi-bin/lpd/lpdhome.pl>

Lighting power density

A comprehensive source for understanding the lighting models underlying the commercial lighting power limits developed in ASHRAE/IESNA 90.1-2004.

Methodology Glossary
Explore lighting power density models for *entire buildings*.
[Whole Building LPD](#)

Public Forum
Explore lighting power density models for *individual spaces*.
[Space Type LPD](#)

Survey
Experiment with your own power density models.
[Calculator](#)

Contacts
View/Download the [User Guide](#) in Adobe Acrobat pdf format.

IESNA
ASHRAE
Members

The IESNA Energy Management Committee (EMC), working with the Lighting Subcommittee of the ASHRAE IESNA 90.1-2004 Standing Standards Project Committee (SSPC) has developed an interactive methodology for determining lighting power densities for both individual spaces and whole buildings. This methodology is the basis for the lighting power density numbers found in the ASHRAE/IESNA 90.1-2004 Standard.

This methodology calculates lighting power allowances for building spaces and whole buildings. The process models lighting design assumptions from a consensus of lighting design professionals for each of the space types used in 90.1-2004, using currently available efficient lamp/ballast/fixture data, and illuminance values from current IESNA illuminance recommendations. In this way, the needs of the occupants are taken into account and energy-efficient design is promoted through the resulting lighting power densities.

Direct questions or concerns about this website to iesna@iesna.org
© 2005 IESNA. All rights reserved.

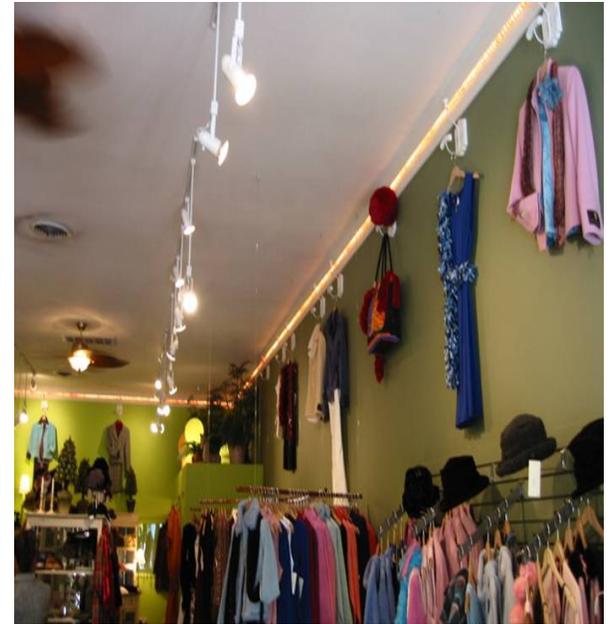
Prescriptive: Additional Lighting Power

- IECC 2000-2006 and 90.1-1999-2004 versions allow some additional lighting power
- These are use-it-or-lose-it allowances
- They must be used only for specific designed use and not for general illumination
- Should be separately switched from other general lighting



Prescriptive: Additional Lighting Power

- 90.1-1999-2004:
 - Decorative luminaires in addition to the general lighting at 1.0 W/ft²
 - Use of specific luminaires designed to eliminate computer screen glare at 0.35 W/ft²
 - **Retail Display Lighting:**
 - **Additional 1.6 W/ft² , or**
 - **Additional 3.9 W/ft² for fine merchandise**
- (90.1-2007 will include greatly revised set of allowances)
- IECC 2006 includes whole building LPD only but does allow the retail display allowances



Exterior Lighting Power

➤ 90.1-1999

- Building grounds lighting over 100 watts must be at least 60 lm/W
 - Exceptions: required by statute, transportation markers, specialized signal/direction, signage, registered historical sites
- Power limits (tradable similar to interior lighting):
 - Entrance w/canopy – 3 W/sq. ft. of canopy area
 - Entrance w/o canopy – 33 W/linear ft. of door
 - Exit – 20 W/linear ft. of door
 - Façade – 0.25 W/sq. ft. of illuminated area



➤ 90.1-2001 separates façade lighting such that it is NOT tradable

➤ IECC 1998-2004

- ALL exterior lighting (other than low voltage landscape) must be at least 45 lumens/W
- Exceptions: Historical, safety, signage, or emergency considerations

Note exterior lighting for multiple building sites can be traded

Exterior Lighting Power – latest code versions!

- 90.1-2004 and IECC 2006 have expanded exterior lighting requirements.....
 - The total exterior lighting power allowance is the sum of the individual lighting power densities [LPD]....
 -plus an additional unrestricted allowance of 5% of that sum. Trade-offs are allowed only among “Tradable Surfaces” applications.
 - Some exemptions apply



Exterior LPDs: 90.1-2004/IECC 2006

Applications	Lighting Power Densities
Tradable Surfaces (Lighting Power Densities for open parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded)	
Uncovered Parking Areas	
Parking Lots and drives	0.15 W/ft ²
Building Grounds	
Walkways less than 10 feet wide	1.0 Watts/linear foot
Walkways 10 feet wide or greater, Plaza areas and Special feature areas	0.2 W/ft ²
Stairways	1.0 W/ft ²

Exterior LPDs: 90.1-2004/IECC 2006

Applications	Lighting Power Densities
More Tradable Surfaces.....	
Building Entrances and Exits	
Main Entries	30 Watts/linear foot of door width
Other doors	20 Watts/linear foot of door width
Canopies and Overhangs	
Canopies (free standing & attached) and overhangs	1.25 W/ft ²
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft ²
Street Frontage for vehicle sales lots in addition to "open area" allowance	20 Watts/linear foot

Exterior LPDs: 90.1-2004/IECC 2006

Applications	Lighting Power Densities
Non-Tradable Surfaces (Lighting Power Density calculations for the following applications can only be used for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowance's are in addition to any allowance otherwise permitted in the Tradable Surfaces section of this table.)	
Building Facades	0.2 W/ft ² for each illuminated wall or surface or 5.0 Watts/linear foot for each illuminated wall or surface length
Automated Teller Machines & Night Depositories	270 watts per location plus 90 watts per additional ATM per location
Entrances and Gatehouse Inspection Stations at guarded facilities	1.25 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)

Exterior LPDs: 90.1-2004/IECC 2006

Applications	Lighting Power Densities
Non-Tradable Surfaces	
Loading Areas for Law Enforcement, Fire, Ambulance and other Emergency Service Vehicles	0.5 W/ft ² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)
Drive-up Windows at Fast Food Restaurants	400 watts per drive-through
Parking near 24-hour Retail Entrances	800 watts per main entry

Exterior Lighting Power Exemptions

- The following are exempt when equipped with separate control:
 - Specialized signal, directional, and marker lighting associated with transportation;
 - Lighting that is integral to advertising signage or directional signage;
 - Lighting that is integral to equipment or instrumentation and is installed by its manufacturer;
 - Lighting for theatrical purposes, including performance, stage, film, and video production;
 - Lighting for athletic playing areas;
 - Temporary lighting;
 - Lighting for industrial production, material handling, transportation sites, and associated storage areas;
 - Theme elements in theme/amusement parks;
 - Lighting used to highlight features of public monuments and registered historic landmark structures or buildings.

Compliance with the code....and Good Design!

Lighting energy code compliance examples

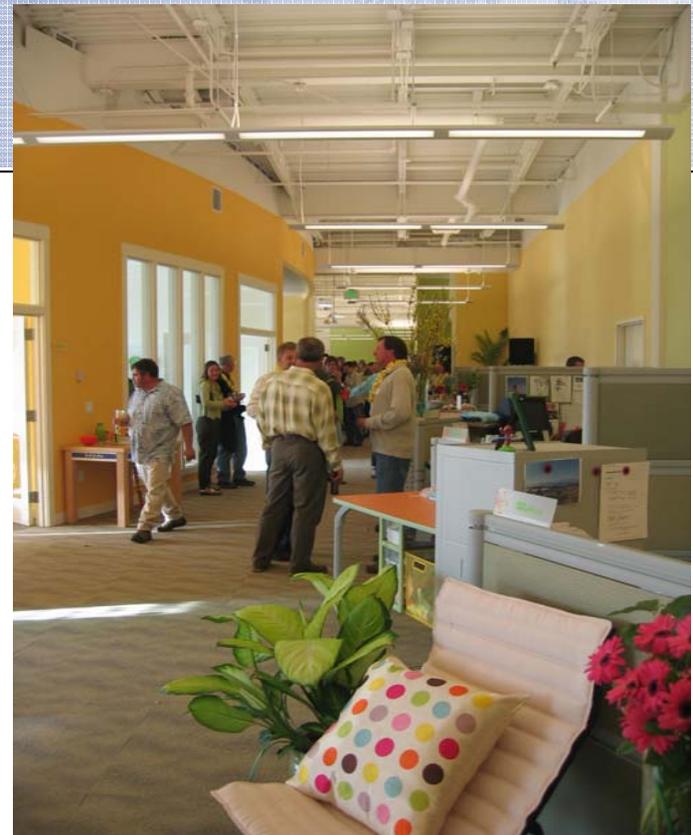
Nancy Clanton, Clanton & Associates Inc.

Putting the Code to Work

- Easy way out --- Whole building method, though less flexible
- Better way --- Space by Space
- Best way --- Performance which demonstrates real time

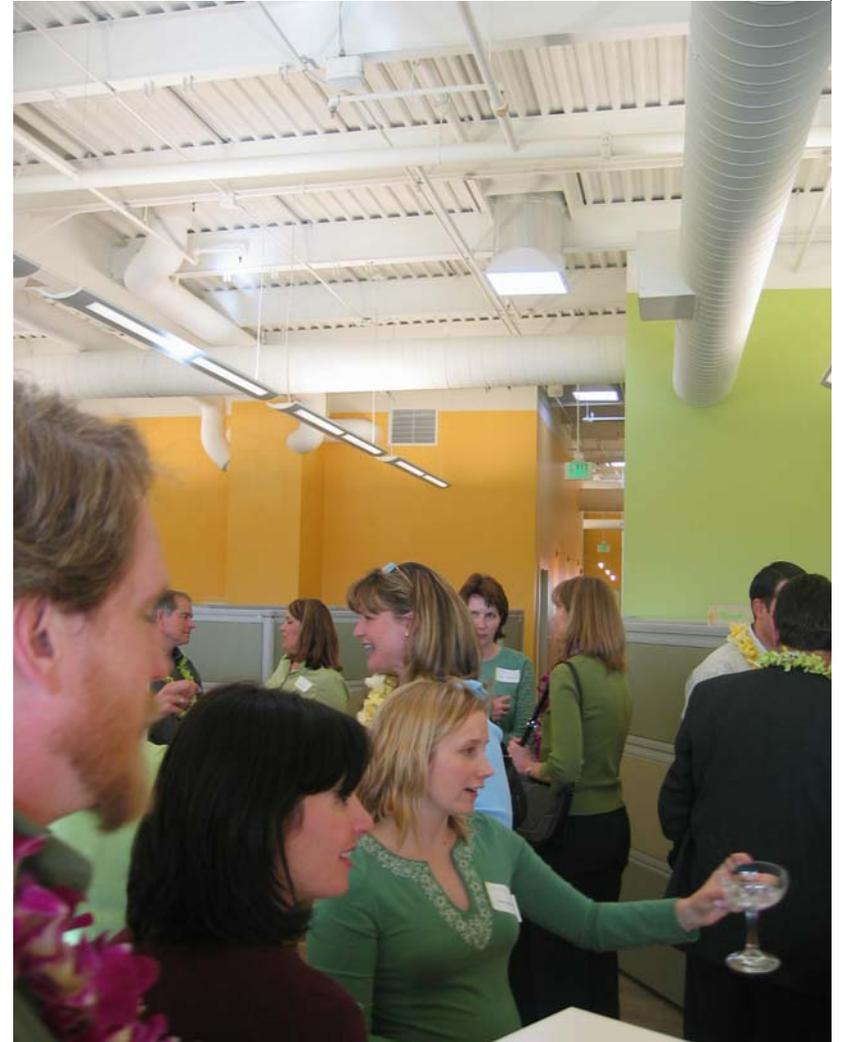
Success tips

- Layer the lighting design
- Light surfaces, not volumes



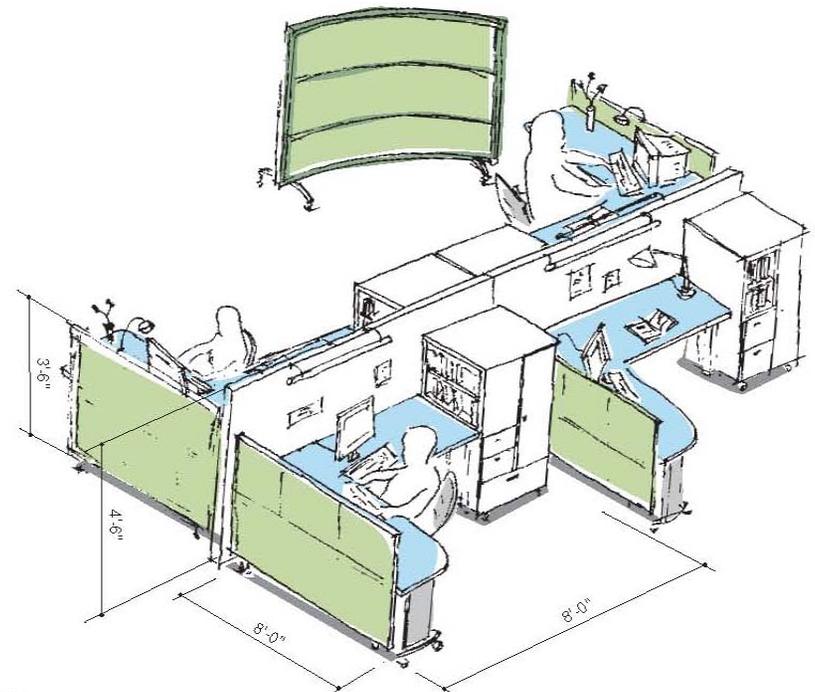
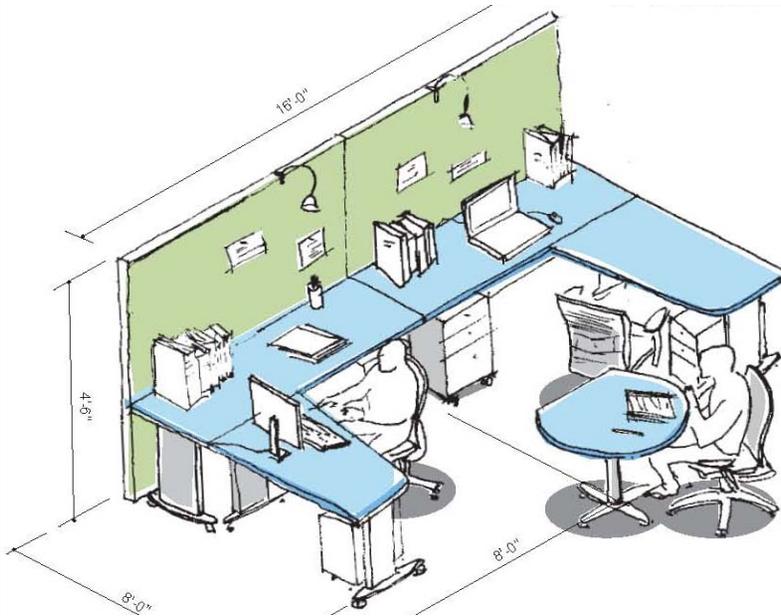
Design Strategies

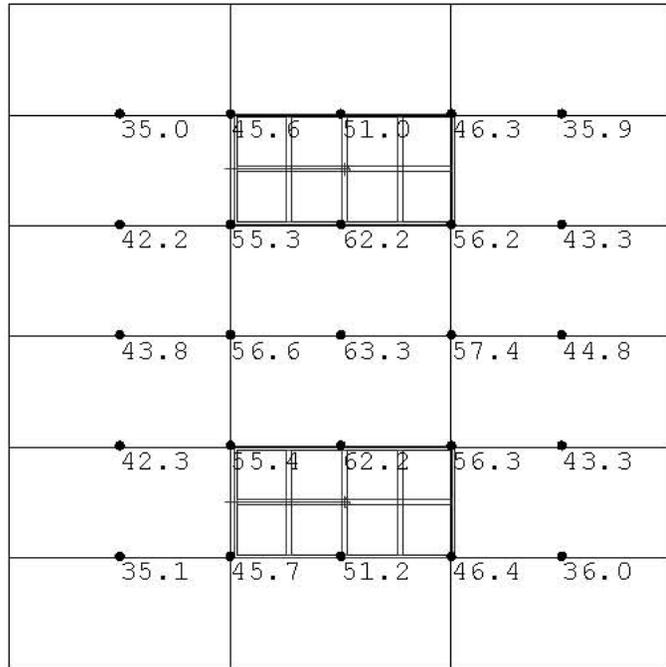
Light surfaces, not volumes



Lowering Lighting Power Densities

- Try two layers of ATA (one for entire area, one for personal space)

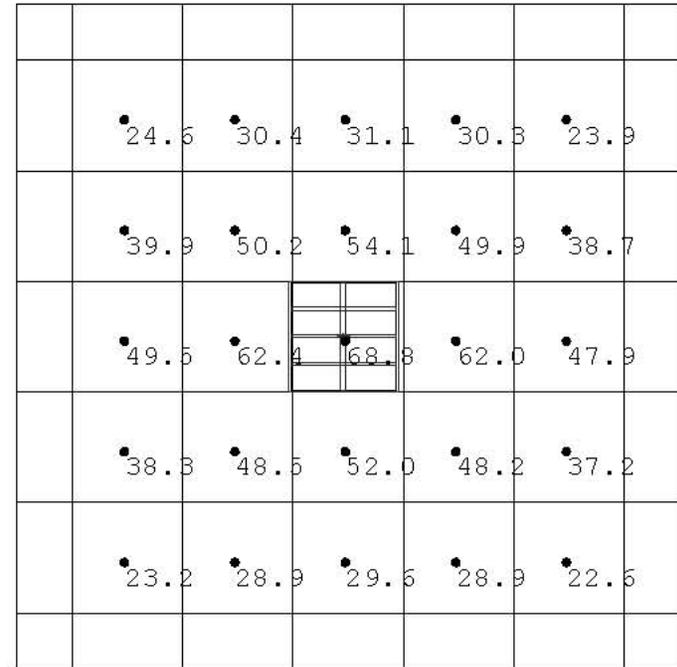




T8 Parabolic 2X4



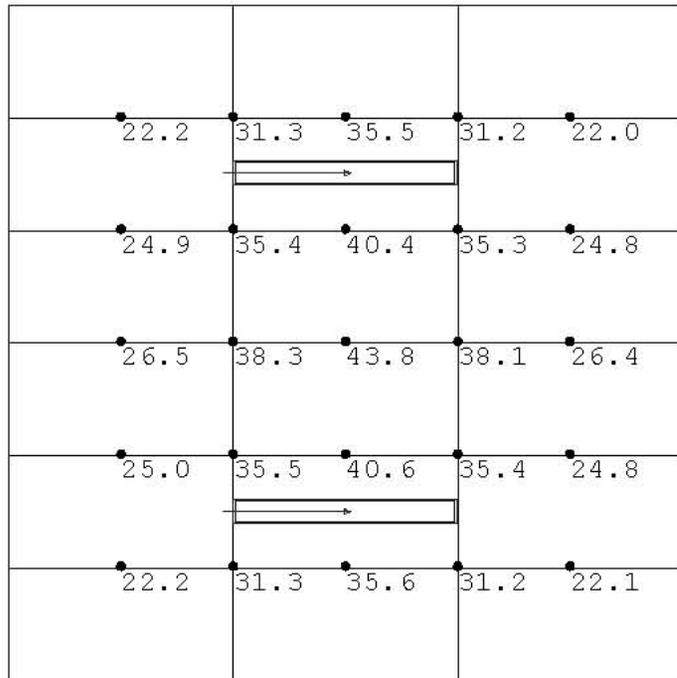
(3) 32 T8 PROGRAM START
49 AVE FC -- 1.18 LPD



T8 Parabolic 2X2



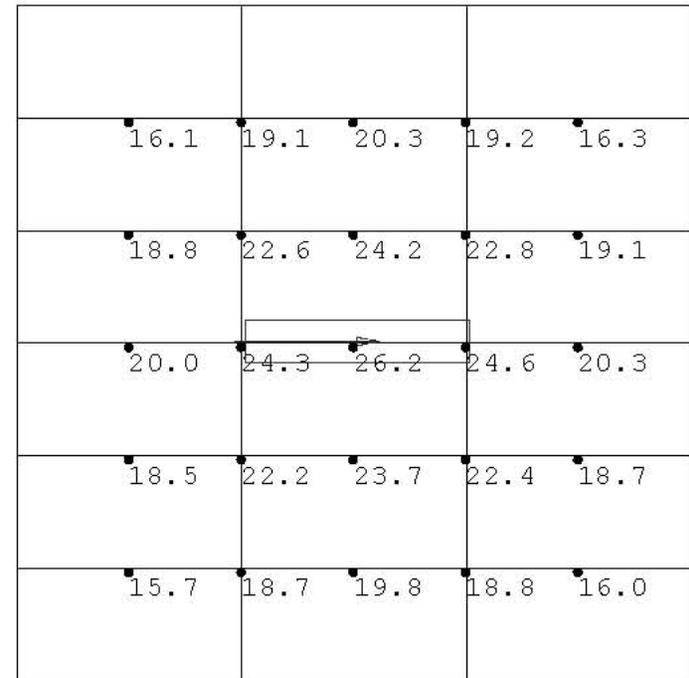
(3) 55 BIAX PROGRAM START
41 AVE FC -- 0.75 LPD



T8 Direct/Indirect



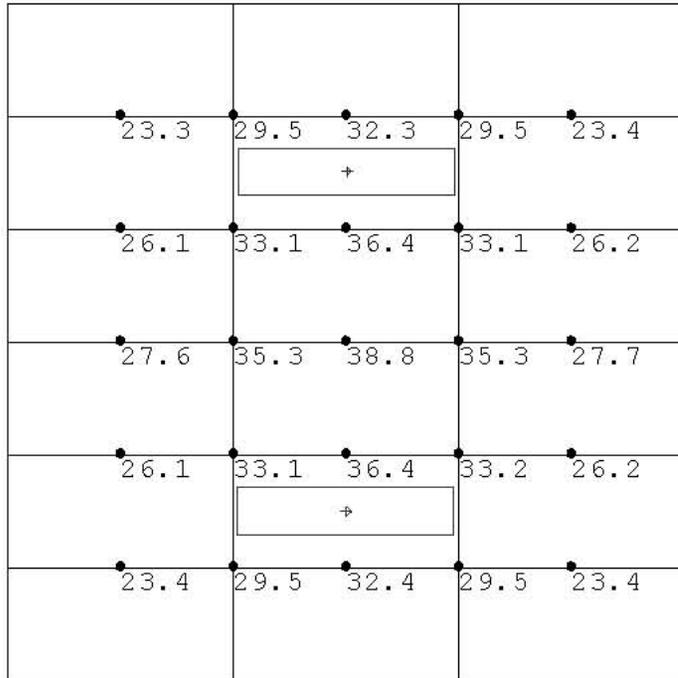
(2) 32 T8 PROGRAM START
31 AVE FC -- 0.81 LPD



T5 Direct/Indirect



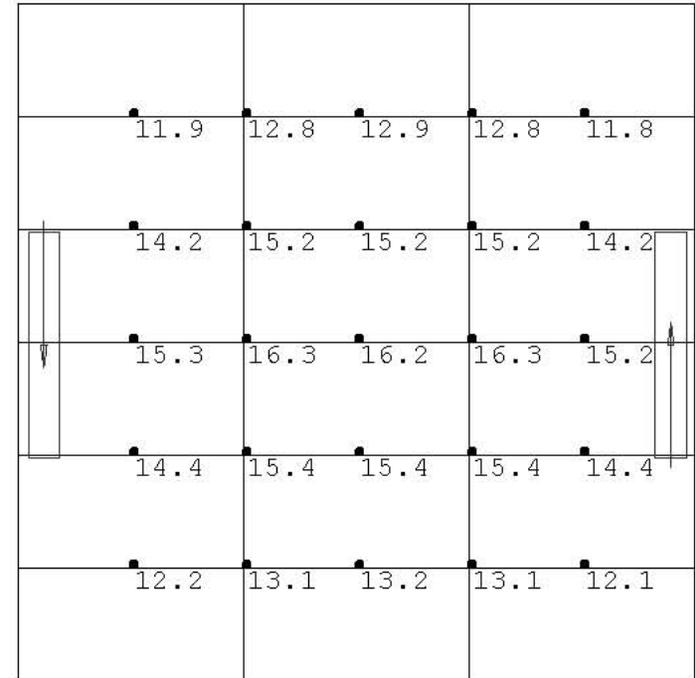
(2) 54 T5 PROGRAM START
20 AVE FC -- 0.82 LPD



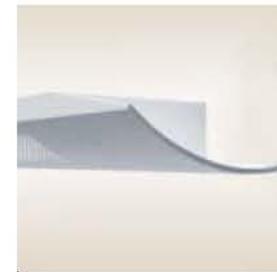
T5 Articulated Lens



(1) 54 T8 PROGRAM START
30 AVE FC -- 0.83 LPD



T5 Wall Mt Direct/Indirect



(1) 54 T5 PROGRAM START
14 AVE FC -- 0.83 LPD

Numeric Summary		
Description	Avg	LPD
(2) 32 PROG ST UP/DOWN	31.19	0.81
(1) 54 PROG ST LENS	30.03	0.83
(3) 32 PROG ST PARABOLIC	48.51	1.18
(2) 54 PROG ST UP/DOWN	20.34	0.82
(1) T5 PROG ST WALL MT	14.17	0.83
(3) 55 PROG ST PARABOLIC	40.84	0.75

SINGLE OFFICE
ILLUMINATION/
ENERGY STUDY

DCR - 7-25-06

Creating High Performance Buildings

Fossil Ridge High School

LEED Silver



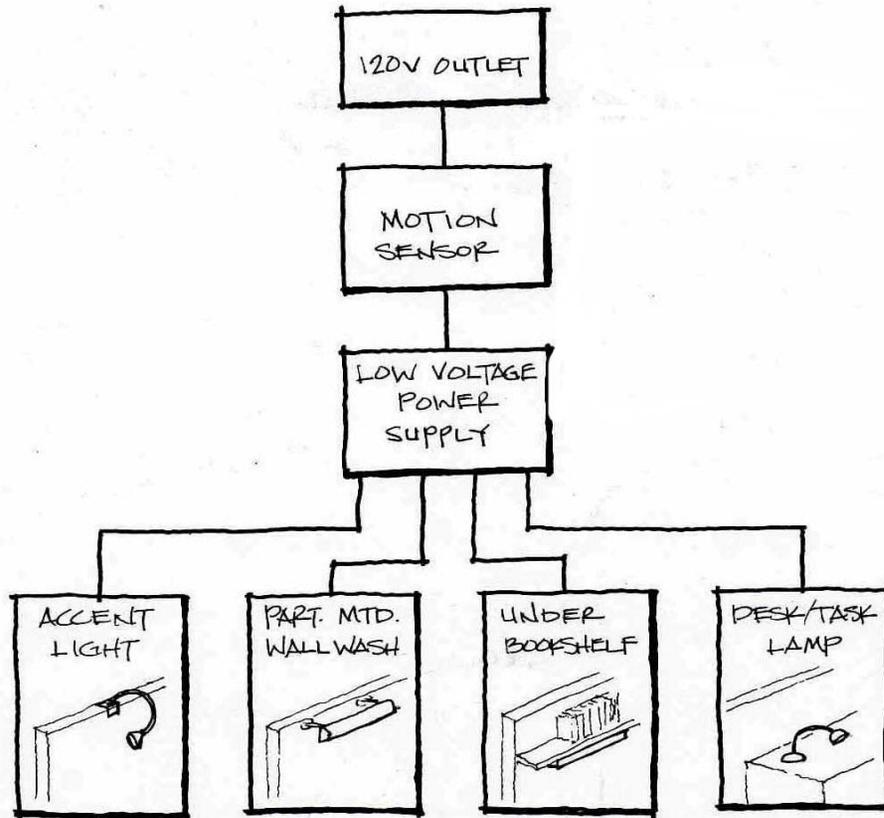
Library



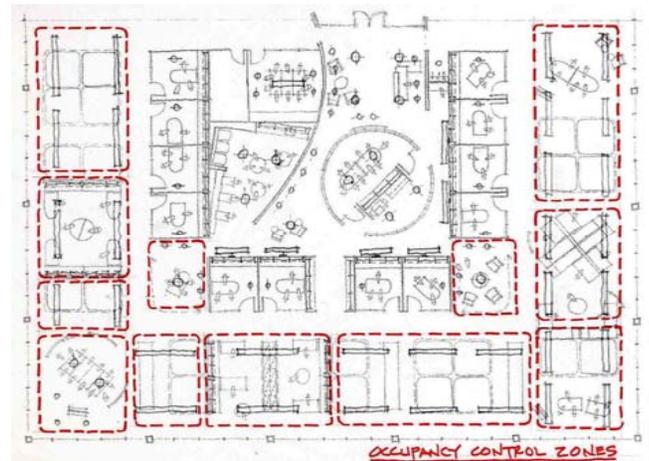
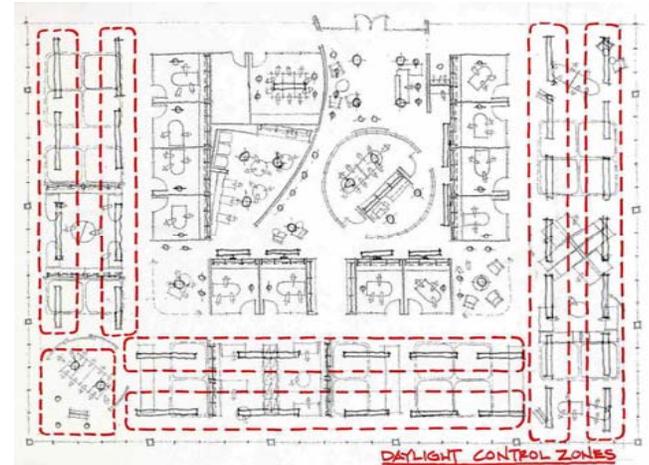
Electric Lighting



Controls, controls and more controls!



WORKSPACE LTG ONE-LINE DIAGRAM



Worker Productivity

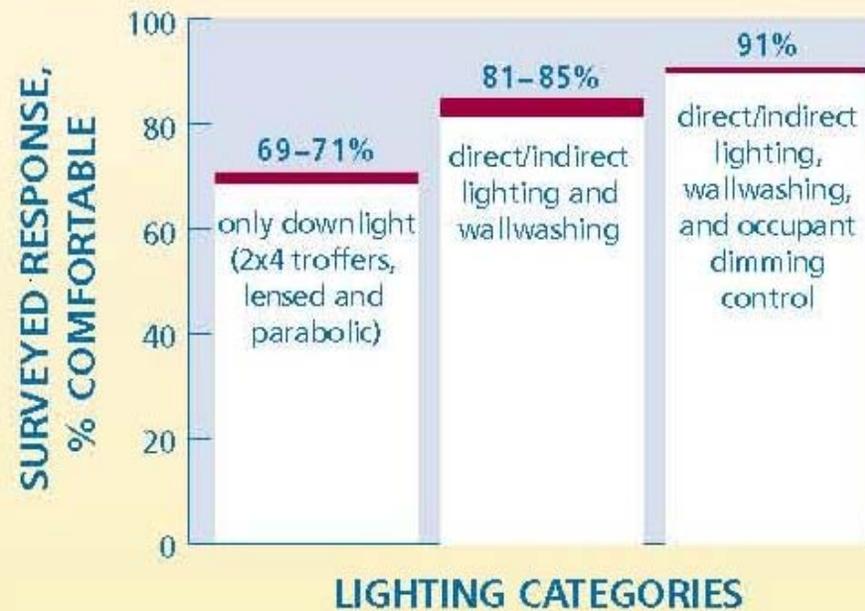
Light Right CONSORTIUM

RESEARCH STUDY | Albany, NY

The Light Right Consortium brings together interested parties and researchers to work toward a common goal—to use research as a basis for market transformation towards quality energy efficient lighting.

www.lightright.org

FIGURE 1



Six conditions were provided and rated by comfort level. The addition of room surface brightness and personal control improved occupant comfort.

Compliance Documentation made easy

- Thanks goodness for computers!
- Auto-Cad can easily add up the areas
- Spreadsheets add up the watts

One project – two different methods (ASHRAE 90.1 – 2003)

Golf Clubhouse				
ASHRAE 90.1 2004 COMPLIANCE - Building Area Method				
ALLOWED LPD				
Area	Type	Area	LPD	Allowed Wattage*
INTERIOR - CLUBHOUSE				
Clubhouse Main Level				
	Dining: Bar Lounge/Leisure	7,505	1.3	9,756.5
	Exercise Center	5,186	1.0	5,186.0
		12,691.0		14,942.5
Clubhouse Lower Level				
	Automotive	12,930	0.9	11,637.0
Interior Maximum Allowed				26,580
INTERIOR - PRO SHOP				
Pro Shop Upper Level				
	Retail	1,710.0	1.5	2,565.0
Pro Shop Lower Level				
	Retail	1,474.0	1.5	2,211.0
Interior Maximum Allowed				4,776
Total Maximum Allowed				31,356
EXTERIOR				
Grounds				
	Walkways < 10' wide	273.0	1.0	273.0
	Special Feature Area	7,485.0	0.2	1,497.0
	Stairways	225.0	1.0	225.0
	Main Entrance	12.0	30.0	360.0
	Other Doors	73.5	20.0	1,470.0
	Canopies	4,429	1.3	5,536.3
Exterior Total Allowed				9,361
DESIGNED LPD				
Interior Load				26,015
Deviation From Maximum				-5,341
Exterior Load				4,201
Deviation From Maximum				-5,160
Total Load				30,216
Total Allowed Load				40,717
% ASHRAE 90.1-2004				74%

Golf Clubhouse						
ASHRAE 90.1 2004 COMPLIANCE - Space X Space Method						
ALLOWED LPD						
INTERIOR						
Room Number	Room Label	Sq Ft	ASHRAE Type	LPD	Allowed Wattage	Decorative Wattage
001	Cart Wash	185	Workshop	1.9	351.5	
002	Cart Storage	4985	Active Storage	0.8	3988	
003	Bag STG/Work STN	800	Active Storage	0.8	640	
004	Cart Repair	144	Workshop	1.9	273.6	
005	Storage	1333	Inactive Storage	0.3	399.9	
006	Battery Storage	102	Inactive Storage	0.3	30.6	
007	Storage	3326	Active Storage	0.8	2660.8	
008	Mech/Elec	846	Electrical/Mech.	1.5	1269	
009	Beverage Carts	252	Active Storage	0.8	201.6	
010	Food/Bev Storage	199	Active Storage	0.8	159.2	
011	Stairs	141	Stairs	0.6	84.6	
012	Restroom	61	Restrooms	0.9	54.9	
100	W Massage	119	Office	1.1	130.9	
136	W Massage	119	Office	1.1	130.9	
137	W Vestibule	37	Corridor	0.5	18.5	
138	W Lounge	427	Lounge	1.2	512.4	427
138	W Lockers	626	Lockers	0.6	375.6	626
141	Treatment	94	Office	1.1	103.4	
143	W/C	202	Restrooms	0.9	181.8	
144	Janitor	33	Elec/Mech	1.5	49.5	
146	Steam Room	263	Restrooms	0.9	236.7	
147	Vanity	77	Restrooms	0.9	69.3	
150	Pro Shop	992	General Sales Are	1.7	1686.4	
150	Pro Shop display	75	9.6.2.c	1.6	120	
151	P S Stairs	185	Stairs	0.6	111	
152	Office	120	Office Enclosed	1.1	132	
153	Office	87	Office Enclosed	1.1	95.7	
154	Changing		Included in Rm 150		0	
156	Toilet	71	Restrooms	0.9	63.9	
157	Toilet	56	Restrooms	0.9	50.4	
158	Changing/Restroom	73	Restrooms	0.9	65.7	
159	Changing/Restroom	77	Restrooms	0.9	69.3	
162	BBQ	106	Food Preparation	1.2	127.2	
Interior Total Allowed		27,142.00			25,462.70	5892
80% Target					20,370.16	

Total Load					30,216.50
Total Allowed Load					38,268.75
% ASHRAE 90.1 - 2004					79%

Luxury Hotel
IECC-2003 COMPLIANCE

ALLOWED LPD

Space	Type	Area	LPD	Allowed Wattage	Decorative Wattage
Lower Level					
100	Foyer	325.0	0.9	292.5	325
101	Lobby	2,438	1.1	2,681.8	2438
130	Elevator Lobby	206	1.3	267.8	
L116	Women's Locker Room	453	0.9	407.7	
L117	Men's Locker Room	370	0.9	333.0	
L119	Fitness	1,391	0.9	1,251.9	
				5,234.7	2763
Lower Level 3					
L304	Prefunction	2,430	1.3	3,159.0	2430
L305	Banquet Room	6,145	1.3	7,988.5	6145
L380	Elevator Lobby	220	1.3	286.0	220
?	Meeting Room 1	520	1.3	676.0	520
?	Meeting Room 2	800	1.3	1,040.0	800
				13,149.5	10115
Total Allowed				18,384.2	12878

ACTUAL LOADS

Luminaire Type	Quantity	Lamp	Load	Total	Decorative Total
P2	1	(2)CF26DD/E	28	28	
R1	24	(1) 54 T5	62.5	1,500	
R2	6	(1) 37MR16	40	240	
R3	40	(1) 37MR17	40	1,600	
R4	99	(1) CF32DT	38	3,762	
R5	8	(1) 37MR16	40	320	
R6	14	(1) CF32DT	35	490	
R7	17	(1) FO32	29	493	
R7D	4	(1) FO32	34	136	
R8	9	(2) FO32	29	261	
R10	16	(2) FO25	55	880	
R10A	20	(2) FO32	68	1,360	
R11	5	(1) CF32DT	39	195	
R12	19	(1) CF32DT	35	665	
R13	3	(1) CF32DT	35	105	
R14	4	(2) FO32	58	232	
S1	37	(1) FO32	34	1,258	
S1A	6	(1) FO25	27.5	165	
S2	156	LED	1.89	295	
S3	9	DECORATIVE	35		315
T1	40	N/A	30	1,200	
W5	11	DECORATIVE	35		385
Total				15,185	700
Percentage of IECC -2003				83%	

IECC - 2003

What to look for ...

- Trading spaces when not allowed
- Adding more watts when doing whole building method
- Using lamp wattage versus system wattage
- Task lighting must be included

**Decoratives can
work!**



Don't let the designers belly-ache

- Codes are minimal compliance standards, not good design
- Illuminance based designs are not good designs
- Controls are very cost effective, they pay back within a few years or instantly when employee satisfaction is entered in

Lighting design strategies

- It's not all about illuminance
- Balance out the luminances within the space



Focus in on the most difficult task



LAUSD - Economics

	Example 1	Example 2	Example 3	Troffer Design
PROJECT DATA				
Room Length	32	32	32	32
Room Width	30	30	30	30
Ceiling Height	10	10	10	10
FIRST COSTS				
AMBIENT SUSPENDED LUMINAIRE				
MATERIALS	INDIRECT T8	SEMI-INDIRECT / DIRECT T8	SEMI-INDIRECT T5HO	PARABOLIC TROFFER
Example Luminaire Description	Light Distribution 90% Indirect / 10% Direct	Light Distribution Uplight Mode: 75% Indirect / 25% Direct Direct Mode: 100% Direct	Light Distribution 82% Indirect / 18% Direct	
Luminaire Row Length	20-foot row	20-foot row	20-foot row	2'x4' recessed troffer
# of Rows	2	2		2
# of lamps per Row	10	15		3
LIFE CYCLE COSTS				
First costs	\$3,623	\$4,623	\$5,456	\$4,887
Annual Costs	\$172.06	\$174.64	\$139.40	\$219.58
Years of Operation	20	20	20	20
Inflation Rate for Annual Costs	4%	4%	4%	4%
Salvage Value at end (20% of First Cost)	\$724.60	\$924.60	\$1,091.20	\$1,177.40
Rebates and incentives				
Present Value of All Costs*	\$5,236.75	\$6,071.81	\$6,245.70	\$8,373.28
Present Value of Lighting System	\$5.46	\$6.32	\$6.51	\$8.72

* - = (First costs) - (Salvage value) - (Rebates & Incentives) - (Present Value of Annual Costs over 20 years)

Introduce daylight and the energy use drops even more!



➤ High Performance Retail



Stop & Shop



T5HO electric lighting
dims seamlessly in
response to daylight

39W MH accent lights
highlight product and
gondola end caps

More efficient envelop,
HVAC, refrigeration, better
IEQ

Achieved the 33% energy
reduction and more!

Creating High Performance Buildings

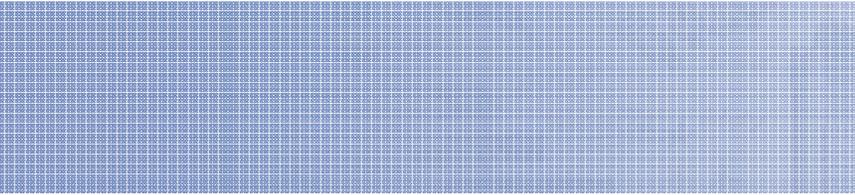
Missouri Department of Natural Resources



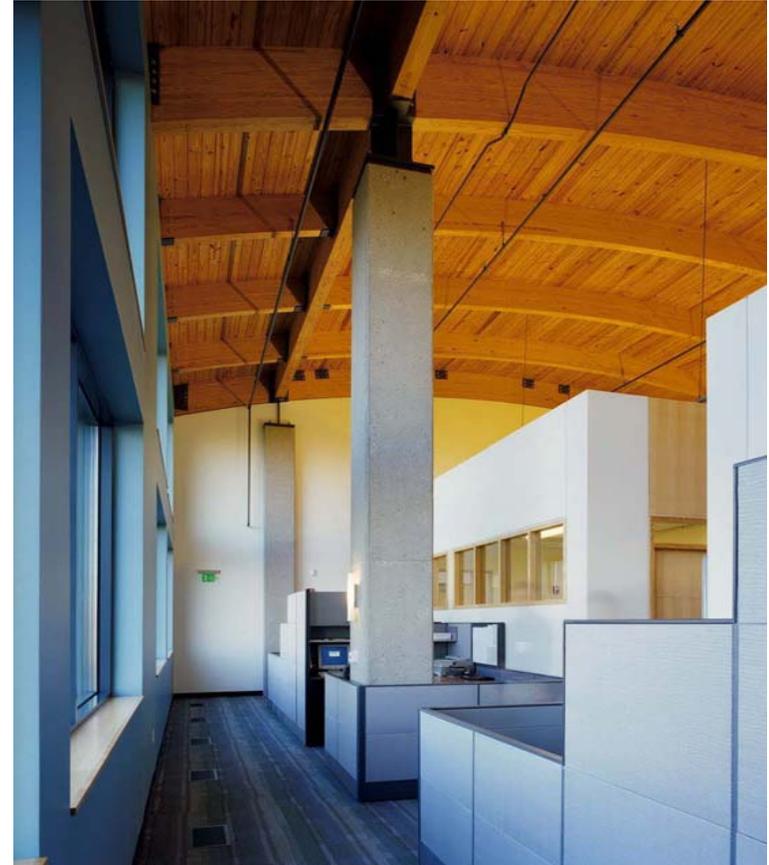
Lewis and Clark Office Building



- Energy savings estimate between \$85,000 and \$92,000 per year
- Uses 46% less energy than other Missouri state office buildings

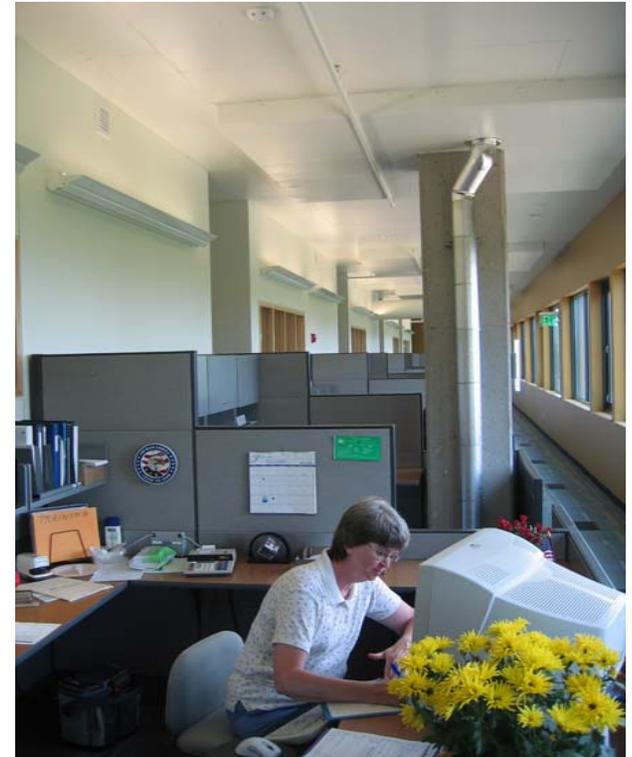


Electric lighting



Lewis and Clark Office Building

- LEED Credits = 53 (PLATINUM)
- SS 8 Light Pollution Reduction
- EA 1.1 Optimize Energy Performance
- EA 1.2 30% New
- EA 1.3 40% New
- EA 1.4 50% New
- EA 1.5 60% New
- EA 6 Green Power
- EA 2.1 Renewable Energy 5%
- EQ 6.2 Controllability, non-perimeter
- EQ 8.1 Daylight and Views 75%
- EQ 8.2 Daylight and Views 90%



Watch for Outdoor Lighting Ordinances that limits lighting even further

- ASHRAE is a one zone system (around an LZ3)
- Model Lighting Ordinance will be 5 zones (LZ0 – LZ4)



Ashrae 90.1 exterior LPD for Parking Lots

LZ1 Parking Lot Maximum Spacing Calculations

Yellow is the limiting factor

Lamp	Lamp Wattage	System Wattage	# of Heads	Photometric Type	Maximum Spacing to meet IESNA RP-20 .2fc minimum, 20:1 max:min (vertical illuminance not considered)					% of ASHRAE 90.1-2004	80% of ASHRAE 90.1-2004	Approx. Average Illuminance @ ASHRAE 90.1-2004	Approx. Average Illuminance @ 80% ASHRAE 90.1-2004	
					Grid Dimensions	Avg. fc	Min. fc	Max:Min	WPF					
15 foot pole														
HPS	50	66	2	Type III	60	80	0.59	0.21	16.67	0.028	18%	23%	3.2	2.6
HPS	70	95	2	Type III	60	85	0.88	0.3	17.99	0.037	25%	31%	3.5	2.8
20 foot pole														
HPS	70	95	2	Type III	75	110	0.77	0.21	15.15	0.023	15%	19%	5.0	4.0
HPS	70	95	4	Type III	80	110	1.45	0.27	18.81	0.043	29%	36%	5.0	4.0
HPS	100	138	1	Type V	65	65	1.01	0.29	13.93	0.033	22%	27%	4.6	3.7
HPS	100	138	2	Type III	80	110	1.1	0.25	18.66	0.031	21%	26%	5.3	4.2
HPS	150	190	1	Type V	80	90	1.26	0.33	19.97	0.026	18%	22%	7.2	5.7
HPS	150	190	2	Type III	90	100	1.97	0.39	19.73	0.042	28%	35%	7.0	5.6
25 foot pole														
HPS	70	95	2	Type III	85	120	0.65	0.21	10.29	0.019	12%	16%	5.2	4.2
HPS	70	95	4	Type III	110	120	0.96	0.2	16.51	0.029	19%	24%	5.0	4.0
HPS	100	138	2	Type III	95	120	0.83	0.23	13.81	0.024	16%	20%	5.1	4.1
HPS	100	138	4	Type III	115	120	1.38	0.26	19.01	0.040	27%	33%	5.2	4.1
HPS	150	190	2	Type III	110	120	1.32	0.28	18.82	0.029	19%	24%	6.9	5.5
HPS	150	190	4	Type III	110	120	2.64	0.51	19.37	0.058	38%	48%	6.9	5.5
HPS	250	310	1	Type V	80	80	1.51	0.47	16.78	0.048	32%	40%	4.7	3.7
HPS	250	310	2	Type III	115	120	2.37	0.51	18.42	0.045	30%	37%	7.9	6.3
HPS	400	464	1	Type V	95	110	2.61	0.71	18.57	0.044	30%	37%	8.8	7.1

Ashrae 90.1 exterior LPD for Parking Lots

LZ4 Parking Lot Maximum Spacing Calculations

Yellow is the limiting factor

						Maximum Spacing to meet IESNA RP-20 Enhanced Security / Retail Guidelines 1.0fc minimum horizontal, .25fc minimum vertical at center, 15:1 max:min									
Lamp	Lamp Wattage	System Wattage	# of Heads	Photometric Type	Grid Dimensions	Avg. fc	Min. fc	Vert. fc	Max:Min	WPF	% of ASHRAE 90.1-2004	80% of ASHRAE 90.1-2004	Approx. Average Illuminance @ ASHRAE 90.1-2004	Approx. Average Illuminance @ 80% ASHRAE 90.1-2004	
											0.15	0.12			
30 foot pole															
HPS	250	310	4	Type III	120	135	3.96	1.01	0.84	13.09	0.077	51%	64%	7.8	6.2
HPS	400	464	1	Type V	95	115	2.43	1.02	0.54	9.24	0.042	28%	35%	8.6	6.9
HPS	400	464	2	Type III	110	150	3.12	1.03	0.77	10.14	0.056	37%	47%	8.3	6.7
HPS	400	464	4	Type III	130	145	5.49	1.29	0.94	14.51	0.098	66%	82%	8.4	6.7
35 foot pole															
HPS	250	310	4	Type III	120	160	3.31	1.01	0.78	9.47	0.065	43%	54%	7.7	6.2
HPS	400	464	2	Type III	120	160	2.65	1.02	0.83	7.56	0.048	32%	40%	8.2	6.6
HPS	400	464	4	Type III	140	180	4.08	1.01	0.73	13.65	0.074	49%	61%	8.3	6.6
HPS	1000	1100	1	Type III	130	160	3.18	1.04	0.7	14.6	0.053	35%	44%	9.0	7.2
HPS	1000	1100	2	Type III	120	160	6.63	1.96	1.44	14.25	0.115	76%	95%	8.7	6.9

Exterior Lighting

Numeric Summary				
Description	Avg	Max	Min	Max/Min
Drive	1.36	2.1	0.7	3.00
Entrance	1.30	1.8	0.6	3.00
Vertical Area 1	1.04	1.14	0.85	1.34
Vertical Area 2	1.29	1.72	1.04	1.65
Vertical Area 3	1.41	1.63	1.23	1.33
Parking Area	1.21	5.8	0.5	11.60

Luminaire Schedule		
Label	Qty	Description
A	30	InVue ICS-150-MP-Volt-4S-AP/VA
A1	5	InVue ICS-150-MP-Volt-4S-AP-HS
B	24	Moldcast VBN-36-70MH-LGY

LPD Area Summary			
Label	Area	Total Watts	LPD
Parking	235551	8237	0.035

0.15 W/SQFT ALLOWED

