PIER Lighting Research Program

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LIGHTING STANDARDS REVIEW REPORT

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1. Executive Summary

This report provides an overview of energy code requirements for efficient lighting, beginning with California's Title 24 requirements, and continuing through the other states to the national and international energy codes. Differences and similarities in code requirements are summarized in tabular form and in text. Lighting guidelines are also included from a number of sources, such as the Collaborative for High Performance Schools, Leadership in Energy and Environmental Design, ENERGY STAR, and Advanced Building Guidelines.

This work is the first task in the larger Lighting R&D/Scoping Study for the PIER Lighting Research Program (LRP). It is intended to inform subsequent tasks that will identify linkages between other PIER LRP projects and the larger world of codes and standards, so the work will be able most effectively to transfer lighting research into standards.

2. Introduction to Lighting Codes

The overall goal of this Lighting R&D/Codes Scoping Study project is to determine how the PIER Lighting Research Program (LRP) can best translate its successes into workable code and standards proposals. The emphasis will be to identify efforts that are likely to have the largest energy savings and/or demand reduction potential. The starting point, contained in this report, is a summary of existing lighting standards and codes. Subsequent work will explore the implications of each of the other projects, and identify ways to either adjust the work or to package the work products to make them most compatible with codes and standards.

The starting point for this review of existing codes and standards is the California Title 24 Building Energy Efficiency Standards. These have been in force since their first adoption in 1978, with subsequent updates. The current version of Title 24 was adopted in 2001. The next update is scheduled to take effect in 2005, and is currently nearing completion in preparation for the formal adoption process. This report covers both the current version and the proposed revisions to Title 24. It then documents the lighting efficiency requirements in other states and in the national model energy codes and guidelines

This report also describes standards that regulate products available in the marketplace for use in construction. For lighting, these include national and state appliance efficiency standards. For each of the major code types, the established mandatory and prescriptive/performance criteria are also illustrated.

Before presenting this information, it is useful for the reader to understand generally how the standards regulate lighting energy efficiency.

2.1 Types of Lighting Standards

The Title 24 lighting standards, and most all other lighting standards as well, include both mandatory measures and prescriptive/performance measures. The mandatory measures are just that; they must be installed wherever they are applicable in a building design. An example of a mandatory measure would be the requirement to provide separate light switches in each separate room of a building. The prescriptive/performance measures govern overall system performance. They usually entail optional trade-offs to assist designers in handling special design situations. An example of a prescriptive/performance lighting requirement would be a whole building limit on installed lighting power density, which can be met in a variety of ways, and may entail special control credits and exceptions for special cases.

Lighting efficiency standards tend to have the greatest impact and reach in the nonresidential buildings sector. Residential lighting standards are more limited in scope, due to the simpler lighting systems and equipment in residences, and the lower lighting energy requirements. Many, but not all, building codes also have requirements for outdoor lighting and lighting in unconditioned buildings such as parking garages or storage warehouses.

In addition to the Title 24 Energy Efficiency Standards, California also has the Title 20 Appliance Efficiency Standards. There are also federal appliance efficiency standards, and some other states also have appliance standards. While the building standards govern what designers may do when specifying the building systems, the appliance standards govern what manufacturers and distributors may sell. In the lighting arena, lighting appliance standards govern such things as ballast efficiency, or the minimum allowable operational characteristics of occupancy sensor controls.

This review of lighting standards provides broad comparisons of the major characteristics of the existing standards. As the PIER LRP work progresses, and the details of the other projects in the LRP are developed, Program participants will be delving deeper into the more arcane requirements of both the building and the appliance standards. As an example of this, the efficacy of light sources that make use of light emitting diodes (LEDs) must be measured differently than the traditional lumens per watt metric applied to more conventional light sources. It may be necessary, therefore, to recommend efforts to update the efficacy measures for LEDs in the standards in order to facilitate the broader application of this highly efficient light source. At the same time, the researchers working on advanced LEDs may need to adjust their work products to accommodate the methods used by the efficiency standards. Similar kinds of linkages between new research products and the standards will likely be identified for many of the PIER LRP projects.

2.2 Purpose and Benefits of Codes

Historically, codes were developed to insure safety in buildings. Since the 1970s, the code development community began to recognize other purposes for codes, particularly in the energy efficiency arena. One purpose of codes is to lock in the energy efficiency obtained through advances in the marketplace. Many times these advances are driven either by raw research or by utility sponsored programs that foster acceptance of an emerging technology or design practice. As technology improves and becomes commercially available, the code can recognize the technological advancement and capture the energy savings through a code update.

2.3 Codes Compared

States are typically the adoption agencies for codes. In most cases, local jurisdictions can supersede code if a local code is shown to be stricter than the code adopted at the state level. For this work, state codes are arranged in three different groups:

1. those that follow the IECC[1], incorporating the ASHRAE[2] Standards by reference,
2. those that have developed state codes based on these national models, and

[1] IECC – International Energy Conservation Code

[2] ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

3. those that have a uniquely designed code or significant variation from one of the other three models.

2.3.1 Scope of ASHRAE Standard

ASHRAE is an international organization with chapters throughout the world. Its purpose is to advance the science of heating, ventilation, air conditioning, and refrigeration through research, standards writing, continuing education, and publications. ASHRAE writes standards that set uniform methods of testing and rating equipment. They also establish accepted practices for the worldwide industry, such as the design of energy efficient buildings.

The standard sets forth design requirements for the efficient use of energy in new buildings intended for human occupancy. The requirements apply to the building envelope, distribution of energy, systems and equipment for auxiliaries, heating, ventilating, air-conditioning, service water heating, lighting and energy management.

The standard applies to all new buildings or portions of building that provide facilities or shelter for human occupancy and use energy primarily to provide human comfort, except single-and multi-family residential buildings of three or fewer stories above grade.

The standard does not apply to:

- Areas of buildings intended primarily for manufacturing or commercial or industrial processing;
- Buildings or separately enclosed identifiable areas having any combination of dedicated space heating, service water heating, ventilating air-conditioning, or lighting systems whose combined peak design rate of energy usage for these purposes is less than 3.5 Btu (h-ft^2) of gross floor area; and
- Buildings of fewer than 100 ft^2 of gross floor area.

ASHRAE is maintained through a process called continuous maintenance, which means that revisions can be generated as often as once per year, although the standard is published on a three-year cycle. ASHRAE is a standard, and doesn’t represent building code until a local jurisdiction adopts it. In addition, when referenced through the IECC, the IECC is the prevailing document when the two documents conflict.

2.3.2 IECC

This comprehensive energy conservation code establishes minimum regulations for energy efficient buildings using prescriptive and performance-related provisions. The principles utilized in the development of this code were based on the intent to establish a code that

1. adequately conserves energy,
2. does not unnecessarily increase construction costs,
3. does not restrict the use of new materials, products or methods of construction; and

4. does not give preferential treatment to particular industries or types or classes or materials, products or methods of construction.

The IECC is designed to be compatible with the entire family of International Codes published by the International Code Council (ICC).

The International Energy Conservation Code provides many benefits, among which is the international code development process that offers an international forum for energy professionals to discuss performance and prescriptive code requirements. This forum provides an excellent arena to debate proposed revisions. This model code also encourages international consistency in the application of provisions.

Effective December 4th, 1995, CABO assigned all rights and responsibilities to the Model Energy Code to the ICC. The first edition of the International Energy Conservation Code, issued in 1998, replaced the 1995 CABO Model Energy Code. To facilitate the transfer of responsibility, the secretariat, committee members, bylaws, appeals procedures and guidelines were simply designated as ICC activities without change.

The model energy code was originally developed jointly by BOCA, ICBO, the National Conference of States on Building Codes and Standards (NCSBCS), and SBCCI, under a contract funded by the United States Department of Energy (DOE).

Starting with the 2000 edition, new editions will be published at three-year intervals. The latest lighting elements are contained in the 2003 edition.

The International Energy Conservation Code is kept up to date through the review of proposed changes submitted by code enforcement officials, industry representatives, design professionals and other interested parties. Proposed changes are carefully considered through an open code development process in which all interested and affected parties may participate.

2.3.3 Code Adoption Status by State

The following two maps illustrate the energy code version for each state, for both residential and commercial construction. The Building Codes Assistance Project produced the first map, which shows the residential energy code status as of September 2002. Jeff Johnson at the New Buildings Institute, Inc., produced the second map, as shown in Figure 2. It shows the commercial code adoption by state as of May 2003.

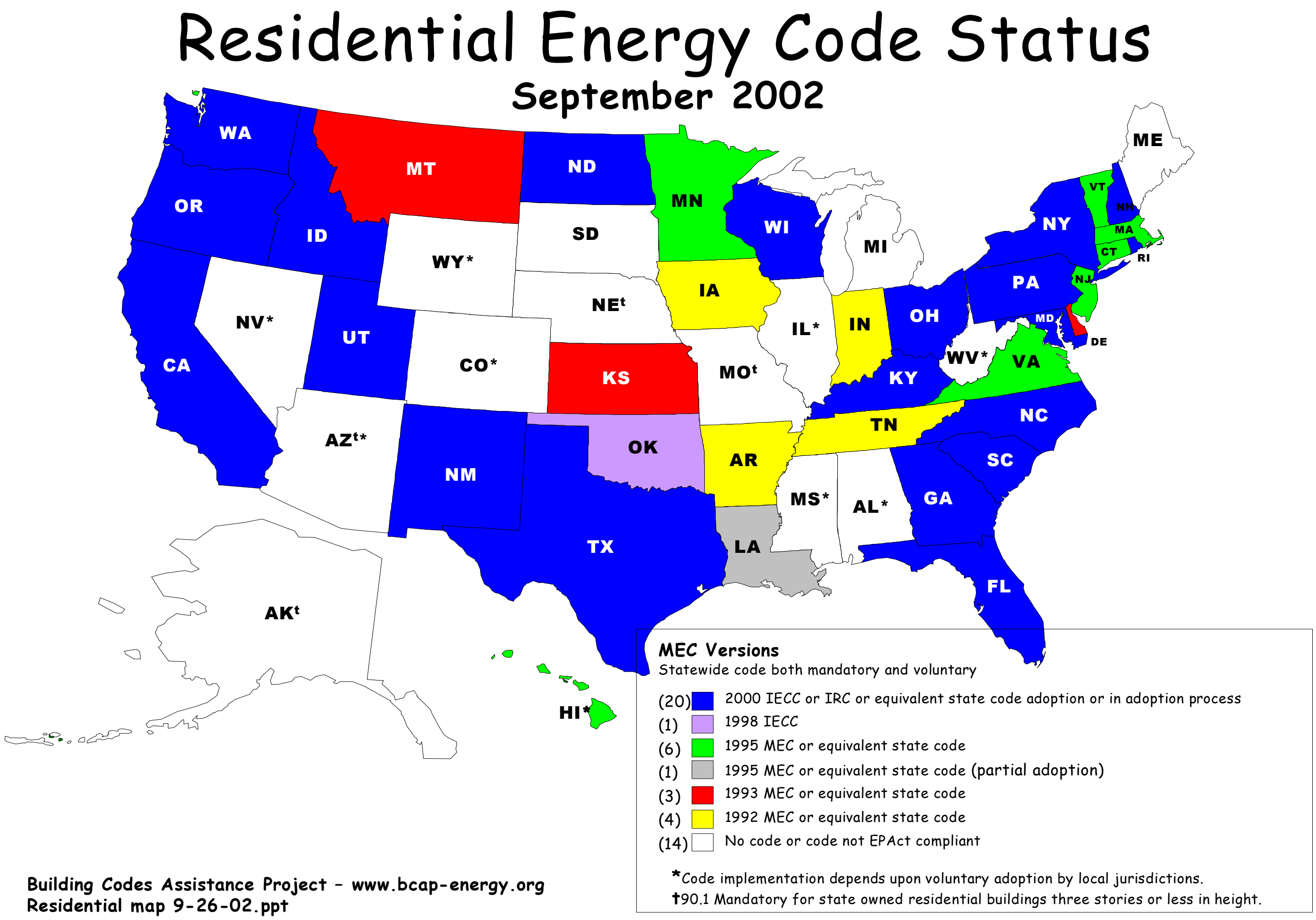

Figure 1 - Residential Code Adoption by State

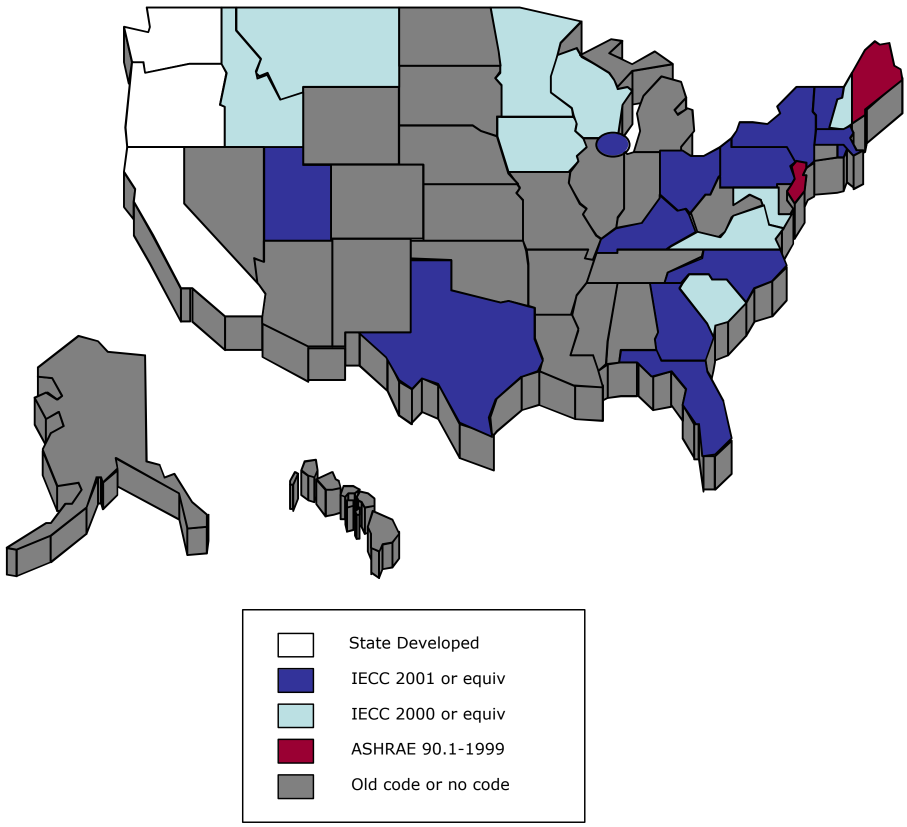

Figure 2 - Commercial Code Adoption by State, May 2003

3. Nonresidential Lighting Efficiency Standards

Nonresidential energy codes have the following standard components: applicability criteria, mandatory features and devices, and prescriptive or performance based lighting power densities.

3.1 Structure of Nonresidential Codes

The lighting codes for nonresidential buildings reflect the wide range of building and space types that occur in this broad market sector.

3.1.1 Applicability

Most states, including California, require that any newly conditioned space where lighting will be installed shall comply with applicable code requirements. For remodels and additions, a California criterion states that if 50 percent of the lights are moved or lighting load increases, then the requirements are triggered. The three major code types also provide a comprehensive list of exempt lighting. Among them are specialized lights for technical purposes, such as medical examination lights that are for sale, specialized display lighting for galleries, and public monuments.

3.2 Mandatory Features and Devices

All major codes also require some type of automated shut off control, for example, a sweep control. Office buildings greater than 5,000 sq. ft. and all school classrooms within the state of Washington, for example, are required to be equipped with automatic controls to shut off the lighting during unoccupied periods. This applies to most states that adopted IECC 2001 (and beyond) and ASHRAE 90.1 1999 code. The automatic controls may be an occupancy sensor, time switch, or another device capable of automatically shutting off lighting.

The City of Seattle developed an energy code that exceeds the state requirements. For example, occupancy sensors are required in buildings greater than 5,000 sq. ft. and all school classrooms. Within these buildings, all office areas less than 300 sq. ft. enclosed by walls or ceiling-height partitions, all meeting and conference rooms, and all school classrooms, are required to be equipped with occupancy sensors. **Table 1** compares the mandatory lighting measures for a number of national standards and state adopted codes.

State/ Jursidiction	Auto Shut Off	Separate / Bi-level Switching	Daylight Controls - Exterior	Daylight Controls - Interior	Other
California	Y	Y	Y	Credit	
California 2005	Y	Y	Y	Credit	
Oregon	Y	Y	Y	N	
Washington	Y	Y	Y	N	
New York	Y	Y	Y	N	
Minnesota	Y	Y	Y	N	
Florida	Y	Y	Y	N	
IECC 2000	Y	Y	Y	N	exit signs
IECC 2003	Y	Y	Y	N	exit signs
ASHRAE 90.1	Y	N	Y	N	exit signs

Table 1 - Nonresidential Mandatory Measures Comparison

3.3 Prescriptive/ Performance Lighting Power Densities

The most universal mechanism for regulating lighting system energy use is to limit the installed lighting power density, expressed as installed watts per square foot of floor area (W/sf). Using density limitations, the code leaves it up to the lighting designer to select the lamps, ballasts and luminaires that will meet the needs of the occupants, while remaining within the allowed lighting power limit. The standards also typically provide rules for how the installed lighting power is calculated. This usually requires that both lamp and ballast power requirements are taken into account.

In some jurisdictions, control credits are available. Control credits allow the designer to discount the wattage of luminaires under the special control. The theory behind control credits is that they are energy neutral. The savings from the operation of the control offsets any additional installed wattage that may be designed into the building as a result of the credit. Originally intended to encourage good design practice rather than to regulate it, these credits have recently come under fire, because no energy savings are guaranteed.

Allowed lighting power density usually varies with occupancy type. For illustrative purposes in this report, the following occupancy types are explored: Office, Retail, Restaurant and School. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor in the ASHRAE process to develop the national model energy code, Standard 90.1, and is otherwise active in tracking and advising on code developments. These densities are based on their recommended illumination levels utilizing certain consensus luminaires and common design practice.

The densities for the various codes and standards are illustrated in **Table 2.**

Lighting Power Densities by Code Location or Type				
State/ Jursidiction	Office Building LPD	Retail Bldg LPD	School Bldg LPD	Restaurant Bldg LPD
California 2001	**1.3**	**1.7**	**1.4**	**1.2**
California 2005	**1.1**	**1.5**	**1.2**	**1.2**
Oregon	**1.4**	**1.9**	**1.5**	**1.2**
Washington	**1.2**	**1.5**	**1.35**	**1.0**
New York	**1.3**	**1.9**	**1.5**	**1.7**
Minnesota	**1.4**	**2.7**	**1.77**	**1.6**
Florida	**1.8**	**3.1**	**2.0**	**1.3**
IECC 2000	**1.3**	**1.9**	**1.5**	**1.7**
IECC 2003	**1.1**	**1.7**	**1.4**	**0.9**
ASHRAE 90.1- 99	**1.25**	**3.63**	**1.59**	**1.45**
ASHRAE 90.1-2001	**1.3**	**1.9**	**1.5**	**1.8**

Table 2 - Representative LPDs by Jurisdiction

Many states allow more than one method to calculate allowed densities for a given space. A whole building number may be applied to the entire building, or different densities may be applied to spaces within the building. In the case of the table above, a whole building value (or a representative area, if whole building wasn't available) was used.

The densities are in many cases customized to reflect the unique needs of the space. For example, ASHRAE 90.1 provides for ornamental and display lighting bonus densities in certain occupancies. In other cases, different definitions of space type yield different lighting power densities. **Table 3** below illustrates the range of allowed LPDs when strict and liberal code interpretations are taken:

Lighting Power Densities by Code Location or Type										
State/ Jursidiction	Office Building LPD	Office Low	Office High	Retail Bldg LPD	Retail Low	Retail High	School Bldg LPD	School Low	School High	Restaurant Bldg LPD
California 2001	**1.3**	1	2.36	**1.7**	1.7	5.99	**1.4**	1.4	4.26	**1.2**
California 2005	**1.1**	1.1	2.34	**1.5**	1.5	5.96	**1.2**	1.2	2.13	**1.2**
Oregon	**1.4**	1.4	1.4	**1.9**	1.7	3.4	**1.5**	1.5	1.5	**1.2**
Washington	**1.2**	1.2	1.2	**1.5**	1.5	1.5	**1.35**	1.35	1.35	**1.0**
New York	**1.3**	1.3	1.5	**1.9**	1.9	2.1	**1.5**	1.5	1.5	**1.7**
Minnesota	**1.4**	1.11	1.4	**2.7**	1.72	2.7	**1.77**	1.26	1.77	**1.6**
Florida	**1.8**	1.8	2.2	**3.1**	2.7	3.1	**2.0**	2.0	2.0	**1.3**
IECC 2000	**1.3**	1.3	1.5	**1.9**	1.9	2.1	**1.5**	1.5	1.5	**1.7**
IECC 2003	**1.1**	1.1	1.45	**1.7**	1.7	3.3	**1.2**	1.2	1.75	**0.9**
ASHRAE 90.1- 99	**1.3**	1.3	1.5	**1.9**	1.8	2.1	**1.5**	1.3	1.6	**1.8**
ASHRAE 90.1-2001	**1.3**	1.3	1.5	**1.9**	1.8	2.1	**1.5**	1.3	1.6	**1.8**

Table 3 - Range of Allowed LPDs by Jurisdiction

In general, the 2005 proposed changes to the California Code are comparable to the 2003 IECC in terms of stringency.

3.4 Highlights of Differences

3.4.1 California Title 24

California Title 24 has the following unique features:

- Control credits are allowed for occupancy sensors, daylighting sensors and other types of control not commonly installed. These credits are given in the form of Power Adjustment Factors. This PAF allows the designer more light than the code minimum because the control will provide equivalence in energy savings.
- Tailored Method of Compliance – This compliance path provides many 'use it or lose it' opportunities to build additional lighting allowance into a project. Designed mainly for retail applications, it provides for as much as six watts per square foot in areas where display lighting or lighting for special needs is installed.

3.4.2 ASHRAE Standard 90.1

One of the primary differences in the ASHRAE standard is that it contains provisions regulating exterior lighting. Lighting for building entrances, with and without canopies, and other building facades have lighting power limits. The 2005 California code will also address outdoor lighting. When the standard was revised in 1999, the lighting control credits were eliminated.

3.4.3 IECC

The lighting section of the IECC covers lighting system controls, the connection of ballasts, defines the maximum lighting power for interior applications, and minimum acceptable lighting equipment for exterior applications. It offers a minimum number of compliance paths and is relatively straightforward. The entire code section is less than four pages, including the Interior Lighting Power Table. The next revision will be published in the 2003 International Energy Conservation Code. In addition, ASHRAE Standard 90.1-2001 was approved for inclusion in the 2003 version of the IECC.

3.4.4 Washington

The 2001 Washington State Non-Residential Energy Code (NREC) is almost equivalent to ASHRAE 90.1 –1999. The NREC requires that all daylit zones be provided with individual controls, or daylight-sensing or occupant-sensing automatic controls, which control the lights independent of general area lighting. The city of Seattle wrote and enforces its own energy code. The 2002 Seattle Energy Code is essentially the 2001 Washington State Energy Code with a number of amendments, such that the city code provides for greater energy efficiency. A number of features unique to the 2002 Seattle Energy Code are described below:

- All daylit zones shall be provided with controls which control the lights independent of general area lighting, and automatically reduce the lighting power in response to available daylight by either a combination of multilevel switching and daylight-sensing automatic controls which are capable of reducing the light level automatically and turning the lights off, or a combination a dimming ballasts and daylight-sensing automatic controls, which are capable of dimming the lights continuously.
- A single controlling device can control continuous daylit zones adjacent to vertical glazing provided that they do not include zones facing more than two adjacent cardinal directions
- Occupancy sensors shall be capable of automatically turning off all the lights in an area no more than 30 minutes after the area has been vacated. Lighting fixtures controlled by occupancy sensors shall have a wall-mounted manual switch capable of turning off lights when the space is occupied.

3.4.5 Oregon

The Oregon Non-Residential Energy Code is a mandatory state-developed code that exceeds ASHRAE 90.1-1989. Oregon is in the process of revising the building codes for both commercial and residential buildings. The state is considering making the commercial code consistent with ASHRAE 90.1-1999. The current code requires no automatic lighting reduction controls for daylit spaces. Proposed changes to the building energy code include the idea of implementing automatic lighting reduction strategies in certain daylit areas. Regarding lighting power density in retail space, both the ASHRAE Standard 90.1-1999 and the City of Seattle Energy Code are more stringent than Oregon's requirements. Proposed changes to the building energy code reduces the lighting power density allowed in retail space and includes concepts from ASHRAE Standard 90.1-1999, the City of Seattle Energy Code, and the California Energy Code.

3.4.6 The Collaborative for High Performance Schools

The Collaborative for High Performance Schools (CHPS) is a voluntary system composed of prerequisites and optional credits. Points are assigned to each credit, and eligible schools must earn at least 28 points and meet all the prerequisites. One particular prerequisite addresses energy efficiency through either a performance or prescriptive approach. One element of the prescriptive approach requires energy efficient lighting with occupancy controls to achieve an average adjusted lighting power density of 0.95 W/sf for the entire school. The average adjusted LPD is a weighted average based on school square footage used by each particular space type. An optional credit that builds on this prescriptive baseline involves daylighting and dimming controls. The credit is awarded when 40 percent of the installed electrical lighting is dimmed or turned off when sufficient natural light is present. Lighting controls can be dimming or stepping type.

In addition, two other optional credits address daylighting in classrooms. Three points are awarded for achieving a two percent minimum Daylight Factor of uniformly distributed daylighting with no direct sunlight penetration in 75 percent of all classroom space, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas. One point is awarded for direct line of sight to vision glazing for 90 percent of classrooms, administration areas, and all regularly occupied spaces, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas.

3.4.7 Leadership in Energy and Environmental Design

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary system composed of prerequisites and optional credits. Points are assigned to each credit, similar to the CHPS approach. A total of 69 points are possible, although only 26 points are necessary for basic LEED certification. One point is available if a minimum Daylight Factor of two percent (excluding all direct sunlight penetration) exists in 75 percent of all space occupied for critical visual tasks. Another point is available if direct line of sight to vision glazing for building occupants is achieved in 90 percent of all regularly occupied spaces.

3.4.8 ENERGY STAR

The EPA ENERGY STAR® program addresses the energy efficiency of lighting applications through a voluntary standards program for both lamps (light bulbs) and lighting fixtures. Fixtures and light bulbs comply with the ENERGY STAR requirements through a self-certification process. The requirements include minimum performance levels for lamp efficacy, color rendition, flicker, warm-up time, cold weather operation, frequency, electromagnetic interference, longevity, lumen depreciation, testing, and labeling requirements. No incandescent fixtures or lamps can comply with the ENERGY STAR efficiency requirements. Screw-in compact fluorescent light bulbs must have electronic ballasts in order to carry the ENERGY STAR label. Residential lighting fixtures may use a magnetic or electronic ballast if the fixture is rated at less than 40 watts.

The ENERGY STAR label provides the consumer with a level of assurance that the lamp and fixture he or she is buying will save considerable energy (up to 75 percent savings), will not flicker, will start within 3 seconds of being turned on, and will meet other high quality construction and performance standards. Because a magnetic ballast can be used in smaller residential lighting fixtures, the performance standards are not identical, particularly for flicker and initial startup characteristics.

The ENERGY STAR requirements for exit signs dictate that the exit sign will use no more than five watts per face, as compared to 12 watts for an exit sign with a compact fluorescent or 40 watts with an incandescent light source. The ENERGY STAR specifications for exit signs are currently under revision. The current draft version requires an input power demand of 3 watts or less per sign.

3.4.9 Advanced Building Guidelines

The Advanced Building Guidelines provide a set of criteria for exceeding ASHRAE 90.1-2001. The Guidelines use a format similar to a standard but go beyond standards in terms of both scope and technology performance. Lighting power density levels are similar to the IECC 2003 but additional controls are required. The Guidelines also require mandatory acceptance testing, a key element of promoting control devices that are self-tuning.

The Guidelines include control requirements for bi-level switching such that the occupant can reduce the connected lighting load in a uniform illumination pattern by at least 50 percent. Automatic control devices are also required in order to shut off lighting for interior and exterior areas. The Guidelines require automatic daylighting controls and states that “in areas with top mount skylights, an automatic, photosensitive control device shall reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Each daylight control zone shall not exceed 2500 square feet.”

The Guidelines require mandatory acceptance testing on manual and automatic daylighting controls, occupancy sensors, and automatic time-switch controls. This includes construction inspection and equipment testing.

4. Residential Lighting Standards

4.1 Issues in Residential Lighting Standards

Lighting standards for residential buildings are not as widely adopted as they are for nonresidential buildings. This is due to several factors. First, the energy savings opportunities are not as large or as universal, because residential lighting usage is not subject to regular business hours like nonresidential lighting, and the lighting wattages are more limited. Second, much of residential lighting is in plug-in lamps, which are not even present when building officials are inspecting the buildings. Third, there is a general reluctance to intervene in private residences and in the fashion/lifestyle choices implicit in residential lighting.

California, however, is leading a trend to use the energy code to broaden the acceptance of high efficacy lighting in residences. The past five to ten years have seen a large increase in the product offerings for high efficacy residential lighting fixtures, lamps and ballasts, as concerns about quality and consumer acceptance have been addressed by the lighting industry. Many segments of the residential market have already seen widespread acceptance of compact fluorescent technology, especially for areas with long hours of operation such as corridors and outdoor security lighting.

A key area of current concern in residential lighting efficiency is the growing trend in the use of recessed downlights, especially in kitchens. These are problematic for two reasons: first, they tend to use incandescent lamps and because of their limited throw and spread, there tend to be many of them; second, they frequently penetrate the ceiling insulation and become a heat leak in the building envelope. Because kitchens are one of the most heavily used rooms in the residence, the resulting energy waste can be significant. Advances in high efficacy luminaires are cited as a good potential solution to this problem. Energy code limits on the installed incandescent wattage can also provide a solution.

4.2 Comparison of Residential Lighting Standards

The residential standards, where they apply, are very similar. All codes researched required that the applicable sections of the nonresidential standards be applied to the nonresidential areas of residential buildings. This typically includes hallways, assembly areas, kitchens and other support areas. While no national code requires LPD calculations in residential spaces, there is typically an efficacy requirement for fixtures in key areas where the code exits. For example, California 2001 code requires high efficacy luminaires in kitchens and baths. An exception is allowed for bathrooms if an occupancy sensor is utilized in the outdoor spaces. The IECC and ASHRAE codes only address the thermal implications of residential lighting, requiring infiltration limits on the installation of recessed cans.

4.2.1 California Title 24

California's Title 24 regulates luminaire efficacies in kitchen, baths and other areas of the home. The code provides for trade offs against bathroom lighting when fluorescent lights are installed in a utility room, laundry room or garage and exterior lighting either be high efficacy or be installed with a motion sensor. Recessed fixtures must be IC rated to minimize the thermal effects when installed next to an unconditioned space.

In 2005, the proposal includes a more extensive application of high efficacy fixtures including areas that were previously optional. It also requires recessed fixtures to be ICAT rated and ballasts over a certain size to be electronic.

4.2.2 ASHRAE Standard 90.2

The scope of the current ASHRAE Standard 90.2 –2001 does not cover any residential lighting requirements. In particular, LPD calculations are not required for residential buildings, including the nonresidential areas within the building. In addition, occupancy sensors and electronic ballasts are not required by the code in any circumstances. No minimum efficacy requirements exist for luminares. Likewise, the next code revision does not cover any residential lighting requirements.

4.2.3 IECC Residential Lighting Requirements

The IECC exempts the dwelling units but applies any applicable commercial section to the commercial areas in residential units (A-1 and A-2 residential buildings).

5. Outdoor Lighting Standards

Historically, there has been little impetus to regulate outdoor lighting. The electric utility industry has generally viewed outdoor lighting as a good load balancing mechanism, using off-peak generation capacity and increasing profitability. A large share of outdoor lighting is for security purposes, and a large majority of people feel that outdoor lighting reduces crime and vandalism (although researchers have not been able definitively to prove this assertion). Another large component of outdoor lighting is advertising and signage, which many view as a commercial necessity.

Nevertheless, a great deal of outdoor lighting is wasted energy. Poorly designed fixtures send lighting energy up into the sky where it does no good. Large areas are lit throughout the night for little apparent reason. There is an escalating competition among commercial interests to be brighter lit than their neighbors. For example, some gas station canopies are lit to provide 100 footcandles of illumination at the pumps, a level almost three times higher than the accepted illuminance level for offices. With the recent energy crises, there is a growing interest in limiting the energy waste from outdoor lighting.

5.1 ASHRAE 90.1 Outdoor Lighting

In ASHRAE, there are separate lighting power allowances for exterior and interior illumination. They cannot be traded off against each other. The densities for exterior lighting are expressed in watts per linear foot (as in exit or entrances) or in watts per square foot (as building facades.). All exterior building grounds luminaires that operate at greater than 100 watts are required to contain lamps having a minimum efficacy of 60 lumens per watt unless a motion sensor controls the luminaire. There are exceptions for outdoor and indoor lighting similar to California Title 24 and other state-adopted codes.

5.2 California's Title 24 Outdoor Lighting Requirements

California does not currently have any requirements governing outdoor lighting other than the trade-off provisions contained in the residential code for porch lighting.

In 2005, if the draft standard is accepted, except for a number of specific exceptions, all permanently installed outdoor luminaires using lamps rated over 100 watts shall either have a lamp efficacy of at least 60 lumens per watt or be controlled by a motion sensor. All outdoor luminaires that use lamps rated 175 watts or greater in hardscape areas including parking lots, building entrances and sales and non-sales canopies, and all outdoor sales areas shall be designated cutoff for light distribution.

5.3 IECC

When the power for exterior lighting is supplied through the energy service to the building, all exterior lighting, other than low voltage landscape lighting, is required to have a source efficacy of at least 45 lumens per watt, except when exempted because of historical, safety, signage or emergency considerations.

5.4 Oregon and Washington Outdoor Lighting Requirements

The exterior lighting requirements are quite similar between the state energy codes for Washington and Oregon. In both states, any exterior lighting that is not intended for 24-hour continuous use shall be automatically switched. This can occur by using a timer, photocell, or a combination of timer and photocell. Automatic time switches must also have some program back-up capability. The back up should prevent the loss of the program and time settings for at least 10 hours, if the supply power is interrupted. In Oregon, the timers should be programmable for a seven-day period, and must also adjust for seasonal daylight variation.

The Oregon Non-Residential Energy Code is a mandatory state-developed code that exceeds ASHRAE 90.1-1989. One specification regarding outdoor lighting is that no incandescent lamps over 10 watts are allowed for exterior building lighting.

The 2002 Seattle Energy Code specifies that the exterior lighting power allowance shall be calculated separately for (1) covered parking, and (2) outdoor parking, outdoor areas, and building exteriors, including signage. The lighting in these two areas shall not be traded. For automobile sales areas and other exterior retail sales, 0.50 W/sf is allowed. The lighting allowance for covered parking shall be 0.20 W/sf at most. The allowance for open parking and outdoor areas and roadways shall be 0.15 W/sf, and luminaires mounted above 15 feet shall have full cut-off characteristics. The lighting allowance for building exteriors and externally illuminated signs (including billboards) shall be calculated either by multiplying the building façade area that is illuminated by 0.15 W/sf or multiplying the building perimeter in feet by 7.5 watts per lineal foot. Any building exterior lighting that exceeds 7.5 watts per lineal foot of total building perimeter is not allowed to be traded with other lighting areas.

5.5 The Collaborative for High Performance Schools

The CHPS Criteria also addresses outdoor lighting to reduce light pollution from the building site and improve night sky access. One credit point is earned if the outdoor lighting does not exceed the Illuminating Engineering Society of North America (IESNA) footcandle level requirements and if interior and exterior lighting is designed such that zero direct beam illumination leaves the building site. Ambient lighting for pre-curfew hours ranges from 0.01 footcandles for areas with dark landscape such as parks, to 1.5 footcandles for areas with high ambient brightness such as urban areas.

5.6 Leadership in Energy and Environmental Design

The LEED Criteria regarding outdoor lighting is very similar to the CHPS Criteria. One point is available for providing lower light levels and uniformity ratios than those recommended by the IESNA. Exterior lighting should be designed such that all exterior luminaires with more than 1000 initial lamp lumens are shielded and all luminaires with more than 3500 initial lamp lumens meet the Full Cutoff IESNA Classification.

5.7 Advanced Building Guidelines

The Guidelines Criteria also address outdoor lighting to promote energy efficiency, reduce light pollution from the building site, and improve night sky access. Specific requirements for lighting power density, controls, and luminaire cut-off are included in the Guidelines. The Guidelines state that "all permanently installed outdoor luminaires that operate at greater than 100 watts, other than low-voltage landscape lighting shall have either: a lamp efficacy of at least 60 lumens per watt, or be controlled by a motion sensor." In addition, automatic controls are required for all permanently installed outdoor lighting. A photosensor is required to control lighting designated for dusk-to-dawn operation.

6. Appliance Standards for Lighting Products

Preemption of federal standards over state standards for most federally regulated appliances results in minimal efforts toward state developed code. Regarding fluorescent lamp ballasts and replacement fluorescent lamp ballasts, **Table 4** illustrates the current standards for the following types of fluorescent lamp ballasts:

1. replacement fluorescent lamp ballasts manufactured on or before June 30, 2010,
2. fluorescent lamp ballasts manufactured on or after January 1, 1990,
3. fluorescent lamp ballasts sold by the manufacturer on or after April 1, 1990, and
4. fluorescent lamp ballasts incorporated into a luminaire by a luminaire manufacturer on or after April 1, 1991.

Application for Operation of	Ballast Input Voltage	Total Nominal Lamp Watts	Minimum Ballast Efficacy Factor
one F40T12 lamp	120 or 277	40	1.805
two F40T12 lamps	120	80	1.060
	277	80	1.050
two F96T12 lamps	120 or 277	150	0.570
two F96T12 HO lamps	120 or 277	220	0.390

Table 4 - Current Standards for Lamp Ballasts

In addition, **Table 5** illustrates the future standards for the following types of fluorescent lamp ballasts:

1. fluorescent lamp ballasts manufactured on or after April 1, 2005,
2. fluorescent lamp ballasts sold by the manufacturer on or after July 1, 2005,
3. replacement fluorescent lamp ballasts manufactured after June 30, 2010, and
4. fluorescent lamp ballasts incorporated into a luminaire by a luminaire manufacturer on or after April 1, 2006.

Application for Operation of	Ballast Input Voltage	Total Nominal Lamp Watts	Minimum Ballast Efficacy Factor
one F40T12 lamp	120 or 277	40	2.29
two F40T12 lamps	120 or 277	80	1.17
two F96T12 lamps	120 or 277	150	0.63
two F96T12 HO lamps	120 or 277	220	0.39

Table 5 - Future Standards for Lamp Ballasts

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2002 Code

http://www.dos.state.ny.us/code/energycode/Code.htm

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C. OR Lighting Code

Code Publications

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