Lighting, Low Vision & Building Codes

It is time that universal design went beyond mobility.

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Abstract

The assumed lighting restrictions associated with the ANSI/ASHRAE/IES 90.1 energy standard are fundamentally based upon recommended light levels found in the Illuminating Engineering Society's (IES) Lighting Handbook. These light levels are historically based upon the needs of normally sighted people. The solitary goal of the energy code has been to reduce energy consumption by imposing limits on the amount of power that can be used for lighting per floor area and therefore ignores quality of light, health, safety and hours of use. While mandating greater use of daylight will help reduce daytime energy use, glare and contrast are quality of light issues yet to be addressed.

Quantity and quality of light are the crucial elements for the low vision population. This presentation will review how we account for these while accommodating the restrictions in the energy code as well as other building codes and standards such as the NFPA, IBC and LEED. Recently, the power densities for senior care facilities in the 90.1 regulation standard were increased substantially after a convincing case was made based on scientific research. Although this increase was made for limited space types, this action paves the way for broader changes to the various building codes in an effort to support the low vision population.

It is time that universal design went beyond mobility and addressed sensory loss, including low vision; to truly be "universal" design.

Introduction

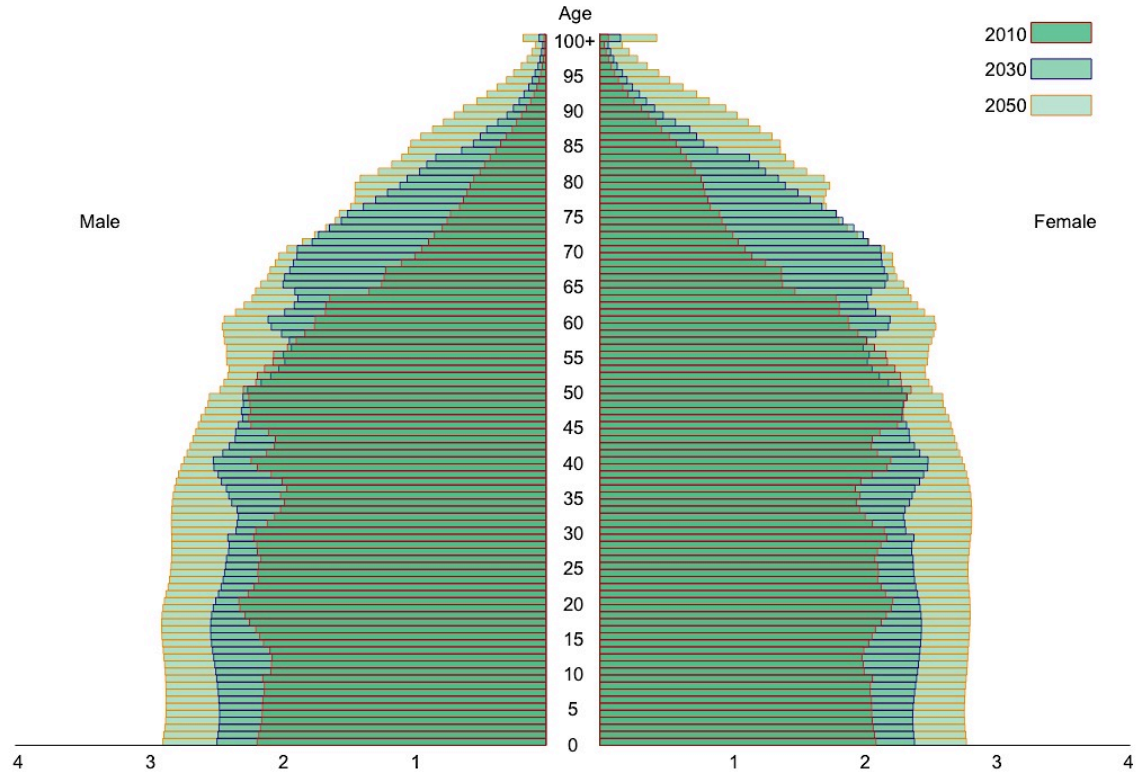
The lighting design industry is moving steadily toward more comprehensive recommended practices for those with low vision. One of the many of the issues we face is a lack of coordination between the development of these recommended practices and the various building codes, regulations and guidelines our industry must follow. The development cycles of these items are often slow, political and fraught with special interests. True progress can only occur when the development industry as a whole recognizes that it is imperative we move beyond a focus of just mobility and address sensory loss with coordinated code requirements that are supportive of qualitative recommended practices. A good example of these efforts are the upcoming changes to the ASHRAE/IES 90.1 energy standard that provide specific enhanced requirements for senior care facilities that recognize the additional lighting needs of that population. This is a small but important step in the right direction.

Conflict: Codes vs. Needs

It's hard to ignore the drumbeat from all corners telling us about the 'Silver Tsunami' that is creeping upon us. The number of persons aged 65 years or older is expected to increase from approximately 40 million in 2010 to an estimated 71+ million in 2030, roughly 20 percent of the U.S. population.

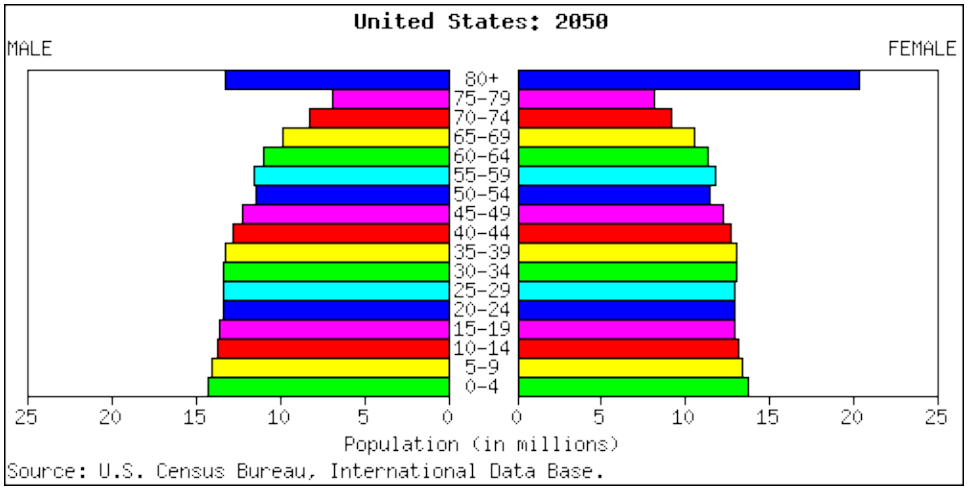
- Population aged >=65 years
  - from 12.4% in 2000 → 19.6% in 2030
  - 35 million in 2000 → 71+ million in 2030
  - roughly 20 percent of the U.S. population
- Population aged >=80 years
  - from 9.3 million in 2000 to 19.5 million in 2030

Figure 6. Age and Sex Structure of the Population for the United States: 2010, 2030, and 2050
2008 National Projections
(In millions)



Source: U.S. Census Bureau, 2008.

By 2050, the single largest age group in the country is estimated to be 80+, and not by a small margin. This older population's growth will impact many industries with particularly great demands placed on building design and healthcare.



However, few people have considered the potential impact lighting can have upon the low vision population's health and quality of life. The low vision population includes those of all ages that access every type of facility. Proper lighting conditions can help increase personal independence, productivity, promote better health and increase safety. All of which have a direct impact on care giving costs, facility operational costs and quality of life. It should be noted that while these types of discussions are often focused on our aging population, the fundamental principals apply to all age groups and all facility types. Low vision does not discriminate and is therefore a very broad population that must be considered in truly inclusive design.

"The biological effects of light are an indispensable health factor."

"Optimum light exposure ought to be as uncontroversial an aim of future health policy as best-possible nutrition. The appreciation of daylight can be understood better when the biological effects of light are known."

Professor Wolfgang Ehrenstein

As our population continues to age, it stands to reason that the incidences of vision loss and low vision will continue to increase. According to Prevent Blindness America, in 2010 nearly 1.3 million Americans 40 and over reported being blind and another 2.9 million reported having vision impairment (20/40 vision or worse). These two statistics don't include instances of Age Related Macular Degeneration, Cataract, Diabetic Retinopathy, Glaucoma, etc. Looking at those numbers tells an even more troubling story of an already immense population of aging Americans with vision disease that will only compound the natural degradation of their visual system.

2010

state	vision problem	race	sex	age	number of cases
UNITED_STATES	AMD	ALL	ALL	40 and older	2,069,403
UNITED_STATES	BLINDNESS	ALL	ALL		1,288,275
UNITED_STATES	CATARACT	ALL	ALL		24,409,978
UNITED_STATES	DIABETIC_RETINOPATHY	ALL	ALL		7,685,237
UNITED_STATES	GLAUCOMA	ALL	ALL		2,719,379
UNITED_STATES	HYPEROPIA	ALL	ALL		14,186,819
UNITED_STATES	MYOPIA	ALL	ALL		34,119,279
UNITED_STATES	VISION_IMPAIRMENT	ALL	ALL		2,907,691

Prevent Blindness America

To understand how this occurs and how it relates to lighting design and our built environment, we must look at some of the more common clinical problems we encounter as we age and what effect that has on our visual system. For the sake of this discussion, these factors fall into two categories. The first being natural, non-disease, age related characteristics that degrade our vision as we age, and the second is the disease component.

- The clinical problems as we age:
  - Natural age related issues
    - Reduction in retinal photoreceptors (Rods)
    - Lens hardens (Presbyopia)
    - Lens yellows (Opacification)
    - Pupil gets smaller (Pupillary Miosos)
    - Floaters
    - Dark adaptation slows (Delayed rhodopsin regeneration)
  - Disease
    - Cataracts
    - Glaucoma
    - Retinal Detachment
    - Age Related Macular Degeneration
    - Diabetic Retinopathy

What do all of these have in common? First, there is a reduction in the amount of light that can enter and be effectively used by the eye. Second, is an increase in the amount of light scatter

within the eye causing a greater likelihood of, or sensitivity to glare. Finally, primarily due to the yellowing of the eye's lens, a reduction of blue wavelengths entering the visual system occurs. These three results are the keys to understanding how we can tune lighting systems to support good health, safety and quality of life.

Vision, sleep and neuroscience research along with in-the-field design work over the past decade has shown direct correlations between the quantity and quality of illumination and a person's quality of life and health. In response to this information and the exponential growth of the low vision population, the lighting design community has begun to develop new and revise existing recommended practices and guidelines. The two primary examples of this are the recent revision of the Illuminating Engineering Society's *Lighting Handbook* now in it's 10th Edition and the continued development of the ANSI/IES RP-28 *Recommend Practice for Lighting and the Visual Environment for Seniors and the Low Vision Population.* The Lighting Handbook has, divided its illuminance recommendations into three age categories, 25 and under, 25-65 and 65+. While its recommendations are still based upon someone with "normal vision", this format at least begins to recognize basic age related visual needs. As the defacto industry standard for lighting recommended practice, this opens the door to greater awareness and design accommodation. The ANSI/IES RP-28 document takes this further by specifically addressing low vision needs in facilities designed primarily to support that population. The recommended practice has become one of the standards referenced in the 2010 *Guidelines for Design and Construction for Health Care Facilities* adopted by 43 states as a part of their regulations for senior care environments.

This ongoing progress being made is encouraging and has a great deal of support from all sides of the lighting and building industry. The problems begin to occur at the implementation level when these recommended practices are brought to the table with current building codes and regulations. Energy codes have developed aggressively with a single-minded quantitative focus on efficiency making it challenging to achieve the enhanced lighting being called for. Add to the mix a green building code that is designed to accomplish an additional level of efficiency beyond the energy code, and designers quickly find their ability to achieve a quality visual environment, as recommended, a serious concern. Finally, old entrenched lighting requirements in building codes such as life safety minimum egress illumination levels do not reflect the low vision population's needs but continue to be difficult to update. This tug-of-war between recommended practices for those with low vision and building codes continues to be a back and forth battle. Fortunately, it is one that most believe is important to address as evidenced by the latest changes being proposed for the next revision of (2013) ASHRAE/IES 90.1 *Energy Conservation in New Buildings Except Low-Rise and Residential Buildings.* The proposed changes will, for the first time, define a set of senior care and healthcare facility types and provide a separate set of Lighting Power Densities reflecting the higher recommended illuminance values for these buildings and their typical population.

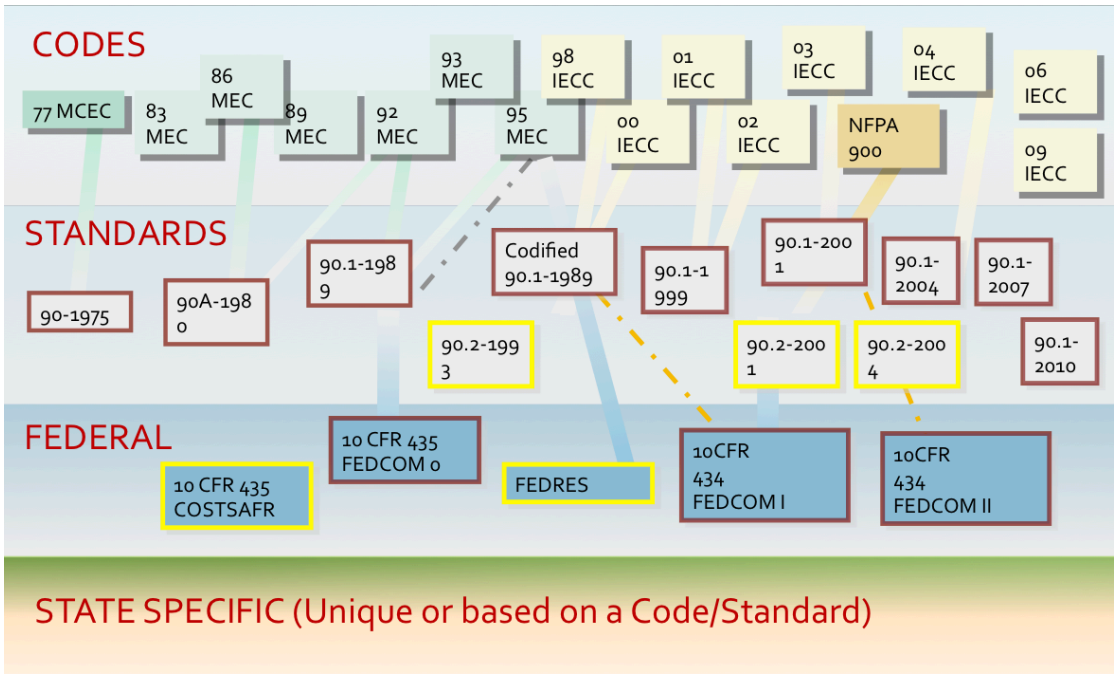
Current Codes & Regulations

What do codes and standards have to do with low vision and seniors? With scientific and medical research showing that these citizens have vision problems, is it not obvious that this special group needs to be treated differently from the general population? The reality is senior communities are often required to comply with an energy code that is only interested in lowering the amount of energy used. The result can be a lower lighting level which exacerbates the poor vision making it difficult to navigate and often leads to falls, resulting in death for 1/3 and a long and costly recovery to the others.

Today the hot button issues in the architectural/building world are sustainability, daylighting, energy efficiency, energy efficiency and energy efficiency. Most of us would likely accept that we have major energy related problems from the supply of oil and the rising seas to global warming. For a number of years there has been an on again, off again effort to create a national energy policy. The US does have energy mechanisms in place but not a real national and consistent energy code. For those of you working in the trenches, you are required to know and understand multiple codes that vary by State and sometimes by cities and counties. Knowing what to do is overwhelming, especially when energy codes contradict each other. It does not end there. There are additional regulations that govern senior living communities. These regulations often supersede the state or local energy codes. Throw programs like LEED and others into the mix and you have the perfect storm.

We end up with a population that has poor vision and reduced mobility, living in a building built under a restrictive energy code. That same building may want to show that its Owners are conscious of the environment and have thus elected to comply with LEED. It's true the building may be energy efficient but the reduced lighting allowed could result in lighting levels not acceptable to its residents. Let's spend a little time looking into the code world so that you understand what is at work here.

The chart below shows the history of energy codes and standards on several levels. Before the first energy crisis in the 1970s the US did not have an energy code and it was not a main stream issue. As we all know, that viewpoint was changed permanently as the nation came to grips with a potentially crippling problem. As you can see, the path of energy codes is long with frequent changes.



Along with codes came energy standards, in particular the work of ASHRAE/IES 90.1. ASHRAE/IES 90.1 is the main underlying foundation of energy codes in the US. It is a standard and not a code unto itself but it is generally adopted by most states therefore making it code. Notice the many versions of 90.1. Just because a new version is published does not mean that the various states also adopt the newer version. Many states today are using versions of 90.1 that are as old as 2004. Given the fast pace of change in the energy efficiency field and in particular lighting, using an old version of 90.1 can seem almost antique. There is also a Federal energy code that applies to all Federal buildings. Interestingly enough, this code is used at the discretion of the Federal agency or project. Lastly there are energy codes adopted by some states and even cities that can be very unique with many requirements.

If you look at the status of energy codes across the US you easily see how varied they are. Some states do not have an energy code and some have a code but only for state buildings. Just look at the adopted variety of ASHRAE/IES 90.1 versions and the problem should be clear

You will find that many codes exempt people with vision problems or medical issues from compliance. The rub is getting code officials to understand that older people almost all have vision problems of one kind or another. Some code officials do not agree with that and counter that the code exemption does not apply to a building full of older people.

ANSI/IES RP28-07 is currently the most referenced standard dealing with low vision and older people containing specific lighting level targets. Little has been done for low-vision design guidance, though in 1995, the Royal National Institute for the Blind (RNIB) in Great Britain published: Building Sight, ‘a handbook of building and interior design solutions to include the deeds of visually impaired people’. In 2001, the British Standards Institute (BSI) first published it and in 2009 updated BS 8300: Design of buildings and their approaches to meet the needs of

disabled people-Code of practice, which addresses means and methods to accommodate partially sighted people.

While researching lighting requirements in other countries a code knowledgeable person directed me to an American publication that did a great job, RP28-07. RP28-07 is specifically mentioned in many codes as the code to follow when designing a senior living community. The rub comes in that many states and municipalities have added changes to the RP thus changing some of its impact. For example Texas has adopted the RP but it can only be found in the state regulations for seniors and not in the energy code. The lighting levels in the RP were changed by Texas along with a requirement that lighting levels were to be taken only during daylight hours. Just finding where the RP is required, who is the responsible person and who enforces the requirement can take you all day.

We are concerned about codes and standards for obvious reasons. We know from researchers in the field of aging and vision that there is indeed a problem and that proper lighting can reduce that problem. Our goal is to create quality illuminated spaces that are inviting and functional for all occupants.

Accomplishments and Future Goals

Members of the NIBS Low Vision Design Committee have been networking with other building standards organizations to raise awareness of the needs of seniors and those with low vision by providing information for their publications and standards.

There has been a long standing relationship with the Facilities Guidelines Institute (FGI), which was formerly called the AIA Guidelines. The 2010 edition of the *FGI: Guidelines for Design and Construction of Health Care Facilities*, *Part 4 Residential Healthcare Facilities* included lighting levels from ANSI/IES RP-28-07, appropriate for aging and those with low vision. The 2014 edition of the *Guidelines*, now in draft form, will be divided into two volumes, *Guidelines for Health Care Facilities: Design and Construction of Hospitals and Outpatient Facilities* and *Guidelines for Residential Care Facilities: Design and Construction of Residential Health, Care, and Support Facilities*. In addition to lighting, drafts of the *Guidelines for Residential Care* also include information on the visual environment, including light reflectance values, value contrast and surface finishes (sheen or gloss) to serve those with low vision.

In addition to working with the FGI, in March of 2012 a presentation was given to the National Fire Protection Association (NFPA) subcommittee to raise awareness of the needs of older people and those with low vision. Formal requests have also been made to amend the minimum egress illumination requirements with higher values. This was a good first step, but a more concentrated effort is needed. We need to identify members of the NFPA who will help us to understand their process and who are willing to raise the issue within their organization.

Coordination has also been ongoing with the ASHRAE/IES 90.1 Committee. Work with the committee began when the first Standard 90.1-1989 was being developed. At that time, facilities which served older people and the visually impaired were exempt from energy

restrictions altogether. However, code officials did not always honor the exemption. Therefore, in 2011, members of the NIBS Low Vision Committee working with the IES Lighting for Aging and Partially Sighed Committee, the AIA Design for Aging Knowledge Community and the ASHRAE/IES 90.1 Committee set out to determine the amount of energy needed to meet the quality and quantity of light (illuminance values) recommended in *ANSI/IES RP-28.* This was accomplished using actual drawings of facilities and commonly used energy-efficient lighting equipment. The energy is stated as Lighting Power Densities (LPD) in watts per meter squared (W/M^2). The increase for senior care facilities is significant.

Comparison of LPD ($W/M^{2)}$ in Typical Spaces and Senior Care:

Space type:	Typical	Senior Care
Dining/Activity Areas:	.89	2.65
Living Room/Recreation:	.73	2.41
Corridors:	.66	.92
Lobbies:	.90	1.80
Restrooms:	.98	1.68
Chapel :	100	2.21

Architects, interior, lighting, and landscape designers need to understand the importance that the environment plays in our ability to see. Quality daylighting and lighting of a space is most important. However, the characteristics of surfaces and materials within a space also play an important part in our ability to see details, especially for those with low vision. Loss of contrast sensitivity is a normal part of aging, increasing even more with Alzheimer's disease.

The general terms for describing color include the hue (red, blue, green), the value (light, medium, dark) and the intensity (saturation or strength of the color). Of these three elements, value is the most important for those with low vision. The value is the lightness or darkness of the surface color rated on a scale of 0 (black – total absorption) to 100 (white – total reflectance). The location of the surface material and its interaction with the light source are what's important. For example, values in the higher range are recommended for ceilings and walls to distribute light throughout an interior space. Design professionals need to realize the importance of light reflectance values and value contrast for the safety of those with low vision, and how contrast improves their ability to see and understand the environment in the following ways:

- Detect level changes, i.e. a step or raised area, the edge of a table, or counter top,
- Locate a handrail, door, or door frame.

- Determine where the floor and wall meet,
- Distinguish objects from their background, i.e. seeing chairs and carts in their path.

Light Reflectance Values: Light Reflectance Values (LRV) are quantified numerically from 0–100. Lighter colors will have higher numbers and darker colors will have lower numbers. What this number tells us is the amount (percentage) of the light that falls on the color that will be reflected back into the room for lighting the space. Light that is not reflected back will be absorbed by the color and will not be available to support vision. The recommended LRV varies, depending on interior or exterior use and location of the material, ceiling, wall, floors, or walkways.

- **Where to find the Information:** The manufacturer provides the LRV of a paint color or material. The LRV of a paint color is typically noted on the back of the paint chip or in the index of the color fan deck. All paint companies can provide this information. Many carpet, vinyl, and tile manufacturers also provide this information. However, if the information is not available, simply match the value of the material to another paint chip to approximate its light reflectance value.
- **Creating Value Contrast:** The walls represent the largest surface area in the built environment and should be the in the higher LRV index range. This range will provide a light background, which will improve the lighting of the space and also be a contrast to darker colors used for accenting doors, door frames, the floor and base molding. The ceiling should be the highest LRV number in the index range.

Specific Light Reflectance Values: Architectural Planes

- **Ceilings:** These values should be the lightest of all, therefore in the highest light reflectance value range of 80 LRV to 90 LRV.
- **Walls:** The walls should be in the mid to high range of light reflectance values, 60 LRV to 80 LRV.
- **Floors:** The value of the floor material should be the darkest of all the architectural planes, but not below the medium-dark light reflectance values. A good range for the floor is between 50 LRV and 30 LRV, but no lower than 30 LRV.

Value Contrast of Architectural Surfaces and Details:

- Floors to walls and/or doors to walls: Provide a contrast of LRV difference of 30 to define the space and passageways.
- Doors, Moldings, and Handrails: These items should be of a darker value than the wall surface in order to stand out visually.
- Level Changes and Stairs: Provide a contrast of LRV difference of 40 as an alert to level changes and on stair nosing.

- Furnishings and Equipment: These items should have a strong value contrast with the surface that they are standing on or their background.

Surface Sheen or Gloss: Gloss is a measure of the proportion of light that is reflected from a surface. Matte finishes are considered low gloss because the light that is reflected is diffused. Polished surfaces are considered high gloss because the reflected light is directional. The combination of the gloss of the material, location, direction and intensity of the light source will determine the user's sensation of luminance, contrast and glare. This glare can temporary blind the user causing pain and optical illusions that may result in an accidental fall.

Challenges and Opportunities

Challenge: Change the International Building Code (IBC) to require built in lighting in all occupied spaces. Currently the code allows for a window or lighting. *Section 1205 Lighting. 1205.1 General: every space intended for human occupancy shall be provided with natural light by means of exterior glazed openings in accordance with Section 1205.2 or shall be provided with artificial light in accordance with 1205.3. Artificial Lighting.* If we all lived near the equator, this might be more acceptable, but with the changing of the seasons, living spaces in the northern part of the nation are in darkness in the morning and late afternoon and evening. Tables and floor lamps could be used, but electrical cords present tripping hazards, which are likely to increase the incidence of falls.

Most buildings go beyond the minimum requirements of the IBC, but when budgets are tight, i.e. low income housing, then the minimum code may become the fall back position. The Elder's Right to Sight Collaborative: Overcoming Barriers to Address Visual Impairment measured and evaluated lighting in ten buildings and 113 individual apartments, all in subsidized housing in the Metro Boston area. Lighting measurements were taken in 9 communal locations and 5 areas throughout the home with minimum and maximum levels recorded. Lighting measurements, available lighting, accessibility, and contrast of furniture and surfaces were all noted. In comparing lighting levels of the apartments with national lighting guidelines (IESNA, RP-28-98), significant differences were noted. All rooms had lighting below the recommended level except the kitchen. (Chu, Y.K.G., Kaldenberg, J., & Huefner, K. (2009). *The Elder's Right to Sight Collaborative: A new model of eye care delivery for the elderly*. Optometry, 80, 651-656.)

Challenge: Reach out to all "Green Building Groups" including LEED, Green Globes, and others to balance their focus on energy use with the lighting needs of those with low vision.

Opportunities: We have discussed energy codes and the restriction of energy used for lighting. In the not too distant future, LED lighting may be the solution. In comparison to incandescent light and fluorescent light sources, LED technology is much more energy efficient. The improvement cycle of typical light sources has been slow, in comparison to that of LEDs. LED technology comes from the semiconductor industry where change is fast and forever improving. For example, how often have you changed the lighting in your home in comparison to updating your computer or cell phone? As this and other lighting technology evolve, we must always be

evaluating how to maintain the balance between energy efficiency and a quality visual environment.

Conclusion

Light is for people. If we are not supporting all people with quality illuminated environments, then that light is inherently wasted. It is our hope that in the future no one will think that they have to compromise the quantity and quality of light for those with low vision for the sake of energy conservation. Until that day comes, we need codes and regulation that protect the independence, health and safety of our low vision population.