Demonstration and Evaluation of Lighting Technologies and Applications • Lighting Research Center

DELTA Portfolio

Lighting Case Studies ▲ Volume 2, Issue 6

McLean Village Apartments
Simsbury, Connecticut

Type:
Independent Living Facility for Seniors

Site Sponsors:
The Connecticut Light and Power Company, an operating company of Northeast Utilities

Project Profile

McLean Village Apartments, an independent living facility for seniors, is part of a retirement community in Simsbury, Connecticut. The larger McLean community consists of multiple cottages built in 1979. This community is committed to continuing care for seniors, providing housing and activities suited to an individual's health and lifestyle choices. McLean Village Apartments, completed in 1998, houses 24 one- and two-bedroom apartments, as well as meeting, dining, and health care spaces used by the whole community. Its electric lighting has been designed to be sensitive to the special visual needs of its older residents, while keeping energy and maintenance costs low. This demonstration installation was sponsored by the local electric utility. DELTA evaluated the apartments and public spaces, including corridors, dining room, lobby, and basement storage rooms.

The residents of McLean Village Apartments consist of both couples and singles, ranging in age from 68 to 90 years, with varying incomes. Most are healthy and active; only a few individuals are disabled. No one is legally defined as partially sighted, although some residents are experiencing the early stages of deteriorating vision common to aging populations.

The lighting was designed to provide a visual environment that helps the residents see comfortably and easily, making them feel safer and more confident in their daily activities. As individuals age, glare becomes a problem because more light is scattered in their eyes, resulting in a loss of clarity and poorer color perception. Also, light is increasingly absorbed by the lens, making it more difficult for older people to see in dim spaces. This means they have difficulty adapting to different brightness levels within rooms or from space to space. Carefully planned lighting can help compensate for these limitations.

McLean Village, Simsbury, Connecticut

Lighting Objectives

- Provide lighting that compensates for the reduced visual capabilities of seniors:
  1) Raise overall light levels slightly to 25 to 50% higher than illuminances recommended for working-age populations by the Illuminating Engineering Society of North America (IESNA).
  2) Raise task lighting illuminances significantly to at least twice the recommendations for working-age populations.
  3) Improve lighting uniformity within spaces.
  4) Provide gradual transitions in brightness between spaces.
  5) Minimize direct and reflected glare.
  6) Improve color discrimination by using good color-rendering lamps.
- Provide lighting that the residents find attractive and comfortable.
- Minimize the lighting power density by using energy-efficient lighting products.
- Minimize hours of lighting operation in some areas by using automatic lighting controls.
- Ensure reliability of operation and low maintenance costs by using quality lighting products.

Lighting and Control Features

- Glare control. Using indirect lighting, baffles, valances, and fascias on luminaires limits the direct view of bright lamps.
- Even lighting. In many areas, lighting is directed toward light-colored surfaces such as walls or ceilings. The reflected light from these surfaces improves uniformity within the room, especially when combined with closely spaced luminaires.
- Transitional spaces. Adjacent spaces are similar in brightness. At entrance lobbies, lighting is brighter during the day when residents are moving from interior spaces to the daylighted outdoors, but can be switched to a lower level at night to help residents' eyes adapt more quickly to the darkness outside.
- Task lighting. In apartments, luminaires provide high illuminances in places where grooming and other difficult visual tasks are performed, such as on kitchen countertops, on sinks, and in showers.
- Convenience and safety. Permanently installed luminaires in apartments are switched at doorways to provide an easily accessible, low level of ambient lighting, rather than relying on switched outlets for table lamps.
- Energy efficiency and maintenance. Primary light sources are all long-life fluorescent, either linear or compact, often operated on electronic ballasts. Occupancy sensors switch off some electric lighting when no one is present.

Techniques

The principal light sources are F32T8 4′ (1220 mm) and compact fluorescent lamps with a color rendering index (CRI) of between 75 and 85 and a correlated color temperature (CCT) of 2700 to 3000 K (warm). Unless otherwise noted, luminaires with CFQ18 or FT24 (compact fluorescent) lamps use rapid-start (RS) magnetic ballasts, while luminaires with CFQ26 and FT36 lamps are operated on RS high-frequency electronic ballasts. Luminaires with T8 lamps are operated on instant-start (IS) high-frequency electronic ballasts. All ballasts are high power factor (HPF).

A 
Compact fluorescent wall sconce providing up- and downlight, 12″ W x 7″ H x 4″ D (310 x 180 x 110 mm). Open at top, prismatic lens at bottom. Lamps: (2) CFQ26W/G24q/827.

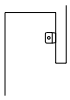
B 
Fluorescent striplight, 4′ (1220 mm) long, one lamp in cross section, mounted within architectural wall slot. Lamp: F32T8/730.

C 
Recessed compact fluorescent downlight with semi-specular clear aluminum cone, 7″ (180 mm) aperture.
Lamps: (2) CFQ18W/G24d/827.

D 
Recessed lensed compact fluorescent wall-washer downlight to match type C, 7″ (180 mm) aperture.
Lamps: (2) CFQ18W/G24d/827.

E 
Pendant-mounted compact fluorescent uplight with decorative translucent acrylic bowl, 3′ (930 mm) in diameter, suspended 2′ (610 mm) from ceiling.
Lamps: (4) FT24W/2G11/830.

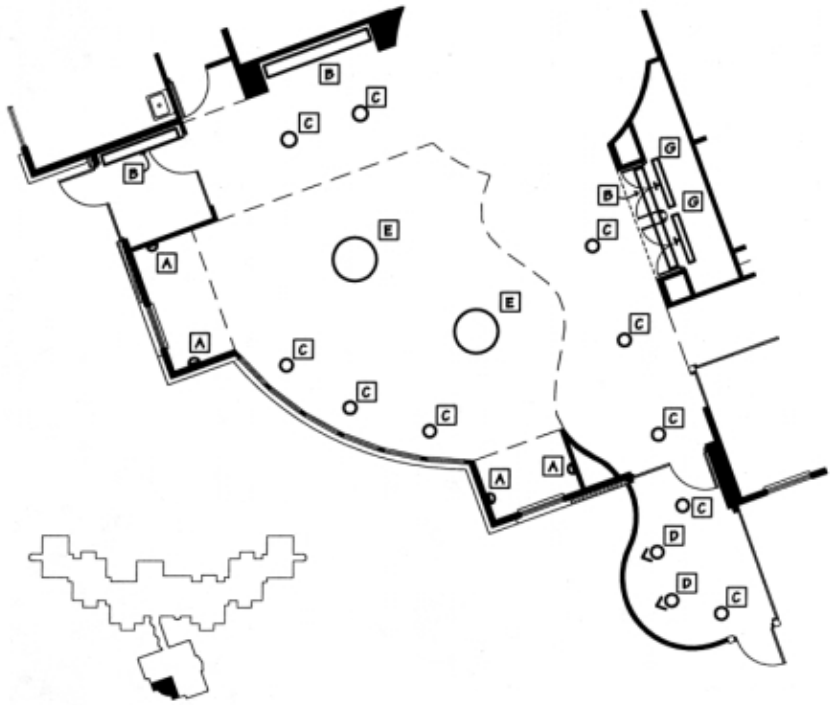
F
Ceiling-mounted fluorescent stacklight, 4′ (1220 mm) long, one lamp in cross section, with U-shaped white-painted aluminum baffles spaced 1″ (25 mm) apart.
Lamp: (1) F32T8/730.

G 
Wall-mounted fluorescent luminaire, 2′ (610 mm) or 4′ (1220 mm) long, one lamp in cross section, with clear acrylic wraparound prismatic lens. Mounted to backside of closet header.
Lamp: F17T8/730 or F32T8/730.

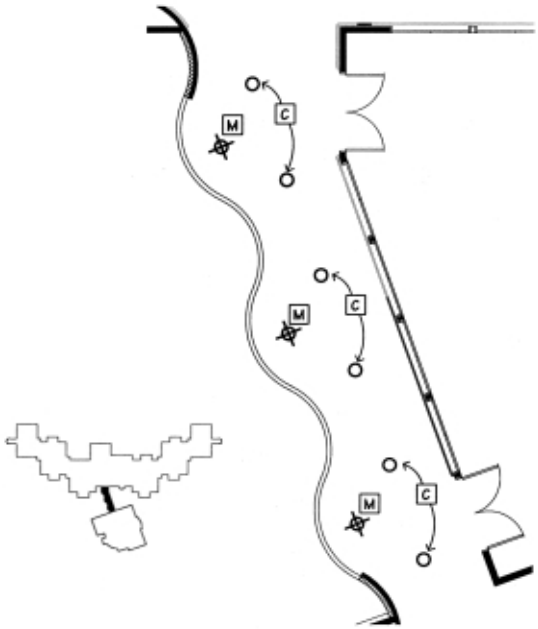
H 
Job-built valance providing up- and downlight using 4′ (1220 mm) fluorescent striplights, two lamps in cross section, with lay-in white-painted aluminum baffles.
Lamps: (2) F32T8/730.

J 
Track lighting, 8′ (2440 mm) long, with PAR30 halogen track heads, mounted on top of valance (type H).
Lamp: 50PAR30/NFL/Halogen.

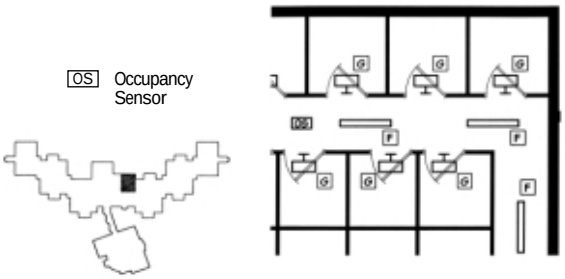
Techniques



Lighting plan, lobby



Lighting plan, undulating wall corridor



Lighting plan, lower level storage area

K Pendant-mounted incandescent chandelier. Five arms with linen shades.
Lamps: (5) 60A19/Halogen.

L Recessed incandescent downlight with white grooved baffle trim, 5″ (130 mm) diameter aperture.
Lamp: 50PAR30/NFL/Halogen.

M Incandescent pendants with 16″ (420 mm) diameter opaque metal shade.
Lamp: 50PAR30/NFL/Halogen.

N Ceiling-mounted compact fluorescent luminaire with translucent acrylic diffuser, 22″ (560 mm) in diameter.
Lamps: (2) FT24W/2G11/830.

P Wall-mounted quarter-sphere compact fluorescent downlight, 12″ W x 6″ H x 6″ D (310 x 150 x 150 mm), with acrylic prismatic lens.
Lamp: CFQ26W/G24q/827.

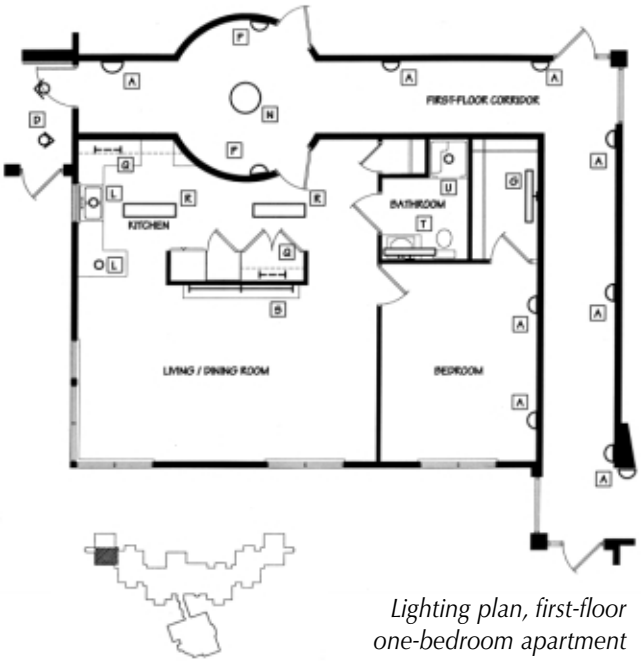
Q Fluorescent undercabinet light, 2′ (610 mm) long, one lamp in cross section, with clear prismatic acrylic lens.
Lamp: F17T8/730.

R Ceiling-mounted fluorescent luminaire, 1′ x 4′ (310 x 1220 mm), two lamps in cross section, with oak louver and housing frame.
Lamps: (2) F32T8/730.

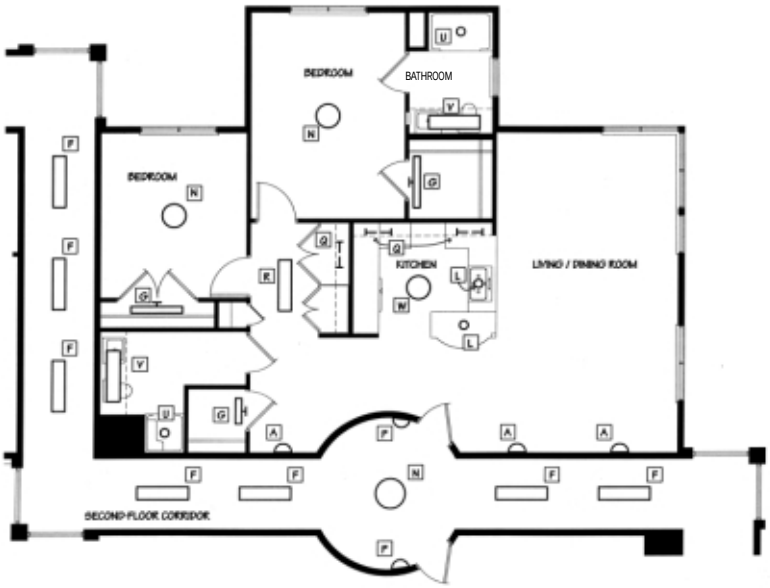
S Job-built wood valance luminaire, using 4′ (1220 mm) fluorescent striplights. One lamp in cross section. Lamp: F32T8/730.

T Wall-mounted fluorescent vanity light providing up- and downlight, 4′ (1220 mm) long, two lamps in cross section. Metal fascia with lighted reveal. Lamps: (2) F32T8/730.

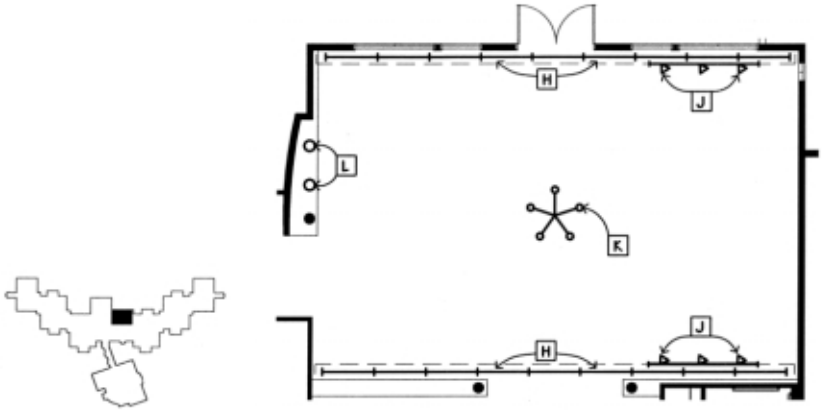
U Recessed compact fluorescent shower downlight with white-painted cone and regressed fresnel lens, 7″ (180 mm) in diameter.
Lamps (2) CFQ18W/G24d/827.

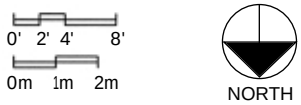


Lighting plan, first-floor one-bedroom apartment



Lighting plan, second-floor two-bedroom apartment





Lighting plan, dining room

V Surface-mounted fluorescent striplight, 4′ (1220 mm) long, two lamps in cross section, mounted in architectural dropped soffit.
Lamps: (2) F32T8/730.

W Pendant-mounted compact fluorescent uplight with decorative translucent acrylic bowl, 27″ (690 mm) in diameter.
Lamps: (3) FT36W/2G11/830.

Wattage

Input wattages for luminaires include ballast watts and are estimated from manufacturers' published literature. All calculations were based on the following values:

T8 fluorescent lamps (electronic ballasts)
- F17T8 (2'): 24 W per 1-lamp ballast
- F32T8 (4'): 31 W per 1-lamp ballast
- F32T8 (4'): 62 W per 2-lamp ballast

FT long twin-tube fluorescent lamps
- FT24: 68 W per 2-lamp magnetic ballast
- FT36: 84 W per 3-lamp electronic ballast

Compact fluorescent lamps
- CFQ18: 43 W per 2-lamp magnetic ballast
- CFQ26: 51 W per 2-lamp electronic ballast
- CFQ26: 35 W per 1-lamp electronic ballast

Incandescent lamps
- 50PAR30/Halogen: 50 W
- 60A19/Halogen: 60 W

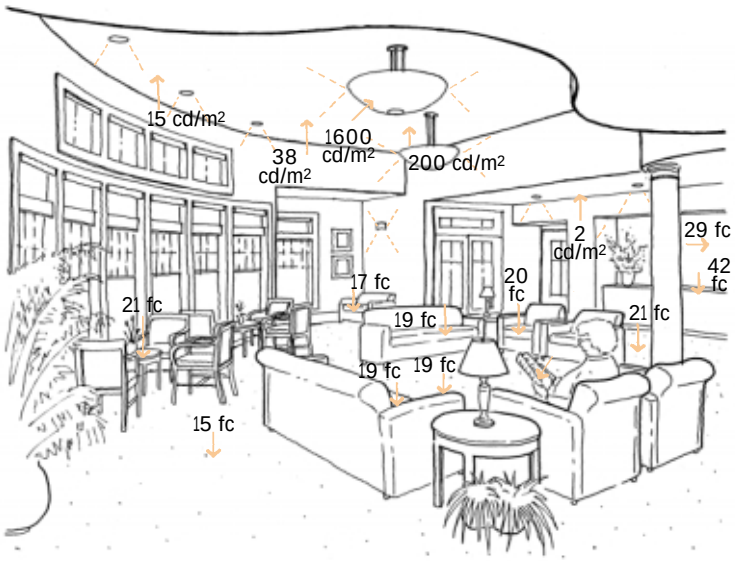
Details

Lobby

Dining room

Common Spaces

Lobby Building residents, as well as residents from the surrounding McLean community, use the lobby. Here you find people reading, chatting, waiting for friends to arrive or activities to begin, or meeting visiting healthcare professionals. Multiple tiers of windows on the sweeping curve of the north wall make this space bright and inviting. Any daylight glare from the windows is controlled with wooden venetian blinds. The electric lighting includes recessed compact fluorescent downlights (type C) in a curved ceiling soffit, pendant uplights with glowing acrylic bowls (type E), direct/indirect wall sconces in reading alcoves (type A), and an architectural slot at an artwork niche (type B). Incandescent table lamps contribute less to task lighting than to a residential atmosphere. At sofa reading locations, horizontal illuminances at night average 20 footcandles (fc) [210 lux (lx)], not including the minimal contribution from table lamps.

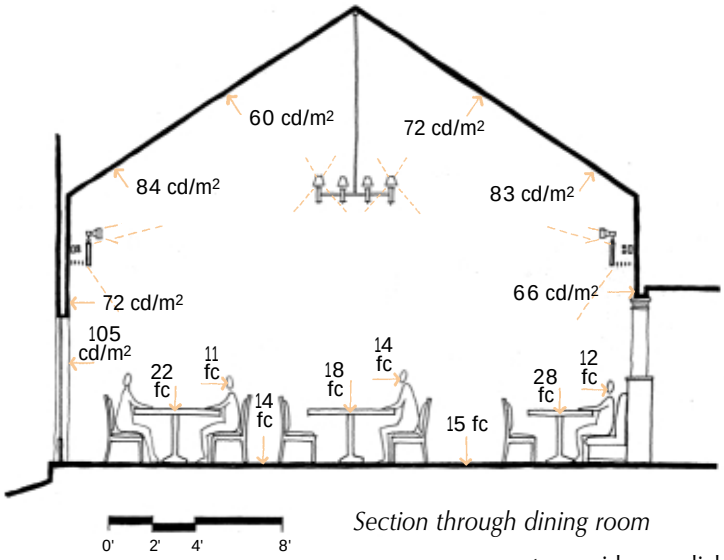


Perspective of lobby (light levels measured at night with table lamps off)

Most of the common spaces in this facility are not used extensively after 6:00 p.m. However, to make it easier for residents and visitors to come and go when it is dark outside, the pendant luminaires (type E) are switched off by the maintenance staff at dusk. This lowers the ambient horizontal illuminance to 5 fc (58 lx) and reduces the overall brightness of the lobby considerably, speeding the adaptation from interior light levels to low outdoor levels.

Dining Room The dining room, where residents can eat dinner, is a popular spot for socializing as well as eating. A painted mural at one end adds visual interest to the space, while the vaulted ceiling makes it seem open and spacious.

For a pleasant, comfortable dining experience, the lighting must help seniors move safely in and out of chairs, read menus, see their food, and view their companions' faces. Uniform



Section through dining room

lighting suits the residents' visual needs while making it possible for the serving staff to position tables anywhere they are needed. Uniformity is achieved with job-built valance luminaires (type H), which direct their light upward and downward onto wall and ceiling surfaces. The reflected light also minimizes glare and makes faces look attractive. A single decorative chandelier (type K) uses halogen A-lamps for improved incandescent lamp life. Track lights using PAR30 halogen lamps (type J) are mounted on top of the valance and are carefully aimed toward the mural to add accent lighting without glare for diners.

Horizontal illuminances on the tables at night ranged from 19 to 28 fc (200 to 300 lx). Vertical illuminances on the face were fairly consistent throughout the space, ranging from 11 to 14 fc (120 to 150 lx).

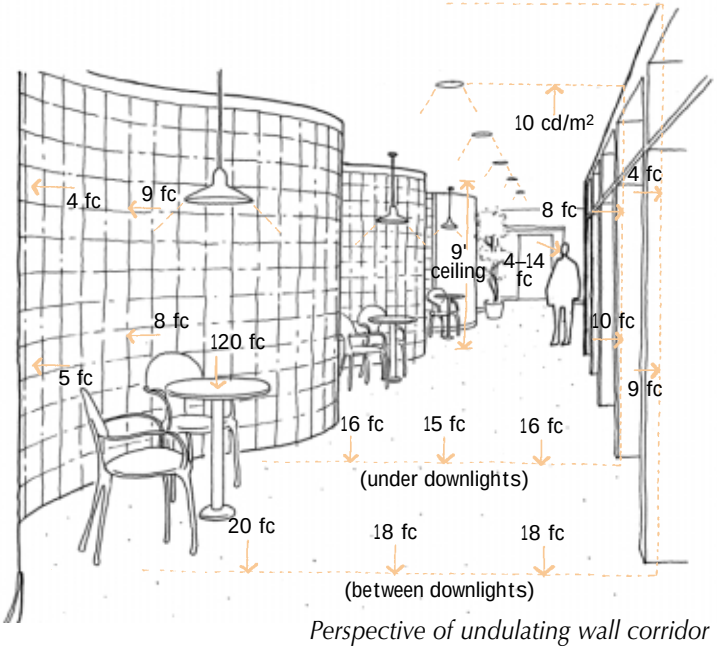
Circulation Spaces

Corridors, staircases, and elevator lobbies in the building were designed to provide even lighting along pathways, with bounced light on walls and ceilings to add to the perception of brightness. Because the older eye is more sensitive to glare, luminaires were selected to conceal bare lamps from residents' normal viewing angles. The older eye also has more difficulty discerning details, so contrasting moldings and baseboards were used to mark edges of corridors and doorways.

In corridors, the lighting must be uniform enough so that dark patches do not conceal obstacles. Patterns of light and shadow should reinforce edges, intersections, and potential hazards. The lighting should not create patterns that imply a stair or level change where none exists. Aging residents may also feel more secure when they are able to recognize faces of people walking toward them. To quantify lighting uniformity in the corridor, DELTA measured both horizontal illuminance on the floor and vertical illuminance at the face at several points in the corridor. Maximum-to-minimum ratios measured on the floor and at the face were less than 4:1. DELTA's observations at McLean Village Apartments suggest that these conditions produce perceptions of good uniformity.

An undulating glass block wall in the corridor on the main floor leading from the lobby to the elevator ushers in daylight. Glare from direct sunlight is not a problem here because the curved wall faces northeast and is shielded by an overhang. Residents can enjoy a view into the gardens while seated at small bistro tables placed in each curve. Deep, recessed compact fluorescent downlights (type C) spaced 8' (2.4 m) on center provide most of the lighting on the pathway, ranging from 15 to 20 fc (170 to 220 lx on the floor) at night. Facial illuminance ranges from 4 to 14 fc (40 to 150 lx), so although this space appears dramatic, the uniformity is still good. Decorative shade

Undulating wall corridor



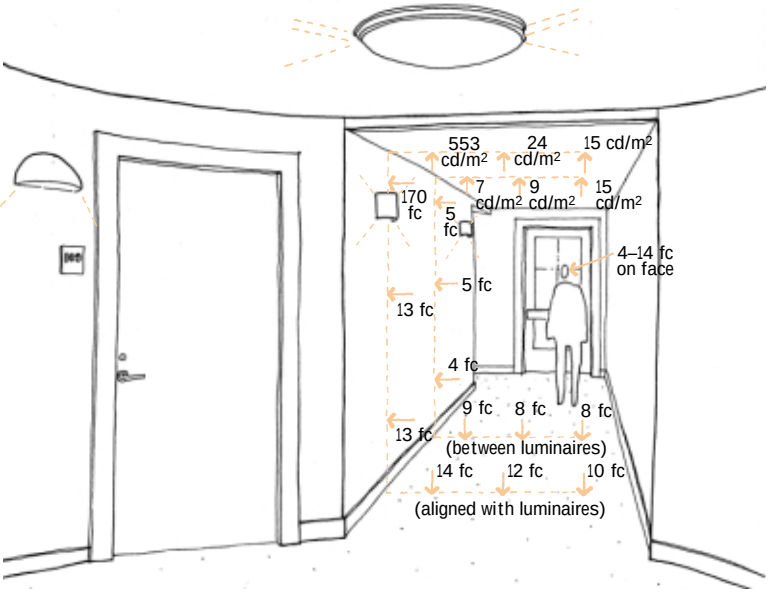
Perspective of undulating wall corridor

Details

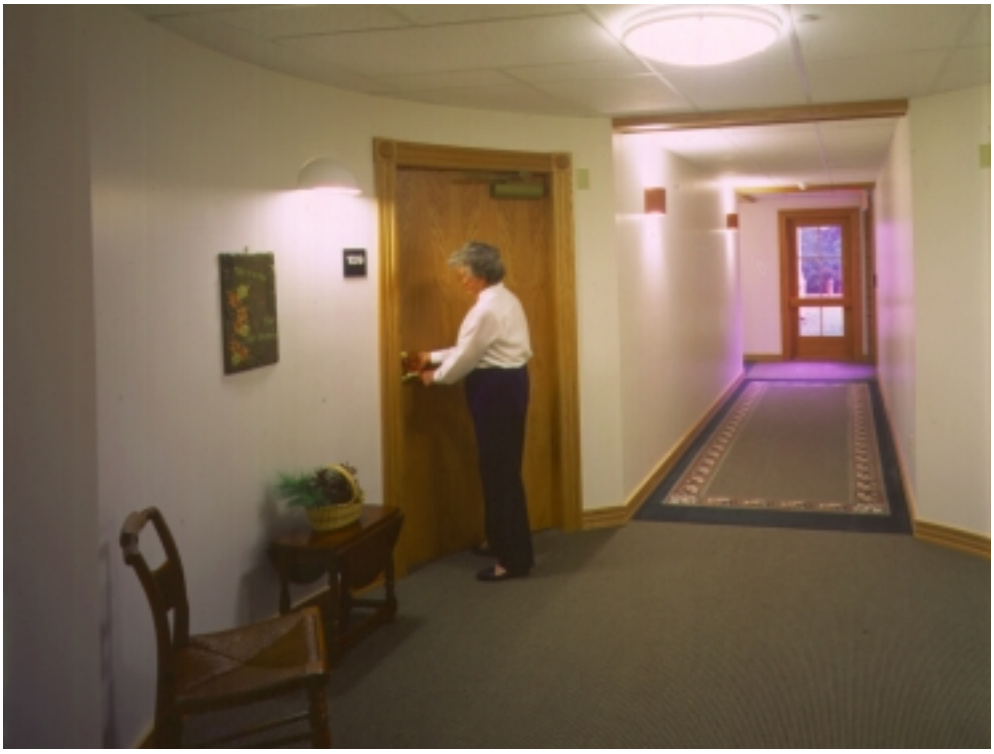
Circulation Spaces, cont.
pendants (type M) suspended over the tables use PAR30 halogen lamps to direct light onto the table but not into the eyes of a seated or strolling resident. A job-built valance luminaire (type B) lights the elevator doors at the end of the corridor, making this destination the brightest object in view (not shown on plan).

DELTA evaluated two designs for corridor lighting in the apartment wings: compact fluorescent wall sconces (type A) spaced 12′ (3.6 m) on center on the first floor, and linear baffled fluorescent stacklights (type F) spaced 8′ (2.4 m) on center on the second floor (see plans in *Techniques*). Both systems performed similarly; the sconces produced floor illuminances ranging from 8 to 14 fc (81 to 150 lx) and facial illuminances of 4 to 14 fc (44 to 150 lx). The stacklights produced floor illuminances ranging from 18 to 22 fc (190 to 240 lx) with facial illuminances of 10 to 22 fc (110 to 240 lx). Although the linear stacklights require less power than the sconces, they spread such even light on the walls that the space appears brighter than the sconce-lighted corridor. Several residents even commented that this solution "wasted energy" because it was on 24 hours a day (see *Resident and Staff Response*).

Circular nodes in the corridors mark the doors to pairs of apartments, forming a gracious entry area. Apartment numbers are clearly marked with large-type, high-contrast signs. The sign is lighted to 31 fc vertical (330 lx) with a quarter-sphere compact fluorescent downlight sconce (type P). The corridor node is evenly lighted with a centered surface-mounted compact fluorescent luminaire (type N) that produces an average of 15 fc (160 lx) on the floor. The luminaire's diffuser measures 128 times the luminance of the ceiling area, so it is very bright, but no residents complained of glare.



Perspective of wall sconce corridor (first floor)



First-floor corridor node with wall sconces

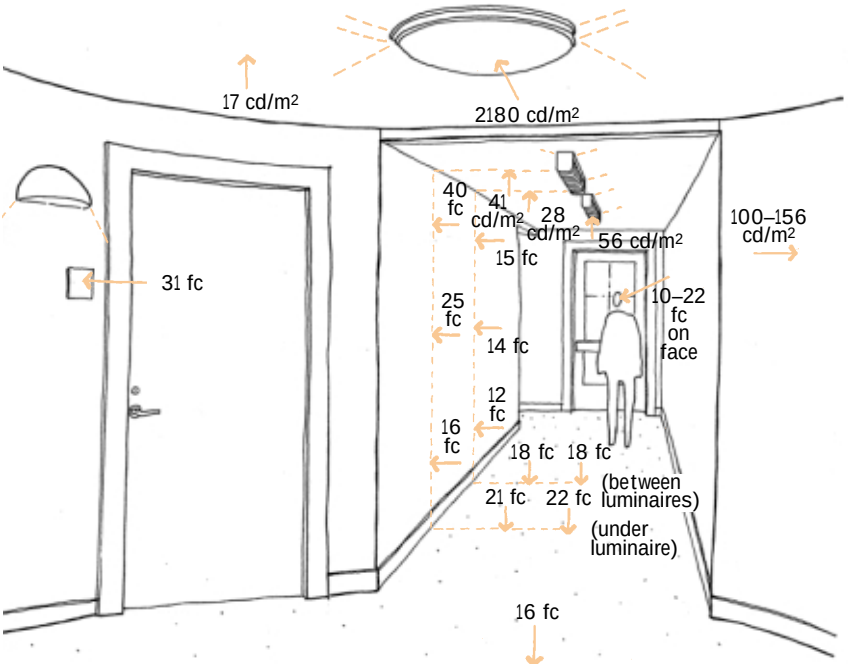
Lower Level Storage Area Each McLean Village apartment is assigned a remote storage closet in the lower level to accommodate additional belongings. The closets are lighted with a 2′ (610 mm) long luminaire (type G) with a fluorescent lamp and wraparound lens, mounted on the back side of the door header. Each closet has its own mechanical timer switch that automatically shuts lights off after 15 minutes if the resident does not remember to switch off the light upon leaving the room.

In the corridor leading to the storage closets, walls and ceilings are painted a light color to increase interreflected light

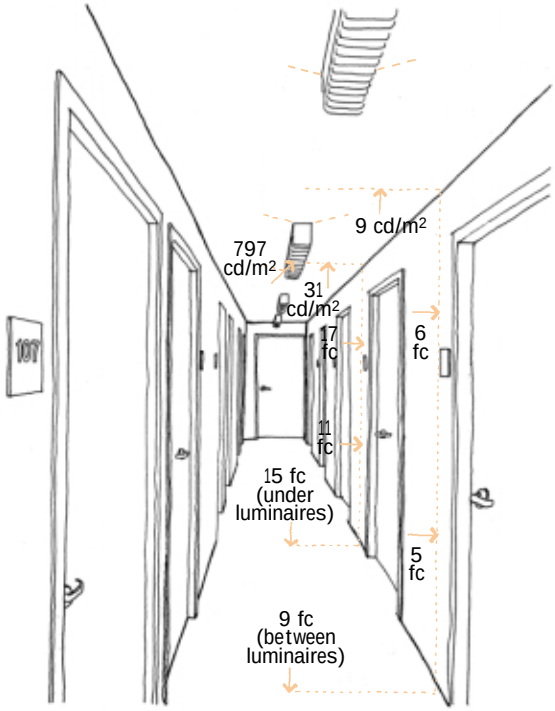
from baffled stacklight luminaires (type F) spaced 10′ (3.1 m) on center. The light is directed onto room surfaces rather than into the eyes of residents walking down the hall. Floor illuminances are very uniform, ranging from 9 to 15 fc (93 to 160 lx). Because this space is infrequently used, the luminaires are controlled by a ceiling-mounted ultrasonic occupancy sensor.

Second-floor corridor node with stacklights

Lower level storage area



Perspective of stacklight corridor (second floor)



Perspective of lower level storage area

Details

Apartments

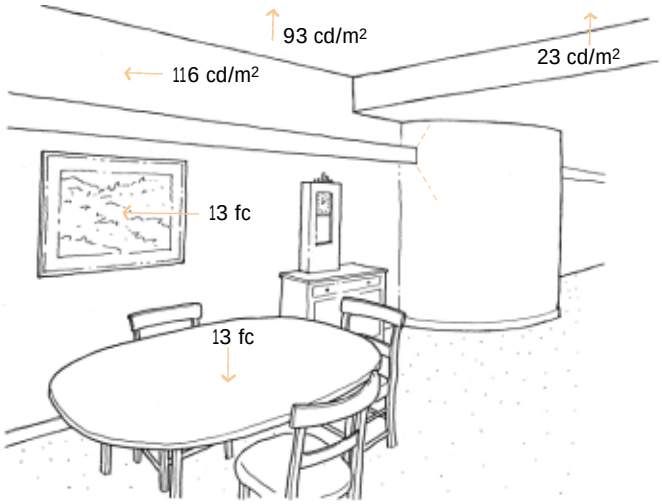
DELTA evaluated two designs in several of the residential spaces at McLean Village Aparments in order to get feedback on a larger number of lighting techniques.

In contemporary residential construction, most apartment rooms rely on switched outlets and portable table lamps to provide ambient light. This practice presents a common problem when a person enters the apartment and cannot turn on the table lamps with a switch by the door because the lamps have been turned off at the base. Such a situation poses an increased risk of falling and injury for seniors, so the design team specified permanently installed lighting operated by a switch near the door to provide a low level of ambient lighting, enough to enable a resident to feel comfortable walking into the room. Residents are still expected to bring in portable lighting for areas where they perform visual tasks (see *Resident and Staff Response*).

Living/Dining Rooms On the first floor, living/dining rooms are illuminated with a linear fluorescent valance luminaire (type S). The light is reflected off the white walls and ceiling, and the oak fascia blocks the view of bright lamps. The result is a low-brightness, uniform ambient light. Residents brought in portable table and floor lamps to personalize their spaces. DELTA's nighttime light measurements in a typical living/dining room are shown below.

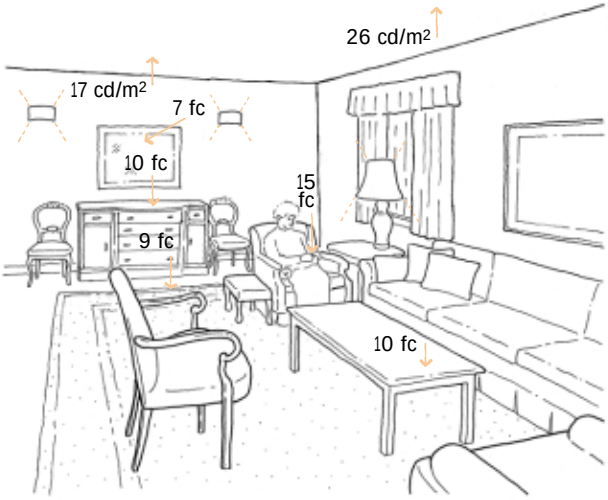
Second-floor living/dining rooms have a pair of up/down compact fluorescent wall sconces (type A). This luminaire looks different from the valance luminaire in the first-floor apartments, but it has an opaque front and throws light upward and downward in the same way. Although residents liked the appearance of both

First-floor living/dining room



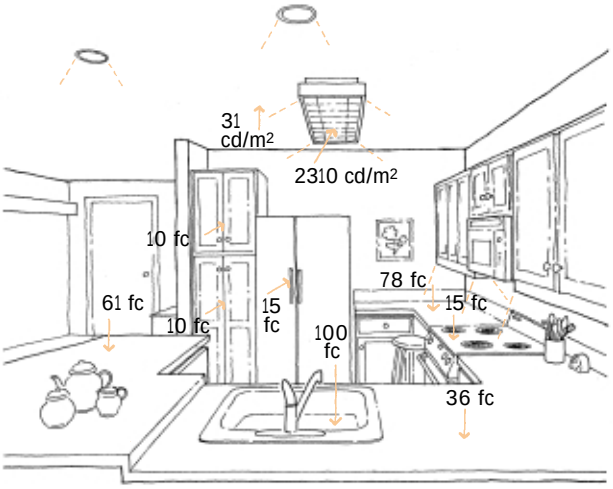
Perspective of first-floor living/dining room (view not shown in plans)

Second-floor living/dining room



Perspective of second-floor living/dining room (light measurements include contribution from table lamps)

First-floor kitchen



Perspective of first-floor kitchen (view not shown on plans)

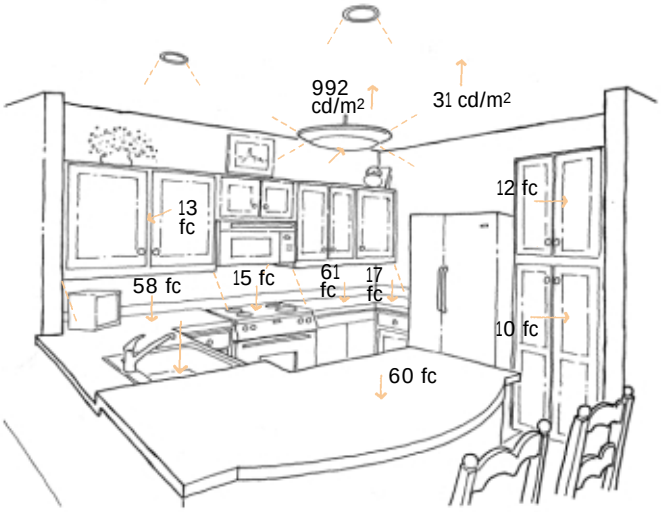
the valance luminaires and the sconces, they preferred the valance luminaires because they produce more light (see *Resident and Staff Response*).

Kitchens Designers also created two lighting plans for the kitchens. Both have a central luminaire to provide consistent ambient lighting of about 20 fc (220 lx) on the counters, plus undercabinet lighting and recessed downlights to concentrate light on task areas such as the sink and countertops. Task area illuminances range from 60 to 80 fc (650 to 860 lx).

First-floor kitchens use a ceiling-mounted fluorescent luminaire (type R) with oak baffles and white diffuser. The diffuser evenly distributes light downward into the room, and the wood baffles help hide the excessive brightness of the diffuser. Task lighting is provided by undercabinet lights (type Q) and recessed downlights (type L). This undercabinet light is mounted as close to the front edge of the countertop as possible to increase illuminance on the edge, and the 2″ (51 mm) lip of the cabinet completely blocks any view of the bright lens. The downlights (type L) concentrate light onto the sink and the breakfast bar countertop.

Second-floor kitchens use a pendant uplight (type W) to provide ambient light. The luminaire has a diffuser on the bottom side, but the majority of its light is directed toward the ceiling. The difference between the luminance of the diffuser and that of the ceiling above is only 3:1; as a result, this is a very comfortable luminaire to view.

Second-floor kitchen

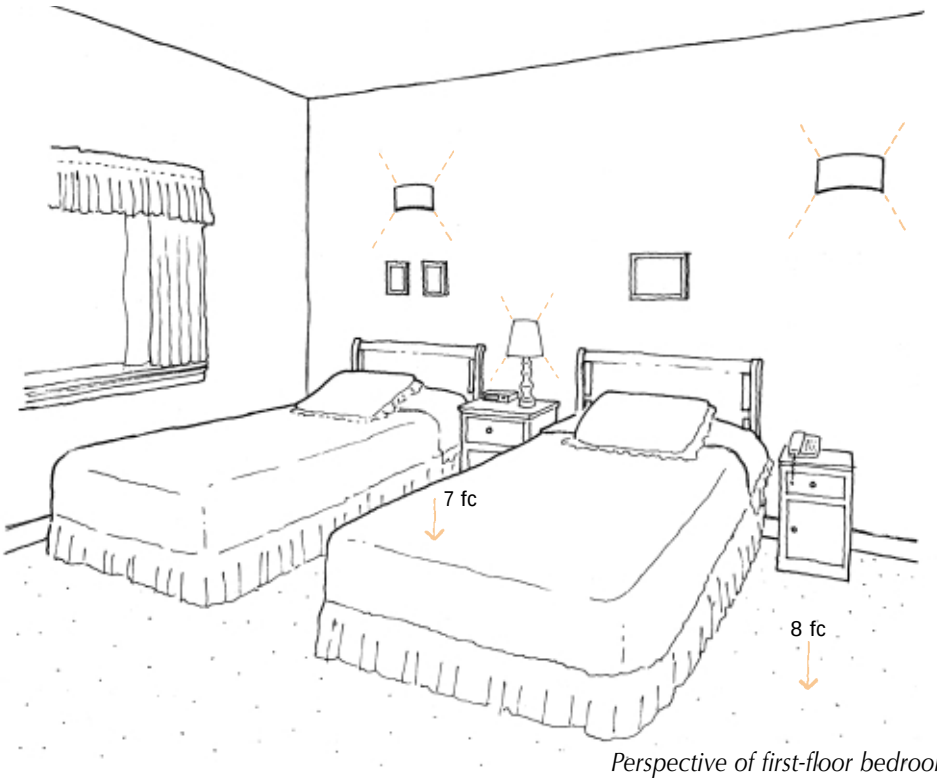


Perspective of second-floor kitchen

Details

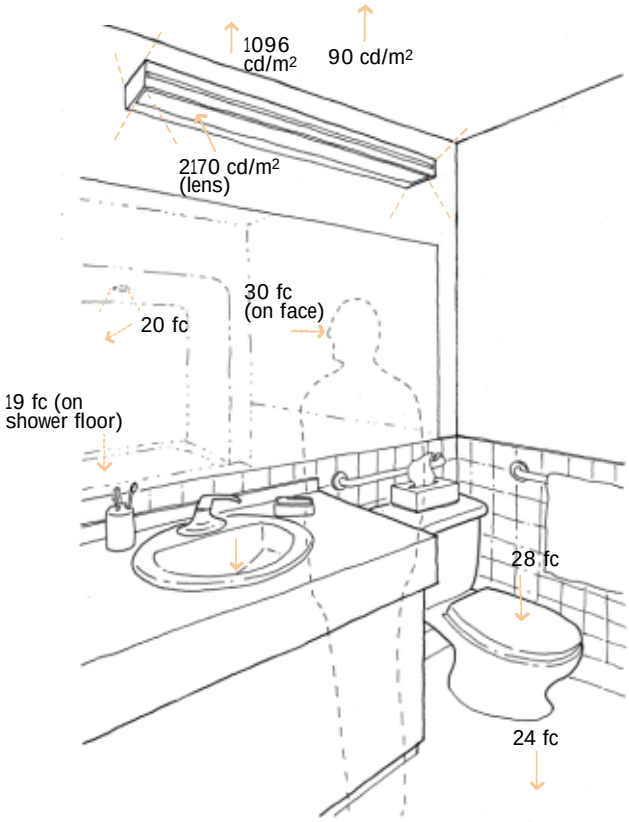
Bathrooms People often perform demanding and potentially hazardous tasks in bathrooms, such as shaving with razors, climbing in and out of slippery showers, or reading fine print on prescription bottles, making this room a prime site for accidents. Bathroom lighting at McLean Village Apartments is designed to help senior residents perform these tasks safely. In addition, vertical illuminances and good color appearance here are very important for washing, dressing, and grooming.

Residents rated first-floor bathrooms higher than the second-floor bathrooms. First-floor bathrooms use a 4′ (1220 mm) long fluorescent up/downlight (type T), with an opaque fascia, mounted above the mirror. The reflected uplight produces even illuminances in the room, and the white diffuser on the bottom side distributes light evenly on the body of the resident standing at the vanity. Vertical illuminances are



Perspective of first-floor bedroom

First-floor bathroom



Perspective of first-floor bathroom

First-floor bedroom

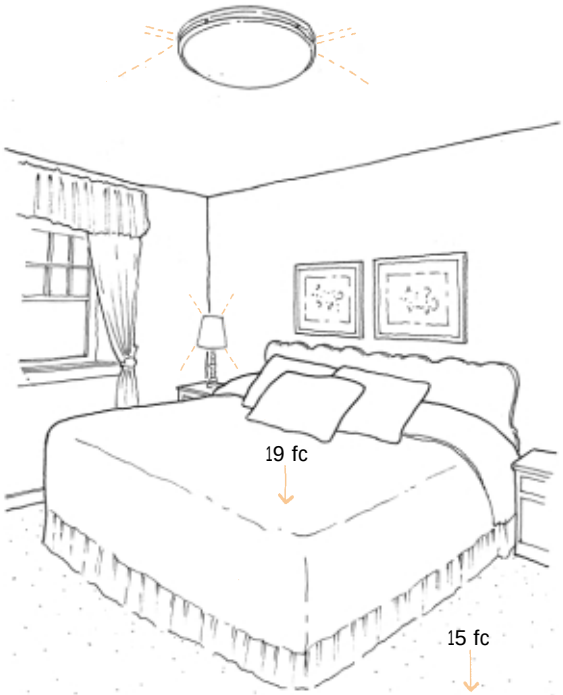
Second-floor bedroom

30 fc (320 lx) on the face at the vanity; horizontal illuminance is 44 fc (480 lx) on the countertop. The shower is equipped with a compact fluorescent recessed downlight (type U) with white reflector cone and fresnel lens. The lens reduces lamp brightness, creating a soft-edged light that illuminates the shower walls and floor. This feature proved to be one of the most popular aspects of the lighting in McLean Village Apartments (see *Resident and Staff Response*).

Second-floor bathrooms are equipped with the same shower lights, but these bathrooms also have a dropped soffit over the vanity (type V). Its diffuser produces soft downlight on the resident's body, but the light is unevenly distributed because the opening is off-center from the vanity (see *Resident and Staff Response*).

Bedrooms In the bedrooms, designers specified fixed luminaires to provide a low level of ambient lighting, 5 to 15 fc (54 to 160 lx), so that seniors will not have to fumble with table lamps in the dark. First-floor bedrooms have a pair of compact fluorescent wall sconces (type A). Second-floor bedrooms have a round, compact fluorescent, ceiling-mounted luminaire (type N) with white diffuser and rings designed to spill a small amount of light onto the ceiling. Residents have brought in their own table lamps for reading.

Apartment bedrooms contain either walk-in or shallow closets with bifold doors. As a convenience to residents and as an energy-saving measure, passive infrared occupancy sensors were supposed to be installed with the closet lighting (type G). This turned out to be a comical calamity (see *Resident and Staff Response*).



Perspective of second-floor bedroom

Project Evaluation

Energy Impact

DELTA used manufacturers' data to calculate lighting power densities (LPDs) for McLean Village Apartments. The tables below give the LPDs for the common spaces and apartments. In order to compare the energy impact on the common spaces of the facility, DELTA consulted the ASHRAE-IESNA/90.1 (1989) standard power densities. To compare power densities in the apartments, DELTA consulted residential baselines developed for the Lighting Research Center publication *The Lighting Pattern Book for Homes*.

Economic and Environmental Analysis

The lighting design of the combined block of apartments at McLean Village achieved lower LPDs than in typical American homes by using energy-efficient luminaires, lamps, and ballasts. In the economic analysis for the apartments, DELTA assumed the following hours of use as suggested by *The Lighting Pattern Book for Homes*:

- 100% of lighting in kitchens on for 3 hours per day
- 100% of lighting in living/dining rooms on for 3 hours per day
- 100% of lighting in bedrooms on for 1 hour per day
- 100% of lighting in bathrooms on for 2 hours per day

The lighting systems in all 24 apartments together save more than $1,300 annually in lighting energy use over typical American residences operating the same hours. Taking into account the estimated impact on the apartment's heating, ventilation, and air-conditioning system, this reduction in lighting energy use corresponds to total annual cost savings of about $1,600. These savings are due to lower overall energy costs, assuming a residential customer rate of 10.6¢/kWh for electricity and $6.67/MBtu for gas. (Calculations adapted from "Worksheet for Life-Cycle Cost-Benefit Analysis" published in *The Lighting Handbook 8th Edition* from IESNA.)

For the common spaces of the facility, the DELTA team, after consulting the McLean Village Apartments building manager, estimated daily hours of use:

- 10.5 hours in lobby
- 1.1 hours in medical offices
- 2.3 hours in function rooms
- 7.1 hours in office space
- 24 hours in undulating wall corridor
- 16 hours in coffee shop area
- 7.1 hours in kitchen area
- 2.3 hours in dining room
- 3.6 hours in restrooms
- 24 hours in first- and second-floor corridors
- 1.9 hours in workout, beauty shop, and store areas
- 15 hours in the second-floor corridor/office area
- 24 hours in lower-level circulation spaces, where there are no occupancy sensors. (The hours of use in the storage areas were assumed to be negligible, because lighting had occupancy sensors and/or timer switches.)

The lighting system in the common spaces saves almost $1500 annually in lighting energy use over spaces operating the same hours lighted to ASHRAE/IESNA standard LPDs. In this case, savings from reduced air conditioning demand are outweighed by additional heating requirements, so the overall savings reduces to $1300. These savings are due to lower overall energy costs, assuming a demand charge of $0.50 per kW and 9.3¢/kWh for electricity and $6.67/MBtu for gas.

According to the region's power utility, Connecticut Light and Power (CL&P), reduced energy from this entire facility will result in annual lower power plant emissions of 23 tons (21 metric tons) of CO_2, 0.13 tons (0.12 metric tons) of SO_2, and 0.36 tons (0.33 metric tons) of NO_X compounds. By reducing these emissions into the atmosphere, the facility contributes less to problems such as global warming, acid rain, and smog.

> ***"Most people who come here the first time notice that the lighting is nice. I think it's a big plus. We love the lighting."***
>
> ***—Resident.***

The lighting construction cost for the entire facility was about $204,000, or $4.29/ft². The local utility company, CL&P, contributed to the cost for this facility with an incentive of $65,000.

Common Spaces and Apartments—Lighting Power Densities (LPD)

Common Spaces	Area (ft²)	Total LPD (W/ft²)	ASHRAE/IESNA[a] Allowed LPD (W/ft²)
Lobby	1502	1.52	1.0
Medical offices	530	1.95	1.4
Function rooms	1423	1.54	1.8
Office	656	1.75	1.8
Undulating wall corridor	702	0.85	1.3
Coffee shop	1405	0.89	2.5
Kitchen/food preparation	1556	1.85	1.4
Dining room	1058	1.79	2.5
Restrooms	472	1.27	1.2
Corridors (2nd floor)	2464	0.89	0.8
Corridors (1st floor)	2464	1.06	0.8
Workout, beauty shop, store	320	3.66	2.0
2nd-floor corridor/office	1930	0.98	1.8
Lower level storage, overall (not used in economic analysis)	4604	0.91	1.0
Lower level circulation only (used in economic analysis)	1126	0.72	N/A
All common spaces	21,086	1.23	1.4

Apartments	Total Area[b] (ft²)	Total LPD[c] (W/ft²)	*Pattern Book*[d] (W/ft²)
Kitchens	3635	1.62	3.12
Living/dining rooms	11,681	1.37	1.55
Bedrooms	7937	1.92	1.75
Bathrooms	2397	1.78	4.27
All apartments	26,460	1.33	2.04

[a] ASHRAE = American Society of Heating, Refrigerating and Air-Conditioning Engineers. IESNA = Illuminating Engineering Society of North America. Although ASHRAE/IESNA does not apply to residential facilities, LPDs were drawn from the category "Nursing Homes" for comparison only.
[b] Areas are totals for all 24 apartments.
[c] Includes portable lighting.
[d] LPDs in typical American homes, based on data from *The Lighting Pattern Book for Homes* (1996).

10.76 ft²=1m²; 1 W/ft² = 10.76 W/m²

Resident and Staff Response

DELTA interviewed residents, management, and maintenance staff about their impressions and experiences with the lighting. They were asked about task visibility, visual comfort, color appearance, and satisfaction with the lighting and controls. Overall, the responses to the lighted environment were very positive. No one made negative comments about color or flicker from fluorescent lighting, except one woman who thought the warm color light made it more difficult to see spots on white shirts in the laundry. Residents expressed feelings of security and comfort.

> ***"The kitchen is very bright, for goodness' sake. The lighting works really well."***
> ***—Resident***

Common Spaces Residents considered the lobby a comfortable and pleasant place for conversation. However, some residents commented that light levels were too low for serious reading. Residents also found the dining room lighting satisfactory and even, but several complained that misaimed track lights were too glaring. Once the track lights were properly aimed toward the mural, the complaints stopped. Corridor lighting was well-liked, except that several people commented that the second-floor corridors using linear fluorescent luminaires (type F) appeared overlit. These responses could reflect a psychological reaction to the brightly lighted walls. Some also remarked that it was a waste of energy to keep all these lights operating 24 hours a day, although this corridor actually uses less energy than the first-floor corridor. The storage areas were well-liked. Several residents commented that the occupancy sensors located here and in the trash area worked very well to provide light when it was needed.

> ***"I like the hallways very much; they're bright but without glare."***
> ***—Resident***

Apartments The chief complaint from residents and staff concerned the erratic operation of occupancy sensors installed in bedroom closets. The passive infrared (PIR) occupancy sensors originally specified were direct line-of-sight devices that would pick up motion only inside the closet doors. However, ultrasonic sensors that have a greater sensitivity to motion beyond the closet doors had been substituted for the PIR sensors. Residents found that any activity in the room kept closet lights on; even rolling over in bed at night sometimes triggered them. The sensor manufacturer was called in to diagnose the problem, and replaced the ultrasonic sensors with PIR sensors. However, many sensors had been incorrectly installed above the header-mounted luminaire so that the luminaire blocked the view of the PIR sensor. As a result, many residents then found that they had to make extreme motions inside the closet in order to turn the light on. Finally, these poorly located sensors were deactivated and replaced with pull-chain switches, to the residents' satisfaction (see *Lessons Learned*).

LIGHTING SURVEY
Percentages of People Who Agree That the Lighting is:

	Good	Neither	Bad
Dining room (n=21)	90	10	0
Lobby (n=15)	87	13	0
Corridors (n=18)	100	0	0
Trash room (n=17)	100	0	0
Lower level storage (n=11)	100	0	0

Residents' Responses to Best- and Worst-lighted Rooms:
(number of responses out of 21)

Room where lighting is Particularly Good:		Particularly Bad:	
Kitchen	13	Dining area	3
Living room	5	Little coat closet (unlighted)	1
Hallway	1	Laundry closet	1
(Entire) Bathroom	1		

> ***"I'm too old to jump up and down to turn the lights on!"***
> ***—Resident***

The fixed living/dining room lighting had been designed to provide a low level of ambient lighting for safe circulation; the design team expected that residents would bring their own portable lighting for reading or craft tasks. In spite of this design decision, residents commented that they wished the light level were high enough for reading. Residents preferred valance luminaires to wall sconces for ambient lighting, because they produce more light for tasks. A common complaint among residents with a separate dining table was that they would like to have a decorative hanging luminaire over the dining table. One solution for future projects might be to provide a junction box above the typical dining table location so that residents could provide their own decorative luminaires.

Many residents commented that they had never had a light in the shower (type U) before, and found it extremely useful for bathing and cleaning. DELTA also received an overwhelmingly positive response to the up/down fluorescent vanity light (type T). Many residents commented that it was easy to see themselves in the mirror for shaving or grooming tasks. However, the response to the lighted soffit (type V) was less positive. The off-center position of the luminaire above the vanity caused one resident to complain that the uneven distribution of light on the right and left sides of his face caused him to shave his sideburns unevenly. DELTA measured a difference of 2:1 in vertical illuminance on the two sides of the face in this type of bathroom.

The building manager confirmed that the overall response to the lighting was positive. She believes that the lighting creates an environment that makes the building more appealing to new residents.

Maintenance and Product Performance

Problems with the performance of the occupancy sensors in closets were the main source of complaint from the residents and staff. Most of these sensors have been replaced by traditional pull-chain switches (see *Resident and Staff Response*).

A greater-than-expected number of ballasts have failed in the type A compact fluorescent sconces, apparently due to a shipment of defective ballasts. The ballast manufacturer has replaced all these ballasts once and continues to replace additional failing ballasts. The maintenance staff also had problems with the bottom lenses of these wall sconces. The prismatic acrylic lens fit so tightly that the lens often broke during relamping or ballast inspection. The sconce manufacturer has shipped smaller replacement lenses to solve the problem.

The facility's maintenance technician commented to DELTA that, aside from the problems described, few lighting maintenance problems have occurred in the first eight months of operation. He replaces halogen PAR30 lamps more frequently than seems normal to him, speculating that vibration in the facility may shorten lamp life.

"Light in the shower is a real plus. I never had this before."

— Resident

Lessons Learned

- **Fluorescent luminaires are acceptable in residential applications.** New technology in fluorescent lamps and electronic ballasts has apparently overcome many of the negative reactions to fluorescent lighting from the past. In fact, none of the residents expressed concerns about color, noise, flicker, or appearance from fluorescent luminaires in their apartments.

- **Residents prefer pendant lights over their apartment dining tables.** Pendant luminaires add style and familiarity to a dining room setting. Residents appreciated ambient light from wall-mounted luminaires, but they still wanted to bring in their own decorative chandeliers or pendants.

- **Shower lights can make tub and shower areas easier to use.** Recessed, lensed compact fluorescent shower lights were well-liked. Residents commented that it was easier to use and clean the shower.

- **Bathroom lighting should be evenly distributed.** Residents preferred the vanity luminaire that directed light up- and downward. Light reflected off the ceiling creates even illumination throughout the room; it also provides vertical illuminance that makes bodies and faces more visible in the mirror. The light directed downward illuminates the countertop as well as the resident's face and body.

- **Occupancy sensors must be carefully selected and installed.** Designers must match the characteristics of occupancy sensors with the application, and make sure that sensors are carefully located. The occupancy sensors used in some closets on this project had to be disabled and retrofitted with pull-chain switches because they were not thoughtfully applied or installed.

- **Well-designed occupancy sensor installations save energy and are appreciated by residents.** In lower-level storage areas and in the building's trash room, occupancy sensors automatically switch lights on and off. This automatic switching is a great convenience to residents who are carrying boxes or trash containers.

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