

Final Report

Field Test DELTA Evaluation:
Occu-smart Light Fixture
Project A70913

Submitted to
LaMar Lighting, Farmingdale, NY

New York State Energy Research
and Development Authority (NYSERDA)
Albany, NY

Submitted by
Lighting Research Center
Rensselaer Polytechnic Institute

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Executive Summary

The following report summarizes the results of the field test of the Occu-smart® light fixture manufactured by LaMar Lighting Company of Farmingdale, NY. The major feature of the Occu-smart light fixture is a built in ultrasonic occupancy sensor that switches the fixture between high and low light levels.

LaMar Lighting arranged to have the Lighting Research Center (LRC) evaluate two sites in which Occu-smart fixtures were retrofitted in egress staircases. The LRC evaluated photometric conditions before and after the field test installation. Human factors evaluations consisted of interviews with owners and maintenance personnel. Energy calculations were performed for both sites based on data from light loggers.

Due to extremely low occupancy in both staircases (0.7%-3.3%), energy savings were significant for both projects (53%-60%) compared to the existing lighting. NYSERDA rebates and high electrical rates in New York City generate a payback period of 5 years for both projects. (Payback would have shortened to 2.6 years on one project had emergency battery packs not been required.) Both sites also showed increased illuminances.

Luminaire Characteristics

Occu-smart[®] is a linear fluorescent fixture intended for use in egress staircases. It is unusual because it incorporates a built-in occupancy sensor that switches the fixture output between high and low light levels. This product is intended for use in environments such as egress staircases, in which minimum illuminance levels are required by building code, but little occupancy is expected (see Appendix 1, Code Implications).

When the Occu-smart fixture senses vacancy, it reduces the lamps to a low light output setting. The benefit of the “low” setting is substantial energy savings. Alternatively, a specifier may have reason to provide much more light than required by code. In this case, the Occu-smart product can provide more light during occupancy without sacrificing energy savings.

Occu-smart fixtures are mounted on landing walls or ceilings of egress staircases. The fixture is shallow enough to meet ADA requirements for mounting on the wall.¹ When the ultrasonic sensor detects occupancy, it signals the ballast to turn the luminaire’s lamps up to full power.

LaMar Lighting provides many options for fixture lamping and quantity, depending on the illumination and energy needs of each project. A specifier can also choose among many high-low settings. Options include ballasts that can provide 33%, 10%, or 5% output, or can turn one or both lamps off entirely.² All these options affect energy savings.

After installation, time delay can be adjusted on each luminaire. After occupancy ends, the fixture continues to operate at full output for between 15 seconds and 30 minutes, depending on the setting. Time delay settings affect energy savings.³

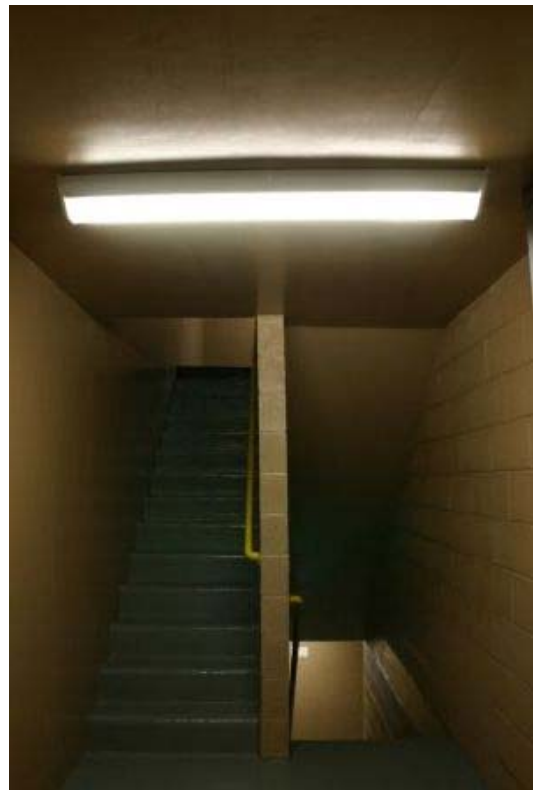


Figure 1: Occu-smart fixture on stair landing



Figure 2: Occu-smart fixture (showing ultrasonic transducers)

¹ U.S. Congress. 1990. Americans with disabilities act of 1990. PL 101-336. Washington: U.S. G.P.O.

² The “all off” option is less desirable for sites with view into staircase through a fireglass window, since the environment may look unsafe for entry. This option also may not meet fail-safe Code requirements.

³ Maniccia, D., Tweed, A., Bierman, A., and Von Neida, B. 2001. "The effects of changing occupancy sensor time-out settings on energy savings, lamp cycling and maintenance costs." *Journal of the Illuminating Engineering Society* 30, no. 2: 97-110

Sensitivity can be adjusted after installation as well, which will impact coverage distance. The manufacturer intends for lights on the landings above and below to be triggered from a door swing. Sensitivity adjustment will affect energy savings, since it affects the number of fixtures that are turned on to the “high” setting for each occupancy event.

Because the lamps spend the majority of their time at a dimmed setting, the IESNA (Illuminating Engineering Society of North America) recommends that lamps be seasoned before operation to reduce likelihood of premature lamp failure.⁴ For this reason, LaMar has provided a lamp seasoning button for use with every lamp change, to power the lamps at full output for 100 hours. An LED indicator light continues to flash until 100 hours have elapsed, at which point the lamps are seasoned according to IESNA recommendations.

The system “fails to on,” meaning that if the occupancy sensor fails, the light fixture does not turn off the lamps, but rather turns lamps to the “low” ballast setting. Failing-to-on is a safety feature required by the NFPA Life Safety Code.⁵ Installations of Occu-smart fixtures may need to meet minimum illuminance Code requirements at the “low” ballast setting.

Because each luminaire has its own sensor, occupancy in one area of a tall staircase will not cause fixtures in the entire staircase to turn up to full output, as would be the case with traditional stand-alone occupancy sensors.

⁴ Illuminating Engineering Society of North America. 1999. IESNA LM-54-99 Guide to Lamp Seasoning.

⁵ National Fire Protection Association. 2003. NFPA 101 Life Safety Code.

Field Test: Rivercross

Project Description and Photographs

The Rivercross site is a high-rise residential complex located on Roosevelt Island, east of Manhattan Island in New York. The complex is composed of three towers, each with separate egress staircases. Staircases are straight run with no mid-floor landing.

LRC researchers evaluated the lighting before and after installation of the Occu-smart lighting.

The existing lighting was installed in the early 1990s, with two-lamp T12ES electronic ballasts. Distribution of the old lighting was primarily downward (see Figures 5 and 6). LRC researchers measured photometric conditions in the staircases when the old lighting was still in place.

In fall 2003, each of the existing light fixtures in the staircases was replaced with an Occu-smart fixture with the 30% ballast option. After commissioning was completed by LaMar Lighting, LRC personnel returned to measure photometric conditions and to interview the building operations staff.

As shown in Table 1 and Figure 7 (page 9), illuminances at the full output setting increased 2-10 times with the new lighting. This is partly due to new T8 lamps with little lumen depreciation and higher mean lumen output. But much of the increased illuminances in the stairs are due to increased optical efficiency of the Occu-smart unit, compared with the old lighting. The lamps are not mounted deep within the recess of the fixture, but rather are wrapped by a diffuser lens (see Figure 4).

The dropped diffuser and lamp mounting location both increase optical efficiency. However these features, together with higher lumen output lamps, may also increase perception of glare since they increase the luminance of the diffuser. The luminance of



Figure 4: Rivercross site, Roosevelt Island, New York



Figure 3: Old fixture (above) and new Occu-smart fixture (below)

the Occu-smart diffuser is 4 times higher than the old fixture (see Table 1). At the same time, contrast with the surrounding surfaces is 3 times *lower* than before, due to the fact that the dropped diffuser distributes light on the ceiling (see Figure 5). Luminance contrast is also a component of perception of glare. LRC researchers estimate that the glare rating of the Occu-smart fixture is equivalent to that of the old fixture, and that both may be considered glaring.⁶ Individuals who are particularly sensitive to glare (such as the elderly) may find either fixture uncomfortable to look at.⁷ However, at the time of this writing, the management at Rivercross had not received any complaints about glare (see Appendix 2).

As shown in the figures below, the Occu-smart fixture emits light at high angles, allowing the light to penetrate deep into the staircase, nearly reaching the top stair. This compares favorably to the previous lighting which created shadowy corners that did not meet minimum illuminance code requirements of 10.76 lux (1 footcandle) along the path of egress (see Photometric Measurements, page 9).

When the space is unoccupied, the lighting is reduced to 30% of full output. Even at the low level, most of the horizontal points measured on the staircase meet minimum code requirements for jurisdictions following the NFPA Life Safety Code (see Appendix 1).



Figure 5: Before (left) and after (right)

⁶ The LRC estimates a glare rating (UGR) of approximately 32 for both products. The Chartered Institution of Building Services and Engineers (CIBSE) publishes lighting recommendations in England, and recommends maximum glare rating of 25 for traffic zones such as stairs. For comparison, a glare rating of 7 is considered imperceptible. See CIBSE *Code for Lighting* (Oxford, UK: Butterworth Heineman, 2002, p. 55).

⁷ Many of the residents of Rivercross are elderly, having lived at the facility for many decades. The complex is owned cooperatively by the residents themselves, which has led to stability in population.

The Illuminating Engineering Society of North America recommends higher illuminances in egress spaces with a change of elevation because staircases are listed as a high hazard space. IESNA recommends a minimum of 54 lux (5 fc) for high hazard spaces.⁸

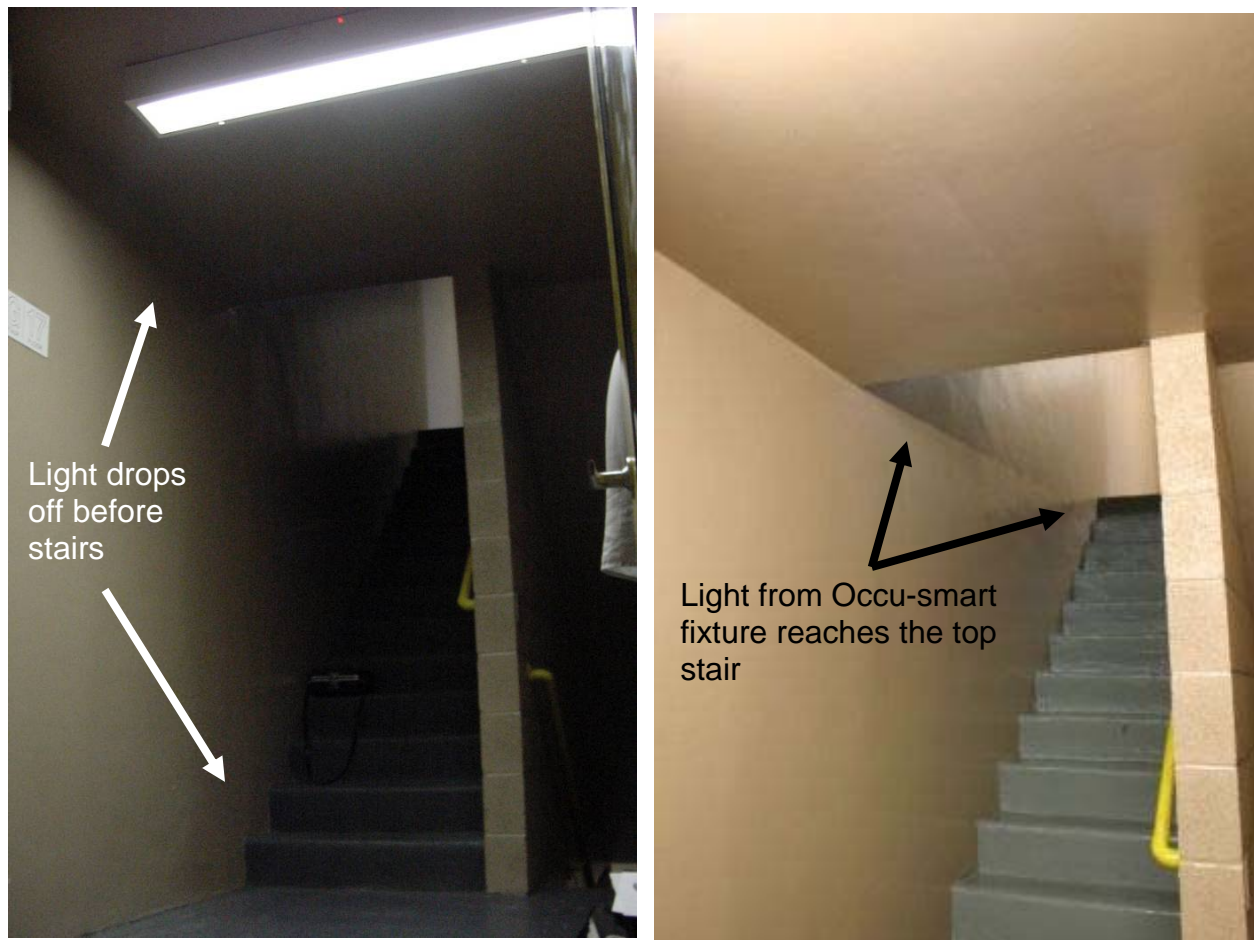


Figure 6: Before (left) and after (right) retrofit; light now penetrates deep into stairwell.

Human Factors

The Rivercross Board did not permit LRC to interview or survey residents at Rivercross. However, LRC researchers did interview the building's general manager and building manager (see Appendix 2).

After three months, there were no complaints about the Occu-smart fixtures, neither in terms of appearance nor maintenance. Residents noticed the increased illuminance levels and were reassured that the new lighting uses less energy because of the occupancy sensors.

The installation is well-received by the people at Rivercross.

⁸ Rea, M.S. *Lighting Handbook: Reference & Application*. 2000. New York, NY: Illuminating Engineering Society of North America 29-2,3.

Photometric Measurements

The “before” condition consists of a 4-foot fixture with flat lens and two recessed T12ES lamps. The “after” condition consists of the Occu-smart fixture with two 4-foot T8 lamps and dropped lens.

The measurements below were performed at the high output condition. The “low” condition can be estimated by multiplying the “after” values by 30%.

Table 1: Rivercross Photometric Measurements, Full Output

		Illuminance (lux)		Illuminance (lux)		
		In Staircase		On Landings		
		Before	After	Before	After	
A	h	65	174 (152)	G	116	208
	v	44	128	H	139	245
	up	4	32	I	108	247
	down	98	328	J	110	215
B	h	12 (3)	60 (34)	K	109	251
	v	7	74	L	114	246
	up	9	52	M	98	197
	down	3	12	N	84	176
C	h	52 (2)	128 (13)	O	88	195
	v	3	21 (17)	P	116	243
	up	58	270	Q	152	271
	down	3	16	R	122	239
D	h	41 (2)	107 (12)	S	80	173
	v	2	20			
	up	24	240			
	down	2	15			
E	h	11 (4)	63 (36)	Luminance (cd/m²)		
	v	9	73	Before	After	
	up	8	65	T	15	36
	down	3	11	U	14	27
F	h	66 (55)	145	V	9	18
	v	42	124	W*	2	30
	up	4	28	X*	1310	5000
	down	37	296	Y*	3	27

* Measured as viewed from stairs

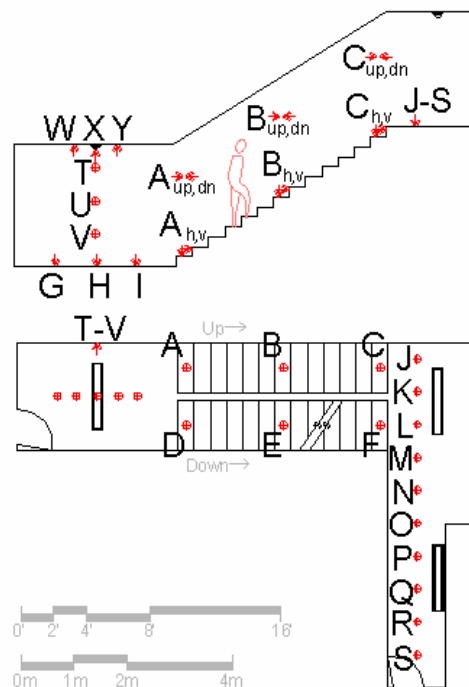


Figure 7: Measurement locations, typical Rivercross staircase

h = horizontal illuminance, measured in center of stair tread. Parentheses indicate darkest spot of tread

v = vertical illuminance on vertical face of tread (upward)

up = vertical illuminance at the eye, facing the upward direction

down = vertical illuminance at the eye, facing the downward direction

Field Test: Lexington

Project Description and Photographs

The Lexington site is a high-rise office building located at 575 Lexington Avenue in New York City. The building has four separate egress staircases. Most staircases are standard scissor stairs, with a landing mid-way between floors.

The existing lighting was installed in the 1960s and consisted of one- and two-lamp 2-foot F20T12 bare fluorescent strip lights.⁹ Luminaires were mounted on ceilings or on walls. LRC researchers measured photometric conditions in several of the staircases when the old lighting was still in place. Horizontal illuminances were in the range of the minimum allowable per Code.

In 2003, the existing strip lights were replaced with Occu-smart fixtures. The new lighting was four feet in length, using two T8 lamps. The ballast was the 10% option, which was important for showing energy savings because of the low wattage (28 W) most of the old fixtures.

After commissioning was completed by LaMar Lighting, LRC researchers took photometric measurements in two of the four staircases and interviewed maintenance staff.

As shown in Table 2, most illuminances at the full output setting increased 3 times with the new lighting. This is due to higher lumen output lamps and an increased number of lamps rather than increased optical efficiency. The Occu-smart bi-level setting allowed the retrofit to increase the maximum lighting wattage in the stairs and still achieve substantial energy savings because the stairs were occupied less than 4% of the time. (see “Energy Savings”, page 17).

Human Factors

LRC interviewed the building’s owner and building manager. After several months, there were no complaints about the Occu-smart fixtures, neither in terms of appearance nor maintenance. Occupancy in the space is negligible, supporting the use of occupancy sensor technology.



Figure 8: 575 Lexington Ave, NY



Figure 9: New Occu-smart fixture, and smoke outline of old fixture (mounted perpendicular to the new fixture)

⁹ The building operations manager estimated that 25% of the fixtures were 2-lamp units.

Photometric Measurements: Staircase A

Staircase A is a scissor stair, with a luminaire on the mid-landing (see Figure 10). As expected, illuminances did increase.

The “before” condition used two-lamp, 2-foot T12ES bare strip lights. The “after” condition was 2-lamp T8 Occu-smart fixtures.

The measurements below were at the high output condition. The “low” condition can be estimated by multiplying the “after” values by 10%.

Table 2: Staircase A Photometric Measurements

		Illuminance (lux)		Illuminance (lux)		
		Before	After	Before	After	
A	h	24	85 (33)	G	31	97
	v	18	77		H	29
B	h	24	90 (54)	I	29	79
	v	23	77	J	36	106
C	h	27 (18)	96 (66)	K	40	127
	v	20	64	L	29	88
D	h	20 (7)	82 (57)	Luminance (cd/m²)		
	v	17	40			
E	h	22 (14)	77 (48)	Before	After	
	v	14	47	M	4168	6000
F	h	26 (20)	81 (38)			
	v	13	48			

h = horizontal illuminance, measured in center of stair tread. Parentheses indicate darkest spot of tread.

v = Vertical illuminance on vertical face of tread (upward)

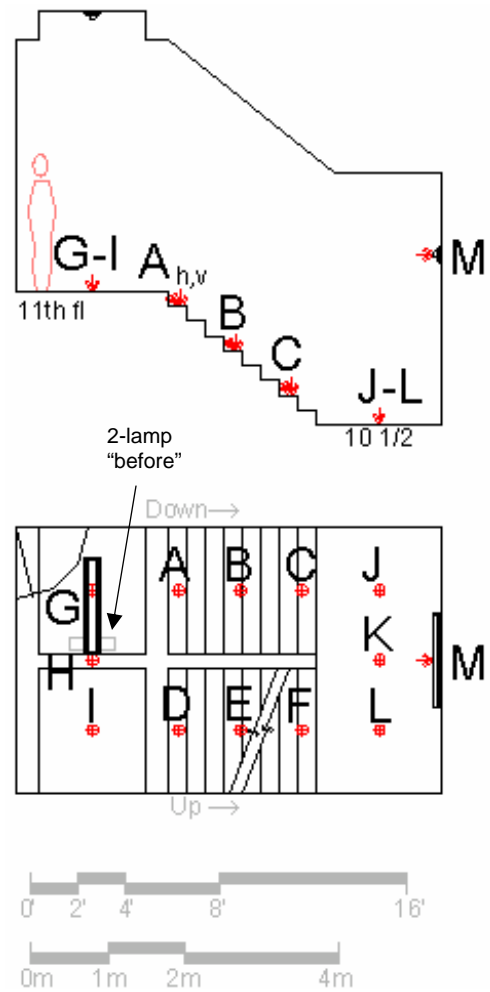


Figure 10: Lexington Staircase A

Photographs: Staircase A

Photos of the “before” condition are unavailable, but evidence of the location of previous strip light fixtures can be seen in the smoky outline (see Figures 9 and 11).



Figure 11: Staircase A, mid-landing between 10-11th floors



Figure 12: Staircase A, 11th floor landing

Photometric Measurements: Staircase A (Straight Run)

LRC researchers measured an instance of a straight run staircase at Lexington, similar to Rivercross stairs. Illuminances increased again, but at the Lexington project this was due primarily to increased lamp quantity and lumen output (rather than increased optical efficiency).

Table 3: Photometric Illuminances, Staircase A (Straight Run)

		Illuminances (lux)	
		Before	After
A	h	16 (2)	55 (6)
	v	1	6
B	h	12 (1)	37 (3)
	v	1	7
C	h	8 (1)	28 (4)
	v	1	10
D	h	9 (3)	50 (28)
	v	4	53
E	h	11 (6)	71 (53)
	v	5	60
F	h	11 (7)	90 (74)
	v	5	52
G		29	114
H		28	92
I		25	76

		Luminances (cd/m ²)	
		Before	After
J		7	25
K		4	30
L		2	8

- h =** Horizontal illuminance, measured in center of stair tread. Parentheses indicate darkest spot of tread.
- v =** Vertical illuminance on vertical face of tread (upward)

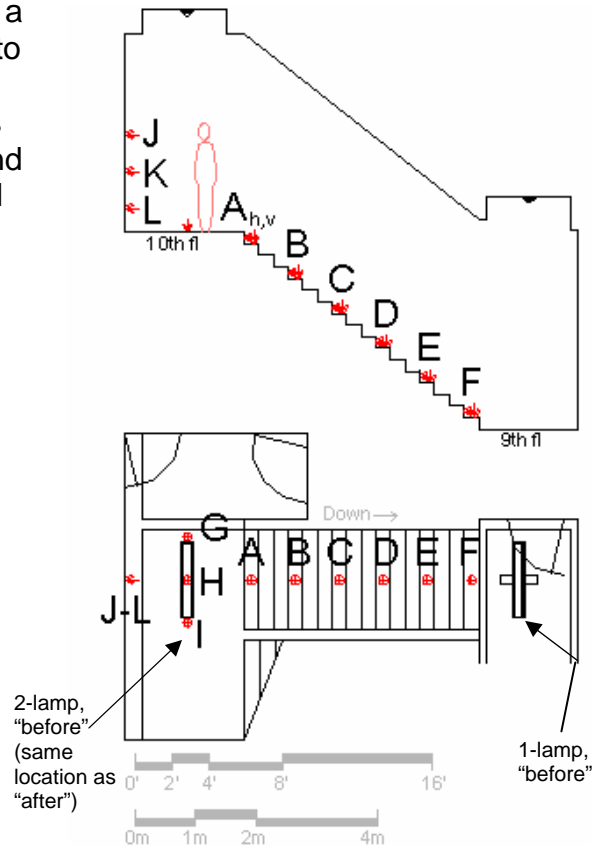


Figure 13: Measurement Locations, Staircase A (Straight Run)

Photographs: Staircase A (Straight Run)



Figure 14: Staircase A (Straight Run), looking downward

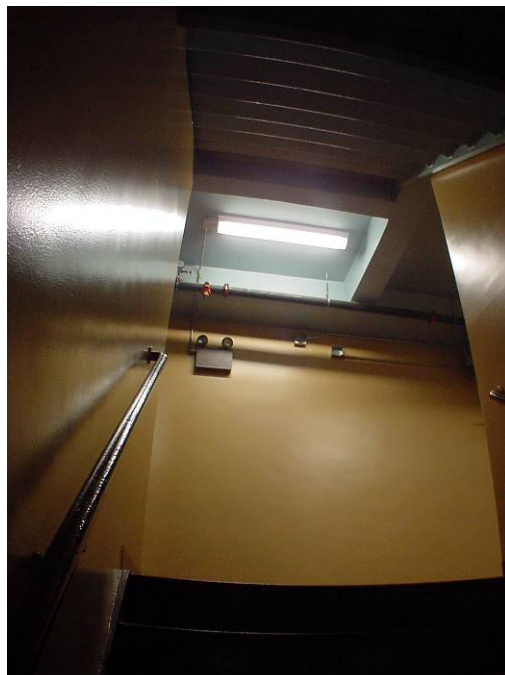


Figure 15: Staircase A (Straight Run), looking upward

Photometric Measurements: Staircase C

Table 4: Photometric Measurements Staircase C

		Illuminance (lx)		Illuminance (lx)	
		Before	After	Before	After
A	h	7 (3)	100 (32)	G	10 111
	v	9	109	H	10 123
B	h	9 (6)	112 (69)	I	10 120
	v	12	137	J	19 147
C	h	13 (10)	141 (107)	K	26 168
	v	13	111	L	19 157
D	h	10 (6)	116 (90)		
	v	5	53		
E	h	10 (5)	120 (79)		
	v	6	73		
F	h	12 (5)	122 (55)		
	v	6	75		

h = Horizontal illuminance, measured in center of stair tread. Parentheses indicate darkest spot of tread.
v = Vertical illuminance on vertical face of tread (uphill)

		Luminance (cd/m ²)	
		Before	After
M		0.5	6
N		8	27
O		0.8	6
P		2896	3400-6500
Q		14	22
R		0.7	12
S		3361	5000
T		33	36
U		3	11
V		0.8	5

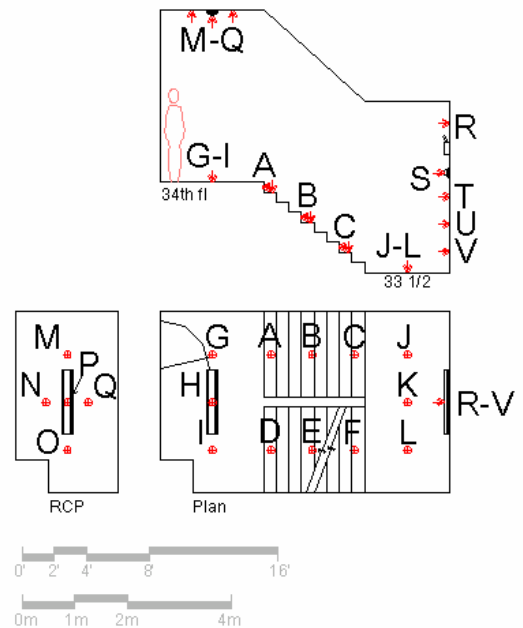


Figure 16: Measurement Locations, Staircase C
 (New fixtures installed in same location as old)

Photographs: Staircase C



Figure17: Staircase C, light distribution shadow (shadow shows direction of light which reaches mid-floor landing)



Figure 18: Staircase C landing, 34th floor

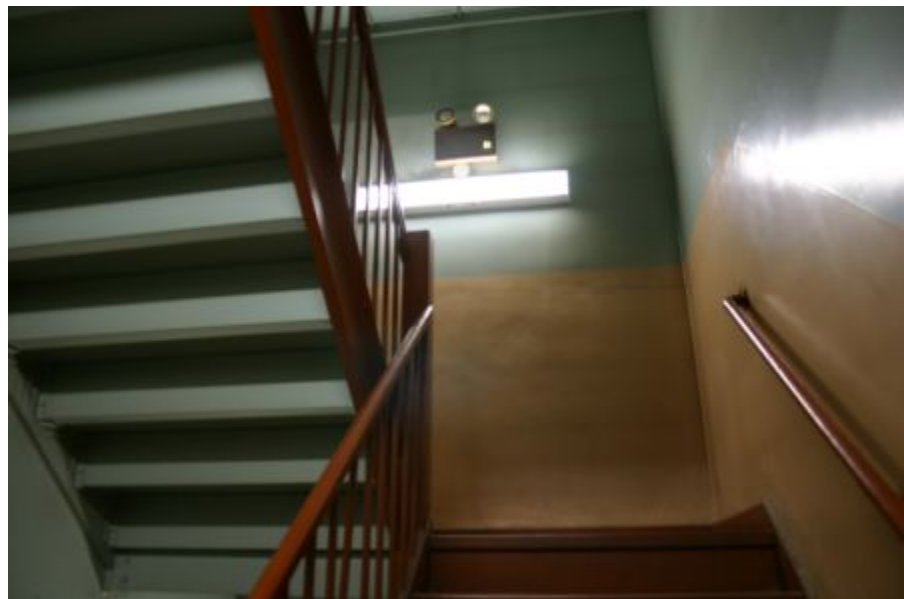


Figure 19: Staircase C, mid-floor landing

Energy Savings

LRC researchers calculated energy savings due to the use of the new Occu-smart fixtures at the Rivercross and Lexington sites. Several data inputs and assumptions were required, as described in Appendix 3.

Watt Stopper IntelliTimer® light loggers were installed (by others) in both projects to estimate typical occupancy percentages. As expected, occupancy percentages were found to be very low in both projects (see Figure 20, right). Lower floors had higher occupancy, and thus were separated in the analysis for increased accuracy.

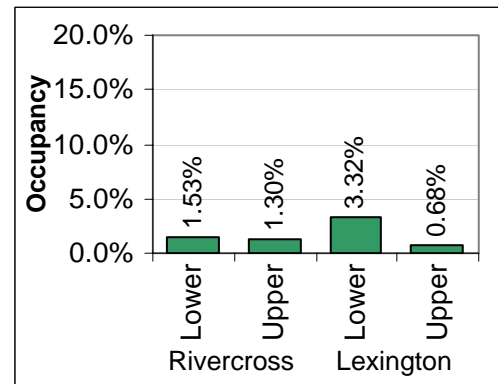


Figure 20: Occupancy Rates

By these estimates, the installation at Rivercross is annually saving 50,303 kWh or 53%. Assuming a conservative 50% demand reduction, these savings translate to \$4,741 per year, or a 4.9 year simple payback (see Appendix 6). If emergency battery packs had not been required, payback would have shortened to 2.6 yrs.

The installation at Lexington is annually saving 45,032 kWh or 60%. Assuming a conservative 50% demand reduction, these savings translate to \$5,916 per year, or a 5.0 year simple payback.

It should be noted that:

- Other installations could show higher energy savings depending on “before” conditions.
- The greater the energy use of the “before” condition, the easier it is to show energy savings in the “after” condition.
- With such low occupancy percentages in staircases, ballast wattage at the low setting drives energy savings. “Overlighting” at the high level has less impact on energy savings than minimizing wattage at the low setting.
- The higher the electricity rates, the shorter the payback times for equivalent systems: Rivercross, approximately \$.085/kWh; Lexington, approximately \$.12/kWh
- As noted in Appendix 1, some codes limit use of occupancy sensors in stairwells to 15-minute delay times. Changes in time delay affect energy savings.
- Energy savings could be increased by using an on/off switching design, rather than high/low. This option must be balanced with occupant needs, since view through a staircase door window may reveal a staircase with no lights on, which may undermine safety in an emergency.

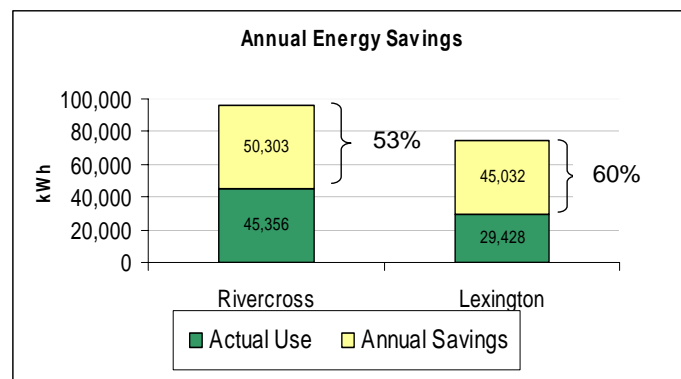


Figure 21: Annual Energy Savings

Laboratory Tests: Ballast Wattage

LaMar Lighting provided the LRC with a sample of each of the high-low ballasts used in the Occu-smart fixtures at the Rivercross and Lexington field test sites. LRC testing verified that the Rivercross ballast (30% light output at low setting) operated as expected, within 6% of manufacturer reported wattage at the low setting.

Lexington used a ballast with a lower light output at the low setting (10% vs. 30% for Rivercross). The ballast sample of the type used at Lexington operated at a higher wattage than reported by the ballast manufacturer. The LRC tested one ballast sample provided by LaMar lighting, which at the low level operated at 30% higher wattage than expected. A second test was done with the same sample operating lamps from different manufacturers; results were similar to the first test: 20%-30% higher wattage than expected. A third test was conducted with an actual Occu-smart fixture operating another ballast sample of the same type. This sample operated at 15%-25% higher wattage than manufacturer reported data. A fourth test was done with another ballast sample sent by LaMar, yielding results similar to the first (wattage elevated by 20%-40%).

After the first wattage test, representatives from the LRC contacted the ballast manufacturer to verify expected wattages, and to determine the cause for the ballasts operating at elevated power settings. Their explanations were many: wattage can vary with lamp manufacturer (confirmed); components used in the manufacture of the recent sample may differ slightly from the original testing; and more samples are suggested to clearly identify actual operating wattage at the low setting.¹⁰

This type of testing is beyond the scope of this project, but may be considered for follow-up work. At this time, the LRC has assumed that the operating wattage at the low setting at the Lexington project is consistent with the ballast manufacturer's data. If future studies reveal that wattage assumptions should be increased, this would impact the energy savings calculation.

¹⁰ Per e-mail correspondence with Technical Engineering Services, Universal Lighting, dated 1/13/04.

Conclusions

For both field test sites, the occupancy sensing feature of Occu-smart fixture is acceptable to maintenance staff and any occupants who have noticed it. More research is needed to determine whether occupants find the fixture uncomfortable to view.

Because energy savings are driven by the wattage at the low ballast setting, it may be valuable for future effort to investigate other ballast and switching options. Energy savings can be increased by using an on/off switching design, rather than high/low. (This is an option offered by LaMar Lighting.) Other options must be balanced with occupant needs, since they may impact safety.

As a result of the occupancy sensor feature, illuminances can be increased when the space is occupied without sacrificing energy savings. Compared to the old lighting in the Rivercross project, the Occu-smart has also improved distribution of light, allowing light to penetrate deep into stairwells.

For both field tests, the Occu-smart fixtures succeeded in saving energy, even when the previous fixtures were very low in wattage. Occupancy in all areas of all stairwells was very low for both projects, justifying the use of occupancy sensors.

Credits and Contact Information

Rivercross

531 Main Street

Roosevelt Island, NY

General Manager: Mitchell Hammer

Building Operations: Zenel Perezic

Project Engineer: Meg Carey, M. C. Energy, Katonah, NY

Other Technical Assistance: Willard Warren, Willard Warren Associates, New York, NY

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Glare Estimation: Yukio Akashi

Graphics: Jennifer Brons

Photography: Dennis Guyon, Jennifer Brons (except Lexington photo, provided by building owner)

Reviewers: Russell Leslie, Sandra Vasconez

Editing: Dennis Guyon

Appendix 1: Code Implications

As per the NFPA Life Safety Code, section 5-8.1.2:

“Automatic, motion sensor-type lighting switches shall be permitted within the means of egress, provided that switch controllers are equipped for fail-safe operation, illumination timers are set for a minimum 15 minute duration, and the motion sensor is activated by any occupant movement in the area served by the lighting units.”

“The floors and other walking surfaces within an exit and within the portions of the exit access and exit discharge designated in 5-8.1.1 shall be illuminated to values of at least 1 ft-candle (10 lux) measured at the floor.”

Since Occu-smart installations can meet the operation requirements of the Life Safety Code, use of this product is not prohibited by Code. Local jurisdictions may place additional requirements on the use of Occu-smart in egress spaces¹¹. Occupants may choose shorter delay times than 15 minutes, which may impact compliance with Code.

¹¹ At the time of this writing, Occu-smart is designed to turn lamps to the low level (rather than “off”) if the occupancy sensor fails. Local fire marshalls may require that the installation meet minimum illuminance requirements at the “low” level.

Appendix 2: Rivercross Interview

Despite repeated requests, occupant surveys were not permitted by the Rivercross Board. LRC researchers interviewed the building's general manager and operations manager in December 2003 and their comments are paraphrased below.

- No complaints from the residents.
- Residents were interested when the lights were installed, asking whether the correct product was installed. They could tell the fixtures provided more light, which they didn't expect in an energy-driven retrofit. The management explained that even though light levels were higher, they were still consuming less energy, due to the occupancy sensors.
- Building residents said, "Wow, they're really bright! Those (Occu-smart fixtures) are brighter than the ones they replaced... is that *right*?"
- Building operations commented that the fixtures are bright enough at the low level, so when they go up to 100%, they are "even too bright." In this person's opinion, the lighting appeared too bright at the high level, not because of discomfort glare, but rather because it seemed wasteful (lamps were viewed early in their life cycle, with highest lumen output).
- The Occu-smart fixtures work.
- A few fixtures here and there seem to stay at 100% output (unverified).
- The lamp life does not seem to be affected by operation at dim condition. A few lamps failed immediately after installation. These may simply have not been seasoned properly, but the rest seem normal. Lamp failure has not been an ongoing problem.

Appendix 3: Energy Calculation Methodology

Occupancy was calculated by use of Watt Stopper IntelliTimer light loggers. Light loggers were provided, installed, retrieved, and data was downloaded by others. LRC researchers did not control the placement of light loggers for either Rivercross or Lexington.

- For Rivercross, data were collected both before and after the Occu-smart installation, for two weeks each in the spring and fall of 2003. LRC researchers used the light logger data to sample typical occupancy in four levels of one staircase.
- For Lexington, data were collected for two weeks in the summer of 2003, after the Occu-smart installation.
- These installations have chosen 5 minute timer settings, meaning that they remain at full output for 5 minutes after occupancy is sensed. When processing light logger data, for every instance occupancy was sensed, LRC assumed at least 5 minutes of illumination took place. These instances were totaled, and divided by the total elapsed time for each light logger location, which generated a value for percentage occupancy.
- Light loggers from upper staircase levels were grouped separately from lower levels. Percentage occupancy was averaged for the upper staircase levels, apart from lower levels to increase accuracy.
- Occupancy percentages were multiplied by hours of the year and fixture quantity and wattage to calculate kilowatt-hour savings.
- Any light logger data indicating the space was “lighted” was ignored since Occu-smart fixtures remain lighted when at the low level. Only “occupied” data were used for this calculation.
- Data were removed from time periods in which light loggers were being installed or removed.
- It was assumed that occupancy sensed by the light loggers was also sensed by the Occu-smart fixtures. IntelliTimer light loggers use infrared sensors, while the Occu-smart uses an ultrasonic sensor. It is possible that the Occu-smart fixtures could be triggered by conditions that the light loggers do not sense.

Energy Calculations

- **Electrical demand savings** were included in the calculation, with the assumption that no more than 50% of the fixtures were at high output during times of peak demand. Demand savings were calculated assuming non-peak rate.
- **Ballast wattage, Rivercross:** Ballasts used in old fixtures were recorded by LRC personnel on site during fixture change out in fall 2003 (model: EBT SSB1 277 2/40). Subsequent investigation revealed that EBT was purchased by Advance Transformer, who reported the ballast wattage. The ballast type in the new fixtures was Universal B232SR277S30. Wattage at high and low levels was reported by Universal, and confirmed in laboratory tests at the LRC.
- **Ballast wattage, Lexington:** Ballasts used in old fixture was assumed to be that of a remaining 1-lamp fixture located on site in December 2003 (model: Advance RLQ-120). Wattage data about an equivalent 2-lamp version (model: Advance HM-

2SP20-TP) was taken from the ballast manufacturer's catalog. Ballast wattage at high and low levels were reported by Universal, but were not confirmed by laboratory tests at the LRC (see page 18 for discussion).

- **Utility rate structure, Rivercross**, was provided by the building's general manager and the building's electricity provider and utility web site.
- **Utility rate structure, Lexington**, was provided by the building owner and utility web site.
- **Fixture quantities and types (before), Lexington**, was estimated by the building superintendent to have been 25% 2-lamp, 75% 1-lamp.
- **Fixture quantities (after)** were confirmed by LaMar Lighting (250 fixtures, all 2-lamp).
- **NYSERDA fixture rebate** information for Rivercross (\$70/ea.) was provided by LaMar Lighting. For Lexington, rebate information was provided by the building owner and updated by LaMar Lighting. (\$70/fixture)
- **Fixture installation cost, Rivercross**, was estimated by the electrician, Harley Electric of Bronx, NY (\$40/fixture)
- **Fixture cost, Rivercross**, was provided by the general manager (\$158/each).
- **Fixture cost and installation cost, Lexington**, was provided by the owner (\$148/each, \$40/each fixture installation)
- **Cost of emergency battery packs, Rivercross**, provided by LaMar lighting (\$60/each). Rivercross used emergency battery packs in the "before" fixtures, so the retrofit Occu-smart fixtures had to duplicate this feature. As a result, payback period is longer than it would have been if no battery packs were necessary (4.9 yrs vs. 2.6 years). Other sites may not require this battery feature.

See Appendices 4-6 for more information about energy calculations.

Appendix 4: Typical Light Logger Calculation Example

				Occupied %	1.431%
Total Monitoring time			362:08	Occupied Time	5:11:00
Entry	Date and Time of Entry	Time	Lighting	Occupancy	Occup
1	10/30/03 10:36 AM	7:32	Unlit	Vacant	
2	October 30, 2003 6:08:00 PM	0:05	Lit	Occupied	0:05:00
3	October 30, 2003 6:13:00 PM	13:41	Unlit	Vacant	
4	October 31, 2003 7:54:00 AM	0:05	Lit	Occupied	0:05:00
5	October 31, 2003 7:59:00 AM	9:24	Unlit	Vacant	
6	October 31, 2003 5:23:00 PM	0:05	Lit	Occupied	0:05:00
7	October 31, 2003 5:28:00 PM	0:01	Unlit	Vacant	
8	October 31, 2003 5:29:00 PM	0:05	Lit	Occupied	0:05:00
9	October 31, 2003 5:34:00 PM	0:02	Unlit	Vacant	
10	October 31, 2003 5:36:00 PM	0:05	Lit	Occupied	0:05:00
11	October 31, 2003 5:41:00 PM	0:35	Unlit	Vacant	
12	October 31, 2003 6:16:00 PM	0:05	Lit	Occupied	0:05:00
13	October 31, 2003 6:21:00 PM	0:11	Unlit	Vacant	
14	October 31, 2003 6:32:00 PM	0:08	Lit	Occupied	0:08:00
15	October 31, 2003 6:40:00 PM	0:02	Unlit	Vacant	
16	October 31, 2003 6:42:00 PM	0:08	Lit	Occupied	0:08:00
17	October 31, 2003 6:50:00 PM	0:12	Unlit	Vacant	
18	October 31, 2003 7:02:00 PM	0:05	Lit	Occupied	0:05:00
19	October 31, 2003 7:07:00 PM	0:04	Unlit	Vacant	
20	October 31, 2003 7:11:00 PM	0:06	Lit	Occupied	0:06:00
21	October 31, 2003 7:17:00 PM	0:02	Unlit	Vacant	
22	October 31, 2003 7:19:00 PM	0:05	Lit	Occupied	0:05:00
23	October 31, 2003 7:24:00 PM	0:01	Unlit	Vacant	
24	October 31, 2003 7:25:00 PM	0:12	Lit	Occupied	0:12:00
etc...					

Appendix 5: Occupancy Percentage Sheets

Table 5: Rivercross Occupancy Percentages

	Occupancy	Set-up date	End Date
2nd floor - Before	0.6%	2/28/03 9:06	3/12/03 6:33
2nd Floor - After	2.42%	10/30/03 10:55	11/14/03 12:49
Average, lower floors	1.53%		
7th Floor - After	1.4%	10/30/03 10:36	11/14/03 12:44
17th Floor - After	1.5%	10/30/03 10:46	11/14/03 12:51
7th floor - Before	0.7%	2/28/03 9:06	3/12/03 6:33
12th floor - Before	1.6%	2/27/03 9:43	3/12/03 6:29
Average, upper floors	1.30%		

Table 6: Lexington Occupancy Percentages

	Occupancy	Set-up date	End date
Stair B - Floor 2 Ceiling.txt	4.08%	7/10/2003 12:12	7/24/2003 9:47
Stair D - Floor 4 Ceiling.txt	2.56%	6/25/2003 13:32	7/24/2003 10:44
Average, lower floors	3.32%		
Stair A - Floor 10 Ceiling.txt	0.86%	7/10/2003 12:07	7/24/2003 10:54
Stair B - Floor 7 Ceiling.txt	0.03%	7/10/2003 12:38	7/24/2003 10:55
Stair C - Floor 32 Ceiling.txt	0.03%	7/10/2003 10:02	7/24/2003 9:30
Stair C - Floor 35 Ceiling.txt	0.12%	7/10/2003 9:54	7/24/2003 9:23
Stair D - Floor 18 Ceiling.txt	0.08%	6/25/2003 12:40	7/24/2003 10:15
Stair D - Floor 24 Ceiling.txt	3.88%	6/25/2003 12:22	7/24/2003 10:13
Stair D - Floor 32 Ceiling.txt	0.17%	6/25/2003 11:57	7/24/2003 10:11
Stair D - Floor 34-35 Wall.txt	0.27%	6/25/2003 10:42	7/24/2003 8:57
Average, upper floors	0.68%		

Appendix 6: Energy Calculation Sheets

The following are energy savings and simple payback calculations for Rivercross and Lexington. More complex economic calculations including the time value of money and estimated electric rate increases may yield estimates of shorter payback periods.

Rivercross used emergency battery packs in the “before” fixtures, so the retrofit Occu-smart fixtures had to duplicate this feature. As a result, payback period is longer than it would have been if no battery packs were necessary (4.9 yrs vs. 2.6 years). Other sites may not require this feature.

Table 7: Rivercross Energy Savings Calculation

				kWh						
Qty	watts	Hours								
Before	182	60	8760	<i>Actual Annual Energy Use, Before</i> 95,659 kWh						
5.824 Max Peak demand reduction										
After	Qty	Occupied			Vacant			Total Energy		
		Occup.	Hours	W	kWh	Vacant	Hours		W	kWh
Lower floors	18	1.53%	134	62	149.6	98.5%	8626	28	4,347	4,497
Above 2nd floor	164	1.30%	113	62	1154	98.7%	8647	28	39,705	<u>40,859</u>
									<i>Calculated Annual Energy Use, After</i>	45,356 kWh
									Annual Energy Savings	50,303 kWh
									Annual Savings (See electricity cost calculation sheet)	\$4,741
									Fixture Installation Cost	\$7,280
									Initial Fixture Material Cost (INCLUDING emergency batteries)	\$28,829
									Less NYSERDA Rebate	<u>(\$12,740)</u>
										\$23,369
									Simple Payback	4.9 yrs
									Fixture Installation Cost	\$7,280
									Initial Fixture Material Cost (EXCLUDING emergency batteries)	\$17,909
									Less NYSERDA Rebate	<u>(\$12,740)</u>
										\$12,449
									Simple Payback	2.6 yrs

Table 8: Rivercross Electricity Cost Calculation

ConEd Rate SC 12, Rate II, Low Tension, PSC 9 (Summer), PSC 2 (Winter)

Annual energy savings

50,303

Demand Savings 50% of total wattage savings, 5.824 kW*50%= 2.912kW
demand savings occurs after 6 PM

On-peak time	41.70%												Total Annual Savings
	Off-peak time	58.30%											
		May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Demand Charge	\$17.50	\$14.61	\$14.61	\$14.61	\$14.61	\$17.63	\$9.14	\$8.77	\$8.84	\$8.82	\$8.47	\$8.75	
Demand Savings	2.912	2.912	2.912	2.912	2.912	2.912	2.912	2.912	2.912	2.912	2.912	2.912	
Demand Cost Savings	\$50.96	\$42.54	\$42.54	\$42.54	\$42.54	\$51.34	\$26.62	\$25.54	\$25.74	\$25.68	\$24.66	\$25.48	\$426.20
Energy Charge on-peak	0.0868	0.0991	0.1163	0.1149	0.0898	0.0826	0.008	0.0086	0.0082	0.0076	0.0089	0.0089	
Energy Charge off-peak	0.0618	0.064	0.0697	0.0676	0.0594	0.058	0.0077	0.0084	0.0087	0.008	0.009	0.009	
Purchase Energy Cost							0.082	0.082	0.082	0.082	0.082	0.082	
SBC	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	
On-peak kWh saved	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	1748.0	
Off-peak kWh saved	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	2443.9	
Energy Cost Savings	\$309.47	\$336.35	\$380.34	\$372.76	\$308.85	\$292.84	\$383.25	\$386.01	\$386.04	\$383.28	\$388.00	\$388.00	\$4,315.17
Grand Total												\$4,741.37	

Table 9: Lexington Energy Savings Calculation

Before	Qty	watts	Hours	kWh	
1 lamp fixture	190	28	8760	<i>Actual Annual Energy Use, Before</i>	46,603 kWh
2 lamp fixture	60	53	8760		<u>27,857</u> kWh
					74,460 kWh
	250		5.250	Max Peak Demand Reduction	

After	Qty	Occupied				Vacant				Total Energy
		Occup.	Hours	W	kWh	Vacant	Hours	W	kWh	
Lower floors	20	3.32%	291	62	360.7	96.7%	8469	13	2,202	2,563
Above 4th floor	230	0.68%	60	62	851.7	99.3%	8700	13	26,014	<u>26,866</u>
									<i>Calculated Annual Energy Use, After</i>	29,428 kWh
									Annual Energy Savings	45,032 kWh
									Annual Savings	\$5,916
									(See calculation sheet)	
									Fixture Installation Cost	\$10,000
									Initial Fixture Material Cost	\$36,875
									Less NYSERDA rebate	<u>-\$17,500</u>
										\$29,375
									Simple Payback	5.0 years

Note: Before retrofit, illuminances in some parts of the Lexington stairs did not meet minimum Code requirements. The old lighting system may have needed to be upgraded even without use of Occu-smart. Depending on the material and installation cost of an alternate system, payback on Occu-smart may have been shorter than shown above.

Table 10: Lexington Electricity Cost Calculation

ConEd Rate SC 4, Rate II, High Tension, PSC 2

Annual energy savings 45,032

Demand Savings 50% of total wattage savings, 5.25 kW*50%= 2.625kW

On-peak time	41.70%												Total Annual Savings
Off-peak time	58.30%												
	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Demand Charge	\$9.56	\$23.70	\$22.73	\$22.75	\$23.60	\$9.42	\$10.05	\$10.09	\$9.73	\$9.78	\$10.12	\$10.13	
Demand Savings	2.625	2.625	2.625	2.625	2.625	2.625	2.625	2.625	2.625	2.625	2.625	2.625	
Demand Cost Savings	\$25.10	\$62.21	\$59.67	\$59.72	\$61.95	\$24.73	\$26.38	\$26.49	\$25.54	\$25.67	\$26.57	\$26.59	\$450.61
Energy Charge on-peak	0.0057	0.0064	0.0015	0.0017	0.0063	0.0052	0.008	0.0086	0.0082	0.0076	0.0089	0.0089	
Energy Charge off-peak	0.0059	0.0069	0.0029	0.0031	0.0068	0.0058	0.0077	0.0084	0.0087	0.008	0.009	0.009	
Purchase Energy Cost	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	0.1131	
SBC	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	
On-peak kWh saved	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	1564.9	
Off-peak kWh saved	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	2187.8	
Energy Cost Savings	\$452.26	\$455.54	\$439.12	\$439.87	\$455.16	\$451.26	\$459.79	\$462.26	\$462.29	\$459.82	\$464.05	\$464.05	\$5,465.48
Grand Total												\$5,916.08	

Appendix 7: Field Test DELTA Snapshot

A Field Test DELTA Snapshot publication was published in March 2004. This publication can be downloaded from the LRC website at any time. www.lrc.rpi.edu/



Field Test Snapshots

STAIRCASE LIGHTING

Demonstration and Evaluation of Lighting Technologies and Applications ▲ Lighting Case Studies

Staircases are required to provide lighting for emergency egress. Lighting typically remains on at full output year-round despite very low occupancy patterns. The Occu-smart® luminaire was developed to help high-rise facilities save energy in staircases while maintaining appropriate lighting conditions for safety. Occu-smart uses a built-in occupancy sensor to automatically dim lamps to a standby level to save energy when the space is unoccupied.

Application Profile

Rivercross is a high-rise residential complex located on Roosevelt Island, in the East River between New York City boroughs of Manhattan and Queens. The complex is composed of three towers, each with separate egress staircases. The staircases are straight run, with no mid-floor landing. DELTA evaluated the lighting before and after retrofit of 182 luminaires at Rivercross. DELTA also evaluated a commercial installation of similar scale in Manhattan, which resulted in comparable energy savings (see reverse).

Lighting Objectives

- Reduce energy use when staircase is unoccupied
- Increase illuminance in staircase

Lighting Features

The luminaires at Rivercross remain at one-third of full light output when stairs are unoccupied. An integral ultrasonic occupancy sensor turns lights up to full output when a person enters the staircase. Because each luminaire has its own occupancy sensor, only luminaires in the immediate area are turned on when residents enter the staircase.

Luminaires, Lamps, and Ballasts

The previous luminaire type used two T12ES linear fluorescent lamps with an electronic ballast (50 W). Lamps were recessed within the housing, and the lens was flat. Distribution of the previous lighting was primarily downward (see inset above).



Before (Inset) and after Occu-smart retrofit, Rivercross staircase, New York

The new Occu-smart luminaire operates two T8 linear fluorescent lamps with an electronic bi-level ballast (83 W full, 28 W standby; see reverse for other options). The luminaire has a wrap-around diffuser, which emits light at high angles (above 90° from vertical). At Rivercross this distribution allows light to penetrate deep into the staircase, nearly reaching the top stair (see photo, left). The Occu-smart provides higher illuminance in the staircase and exceeds the minimum code requirements of 11 lux (1 footcandle) along the path of egress, even when dimmed to standby level (see drawing on reverse).

Residents have noticed the increased illuminance in the staircases. Building operations personnel have reassured residents that the lighting system uses less energy. Both the previous and the new luminaires feature emergency battery packs.

"Wow, they're really bright! How can they be more energy-efficient?"

—Typical comment from building resident



Distribution at high angles allows light to reach the top stair

Field Test Snapshots Issue 1 STAIRCASE LIGHTING

Field Test Snapshots

STAIRCASE LIGHTING



Perspective showing photometric conditions at full output in typical Rivercross staircase (measurements of previous lighting shown in parentheses); for standby levels, divide values by 3

Energy savings comparison, Occu-smart® options

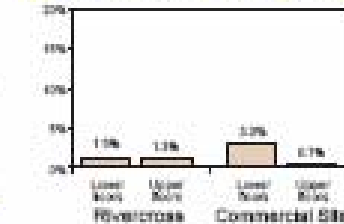
Compared to the existing luminaires at Rivercross, the following table shows what energy savings would have resulted if other bi-level ballast options had been selected.

Standby state (when unoccupied)	4-foot lamp quantity	Energy savings	Comments
Lamp(s) off	1	99%	Option may be unsuitable for use in staircase applications.
	2	99%	
1 lamp on, 1 lamp off	2	46%	
Lamp(s) dimmed to 50% output	1	76%	Option chosen by Rivercross.
	2	83%	
Lamp(s) dimmed to 10% output	2	77%	Nominally 10% output, but may be lower. Ballast factor reported as .88 at standby.
Lamp(s) dimmed to 5% output	1	84-90%	Multiple ballast manufacturers may be used, resulting in a range of savings.
	2	78-77%	

Notes:

- DELTA assumes lamp output and ballast wattage to be those reported by luminaire/ballast manufacturers. DELTA has not verified all operating wattages.
- Single-lamp configuration not acceptable to Rivercross.
- Other sites may have higher or lower savings depending on previous conditions and occupancy percentages.

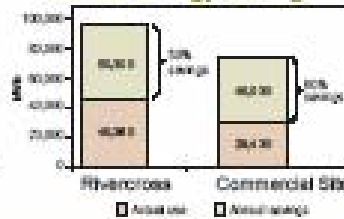
Typical Staircase Occupancy



Illuminance and Energy

The new luminaires have increased illuminances without sacrificing energy savings. At Rivercross, use of occupancy sensors resulted in a 53% energy savings, or 50,300 kWh annually. Occupancy in the staircases at Rivercross was measured to be less than 2%. As a result, the ballasts are operating at the standby level (28 W) 98% of the time. A commercial site evaluated by DELTA showed similar occupancy rates in the staircases. Other installations could show lower or higher energy savings depending on previous conditions, occupancy rates, and Occu-smart standby levels (see 'Energy savings comparison' above).

Annual Energy Savings



Field Test DELTA Snapshots
 Issues 1, March 2004
 Staircase Lighting
 Site Sponsors: Lullier Lighting, New York State Energy Research and Development Authority (NYSERDA)



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 Field Test DELTA evaluates new energy-efficient lighting products to independently verify field performance claims and to suggest improvements. A primary goal of the Field Test DELTA program is to facilitate rapid market acceptance of innovative energy-efficient technologies.



Lighting Research Center

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