STUDY

Detailed Lighting Feasibility Study for San Diego City Libraries

May 2004

San Diego Regional Energy Office

public agency energy partnership

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The San Diego Public Agency Energy Partnership Program provides information, education and technical assistance to help local public agencies take energy efficiency measures from idea to implementation. Through this program, SDREO assists public agencies to develop comprehensive energy management strategies, develop and adopt efficient energy policies and practices, and implement specific energy projects. SDREO provides free energy assessments and seminars on energy efficiency topics. The program is sponsored by the California Public Utilities Commission.

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1.0 INTRODUCTION

On January 14, 2004 the California Energy Commission approved a loan for the City of San Diego to implement 68 energy efficient upgrades at libraries and police stations across the city. A majority of these retrofits are lighting related upgrades. To insure proper use of the loan funds, SDREO hired consultant Stan Walerczyk, LC, to complete a lighting feasibility study at the six main libraries receiving lighting upgrades.

Utilizing the recommendations herein, 0.7 – 0.9 Watts per square foot without daylight contribution is realistically achievable. That is significantly lower than current and upcoming Title 24 requirements. This report can also be applicable with regard to retrofit, remodel and new construction to other libraries and office facilities.

2.0 LIGHTING BEST PRACTICES

2.1 High performance 32W F32 T8s

The 3100 lumen, 82+ CRI, 5000 K, 24,000 hour rated based on 3-hour cycles with instant start ballasts, and LEED approved lamps are recommended. Two lamps qualify and are listed below in alphabetical order.

- GE F32T8/HL/SPX50/HL/ECO
  - 5000 K version should be available by June of 2004.
  - Lumens may only be 3000 initially.
- Philips F32T8/ADV850/ALTO

The following two tables detail the lamp life (Table 1) and efficacy (Table 2) of different four-foot fluorescent lamps available today. The two tables are from '3Rs', in the March 2004 edition of *LD+A*, the monthly magazine of the IESNA (www.iesna.org). Also available at www.sunenergysolutionsllc.com.

Table 1: Life expectancy of the fluorescent lamps

4' T8 LAMP LIFE							
LAMP	WATTS	LAMP LIFE HOURS WITH VARIOUS BALLASTS & CYCLES					
		INSTANT START		RAPID START		PROGRAM START	
		3 HR	12 HR	3 HR	12 HR	3 HR	12 HR
BASIC GRADE	32	15,000	20,000	20,000	24,000	20,000	24,000
MID GRADE	32	18,000	24,000	24,000	30,000	24,000	30,000
GE HL	**32**	**24,000**	**30,000**	**24,000**	**30,000**	**30,000**	**36,000**
PHILIPS PLUS & ADV	**32**	**24,000**	**30,000**	**30,000**	**36,000**	**30,000**	**36,000**
SYLVANIA XPS ™	**32**	**15,000**	**24,000**	**20,000**	**28,000**	**30,000**	**34,000**
SYLVANIA XP ®	**32**	**18,000**	**26,000**	**24,000**	**30,000**	**24,000**	**30,000**
GE WM	**30**	**20,000**	**24,000**	**NA**	**NA**	**NA**	**NA**
GE XL WM	**30**	**24,000**	**29,000**	**NA**	**NA**	**NA**	**NA**
PHILIPS ADV EW	**30**	**20,000**	**25,000**	**NA**	**NA**	**NA**	**NA**
SYLVANIA 30W SS	**30**	**18,000**	**26,000**	**NA**	**NA**	**24,000**	**TBD**
SYLVANIA FO28 SS	**28**	**18,000**	**26,000**	**NA**	**NA**	**24,000**	**TBD**
GE F28	**28**	**18,000**	**24,000**	**NA**	**NA**	**NA**	**NA**
F34T12 & mag ballast	34	NA	NA	20,000	27,000+	NA	NA
F28T5	28	*	*	*	*	20,000	25,000
F54T5HO	54	*	*	*	*	20,000	25,000
notes							
Rated hours provided by Amy Brown at GE, John Wilson at Philips, and Jeff Waymouth at Sylvania during January 2004							
Lamp manufacturers may alter rated lamp life specifications, so get updates from manufacturers.							
Although one manfacturer may have higher ratings for basic and mid grade T8s, listed numbers are for the majority.							
Please be aware that some manufacturers are more conservative than others on some products.							
Sylvania lamp life with program start ballast is based on Sylvania PSX ballast, and may be less with other ballasts.							
Program start ballasts include fixed output and most dimming ballasts.							
All ballasts, except for T12, are electronic.							
* is for most manufacturers do not warranty their lamps with rapid or instant start ballasts. Life significantly reduced.							
Even though listed as NA (not applicable) some rapid start & program start ballasts can operate some 28-30W lamps.							

Table 2: Fluorescent lamp efficacies

4' LINEAR FLUORSCENT EFFICACY TABLE											
4' lamp type	*lamp lumens*	*lamp watts*	*lamp lumens per lamp watts*	*lamp quant*	*ballast type*	*ballast factor*	*system watts*	*initial system lumens*	*initial system lumens per watt*	*end of life lumen maint-enance*	*end of life system lumens per watt*
high perform. F32T8	3100	32	96.9	2	EE IS	0.87	53	5394	101.8	92%	93.6
F28T8	2750	28	98.2	2	EE IS	0.87	48	4785	99.7	92%	91.7
energy saver F32T8	2850	30	95.0	2	EE IS	0.87	52	4959	95.4	92%	87.7
F28T5	2900	28	103.6	2	PS	1.00	64	5800	90.6	94%	85.2
basic grade F32T8	2850	32	89.1	2	EE IS	0.87	53	4959	93.6	90%	84.2
F54T5HO	5000	54	92.6	2	PS	1.00	117	10000	85.5	93%	79.5
F34T12 CW	2650	34	77.9	2	RS	0.88	72	4664	64.8	78%	50.5
notes: Lumens, lumen maintenance, ballast factors and wattages may vary among various manufacturers.											
Although efficacy can be improved with IS and RS ballasts with T5s and T5HOs, lamp life can be greatly reduced and lamp manufacturers may not warranty the lamps.											
93% is used as an average EOL lumen maintenance for T5HOs. 90% - 94% range among manufacturers.											
All wattages based on 277V. EE IS is extra efficient instant start. PS is program start. RS is rapid start.											

Dr. Sam Berman discusses scotopically[1] enhanced lighting (5000 K lamps) in 'The Coming Revolution in Lighting Practice', in the October 2000 edition of *Energy User News*. Similar results from recent DOE research and PG&E retrofits are very positive. Brian Liebel's paper on his DOE research on scotopically enhanced lighting has just been made public: "Energy Conservation Using Scotopically Enhance Fluorescent Lighting in an Office Environment". A copy of the Executive Summary is in the Appendix (page 29). 5000 K lamps provide light that is more like daylight (i.e. 7500 K) than from lower Kelvin lamps. Table 3 below shows how much wattage can be saved with 5000 K high lumen lamps compared to other T8s.

Table 3: Scotopically enhanced lighting

S/P Ratio Example of some 32W F32T8s					
lamp	initial photopic (catalog) lumens	S/P ratio	brightness $P(S/P)^{.5}$	paper $P(S/P)^{.78}$	computer $P(S/P)^{1.0}$
735	2800	1.30	3196	3436	3640
741	2800	1.56	3497	3960	4368
835	3100	1.41	3681	4053	4371
841	3100	1.62	3946	4516	5022
850	3100	1.90	4273	5114	5890
Increase of energy efficiency of 850 when considering full field of view compared to 735, 741, 835 and 841 lamps.		735	**34%**	**49%**	**62%**
		741	**22%**	**29%**	**35%**
		835	**16%**	**26%**	**35%**
		841	**8%**	**13%**	**17%**
notes					
Initial lumens can range. For example, some 700 series lamps have 2850					
lumens and 800 series T8s are available from 2950 to 3100+ lumens.					
S/P ratios vary among lamps and correction factor used.					

[1] Lighting is scotopically enhanced if it contains more blue in its spectrum. The added blue content activates a visual response that heightens the sensation of brightness and adds to visual clarity.

S/P Ratio: scotopic and photopic is the amount light registered by the rods and cones (respectively) of the human eye. These ratios can be used to determine more accurate visual efficiencies for tasks. This method has not yet been recognized by the IESNA. Photopic lighting levels are measured by current lighting meters in lumens.

Lamp disposal: All fluorescent lamps used in nonresidential facilities need to be recycled, which costs about $0.08 – $ 0.10 per linear foot. Many T8s are only rated for 15,000 – 20,000 hours with instant start ballasts. Recommended 24,000 hour rated T8s reduce disposal costs as well as replacement parts and labor costs. Mercury concentrations are as follows:

- GE HL has about 6 – 9 mg.
- Philips Advantage has 3.5 mg.

It is our understanding that both of these lamps qualify for LEED.
http://www.usgbc.org/leed/leed_main.asp

In decent quantities the GE and Philips lamps should cost $2.10 – $2.25 excluding sales tax and freight from distribution (should be free freight).

2.2 Minimize lamp types

Linear Fluorescent Lamps: Try to only use 4' F32T8s and, if necessary, also 2' F17T8 800 series for linear fluorescents**.** Avoid the following:

- U-bend 2' long
- Biax lamps
- 3' lamps
- 6' lamps
- 8' lamps

Compact Fluorescent Lamps (CFLs): It is recommended to use F17T8s instead of CFLs for many applications. T8s have double the lamp life, higher lumens per watt, and usually are lower cost. Many 2' long fixtures are commercially available for F17T8s including wraps, corridor wraps, troffers, seal tights, strips, hooded industrials, floods, etc. Finally many screw-in CFLs have premature failure in recessed cans and enclosed fixtures due to heat and are also susceptible to "snap back", i.e. returning back to screw-in incandescent lamps. If CFLs are installed, only use one or two types per facility.

High Intensity Discharge (HID) lamps: HID lamps include metal halide, mercury vapor, and high and low pressure sodium lamps. These lamps should be eliminated from interior applications. Also, minimize types and wattages for exterior applications.

2.3 Extra efficient instant start ballasts

Extra efficient instant start ballasts save 3 – 6 watts compared to basic grade instant start ballasts of the same ballast factor. These ballasts save even more wattage when compared to basic grade program start ballasts. Another advantage includes more light per watt than extra efficient program start ballasts while costing significantly less. Recommended manufacturers and models include:

- Advance Optanium
  - Low and standard ballast factor
  - Separate ballasts for different line voltages
  - By end of 2004 or first quarter of 2005 should have universal voltage
  - Philips owns Advance
- GE Ultramax
  - Low, standard and high ballast factor
  - Universal voltage for both 120 and 277V
- Sylvania QHE (quicktronic high efficiency)
  - Low, standard and high ballast factor
  - Universal voltage for both 120 and 277V
  - Brand new
- Universal ULTim8 (Universal used to be Magnetek)
  - Low and standard ballast factor
  - Universal voltage for both 120 and 277V

Sometimes warranty issues are made easier if lamps and ballasts are from the same parent company, like GE lamps and ballasts or Philips lamps and Advance ballasts.

Ballast factor (BF)[2] and costs

- .75 - .78 is considered low BF
- .87 - .90 is considered standard BF
- 1.14 – 1.20 is considered high BF

In decent quantities, approximate pricing from distribution excluding sales tax and freight follow. (Should be able to get free freight) $10.00 – $12.00 for one and two lamp low and standard BF ballasts (a few dollars higher for high BF) and $13.00 – $16.00 for three and four lamp low and standard BF ballasts (a few dollars higher for high BF).

Extra efficient instant start ballasts should be used for retrofitting and new fixtures. If extra efficient instant start ballasts are not specified when ordering new fixtures, they will probably come with basic grade generic instant start ballasts. On the following page, the Ballast Efficacy Factor Table list the efficiency of lamp / ballast combinations verses ballast type and ballast factor.

[2] Which BF is used when? As a rule of thumb when there is a one for one retrofit one should use the low BF ballast. When there is a retrofit with delamping (i.e. going from two lamps to one lamp) one should use either the standard or high BF depending on the amount of light required in the area.

2.4 Dimming ballasts

Although many people think that dimming ballasts save so much KWH in daylight applications, this is not really the case when one compares dimming ballast verses extra efficient instant start ballasts. This is described in the following two tables, which are from '3Rs' in June 2004 edition of *LD+A*. The text in that article further explains this issue. Also available at www.sunenergysolutionsllc.com.

BALLAST EFFICACY FACTOR TABLE - 2F32T8				
general type	*further description*	*ballast factor*	*system watts*	*BEF*
IS	extra efficient	0.87	53	1.64
	basic grade	0.87	58	1.50
	extra efficient	0.77	48	1.60
	basic grade	0.77	51	1.51
	extra efficient	1.15	72	1.60
	basic grade	1.15	77	1.49
PS	extra efficient	0.88	55	1.60
	basic grade	0.88	62	1.42
	extra efficient	0.71	46	1.54
RS/PS dimming	continuous 0-10V	0.88	64	1.38
		0.05	14	0.36
	continuous powerline	1.00	68	1.47
		0.05	15	0.33
	continous DALI	1.00	70	1.43
		0.54	45	1.20
		0.05	17	0.29
	three stages	0.88	62	1.42
		0.58	45	1.29
		0.27	28	0.96
notes: Wattages based on 277V.				
Values will vary among specific ballasts				

Ballast Efficacy Factor:

BEF = (BF x 100) / system watts

The higher the BEF, the better.

DIMMING BALLASTS vs. STAGED FIXED BF EXTRA EFFICIENT IS BALLASTS										
ballast type	*number of 2F32T8 ballasts per fixture*	*BF*	*number of F32T8s on per fixture*	*wattage per fixture*	*annual hours*	*KWH rate*	*itemized annual KWH*	*total annual electrical cost per fixture*	*total annual electrical cost per 100 fixtures*	*advantage with fixed BF EE IS ballasts*
dimming	**3**	**0.88**	**6**	**189**	**1560**	**$0.10**	**$29.48**			
	3	**0.59**	**6**	**138**	**1040**	**$0.10**	**$14.35**	**$62.56**	**$6,255.60**	
	3	**0.29**	**6**	**90**	**2080**	**$0.10**	**$18.72**			
fixed BF EE IS	**3**	**0.88**	**6**	**162**	**1560**	**$0.10**	**$25.27**			**24%**
	3	**0.88**	**4**	**108**	**1040**	**$0.10**	**$11.23**	**$47.74**	**$4,773.60**	
	3	**0.88**	**2**	**54**	**2080**	**$0.10**	**$11.23**			
notes:										
Dimming ballasts can either be continous or stage dimming.										
Fixed BF EE IS is fixed ballast factor extra efficient instant start.										
Each fixture could also have 3 2-lamp dimming ballasts or 1 4-lamp ballast and 1 2-lamp EE IS ballast.										
Numbers will vary dependent on specific ballasts considered.Please do your own comparisons										

2.5 Delamping

With high lumen 5000 K T8s and a combination of standard and high BF electronic ballasts, delamping is often the best solution. But, the 2x4 18 cell and some other parabolic fixtures should not be delamped because it ruins the proper cut-off angles, which increases glare. In delamped fixtures it is important to provide the following: (1) Sufficient light levels and (2) Even distribution.

You do not always have to center lamps to provide good distribution. One can go right, left, right, etc. in many end to end wraps, troffers, strips and hooded industrials. You can go one side in most individual strips and hooded industrials that have the ballast located above the lamps.

It is important to know that reflectors are often not necessary with delamping. In fixtures with angled interior sides and good white reflective surfaces, reflectors usually do not provide sufficient cost effective benefits. Most of the benefits of delamping come from delamping, not from the reflectors. But, reflectors are good in 2x2 troffers that have U-bend lamps, some strips that uplight is not needed, and surface mount 2x4s that have vertical interior sides. These points are detailed in 'Cutting Edge Retrofitting, Relighting & Redesigning', in the November 2003 edition of *Energy & High Performance Facility Sourcebook*, which are the proceedings of the World Energy Engineering Congress**.** Also available at www.sunenergysolutionsllc.com.

When reflectors are required (for less than 14 ft high) the author prefers white over specular. White powder coat is recommended over white paint because it more reflective and more environmentally friendly than white paint. Manufactures of white powder coat reflectors include Wellmade www.wlmd.com and Amerillum www.amerillum.com. For ceilings higher than 14 ft enhanced aluminum reflectors with at least 95% reflectivity is usually recommended.

2.6 Lenses

It is recommend that clear prismatic or linear (flat) lenses be installed. These lenses are superior because:

- They only block about 10% of useable light
- White lenses can block 30 - 40% (they should be replaced)
- White lenses can be a glare bomb to the aged eye.
- Old yellowed lenses can also block 30-40% of useable light (they should be replaced)

All existing lenses should be cleaned during a retrofit. All existing reflective metal surfaces should also be cleaned during a retrofit.

2.7 Lamp holders for T-8s

The T8 lamps use the same lamp holders as T12s. In a T12 to T8 retrofit existing lamp holders can be kept if:

- They are in good shape
- There is not a lot of carbon black on them, which is caused from not the best electrical connection with lamps
- There is a very low chance of "snap back" to T12 lamps

There are new lamp holders available with a dimple, which prevents T12 lamps to be installed**.** New lamp holders with and without dimples cost about $0.25 each.

2.8 Retrofitting end-to-end fixtures with tandem wired ballasts and T8s

There are up to 4-lamp ballasts for T8s. It is usually cost effective to tandem wire end to end fixtures. Some examples are:

- 4-lamp ballast for 4 end to end single lamp fixtures
- 4-lamp ballast for 2 end to end dual lamp fixtures
- 3-lamp ballast for 3 end to end single lamp fixtures
- 2-lamp ballast for 2 end to end single lamp fixtures
- One lamp ballasts should be avoided because efficiency is not good for single lamp ballasts. For example in a row of 17 fixtures, three 4-lamp, one 3-lamp, and one 2-lamp ballasts should be used.

Without any marking, maintenance people can waste a lot of time trying to find a burned out ballast in tandem wired fixtures. It is highly recommended that during retrofits, a long lasting sticky label is attached to the outside of ballast covers that have ballasts in tandem wired fixtures.

2.9 New direct linear fluorescent fixtures

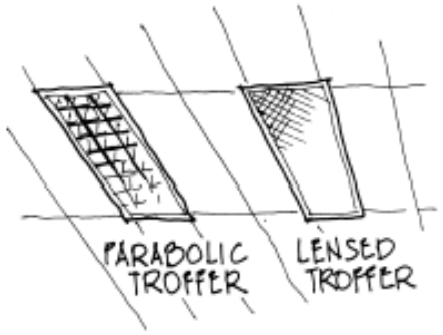
This section applies to replacing damaged fixtures or fixtures not worth retrofitting i.e. wraps with yellowed lenses (the replacement lenses would be quite costly).

It is recommended to specify new fixtures with extra efficient instant start ballasts. Without this specification the user will get basic grade instant start ballasts. For troffers, wraps, strips and hooded industrials a white powder coat reflective surfaces and body is suggested. The fixtures provide more reflective and are more environmentally friendly than white paint. Manufactures include Wellmade www.wlmd.com, H. E. Williams http://www.hew.com/williams/, and others.

For troffers and wraps 4 lamps per fixture are not recommended. This results in too much wasted light due to (1) high temperature in lamp compartment and (2) wasted light from light bouncing into adjacent lamps. For troffers and wraps one, two, and three lamps per fixture are okay. It is recommend to go with the fewest lamps per fixture when appropriate, such as:

- Instead of typical 2 F32T8s with low or standard BF ballast in wrap, strip, hooded industrial, or 1x4 troffer – we recommend 1 F32T8 with high BF ballast
- Instead of typical 3 F32T8s with low or standard BF ballast in 2x4 troffer – we recommend 2 F32T8s with standard or high BF ballast

For lenses we recommend clear prismatic or linear.



Do not recommend parabolics.

- Create more overhead glare than lensed fixtures
- Create dark ceilings and upper walls
- Paracubes are very inefficient

Regarding troffers only: make sure angled interior is on long sides. This provides a better luminaire efficiency than with vertical sides. Also, make sure fixtures have good hinge and closure systems. Many troffers have inferior systems that make opening and closing doorframes problematic.

2.10 New suspended indirect fluorescent fixtures

Although replacing existing direct fixtures with suspended indirect fixtures costs about four to eight times more than retrofitting existing fixtures, suspended indirect fixtures usually provide a much better quality of lighting and make the space feel more appealing. They can also often consume less wattage. For gut rehabs and new construction the total installed cost for suspended indirects is usually less than for direct fixtures.

Two good websites on the benefits of suspended indirects are www.designlights.org and www.lightright.org.

Note: Although technically the definition of suspended indirects is 100 – 90% uplight with 0 – 10% downlight, suspended indirects in this report will allow 100 – 70% uplight with 0 – 30% downlight.

There are numerous manufacturers that make suspended indirect fixtures. One that has very good cost effective products, fast shipping and a good website is Finelite www.finelite.com.

- Several series for at least 9.5' ceilings.
- Series 15 can be used in as low as 8' ceilings.
- Many contractors and installers that have not installed easy to install suspended indirects tend to quote quite high prices for CYA insurance.
- Finelite has a very useful contractor support programs section in it's website, including easy level system. http://www.finelite.com/content/supportset.html?59,48
- If Finelite product is purchased, A Finelite person is willing to come down to San Diego to train the installers at no additional cost.

Turning some lamps off and on in suspended indirects can be less annoying than in direct troffers, which can be a big plus for daylight harvesting applications.

If more than 50% of fixtures are replaced, Title 24 permit and controls probably required.

2.11 Ceiling reflectivity for suspended indirects

With suspended indirects, ceiling reflectivity should be at least 70% and preferably at least 80%. Typical white ceiling tiles and white paint are sufficient. For gut rehabs and new construction we recommend T-bar ceiling tiles that are specially designed for suspended indirects, which have about 90% reflectivity.

2.12 Exit sign fixtures

Although there are LED kits for exit signs, they are not UL listed. We recommend replacing all incandescent and fluorescent exit signs with new universal mount red LED exit signs that have internal battery backup. With the low wattage of LED signs, the battery backup option adds very little cost to the project. The battery backup can be very helpful when the electricity is turned off. But it may be more cost effective retrofitting existing signs that have flood heads with red LED kits, than replacing those signs with new signs that have flood heads. If additional exit signs are needed and are not located near unswitched power, the new generation of photoluminescence exit signs are recommended. One good manufacturer is SafeSIGN www.safesigncorp.com.

2.13 Task lights on reading tables

Task lights on reading tables are a very good way to provide sufficient light levels for reading, especially for senior citizens, and is much more efficient (inverse square law) than providing those light levels from ambient (i.e. ceiling light fixtures). Linda Vista is the only one of these six libraries that has some task lights on reading tables. Most of these six libraries do not have existing floor plugs near reading tables. Installing task lights on reading tables, would require running power, which would be expensive. Another option could be using fluorescents with rechargeable batteries for a dedicated senior citizen and challenged eye site reading table. Recommend task lights for reading tables with T8s instead of CFLs.

2.14 Book rack fixtures

F32T8 fixtures, positioned over the middle of each bookrack aisle, and mounted to one bookrack, mounted to two bookracks, or mounted to the ceiling is an effective way to provide sufficient vertical fc on books. Commonly an occupancy sensor is installed to turn all or the majority of lamps off in a book rack aisle when there is nobody there. But with the relatively short burn times (operational hours) of these six libraries, the parts, installation and commissioning of occupancy sensors are probably not cost effective. North Park is the only one of these six libraries that has bookrack fixtures, and they have no occupancy sensors. There are several manufacturers of these fixtures such as Lightolier, Precision Architectural Lighting, Litecontrol and Columbia Lighting. Or these fixture assemblies can be constructed out of regular fixtures and conduit, like the North Park library.

2.15 Battery packs for emergency lighting in typical fluorescent fixtures

None of these fixtures were seen in these 6 libraries, but some may exist. Many of the battery backups that work with magnetic ballasts and T12s do not work with electronic ballasts and T8s. We recommend replacing all existing fixtures (with mounted battery backup units) with new fixtures designed for electronic ballasts and T8s.

2.16 Comprehensive lamp and ballast replacement

To minimize lamp and ballast types that have to be ordered, stocked and installed and to reduce confusion for which lamps and ballasts should be used, the author highly recommends retrofitting or replacing all incandescent and T12 fixtures, even ones with very low annual hours of operation (i.e. closet and restroom fixtures).

2.17 Lighting controls

Manual switches can be the most cost effective control if used properly. During our walk-throughs, library staff and the public did quite a good job turning off lights in unoccupied rooms. Signs on public restrooms have been very helpful. Continual education and motivation may be helpful for staff (we found the lights on in some unoccupied work and staff rooms). If continual motivation does not work, installing occupancy sensors could be considered. Because of the short hours of operation, sensors may not be cost effective.

Daylight harvesting controls: Manual control is recommended. The staff at Tierrasanta and Linda Vista already do a very good job at manually turning on and off lights based on how much light is coming through the large skylights. It is recommended that existing manual control be maintained in the libraries that are considered to get skylights (instead of installing automatic controls). This saves considerable money on parts and installation compared to automatic controls. Manual control can prevent lights automatically turning on and off too frequently (annoying photocell control). Some of the libraries already have existing circuitry that will allow only a partial number of lighting fixtures to be turned off during cloudy days and late winter afternoons.

Other libraries do not have bi-level electric lighting in open areas. All of the electric lights will have to be left on until sufficient daylight is available.

Automatic control options: If automatic controls are required, following are three options.

- Watt Stopper www.wattstopper.com
  - LCO-103 controller (approximate $550, plus labor)
  - LS-I50 photocell (approximate $65 each, plus labor)

- PLC Multipoint www.plcmultipoint.com
  - LC8 controller with photocell (approximate $235, plus labor)
  - Power cube switcher (approximate $50 each, plus labor)

- 365 day programmable digital time clock with battery backup
  - Numerous manufacturers, including Watt Stopper
  - The Watt Stopper LP8 may cost about $650, plus labor.

2.18 Light levels

Both horizontal and vertical footcandles (fc) are important for various tasks in libraries. Based on tables at the end of Chapter 10 of 9th edition of the IESNA *Lighting Handbook:*

- For finding a book in a bookrack, vertical fc is the most important.
  - 30 vertical fc are recommended.
- For most other reading tasks, horizontal fc is the most important
  - 30 horizontal fc at desk height are recommended
- See the Appendix for more information (pages 30-31).

Although the IESNA does not yet fully accept scotopically enhanced lighting, it is the author's opinion that vision science and numerous retrofits have substantiated the premise of scotopically enhanced lighting. With 5000 K lamps, 20 – 25 vertical fc for bookracks and 20 – 25 horizontal fc measured with typical photopic light meter for most other reading tasks should be sufficient. These lamps should be perceived about the same to the human eye as 30 vertical and horizontal fc with lower Kelvin lamps. There is a new light meter by Solar Light that measures both photopic and scotopic light levels (www.solar.com). The unit costs about $3000.

Older people, including senior citizens, require significantly more light for the same task than younger adults, teenagers and children. Based just on photopic light measurements, 50 horizontal and vertical fc are good targets. Based on scotopic enhanced lighting measurements, 35 – 40 horizontal and vertical fc are good targets. In libraries that will get adequate skylights, significantly higher light levels should be available during daylight times. Energy efficient task lights mounted on reading tables are often a very cost effective way to provide suitable light levels.

2.19 Natural day lighting (skylights)

Although skylight specification and installed pricing are really not included in the scope of this report, the following is an example.

- 21" diameter solar tube type, each covering about 250 sq ft: approximate installed cost is $900 per unit

With well-designed and spaced skylights that pick up sufficient daylight from 1 – 2 hours after sunrise to 1 – 2 hours before sunset, there should be sufficient daylight in the libraries to turn off all the lamps. This will save considerable KWH especially during peak load times. The skylight installation company should provide a **guarantee** against leaky roofs caused by the skylights. Some libraries, that have large windows that also provide substantial daylight, will not need skylights installed close to those windows. Significant daylight is provided into a space, about twice the header height of the window. For example, if the top of the window is 12' high, daylight will penetrate about 24' into the room cavity.

2.20 Conclusion

Careful planning can help ensure the success of your lighting retrofit projects. This involves looking at a wide range of issues including relamp, retrofit or redesign, maintenance costs, energy efficiency and initial implementation costs. As Willard Warren states, "Retrofitting a lousy lighting system into an energy efficient lousy lighting system is a wasted opportunity". A summary of this report's recommendations are as follows:

- Install 3100 lumen, 82+ CRI, 5000 K, 24,000 hour rated high performance 32W F32 T8s
- Install extra efficient instant start ballasts
- Minimize lamp types
- De-lamp were possible
- Retrofit all lamps including closets, restrooms and other low usage areas
- Manual control of lights has proven successful with continued motivation
- Consider task lighting to increase light levels at reading tables
- Label outside of ballast covers that have ballasts in tandem wired fixtures. Without any marking, maintenance people can waste a lot of time trying to find a burned out ballast. Also, include lamp and ballast model numbers so that correct parts are used.

With any new efficient retrofit, there are critics. Critics will say, "We find that we initially install these high efficiency lamps and their ballast, and the maintenance people unknowingly re-lamp with standard T8 lamps causing even greater problems." Education should be included with all new projects. Also, the City should be encouraged to begin retrofitting all T-12 and standard T-8 lamps in City owned buildings with the next generation of high efficiency T-8 lamps. A 10-30% decrease in lighting energy usage is possible compared to basic grade T-8s (even more with T-12s).

3.0 DETAILED ASSESSMENT

A detailed assessment was performed at the Clairemont library located on 2920 Burgener Blvd. This 4,437 sq ft library uses approximately 33,324 kWh/yr. This equates to an energy density of 7.5 kWh/sq ft-yr.

3.1 Suppositions

- 2700 annual hours of operation for most area electric lights without skylight contribution
    - Based on library opened 12 – 8 on Mon & Wed, 9:30 – 5:30 on Tue, Thu, Fri & Sat, lights turned on 1hour before libraries open, and deduction for about 10 holidays
- 1000 annual hours of operation for electric lights fully on in areas with skylights or windows
    - Which means that the electric lights in areas with skylights or windows can be totally off the rest of the 1700 hours
- $0.18 blended KWH rate including taxes and other misc. charges
- All 4' T12 fluorescent lamps considered energy saving F34T12 CW, which used to be called 34W F40T12 CW.
- $0.40 disposal fee for each F34T12
- All T12 ballasts are considered to be energy saving magnetic
    - If there are ballasts older than 1985, they could consume more wattage
    - If there are ballasts older than 1980, they would also contain PCBs, which would require proper ballast disposal, which would require additional cost of about $2.60 per ballast
- $51.50 is considered the hourly labor rate for installers.
    - Approximate installed costs are just that, because experience and speed of these installers is unknown.
- SDG&E Express Efficiency Rebates
    - Even with skylights this is generally better than the $0.05 per KWH saved with the Standard Performance Contract (SPC) program.
- Although the installed cost of skylights is not included in this proposal, the savings and SPC incentives are, resulting from reducing the electric lighting load during daylight times.
- Existing horizontal light levels at table height
    - Approximate 40 fc with daylight contribution
        - Which is considered sufficient
    - Approximate 20 fc with no daylight contribution (nighttime)
        - Which is considered insufficient for senior citizens
- Based on information from head librarian
    - 50 – 60% of people that come to this library are senior citizens, who tend to need significantly more light than younger people.
        - The vast majority of the seniors come to the library during daylight times.

3.2 Clairemont library lighting

The main fixtures in these areas are 4’ wraps (surface mounted with “wrapped lenses”), each with two F34T12 CW lamps and one 2-lamp magnetic ballast, which consume 72 Watts each. Most of these 4’wraps are mounted end to end in 8’, 12’ and 16’ arrays, with the 16’ arrays being the vast majority. Below is a picture of the main library room.

3.3 Retrofit option

The following specific electric lighting recommendations are based on Section 2 of this report: Lighting Best Practices. Since the light levels are considered low without daylight contribution, it is recommended to retrofit each 4’ fixture with two high performance F32T8 850 lamps and low (.77 - .78) ballast factor (BF) extra efficient instant start (IS) electronic ballasting. Each end to end pair of 4’ fixtures should get one 4-lamp ballast. Individual 4’ fixtures should get one 2-lamp ballast. Either way, the wattage would be 48 Watts for each 4’section, which is a 33% reduction in energy, while increasing light levels.

3.4 Replacement option

Although this option cost a lot more than retrofitting, it provides a much better quality of lighting, make the space feel more open, appealing and inviting, and can save extra wattage than a simple retrofit.

Each 4' wrap section could be replaced with a 4' section of a suspended indirect fixture, such as Finelite series 10 – WCB – open - EP (www.finelite.com). Suspended indirect fixtures are available in 4', 8', and 12' lengths. For example, one 12' suspended fixture can replace three end to end 4' wraps. Each 4' section would have one high performance F32T8 850 lamp driven by 1.15 BF extra efficient IS ballasting, tandem wired in 8' and 12' fixtures. The wattage would be 41 Watts per 4' section.

Labor time is difficult to quote for suspended indirects. It takes some time to get used to hanging them level and even. Some installers have a lot of experience and may only take 0.75 man-hours per single 8' section. Others may never have installed them before and may take 1.5 man-hours. Labor pricing will be based on 1.50 hours for an 8' section, including removing existing wraps and either patch and painting or installing a white metal plate to cover the wraps foot print. In Section 2: Lighting Best Practice report includes some tools on suspended labor issues.

Although not included as a dedicated option in the Excel spreadsheets, another new fixture option is the Lithonia Avante 1x4 surface/suspended.
http://www.lithonia.com/products/groups/fluorescent/avante/ProductLine.asp

Fixture pricing will probably be more than the Finelite, but if mounted directly to the ceiling, installers will not have patch and paint the ceiling after removing the existing wraps. Total installed cost may be about the same or slightly less this way. Wattage would most like be the same as the Finelite units.

3.5 Exit sign

There is only one exit sign, which is over the door in the SW corner of the open library room. It has two 20 Watt or 23 Watt screw-in CFLs, which would be overkill, but both lamps were burned out. For energy calculations, wattage is based on both lamps working.

It is recommended to replace this exist sign with a red LED Exit sign that has internal battery back. New sign wattage is considered to be 4 Watts including backup battery unit. Examples are the Mule Mulennium MXBRU and E-Star PSX 1/2C WWR with or without downlight. www.mulelighting.com.

3.6 Reading tables

None of the reading tables currently have table mounted task light fixtures. For extra light, the City and library could consider getting one or two table mounted task light fixtures on at least one table, dedicated to senior citizens and others that are vision impaired.

3.7 Controls in library room

All the light switches for the library room are clustered together by the main desk. If skylights are installed, it is highly recommended that the library staff is educated and motivated to manually turn on and off the lights depending on how much daylight there is. This avoids the need to buy and install relatively expensive automatic controls. Plus this avoids the potentially annoying occurrence of lamps turning on and off too frequently from photocells (e.g. when clouds move across the sky).

If automatic controls are requested, they would cost extra and are listed in Section 2: Lighting Best Practices.

3.8 Controls in work room and staff room

When we visited this facility twice in one day, the lights were on in the unoccupied work and staff rooms both times. For many tasks there was sufficient daylight through the windows. If skylights are installed, there will be more daylight in these rooms.

Preferred recommendation is for City of San Diego to educate/motivate library staff to turn off lights in these two rooms when sufficient daylight is in these spaces.

If that does not work, two wall mounted combined occupancy sensors and photocontrol can be installed at additional cost, not included in the tables. These units turn on electric lights with there is occupancy and not enough daylight. An example is Watt Stopper WS-200. www.wattstopper.com.

3.9 Staff restroom

This room has two ceiling fixtures. One is assumed to have two quad 13 compact fluorescent lamps with magnetic ballasts, consuming 30 Watts. The other is assumed to have two PL13 compact fluorescent lamps and two magnetic ballasts, consuming an additional 30 Watts. These lamps flicker on-off-on-off-on when turned on, which can be annoying. In some projects that we have seen, people felt so annoyed, that they left lights on all day. These lamps are rated for 10,000 hours. The PL13s probably cost about $2.00. The quad 13s probably cost about $5.

It is recommended to replace both of these fixtures with a wrap that has 1 high performance F32T8 850 lamp (which is rated for 24,000 hours and costs about $2.25), .87 - .88 BF extra efficient IS electronic ballast, which consumes 28 Watts and clear prismatic lens. An example of this fixture is the Wellmade 111-148T8. www.wlmd.com. If a watertight fixture is required, then a more expensive 4’ seal-tight fixture could be used. An example is the Wellmade 191-148T8.

T8 lamps with IS ballasts have instant on without any flicker. It should be verified that a 4' fixture would fit in this space.

The existing fixtures are considered to be on 1000 hours per year. Avoided maintenance parts and labor savings would probably be greater than electrical savings. This replacement would help minimize lamp types that have to be purchased, stocked and installed in this facility.

3.10 Men and women's restroom

Each of these restrooms has one 4' wrap with two F34T12 CW lamps and magnetic ballast, which consumes 72 Watts. Each of these wraps could be replaced with a new 4' wrap that has one high performance F32T8 850 lamp and .87 - .88 BF extra efficient IS electronic ballast, which consumes 28 Watts. An example is the Wellmade 111-148T8.

With the help of the signs on the doors, it seems that the public turns off the lights most of the time when they leave. So annual burn time is considered to be 1,000 hours.

Although not recommended, a cheaper solution would be to retrofit the existing fixture with one high performance F32T8 850 and .87 - .88 BF extra efficient IS electronic ballast, which consumes 28 Watts.

3.11 Custodial and mechanical room

Both of these rooms have energy efficient screw-in CFLs. Since the burn time is so low, probably 500 or less hours per year, nothing is recommended.

3.12 Exterior lighting

Although exterior lighting is not really in the scope of this project, the following are some observations and recommendations.

The lights are set by a time clock to turn off at 11 PM, so the burn time is not that great. It looks like there are numerous HID lamp types, wattages and ballasts on the building and on the poles. The City and library could consider minimizing lamp and ballast types as existing lamps and ballasts burn out. That could make maintenance easier down the road and reduce maintenance costs.

3.13 General

Although maintenance savings can be hard to quantify, avoided parts and labor savings are substantial. If this lighting project is not done, existing lamps and ballasts will have to

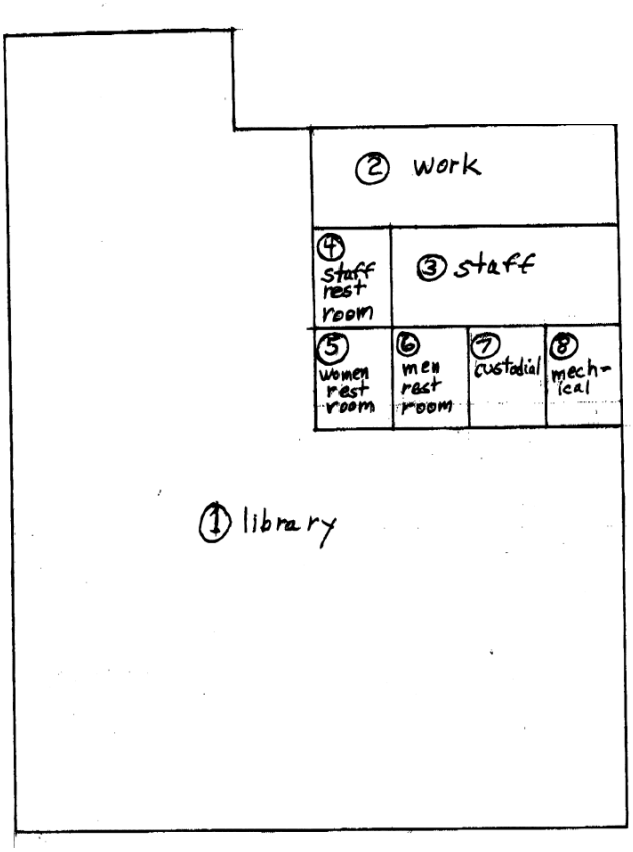
be replaced as they burn out. The new electronic ballasts have a 5-year parts and labor warranty from the manufacturer and a 60,000 hour rated life. The new T8s have a 2 or 3-year parts warranty from the manufacturer and a 24,000-hour rated life, which is 4,000 hours longer than F34T12s. Plus, replacing the 10,000 hour rated CFLs will also reduce maintenance costs. In the Excel tables, maintenance savings are considered to offset cost of money in 15-year benefits. (i.e. if one does not spend the money on lighting, one could invest it in a bank, stocks, etc.)

Although some manufacturers and models are listed, there is no endorsement of those products. Equivalents with the same or better specifications and performance are allowed.

If more than half of the fixtures are replaced, then Title 24 permit may be required. That would require additional costs and probably automatic controls.

3.14 Savings calculations

Below is an approximate facility layout of the Clairemont library (not to scale). Each area is labeled 1 through 8. The Excel spreadsheets on the following four pages represent the associated cost breakdown for each area for four potential scenarios (1) retrofit & daylight savings, (2) indirect & daylight savings, (3) replace & no daylight savings and (4) retrofit & no daylight savings.



CLAIREMONT LIBRARY - TABLE FOR RETROFIT & DAYLIGHT SAVINGS OPTIONS (not including skylight costs)

room	existing						proposed													
	fixture type	fixture watts	annual hours	qua-ntity	annual KWH	annual electric cost	retrofit or replace type	appr. unit parts cost	appr. unit labor cost	fixture watts	annual hours	qua-ntity	annual KWH	annual KWH savings	annual electric cost	annual electric savings	appr. total cost	SDG&E Express Effic-iency	pay-back in years	15 year benefit
1	4W 2F34	72	2700	2	388.8	$69.98	2F32L	$18	$18	48	1000	2	96.0	292.8	$17.28	$52.70	$72	$17.00	1.0	$736
1	4W 2F34 T2	144	2700	1	388.8	$69.98	2F32L T2 1B	$26	$34	97	1000	1	97.0	291.8	$17.46	$52.52	$60	$17.00	0.8	$745
1	4W 2F34 T3	216	2700	3	1749.6	$314.93	2F32L T3 2B	$44	$52	145	1000	3	435.0	1314.6	$78.30	$236.63	$288	$76.50	0.9	$3,338
1	4W 2F34 T4	288	2700	14	10886.4	$1,959.55	2F32L T4 2B	$52	$68	197	1000	14	2758.0	8128.4	$496.44	$1,463.11	$1,680	$476.00	0.8	$20,743
1	Exit 2x23CFL	40	8760	1	350.4	$63.07	N RLED sign	$30	$25	4	8760	1	35.0	315.4	$6.31	$56.76	$55	$27.00	0.5	$823
2	4W 2F34 T2	144	2700	3	1166.4	$209.95	2F32L T2 1B	$26	$34	97	1000	3	291.0	875.4	$52.38	$157.57	$180	$51.00	0.8	$2,235
3	4W 2F34 T2	144	2700	2	777.6	$139.97	2F32L T2 1B	$26	$34	97	1000	2	194.0	583.6	$34.92	$105.05	$120	$34.00	0.8	$1,490
4	Ceiling (2x15)CF	30	1000	2	60.0	$10.80	N 4W 1F32S	$45	$25	28	750	1	21.0	39.0	$3.78	$7.02	$70	$2.00	9.7	$37
5	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
6	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
	TOTALS			**30**	**15912.0**	**$2,864.16**	**TOTALS**					**29**	**3983.0**	**11929.0**	**$716.95**	**$2,147.21**	**$2,655**	**$721.00**	**0.9**	**$30,274**

Notes:

KWH is considered to be $0.18.

fixture code examples: 4W 2F34 = 4' wrap with 2F34T12s, 4W 2F34 T4 = 16' row of end to end 4' wraps, each with 2F34T12s

retrofit type examples: 2F32L T4 2B = in 16' row of end to end 4' wraps, install 2 F32T8s in each 4' section, which totals 8 lamps, and use 2 4-lamp low (.77 - .78) BF ballasts

replace type examples: N RLED sign = new red LED exit sign with battery backup, N 4W 1F32 = new 4' wrap with 1 F32T8 and standard (.87-.88) BF ballast

Approximate parts costs include sales tax.

Approximate labor costs include cleaning and disposal costs, other than PCB disposal costs, which would be extra. Labor rate is considered to be $51.50 per hour.

15 year benefit is calculated as (annual electrical savings x 15) + incentive - total cost. Maintenance savings and cost of money are not included, because they can cancel each other out.

15 year benefit may be significantly higher if electric rates increase more than inflation over the next 15 years, which is a very real possibility.

CLAIREMONT LIBRARY - TABLE FOR REPLACE & DAYLIGHT SAVINGS OPTIONS (not including skylight costs)

	existing						proposed													
room	fixture type	fixture watts	annual hours	qua-ntity	annual KWH	annual electric cost	retrofit or replace type	appr. unit parts cost	appr.unit labor cost	fixture watts	annual hours	qua-ntity	annual KWH	annual KWH savings	annual electric cost	annual electric savings	appr. total cost	SDG&E Express Effic-iency	pay-back in years	15 year benefit
1	4W 2F34	72	2700	2	388.8	$69.98	N 4SI 1F32H	$140	$65	41	1000	2	82.0	306.8	$14.76	$55.22	$410	$20.50	7.1	$439
1	4W 2F34 T2	144	2700	1	388.8	$69.98	N 8SI 2F32H	$280	$80	73	1000	1	73.0	315.8	$13.14	$56.84	$360	$20.50	6.0	$513
1	4W 2F34 T3	216	2700	3	1749.6	$314.93	N 12SI 3F32H	$420	$90	110	1000	3	330.0	1419.6	$59.40	$255.53	$1,530	$92.25	5.6	$2,395
1	4W 2F34 T4	288	2700	14	10886.4	$1,959.55	N 16SI 4F32H	$560	$160	146	1000	14	2044.0	8842.4	$367.92	$1,591.63	$10,080	$574.00	6.0	$14,368
1	Exit 2x23CFL	40	8760	1	350.4	$63.07	N RLED sign	$30	$25	4	8760	1	35.0	315.4	$6.31	$56.76	$55	$27.00	0.5	$823
2	4W 2F34 T2	144	2700	3	1166.4	$209.95	N 8SI 2F32H	$280	$80	73	1000	3	219.0	947.4	$39.42	$170.53	$1,080	$61.50	6.0	$1,539
3	4W 2F34 T2	144	2700	2	777.6	$139.97	N 8SI 2F32H	$280	$80	73	1000	2	146.0	631.6	$26.28	$113.69	$720	$41.00	6.0	$1,026
4	Ceiling (2x15)CF	30	1000	2	60.0	$10.80	N 4W 1F32S	$45	$25	28	750	1	21.0	39.0	$3.78	$7.02	$70	$2.00	9.7	$37
5	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
6	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
	TOTALS			**30**	**15912.0**	**$2,864.16**	**TOTALS**					**29**	**3006.0**	**12906.0**	**$541.09**	**$2,323.07**	**$14,435**	**$859.25**	**5.8**	**$21,270**

Notes:

KWH is considered to be $0.18.

fixture code examples: 4W 2F34 = 4' wrap with 2F34T12s, 4W 2F34 T4 = 16' row of end to end 4' wraps, each with 2F34T12s

replace type examples: N RLED sign = new red LED exit sign with battery backup, N 12SI 3 F32H = new 12' suspended indirect with 3 F32T8s and high (1.15) BF ballast

Approximate parts costs include sales tax.

Approximate labor costs include cleaning and disposal costs, other than PCB disposal costs, which would be extra. Labor rate is considered to be $51.50 per hour.

15 year benefit is calculated as (annual electrical savings x 15) + incentive - total cost. Maintenance savings and cost of money are not included, because they can cancel each other out.

15 year benefit may be significantly higher if electric rates increase more than inflation over the next 15 years, which is a very real possibility.

CLAIREMONT LIBRARY - TABLE FOR RETROFIT & NO DAYLIGHT SAVINGS OPTIONS

	existing						proposed												
room	fixture type	fixture watts	annual hours	qua-ntity	annual KWH	annual electric cost	retrofit or replace type	appr. unit parts cost	appr.u nit labor cost	fixture watts	annual hours	qua-ntity	annual KWH	annual KWH savings	annual electric cost	annual electric savings	appr. total cost	SDG&E Express Effic-iency	pay-back in years	15 year benefit
1	4W 2F34	72	2700	2	388.8	$69.98	2F32L	$18	$18	48	2700	2	259.2	129.6	$46.66	$23.33	$72	$17.00	2.4	$295
1	4W 2F34 T2	144	2700	1	388.8	$69.98	2F32L T2 1B	$26	$34	97	2700	1	261.9	126.9	$47.14	$22.84	$60	$17.00	1.9	$300
1	4W 2F34 T3	216	2700	3	1749.6	$314.93	2F32L T3 2B	$44	$52	145	2700	3	1174.5	575.1	$211.41	$103.52	$288	$76.50	2.0	$1,341
1	4W 2F34 T4	288	2700	14	10886.4	$1,959.55	2F32L T4 2B	$52	$68	197	2700	14	7446.6	3439.8	$1,340.39	$619.16	$1,680	$476.00	1.9	$8,083
1	Exit 2x23CFL	40	8760	1	350.4	$63.07	N RLED sign	$30	$25	4	8760	1	35.0	315.4	$6.31	$56.76	$55	$27.00	0.5	$823
2	4W 2F34 T2	144	2700	3	1166.4	$209.95	2F32L T2 1B	$26	$34	97	2000	3	582.0	584.4	$104.76	$105.19	$180	$51.00	1.2	$1,449
3	4W 2F34 T2	144	2700	2	777.6	$139.97	2F32L T2 1B	$26	$34	97	2000	2	388.0	389.6	$69.84	$70.13	$120	$34.00	1.2	$966
4	Ceiling (2x15)CF	30	1000	2	60.0	$10.80	N 4W 1F32S	$45	$25	28	750	1	21.0	39.0	$3.78	$7.02	$70	$2.00	9.7	$37
5	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
6	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
	TOTALS			**30**	**15912.0**	**$2,864.16**	**TOTALS**					**29**	**10224.2**	**5687.8**	**$1,840.36**	**$1,023.80**	**$2,655**	**$721.00**	**1.9**	**$13,423**

Notes:

KWH is considered to be $0.18.

fixture code examples: 4W 2F34 = 4' wrap with 2F34T12s, 4W 2F34 T4 = 16' row of end to end 4' wraps, each with 2F34T12s

retrofit type examples: 2F32L T4 2B = in 16' row of end to end 4' wraps, install 2 F32T8s in each 4' section, which totals 8 lamps, and use 2 4-lamp low (.77 - .78) BF ballasts

replace type examples: N RLED sign = new red LED exit sign with battery backup, N 4W 1F32 = new 4' wrap with 1 F32T8 and standard (.87-.88) BF ballast

Approximate parts costs include sales tax.

Approximate labor costs include cleaning and disposal costs, other than PCB disposal costs, which would be extra. Labor rate is considered to be $51.50 per hour.

15 year benefit is calculated as (annual electrical savings x 15) + incentive - total cost. Maintenance savings and cost of money are not included, because they can cancel each other out.

15 year benefit may be significantly higher if electric rates increase more than inflation over the next 15 years, which is a very real possibility.

CLAIREMONT LIBRARY - TABLE FOR REPLACE & NO DAYLIGHT SAVINGS OPTIONS

room	existing						proposed												
	fixture type	fixture watts	annual hours	quantity	annual KWH	annual electric cost	retrofit or replace type	appr. unit parts cost	appr.unit labor cost	fixture watts	annual hours	quantity	annual KWH	annual KWH savings	annual electric cost	annual electric savings	appr. total cost	SDG&E Express Effic-iency	pay-back in years	15 year benefit
1	4W 2F34	72	2700	2	388.8	$69.98	N 4SI 1F32H	$140	$65	41	2700	2	221.4	167.4	$39.85	$30.13	$410	$20.50	12.9	$62
1	4W 2F34 T2	144	2700	1	388.8	$69.98	N 8SI 2F32H	$280	$80	73	2700	1	197.1	191.7	$35.48	$34.51	$360	$20.50	9.8	$178
1	4W 2F34 T3	216	2700	3	1749.6	$314.93	N 12SI 3F32H	$420	$90	110	2700	3	891.0	858.6	$160.38	$154.55	$1,530	$92.25	9.3	$880
1	4W 2F34 T4	288	2700	14	10886.4	$1,959.55	N 16SI 4F32H	$560	$160	146	2700	14	5518.8	5367.6	$993.38	$966.17	$10,080	$574.00	9.8	$4,987
1	Exit 2x23CFL	40	8760	1	350.4	$63.07	N RLED sign	$30	$25	4	8760	1	35.0	315.4	$6.31	$56.76	$55	$27.00	0.5	$823
2	4W 2F34 T2	144	2700	3	1166.4	$209.95	N 8SI 2F32H	$280	$80	73	2000	3	438.0	728.4	$78.84	$131.11	$1,080	$61.50	7.8	$948
3	4W 2F34 T2	144	2700	2	777.6	$139.97	N 8SI 2F32H	$280	$80	73	2000	2	292.0	485.6	$52.56	$87.41	$720	$41.00	7.8	$632
4	Ceiling (2x15)CF	30	1000	2	60.0	$10.80	N 4W 1F32S	$45	$25	28	750	1	21.0	39.0	$3.78	$7.02	$70	$2.00	9.7	$37
5	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
6	4W 2F34	72	1000	1	72.0	$12.96	N 4W 1F32S	$45	$20	28	1000	1	28.0	44.0	$5.04	$7.92	$65	$10.25	6.9	$64
	TOTALS			**30**	**15912.0**	**$2,864.16**	**TOTALS**					**29**	**7670.3**	**8241.7**	**$1,380.66**	**$1,483.50**	**$14,435**	**$859.25**	**9.2**	**$8,677**

Notes:

KWH is considered to be $0.18.

fixture code examples: 4W 2F34 = 4' wrap with 2F34T12s, 4W 2F34 T4 = 16' row of end to end 4' wraps, each with 2F34T12s

replace type examples: N RLED sign = new red LED exit sign with battery backup, N 12SI 3 F32H = new 12' suspended indirect with 3 F32T8s and high (1.15) BF ballast

Approximate parts costs include sales tax.

Approximate labor costs include cleaning and disposal costs, other than PCB disposal costs, which would be extra. Labor rate is considered to be $51.50 per hour.

15 year benefit is calculated as (annual electrical savings x 15) + incentive - total cost. Maintenance savings and cost of money are not included, because they can cancel each other out.

15 year benefit may be significantly higher if electric rates increase more than inflation over the next 15 years, which is a very real possibility.

APPENDIX

From "Energy Conservation Using Scotopically Enhance Fluorescent Lighting in an Office Environment". Prepared by Afterimage + Space for the US Department of Energy: Office of Energy Efficiency and Renewable Energy. March 2004. Download at http://www.netl.doe.gov and enter 'scotopically' in the search box.

EXECUTIVE SUMMARY

This study was conducted in a recently built and occupied office building (University of California Office of the President, UCOP) to determine whether the energy savings benefits of scotopically enhanced fluorescent lighting[1] can be achieved while maintaining user acceptability.

The pre-existing lighting in the test building employed the traditional and widely used 3500 Kelvin (K) lamps with a mix of 2 levels of Color Rendering Index (CRI) values of 75 and 85. For this study, two nearly identical floors of the office building were retrofit with new lamps and dimming ballasts to compare differences in light level, energy and user acceptance. Each floor was approximately 30,000 square feet in area, and consisted of open areas with office cubicles as well as private offices. There were approximately 60 offices of each type per floor. The open office area lighting consisted of pendant indirect luminaires, while the private office lighting consisted of recessed parabolic direct luminaires.

In this study, one floor was re-lamped with new 3500 Kelvin (K) lamps (reference lamp) and the other with new 5000K lamps (scotopically enhanced). Both new lamp types had a CRI of 86. Electronic dimming ballasts were installed in the existing luminaires on both floors to adjust the light levels. The floor with 3500K lamps (835) had the lighting levels adjusted to approximately the same light level that existed prior to re-lamping. The lighting levels in the offices on the floor with the 5000K lamps (850) were set at approximately 20% lower light levels than the floor with the 835 lamps.[2] Open office area occupants were not able to modify their light level, while private offices were outfitted with computer software controls that allowed the individual occupants to adjust the light level at their own discretion. Occupants on both floors were surveyed to determine differences in occupant acceptance between the 835 and 850 lamps.

For open office areas, the following conclusions were made:

1. There was no statistically significant difference in occupant acceptance of the 850 lamp as compared to 835 lamp under the conditions of having the 850 lighting system illuminances reduced approximately 20% below that of the 835 lighting system.
2. **The energy savings potential due to the spectral effect of the 850 lamp, as a scotopically enhanced light source, ranges between 17-24% when compared to the 835 lamp. By extension, the energy savings potential due to the spectral effect of the 850 lamp ranges between 22-30% when compared to the 735 lamp.**
3. The previously derived illuminance-based design method for scotopically enhanced lighting proved to be an adequate predictor of light level reduction and energy savings potential in an open office application, based on the tasks being performed.

For private offices, there was no statistically significant difference in occupant acceptance of the 850 lamps compared to the 835 lamps. However, no conclusive results were obtained in the private offices for light level and energy savings potential due to the unforeseen circumstances of the insignificant number of occupied non-daylit private offices, the confounding variables of daylight in perimeter offices, and the confounding variable introduced by a computer interface occupant control system that was nearly universally unused by private office occupants.

[1] Scotopically enhanced lighting is white light with a higher bluish content generally achieved by adjustment of the spectrum to produce a higher correlated color temperature. Lamps with this property are readily commercially available at approximately the same cost as other more traditionally used lamps.

[2] The light level reduction of the 850 lamps was set at 20% to test a previously derived predictive design method.

The following chart is used to determine lighting levels and is from the IESNA *Lighting Handbook*, Ninth Edition.

Figure 10-9. Determination of Illuminance Categories*

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.

A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)

Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.

D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)

Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.

G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with ± 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

Use **Figure 10-9** above to determine illuminance levels required (both horizontal and vertical). For example: D = 30 foot-candles.

I. INTERIOR LOCATIONS AND TASKS	Very Important	Important	Somewhat important	Blank = Not important or not applicable																				
Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Libraries (10)																								Ch. 12
Reading stacks																				D				
Bookstacks																								
Active																		(7)				D	(12)	
Inactive																		(7)				B	(12)	
Book repair or binding																		(7)		D		A		
Cataloguing																		(7)		D				
Card files (paper)																				D		B		
Carrels, individual study desks																				D				
Circulation desk																				D				
Map and print room (see Graphic Design and Material)																		(7)		D				
Audiovisual areas																				D				
Audio listening areas																				D				
Microform areas																				D				