BUILDING TECHNOLOGIES PROGRAM

PG&E Santa Rosa Service Center Building

U.S. Forest Service, Mare Island, Western Regional Headquarters

Port Hueneme Military Base, Building 1000

Spectrally Enhanced Lighting Economics Validation Study

Three-building Field Assessment Validates Energy Savings and Economics

Spectrally Enhanced Lighting (SEL) is a simple strategy that uses existing products and technology to significantly reduce energy use in commercial buildings. A 2002 study conducted at the University of California Office of the President (UCOP) demonstrated that the high CCT color of lighting used in spectrally enhanced lighting was not objectionable to building occupants, removing a significant barrier to widespread implementation of SEL. The UCOP study compared two similar floors of an 11-story building and found equal occupant acceptance for the commonly used 835 lighting and the 850 SEL lighting, even with the SEL light levels reduced by 20% as calculated using the SEL design method.

In 2004, the U.S. Department of Energy, AfterImage + Space, and Pacific Northwest National Laboratory conducted a more extensive study involving three California buildings where the lighting was completely retrofit using spectrally enhanced lighting strategies. The UCOP study used dimming ballasts due to uncertainties about whether the lowered illuminance would be acceptable. But the 2004 Economics Validation Study was specifically designed to determine whether SEL could be used as a cost effective lighting retrofit strategy, and included assessment of design method risk using standard lighting equipment instead of dimming ballasts, assessment of compensatory task lighting, and further assessment of occupant satisfaction.

The Economics Validation Study was conducted at the following facilities:

- PG&E Santa Rosa Service Center Building
- U.S. Forest Service, Mare Island, Western Regional Headquarters
- Port Hueneme Military Base, Building 1000

Each building owner hired their own lighting retrofit contractor, and all work was completed outside of business hours, with no disruption of office activity or productivity. All three buildings had similar pre-retrofit lighting systems consisting of three-lamp, 18-cell parabolic luminaires, although each building had different pre-retrofit lamp colors. In one building, the pre-retrofit lighting system contained T12 lamps and magnetic ballasts, while the other two buildings had T8 lamps and electronic ballasts.

The project team conducted pre- and post-retrofit lighting measurements to validate the design process calculations, as well as before and after surveys to determine occupant satisfaction. The team measured overhead lighting electrical loads, light levels in the workspace, task lighting usage, and occupant ratings of satisfaction with the lighting.

Key Conclusions

- Measured energy savings: 19-46%.
- Task lighting usage, measured both pre- and post-installation, showed no significant change even though the overhead light levels were reduced.
- Occupant satisfaction, measured both pre- and post-installation, showed no significant change.
- Payback for T8 retrofits: 3-4 years.
- Payback for T12 retrofits: 1.4 years.

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PG&E Santa Rosa Service Center Building

The PG&E Santa Rosa Service Center Building is a 57,000-sq ft, one-story office building located in Santa Rosa, California. Approximately 1,700 overhead lamps were replaced in this building. The original overhead lighting was provided by Philips F34T12/SPEC35/RS/EW lamps with magnetic rapid start ballasts (ballast factor 0.88), installed in predominantly 2x4-foot, 3-lamp fixtures. The building includes 30 enclosed offices, 103 cubicles, six small conference rooms, one large conference room, a training room, a transient work room, a customer service room, and three hallways. Lamps in all fixtures were replaced with new Philips F32T8/ADV850/XEW lamps. Ballasts were replaced with electronic instant start ballasts with a ballast factor of 0.77.

Conclusions

- Connected load decreased 45.6%.
- Estimated annual energy savings are approximately 44,000 kWh/yr.
- The light level measurements taken in a sample of workstations indicate that horizontal photopic light levels decreased by 20% following the retrofit. Horizontal scotopic light levels increased by 13%, and the S/P ratio increased by 40%.
- Occupant satisfaction, measured both pre- and post-installation, showed no significant change.
- Task lighting usage, measured both pre- and post-installation, showed no significant change.

	Pre-Retrofit Lamps and Ballasts	Post-Retrofit Lamps and Ballasts
Lamp	F34T12/SPEC35/RS/EW	F32T8/ADV850/XEW
Nominal Lamp Wattage	34	25
Lamp Color	735	850
Rated Photopic Lumens (P)	2800	2400
Ballast Factor (BF)	0.88	0.77
Lumen Output (P x BF)	2464	1848
S/P Ratio	1.32	1.87
Visually Effective Lumens $(P \times BF) \times (S/P)^{.78}$	3060	3011
Measured Connected Load	37.7 w/lamp	20.5 w/lamp
		45.6% energy savings

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Field Evaluation,* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

Payback Including Life Cycle Annual Savings*	
Total installed cost for the area	$25,210
Annual savings from retrofit	$17,921
Payback (years)	1.41
Rate of Return	71%

** Payback analysis was performed using the life-cycle cost-benefit analysis in accordance with the IESNA Handbook.*

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Economics Validation Study* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

U.S. Forest Service, Mare Island, Western Regional Headquarters

The U.S. Forest Service, Mare Island, Western Regional Headquarters Building is a 119,000-sq ft, four-story office building located in Vallejo, California. Approximately 2,800 overhead lamps were replaced in this building. The original overhead lighting was provided by General Electric F32T8/SP30/ECO lamps and electronic instant start ballasts with ballast factor of 0.88. These lamps were found in 2x4-foot, 3-lamp fixtures, which lighted 20 enclosed offices (four shared), 122 cubicles, 15 conference rooms, 18 hallways, a library, and four training rooms. Lamps in all fixtures were replaced with new GE F32T8/SPX50/HLEC lamps. Ballasts were replaced with electronic programmed start ballasts with a ballast factor of 0.60.

Conclusions

- Connected load decreased 19.8%.
- Estimated annual energy savings are approximately 60,000 kWh/yr.
- The light level measurements taken in a sample of workstations indicate that horizontal photopic light levels decreased by 31% following the retrofit. Horizontal scotopic light levels did not change, but the S/P ratio increased by 46%.
- Occupant satisfaction, measured both pre- and post-installation, showed no significant change.
- Task lighting usage, measured both pre- and post-installation, showed no significant change.

	Pre-Retrofit Lamps and Ballasts	Post-Retrofit Lamps and Ballasts
Lamp	F32T8/SP30/ECO	F32T8/XL/SPX50/HLEC
Nominal Lamp Wattage	32	32
Lamp Color	730	850
Rated Photopic Lumens (P)	2800	3000
Ballast Factor (BF)	0.88	0.60
Lumen Output (P x BF)	2464	1800
S/P Ratio	1.30	2.00
Visually Effective Lumens $(P \times BF) \times (S/P)^{.78}$	3024	3091
Measured Connected Load	29.08 w/lamp	23.32 w/lamp
		19.8% energy savings

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Field Evaluation,* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

Payback Including Life Cycle Annual Savings*	
Total installed cost for the area	$56,049
Annual savings from retrofit	$ 15,557
Payback (years)	3.60
Rate of Return	28%

** Payback analysis was performed using the life-cycle cost-benefit analysis in accordance with the IESNA Handbook.*

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Economics Validation Study* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

Port Hueneme Military Base, Building 1000

The Port Hueneme Military Base Building 1000 is a 67,000-sq ft, two-story office building located in Oxnard, California. Approximately 2,300 overhead lamps were replaced in this building. The original overhead lighting was provided by Philips FO32/741/ECO lamps and electronic instant start ballasts with ballast factor of 0.88. These were found in predominately 2x4-foot, 3-lamp fixtures, which lighted 57 enclosed offices, 168 cubicles, nine conference rooms, and eight hallways. Lamps in all fixtures were replaced with new Sylvania FO30/850 XP/SS/ECO lamps. Ballasts were replaced with electronic programmed start ballasts with a ballast factor of 0.71.

Conclusions

- Connected load decreased 20.5%.
- Annual energy savings are estimated at approximately 37,000 kWh/yr.
- The light level measurements taken in a sample of workstations indicate that horizontal photopic light levels decreased by 15% following the retrofit. Horizontal scotopic light levels did not change, but the S/P ratio increased by 19%.
- Occupant satisfaction, measured both pre- and post-installation, showed no significant change.
- Task lighting usage, measured both pre- and post-installation, showed no significant change.

	Pre-Retrofit Lamps and Ballasts	Post-Retrofit Lamps and Ballasts
Lamp	FO32/741/ECO	FO30/850XP/SS/ECO
Nominal Lamp Wattage	32	30
Lamp Color	741	850
Rated Photopic Lumens (P)	2800	2800
Ballast Factor (BF)	0.88	0.71
Lumen Output (P x BF)	2464	1988
S/P Ratio	1.56	1.85
Visually Effective Lumens $(P \times BF) \times (S/P)^{.78}$	3486	3212
Measured Connected Load	27.11 w/lamp	21.56 w/lamp
		20.5% energy savings

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Field Evaluation,* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

Payback Including Life Cycle Annual Savings*	
Total installed cost for the area	$32,354
Annual savings from retrofit	$9,276
Payback (years)	3.49
Rate of Return	29%

** Payback analysis was performed using the life-cycle cost-benefit analysis in accordance with the IESNA Handbook.*

Source: *Spectrally Enhanced Lighting Program Implementation for Energy Savings, Economics Validation Study* conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (August 2006).

For More Information

To learn more about spectrally enhanced lighting, or to download the complete technical reports discussed in this document, visit http://www.eere.energy.gov/buildings/tech/lighting/sel.