Customer Advanced Technologies Program
Technology Evaluation Report

Lighting Circuit Power Reducers
for Fluorescent Lighting Applications

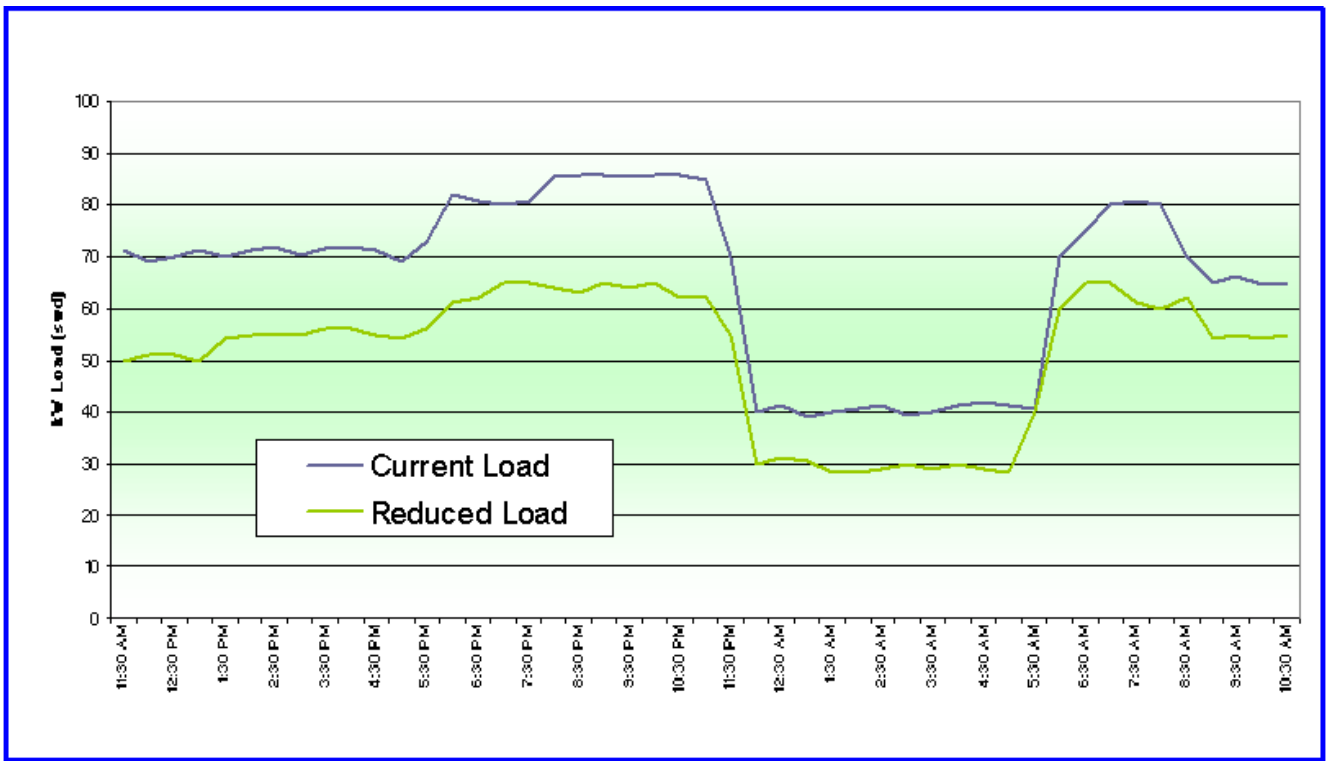

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Table of Contents

Introduction

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to encourage the use of and evaluate new technologies. The program provides funding for customers in exchange for monitoring rights. Completed demonstration projects include lighting technologies, light emitting diodes (LEDs), residential building shell construction, geothermal heat pumps, indirect / direct evaporative cooling, non-chemical water treatment and a wide variety of other technologies.

Technology Description

Over the past couple of years, a new generation of lighting control systems have been introduced to the Sacramento area. Instead of the traditional approach of controlling individual or small groups of lighting fixtures, these systems are retrofitted into a customer's electrical panel and are used to control entire lighting circuits (hence the name 'lighting circuit power reducers'). These systems reduce the supply voltage to fluorescent and high intensity discharge (HID) lighting systems. When this occurs, the power consumption and light output levels are reduced. Lighting circuit power reducers can be separated into two basic categories:

1) **Autotransformer power reducers**
   - Decrease the voltage to the lighting load but preserve the voltage waveform
   - Tend to be heavy (often weigh more than 100 pounds)
   - Have little or no adverse effect upon power quality. In fact, models that use torridal transformers may actually produce modest *improvements* in power quality.
   - Often used to control HID lighting systems

2) **Electronic power reducers**
   - Decrease the voltage by 'chopping' part of the voltage cycle
   - Smaller and lighter than autotransformers
   - May have an adverse impact upon power quality.
   - Some products include capacitance for power factor correction

Both types of systems supply full voltage during start up and allow the lamps to warm up before reducing the voltage levels to a predetermined set point. Some models offer the ability to vary the set points when used in conjunction with time clocks, photo sensors or energy management systems.

Although this technology is suitable for both fluorescent and high-intensity-discharge (HID) systems, the scope of this evaluation is limited to fluorescent lighting applications. Several demonstration projects are currently underway for HID systems. The results for these projects will be presented at a later date in a separate report.

Observations

Lighting Levels Versus Energy Consumption

Manufacturers sometimes claim these systems save energy without any perceptible loss of light. The key word is *perceptible*. Experience has shown that most people may not notice lighting level reductions of 10 to 15% if the levels are reduced gradually. Tests conducted by the National Lighting Product Information Program[1] (NLPIP) have shown that the power consumption and lighting output appear to be reduced by approximately the same amount. In other words, setting the controls to reduce power consumption by 25% will also reduce the illumination levels by at least 25%.

Although this technology definitely reduces illumination levels, many commercial facilities are over-lit. Consequently, this technology may have the potential for widespread application. Some particularly attractive applications may include:

- Areas that are over lit and where permanent de-lamping or retrofitting is difficult or undesirable. For example: a three-lamp fluorescent lighting system with parabolic, egg-crate type lenses that has already been retrofitted with T8 lamps and electronic ballasts, but still produces too much light.
- Parking garages, open office spaces, supermarkets, distribution centers and manufacturers.
- Customers who are participating in 'demand responsive' load shed programs. When asked by local utility, these customers could reduce power consumption by temporarily reducing lighting levels.
- Customers who wish to vary the overall illumination levels for different operating conditions. For example, grocery and retail stores often reduce illumination levels at night while restocking the shelves. Restaurants may also wish to use different lighting levels for lunch and dinner.

Important note: *some lighting circuit power reducers are preset by the factory and cannot be easily adjusted by the end user. Other systems can be controlled via energy management software and offer a high degree of flexibility. The preset systems are not suitable for the 'demand responsive load shed programs' or situations with varying illumination levels described above. Customers should carefully consider their needs when comparing lighting circuit power reducers.*

Lamp Life

The life expectancy of fluorescent lamps is affected by several factors including the ballast factor, the voltage applied to the lamp cathodes, lamp current crest factor, and the number of times the lamps are turned on and off.

Ballast Factor and Lamp Cathode Voltage: According to lamp manufacturers, the life expectancy of fluorescent lamps may be reduced by 25% when they are connected to a system with a ballast factor of 1.25 or greater. Conversely, some manufacturers have suggested that 'under driving' the lamps may extend their useful life. Since lighting circuit power reducers reduce the power to the ballasts, the net effect is under driving the lamps. However, reducing the operating voltage to the lamp cathodes may

actually *shorten* lamp life by causing sputtering. When rating lamps, manufacturers usually assume a minimum electrode operating voltage of 2.5 to 4.0 volts for rapid start fluorescent lamps. *All of the products tested in the NPLIP report failed to maintain this required minimum voltage to the lamp cathodes*. Customers should consult with lamp manufacturers for specific warranty information before purchasing any particular product.

Lamp Current Crest Factor: The lamp current crest factor, or CCF, is the ratio of the peak electrical current divided by the root-mean-square (RMS) current. A current crest factor above 1.7 can significantly reduce lamp life by causing damage to the cathodes. *One of the products tested in the NLPIP report produced a CCF of 1.9.*

Ballast Life

It is a well-known fact that the operating temperature affects the life expectancy of ballasts. Fluorescent ballasts that operate at elevated temperatures will experience shortened life. Although the American National Standards Institute (ANSI) and Underwriters Laboratories (UL) specify a maximum allowable case temperature for fluorescent ballasts of 90°C, manufacturers often rate the life expectancy of their ballasts at lower temperatures.

According to the NLPIP Specifiers Report, ballast life will be reduced by approximately 50% for every 10°C increase in temperature above the rated temperature for the ballast. As mentioned earlier, lighting circuit power reducers can reduce the power consumption of the ballasts. Theoretically, this should cause the ballasts to operate at lower temperatures and extend their life. However, since the operating set point for these systems is a variable that is controlled by the end user, no attempt will be made in this report to estimate this technology's affect upon the life of the ballasts.

[1]Source: National Lighting Product Information Program Specifier Report Volume 6, Number 2, September 1998

Showcase Project

Customer: Raley's Supermarket
5157 Fair Oaks Blvd
Carmichael, CA 95608

Project Objective: **Reduce the power consumption of the existing lighting system via a centralized control system**

Basecase:

- T8 fluorescent lighting systems
- Peak electrical demand (measured) = 80.1 kW
- Average electrical demand (measured) = 63.6 kW
- Estimated hours of operation = 8,760 hours / year
- Estimated energy consumption = 556,970 kWh / year
- Estimated electrical costs = $45,827 / year
- Light levels = average of 108 fc (foot-candles)

New System:

- Installed Electric City EnergySaver® to control the existing lighting systems
- Peak electrical demand (measured) = 65.6 kW (controls set to reduce voltage by 19%)
- Average electrical demand (measured) = 51.2 kW
- Estimated hours of operation = 8,760 hours / year
- Estimated energy consumption = 448,833 kWh / year
- Estimated electrical costs = $36,930 / year
- Light levels = average of 88 fc (foot-candles)
- Project cost[1] = $26,000

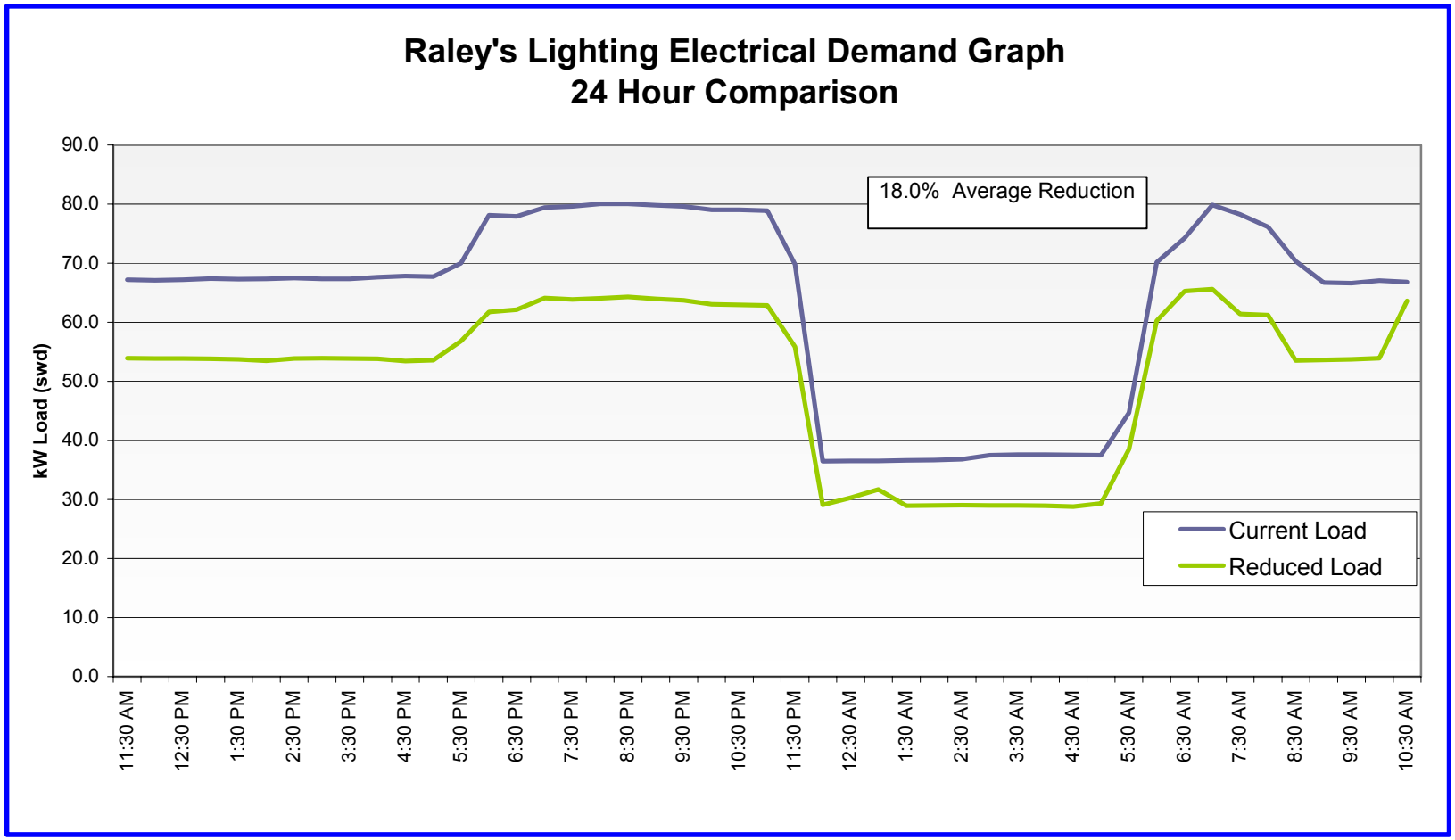
Results:

- Peak electrical demand reduction = 14.5 kW (18% reduction)
- Average electrical demand reduction = 12.3 kW (19.4% reduction)
- Estimated annual energy savings = 108,136 kWh (19.4 % reduction)
- Reduction in illumination levels = 20 foot-candles (18%)
- Estimated electrical cost savings = $8,897 per year
- Calculated simple payback = 2.9 years[1]

[3]Project cost and simple payback do not include the Customer Advanced Technologies program grant

Comments:

- Customer reaction: Very pleased. Commented on the benefits of being able to control the lighting system and respond to electrical emergencies.
- Demand and energy reductions of over 18% (see graphs and data on the following pages)



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Raley's Meter Data Summary

9/16/2002

Energy Saver Off

Date	Avg Volts	Avg Amps	Total kWh	Avg kW swd	Peak kW swd
02/22 & 02/23	278	76.7	1,427	63.58	80.1

Energy Saver on

Date	Avg Volts	Avg Amps	Total kWh	Avg kW swd	Peak kW swd
02/21 & 02/22	280	61.8	1,150	51.24	65.6

Peak kW Saved =	**14.5**	KW
KW Avg Saved =	**12.3**	KW
KWh Saved =	**277**	KWh
Duration of Monitoring Period =	**22.5**	**hours**
Average Hourly kWh Savings =	**12.3**	**KWh / hour**
Annual Hours of Operation =	**8,760**	**hrs /year**

Baseline Energy Consumption (estimated) =	**556,970**	**KWh / year**
Retrofit Energy Consumption (estimated) =	**448,833**	**KWh / year**
Estimated Annual Savings =	**108,136**	**KWh / year**

Peak kW Savings (%) =	**18.05%**
Average kW Savings (%) =	**19.42%**
Energy Savings (%) =	**19.40%**

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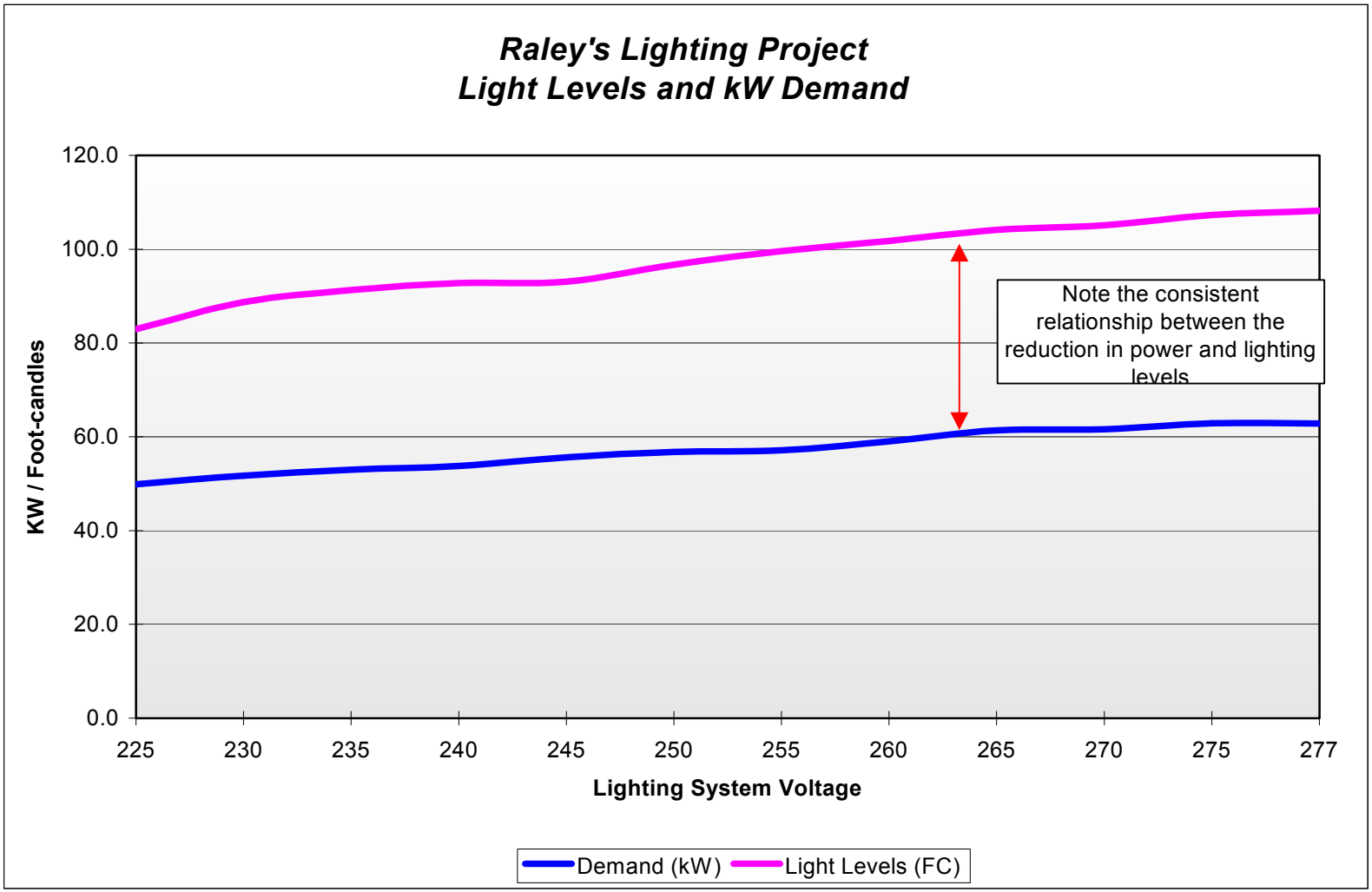

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Conclusion

Market Potential and Barriers

Since many commercial buildings are over lit, the potential market for this technology is huge. It may be especially valuable for customers who are participating in 'demand responsive' load shed programs- as long as they choose systems that can be easily adjusted (see recommendations below).

Recommendations

- Some lighting circuit power reducers are preset by the factory and cannot be easily adjusted by the end user. Other systems can be controlled via energy management software and offer a high degree of flexibility. The preset systems are not suitable for the demand responsive load shed programs. Customers should carefully consider their needs when comparing lighting circuit power reducers.
- Most fluorescent ballast manufacturers offer a five-year product warranty. For applications involving newer buildings (or new lighting systems) customers should contact the ballast manufacturer to ensure that ballast warranty will not be impacted by the application of lighting circuit power reducers.
- Customers should not reduce illumination levels below the standards established by the Illuminating Engineering Society of North America (IESNA)
- Although this technology has the potential to save a significant amount of energy, it does not improve the quality of a lighting system. If improving the quality of a lighting system is a primary goal, customers who are using T12 lamps and magnetic ballasts should consider replacing these systems with T8 or T5 lamps and electronic ballasts instead of purchasing a lighting circuit power reducer.
- Customers should carefully consider power quality implications when comparing products.
- Results will vary greatly with different ballast and lamp combinations. Contact the vendor for guidance.
- Lighting circuit power reducers should only be applied to circuits that are dedicated to lighting systems. In many older buildings, the lighting circuits may have been 'tapped' to provide power for vending machines, office equipment or other devices.
- Active front-end ballasts will not work with this technology. Although these types of ballasts are rare, it is important to check for them before considering this technology.

Technology Transfer

This technology is already commercially available and is continuing to gain acceptance in the marketplace. Because of this, no additional demonstration projects are planned at this time. However, this evaluation report will be posted to the Customer Advanced Technologies web page at http://www.smud.org/community/cat.html in an effort to share information with our Customer-Owners.