

*Customer Advanced Technologies Program  
Technology Evaluation Report*

**The California Kitchen Lighting System**



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### **About the Customer Advanced Technologies Program**

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to encourage the use and evaluation of new or underutilized 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 systems and a wide variety of other technologies.

For more program information, please visit: <http://www.smud.org/education/cat/index.html>

## ***Introduction***

A big change is coming. In October of 2005 homebuilders in California will face tough new Title 24 energy efficiency standards. These new standards include specific requirements that will make it very difficult to install anything other than fluorescent lighting systems in residential kitchens. Is this a big deal? Well, it is if you are a homebuilder, in the market to buy a new home or have been considering remodeling your kitchen!

Fortunately, the California Energy Commission recognized the need to develop high-quality, energy-efficient lighting alternatives and funded research to help residential customers meet the tighter energy codes. Since then, SMUD has been working with the California Lighting Technology Center at U.C. Davis, Lawrence Berkeley National Lab, the California Energy Commission and Lithonia Lighting to develop a cutting edge lighting system for residential kitchens. These new compact fluorescent downlights use one quarter of the energy of incandescent downlights, significantly reduce the cost of typical compact fluorescent downlight systems, and offer lighting quality that is as good or better than recessed incandescent lighting systems.

The next time you visit a new model home – go in to the kitchen and look up at the ceiling. Chances are good that you will see several recessed downlights and most of them will have 65-watt incandescent lamps. Many interior decorators, architects and consumers prefer using recessed downlights instead of linear fluorescents to create the “clean ceiling” look. Unfortunately, incandescent lamps waste a lot of energy and produce a tremendous amount of heat. The 2005 Title 24 energy standards will make incandescent lights in residential kitchens a thing of the past. The good news is that consumers now have a better option available to them.



Recessed downlights

## ***The Project Team***

About three years ago, the California Energy Commission’s Public Interest Energy Research (PIER) Program launched a project to develop energy efficient recessed lighting systems for residential kitchen applications. The primary purpose of PIER is to fund development of energy efficient technologies. The Commission hired Dr. Michael Siminovitch and Erik Page at Lawrence Berkeley Lab.

Dr. Siminovitch, who is now the Director of the California Lighting Technology Center at U.C. Davis, knew from past experience that the best way to tackle this project was through a team approach. He assembled a team that included:

California Energy Commission  
Lawrence Berkeley National Lab  
Sacramento Municipal Utility District  
Homebuilders

California Lighting Technology Center at U.C. Davis  
Lithonia Lighting  
National Resource Defense Council  
Electrical contractors

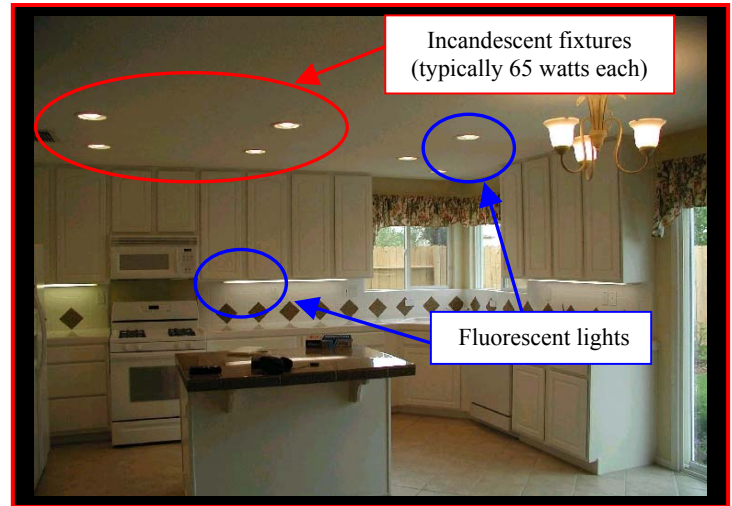
The project team began by researching current industry practices and the problems associated with existing residential compact fluorescent lighting systems.

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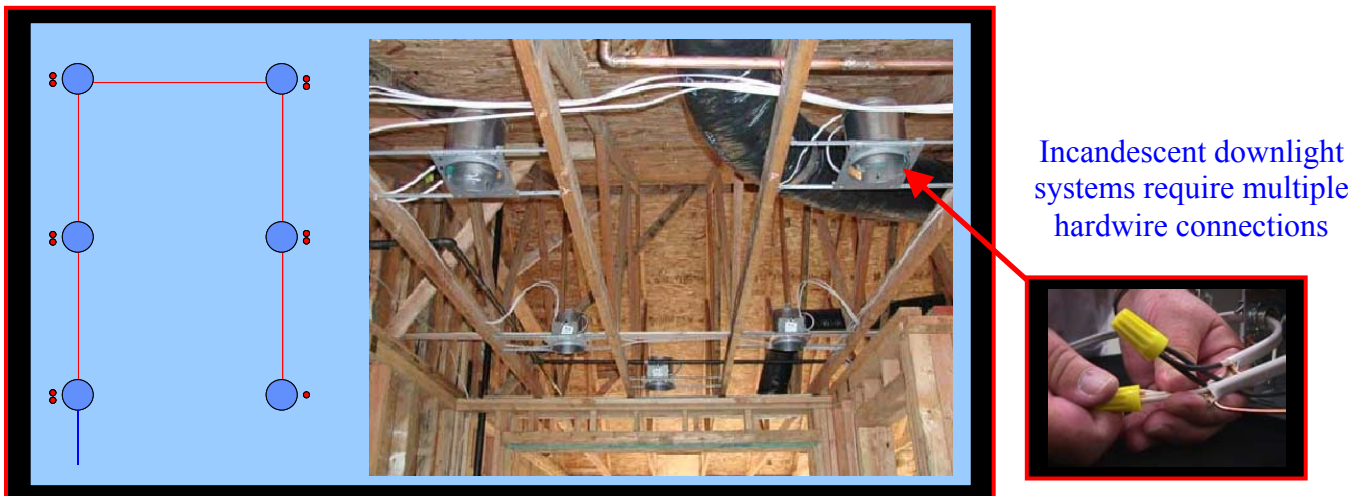
## Current Industry Practices

Although existing Title 24 energy standards already require fluorescent lighting in residential kitchens, the current market trend is towards recessed downlights. This creates a significant problem for builders since most existing compact fluorescent downlights suffer from a variety of performance issues. Many builders in California have chosen to install both fluorescent and incandescent systems to satisfy their customers while meeting current energy standards (see photo). Unfortunately, this practice is very labor intensive and defeats the original intent of the Title 24 energy requirements.

Current industry trends use inexpensive components that are very labor intensive to install. In fact, labor usually accounts for the majority of overall system costs.



Most builders use an average of six incandescent downlights for kitchens. After mounting the fixtures, the installer must strip and connect each of the wires (see below). This type of connection, commonly referred to as a “hardwire connection,” is time consuming and may be a source of future callbacks. The average six-lamp system would require a total of eleven hardwire connections.



The use of downlights in new homes is not limited to kitchens; they are also used in bathrooms, living rooms, hallways and even in bedrooms. In fact, some of the larger homes in California include over forty recessed downlights and almost all of them are incandescent. Imagine living in a home with over 2,600 watts of recessed downlights!

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## ***Problems With Existing Residential Compact Fluorescent Downlights***

Although lighting catalogs are filled with literally hundreds of different products for commercial applications, choices for residential recessed lighting systems are very limited. To make matters worse, compact fluorescents have earned somewhat of a bad reputation; many of them blink when you turn them on, suffer from premature failures and do not produce enough light. For the most part, consumers have been limited to two basic choices:



Commercial downlights are available in a wide variety of configurations

➤ **13-watt compact fluorescent downlights with magnetic ballasts:** many homebuilders use these lights to comply with current Title 24 energy standards. These systems blink several times during start up and do not produce much light (please see “ballast basics” on page four). Homeowners often replace these lights with incandescent downlights after the home has been purchased.

➤ **Screw-in compact fluorescent lamps:** homeowners often buy screw-in compact fluorescent lamps to save energy. Although it is true that compact fluorescent lamps are more energy efficient and generally last longer than incandescent lamps, most recessed downlight fixtures are designed for incandescent lamps. This creates two major problems:

- 1) Most screw-in compact fluorescent lamps use electronic ballasts that are built into the base of the lamp. Unfortunately, electronic ballasts are very vulnerable to heat. When these lamps are screwed into a recessed downlight housing, the heat is trapped within the fixture. The result? Many of these lamps fail prematurely.
- 2) Incandescent recessed downlights are designed for use with reflector (i.e. flood) lamps. Since most compact fluorescent lamps do not incorporate optics, the majority of the light produced by the lamp is trapped within the fixture (see photos below).



65-watt incandescent flood lamp



Screw-in compact fluorescent lamp with electronic ballast



Screw-in compact fluorescent installed in a conventional recessed downlight

Both of these approaches suffer from serious drawbacks. Consequently, many homebuilders and homeowners have been disappointed and are now reluctant to embrace compact fluorescent lighting systems. A better solution was clearly needed to help consumers deal with the upcoming 2005 energy standards.

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## *The Quest for a Better Lighting System*

The project team began the task of developing a better fluorescent lighting system by reviewing hundreds of electrical plans and searching through seemingly endless lamp and ballast catalogs. The next step was interviewing builders, electrical contractors and homeowners, to determine their needs. To be successful, the new system would have to address the performance issues mentioned earlier and have the following characteristics:

- **Must be downlights:** even though there are more efficient ways to illuminate kitchens, homeowners like the clean ceiling look that recessed lighting systems provide.
- **Instant on, flicker free operation:** many consumers are annoyed by lights that blink during start-up (i.e. systems with magnetic ballasts).
- **Long life:** system must be reliable. Callbacks are expensive and lead to customer dissatisfaction.
- **Provide high quality lighting:** people like well-lit kitchens. The system must provide enough light and render colors accurately. The lamps should not protrude from the bottom of the fixture or cause glare.
- **Ease to install & competitively priced:** system must be easy to install and the total installation cost must be comparable to existing recessed lighting systems.
- **Reduced inventory:** many builders and electrical contractors have very limited available warehouse space. Furthermore, having to stock too many options is confusing and often leads to mistakes in the field. Ideally, the new system should be simple and configured to meet the needs of almost every job site while offering trim options to accommodate different styles and tastes.
- **Simplified Title 24 compliance process:** As mentioned earlier in this report, California homebuilders are often caught between meeting existing energy standards and the individual preferences of their customers. Since most existing compact fluorescent downlights suffer from a variety of performance issues, many builders have chosen to install both fluorescent and incandescent systems. Developing one system that will meet both needs is a high priority for builders.
- **System must be readily available:** developing the “ultimate lighting system” does not help builders if the system is not available through established distribution channels or is in short supply. The manufacturer must be large enough to meet the needs of the California market. Consumers must have easy access to replacement lamps (i.e. through home improvement and hardware stores).
- **Maintenance friendly:** Ballasts must be easily accessible from within the kitchen.

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### *Ballast Basics*

#### **Q: What is a ballast?**

A: Unlike incandescent lamps, fluorescent systems require a ballast to start and operate the lamps. The ballast regulates the voltage and flow of electricity to the lamp. Ballasts may be either electronic or magnetic (core and coil).

#### **Q. Which are better: magnetic or electronic ballasts?**

A. Lamps driven by magnetic ballasts blink during start up and may flicker. Electronic ballasts provide instant on, flicker-free operation and are more energy efficient than magnetic ballasts. However, magnetic ballasts tend to last longer than electronic ballasts due to heat – especially in recessed lighting fixtures.

#### **Q. Do screw-in compact fluorescent lamps have ballasts?**

A. Yes. The ballasts for screw-in compact fluorescents are built into the base of the lamp and are usually electronic.

During the last two years the project team designed, tested and redesigned the lighting system. Several prototypes were made and presented to builders, electricians, and homeowners for testing and feedback. The system was submitted and approved by Underwriters Laboratories (U.L.). After more than three years of hard work, the system is now ready to be introduced to the public.

## ***The California Kitchen Lighting System***

### **Overview**

The California Kitchen Lighting System is designed to provide high quality lighting while meeting the needs of builders, electrical contractors, and homeowners. It is based upon master / slave ballast technology and incorporates the following features:

- **System approach:** integrated design for performance and cost savings. The fixture optics have been specifically designed for use with 26-watt compact fluorescent lamps. This ensures that most of the light produced by the lamps is delivered to the task.
- **Builder friendly and cost competitive:** high performance lighting system allows the use of fewer fixtures and incorporates “plug and play” hardware that reduces the number of hard wire connections by at least 50%. Since only one ballast is required for every two downlights, installation is less labor intensive and less prone to error. These factors make the total installed system cost comparable to other recessed lighting systems.
- **Thermally enhanced, multi-lamp electronic ballasts:** system has been built around the use of two-lamp, electronic ballasts that have been placed in a location within the fixture that provides enhanced thermal performance and ease of access for maintenance.
- **High quality illumination:** system utilizes high performance optics, electronic ballasts and high quality 26-watt compact fluorescent lamps. This combination provides more light than conventional incandescent downlights, long life and good color rendering. The electronic ballast provides flicker free start-up and operation.
- **Simplified Title 24 compliance process:** the California Kitchen Lighting System will enable builders to provide a high quality lighting system to their customers while meeting the requirements of the 2005 Title 24 residential kitchen lighting standards.



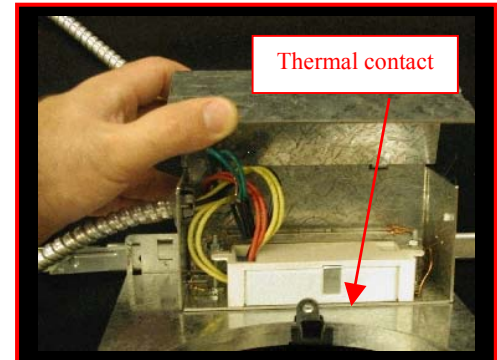
The California Kitchen Lighting System

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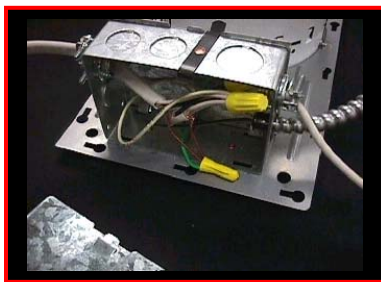
## System Components

**Electronic two-lamp ballast:** historically speaking, manufacturers have only offered 13-watt compact fluorescent systems with magnetic ballasts for residential applications. The reason? Heat. During the summer, attics may easily reach temperatures of 140° F (or more). This environment will quickly kill most electronic ballasts – unless some way is found to keep the ballasts from overheating. Fortunately, the project team found a way to do just that!

The ballast is thermally connected to the fixture housing, which itself is in thermal contact with the sheetrock. Tests conducted by Lawrence Berkeley National Labs show that this thermal management system keeps the ballast temperatures well under manufacturer warranty limits - even when the fixture is buried in insulation and placed in super-heated attics. Consumers will now be able to enjoy the benefits of 26-watt, electronically ballasted systems in their homes.



**“Plug and Play” hardware:** conventional systems require completing at least three connections per fixture. This involves securing the wire, removing the wiring sheath, stripping the wire and using twist connectors (a.k.a. wire nuts) to make the connections. The California Kitchen Lighting System’s unique master / slave ballast configuration and “plug and play” hardware reduces the number of required field-wired connections by a least 50%. Since the system requires only one ballast for every two downlights, installation and maintenance costs will be significantly lower than other compact fluorescent recessed lighting systems.



Conventional system requires completing at least three connections for each fixture



Simple “plug & play” connection reduces the number of field-wired connections by at least 50%

**High performance optics:** in the past, many consumers have experienced disappointing results with using screw-in fluorescent downlights. The main problem is that the fixtures simply are not designed for compact fluorescent lamps. Consequently, more than half of the light produced by the lamp may be trapped within the fixture. The California Kitchen Lighting System uses commercial grade optics that have been specifically designed for use with 26-watt compact fluorescent lamps. These optics deliver more than 70% of the light to the task without producing annoying glare.

**Compact fluorescent lamps:** most of us know that compact fluorescent lamps are energy efficient and last up to ten times longer than incandescent lamps (10,000 hours). However, fluorescent lamps are sensitive to temperature and usually require a few minutes to reach maximum light output after being turned on - especially in cold environments. When compact fluorescents operate in hot environments (e.g. recessed downlights), the heat may actually reduce the light output of the lamp by as much as fifteen percent. Fortunately, lamp manufacturers have addressed this issue by adding a substance known as amalgam to the lamp fill. This will enhance the performance of the lamps in recessed lighting fixture applications.

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## System Comparison

When comparing lighting systems, it is important to remember that not all systems are created equal – some systems produce more light and are easier to install than others. To make a fair comparison these factors must be included. The table presented below compares the performance (lumens), fixture costs, installation costs and energy costs for three types of systems.

	Standard Incandescent (65BR30/FL/RP lamps)	Standard CFL System (CF13DD827RP lamps)	California Kitchen Lighting System (CF26DT/E/IN/830 lamps)
Total # of Downlights	10	10	6
Nominal lamp lumens	640 lumens	780 lumens	1,800 lumens
Nominal lamp wattage	65 watts	13 watts	26 watts
Fixture efficiency <sup>1</sup> (optical)	95 %	50 %	72 %
Lumens per Downlight	608 lumens	390 lumens	1,300 lumens
Lamp Power per Downlight <sup>2</sup>	65 watts	15 watts	30 watts
Material Cost per Downlight	\$20 per fixture	\$35 per fixture	\$45 per fixture
Installation Cost per Downlight	\$30 per fixture	\$30 per fixture	\$25 per fixture
<b>Total Kitchen Lamp Lumens</b>	<b>6,080 lumens</b>	<b>3,900 lumens</b>	<b>7,800 lumens</b>
<b>Total Kitchen Power</b>	<b>650 watts</b>	<b>150 watts</b>	<b>180 watts</b>
<b>Total Initial Installed Cost</b>	<b>\$500</b>	<b>\$650</b>	<b>\$420</b>
<b>Operating Cost per year<sup>3</sup></b>	<b>\$75.92 per year</b>	<b>\$17.52 per year</b>	<b>\$21.02 per year</b>
Additional Initial Cost vs. Incandescent	n/a	\$150	-\$80
Annual Savings vs. Incandescent	n/a	\$58.40 per year	\$54.90 per year
Simple Payback	n/a	2.6 years	(1.46) years

<sup>1</sup>Fixture efficiency for the incandescent fixture is based upon the use of reflector lamps.

<sup>2</sup> Total power for the fluorescent fixtures includes the ballasts.

<sup>3</sup> Operating cost is based on average use of four hours per day and an electricity cost of \$0.08 per kWh.

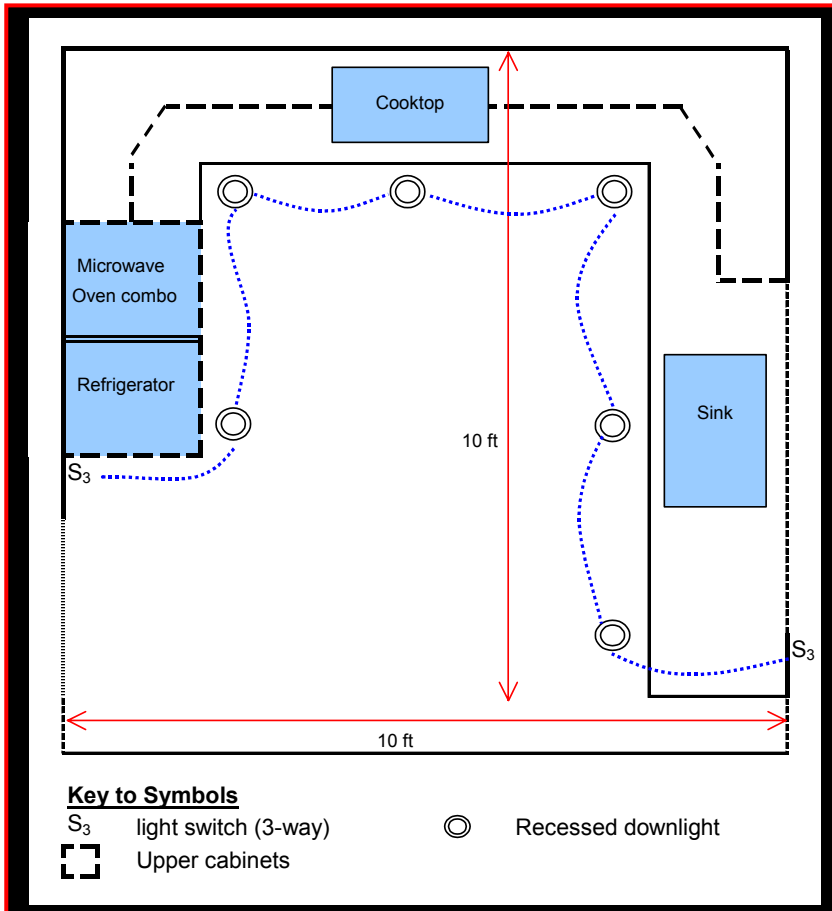
## Key Observations

- Although the material cost for each California Kitchen Lighting System fixture is more expensive than either of the other two systems, fewer fixtures are required.
- The installation cost per fixture is lower for the California Kitchen Lighting System, since the plug and play connectors are easier to use than traditional field wiring.
- Although the annual operating cost for the California Kitchen Lighting System is slightly higher than the standard CFL system, the California Kitchen Lighting System provides twice as much light!

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## Practical Example

SMUD is presently working with twenty-five customers who are remodeling their kitchens and have agreed to install the California Kitchen Lighting System. One of these customers was originally considering installing six incandescent recessed fixtures (see diagram). The illumination (lighting) levels for both of these options have been calculated and are presented below.



### Recessed Incandescent System

Number of fixtures: six  
Lamp type: 65BR30/FL/RP  
Description: 65-watt incandescent flood  
System power: 390 watts  
Average Illumination level: 36 foot-candles  
Max/Min ratio: 40 (**very spotty illumination**)

### California Kitchen Lighting System

Number of fixtures: six  
Lamp type: CF26DT/E/IN/830  
Description: 26-watt compact fluorescent  
System power: 156 watts  
Average Illumination level: 52 foot-candles  
Max/Min ratio: 5 (**uniform illumination**)

## Observations

For this particular scenario, the California Kitchen Lighting System will:

- Provide 30% more illumination than the incandescent system.
- Provide more even lighting – the incandescent system would be very spotty.
- Consume 60% less power than the incandescent system.
- Produce much less heat (incandescent lamps are very hot).



“Easy to install...twice the light...for about the same cost. Where is the down side?”  
- Brett Parent, Marticus Electric

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## Showcase Project

**Project:** Cavalli Hills  
Fair Oaks, California  
Evans Construction Company

**Electrical contractor:** L & M Electric

**Background:** Michael Evans has earned a reputation as one of the most progressive custom homebuilders around. His latest project, Cavalli Hills, is a twelve-unit subdivision that incorporates insulated concrete form (ICF) construction as well as several other cutting edge building technologies. When asked to help test the California Kitchen Lighting System, Mr. Evans agreed in his usual soft-spoken manner and set up a meeting with L & M Electric, his electrical contractor. *Shortly thereafter, Evans Construction became the first commercial homebuilder in the nation to install the California Kitchen Lighting System.*



### Observations & Comments From the Installers:



**Making the connection:** accessing the electrical junction box may be difficult. The “plug & play” connection really simplifies installation in these situations.

- Overall, the installers liked the system and felt that it was easier to install than conventional systems.
- At first, installers were concerned about the length of the flex cable that linked the master downlight to the slave downlight. Would the ten-foot cables be long enough? If the cables were too long, would building inspectors have a problem with coiling the excess cable? Fortunately the cables were long enough and the inspectors were ok with the excess cable – as long as it was securely strapped.
- According to Del McCracken, owner of L & M Electric, higher end homes often use dimmers in the kitchen. The team is now considering offering a dimmable system in the future.

**“Using the new California Kitchen Lighting System was an easy decision for me. Fewer lights, better lighting and less heat build up in the home, is a win-win situation.”**

**- Michael Evans, Owner  
Evans Construction Company**



Michael Evans

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## Showcase Project

**Project:** Creekside  
Elk Grove, California  
Morrison Homes

**Electrical contractor:** Marticus Electric

**Background:** Morrison Homes ranks in the top ten percent of all U.S. homebuilders in customer satisfaction and was named “America's Best Builder” by BUILDER magazine and the National Association of Home Builders (NAHB) in 2000. Locally, Morrison Homes has been an active partner in SMUD’s Advantage Home and Zero Energy Home programs. The Creekside development will feature ninety-six single-family homes ranging in size from 1,900 to 3,200 square feet. Morrison Homes has installed the California Kitchen Lighting System in the model homes and will offer the system to a limited number of customers as a no-cost upgrade option.



The ten-foot flexible cables proved to be long enough to handle various installations

### Observations & Comments From the Installers:

- The installers made several helpful suggestions to improve access to the electrical junction box (a.k.a. “J-Box”) that have since been incorporated into the final system. Overall, the installers liked the system and felt that it would be easier to install than conventional systems once the J-box was modified.
- Wire staples should not be used to strap the flexible cables (local code violation). Lithonia Lighting should provide (or at least specify) appropriate conduit straps that should be used with the system.
- White trims should be offered as an option (editors note – white trims are now available).



Forest Grimes, VP Operations  
Morrison Homes

“We at Morrison Homes continue to be proactive in building environmentally sensitive homes. Through our It's Easy to be Green campaign we have enjoyed participating in past SMUD programs and are presently offering a Zero Energy House as an option in our Lakeside Community in Elk Grove. We consider SMUD to be a key trade partner and feel that it is our responsibility to be part of the energy solution moving forward. As such, we are proud to be an early participant in this program and have recently completed installation of this system in our Creekside models located at Bond and Elk Grove Florin in Elk Grove. Morrison Homes is confident that our future homeowners will appreciate the many benefits provided by this progressive lighting system and anticipate a good reception as we bring our homes to market.”

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## Conclusions

When the 2005 Title 24 energy standards go into effect, California homebuilders and remodeling contractors will be required to install fluorescent lighting systems in residential kitchens. The California Kitchen Lighting System will provide an attractive option for those who prefer to use recessed downlight systems.

## Market Availability

For the past fifty-five years, Lithonia Lighting has been one of the largest lighting manufacturers in North America. Today, they produce over forty million residential and commercial lighting fixtures each year and are well positioned to meet the lighting needs of the California building market. The California Kitchen Lighting System is scheduled for full-scale production in September of 2004 and is available today by special order from Lithonia Lighting.

## Market Barriers

The California Kitchen Lighting System faces two major challenges:

- **Consumer perception:** many consumers have been disappointed with the performance of conventional compact fluorescent recessed lighting systems. Consequently, it will require considerable outreach efforts to educate and reshape consumer perceptions.
- **Cost Driven Market:** the new housing industry is very competitive. Because of this, some homebuilders often make decisions based primarily upon first cost considerations. This is especially true when selecting subcontractors for electrical, plumbing, painting, and other trades. Since there will undoubtedly be cheaper lighting systems available in the future, builders should carefully consider factors such as lighting quality and customer satisfaction when deciding which system to install.

## Recommendations

The California Energy Commission and electric utilities should help homebuilders prepare for the new energy standards by promoting high efficiency lighting systems such as the California Kitchen Lighting System.



### The Power of Perception

Recently, SMUD featured the California Kitchen Lighting System at a local home & garden show. The booth was illuminated by four of the downlights and featured hands-on displays and graphics. Many customers were surprised to learn that the system was fluorescent when they saw how bright the lights were. However, the best testimonial was when a convention center employee pointed to the lights and told us that we would have to pay additional charges for “consuming too much electricity.” When he found out that each light only consumes 26 watts, he was absolutely amazed!

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## ***The Value of Partnerships***

The success of this project was achieved through the hard work, dedication and contributions of the project team. The experience, perspectives, insights and resources of each team member were the key factors in bringing the California Kitchen Lighting System to the residential building market.

**California Energy Commission:** provided critical funding for initial project research, system development and testing.

**Lawrence Berkeley National Lab and the California Lighting Technology Center:** Dr. Siminovitch, Erik Page and the project team developed the initial system at LBL. The lighting team has since moved from LBL to establish the Lighting Technology Center at Davis. Today the industry and utility partnership continues at the Lighting Technology Center.

**Lithonia Lighting:** Lithonia's engineering, manufacturing experience and resources helped ensure the California Kitchen Lighting System will be reliable, competitively priced and readily available.

**ConSol:** The ConSol Builders Group was instrumental in providing builder insights and review during this program. They helped greatly in understanding key interests of the builder community by representing energy efficiency interests and compliance issues from the builders' perspective. ConSol also provided detailed information as to market trends and home design so that the technology would be broadly acceptable.

**National Resource Defense Council:** NRDC is a national environmental advocacy group involved with energy efficiency and sustainability issues. Their expertise in understanding efficiency and regulatory issues was valuable in the development of the programs and technologies that went into the system.

**Sacramento Municipal Utility District:** SMUD engineers and program managers worked with the team from the initial kick off to help evolve a system approach to the design. SMUD has developed relationships with homebuilders through the Advantage Home program that were key to bringing builders on board and implementing local field demonstration projects.

**Homebuilders and Electric Contractors:** these team members provided key insights and valuable feedback during system development and field-testing:

- **Evans Construction**
- **Morrison Homes**
- **John Laing Homes**
- **Marticus Electric**
- **Centex Homes**
- **Dunmore Homes**
- **L & M Electric**

### **California Lighting Technology Center**

The California Lighting Technology Center is a newly developed non-profit group set up at the University of California at Davis through a wide industry, government, utility partnership. The center will concentrate on the development of new technology applications, outreach and training and in demonstrations of new lighting technologies with the utilities. This technology development activity is being supported through partnership with the industry and the California Energy Commission.

The Center's strength is the ability to work as a team in partnership with the industry...this approach is fundamental to any lighting research effort and underscore success in moving new technologies into the market place

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