

DR12SCE2.06: DR-READY LED LIGHTING SYSTEMS WITH ADVANCED CONTROLS IN FAST FOOD RESTAURANTS

REAL-WORLD TESTING OF ADVANCED LIGHTING CONTROL SYSTEMS

Five fast food restaurants, in the Inland Empire region in southern California, were selected to test four Advanced Lighting Control Systems (ALCS) and to monitor the demand reduction associated with these technologies. The sites were chosen because of similarities among their lighting systems and operating conditions. All five sites are from the same chain of fast food restaurants, which are owned and operated by two independent franchises, and are located within 30 miles of each other. All of the controlled lighting systems used for this study had new LED fixtures but varied in the number and type of fixtures.

The study tested the products to measure the demand reduction from manual demand response (DR) and automated DR (AutoDR) signals. By testing in real-world settings, the study was also able to test the compatibility of systems produced by separate manufacturers.



INTRODUCTION

What is this technology?

Four different Advanced Lighting Control Systems (ALCS) developed by Daintree, Enlighted, nLight and WattStopper were evaluated. Two of the sites used the same Enlighted product. The four different ALCSs used provide dimming, daylight harvesting, and demand response control of interior lighting.

Data Acquisition Equipment

Multi-channel data loggers were used to monitor power consumption of the lighting systems. These loggers record electric energy, analog signals, and digital pulses. The logger samples the full 60 Hertz waveform once every 5 seconds, and the data samples are averaged and recorded in 1-minute intervals. Data was collected remotely via telephone land lines at each site and modems in each of the loggers. A central computer retrieved data daily.

Prior to installing monitoring equipment, the lighting power for all the interior lighting was traced. One current transducer was installed to monitor the power of each individual circuit. In a few cases there were non-controlled lighting loads connected to the same circuits as the controlled lighting. Examples include incandescent lamps inside of walk-in coolers and freezers and exhaust hood lamps. The data analysis accounts for these few cases.

To achieve the project objectives, electric load monitoring was conducted for the interior lighting in each participating restaurant. Manual DR and AutoDR testing events were conducted and results analyzed to quantify the demand reduction at each restaurant.

Table 1: Summary of Lighting Control Products by Location

Location (City – Street)	Controller Manufacturer	Site Square Feet
Corona – Magnolia Avenue	WattStopper	2,967
Rancho Cucamonga	Daintree Networks	2,251
Corona – Temescal Canyon	Enlighted, Inc.	3,111
Upland	Enlighted, Inc.	2,555
Montclair	Acuity nLight	2,651

What We Did?

Approach

Two general DR test approaches were taken. One approach used manual DR testing, which was implemented by the lighting controller manufacturer's representatives. The other approach used AutoDR testing implemented by SCE personnel.

Manual DR testing was scheduled to be conducted on the same business hours over three separate days at each of the five restaurants. Power recording intervals were set at 1 minute during the DR test periods. The testing procedure included changing the lighting level to five different settings. Each test was scheduled to last for one hour, after which the setting was returned to the baseline DR level of 0%.

Table 2: Lighting Manual Demand Response Test Schedule

DR Level (%)	Control System Timing
15	9:30 AM – 10:30 AM
0	10:30 AM – 11:00 AM
20	11:00 AM – 12:00 PM
0	12:00 PM – 1:00 PM
25	1:00 PM – 2:00 PM
0	2:00 PM – 2:30 PM
30	2:30 PM – 3:30 PM
0	3:30 PM – 4:00 PM
50	4:00 PM – 5:00 PM

AutoDR testing was scheduled to occur on only two days and only tested 15%, 20% and 30% DR levels. Two strategies were employed to conduct the AutoDR testing to ensure that the signal was sent to the ALCSs:

1. Leveraging the DR Automated Server (DRAS), DR events were sent using the OpenADR specification. Two different scheduling methodologies were used to schedule an event that would test the full set of capabilities provided by each ALCS.
2. A simpler method followed the traditional means of scheduling an AutoDR event in the DRAS, but it did not allow for the event-mode level to be set. The default event mode level was set to "high" in the test DRAS. In order to test the controllers' abilities to respond to different event-mode levels, an alternative scheduling method was used where the client was switched to a "manual" mode in the test DRAS, and a two-step process was followed. The first step identified the event-mode level, denoted "low", "medium" or "high", and the second step scheduled the DR event to signal the client to enter the desired event-mode at the appropriate time.

MANUAL DR RESULTS

All ALCSSs showed a demand reduction for the interior lights, ranging from 0.35 kW to 0.63 kW at the 50% DR level. The average demand reduction for the sites was 0.50 kW at the 50% DR level. Data was normalized for demand reduction in watts per square foot (W/sf) for each DR level at each restaurant due to the different facility sizes. The demand reduction for the interior lights ranged from 0.15 W/sf to 0.23 W/sf at the 50% DR level. The average demand reduction for the five restaurants was 0.19 W/sf at the 50% DR level.

Table 3: Manual Demand Reduction Normalized to W/sf at Various DR Levels by Restaurant

Manual DR Level (%)	WattStopper/ Corona – Magnolia (W/sf)	Daintree/ Rancho Cucamonga (W/sf)	Enlighted (A)/ Corona – Temescal (W/sf)	Enlighted (B)/ Upland (W/sf)	nLight/ Montclair (W/sf)	Average Demand Reduction (W/sf)
15	0.052	0.034	0.064	0.061		0.053
20	0.072	0.058	0.090	0.102		0.081
25	0.090	0.073	0.119	0.111		0.098
30	0.101	0.093	0.143	0.140		0.119
50	0.149	0.157	0.201	0.227	0.184	0.186

The table below presents the percentage demand reduction for each of the controllers and DR level scenarios. The percentage reduction was calculated by dividing the demand reductions (kW) by the commissioned LED baseline at 80% (kW). At the 50% DR level, the measured demand reduction percentage ranged from 31% to 53% with an average of 42%.

Table 4: Percent Manual Demand Reduction at Various DR Levels by Restaurant

Manual DR Level (%)	WattStopper/ Corona – Magnolia (%)	Daintree/ Rancho Cucamonga (%)	Enlighted (A)/ Corona – Temescal (%)	Enlighted (B)/ Upland (%)	nLight/ Montclair (%)	Average Demand Reduction (%)
15	11.0	8.8	16.8	11.2		12.0
20	15.1	15.3	23.7	18.6		18.2
25	19.0	19.2	31.3	20.2		22.4
30	21.3	24.4	37.7	25.6		27.2
50	31.4	41.2	52.9	41.4	43.9	42.2

AUTOMATED DR RESULTS

The only two systems that responded to the AutoDR testing were the WattStopper (Corona – Magnolia Avenue) and the Daintree Networks (Rancho Cucamonga). The Daintree Networks controller performed reliably and provided the expected demand response result. The WattStopper also provided the expected demand response but was not initially setup to reset after the DR period ended. The two Enlighted controllers received the signal but could not properly implement the response. This problem is being addressed and is expected to be resolved. The Acuity nLight controller was not able to respond to the AutoDR signal.

The WattStopper and Daintree products showed very similar demand reductions as shown in the table below. For both products, a high level AutoDR event sheds almost 0.09 W/sf.

Table 5: Automated Demand Normalized to W/sf at Various DR Levels by Restaurant

Auto DR Level (%)	WattStopper/ Corona – Magnolia (W/sf)	Daintree/ Rancho Cucamonga (W/sf)	Average Demand Reduction (W/sf)
20 (Medium)	0.052	0.053	0.052
30 (High)	0.086	0.088	0.087

CONCLUSIONS

What We Concluded?

The main objectives and conclusions of the project are:

- Determine whether the advanced lighting controls systems can be scheduled for reliable control of lighting loads as part of a Manual DR test events.
 - All controllers were able to reliably reduce lighting loads by means of a manually initiated test.
- Determine whether the ALCs can be scheduled for reliable control of lighting loads as part of an AutoDR test.
 - The Daintree Networks controller performed reliably and provided the expected demand response result.
 - The WattStopper also provided the expected demand response but was not initially setup to reset after the DR period ended.
 - The two Enlighted controllers received the signal but could not properly implement the response. This problem is being addressed and is expected to be resolved.
 - The Acuity nLight controller was not able to respond to the AutoDR signal. The data from the DR testing showed the Acuity nLight controls were not set up with the same dimming settings as the other controllers. The nLight controls did overlap with the other controllers at the 50% DR level and showed that the nLight lighting was reduced very near the average of the other systems. Therefore, it is likely that the nLight system, if setup correctly, would provide similar reductions as the other ALCs in each DR level. Although the nLight controller is only able to dim in 10% increments.

The most successful AutoDR occurred when the event was scheduled, and the AutoDR signal requested a high mode of demand reduction.

Lessons Learned

RECOMMENDATIONS

The results of this field evaluation show that demand reductions can be achieved by dimming lighting in response to a DR request. As with some new technologies, there are compatibility issues that need to be addressed during specification of equipment prior to installation.

Because many of these lighting control solutions are new, installers should learn how to properly install them in order to provide an effective product to the market place.

The demand reductions are similar among the various ALCs tested. The DR results are dependent on how much the lights are operated during a DR event. The daily lighting profiles are not the same for all sites. These differences can influence how various systems compare to each other.

Further studies should be conducted to determine whether it is possible for all of these ALCs to reliably provide AutoDR strategies. Additionally, future studies should include the customer/employee response during the DR events, and to the new systems in general.



These Findings are based on the report “DR-Ready LED Lighting Systems with Advanced Controls in Fast Food Restaurants” which is available from the ETCC program website, <https://www.etcc-ca.com/reports>.