LED Traffic Signals in California: Is It Time To Put On The Brakes?

Corina Stetiu Jump and John Cavalli, Quantum Consulting
Chris Ann Dickerson, Pacific Gas and Electric Company

ABSTRACT

This paper describes the research activities conducted to develop an estimate of the remaining market potential for LED traffic signals in California. To meet this goal, three additional research objectives are developed: (1) estimate the baseline energy usage of traffic signals in the absence of the LED technology, (2) estimate the market potential for retrofitting traffic signals with LEDs, and (3) estimate the current saturation of LED traffic signals. A number of technical parameters are quantified as key intermediate outputs for this study, including typical wattage of incandescent and LED signals for each signal type, and duty cycles for each signal type.

The results of this study show the progress achieved recently in the implementation of energy efficient traffic lights, and they discuss the cost-effectiveness of the LED traffic light programs. As the study presents typical values of traffic signal wattages and duty cycles, as well as two methods for determining the saturation of traffic signal retrofits, it will be of interest to other utilities and organizations that are contemplating traffic light retrofit programs of their own.

Introduction

Over the past five years, there has been significant LED traffic signal retrofit activity in California. Most of this activity is attributable to programs implemented by Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E), and in the past two years, to the California Energy Commission (CEC) summer programs. The goal of this statewide study was to develop an estimate of the remaining market potential for LED traffic signals.

To meet this goal, three additional research objectives were developed: (1) to estimate the baseline energy usage of traffic signals in the absence of the LED technology, (2) to estimate the market potential for retrofitting traffic signals with LEDs, and (3) to estimate the current saturation of LED traffic signals. A key set of intermediate outputs that were developed as part of this study were estimates of a number of technical parameters including: (1) typical wattage of incandescent signals for each signal type, (2) typical wattage of LED signals for each signal type, and (3) duty cycles for each signal type[1].

Methodology

The LED Traffic Signal study was conducted in three stages; the methods employed for conducting the analysis at each stage are presented below.

---

[1] It should be noted that only energy duty cycles were developed for this Study. Demand duty cycles are expected to be very close to the energy duty cycles.

Baseline Analysis

This first stage of the study estimates the baseline usage of traffic signals, i.e. the usage of traffic signals in the absence of any LED traffic signal program. To accomplish this task we relied on 1995 billing data, assuming that few or no LED traffic signals were installed in any of the IOU service territories at that time. Using all of the account data corresponding to traffic signals for PG&E and SCE, we calculated the average usage per account (intersection) in 1995:

$$\text{Average Intersection Usage in 1995} = \frac{\text{Total Intersection Usage in 1995}}{\text{Number of Intersections in 1995}} \quad (1)$$

Unfortunately, similar 1995 billing data were not available from SDG&E. Consequently, we estimated the baseline usage for SDG&E to be equal to the current usage of their traffic signal accounts, plus the kWh impacts associated with LED measures implemented prior to the 2000 calendar year:

$$\text{Average SDG\&E Intersection Usage in 1995} = \text{Total Current Intersection Usage} + \text{Pre-2000 kWh Impacts} \quad (2)$$

Using billing data for a year starting in Spring 2000 and ending in Spring 2001, we then determined the number of accounts (intersections) currently active in each of the IOU service territories. The number of current intersections, multiplied by the average intersection usage in 1995, provided the baseline usage of traffic signals.

$$\text{1995 Baseline} = \text{Current Number of Intersections} * \text{Average Intersection Usage in 1995} \quad (3)$$

This baseline usage represents the estimated usage of all current intersections, assuming that no signals were retrofit. We estimate that the baseline usage for all intersections is 134.1 GWh/yr for PG&E, 176.8 GWh/yr for SCE, and 46.3 GWh/yr for SDG&E.

Market Potential of LED Traffic Signals

To develop an estimate of the full potential of LED retrofits, we employed data such as number and type of signals for the typical intersection from PG&E's 1997-98 Retrofit Express study. We also relied on literature and secondary data sources such as Work Papers and Technical Documentation from each of the IOU's Applications and Advice Filings, PG&E's Pre-1998 CEEI Impact Evaluation (Quantum Consulting, 2000), PG&E's PSP Impact Evaluations; evaluations conducted by the CEC and Schiller Associates, studies such as Suozzo, 1998 and Houghton, 1994, and manufacturer data, to develop estimates for pre-retrofit wattage, post-retrofit wattage, and average hourly duty cycles (or annual operating hours) for each measure covered by the LED traffic signal programs.

By using the average intersection data in conjunction with the pre- and post-wattage and duty cycle data by traffic signal type, we estimated that the technical potential associated with retrofitting all incandescent traffic signals with currently-available LED signals is 89% of baseline (see Table 1). [2]

[2] To be clear, the technical potential corresponds to the savings that could be achieved relative to the 1995 baseline level of consumption developed in the previous section, prior to any LED retrofit activity. The 89%

Table 1. LED Traffic Signals Technical Potential Calculations for the Average Intersection

Traffic Signal Type	Average Number of Signals	Pre Wattage	Post Wattage Nominal (@ 25°C)	Wattage Change	kWh Duty Cycle	Annual Baseline MWh	Annual Impact MWh
Red Signals							
Red Ball - 12 Inch	3.8	150	11	139	55%	2,746	2,545
Red Arrow - 12 Inch	2	150	9	141	80%	2,102	1,976
Red Ball - 8 Inch	7.7	69	8	61	55%	2,560	2,263
Yellow Signals							
Yellow Ball - 12 Inch	2.5	150	22	128	3%	99	84
Yellow Arrow - 12 Inch	0	150	11	139	3%	0	0
Yellow Ball - 8 Inch	9	69	13	56	3%	163	132
Green Signals							
Green Ball - 12 Inch	2.5	150	15	135	42%	1,380	1,242
Green Arrow - 12 Inch	2	150	11	139	20%	526	487
Green Ball - 8 Inch	9	69	12	57	42%	2,285	1,887
LED Yellow Flashing Beacon							
Yellow Flashing - 12 Inch	0.2	150	22	128	50%	133	113
Yellow Flashing - 8 Inch	0.1	69	13	56	50%	38	31
LED Pedestrian Signals							
Hand/Walking Person - Combo	4	69	9	60	90%	2,176	1,892
All Signals							
All	42.8					14,207	12,653
Technical Potential for LED Retrofits						**89%**	

In Table 1:

$$\text{Baseline MWh} = \text{Average Number of Signals} * \text{Pre Wattage}/10^6 * \text{kWh Duty Cycle} * 8760\ \text{h/year} \quad (4)$$

$$\text{Annual Impact MWh} = \text{Average Number of Signals} * \text{Wattage Change}/10^6 * \text{kWh Duty Cycle} * 8760\ \text{h/year} \quad (5)$$

and

$$\text{Technical Potential} = \frac{\text{Annual Impact MWh}}{\text{Baseline MWh}} \quad (6)$$

The study used a more conservative technical potential of 80%, for the following reasons:

1. Some traffic signals, such as polarized signals, cannot be retrofit for safety reasons. For others, such as most yellow signals that stay on for very short period of times, a retrofit is not cost-effective.

---

technical potential can be considered relatively conservative, as the distribution of 8” and 12” signals retrofit statewide indicated that there may be a greater proportion of 12” signals. This would result in a slightly larger estimate of potential.

2. The wattage of LED traffic signals that have been retrofit prior to year 2000 is slightly higher than the wattage of LED signals currently available.
3. At high temperatures the connected load of LEDs can increase.
4. Traffic signal accounts include additional loads (control boxes, street lighting sometimes), and these loads will not be reduced by retrofitting the signals.

Market Penetration/Saturation of LED Traffic Signals

To determine the current penetration or saturation of LED traffic signals, the current number of traffic signal accounts for each IOU was used in conjunction with the current usage per account to determine the total usage currently attributable to traffic signals. By dividing the total usage by the technical potential of LED traffic signal retrofits, we estimated the current LED saturation levels by IOU, as well as across all IOUs:

$$\text{Current LED Saturation Level} = \frac{\text{Total Current Intersection Usage}}{\text{Technical Potential of LED Retrofits}} \quad (7) \quad \text{,OR}$$

$$\text{Current LED Saturation Level} = \frac{\text{Total Current Intersection Usage}}{80\% * \text{Total Intersection Usage in 1995}} \quad (8)$$

Results

Based on the current billing data, we estimate that, in Spring/Summer 2001, the saturation level of LED traffic signals was 40% in PG&E territory, 10% in SCE territory, and 43% in SDG&E territory. The LED saturation level across the IOU territories was approximately 26% (Table 2).

While analyzing the most current billing data, we observed that the usage per account has substantially decreased in the most recent months, probably as a result of the 2000-2001 statewide Summer Initiatives. By projecting the Spring 2001 data to a full year, the LED traffic signal penetration levels increase to 45% in PG&E territory, 18% in SCE territory, and 57% in SDG&E territory. LED traffic signal penetration across the IOUs is projected to 33% (Table 4).

Table 2. LED Traffic Signal Saturation Analysis

	PG&E	SCE	SDG&E	All IOUs
Baseline Usage Calculation				
Pre-1995 Baseline Usage per Account (MWh/year/acct)	13.3	14.9	11.8	13.8
Current Nr. Accounts	10,120	11,906	3,933	25,960
IOU Traffic Signal Baseline (MWh/year)	134,165	176,854	46,312	357,331
LED Traffic Light Saturation - Technical Potential Equal to 80% of Baseline				
Potential impact (MWh/year)	107,332	141,483	37,050	285,865
Penetration Observed from Billing Data as of Spring/Summer 2001				
Current Nr. Accounts	10,120	11,906	3,933	25,960
Current Usage per Account (MWh/year/acct)	9.0	13.6	7.7	10.9
Most recent bills (1 yr of data) (MWh)	91,058	162,487	30,462	284,007
% of Potential impact reflected in most recent bills	40%	10%	43%	26%
Total Program Impacts and Achievements †				
Total program impacts claimed (MWh/year)	94,006	102,285	37,050	233,341
% of Potential Achieved by Committed Projects	88%	72%	100%	82%
% of Potential Remaining after Implementing all Projects	12%	28%	0%	18%

† Program Achievements assume that all committed measures are installed

To confirm the penetration levels estimated using billing data, we developed a back-up estimate based on program accomplishments to date. We collected all available program tracking data associated with LED traffic signal initiatives from each of the IOUs and the CEC (see Table 4). These data provided an estimate for program savings to date, and agree well with our billing estimates developed above. We do not believe there has been significant LED retrofit activity outside of these programs. It is interesting to note that, while more than half of the LED traffic light impacts in PG&E and SDG&E territories are due to pre-2000 programs, all of the impacts in SCE territory are due to the 2000-2001 programs.

Finally, the IOU Program data provided an estimate for total expected program savings, assuming that all committed projects will be implemented. Using these data in conjunction with our saturation/penetration estimates, we estimated that the remaining market potential for LED traffic signals for 2002 and beyond is 12% in PG&E territory, 28% in SCE territory, and 0% in SDG&E territory (or 18% across the IOU territories). Table 3 below illustrates the remaining market potential in the three IOU service territories.[3]

Table 3. Remaining Market Potential for LED Traffic Signals

Remaining Potential After PY2000/2001 Programs	PG&E	SCE	SDG&E	All IOUs
Percent Remaining	12%	28%	0%	18%
MWh/year Remaining	13,325	39,199	0	52,524
Coincident Peak kW Remaining	1,521	4,475	0	5,996

[3] The remaining coincident peak kW potential is estimated assuming that the coincident demand duty cycles are equal to the energy duty cycles.

Table 4. LED Traffic Signal Program Summary

	PG&E Territory	SCE Territory	SDG&E Territory	ALL IOUs
Total Achievements Claimed Through 2001 Programs				
Total Committed Rebate Amount ($)	$20,426,364	$15,316,864	$6,653,963	$42,397,191
Total MWh Committed/Paid	94,006	102,285	37,050	233,341
Total Achievements Claimed by pre-2001 Programs				
Savings Claimed by pre-2001 Programs	45,926	19,122	19,633	84,680
% of Potential Claimed by pre-2001 Programs	43%	14%	53%	30%
Total Savings Measured in Billing Data Associated with pre-2001 Programs				
Savings Estimated in Billing Data (MWh)	48,531	25,061	21,150	94,742
% of Potential Estimated in Billing Data	45%	18%	57%	33%

Conclusions

These results indicate that the IOUs' programs have had a significant impact on the traffic signal market, achieving an 88% market saturation. Is it time to put on the brakes with energy efficiency programs that rebate the installation of LED traffic signals? It would appear so. However, there is still 26% remaining potential in SCE's service territory, and another 12% in PG&E's. Perhaps a more cost-effective strategy would be an educational program focused on those entities that have yet to retrofit their traffic signals.

The methodology adopted for this study relied on IOU billing data to develop baseline usage for traffic signals, on secondary literature sources to develop the technical potential for LED traffic signal retrofits, and on a combination of these to estimate the saturation levels for traffic signals. The saturation levels thus derived were verified by comparing them with IOU/CEC Program accomplishments to date.

The results of this study show the progress achieved recently in the implementation of energy efficient traffic lights, and they discuss the cost-effectiveness of the LED traffic light programs. As the study presents typical values of traffic signal wattages and duty cycles, as well as two methods for determining the saturation of traffic signal retrofits, it will be of interest to other utilities and organizations that are contemplating traffic light retrofit programs of their own.

References

Quantum Consulting Inc., Evaluation of Pacific Gas & Electric Company's pre-1998 Commercial Energy Efficiency Incentives Program Carry-Over: Traffic Signal Technologies, PG&E Study ID #404D, March 2000.

Suozzo, M., A Market Transformation Opportunity Assessment for LED Traffic Signals, ACEEE, Washington, DC, 1998.

Houghton, D., LED Traffic Lights – New Technology Signals Major Energy Savings, E-Source Tech Update #TU-94-1, Boulder, CO, 1994.