# QUANTIFICATION OF ELECTRICITY SAVINGS FOR INDUSTRIAL APPLICATIONS THROUGH ON-SITE VERIFICATION AND METERING

Mark S. Martinez, Southern California Edison Company
W. Craig Racine, Alternative Energy Systems Consulting, Inc.

Industrial customers provided approximately 13 percent of Southern California Edison's (SCE) electric utility revenues in 1994. Industrial customer electric revenues amounted to $ 1 billion last year.[1]

Compared with the residential and commercial customer groups, energy use in SCE's industrial market is extremely diverse and complex. Therefore, industrial energy end-use is very difficult to characterize. In order to provide industrial customers with superior service, it is important to understand their diverse energy use characteristics and to verify the impacts of methods that these customers use to reduce energy consumption and cost. This paper discusses a pilot study in which SCE verified electricity savings for industrial energy conservation measures at various industrial customer sites.

## ENERGY MANAGEMENT INCENTIVES

SCE has a large, well-developed Demand Side Management (DSM) effort to assist its customers in saving electrical energy. This effort, which covers all customer groups, resulted in overall annualized energy savings of 970 million kWh during 1993. Demand savings of 190 MW also resulted.

A major component of the overall DSM effort in 1993 was the Energy Management Hardware Rebate Program (EMHRP). The program offered financial rebates to customers who installed energy-efficient equipment. Rebates were based on the annual energy savings, up to a maximum percentage of the equipment's installed cost. In 1993 EMHRP resulted in implementation of over 11,000 energy conservation measures (ECMs) which were credited with annual energy savings of over 414 million kWh and net peak load reductions of 62 MW. The energy savings estimates by group are shown in Table 1.

Table 1
EMHRP 1993 Annual Energy Savings Estimates

| Customer Group | ECMs ( Number ) | Energy Savings ( kWh per year ) |
|---|---|---|
| Commercial | 9,155 | 208 million |
| Industrial | 1,552 | 191 million |
| Agricultural | 508 | 15 million |
| 1993 TOTALS | 11,215 | 414 million |

Further calculations using Table 1 reveal that estimated annual energy savings per ECM in the industrial group are about 123,000 kWh per year, the highest per capita energy savings of any customer class.[2]

## STUDY OBJECTIVES

SCE conducted a pilot study to verify electricity savings estimates from sample industrial ECMs installed under SCE rebate programs. The study used three approaches to verify customer energy savings:

- Engineering review of initial savings calculations
- On-site field inspections of ECMs
- Short-term metering at sites

The results, discussed below, provided SCE with insight into effective methods for calculating, verifying and presenting savings estimates. These results are useful for both utility program evaluation and customer understanding of ECM benefits.

## CASE STUDY SUMMARIES

### Injection Molding Machines

Many of SCE's injection molding customers have replaced constant speed motors with adjustable speed drives (ASD) and programmable controllers. These systems vary motor speed to minimize power consumption while maintaining process control. In general, ASD system vendors estimate customer energy savings as part of their sales effort. SCE estimates that rebated ASD injection molding customers saved over 7.9 million kWh in 1993.

SCE verified ASD injection molding savings through site visits and short-term monitoring at a number of sites. Researchers ran injection molding machines through parts production cycles and recorded the kWh used. They then compared the results with pre-retrofit energy consumption estimates. Vendor energy savings estimates, which ranged from 40 to 60 percent for most applications, were found to be accurate. Site visits revealed that the ASD systems provided additional non-energy benefits to injection molding customers:

- Faster machine set-up time
- Reduced factory noise levels
- Less hydraulic oil leakage
- Reduced loads on oil cooling systems

**Conveyor Drives**

ASDs are being used by SCE's manufacturing customers to control process speed. One example involves a large brewery which installed ASDs to control the speed of its main conveyor line. Initial estimates of energy savings assumed that the ASDs would always control the motors to run slower than in the uncontrolled case. This resulted in calculated savings of about 75 percent compared with the uncontrolled case.

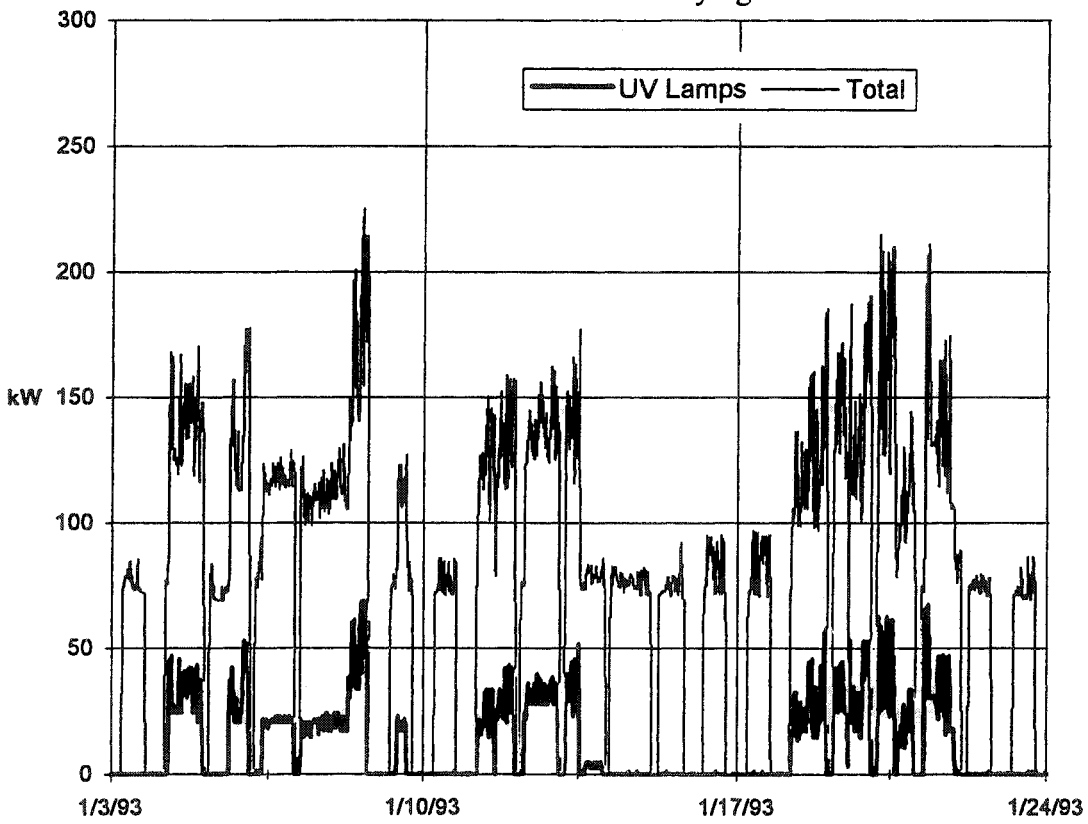
SCE reviewed the savings calculations and discussed the actual operating parameters with the customer. Brewery engineers found that the ASDs provided them with unexpected flexibility in controlling their manufacturing process. The engineers were able to use the ASDs to control individual motor speed from 50 to 150 percent of rated speed. This large variance in speed, while improving process control, caused the actual energy savings to be approximately 40 percent less than initially predicted.[3]

**Printing**

SCE's industrial printing customers continually search for alternative methods of ink drying. The traditional hot combustion air techniques do not comply with local air quality regulations. One business forms printer installed a new press which uses UV lamps for ink drying. The customer submetered circuits containing the UV printer and concluded that the new printer's electric consumption increased more than the company had anticipated.

SCE engineers visited the site and determined that the customer's submeter was monitoring more than the new printer. SCE followed up by submetering only the new printer and UV lamps. The results are plotted for three typical weeks in Figure 1.

Figure 1
15 Minute Demand - UV Ink Drying Printer



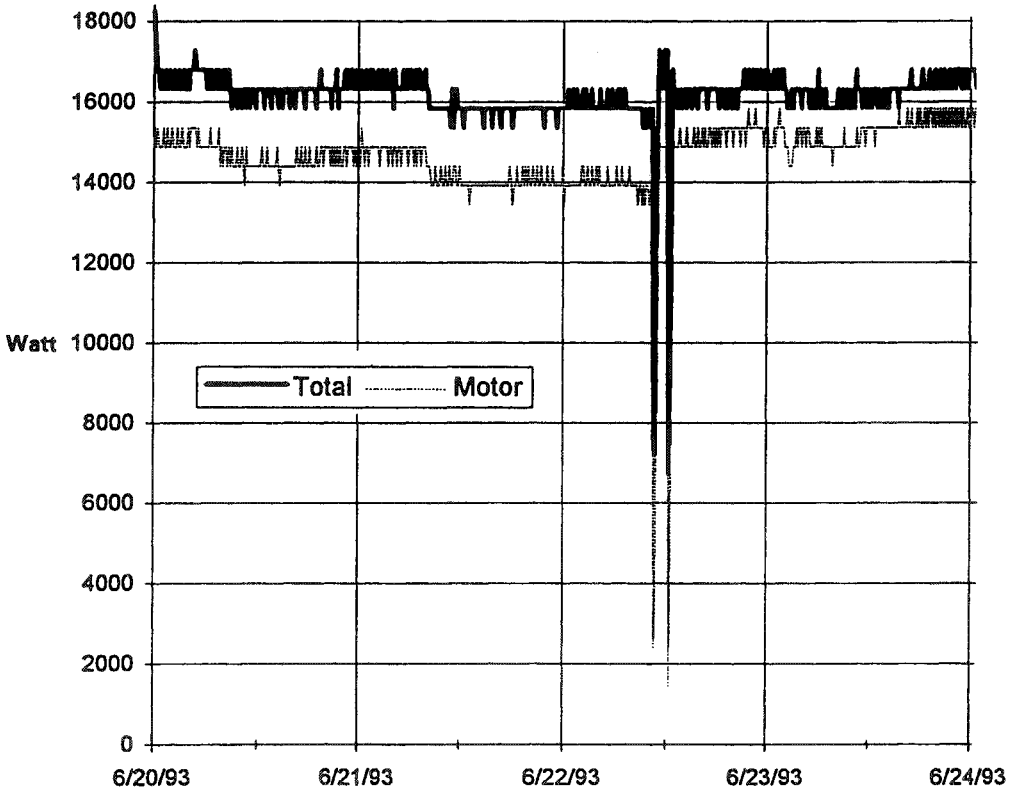

The monitoring data indicated that UV lamp energy use was lower than pre-installation estimates. SCE researchers discovered that the customer's reported increase in energy consumption had been caused by changes in plant operation. Because of its rapid drying characteristics, the new UV printer was able to substantially increase plant output. This resulted in increased overall plant energy consumption, even though the UV lamp electric consumption was less than anticipated.

**Plastic Extrusion**

Traditional plastic extrusion machines use AC motor drives with resistance heaters controlled by analog thermostats. Many SCE customers are considering advanced equipment using DC motors with digital heater controls. One customer, which had both machine types, requested SCE's help in evaluating the energy savings from this ECM.

SCE submetered the motors and heaters for both machines. Figure 2 illustrates the energy use characteristics of the advanced machine with DC motors and digital heater controls.

Figure 2
10 Minute Demand - Advanced Plastic Extrusion Machine




The advanced machine used 50 percent less energy during the test week, a larger savings than the plant engineer had anticipated. The advanced machine's DC motor used 35 percent less energy than the conventional AC motor and the digitally controlled heater used 85 percent less energy than the analog controlled heater. Based on SCE's monitoring results, the customer is retrofitting all extrusion lines with the new motors and temperature controllers.

**Painting Booths**

To comply with environmental regulations, SCE industrial painting customers are changing from water wash to air filter clean-up of paint booth exhaust. Generally, the air filters have a lower pressure drop than water wash systems, which requires installation of new fans to match this new operating requirement. One customer made the retrofit without changing fans. They installed ASDs on the existing fan motors, which allowed them to run the existing fans at lower speed.

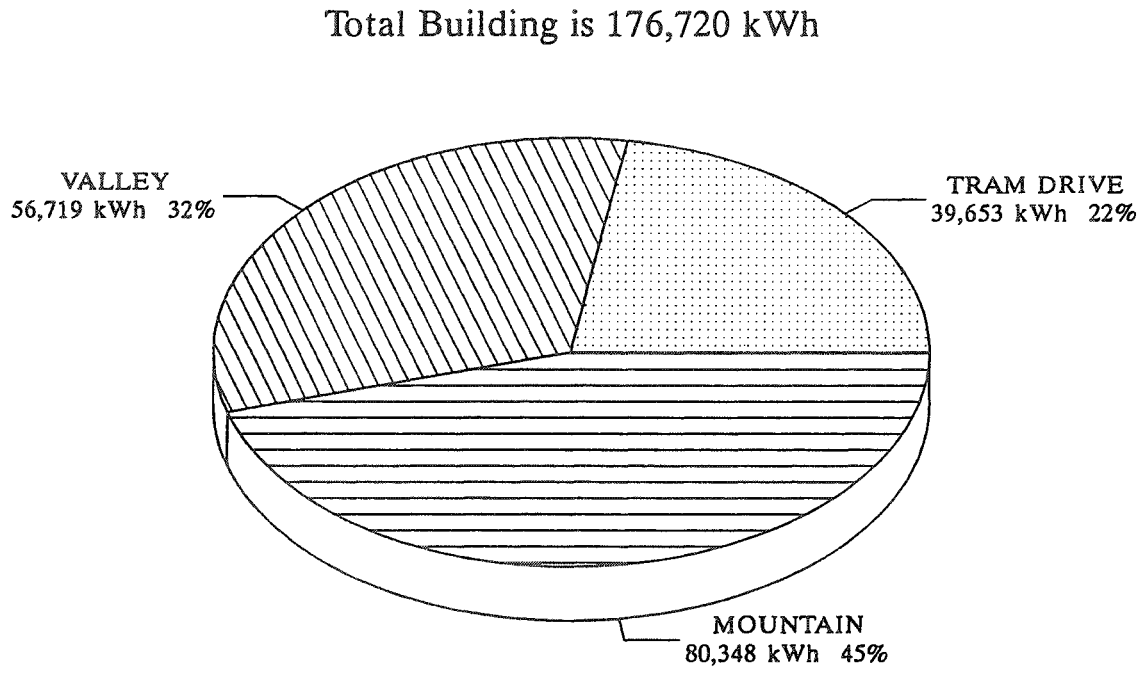
SCE reviewed the energy savings estimates and discussed operation with the customer. The ASDs provided the paint booth operator with the flexibility to set fan flow rates to exactly match the new process requirements. In addition, ASD-controlled fan motors used approximately 30 percent less energy than constant speed fan motors.[3]

**Mountain Tramway**

One resort customer retrofitted a mountain gondola tramway with a new DC motor drive system. The customer had only one meter to measure all site loads, including the tram, offices, restaurant and support buildings. The energy savings from the DC motor ECM were not apparent from the single meter.

SCE inspected the site and submetered the three major loads; tram drive, valley buildings and mountain buildings. As shown in Figure 3, researchers found that the DC tramway drive represented only a small portion (about 22 percent) of the site's energy consumption. Therefore the savings from the DC motor were difficult for the customer to see on the single meter.

Figure 3
Monthly Energy Consumption - Tramway Site
May 12 - June 13, 1994




However, by comparing the facility's energy bills from the previous year and disaggregating the valley and mountain loads, SCE was able to determine the savings attributable to the tramway DC drive.

## CONCLUSIONS

SCE offers the following conclusions based on this pilot study of industrial ECM energy savings.

### Verify Energy Savings Estimating Techniques

When estimating energy savings from ECMs, utilities should take care to use reliable and accurate engineering models. In addition, model inputs such as plant operating schedules, energy consuming equipment configurations, and motor load factors should be field verified. When possible, model results should be calibrated using actual metering data.

### Understand the Process Impacts

Many ECMs will not only decrease specific energy consumption, but may improve process control and/or output. Process benefits may include reduction in maintenance costs, faster start-up of machines, reduced noise, increased output, and better control of product quality. The effects of these process changes should be determined prior to calculating energy savings.

### Carefully Match Instrumentation with Application

Care should be taken to insure that the subcircuits being monitored represent the actual loads under study. In addition, for applications using advanced technologies (i.e., ASDs and electronic controllers), special metering equipment may be required.

### Educate the Customer

Industrial customers are deeply involved in making their individual businesses successful. Some of the larger industrial customers have energy engineers, but most industrial customers are not energy conservation experts. Therefore, it is important to work with customers to insure that they understand the positive impacts that ECMs can provide to help their businesses succeed.

## REFERENCES


1. SCEcorp 1994 Annual Report, April 1995, SCEcorp.

2. Annual DSM Summary Report, 1993 Results-1994 Plans, April 1994, Southern California Edison.

3. Verification of Energy Savings Estimates from Adjustable Speed Drives, February 1995, Alternative Energy Systems Consulting, Inc.