APPLICATION OF AN ENERGY MANAGEMENT SYSTEM TO A DISTRIBUTION CENTER

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ABSTRACT

Capital outlays for energy management must be economically attractive to warrant an expenditure. An energy management system has one of the most economic returns for an investment decision, if applied effectively. The Quaker Oats Company installed such a system in its Dallas Distribution Center. In one year the electric bills were reduced by a total of $17,668.91. Electric consumption (KWH) was reduced by thirty-one percent, electrical demand (KW) was reduced by thirty-six percent while plant operations expanded. This paper discusses the control strategies employed by the energy management system and provides the resultant savings that was obtained from the first year of operation.

INTRODUCTION

Facility management is now viewing the economics of energy management. No longer can capital outlays for energy management be justified by the "Energy Crisis" or for social ethics. Such an expenditure must truly warrant a return. Defining energy management as the effective reduction of energy utilization in a facility without a decrease in human comfort levels, business production levels or corporate plans, a measurement for energy conservation opportunities can be employed. Variables that affect energy consumption that need to be accounted for when measuring conservation investments include climatic changes, expansion plans of a business, operational hours and occupancy levels. By either adjusting energy figures for these factors or documenting their existence, management may affix conservation savings to an investment.

The Quaker Oats Company invested capital for an energy management system (EMS) to control energy expenditures at its Dallas Distribution Center.[1] During the first year of its operation, the EMS reduced energy consumption (KWH) by 31%, energy demand (KW) by 36% and provided an electric savings of $17,668.91.

The EMS controls the two HVAC units, all warehouse lighting, office lights and outside lights, photostatic copiers, forklift battery chargers, electric hot water heaters, circulating and exhaust fans, gas unit heaters, an air compressor and the M.G. panel for the facility. Each of these energy consuming loads will be explained along with the conservation strategies applied to them. Savings from electrical billings were measured from the base year March 3, 1982 to March 3, 1983. The billing savings period ranged from March 3, 1983 to April 2, 1984. Resultant savings were a 1058 KW and a 271,073 KWH reduction from monthly billings. In the savings calculations, no adjustments were made for variables such as climate changes from one year to the next, expansion of operational hours or for overtime hours that occurred. Adjustments were made on electric billings to make a comparison according to an equal number of days usage. Reasons for the savings basis are as follows:

1. An added shift to existing operations is a normal occurrence for an expanding, prosperous company. Since an increase in operational hours was experienced and noted by management after the installation, the savings by the EMS were reduced. Instead of estimating "lost savings" actual recorded savings were used.

2. Weather constantly changes from one year to the next. A business is a going concern, from one year to the next. A colder winter was experienced and noted. Instead of theorizing with load calculations as to the expected savings, actual consumption was weighed against the base.

3. Equating a billing period by the exact days of usage, both in number and by date of occurrence, was performed to begin an energy accounting system. The base year of March 3, 1982 to March 3, 1983 was used to determine savings. Equating billings to this period was made to secure a foundation for future measurement and successive trend logging (see eq. 1).

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[1] Energy Management System (EMS) - A microprocessor based central controller that accepts both local and remote inputs, analog or digital, evaluates these inputs and provides the desired output functions to energy consuming loads.

EMS CONTROL STRATEGIES OF LOADS

The EMS controls an array of energy consuming loads. By scheduling these loads to fulfill the needs of the facility while at the same time reduce energy usage, a successful energy management investment was obtained. The EMS controls all lighting, the two HVAC units, forklift battery chargers, photostatic copiers, an air compressor, circulating and exhaust fans, unit heaters, the hotwater heaters and the M.G. panel.

The lighting consists of office, outside and warehouse lighting. Prior to the EMS installation, office lights were turned ON and OFF by anyone whenever lights were needed. Outside lights were placed on a time clock to be ON during dusk-to-dawn hours. Warehouse lighting was allowed to run starting when the first employee arrived on Monday mornings and turned OFF when the last person left on Friday nights. Many times lights were left on throughout the facility. Once the EMS was installed, the H.P.S. outside lights were placed on a time schedule parameter along with a photocell sensor input, to sense the ambient light level of the morning and evening sun. During periods of sufficient light, the photocell disables the outside lighting. The office lighting was placed on a strict time schedule with timed overrides for employees to utilize during overtime hours. Back offices were scheduled ON 73 hours a week, OFF Sundays and holidays, while front offices were scheduled ON 50 hours a week and OFF weekends and holidays. The warehouse lights are 400 W H.P.S., Two photocells are located in the warehouse to sense ambient light shining down from the Hi-bay skylights. Whenever light levels are sufficient, forty percent of the warehouse lights are cut off along with truckdock lighting. Timed overrides are located at each entrance to the warehouse to enable lighting where it is needed, whether at the raildocks, the truckdocks, night lighting or overtime lighting. Time schedules call for lights to be OFF at 3:45 p.m. and back ON at 10:30 p.m. for the last shift. Fridays have no night scheduling.

There are eighteen batterychargers and three cart chargers that were allowed to be charged at 2:30 p.m. daily, before the EMS installation. This allowed 104 kw to be brought on-line in the middle of the day, the high demand period! Control strategies for these chargers now allow them to be plugged in at the end of the first shift but not be energized until all of the lights and the back HVAC system are scheduled OFF by the EMS; then these loads are staggered ON starting at 4:00 p.m. and scheduled to have a full charge by the morning shift. When overtime hours are incurred by the distribution center, the chargers are governed by a demand limiting function of the EMS.[2] This demand limiting function also places the hot water heaters, the photocell controlled warehouse lights, the exhaust fans, the back office HVAC and the air compressor on this control strategy.

The two electric HVAC units at the distribution center provide climatic comfort for the front and the warehouse offices. Past control of these loads was performed by a thermostat only. The EMS is controlling both these units by a time schedule with the allowances for a night setback/setup and an advance start feature. After hours on weekdays, the HVAC systems are allowed to be setback to 85°F in the summer and 65° F in the winter. The advance start feature allows for a comparison of inside and outside zone temperatures. Through an algorithm, the EMS calculates the amount of prestart time that is needed in order to have inside zone temperatures at 77° F in the summer and 70° F in the winter by scheduled start time. Time scheduling calls for the front office to start at 7:00 a.m. and stop at 5:00 p.m. on weekdays. Weekends and holidays are scheduled OFF; unless a timed override switch, programmed for two hours, is enabled by an employee. The back office HVAC unit calls for a 6:00 a.m. to 4:00p.m. time schedule on weekdays and a 5:00 a.m. to 3:45 p.m. saturday schedule. Sundays and holidays are scheduled OFF, there is also a one hour programmed override available for warehouse employees.

The unit heaters for the warehouse area were allowed to run constantly before the EMS control. After the EMS installation, the heaters were placed on a normal operating time schedule and are not allowed to operate until the outside zone temperature is under 50° F.

The photostatic copiers are used first thing when the raildock foreman arrives in the morning. Before the EMS installation, the copiers were allowed to run continuously. Since the installation of the EMS, the copiers are shut OFF at the end of the day at 5:00 p.m. and enabled ON for the 5:30 a.m. foreman arrival. During weekends and holidays, the copiers are scheduled OFF.

The air compressor at the distribution center is used to run packaging tools for shipments. In the past, control was performed by the pressure of the compressor tank. By allowing the EMS to control the compressor, both a time and a pressure parameter must be met before the compressor is enabled. Time schedules of 10:15 p.m. ON on Sunday and 3:45 p.m. OFF on Monday plus a 10:30 p.m. to 3:45 p.m. weekday schedule has allowed the compressor to operate without hindering operations.

The five electric hot water heaters that serve the facility were allowed to run 24 hours every day before being controlled by the EMS. The hot water usage is used primarily for clean up at the days end. Since installing the EMS, a time parameter and a demand limiting function are employed to cut energy usage. The weekday scheduling calls for an ON time from 4:00 a.m. to 3:30 p.m. to provide the hot water needs of the facility.

With the control strategies that were mentioned above, the distribution center was able to cut kwh consumption by 31%. By monitoring the EMS remotely from its office, C & F Engineering was able to "fine tune" the system to further enhance realized savings. Monitoring, via a dedicated telephone line, data such as scheduled and actual ON times for loads, hourly kw and zone temperatures provided the needed information to reschedule operating times of energy loads and its temperature parameters. Savings climaxed with the added shift that was introduced in the winter. This added shift meant that warehouse lights(400 W H.P.S) were to run longer. Even with this added shift, a total of over $17,000.00 was realized.

ENERGY SAVINGS

The energy savings realized by The Quaker Oats Company was 271,073 kwh and 1058 kw. These savings are provided from a base year from March 3, 1982 to March 3, 1983. Adjustments to the electrical billings are made only to correct the number of days of usage under a billing period. Actual dollar amounts were calculated according to the accounting method used by the electric company (see savings calculation example). No other adjustments were made. Even though such

[2] Demand limiting is a control strategy that de-energizes an energy load for a determined time period when the kw demand reaches a preprogrammed setpoint, thereby curbing high demand utilization.

variables as climate and operational changes occurred from the base period, and it is realized that these changes do affect energy usage, the attributed energy utilization would have to be estimated using several theories. It was therefore felt that until further data can be documented and logged, no further correction factors would be used.

SAVINGS SUMMARY OF THE QUAKER OATS COMPANY

MONTH	BASE KW	NEW KW	BASE KWH	NEW KWH
May	221	152	74880	50892
June	235	152	77952	41088
July	263	166	85248	49152
Aug.	256	152	70272	48768
Sept.	276	152	81408	55680
Oct.	263	152	82176	53376
Nov.	235	138	70272	44903
Dec.	235	138	69120	49561
Jan.	228	159	74112	66005
Feb.	235	159	64128	59179
Mar.	235	159	63744	50304
Apr.	221	166	73728	47059
Totals	2903	1845	887040	615967

MONTH	SAVINGS KW	SAVINGS KWH	SAVINGS $
May	69	23988	$1,381.89
June	83	36864	2,125.48
July	97	36096	2,489.29
Aug.	104	21504	1,604.28
Sept.	124	25728	1,704.28
Oct.	111	28800	1,789.87
Nov.	97	25369	1,570.78
Dec.	97	19559	1,378.99
Jan.	69	8107	679.86
Feb.	76	4949	545.11
Mar.	76	13440	1,031.68
Apr.	55	26669	1,367.40
Totals	1058	271073	$17,668.91

As stated, the base year for measurement occurs from March 82 to March 83. When savings calculations were performed, energy consumption (kwh/day) adjustments were made to equate the new billing to the base year. After adjustments were made to the new billings, they were deducted from the base year to arrive at the savings that occurred for that time period. Current methods of accounting, exact to the methods used by the utility, were employed to formulate that month's savings. The dollar amounts provide for the fuel cost factor that was calculated under the billing period, rate increases that were experienced and applicable tax rates.

The savings that were experienced can be measured by a number of different financial techniques. The simple payback method is the most widely used tool of financial measurement. While lacking in the factor of time value, the measurement can still depict a good investment. By investing in an energy management system, over $17,650.00 in energy expenditures were avoided in its first year of operation. This cost avoidance was made with an investment of under $25,000.00! By means of a simple payback, the investment will succeed in producing a payback in less than 1.5 years.

$$\frac{\text{INVESTMENT}}{\text{SAVINGS}} = \text{SIMPLE PAYBACK} = \frac{25{,}000}{17{,}600} = 1.5$$

When subsequent savings are calculated and logged, a more precise means of savings determination will be approached. Factors that cause the energy billings to vary and a financial tool that will accept historical data accurately to achieve a life-cycle cost analysis are needed to follow up this initial document.

EMS INSTALLATION

The EMS uses a microprocessor based system that utilizes both hard wiring and a line carrier communication system to control the loads in the facility. The line carrier system operates with the output from the central controller. This output signal, ON or OFF, is converted into a digitally modulated high frequency code by means of a command converter. The high frequency signal is then amplified and superimposed on existing AC wiring by means of a command transmitter. Located at each load is a receiver with a relay. The receiver is addressed by a 12 position dipswitch that codes in the desired control number for the load. Each receiver has a 9 bit access code, an override switch, an ON/OFF start switch and a bit for the load to take an ON action if the signal is ever lost. All loads numbered greater than sixteen are controlled by the line carrier system.

Current transformers take readings from the incoming power lines and transmit the data to a watt transducer, where it is fed into the central controller. The kw being drawn by the facility is held in memory for data storage and for any limiting function that is programmed, when the kw setpoint is reached.

Data polling may originate from a video display unit or a remote computer. A dedicated telephone line with an answer only modem is used to access the central controller. Unwanted access to the controller is prevented by passwords if accessed remotely or by the use of a programming key switch if at the unit.

CONCLUSION

Presented are documented facts on the resultant savings from the operation of an energy management system. Through the means of careful planning, reliable equipment and dedication to the energy conservation field, The Quaker Oats Company has realized a substantial savings of energy at its Dallas Distribution Center. The savings of 31% and 36% off the kw and kwh billings reflect the conservation potential for similar types of facilities that can be expected by an effective energy conservation program.

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EQUATIONS

Eq. 1) November Billing Comparison

Base	9/30/82 - 10/29/82 Billed kw - 235 kw 70,272 kwh	29 Days
1983	9/30/83 - 10/31/83 Billed kw - 138 kw 48,000 kwh	31 Days

$$\frac{48{,}000\ \text{kwh}}{31\ \text{days}} \times 29\ \text{days} = 44{,}903\ \text{kwh}$$

3,097 kwh added to December bill

Base	70,272 kwh
1983	-44,903 kwh
Savings	25,369 kwh

SAVINGS CALCULATIONS EXAMPLE

November Billing

	kw	kwh
Base	235	70,272
Adj. 1983	138	44,903
Savings	97 kw	25,369 kwh

1) 97 kw
x $3.54/kw
$343.38

2) 97 kw x 200kwh/kw = 19,400

19,400 kwh
x $.0233/kwh
$452.02

3) 25,369 kwh
-19,400 kwh

5,969 kwh
x $.005/kwh

$29.85

4) 25,369 kwh
x $.026439/kwh

$670.73

5) $670.73
452.02
343.38
+ 29.85

$ Savings	$1,495.98
Tax	74.80
Total	$1,570.78

Basis:

- Dallas Power & Light, Rate Schedule G

Demand Charge:
$3.54 net, per kw for all kw in excess of 5 kw

Energy Charge:
2.33¢ net, per kwh for the next 7100 plus 200 kwh per kw of demand

.50¢ net, per kwh for all additional kwh

Fuel Cost Charge:
Calculated in accordance with Schedule FC.
Nov. $.026439/kwh

- Tax Rate of five percent

- Kwh/day adjustment to allow for 29 days

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