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 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. During the first year of its operation, the EMS reduced energy consumption (KWH) by 31% and electrical 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 a 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 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).

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.

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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 reducing energy usage, a successful energy management investment was obtained. The EMS controls all lighting, the two HVAC units, forklift battery chargers, photo-cell control of the overhead warehouse skylights, and the temperature control of the forklift battery chargers and the HVAC units. Prior to the EMS installation, office lighting was 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 employee left on Friday nights. Many outside 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 strip, to sense the ambient light level of the morning and evening sun. During periods of sufficient light, the photocell disabled the outside lighting. The office lighting was placed on a strict time schedule with timed overrides for employees to utilize during overtime hours. Back office lights 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 truck dock lighting. Timed overrides are located at each entrance to the warehouse to enable lighting where it is needed, whether at the raildocks, the truck-docks, night lighting or on emergency lighting. Time switching for these chargers now allow them to be plugged in at any time, as scheduled and actual ON times for loads, hourly kw demand limit limiting function are employed to cut energy costs. Savings climaxed with the installation of the EMS, a time parameter and a demand limiting function that are employed to cut energy usage. The warehouse 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 central control strategies that were mentioned above, the distribution center was able to cut both consumption by 31%. By monitoring the EMS remotely from its office, C & R Engineering was able to "time 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 schedule operating times of energy loads and its temperature parameters. Savings climaxed with the added shift that was added to the system. This added shift meant that warehouse lights (400 W H.P.S.) were to run from 10:30 p.m. to 3:45 a.m. for the last shifts. Fridays have no night scheduling. There are eighteen battery chargers and three cart chargers that were allowed to be charged at 2:30 p.m. daily, before the EMS installation. This allowed the battery chargers to be brought on-line in the middle of the night. The added shift meant that warehouse lights 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 1, 1982 to March 1, 1983. These savings are used only to correct the number of days usage the following past year's account statement was calculated according to the accounting method used by the electric company (the savings calculation example). In other applications we made from such a
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

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<thead>
<tr>
<th>MONTH</th>
<th>BASE KW</th>
<th>NEW KW</th>
<th>Diffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>231</td>
<td>152</td>
<td>7892</td>
</tr>
<tr>
<td>June</td>
<td>235</td>
<td>152</td>
<td>77952</td>
</tr>
<tr>
<td>July</td>
<td>263</td>
<td>166</td>
<td>89248</td>
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<tr>
<td>Aug</td>
<td>256</td>
<td>152</td>
<td>70727</td>
</tr>
<tr>
<td>Sep</td>
<td>276</td>
<td>152</td>
<td>91458</td>
</tr>
<tr>
<td>Oct</td>
<td>263</td>
<td>152</td>
<td>72767</td>
</tr>
<tr>
<td>Nov</td>
<td>235</td>
<td>152</td>
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<tr>
<td>Dec</td>
<td>235</td>
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<td>235</td>
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<td>91920</td>
</tr>
<tr>
<td>Apr</td>
<td>231</td>
<td>152</td>
<td>7892</td>
</tr>
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Totals 2903 1655 81040 61967

<table>
<thead>
<tr>
<th>MONTH</th>
<th>SAVINGS $</th>
<th>BASE KWH</th>
<th>NEW KWH</th>
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<tbody>
<tr>
<td>May</td>
<td>69</td>
<td>23995</td>
<td>5,382,89</td>
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<tr>
<td>June</td>
<td>93</td>
<td>36864</td>
<td>2,235,60</td>
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<td>July</td>
<td>97</td>
<td>36996</td>
<td>2,488,20</td>
</tr>
<tr>
<td>Aug</td>
<td>104</td>
<td>21504</td>
<td>1,464,28</td>
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<td>Sept</td>
<td>25728</td>
<td>1,170,28</td>
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<tr>
<td>Oct</td>
<td>111</td>
<td>28800</td>
<td>1,709,47</td>
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<tr>
<td>Nov</td>
<td>97</td>
<td>27469</td>
<td>1,370,78</td>
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<td>89</td>
<td>8107</td>
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<td>76</td>
<td>13640</td>
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<td>Apr</td>
<td>35</td>
<td>25684</td>
<td>1,107,50</td>
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Totals 1058 273073 887,668,91

As stated, the base year for measurement occurs from March 22 to March 1. 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 facet 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.

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EQUATIONS

\[
\text{Eq. 1) November Billing Comparison}
\]

- **Base**: 9/30/82 - 10/29/82 29 Days
- **Bill**: kw - 235 kw
  - 70,272 kwh

1981
- 9/30/83 - 10/31/83 31 Days
- **Bill**: kw - 138 kw
  - 48,000 kwh

\[
\begin{align*}
48,000 \text{ kwh} \times \frac{29 \text{ days}}{31 \text{ days}} &= 44,903 \text{ kwh} \\
3,097 \text{ kwh} & \text{ added to December bill}
\end{align*}
\]

- **Base**: 70,272 kwh
- **Adj.**: 1983
- **Savings**: 23,369 kwh

**SAVINGS CALCULATIONS EXAMPLE**

<table>
<thead>
<tr>
<th>November Billing</th>
<th>kw</th>
<th>kwh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>235</td>
<td>70,272</td>
</tr>
<tr>
<td>Adj. 1983</td>
<td>138</td>
<td>44,903</td>
</tr>
<tr>
<td>Savings</td>
<td>97</td>
<td>23,369</td>
</tr>
</tbody>
</table>

1) 97 kw

2) 97 kw \times 200\text{kwh/kw} = 19,400

\[
\begin{align*}
97 \text{ kw} & \times 200 \text{ kwh/kw} = 19,400 \\
\$343.38 & = 19,400 \text{ kwh} \times \$0.0233/\text{kwh}
\end{align*}
\]

3) 25,369 kwh

4) 25,369 kwh

\[
\begin{align*}
25,369 \text{ kwh} & \times 1.024438/\text{kwh} \\
\$5,670.73 & = 25,369 \text{ kwh} \times \$0.024438/\text{kwh}
\end{align*}
\]

\[
\begin{align*}
\$29.35 & = 29.35 \\
\$670.73 & = 670.73 \\
452.40 & = 452.40 \\
343.38 & = 343.38 \\
+ 29.35 & = 29.35
\end{align*}
\]

\[
\begin{align*}
\text{Savings} & = \$1,045.98 \\
\text{Tax} & = \$21.80 \\
\text{Total} & = \$1,067.78
\end{align*}
\]

**Basis:**
- Dallas Power & Light, Rate Schedule G
- **Demand Charge**: $3.34 net, per kw for all kw in excess of 5 kw
- **Energy Charge**: 2.32¢ net, per kwh for the next 7100 plus 200 kwh per kw of demand

\[
\begin{align*}
\text{Tax} & = \$21.80 \\
\text{Total} & = \$1,067.78
\end{align*}
\]

**MATERIALS AND DOCUMENTS**

6. Unknown, "Electrical Cost Considerations".

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