AUDIT IMPLEMENTATION ANALYSIS FOR A CHEMICAL PLANT

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ABSTRACT

An Energy Analysis and Diagnostic Center energy audit prepared in late 1993 for a chemical plant contained nine conservation recommendations and identified potential energy savings of over 20 %. An analysis of audit implementation conducted at the end of 1994 revealed that six recommendations had been wholly or partially implemented with the others scheduled for 1995. Because the plant is a heavy user of steam, measures to improve the steam system offered the quickest return on investment and were implemented first. Examination of plant utility data revealed that plant production efficiency in Btu per pound of product has decreased from 3,450 to 1,985 following audit implementation and a modification to the process, an improvement of almost 40%. This study evaluates the savings resulting from each measure to provide a guide in formulating energy conservation plans at similar batch chemical operating plants.

INTRODUCTION

Industrial energy audits are developed to provide manufacturers with a master plan for energy management at a facility. Implementation of the recommendations contained in the energy survey improves plant operating efficiency, reduces operating costs and serves to increase profits for the operation. Unfortunately, most of the energy analysis conducted at a plant ends with the completion of the audit report. Because an audit is a paper document, taken alone it provides no savings of energy. This paper looks at the effect of implementing the recommendations contained in a comprehensive audit on plant energy consumption. The result of this implementation analysis indicates that tracking of energy consumption following an audit is crucial if its full benefit is to be achieved.

BACKGROUND

Henkel Chemical Corporation is a producer of specialty chemicals located in Cedartown, Georgia. The plant was originally constructed in 1900 as a textile finishing mill and was converted to a chemical plant in 1937. Several years ago, the facility underwent a $25 million renovation which doubled plant capacity and reduced the workforce to the current level of 125 employees. Approximately 200 different products are formulated at this location, and the plant contains a large number of chemical reactors and raw-material storage tanks.

Steam is an integral part of the production process because all raw material blends are heated to yield the desired final product. This year alone the Cedartown plant will consume over 100 million pounds of steam for the dual purposes of plant and process heating. Because a considerable amount of steam is employed for raw material and product heat tracing, winter steam demand is 4 to 5 times greater than summer.

With annual energy expenditures exceeding $1 million, group managers recognized the negative impact energy waste could have on company profits. To help site engineers improve the effectiveness of their conservation efforts, Georgia Tech conducted a facilitywide energy audit in the fall of 1993.

ENERGY AUDIT RECOMMENDATIONS

The energy audit was performed through Georgia Tech's Energy Analysis and Diagnostic Center in the fall of 1993. Table 1 shows the recommendations contained in the report. The audit revealed nine cost-effective recommendations worthy of consideration. The recommendations fell into three broad classes: steam system, lighting, and miscellaneous electrical improvements. Estimated energy savings for the plant 20.6 percent.

TABLE 1
ENERGY AUDIT RECOMMENDATIONS

No.	Recommendation	Energy Savings (MMBtu)	Simple Payback (Years)
1	Downsize Boiler	36,634	1.9
2	Increase Condensate Return	2,760	0.7
3	Repair Steam Leaks	5,626	0.1
4	Repair Steam Traps	6,740	0.1
5	Install Energy-Efficient Lighting and Electronic Ballasts	278	2.4
6	Replace Incandescent with Fluorescent Lighting	46	1.0
7	Replace Mercury Vapor with Metal Halide Lighting	49	2.9
8	Use High Efficiency Motors	125	2.8
9	Relocate Compressed Air Intake	83	0.2
		52,341	1.4

Steam System Recommendations
Four measures suggested improvements to the steam system.

The first recommendation, and the recommendation promising the most cost savings, was to downsize the existing boiler. The plant had an 80,000 pph natural gas boiler that was only loaded at 23 percent even during peak periods. Boiler load varies to a low of 14 percent in the summer. Boilers with loads below 40 percent display low efficiency due to excessive shell losses and poor combustion efficiency resulting from an exorbitant amount of combustion air. To more closely match actual plant steam demand, a 750 hp (25,875 pph) firetube boiler was recommended to replace the existing boiler. Estimated fuel savings for "right-sizing" the boiler is 10 percent of the original input.

The second steam system recommendation is to increase the amount of condensate being returned. Condensate is at a higher temperature than make-up water, and thus less energy is required to bring the already hot condensate to boiling. Cost savings will also result from reduced water and water chemical usage. Condensate was observed to being dumped in four different locations. Measurement of the condensate indicated 3.7 gallons were being lost per minute. By installing 600 feet of piping, this condensate can be returned to an existing receiver.

Sixteen steam leaks were found throughout the plant. Such leaks are not uncommon in plants which use a lot of steam. However, these leaks should not be tolerated. Any steam escaping the steam system must be replaced by the boiler. The sixteen steam leaks found were losing an estimated 5,626 million Btus per year.

The last steam system recommendation is to repair steam traps. Steam traps are one area often overlooked in a steam system. Steam traps, as mechanical devices, fail periodically. When this occurs, steam traps no longer capture steam for condensation, but allow it to pass virtually unrestricted. Failed or worn traps result in the waste of high quality steam and should be repaired to reduce the load on the boiler and save energy.

Lighting Recommendations
Three recommendations involved improvements to the plant's lighting system. The measures were use of energy-efficient lamps and electronic ballasts in fluorescent fixtures, replace existing incandescent lighting with fluorescent, and replace mercury vapor lighting with metal halide.

The use of energy-efficient fluorescent lamps and electronic ballasts can reduce fluorescent light energy consumption by 14 to 43 percent per fixture. The plant uses a variety of eight-foot and four-foot fluorescent fixtures in offices and warehouses throughout the facility. Lamps in four-foot fixtures can be replaced with T8 lamps that are one inch in diameter and rated at 32 watts each. The eight-foot lamps should be replaced with energy efficient lamps that are rated at 60 watts each.

The stockroom at the plant is currently lighted with 15 150-watt incandescent lamps. If these fixtures were replaced with fluorescent fixtures on an equivalent lumen basis, only six two-lamp, eight-foot fixtures would be needed. This leads to a savings of 13,469 kWh/yr per year. In addition, fluorescent lamps last up to ten times longer than incandescent lamps.

The drumming area is currently lighted with 250-watt mercury vapor lamps. Metal halide lamps are available as a direct replacement for the mercury vapor lamps. The lamps, rated at 215 watts, will provide as much light as the mercury vapor lamps and allow a reduction of 35 watts per lamp. The mercury vapor lamps should be replaced with metal halide as they burn out.

Miscellaneous Electrical Recommendations
Two other measures, using high efficiency motors and relocating the compressed air intake, were included in the energy audit.

High efficiency motors, which are 2-3 percent more efficient than standard motors, were recommended as replacements when the standard efficiency motors fail.

Relocating the compressed air intake from an indoor to an outdoor location, preferably a shady location with northern exposure, will result in energy savings. Moving intakes outdoors results in cooler air intake temperatures throughout the year. Less work is required to compress the cooler air, thereby saving energy. Although the savings associated with this measure is small, the associated capital expenditure is also usually low.

IMPLEMENTATION ANALYSIS
Using the audit report as a guide, plant engineers devised a master energy management plan in early 1994. One of four actions, rejection, incremental implementation, immediate implementation or near-term implementation, was assigned to each measure. Only one measure, relocate compressor intake was rejected outright. Plans to implement the remaining measures were then formulated

With fossil fuel, natural gas and fuel oil, comprising 87.3 percent of the energy used at the plant, steam system measures offered the greatest energy and cost savings potential and were addressed first. Steam system maintenance items, leaking pipes and traps, were implemented immediately. The maintenance staff was directed to conduct weekly surveys to identify and repair steam leaks. This procedure significantly reduced losses due to leaks.

An ultrasonic diagnostic tool for quantifying steam trap leaks was purchased and used to survey the traps. Before the surveys were begun, the traps were not tagged and an accurate count of plant traps did not exist. After purchasing the diagnostic tool, the traps were tagged, entered into a database, and tested for leakage monthly in the winter and quarterly in the summer. The diagnostic device determines the amount of leakage from each trap so that a steam leakage cost can be calculated. Traps are repaired when the energy loss due to leakage exceeds a set value. Between 5-10 traps with heavy leakage are found each survey.

The two other steam system measures, downsize boiler and increase condensate return, were selected for implementation later due to the large investment involved. A smaller boiler was installed in October, 1994. Energy data since its installation has not shown significant savings, but this is not unexpected because most of the savings were expected during the low-load months of summer. Additional condensate return piping will probably be installed sometime in 1996. Because some long runs are involved and the investment large, it was delayed primarily due to the relatively small savings.

The lighting measures and energy-efficient motors are being implemented incrementally as the existing lights and motors fail. Because the expected savings was not large and implementation is incremental, only small savings to date are expected for these measures.

Because the production rate and energy costs vary from year to year, savings are best determined by calculating production efficiency in Btu/lb (see Figure 1). Production efficiency is found when the plant energy consumption in Btu is divided by the annual production in pounds. Using 1993 as the base year, savings were determined for 1994 and 1995. Data for 1995 is based on the first four months. The 1995 production efficiency to date is 7.7 percent better than the base year and about 1.5 percent better than 1994.

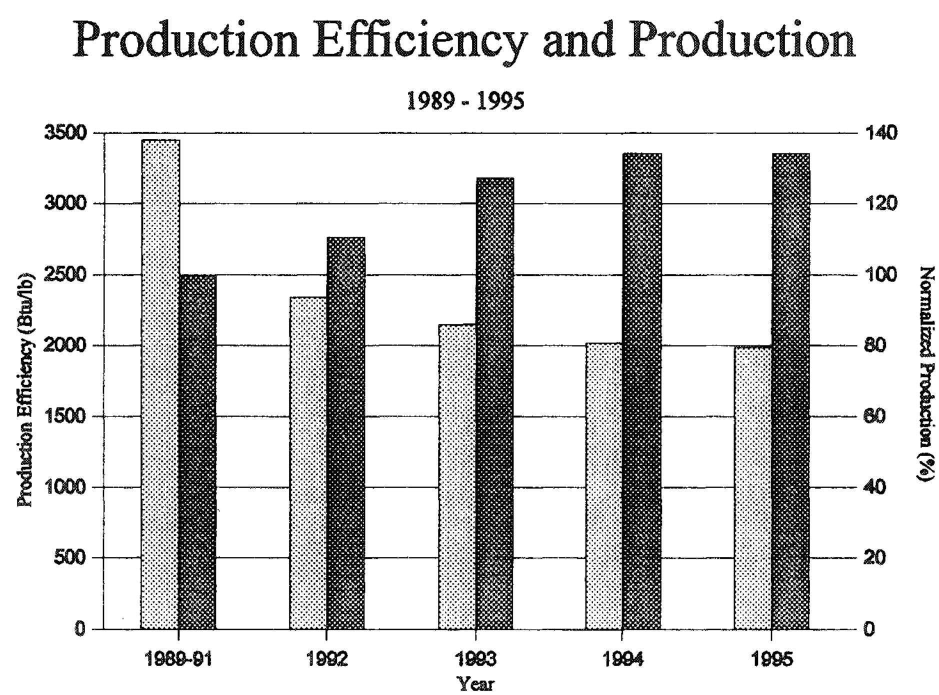

Figure 1

While complete data is not yet available due to incremental implementation and winter only consumption information following installation of the new boiler, the changes accomplished thus far have netted a positive energy savings. Work is continuing on the remaining measures, but the improvement in plant efficiency already achieved is a great incentive to continue the process. Because production has been expanding each year, if the plant maintained the same efficiency in 1995 as 1993, the year before the improvements were started, energy consumption would be approximately 22,300 MMBtu less. Using an average energy cost of $3.50/MMBtu, the annual cost savings over the base year efficiency is estimated to be near $80,000.

While audit implementation has yielded more than 7 percent improvement in production efficiency since 1993, the greatest gain occurred in 1992 before the audit was performed. During this year an inefficient hot oil heater was eliminated and replaced with steam. The hot oil unit consumed a large amount of electricity and could be replaced easily by steam.

CONCLUSION

While energy audits provide a comprehensive plan for energy management, generation of actual savings depends on proper implementation. Our analysis found energy savings had been achieved at the plant analyzed, though not up to the level expected. Two conclusions can be deduced from this outcome. First, industrial plants are extremely complex operations and calculated energy savings after a one-day audit may not be highly accurate. Maintenance items like steam and air leaks and leaking steam traps may be especially difficult to assess accurately. Second, failure to achieve estimated savings could be due to the misapplication of the specified conservation technology.

Continued tracking of energy efficiency is helpful in determining if implemented measures are effective and still active. Plant personnel need to be aggressive in tracking savings resulting from audit implementation. A normalized measure, like production efficiency, can be used to determine if savings estimates are being achieved.