EPIC ENERGY MANAGEMENT SERIES

U.S. DEPARTMENT OF COMMERCE
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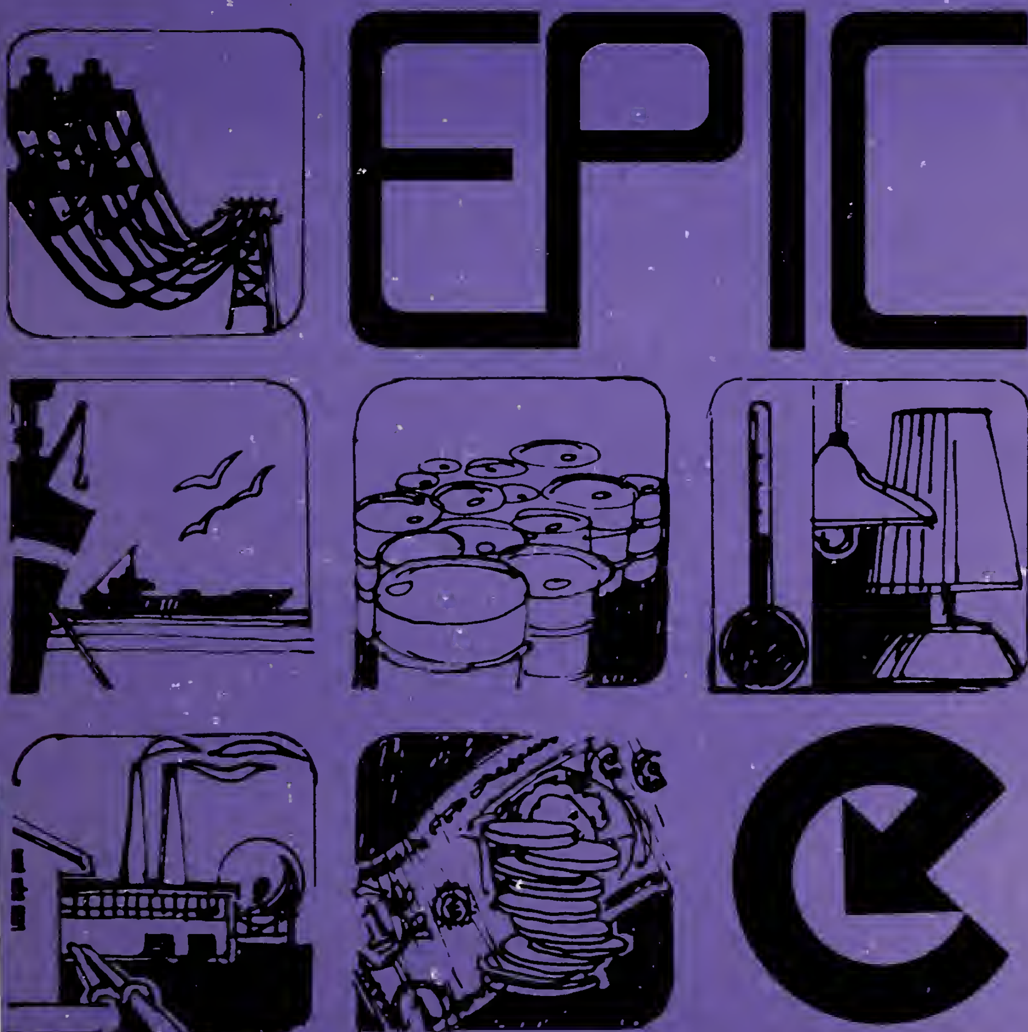
Energy Management Guide for Light Industry and Commerce



The EPIC Energy Management Series is an on-going series of publications designed to assist business leaders in developing and maintaining effective energy management programs, and will cover both technical and non-technical subjects. This series grew out of the original EPIC (Energy Conservation Program Guide for Industry and Commerce) published jointly by the National Bureau of Standards and the Federal Energy Administration.

Energy Management Guide for Light Industry and Commerce

NBS HANDBOOK 120

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Summary

This Energy Management Guide describes some simple methods by which the manager of a small business can analyze his energy use, determine the areas in which energy savings can be made, and estimate the magnitude of the possible cost savings.

The program starts with an energy audit based on fuel and utility bills. A more detailed audit, designed to locate the major energy uses and, therefore, the most promising targets for energy conservation, is discussed in some detail. The methods described require little or no instrumentation; they primarily involve the summarizing of data taken from such sources as light bulb labels and the nameplates on electric motors. The importance of this audit is stressed as a necessary prelude to a good energy management program.

A check list suggests some seventy items which might be important cost saving opportunities to an individual business. Eight of these opportunities are expanded in the appendix into miniature case studies illustrating simple methods for estimating savings. These Cost Saving Opportunities (CSO's) range from the simple case of reducing temperatures at night and on weekends (saving up to a third of the heating fuel), to the more complex case of installing a heat exchanger on a restaurant air conditioner (cost $800) in order to save money in heating water (saving $1100 yearly).

It is pointed out that while many energy conservation actions will require no outside help and little or no capital investment, others, particularly those involving a major expenditure, should be discussed with an expert in the field. A listing of sources of assistance is included as a guide to obtaining such consulting advice.

Energy Management Guide for Light Industry and Commerce

W. J. Kelnhofer and L. A. Wood

The Energy Management Guide for Light Industry and Commerce is a training tool to assist small industrial and commercial organizations in an energy conservation program. It is part of a planned series, starting with NBS HB–115 (EPIC), of guides and training aids to assist industry in making the most efficient use of the energy supply.

While much of the information in the Light Industry Guide has been published in EPIC, the material has been edited and re-written in shortened form for use by the large number of small organizations with a limited supply of technical manpower. The energy conservation case studies (Cost Saving Opportunities) have been written with this target audience in mind.

Key words: Energy conservation; energy conservation guide; energy conservation program; industrial energy conservation.

Introduction

The energy crisis has had considerable impact on industry and commerce in the United States, as well as in every industrialized country in the world. We are faced with the fact that the supply of easily recovered gas and oil is finite, and prices are rising to reflect this realization. We will eventually alleviate the supply problem with other developing energy sources such as solar power, or even nuclear fusion, but the relative price of energy is not likely to return to the levels of the 1960's.

Light industry and commerce [1] may be particularly caught up in this situation. For various causes in addition to energy prices, there have been increased operating and production costs, reduction in sales, reduction in profit levels, and in some cases, serious unemployment. Under such circumstances, even a moderate saving in energy costs can make the difference between a healthy business and one that is forced to close. This applies particularly to small business. The National Federation of Independent Business reports (Sept. 1975) that in smaller businesses energy is an important item of expense. Its conservation will normally result in a direct increase in pretax profits.

While many companies have been affected adversely by the energy situation, there are many resourceful and adaptive organizations that have met these problems head on. They have learned how to make better use of the raw materials and supplies available to them, but equally important they have learned to reduce their energy usage by as much as 30 percent. This result, both in businesses that are energy-intensive and those that are not, has been accomplished through commitment to well organized and executed Energy Management Programs.

The purpose of this publication is to assist in the steps needed to carry out an effective program. The techniques are the same as those that would be applied to any aspect of a well run business. They have been derived from several successful energy management programs in both large and small industries. The program consists of four major steps:

- Organize the program
- Conduct an energy audit
- Take action to save energy
- Promote the program to your employees

[1] Light industry and commerce is defined as those businesses that are not large users of energy, and whose primary use is for heating, lighting, and refrigeration. They do not usually employ an engineering staff. Examples would include motels, food stores, laundries, garages, job shops, small assembly plants, etc.

Each step will be discussed in the material that follows. Also included is a checklist of representative energy saving opportunities, some case studies of specific Cost Saving Opportunities (CSO's), in appendix I, and a brief section on cost analysis procedures for those energy saving proposals where some capital investment is required.

Energy Management Program

Four main points, each of them discussed below, make up the energy management program. The presentation of these points should be considered as a guide; you must tailor the program to fit your own specific needs.

Organization of the Program

The success of any program will be directly related to the degree of commitment by the top management. This is true whether your firm has one employee or one hundred. In addition to commitment, top management must also provide adequate resources to meet the commitment. This means the appointment of one person to assume the responsibility as energy coordinator. This person is in charge of the energy audit, of listing and summarizing conservation opportunities, and of implementing those opportunities that are promising and are approved. The energy coordinator will be most successful if he is someone very familiar with all the operations of the firm and of its energy needs. He may be the assistant manager, the building superintendent, the manufacturing manager, or in a very small concern, the owner.

If the organization is reasonably large, it may be necessary to assist the coordinator with an energy management committee, with the coordinator sitting as chairman. The members should be able to represent authoritatively the different business functions such as manufacturing, delivery, building services, office personnel, etc. Their duties are to perform the coordination function within their separate departments.

Whatever organizational format you choose, the leadership must be strong and knowledgeable. They must be fully aware of the outlines of the energy management program, and of its importance to the business.

During the organizational phase, one should consider the use of outside engineering help to advise the coordinator and his committee. It is true that many energy saving opportunities do not require engineering expertise; e.g., turn off unnecessary lights, weatherstrip leaky windows, and shut down equipment that is not in use. Engineering assistance is recommended, however, if a proposal is complex or if it involves a large capital investment. Outside help is also often valuable in spotting energy wastes that are not apparent to insiders because of long familiarity with things as they are. Consulting firms are available throughout the country, utility representatives are frequently available for help, and other sources of assistance are listed in a later section of this publication.

Conducting an Energy Audit

When an energy audit is completed it shows how much energy came into your business during a month, and how it was used within the plant. It may be considered as similar to the monthly closing statement of a double-entry accounting system. One series of entries consists of the amounts of energy which was purchased during the month in the form of electricity, gas, fuel oil, etc. The second series lists how this energy was used; how much in lighting, in air conditioning, in delivery trucks, in drying ovens, etc. Since the two series of entries (sides of the ledger) must balance, it may be necessary to list some estimates or some unknown losses.

The Gross Energy Audit

The first step is to determine your gross energy, the amount of energy entering your business. It is usually measured from your monthly utility and other fuel bills. It is useful to scan all of the bills for the past twelve months and summarize the monthly use and cost of energy by month for the year. The amount and the cost of each type of energy (electricity, gas, oil, etc.) should be entered separately.

Such a gross audit alone can answer several questions.

- What is your total energy cost?
- Is the cost increasing?
- Is energy an important fraction of total operating cost?
- Is energy cost apt to become more important?

In addition, an audit can become a means to judge the progress of an energy management program; a means of finding out whether energy saving measures are actually reducing the amount of energy used per unit of manufacture, per dollar of sales or any other convenient measure.

A suggested form for the monthly energy audit is shown in figure 1. It is suggested that you convert all the sources of energy used to a common unit, the British thermal unit, or Btu. (Technically the amount of energy required to raise the temperature of a pound of water by one degree Fahrenheit). This will enable you to add up the total energy used, to calculate the energy used per pound of product, or per dollar of sales, and to track month by month the results of an energy management program. Table I, below left, lists the energy content of the common energy sources.

FIGURE 1

MONTHLY GROSS ENERGY AUDIT Date ____________________

Energy Source	Usage	Price	Monthly Cost	Btu's(1)	Demand (2) ____kW—$____
Electricity	kWh	(3)			
Natural Gas	kcf(4)				
Fuel oil	gal				
Gasoline	gal				
Propane	gal				
Coal	ton				
etc.					
	TOTALS		$______	______Btu's	

NOTES: (1) See the text for a discussion of British thermal units (Btu's).
(2) This item is discussed later in this guide.
(3) Electricity—the price needed is the dollar amount of the monthly bill divided by the kilowatt hours (kWh) used. This is important since utility bills may list a price per kWh, plus a fuel adjustment, and sometimes plus a tax, a demand charge, and a power factor penalty. If either of the latter two items are on your bill, discuss them with a consultant or an engineer from the power company.
(4) Gas is usually in thousands of cubic feet (kcf) Gas companies often use the abbreviation "Mcf" to mean the same thing, but the abbreviation "k", for kilo, is the modern preference.

TABLE I

Source	Unit	Btu's per unit
Electricity	kWh	3412
Natural gas	kcf	1,000,000
Fuel oil (#2)	gallon	140,000
Gasoline	gallon	130,000
Propane	gallon	91,000
Coal	ton	24,000,000
Steam (purchased)	1000 lb	1,000,000

The gross energy audit tells you how much energy you are using, and how this usage varies with production rate and with the time of year.

The Detailed Energy Audit

This audit is to find just what your energy is used for. The audit data leads to the evaluation of energy uses; whether each use is essential, and whether it might be reduced in amount. To conduct such an audit, consider one energy source at a time and try to find out how the month's supply was used.

In the case of electricity, the problem may be attacked rather simply. To estimate the amount used for lighting, count the number of bulbs or fluorescent tubes, read off their rating in watts (add 20 percent for the ballast used with each fluorescent) and multiply by the number of hours used per month. The answer will be in watt hours per month, so divide by 1000 to get kWh. For example 200 × 75 watt flourescents, operating 310 hours per month, will use

$$\frac{200 \times 75 \times 1.20 \times 310}{1000} = 5580 \text{ kWh per month.}$$

Electric motors offer some difficulty for complete accuracy, but an estimate can be made from the data on the name plate and estimated use factor. If a motor is labeled at 115 volts, and a full load current of 5.5 amperes (5.5 A FL), it will use 115 V × 5.5 A = 632 watts each hour of operation at full load. Motors seldom really operate at full load, 70 percent of full load is a good average. With an actual load of 70 percent and operation for 200 hours per month, the electricity used per month is

$$\frac{632 \text{ watts} \times 0.70 \times 200 \text{ hours}}{1000} = 88 \text{ kWh.}$$

For a motor labeled "3 phase," the calculation of watts is voltage times ampere times 1.732. For example, a 220 volt, three-phase motor, rated at a full load current of 2.2 amperes, will use 220 × 2.2 × 1.732, or 838 watts at full load.

Electric heating elements are rated in watts and no correction factor is involved. The kWh usage is simply the wattage times the hours of operation per month, divided by 1000.

In some cases it may be very difficult to estimate the hours of actual operation, particularly in equipment that is controlled with a thermostat such as the compressor motor on an air-conditioner, or the heat-

FIGURE 2

MONTHLY DETAILED ENERGY AUDIT—ELECTRICAL

Date__________________

Usage (except motors)	Rated Watts(1)	H	kWh	Btu
Office lighting				
Outside lighting				
Space heating				
Soldering irons				
Tank heaters				
etc.				

Motors	Rated Watts(1)	Watts(2)	H	kWh	Btu
Ventilating fans					
Exhaust fans					
Air-conditioners					
Hand tools					
Big motor #1					
Big motor #2					
etc.					

TOTALS ________ ________

DEMAND________kW POWER FACTORS______________

NOTES: (1) Name-plate data, Watts equals volts time amperes. For fluorescent tubes, add 20 percent for the ballast; i.e., multiply the rating by 1.20. For three-phase motors, watts equals volts times amperes times 1.732.

(2) Rated watts times the fraction of full load, usually about 70 percent If the operating current has been measured, use voltage times the measured current (times 1.732 if it is a three-phase motor.)

ing elements on an electric oven. In such cases, you may need to have an electrician connect a simple electric clock across the motor terminals and read the clock every twelve hours for a day or so. The elapsed time shown on the clock at each reading will be the hours of operation for the past twelve hours of real time. It must be recognized that this type of measurement for a few days is not always representative of a yearly average energy use. Air-conditioners, for example, can be expected to vary their energy demand widely with the time of year, while a drying oven's demand pattern may depend wholly on the rate of production.

When the electric audit is finished, tabulate the results in some such fashion as figure 2, using the horizontal lines to categorize the usage in a form which you can use for later analysis. For example, one line might be office lighting, another warehouse lighting, a third air-conditioning, and a fourth ventilating fans, etc. Large uses, such as an electric furnace or a big motor, you might list separately.

The total of this tabulation, estimated for a month's usage, should be equal (within 10 percent or so) to the kWh used according to an average month's electric bill. If it isn't, you may have missed some pieces of equipment, or you may have not estimated the time of operation correctly, or if motors are a big portion of the load they may be loaded to more or less than the 70 percent which was assumed. If you have trouble reaching a reasonable balance, an electrician using a "clamp-on" ammeter can probably find the discrepancy, or a man from your local utility may be of help. If the problem is a very low power factor (less than 0.70) on a large group of motors, you may need the power company's help to locate the trouble. They will also be glad to advise as to methods of improving the power factor and thus lowering your monthly bill.

The following two paragraphs are brief explanations of electrical "Demand" and "Power Factor" charges. An understanding of these terms is helpful in reducing the electric bill.

Demand charges reflect the maximum rate at which you used electric power over some short period, usually about 15 minutes, during the month. If you are a small user, on a "domestic" contract with the utility, you probably do not pay a separate demand charge, it is averaged into the rate you pay per kilowatt hour. A larger user on a "commercial" contract will probably pay a lower rate per kilowatt hour, but will be billed a demand charge based on the maximum rate of use, and some times on the time of day at which this maximum occurred. You can minimize this charge by scheduling the major users of electricity such as very large motors or electric furnaces so that they do not all require power at the same time. In some cases, you can reduce the demand charge by operating the large power users on the night shift and not during the day. The best technique depends on your individual contract with the utility and your flexibility in scheduling operations.

Power Factor is a measure of the "phantom" currents that are needed to set up the magnetic field required for the operation of a motor. These currents are real enough; they are sometimes labeled "phantom" because they do not show up in the kilowatt hours recorded on the standard watt hour meter. They do, however, reflect lost energy in heating transmission lines and transformers. For this reason, if a high percentage of your load is electric motors, the utility may be adding an additional charge to your bill for a "low power factor." This charge can usually be eliminated by mounting the proper kind of capacitor on your larger motors. The utility will be glad to advise you as to the proper type and size.

The *oil and gas* detailed audits follow exactly the same pattern as the electrical one just described.

If the fuel being audited is used on only one piece of equipment such as a space heating furnace, the audit is quite simple. This simplicity also exists if the usage is only on a number of identical units such as small furnaces or dryers. If the usage is on a number of units of different design, however, it may be necessary to install meters on some individual pieces of equipment in order to get a suitable audit. These may be rather simple flow-meters, reading the fuel usage in terms of gallons per minute or cubic feet of gas per hour, or they may be more sophisticated (but more convenient) meters which record the total fuel used and can be read at daily or weekly intervals. Engineering consultation is suggested, so that the choice and installation of such meters is suitable for your particular case. Many firms have found that the installation of individual meters saves energy simply because the equipment operators are reminded at frequent intervals just how much expensive fuel is being used, and start thinking of energy saving ideas.

Gasoline usage should be audited by records on individual vehicles, and on individual drivers. Several companies have found that the most important factor in better mileage on trucks used for delivery is the training of the driver, and his motivation to save energy. If gasoline usage is an important item in your energy cost, good records can help you decide on the importance of better driver training, improved maintenance, using smaller vehicles, etc.

Analyzing the Energy Audit

The first question to ask when a monthly audit is complete is whether or not it balances; the quantity of energy used must be equal to the quantity that came into the plant. If 500 kcf of gas was purchased, and only 300 kcf can be accounted for, even by making some generous estimates, then the auditing technique should be refined.

The second question is to find the processes, or departments, or the pieces of equipment that are the big users of energy. This information tells one where to start first in looking for savings opportunities.

Lastly, as the audit is updated month by month, one must watch for the variations caused by the weather, by variations in product output, and of course for the reductions due to good energy management.

Taking Action on Energy Saving

This is the time when some Energy Management programs lose momentum and become ineffective. Things may look too complicated, and there seems no good place to start. But unless you start, there will be no savings in energy or in dollars.

Simple housekeeping items are always first in importance, because they are easy to see, and generally cost little money to fix.

(1) Read the check list of energy saving ideas following this section. Make sure that your energy coordinator reads it, as well as any involved department managers or section foremen.

(2) Take a walk through the facility with your people, looking for energy wastes. Ask some of the simple questions;

Why are the lights on in this room with no one in it?

Can the thermostat setting be lowered (in the winter), or raised (in the summer)?

Are there motors running idle, or empty furnaces running hot?

When was the last time the heating plant was adjusted for the best fuel/air ratio and the filters changed or cleaned?

(3) Make a list of the "no cost" energy saving ideas and assign someone to follow up on each one. You, or the energy coordinator, should follow up on him. Just this much of a program has frequently produced savings of 10 to 15 percent of the energy usage.

The *major cost saving items* are sometimes those which will require some capital investment. In such cases, the services of an independent consultant is suggested unless you have some in-house expertise. Suppose, for example, that you are operating a medium sized steam boiler which according to your detailed audit is using 30 percent of your total energy. It does not require a consultant to suggest that you should insulate any bare steam pipe, replace or repair steam traps that are leaking live steam, or operate the boiler at the minimum pressure that is actually required. It does, however, require some expertise to analyze the flue gases, estimate a heat balance on the boiler, and determine what savings might be made by adjusting the air/fuel ratio. It is not unusual to find in older boilers that 20 or 30 percent of the heat in the fuel is being wasted as hot stack gas, and that a modest investment in better combustion control equipment is capable of paying for itself in a very short time.

Promoting the Program

An energy management program that starts with a flourish and then is allowed to die because of lack of interest does not accomplish very much. Two types of follow up are needed.

(1) Measure the results:

Repeat the gross energy audit each month, and calculate the change in Btu's used per unit of product. When savings are made, determine what action caused the savings, and what programs were apparently not successful. Analyze what can be done to promote more savings, and to rescue projects which are failing.

(2) Involve your employees:

Publicize the program; explain its importance to the business and to them. Assign as many as possible to an active part in the program, even if only a small part. Reward good energy saving ideas, either with publicity or by more substantial means. Keep them up-to-date with the progress of the program. Consider telling your customers and your community about it—it could be good advertising.

Checklists for Reducing Energy Usage

Good energy management implies a reduction of energy usage by elimination of all unnecessary uses of energy and improving the remaining utilization of energy. Checklists of possibilities for accomplishing the goal are given in this section. Every item in the categorized lists will not apply to all light industry and commerce, but hopefully the suggestions will stimulate you to develop special checklists applicable to your own business.

It should not be forgotten that your employees can help significantly to accomplish your energy utilization goal. One way to encourage and guide them in this direction is to post and/or distribute the checklists that you specifically have designed.

Buildings and Grounds

- Reduce ventilation rates when possible
- Close off all unused openings and stacks
- Reduce exhaust air when possible
- Repair broken windows, skylights, doors
- Consider modern replacements for old windows
- Weatherstrip windows and doors; caulk or eliminate all cracks in building
- Insulate walls, roofs, crawl spaces, floors and foundations
- Eliminate unnecessary windows
- Use evaporative cooling on roofs to reduce air-conditioning load
- Raise building thermostat settings during cooling season [2] and lower them during heating season to maximum extent possible
- Eliminate heating/cooling from all unused buildings or rooms
- Install window shades to reduce heat gain from summer sun
- Utilize trees and shrubs as sun shades and windbreaks
- Make sure that trees and shrubs do not block air intake and exhaust openings in buildings, or proper functioning of window air-conditioners
- Use color schemes inside and out for reflection of light and solar radiation

Electricity

- Do not use electric motor larger than necessary for the job
- Reduce lighting level wherever possible. Use more efficient fixtures and bulbs
- Use timers or photo cells in lighting circuit when feasible
- Use natural light when and where possible
- Use reduced lighting during clean up operations
- Install light fixtures at as low a height as is practical
- Clean surfaces of light bulbs, tubes and reflectors periodically
- Eliminate or reduce lighting of outdoor displays and signs
- Turn off lights, typewriters, coffee pots, radios, TV sets, etc., when not in use
- Make sure that all electrical wiring is of proper size and in good condition
- Modify schedule of electrical power use to minimize electrical demand charge
- Do not let motors run idle
- Review energy efficiency ratings for all new electrical equipment
- Reduce lighting in parking lots when empty

Equipment and processes

- Schedule heating and air-conditioning system to operate only when required

[2] Sometimes impractical on large central systems.

- Check that all mechanical equipment is in good repair and operating properly—replace worn bearings and worn belts, have proper belt tension, lubricate as required
- Eliminate leaks in supply and return air system
- Eliminate leaks in steam and water supply or return lines, valves, steam traps, pump seals, etc.
- Install automatic controls to shut down equipment when not needed
- Properly maintain and calibrate automatic controls on all equipment
- Clean or replace dirty filters (air, water, oil, etc.,) as necessary
- Insulate bare steam, hot water and chilled water lines
- Recover energy available from exhaust air, stack gas, waste water and condensate
- Check boiler operation for proper air/fuel ratio as often as possible
- Clean and maintain boiler heat transfer surfaces often
- Inspect and repair faulty boiler insulation as required
- Do not exceed temperature required for any process, hot water, or steam supply
- Turn off power tools and support equipment when not being used
- Consider connecting exhaust fans in kitchens, wash rooms, hoods, etc., with light or equipment switch
- Clean and maintain all heating and cooling coil surfaces as often as necessary to maintain high efficiency of heat transfer
- Reduce water flow rates to a minimum in all flushing and cleaning processes
- Maintain all equipment according to manufacturer's directions
- Cover liquid treatment tanks, condensate tanks, swimming pools, etc. when not in use to minimize heat loss

Vehicles

- Maintain all vehicles in peak operating condition
- Turn off lift trucks, diesel construction equipment, delivery trucks, etc., when not in use, i.e., while loading, unloading, or waiting
- Size vehicles to the job
- Provide incentive to have customers take merchandise with them
- Organize optimum salesmen's routes and frequency of calls
- Coordinate sales calls with deliveries when possible
- Minimize same day deliveries and special deliveries
- Reduce frequency of deliveries to outlying areas
- Consolidate deliveries with other companies when possible
- Keep records on delivery vehicles, for example:

    Total route sales per period
    Total route miles per period
    Total fuel costs per period
    Route sales per vehicle mile
    Miles per gallon of fuel
    Maintenance costs per mile
    Total vehicle costs per dollar sales
    Compare data for various vehicles and drivers

Although not contributing directly to company energy savings, employees should be encouraged to form and use carpools. You might even wish to consider providing a company bus service or arranging for bus pooling with other near-by companies. These actions will help develop an energy-saving mode of thinking on the part of your employees and save them money. It will also help you to gain acceptance of other actions to save energy.

Cost Analysis Procedures

The checklist in the previous section contains some suggestions for energy saving which will require the investment of capital dollars in order to achieve savings. In some cases the savings per year may be so large, and the capital cost so small, that the desirability of the project is obvious. In other cases, a more detailed analysis is needed.

This section discusses two of a number of procedures for making a financial analysis of your cost saving opportunities. An important factor in your analysis is the amount you are paying for your energy.

The reason for determining energy costs is to allow you to make valid analysis of the actions you might need to take to save energy and money. The cost varies widely with the fuel source used. Table II shows the cost of energy at various fuel and electricity prices.

The energy costs listed assume that all of the energy content of the fuel is used, i.e., that there are no losses or inefficiencies. In actuality, there are losses, and efficiency is usually less than 100 percent. For example, in space heating with oil or gas, some of the heat is lost out the furnace stack. This results in a range of efficiency of 50 to 85 percent, with 60 percent being an average figure. Thus, if oil at $0.42 per gal-

Table II

Fuel or electricity prices					Resulting energy cost, $/MBtu [a]
Electricity, $/kWh	Oil, $/gal	Gas, $/kcf	Propane, $/gal	Coal $/Ton	
0.0034	0.14	1.00	0.092	24.00	1
.0068	.28	2.00	.183	48.00	2
.0102	.42	3.00	.275	72.00	3
.0136	.56	4.00	.366	96.00	4
.0171	.70	5.00	.458	120.00	5
.0205	.84	6.00	.550	144.00	6
.0239	.98	7.00	.641		7
.0273	1.12	8.00	.733		8
.0307		9.00			9
.0341		10.00			10
.0512					15
.0682					20
.0853					25
.102					30

[a] MBtu equals one million Btu's.

lon is used for space heating at an efficiency of 70 percent, the actual cost per MBtu delivered as useful heat is $3.00 divided by 0.70, or $4.29 per MBtu. Note that electricity is by far our most expensive form of energy. But of course, it is also our most convenient and efficient form and has no replacement for some applications.

Benefit/Cost Analysis

The benefit/cost analysis can be used to decide if a capital investment is economically justified, or it can be used as a basis to choose between several alternatives after a decision to invest has been made. First, all benefits and all costs are reduced to a dollar value, and the ratio of benefits to costs is taken. If the ratio is greater than unity, the project may be economically justified and should be more fully examined.

Example—a heat recovery unit for a small heat treating plant costs $55,000 installed. It is estimated that the unit will save $12,000 annually in fuel and have a life of 10 years. Annual maintenance costs will be $500. The benefit/cost ratio is determined as follows:

Benefit = $12,000 − $500 = $11,500 per year.

Costs: Assume money is available at 10 percent interest. The annual cost will be the amortization cost, or annual payment required to repay the debt at 10 percent interest in 10 years. This is found by multiplying the total loan by a capital recovery factor, F, as found in table III. Thus, for an interest rate of 10 percent for 10 years, F = 0.1628, and cost = $55,000 × 0.1628 = $8,954 and,

Benefit/cost ratio = $11,500/$8,954 = 1.28

The investment is profitable since the benefit/cost is larger than unity.

Example—It has been decided by a small manufacturing company to make a capital investment in a wastewater, heat recovery unit. Two systems are available:

System—A:

Total Cost	$14,000
Annual operation and maintenance costs	$ 900

System—B:

Total Cost	$12,000
Annual operation and maintenance costs	$ 1,400

Table III

Capital recovery factor—F

Yr	Interest rate				
n	6.0%	7.0%	8.0%	10.0%	12.0%
5	0.2374	0.24389	0.25046	0.26380	0.27741
10	.1359	.14238	.14903	.16275	.17698
15	.1030	.10979	.11683	.13147	.14682
20	.0872	.09439	.10185	.11746	.13388
25	.0782	.08581	.09368	.11017	.12750
30	.0726	.08059	.08883	.10608	.12414
40	.0665	.07501	.08386	.10226	.12130

Both systems reduce energy utilization by the same amount, and both systems have estimated lives of 15 years. Money is available at 10 percent. Which system should provide the greater long term savings? Net Benefit per year of System A over System B = $500. Additional cost of System A over System B = $2,000. For 10 percent interest rates over 15 years, the capital recovery factor, is F = 0.1315 (from table III). Thus, the cost per year for the additional $2,000 of capital investment is:

Cost = $2,000 × 0.1315 = $263.

and

Benefit/cost = $500/$263 = 1.90

Although the original cost of System—A is 16.7 percent more than System—B, System—A will provide the greater long-term savings over the life of the system.

Time to Recoup Investment

Another approach is to determine how long it will take to recoup the investment required to accomplish a particular energy (dollar) savings. It is assumed that the annual savings is used to pay off the required loan at the current interest rate. If the investment is recouped in a period less than the life of the equipment, the investment is considered profitable. Table IV can be used to estimate the "time to recoup investment."

Example—It has been estimated that an investment of $22,000 is required to update the air-conditioning and heating system equipment and controls installed in an older five-story office building. The life of the system will be extended for ten years. The annual savings in energy purchased plus reduced maintenance cost should be approximately $5,500. Money is available at 10 percent interest. To find the time to recoup the investment the following ratio is calculated:

TABLE IV

Years to recoup investment

Investment/ savings ratio	Interest rate			
	6%	8%	10%	12%
2	2.19	2.27	2.34	2.42
3	3.41	3.57	3.74	3.94
4	4.71	5.01	5.36	5.77
5	6.12	6.64	7.27	8.08
6	7.66	8.50	9.61	11.2
7	9.35	10.7	12.6	16.2
8	11.2	13.3	16.9	28.4

Capital investment/annual savings
= $22,500/$5,500
= 4.09

Referring to table IV, at an investment/savings ratio of 4, and an interest rate of 10 percent:

Time to recoup investment = 5.36 years

This is less than the extended life of the systems, and so the investment would be profitable.

These examples of cost analysis do not, of course, take into consideration some important considerations such as the value of the money spent if it were to be spent in some other way, or the impact of the state, local and Federal taxes.

It is recommended that, if an investment of any significant size is being considered, you conduct more detailed analysis of the life-cycle costs. An excellent publication which addresses this subject in considerable detail is reference 18.

"Energy Conservation in Buildings:
Techniques For Economical Design,"
($20.00), 1974
Construction Specifications Institute, Inc.
1150 17th Street, N.W.
Washington, D.C. 20036

Assistance

Probably one of the biggest mistakes the management can make is not to seek outside help and assistance for finding solutions to problems related to energy usage. Recognizing that energy availability and rising energy prices are national problems you can be assured that your problems are not unique. Many industrial and commercial firms are finding solutions to these problems. Most solutions to energy usage problems are not mysterious nor proprietary. No one person knows and understands them all. Some "solutions," if incorrectly applied, tend to increase energy usage rather than reduce it. Therefore, outside advice may at times be desirable and necessary.

This section lists sources of help and assistance. Indications are generally made as to the level and type of help they can provide, and suggestions are given for obtaining best results.

Private Consultants

The help of local, private engineering consultants can be valuable in many ways. First, a good energy consultant understands the problems from a technical viewpoint, but he is also sensitive to the economics involved. Probably he has already been concerned with energy management problems and his experience will be available to you. He can help you organize an energy audit procedure, suggest proper metering techniques, and help derive maximum benefit from the results. He is an "outsider" and therefore he will quickly observe practices that result in inefficient use of energy.[3] He can recommend new and efficient equipment, or suggest how to improve the operation of existing equipment. He can help to make proper cost analyses. Also, he will be familiar with local codes, and EPA and OSHA regulations. His fees may seem high, but the results of one or two days of his work may reduce your energy costs many times over.

Most private consultants who are registered professional engineers are listed in the local telephone directory. They specialize in certain areas such as mechanical work, electrical work, structural work, etc. In large cities, offices of state and national chapters of professional engineers are maintained. These offices may be listed in the classified section of the telephone directory under "Engineers". If contacted, such offices can be helpful in supplying names of qualified local consultants. Also, many local mechanical, electrical, and building contracting firms retain registered professional engineers who are available for consulting services.

[3] It has been proven time and time again that in-house people tend to overlook inefficient practices, but technically trained outsiders observe these practices immediately.

Utility Companies and Oil Suppliers

Most utility companies are now offering technical advice on ways to best utilize their products. Electrical power companies can advise you on proper sizing, installation, operation and maintenance of electrical equipment from appliances to air-conditioning, heating units, and motors. They can make suggestions on proper metering techniques and auditing electrical energy. They can also advise you on how to best use electricity, like reducing peak load demand, to minimize electrical bills.

Future supplies and allocations of natural gas are uncertain. The gas companies can advise you on the availability for your company and the alternatives should the supply run short. Gas companies can sometimes loan extra meters for the submetering of gas. They may also offer maintenance services for gas burning equipment.

Oil supply companies can keep you informed about future supplies. If your company has been a good customer of a supplier, chances are that you can make arrangement with him for minimum supplies during peak demand periods, unless allocation practices return. Oil supply companies may also offer maintenance services for oil burners, and they can often perform simple efficiency tests on furnaces.

Trade Associations

Trade associations whose members are concerned with manufacturing products or providing services can be of assistance in energy related problems. Many associations have already formed energy committees or councils to study the particular problems that their members are having. They have collected data on energy needs, estimated effects of the crisis, developed energy management procedures and published back-up literature for their members. Some associations have held local or regional meetings with members to discuss and exchange energy management ideas, and to discuss short and long range plans for better energy use, utilization of waste products and alternate fuels.

One of the most useful services your association can provide is to conduct a detailed survey of energy usage to make up an energy profile of your industry. Results of the survey can be used to show where you stand on energy usage relative to size, structure, location, production, etc. It forms the basis for planning a course of action for better energy management in the future. If your industry does not have an energy profile, urge your trade association to help provide one.

If your company is not a member of a trade association, and if you would like general information regarding associations related to your business, write to:

American Society of Association Executives
1101 16th Street, N.W.
Washington, D.C. 20036

Government Organizations

Government, both at the State and Federal levels, can provide information and guidance on energy related problems. Most local governments can provide names and offices to contact in their respective organizations.

On the Federal level, the Department of Commerce, the Federal Energy Administration, the Small Business Administration and the Energy Research and Development Administration can offer a great deal of assistance to light industry and commerce. There are nummerous publications available, many of which are free.

For information about Department of Commerce programs and assistance, write:

Office of Energy Programs
Department of Commerce
Washington, D.C. 20230

For information about Federal Energy Administration programs and assistance, write:

Industrial Programs, Conservation & Environment
Federal Energy Administration
Washington, D.C. 20461

Both the Department of Commerce and the Federal Energy Administration maintain a network of field offices which are sources of assistance and information. A list of the location of these offices is shown in appendix II.

The Small Business Administration maintains a large number of offices throughout the country. To obtain assistance from SBA, consult your telephone directory for the local office nearest you.

Interaction With OSHA and EPA Requirements

Almost all industry and commerce today must be aware of the safety and environmental requirements and standards issued by the Department of Labor, Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). Attempts to meet these requirements in your business may in some cases conflict with energy management concepts. In other cases they are compatible.

Energy management actions that involve reductions in ventilation may or may not be counter to health and safety regulations. Minimum requirements for ventilation air flow rates to remove odors, contaminants, smoke, dust and abrasive particles, flammable or combustible materials, etc. must be strictly observed. However, it has been found that actual ventilation rates often far execeed minimum requirements. Sometimes, ventilation is provided continuously whether the process requiring ventilation is operating or not. Excess energy usage in these cases can be eliminated without danger to safety or health.

When large quantities of warm contaminated air must be exhausted from a building during the heating season, it can, by the use of a heat exchanger, pre-heat fresh outside air taken into the building. During the cooling season, warm outside air brought into the building can be partially cooled down with colder exhaust air.

Heating and lighting in industry have not been regulated by OSHA, but OSHA has implied that employee efficiency and comfort must be satisfied. It is well known that many buildings are kept too warm for the majority of people, and thus energy is wasted. Lighting is often inefficient, and can be replaced by improved lamps and fixtures which use less energy and still provide satisfactory illumination.

Meeting air emission standards and anti-pollution requirements established by EPA can involve large capital investments. In many cases, economic justification can be made by combining the requirement with an energy management concept that reduces energy usage. Combustible fumes that cannot be released to the environment can be burned and the released heat recovered and used for producing low pressure steam or hot water, which can be used for heating, cleaning, etc. Many industries have found that wet or dry scrubbers necessary to meet exhaust gas emission standards allow them to burn natural gas, coal, oil, and waste products such as paper and sawdust.

The energy coordinator should be familiar with and have copies of the OSHA and EPA regulations for his business. In questionable or involved situations professional assistance from a consultant may be necessary (Note references 7 and 8 in appendix III).

Appendix I

Cost Saving Opportunities (CSO's)

The main body of this guide contains checklists of suggested items to look for to reduce energy usage in your business. No specific values of reductions were given, since there are many factors varying from business to business which will affect reduction figures. However, the list of success stories of effective energy management programs in industry and commerce is growing longer, and in these stories are case histories of how energy usage was reduced and to what extent.

This appendix contains a few of the case histories showing specific ways in which reduction in energy usage and cost savings have been accomplished. They are called cost saving opportunities (CSO's)[4]. Each CSO contains a brief description of the situation, how the saving was accomplished, how much was saved, and general suggested actions that other businesses may take.

Often, similar case histories are reported by several different sources. Where appropriate, the source of the case history for the CSO is identified.

While all CSO's will not have direct application to every business, the reader should try to parallel as closely as possible the main idea behind the CSO with specific operations of his company.

CSO #1 *Savings by Use of Water Flow Control Valves*

The usage of hot and cold water is frequently more than is required. If usage can be reduced, particularly in the case of hot water, savings can be made on fuel, water, and sewage bills. Water flow control valves for showers and wash basins are available, which limit the water flow but still provide satisfactory service. They may be purchased from most plumbing supply houses.

Example:

A motor hotel in Virginia with 100 rooms installed flow control valves just before the shower head in each bathroom. The valves reduced the water flow from five gallons per minute to 2.5 gallons per minute. The cost of the valves, and installation by the maintenance crew was $700. Assuming 1.5 daily showers lasting 5 minutes each and an average occupancy rate of 70 percent, the total saving in water usage was calculated as 480,000 gallons per year.

Water Saving

Since the water rate and the sewage rate totals $1.00 per 1000 gallons, the saving due to reduced water used is $480.00 per year.

[4] Reference 1 contains additional case histories called energy conservation opportunities (ECO's). Many of these ECO's are applicable to light industry and commerce.

Fuel Savings

In addition to saving water, the cost of fuel needed to heat about two-thirds of this water, or 320,000 gallons, was also saved. The amount of energy needed to heat this water from 65 to 140 °F may be estimated as follows:

By definition, it takes 1 Btu to raise the temperature of one pound of water by 1 °F. Thus, to heat a pound of water from 65 to 140 °F, the energy required is 140–65, or 75 Btu's. Since water weighs 8.34 pounds per gallon, the total weight of water involved is 320,000 gal × 8.34 lb/gal, or 2,668,800 lb. The total energy required is therefore 2,668,800 lb × 75 Btu/lb, or 200.16 million Btu (MBtu).

The water would have been heated with oil at $0.35 per gallon. Reference to table II page 8, shows that oil at this price is equivalent to about $2.50 per MBtu at 100 percent efficiency. Assuming an actual efficiency of 70 percent the cost becomes $2.50 divided by 0.70, or $3.57 per MBtu.

The annual saving is 200 MBtu × $3.57/MBtu or $715 per year.

Total Savings:

Saving in water use	$ 480	
Saving in fuel use	715	
Total saving	$1,195	per year.

Suggested Action

Consider the possibility of installing water flow control valves on all showers and wash basins. This can be done in any motel, hotel, school, factory, business office, apartment house, or home. Several makes of flow control valves are available. Contact your local plumbing fixture supply house.

Source

Operations Bulletin (Oct. 1973)
American Hotel and Motel Association
888 Seventh Avenue
New York, N.Y. 10019

CSO #2 *Savings by Repairing or Replacing Leaky Steam Traps*

The purpose of a steam trap is to hold steam in a heat exchanger (such as a radiator, water heater, plastic molding machine, etc.) until the steam gives up its heat, and then to let the condensate (hot water) drain out and return to the boiler. It does this by means of an automatic valve which opens when a certain amount of condensate has collected behind it, and closes again when live steam starts to escape. If such a trap fails in the "valve open" position, considerable energy and money can be wasted.

The amount of energy lost depends both on steam pressures and on the size of the orifice in the valve. The following table can be used to determine the loss in terms of MBtu per 1000 hours of leakage.

Loss due to steam leaks—MBtu per thousand hours

Steam pressure	Orifice Size		
	⅛"	¼"	⅜"
20 psi	12.3	47.9	79.9
50 psi	30.8	120	200
100	61.6	240	400

This means that if a trap with a ¼" orifice on a 100 psi steam line is stuck in the open position for 12 hours a day, six days per week, the yearly loss in energy will be 3600 hours × 240 MBtu/1000 hours, or 864 MBtu per year. The cost of this energy depends, of course, on the fuel used and the efficiency with which it's used. Referring again to table II, page 8, if the boiler is fired with natural gas at $1.75 per thousand cubic feet, and the boiler efficiency is 65 percent, the cost is $1.75 divided by 0.65, or $2.69 per MBtu.

The cost of repairing or replacing such a trap will fall in the range of $50 to $200. The annual saving possible is 864 MBtu × $2.69/MBtu, or $2320 per year.

Suggested Action

It is recommended that steam traps be checked on a monthly basis. The ideal method of checking is to visually observe the discharge, perhaps by means of a special test valve. If the trap is working properly there will be a stream of hot water or of mixed water and steam lasting for a few seconds, followed by a period of no discharge for several seconds, and the cycle will repeat. If the trap is stuck in the open position, there will be a constant discharge of steam. A failure in the closed position will be indicated by no discharge, and by the fact that the equipment is not being heated.

If it is not practical to observe the discharge, one can with practice hear the pulsating discharge of a properly working trap, using a mechanics stethoscope, or in an emergency a long screw driver with the bit pressed to the trap and one's ear to the handle. An open trap will produce a continuous hiss, perhaps high enough in pitch to be almost inaudible, and will be very hot. A trap frozen shut is, of course, silent and cold.

It is possible to check traps by checking the pipe temperatures on the inlet and outlet sides. With a leaking trap both sides will be hot, and at the same temperature. A properly working trap will measure somewhat cooler on the discharge side. Good measuring equipment and great care are necessary in using this technique.

If in doubt, a representative of the trap manufacture should be contacted to recommend the best method of checking his particular traps.

Note: For additional information see ECO 3.4.5 and ECO 3.4.6. (Energy Conservation Opportunities) in reference 1., *Energy Conservation Program Guide for Industry and Commerce.*

CSO #3 *Savings by Reduction of Building Ventilation Rates*

The conditioning of outside ventilation air (heating in winter and cooling in summer) for office buildings stores, factories, etc. can account for a large percentage of the energy usage in a building. The energy required depends on the indoor-outdoor temperatures, the ventilation rates, and length of time of ventilation.

In many cases full ventilation air is provided 24 hours per day even when the building is only lightly occupied. Often, the rates of ventilation are much too high. Many case histories from all over the country show that considerable reduction in fuel usage and dollar savings can be achieved by a reduction of ventilation air rates, while still maintaining conditions of comfort.

Example

An office building in Minneapolis, Minnesota has an occupancy of 667 people and was supplied with 30 cubic feet per minute per person (30 CFM/person) of outside ventilation air 40 hours/week during the heating season. A consultant determined that the ventilation air rates could be reduced to 8 CFM/person.

Ventilation Rate Reduction =
(30 − 8) CFM/person × 667 persons
= 14,700 CFM

This reduction in the flow of cold outside air results in an energy saving; the air doesn't have to be heated from a low temperature up to 68 °F. The energy required is a function of the length and severity of the heating season in your location. Numerically, this function is "degree days," a number which can be obtained for an average winter in your locality from your heating contractor, the local weather bureau, or your supplier of gas or oil. It varies from almost 10,000 along the north border of Minnesota to less than 500 in Miami. In Minneapolis, there are about 8000 degree days per year.

The reduction in energy is also a function of the length of time that the ventilating fans are operated during the heating season. It is obvious that if cold air is blown in only 8 hours per day, less heating energy will be needed than for 24 hours operation.

Heating energy for ventilation air

Degree Days	MBtu per season per 1000 CFM of ventilation			
	40 hr/wk	72 h/wk	112 h/wk	168 h/wk (continuous)
2000	13.1	23.6	36.7	55.0
4000	26.2	47.1	73.3	110
6000	39.3	70.7	110	165
8000	52.4	94.3	147	220

From the above table, note that in Minneapolis at 8000 degree days per year, each 1000 CFM of ventilation provided 40 hours per week requires 52.4 MBtu of heating energy for the season. In the present example, the ventilation rate was reduced by 14,700 CFM. The yearly energy savings, therefore, was 52.4 MBtu/1000 CFM × 14,700 CFM, or 770 MBtu per year.

The cost savings can be estimated from table II, page 8. If the heating was done with oil at $0.35 per gallon, and a furnace efficiency of 70 percent, the saving was $2.50 divided by 0.70, or $3.57 per MBtu. The annual savings was $3.57/MBtu times 770 MBtu, or $2750 per year.

Suggested Action

If knowledgeable people are available in your company, have them determine present ventilation air rates, either from the ventilating fan ratings, or by measuring with an anemometer. These should be checked against minimum required rates as established by the codes for your business.

CSO #4 *Savings by Reducing Lighting in Buildings During the Cooling Season*

During the cooling season, a large portion of the cooling load comes from internal heat gains, i.e., heat given off by occupants, running motors, ovens, lights, computers, or any other equipment. If it is possible to eliminate these "heat sources" energy usage will be reduced in two ways. First, the energy usage required to operate the source is eliminated, and second the energy usage required to operate the cooling system is reduced. For office buildings, chain and department stores, and institutions, lighting reduction is very effective.

Consider a building lighted with a total of 2000 fluorescent lamps rated at 40 watts each. Assume, as often has been found to be the case, that about one third of these lamps can be turned off during the summer for eight hours per day, and that satisfactory lighting levels will be maintained. (NOTE: Because of the design of fluorescent fixtures it is usually not possible to simply remove every third lamp. The local light fixture supplier can advise as to how it should be done.)

The present power demand for lighting is 2000 lamps × 40 watts per lamp, or 80,000 watts, plus an additional 20 percent for the ballast transformers, making 96,000 watts or 96 kilowatts. Turning off one third of the lamps and their associated ballasts will therefore save 32 kW.

With a cooling season of 100 days, the energy saved per season will be 32 kW × 8 h/day × 100 days, or 25,600 kWh.

The saving in heat load on the air-conditioner is 25,600 kWh × 3412 Btu/kWh, or 87 MBtu per season.

To estimate the energy that the air-conditioner would have used to pump this heat out of the building, one must know something about the efficiency of the cooling system. This is expressed as Energy Efficiency Ratio (EER), and is numerically the number of Btu's transferred per watt hour of electricity supplied. On many newer window-type units, the back label will show an EER rating ranging from less than five for a small poorly designed unit to more than ten for a larger more efficient cooler.

If your air-conditioners are not labeled with an EER rating, they may well list a cooling capacity (in Btu per hour), and an electrical demand (in watts); in such case the EER can be readily calculated. For example, a unit rated at a cooling capacity of 8000 Btu/hour and an electrical demand of 1000 watts, has an EER of 8000 divided by 1000, or 8.0 Btu/watt hour. In some cases on large central units, the designer may have calculated a Coefficient of Performance (COP) for the cooling unit. EER = COP × 3.4. If no data are available, assume an average EER of 7.5 (COP = 2.20).

In the present example, there is a total of 87 MBtu that does not have to be pumped out of the building because of reduced lighting. Assuming an EER of 7.5, the electrical energy saving is 87 MBtu divided by 7.5 Btu/watt hour, or 11,600,000 watt hours (11,600 kWh).

The total electrical energy saved is 25,600 kWh for lighting plus 11,600 kWh for air-conditioning, or 37,200 kWh per year.

The annual cost saving, at 4.5¢ per kWh, is 37,200 kWh × $0.045/kWh, or $1,670.

Suggested Action

Reduce lighting and other heat sources as much as is practical, particularly during the air-conditioning season. Savings due to reduced lighting during the heating season will not be as great, but some savings will still be obtained.

Source

"Guidelines for Energy Saving in Existing Buildings"
Part I (GPO–041–018–000–79–8) ($5.05)
Part II (GPO–041–018–000–80–1) ($5.25)
Available from:

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

CSO #5 *Savings Due to Recovery of Waste Heat*

Whenever a hot stream of material leaves the premises, energy is being wasted and the possibility exists that energy and money can be conserved. The technique for saving, and the amount to be saved, depends on whether the stream is hot water, hot air, hot flue gas, hot bricks, or hot steel. It will usually require the services of a consultant to determine the best method of saving and to estimate the dollar amount of the savings that can be achieved. Hundreds of examples have been documented on saving waste heat from such diverse sources as hot air from paint booth exhausts, hot water from cooling welding machines, hot flue gas from a heat treating furnace, and waste heat from air compressors, refrigerators and air conditioners.

This example concerns saving waste energy from a 25-ton air-conditioner in a restaurant, $1100 per year in savings for an $800 investment.

Example—A restaurant open 12 hours per day served an average of 1000 meals per day during the summer season. Air-conditioning was required for about 84 days of the four month busy season and was furnished by a 25-ton cooling unit. The unit was equipped with a water cooled condenser, and heat was wasted in the hot water being dumped to the sewer. The restaurant also required 3500 gallons of hot water per day. This was heated electrically from 75 to 150 °F, requiring (150–75) Btu/lb × 8.34 lb/gal × 3500 gal/day × 84 days, or 184 MBtu for the air-conditioning season.

A consultant suggested recovering some of the waste heat from the air-conditioner and using it to heat water for the kitchen. He estimated that a heat exchanger installed between the compressor and the condenser could readily heat water to 150 °F, and that the heat recovery rate would be 150,000 Btu/h. He also determined that the compressor operated 50 percent of the time, or 6 hours per days, and that the total energy saved would be 150,000 Btu/h × 6 h/day × 84 days, or 75.6 MBtu. With an electrical rate of 5¢ per kWh, refer to table II, page 8, and note that this corresponds to an energy cost of almost $15 per MBtu.

The annual saving was 75.6 MBtu × $15.00/MBtu, or $1100. The cost of installing the heat exchanger with the necessary piping was less than $800.

Suggested Action

Knowing the size of the air-conditioning system in your business, consider the possibility of recovering heat from the condenser. As a rule of thumb, each ton of refrigeration represents 4,000 to 8,000 Btu of recoverable energy per hour of operation. Consultation with a technical person in this field will be worthwhile.

Application of the idea is especially attractive for large office buildings that require air-conditioning year around. Stores that need refrigeration continuously for food preservation can also apply this concept of heat recovery.

Source

"Building System Design"
January 1975 issue, page 13.

CSO #6 *Savings by Thermostat "Setback" During Unoccupied Hours*

The temperature of many plants and offices can be reduced by 10, 15, or even 20 °F during nights and weekends. The savings in energy and money can be substantial.

The amount of savings depends on (1) the average seasonal heating bill without any night setback, (2) the percent of the time that it is proposed to setback the thermostat, (3) the number of degrees that the temperature will be reduced during the unoccupied periods, and (4) the length and severity of the heating season expressed in degree days. (The number of degree days for a given locality can be obtained from the weather bureau or from a local gas or fuel oil supplier.)

The following table shows the savings to be expected at different amounts of nightly temperature setback for different climates. The table assumes that the thermostat will be at the lowered temperature 50 percent of the time. The numbers listed are percent reduction of the "normal" fuel usage at 68 °F continuously.

Percent saved by setting back thermostat 50 percent of the time

Degree days	Amount of setback			
	5 °F	10 °F	15 °F	20 °F
8000	9	18	26	32
6000	11	21	30	36
4000	13	24	34	40
2000	17	31	40	47

Example

A small office building is located in Cleveland with an average heating season of 6000 degree days. The building was normally kept warm 24 hours per day, seven days per week. The gas usage for space heating was 8100 kcf per season, at a cost of $1.50 per kcf.

It is planned in the next heating season to set the thermostat back 15 °F for 12 hours per day Monday through Friday, 16 hours on Saturday, and 24 hours on Sunday for a total of 100 hours per week. This is equal to 100 divided by 168 hours per week, or 59.5 percent of the time.

From the table above, the saving at 50 percent of the time is 30 percent of the fuel used; for 59.5 percent it is 30 percent $\times \frac{59.5}{50}$, or 35.7 percent of the fuel.

The estimated annual saving is 8100 kcf × $1.50/kcf × 0.357, or $4,300.

Suggested Action

Whenever possible lower building thermostats to a minimum and still maintain comfort during occupied hours. During unoccupied hours, thermostats should be lowered to whatever extent possible within the relevant building codes for plumbing, fire protection, etc. Also, radiators in vestibules, lobbies, hallways, storage areas, and unoccupied areas might be turned off permanently if possible.

Source

"Guidelines for Energy Saving in Existing Buildings"
Part I (GPO–041–018–000–79–8) ($5.05)
Part II (GPO–041–018–000–80–1) ($5.25)
Available from:

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

CSO #7 *Energy Conservation in Furnaces and Boilers*

In some businesses, a steam boiler or a high-temperature furnace may be the major user of energy and is thus definitely a prime candidate for energy saving possibilities. Many books have been written on furnace and boiler efficiency, and it is impossible to condense all the information they contain into a small space. It can be stated however, and all the authors agree, that the single greatest source of inefficiency is the energy that is lost up the stack or the chimney.

If a cubic foot of gas is burned with precisely the required amount of air, about 11 cubic feet of flue gas will go up the stack. Since this gas is hot, it represents lost energy. If the amount of air used is twice the required amount (100 percent excess air), there will be 21 cubic feet of flue gas, and the energy lost will be almost twice as great.

It is possible to calculate the stack loss, whether the fuel be gas, oil, or coal, knowing only two bits of information:

(1) The temperature of the flue gas, and
(2) The amount of excess air.

The first requires a thermometer; the second a rather simple flue gas analysis taking about an hour or less. The following table lists the stack loss as a percentage of the energy in the fuel burned for different values of stack temperature and of percent excess air.

Stack loss as percent of fuel burned

Percent Excess air	Stack temperature				
	300 °F	500 °F	700 °F	900 °F	1100 °F
0	4.0	8.0	12	16	20
20	4.7	9.4	14	19	24
40	5.4	11	16	22	27
60	6.1	12	19	24	31
80	6.8	14	21	27	34
100	7.5	15	23	30	38

A medium sized steam boiler should operate, when burning oil, at 10 to 20 percent excess air and a stack temperature as low as practical, usually about 300 to 400 °F. Under these conditions, about 7 percent of the energy in the fuel will be lost up the stack.

Several surveys of small industrial boilers show that a large number of installations are operating at conditions which are far from the optimum. It is not unusual to find a boiler using 100 percent excess air, and indicating a stack temperature of 700 or 800 °F. Under these conditions, the stack loss will be about 25 percent of the fuel energy. Usually, such conditions can be returned to normal by appropriate testing and maintenance procedures. A high stack temperature, for example, is often caused by fouling of the interior surfaces, either by soot from misadjusted burners, or scale from improper feed water treatment, or both. The large quantity of excess air can be reduced by proper adjustment of the stack damper and the air inlets.

Note that too little air is also an inefficient condition since unburned or partially burned fuel will escape.

Example

Assume an oil fired boiler rated at 5,000 pounds of steam per hour, which operates 4,000 hours per year at an average load of about two thirds of its rating. If this boiler is reasonably modern, with suitable controls and well maintained, it will burn 120,000 gallons of oil per year. The stack loss, as noted in the paragraphs above, will be about 7 percent. If the boiler is not properly maintained and adjusted, the loss may increase to as much as 25 percent, and the boiler will use 145,000 gallons per year to maintain the same steam output.

The saving involved in keeping the boiler clean and well adjusted is 25,000 gallons of oil, which if priced at $0.40 per gallon amounts to $10,000 annually. The cost of such maintenance will probably be less than $1,000 per year.

Suggested Action

If a steam boiler or a process furnace is an important part of your energy budget, arrange for regular (at least quarterly) checks on stack temperature and flue gas analysis. Outside contractors will do the job, or a trained employee can perform the checks with a few hours training and $150 to $300 investment in test equipment.

NOTE: While stack loss is the largest single source of heat loss in boilers and furnaces, it is not the only source of inefficiency. See the section on Assistance for sources of help in running a complete heat balance on your boiler and determining whether other losses are wasting energy. Your boiler manufacturer can be of help in advising as to methods of saving energy.

CSO #8 *Savings by Insulating Steam and/or Water Pipes*

Large amounts of energy can be lost to the surrounding atmosphere by bare steam or hot water pipes. In all cases of bare pipes, the addition of insulation is a very attractive investment. The following table can be used to estimate the energy and cost savings which can be achieved by insulating bare pipes.

Energy saved by adding 1-½" fiber glass insulation to bare pipes

Btu/hour/foot of pipe			
Nominal pipe size	Steam pressure		
	15 psi	50 psi	200 psi
½"	108	136	192
1"	167	237	381
2"	291	398	662
3"	413	571	962

Example

Consider 100 feet of 2″ pipe carrying steam at 50 psi, with no insulation, and operating about half the time, or 4000 hours per year. The above table indicates that if this pipe is insulated with 1½″ of fiberglass insulation the energy saving will be 398 Btu/h ft × 100 ft × 4000 h, or 159 MBtu per year.

If the steam boiler is fired with fuel oil at 42¢ per gallon, and operates at 65 percent efficiency, one can determine from table II, page 8, that the energy cost is $3.00 divided by 0.65, or $4.62 per MBtu.

The total saving is 159 MBtu × $4.62/MBtu, or $735 per year.

The cost of insulating 100 feet of 2″ pipe will, of course, vary with location and the individual contractor; a typical cost would be $250 to $300.

Notes

(1) The above table assumes that the pipes are located inside a building at an ambient tempertaure of 75 °F. If the pipe is outside exposed to low temperatures and rain, the losses will be greater. The cost of insulation will also be slightly higher since outside insulation must carry a water-proof covering to keep it dry.

(2) The table assumes the use of 1½″ insulation, which is an average thickness for many purposes; it may not, however, be the most efficient thickness if the investment is to be amortized over a number of years. For the detailed calculation of most efficient insulation thickness contact a consultant or a reputable insulation contractor, or you can perform most of the necessary calculations wtih information available in the publications of:

Thermal Insulation Manufacturers Association
7 Kirby Plaza
Mt. Kisco, New York 10549

(3) Any cold pipe which drips from atmospheric condensation or which forms frost is absorbing heat from the air. Insulation will not only relieve the nuisance, but will conserve energy used to drive the refrigeration equipment.

Appendix II

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X	Jack B. Robertson, Reg. Admin 1992 Federal Building 915 Second Avenue Seattle, Washington 98174	(206) 442-7280

Appendix III

References

A short list of reference documents is given which address the subject of energy management (the term "Conservation" is frequently used) on more or less the same technical level as does this document. Some of these documents (particularly Nos. 1 and 2) list additional references, so that if the reader wishes to study in detail any aspect of energy management he will be able to find more helpful material.

1. Energy Conservation Program Guide for Industry and Commerce

   NBS Handbook 115, issued September 1974
   ($2.90)

   NBS Handbook 115 Supplement 1, issued December 1975
   ($2.25)

   Available from:

   Superintendent of Documents
   Government Printing Office
   Washington, D. C. 20402

2. Total Energy Management—A Practical Handbook on Energy Conservation and Management

   Available from:

   National Electrical Manufacturers Association
   155 East 44th Street
   New York, N.Y. 10017

3. How to Conserve Fuel Oil, Gasoline, Solvent, Electricity and Other Essential Needs: Special Reporter, Vol 2, March 1974
   ($1.00)

   Available from:

   International Fabricare Institute
   South Chicago at Doris Avenue
   Joliet, Illinois 60434

4. A Guide to Energy Management—How to Conduct an Energy Audit, 1974
   ($5.00)

   Available from:

   American Society of Association Exectuives
   1101 16th Street, N.W.
   Washington, D. C. 20036

5. (A) Energy Management: Trade Associations and the Economics of Energy
(30¢)

(B) How to Start an Energy Management Program
(25¢)

(C) Energy Conservation Handbook for Light Industries and Commercial Buildings
(35¢)

These three booklets are available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

6. Recommended Guidelines for Supermarket Energy Conservation CRMA.EC.I.
($1.00)

Available from:

Commercial Refrigerators Manufacturers Assn.
Executive Office
1730 Pennsylvania Avenue, N.W.
Washington, D. C. 20006

7. General Industry Safety and Health Regulations Part 1910 June 1974, OSHA #2206
($3.85)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

8. Construction Safety and Health Regulations Part 1926, June 1974, OSHA #2207
($1.55)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

9. Energy Management Case Histories
(GPO–041–018–00062–3)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

10. Energy Management Case Histories
(PB–246–763/AS—November 1975)

Available from:

National Technical Information Service
Springfield, Virginia 22161

11. Light and Thermal Operations Guidelines
($2.30)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

12. Lighting and Thermal Operations: Building Energy Report Case Studies

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

13. Study of the Impact of Reduced Store Operating Hours on Sales, Employment, Economic Concentration, and Energy Consumption
PB–243 579/AS

Available from:

National Technical Information Service
Springfield, Virginia 22161

14. Lighting and Thermal Operations: Energy Conservation Principles Applied to Office Lighting
PB 244–154/AS

Available from:

National Technical Information Service
Springfield, Virginia 22161

15. Guidelines for Saving Energy in Existing Buildings: Owners and Operators Manual—ECM 1
041–018–000–79–8 ($5.05)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

16. Guidelines for Saving Energy in Existing Buildings: Engineers, Architects, and Operators Manual—ECM 2
041–018–000–80–1 ($5.25)

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

17. Guide to Energy Conservation for Food Service October, 1975
041–018–00085–2

Available from:

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

18. Energy Conservation in Buildings: Techniques for Economical Design, 1974
($20.00)

Available from:

Construction Specifications Institute, Inc.
1150 17th Street, N.W.
Washington, D. C. 20036

Appendix IV

Conversion Table to SI Units

The policy of the National Bureau of Standards is to encourage and lead in national use of the metric system, formally called the International System of Units (SI). This publication uses customary English units, however, for the convenience of engineers and others who use them habitually. The reader interested in conversion to SI units is referred to:

(1) NBS SP 330, 1974 Edition, "The International System of Units"
(2) E380–74 ASTM Metric Practice Guide (American National Standard Z210.1).
The following table shows conversion factors for the units used in this handbook.

Quantity	To convert from	To	Multiply by
Length	inch	m (meter)	2.540×10^{-2}
	foot	m	3.048×10^{-1}
	mile	m	1.609×10^{3}
Area	sq in	m^2	6.452×10^{-4}
	sq ft	m^2	9.290×10^{-2}
Volume	cu in	m^3	1.639×10^{-5}
	cu ft	m^3	2.832×10^{-2}
	gallon	m^3	3.785×10^{-3}
Temperature	F	C	$t_c=(t_F-32)/1.8$
T. difference	Δt_F	K	$\Delta t_K=\Delta t_F/1.8$
Mass	pound	kg	4.536×10^{-1}
	ounce	kg	2.835×10^{-2}
Pressure	psi	Pa	6.895×10^{3}
	in of water	Pa	2.488×10^{2}
	in of Hg	Pa	3.386×10^{3}
	mm Hg	Pa	1.333×10^{2}
Energy	Btu	J	1.055×10^{3}
	MBtu	J	1.055×10^{9}
	kWh	J	3.600×10^{6}
	ft lb	J	1.356×10^{0}
Power	Btu/h	W	2.931×10^{-1}
	hp	W	7.460×10^{2}
Flow	gpm	m^3/s	6.309×10^{-5}
	cfm	m^3/s	4.719×10^{-4}
Density	lb/cu ft	kg/m^3	1.602×10^{1}
	lb/gal	kg/m^3	1.198×10^{2}
Heat Capacity	Btu/lb·F	J/kg·K	4.187×10^{3}
	Btu/cu ft·F	J/m^3K	6.707×10^{4}
Conductivity	Btu·in/h·sq ft·F	W/m·K	1.442×10^{-1}
Heat of Combustion	Btu/gal	J/m^3	2.787×10^{5}
	Btu/lb	J/kg	2.327×10^{3}
	Btu/cu ft	J/m^3	3.728×10^{4}
Barrel (Petroleum)	42 gal	m^3	1.590×10^{-1}

NBS-114A (REV. 7-73)

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4. TITLE AND SUBTITLE ENERGY MANAGEMENT GUIDE FOR LIGHT INDUSTRY AND COMMERCE			5. Publication Date December 1976
			6. Performing Organization Code
7. AUTHOR(S) Wm. J. Kelnhofer and L. A. Wood			8. Performing Organ. Report No.
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234			10. Project/Task/Work Unit No.
			11. Contract/Grant No.
12. Sponsoring Organization Name and Complete Address (*Street, City, State, ZIP*) Office of Energy Policies and Programs Department of Commerce			13. Type of Report & Period Covered Final
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15. SUPPLEMENTARY NOTES

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16. ABSTRACT (*A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.*)

The Energy Management Guide for Light Industry and Commerce is a training tool to assist small industrial and commercial organizations in an energy conservation program. It is part of a planned series, starting with NBS HB-115 (EPIC), of guides and training aids to assist industry in making the most efficient use of the energy supply.

While much of the information in the Light Industry Guide has been published in EPIC, the material has been edited and re-written in shortened form for use by the large number of small organizations with a limited supply of technical manpower. The energy conservation case studies (Cost Saving Opportunities) have been written with this target audience in mind.

17. KEY WORDS (*six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons*)

Energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

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Engineering Conservation Program Guide
for Industry and Commerce.
NBS Handbook 115, September 1974 ($2.90)
NBS Handbook 115, Supplement 1,
December 1975 ($2.25)

Energy Management Guide for Light
Industry and Commerce.
NBS Handbook 120, November 1976 (70 cents)

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