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ABSTRACT

This workbook provides a fill-in-the-blanks approach to an energy conservation program for schools which lack full-time engineering personnel. The generalized approach given here is not as detailed as an energy audit, but it allows school administrators, maintenance personnel, or building operators to analyze energy uses and to determine energy conservation steps and estimate savings in accordance with U.S. Department of Energy Class C Information Audit procedures. The four chapters present: (1) no cost maintenance and operation changes; (2) example problems for determining savings of energy conservation measures; (3) lists of energy conservation measures; and (4) how to prepare an energy conservation plan for your school. (MR)

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U.S. Department of Energy
Assistant Secretary for Conservation
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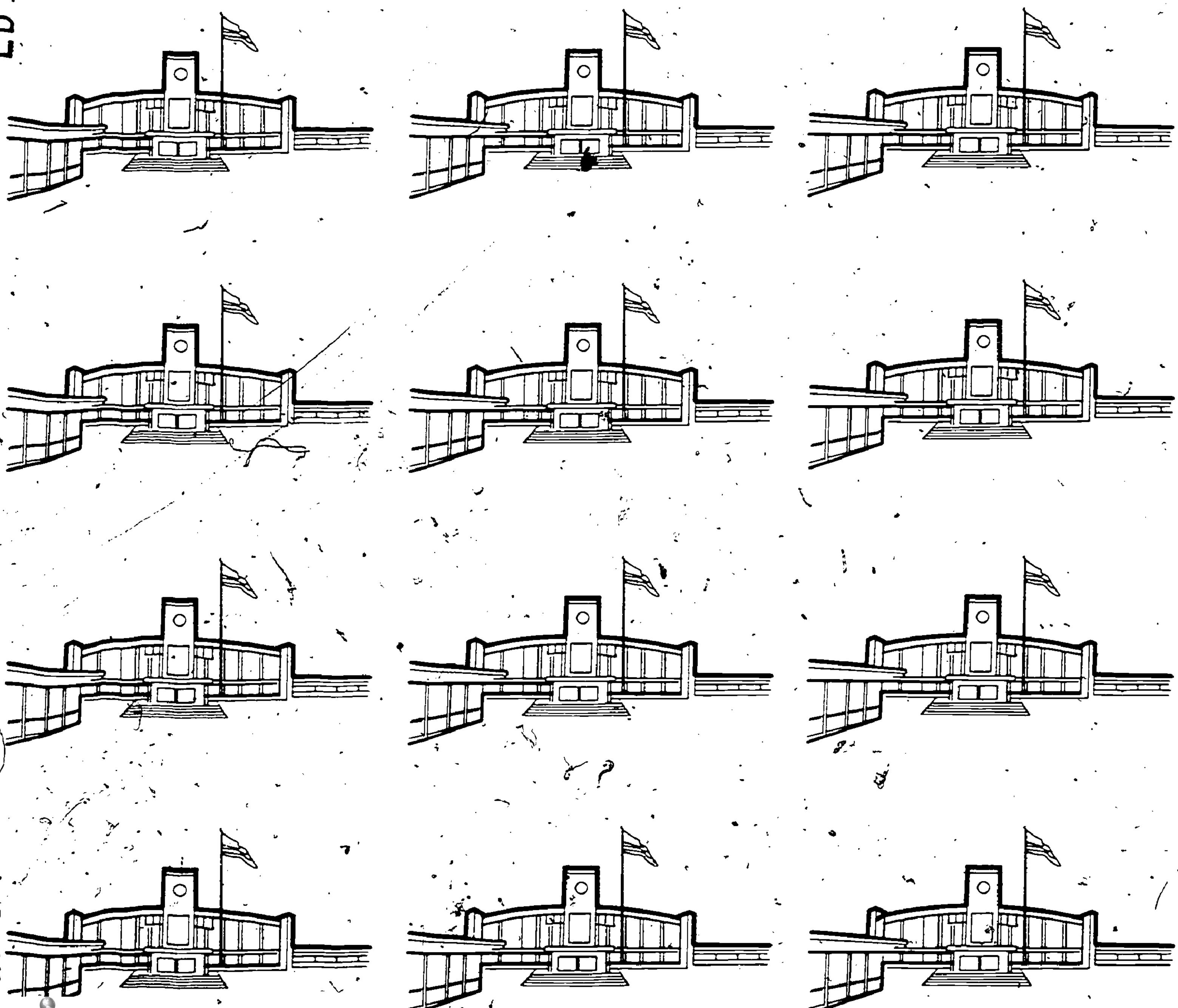

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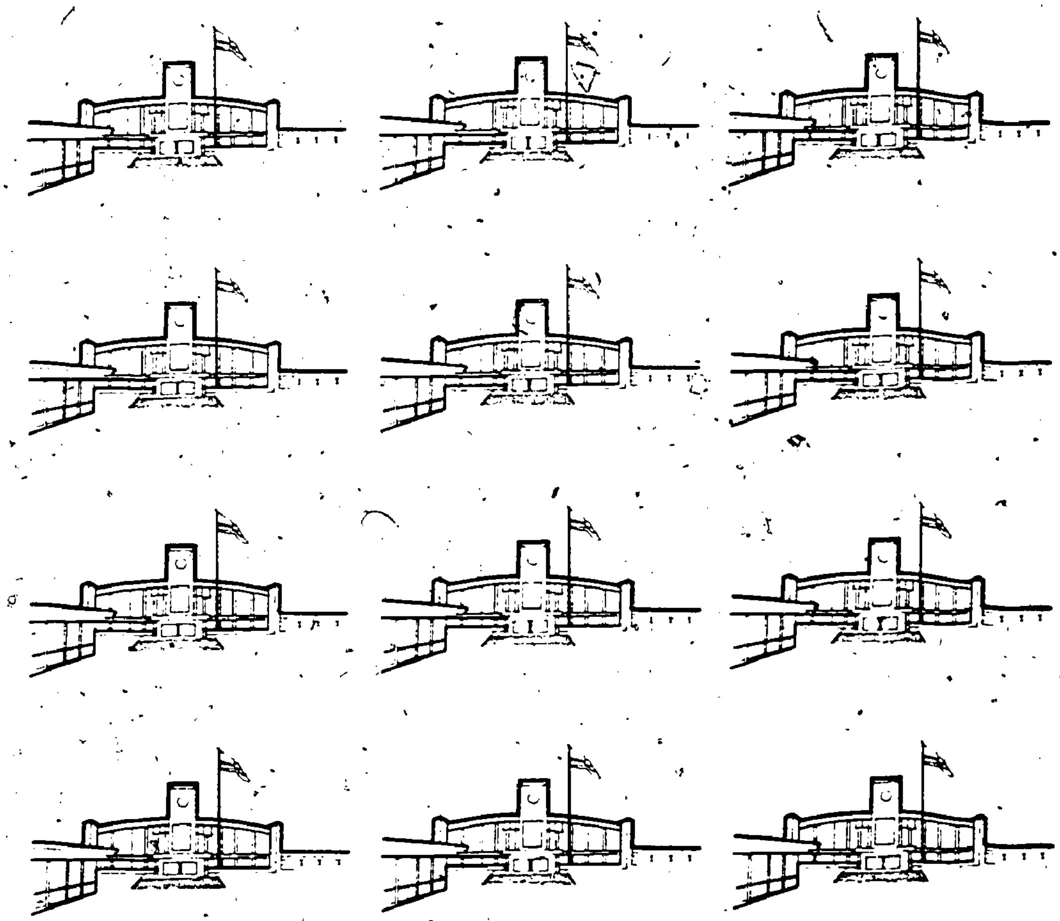


FOREWORD

This workbook has been prepared for use by State Energy Offices as a tool in assisting school administrators and maintenance managers in performing Class C information energy audits to identify energy conservation measures.

This workbook is one of a series of eleven (11) workbooks for different types of buildings; one each for apartments, bakeries, die-cast plants, educational institutions, hospitals, hotels and motels, offices, restaurants, retail stores, transportation terminals, and warehouses and storage facilities. In addition, a two-volume instruction manual has been prepared to assist energy auditors in performing Class A energy audits.

Fuel and Energy Consultants assisted in the preparation of the workbooks and the States of New Mexico, New York, Michigan, Minnesota, and Texas participated in a field test of the workbooks. Their participation and invaluable comments and suggestions are deeply appreciated.

PREFACE

While all administrators and maintenance managers of schools wish to do their part by conserving energy, they often overlook the positive impact that energy conservation can have on their operating budgets.

In a typical school, it is possible to save as much as 15% of utility costs through common sense actions without any appreciable capital expenditure. (A school is considered typical if the original facility was built 20 to 50 years ago, with wings and other additions added over intervals up to the present.) Even if a building was built after 1976, it is still possible to find many opportunities to conserve energy.

As the administrator or manager, you do not have to be an engineer to identify those areas where energy and real dollar savings can be realized. Just keep in mind that, up until about 1975 or 1976, energy conservation was not a major factor in the design of the facilities. Look for the obvious -- and that is the purpose of this workbook: finding the obvious savings through an energy audit.

The first obvious thing to look at is the lighting. Are the hallways, classrooms, lobbies, kitchens, cafeterias, mechanical rooms, and nonessential areas overlighted? Common sense will tell you which areas are and good guesswork can enable you to reduce the number of lamps in the excessively bright areas. Since fluorescent lamps use much less energy than incandescent lamps, it is feasible to replace incandescent lamps with fluorescent fixtures, where possible. If a mechanical room has only incandescent lamps, good economic sense tells you not to replace the lamps if the room is used only one or two hours a week. Just make sure that the lamps are turned off when the room is not occupied. For that matter, turning off lights when not needed is an obvious goal.

The workbook will show you some easy ways of determining how much energy can be saved by turning off lights. For example, if your maintenance people read the main electric meter daily at six in the morning and at nine or ten in the evening, you could easily see how much electrical energy you used during the day and night hours. To make the comparison, calculate the kWh per hour used from 6 a.m. to 10 p.m. and the kWh per hour used from 10 p.m. to 6 a.m. and compare the two periods. If you find that there is not a dramatic reduction in the night time consumption, you may discover that certain lights (and electrical equipment) are being left on when they're not needed.

Consider another obvious thing which will be brought out in the workbook -- "domestic hot water." The hot water used for showers and washing by the students and staff should not be over 105 to 110°F. Do you have to mix cold water with hot water at the taps and shower heads to adjust the hot water temperature? Or, (ask your maintenance personnel) is your domestic hot water cooled through an automatic hot-cold water mixing system prior to delivery to the points of use? If so, and your facility is typical, your hot water system is set for 160 to 180°F, perhaps less but considerably more than 110°F. By lowering the temperature control to 110 to 120°F, a significant energy and dollar savings can be realized.

If your heating, ventilating and air conditioning system (HVAC) is typical, did you know that you probably have your chiller (air conditioner) operating when the outside temperature is only 50 to 55°F? Why? Because that is the way that most HVAC control systems were designed before the 1974 Arab oil embargo. The systems are designed to mix fresh outside air with hot returned inside air in a mixing chamber and adjust the mixed air's temperature by cooling to the desired thermostat control setting. There is no law that says the chiller must operate when the outside air is 55°F. Change the controls so that the chiller will turn on at say, 63°F instead. More fresh air will be brought in and more inside hot air will be rejected to arrive at the proper mix. Your maintenance people or your HVAC contractor can do this for you. What do you save? The usual large school will have 300 to 500-ton chillers. When the chillers operate over the 50 degree to 63 degree outside temperature range, they may operate at 1/3 to 1/2 of their designed ratings. When the chiller is operating under these conditions, the hourly energy cost is about $3.50 - $7.50, depending on the rate schedule, plus demand charges plus fuel adjustment charges plus tax. The savings are obvious.

The purpose of the workbook is to bring "the obvious" to your attention. This can be readily accomplished by you through filling out the form and following the examples given in the workbook. You will be surprised at how many items you will find that will offer you savings.

Some of the sections of the book will not apply to you. For example, if your facility burns only gas, ignore sections of the form which are directed towards oil or coal. If your school does not have a boiler, skip that section -- and so on. Make every effort to thoroughly understand your utility billings. When in doubt, do not hesitate to call the utility sales representative and ask for a full explanation. They will be glad to cooperate.

TABLE OF CONTENTS

INTRODUCTION

This workbook describes some simple methods by which the administrator, maintenance manager, or operator of a school can analyze energy uses, determine areas in which energy savings can be made, and estimate the magnitude of cost savings in accordance with U.S. Department of Energy procedures described as Class C Information Audits.

The workbook provides a do-it-yourself, fill-in-the-blanks approach to an energy conservation program for schools which do not have full-time engineering personnel. Of necessity, it is a generalized approach which cannot be as detailed as an energy audit conducted by an engineering team.

Although this workbook emphasizes the energy-intensive processes and some of the recognized areas of energy waste in schools, it should be used selectively because each building has its unique energy-use patterns. If a particular suggestion does not apply to your school, read on; the next one probably will.

Start the energy audit of your school by assembling energy consumption data for the last 12 months. Your gas, oil and/or electric bills are a good place to start. If you haven't already summarized your building's energy consumption needs, you may wish to use the form in Chapter 2 for this purpose. Record both price and actual consumption. You can tell a lot about your building(s) by examining the monthly records. For example, if electric usage is lowest during some months, it may well be that usage is a basic minimum including lights and hot water. If oil consumption goes to zero during July and August, you can be sure that the oil is being used only for heating.

Next, make yourself aware of your school's geographic location and site conditions. Obtain from your library, utility, weather station, or State Energy Office the average monthly degree days and the past 12 months of degree days for both heating (winter) and cooling (summer). These climate conditions will be useful in many ways, including identifying the magnitudes of oil consumption for heating and electricity consumption for cooling that your school may need. You will need this information to fill out the Energy Management Form in Chapter 2 and, subsequently, to work out the problems in that section.

The next step in your energy audit is to have your school's description at hand -- the building size, floor plan, general condition, insulation, type and size of windows, wall materials, roofing material and roof size, doorways, garage, and any other aspect of your building that may lead to an understanding of its basic construction. Obviously, a set of building plans would answer this need very well.

Next, list the heating plant, air-conditioning equipment, electrical equipment and lighting fixtures that are controlled by you, the school's administrator or manager, rather than by students and staff. These systems are the biggest energy users in school, and you will want to understand them to help identify means of making them more efficient with the aid of this workbook.

This completes the information gathering required for your energy audit. The information will provide a base for implementing the Maintenance and Operational Changes and Energy Conservation Measures that will make your school as energy efficient as your time, budget, and enthusiasm will permit.

Chapter 1 will provide suggestions that will enable you, without cost, to increase your school's present energy efficiency by Maintenance and Operational Changes.

MAINTENANCE AND OPERATIONAL CHANGES

By diligently following a maintenance program, a school administrator, or maintenance manager can conserve a substantial quantity of energy by maintaining the building at its optimum designed conditions. Energy saved as a result of such a program is obviously dollars saved, since little or no capital investment is required.

To conduct a continuing energy conservation/m... ...ance program, a checklist of items to be done on a regular ba... ...hould be set down and followed faithfully. This section of the workbook is in the form of a checklist that will aid in identifying maintenance and operational changes that will result in energy conservation.

The general energy users in a school have been categorized into headings such as space heating, air conditioning, ventilation, etc. Under these broad categories the pertinent maintenance and operational changes have been listed.

Several of the items listed have been shown to be particularly appli-cable to most schools since they result in the quickest energy and dollar savings. For reference they are as follows (they will also appear in their respective functional headings in this chapter):

1. Lower the thermostats during the heating season and raise them during the cooling season. You can save about 8% of your heating fuel bill by lowering the thermostats a mere five degrees.

2. Set back the heating season thermostats 10° during the night.

3. Examine the entire building for air leaks around windows, doors and any place that they might occur. Seal up the leaks.

4. Remove unnecessary lights in hallways and classrooms.

5. Lower the domestic hot water to 110°F.

6. Make the monthly energy consumption and cost data available to the administrator and maintenance manager so that they can evaluate and compare against previous months and normal budget.

7. Involve the faculty and students in the goals of energy conser-vation.

8. Turn off the cooling system during the night. Use ventilation air to cool the building.

9. If there is a pool in the building, turn off the filter and heating system at night.

After reading through the check list pick up a pencil, put on your walking shoes, and start walking through the building. Examine the suggested maintenance and operational changes that pertain to your facility. Make notes as you go along. Accomplish the items that can be done immediately, then explore the possibility of doing the other steps which may require more information or advice. Start incorporating the applicable preventative maintenance items into a regular program immediately.

LIST OF MAINTENANCE AND OPERATIONAL CHANGES

A. GENERAL BUILDING

1. Reduce the use of heating and cooling systems in spaces which are used infrequently or only for short periods of time.

2. Turn off heating or cooling systems during the last half hour of occupancy.

3. Windows or outside doors left open during the heating or cooling seasons represent an energy loss if the heaters or air conditioners are running. Make sure they are shut.

4. Make the monthly energy consumption and cost data available to the school administrator or regional administrator so that they can evaluate and compare against previous months and normal budget.

5. Involve building staff with energy conservation measures so that each individual has responsibility.

6. Provide a temperature control training program for the maintenance crew that will give them a thorough understanding of how the heating and ventilating systems were designed to operate. Include optimization of energy via temperature control.

7. Conduct a survey of the total building on a space by space basis to determine the actual energy needs.

8. Change the spring, fall and winter day-night timeclock settings to operate heating, ventilation, and cooling equipment fewer hours on the day cycle.

9. Disconnect all refrigerated water fountains if acceptable to staff.

10. Be certain that all operable windows have sealing gaskets and cam latches that are in proper working order.

11. If you have a heated pool in the building, consider turning off the heater and circulating pumps at night, and back on an hour before classes begin.

12. Establish rules for all building staff regarding opening and closing of doors, directing them to keep doors closed whenever possible.

13. Inspect electrical contacts and working parts of relays and maintain in good working order.

14. Caulk around door frames.

15. Caulk around window frames (exterior and interior) if cracks are evident.

16. Control the building electric load demand so that no excessive peak will be experienced.

17. Close off unused areas and rooms. Where possible, be certain that blinds or other shading devices are drawn, registers closed, etc.

18. Seal ducts and access doors in equipment rooms to minimize bypassing of hot and cold air.

19. Schedule operating, maintenance and cleaning to overlap more with normal working hours or when daylight is available and sufficient for the task.

20. Provide adequate preventative maintenance on power distribution equipment so as to assure minimum power loss from loose connections and/or contacts.

B. SPACE HEATING - GENERAL

1. Lower the thermostats during the heating season and raise them during the cooling season. If your building is like most, you can save about 8% of your heating fuel bill by lowering the thermostat(s) a mere five degrees.

2. Set all thermostats at 68°F or less for winter space heating.

3. Surfaces of radiators, convectors, baseboards, and finned-tube heaters must be kept clean for efficient operation.

4. If you use hot water for heating, reduce the space heating hot water temperature to a level that will just satisfy heating needs.

5. Set back the heating season thermostats 10°F during the night. Up to 6% energy savings are achievable.

6. Inform teachers and building operators of savings by closing drapes and shades at night.

7. Determine if all installed radiation is really necessary.

8. Shut off (or remove) heating units from vestibules, lobbies, and corridors.

9. Do not heat parking garages.

10. Do not heat storage rooms unless it is necessary for protection of stored contents.

11. Inspect oil heaters to ensure that oil temperatures are being maintained according to manufacturer's or oil supplier's recommendations.

12. If you have infrared heaters, check to see if the reflectors are beamed in the right direction, and the surface is clean.

13. Check automatic temperature-control system and related control valves and accessory equipment to ensure that they are regulating the system properly.

14. If you have a coal-fired system, check stoker(s), grate(s) and controls for efficient operation.

C. SCHOOLS THAT USE BOILERS FOR SPACE HEATING

1. If you use steam only for space heating, shut off boilers in the spring and fall when the air conditioning system is on and temperature control is not needed.

2. If the boiler has a natural gas standing pilot, turn it off during the summer months when the boiler is off.

3. If two boilers are used, leave one off during most of the winter heating season and perhaps during the entire season if one boiler is capable of carrying the entire load under design conditions. A single boiler carrying the building space heating load will operate at a higher annual efficiency than two boilers dividing the load.

4. Keep a daily log of pressure, temperature, and other data obtained from instrumentation. This is the best method available to determine the need for tube and nozzle cleaning, pressure or linkage adjustments, and related measures. Variations from normal can be spotted quickly, enabling immediate action to avoid serious trouble. On an oil-fired unit, indications of problems include an oil pressure drop, which may indicate a plugged strainer, faulty regulator valve, or an air leak in the suction line. An oil temperature drop can indicate a temperature control malfunction, or a fouled heating element. On a gas-fired unit, a drop in gas pressure can indicate a drop in the gas supply pressure, or a malfunctioning regulator.

5. Observe the fire when the boiler shuts down. If the fire does not cut off immediately, it could indicate a faulty solenoid valve. Repair or replace as necessary.

6. Inspect exhaust stacks. They should not be giving off smoke. If they are smoky, it probably indicates that a burner adjustment is necessary.

7. Consider eliminating a hot standby boiler, since in many cases, a boiler failure will not cause serious hardships.

8. Inspect zone shut-off valves. All should be operable so that steam going into unoccupied spaces may be shut off.

9. Operate only the heating water pumps necessary for required heating.

10. Check and repair oil leaks at pump glands, valves, or relief valves.

11. Clean mineral or corrosion build-up on gas burners.

12. Inspect oil line strainers. Clean or replace if dirty.

13. Inspect nozzles of oil-fired units on a regular basis. Clean as necessary.

14. At the end of the heating season, or when a rise in the stack temperature occurs, inspect the fireside of the furnace and water tubes for deposits of soot, flyash and slag (molten ash). Also examine the fireside of all boiler insulation refractory, brickwork, and casing for hot spots and air leaks.

15. Measure with the gas meter the fuel consumption of the boiler on manual vs. automatic firing. During moderate temperature periods, the manual low fire setting should result in the boiler operating longer periods of time at higher efficiency.

16. Adjust the boiler so that during the spring and fall it will come on line at low fire and stay on low fire until the heating requirement is satisfied. The boiler will cycle less often and maintain a higher overall annual efficiency with this procedure.

17. Reduce the amount of fresh air admitted to the boiler room in winter. (Do not choke boilers, however.)

D. SCHOOLS THAT ARE ELECTRICALLY HEATED

1. Keep heat transfer surfaces of all electric heating units clean and unobstructed.

2. Keep air movement in and out of the electric units unobstructed.

3. Inspect electric heating elements, controls and, as applicable, fans, on a periodic basis to ensure proper functioning.

4. Lower the thermostats during the heating season and raise the thermostats during the cooling season. If your building is like most, you can save about 8% of your heating fuel bill by lowering the thermostat(s) a mere five degrees.

E. AIR CONDITIONING SYSTEM CONSERVATION

1. Raise room temperatures seasonally by steps to match the increases in outside temperatures.

2. Shade windows from direct sun from April through October.

3. If your central air conditioning system does not have a hot deck or reheat coil, set the thermostat to 78°F in the summer.

4. If the system has a typical arrangement of hot and cold decks, have an air conditioning technician adjust the system to maintain optimum operating conditions.

5. Operate one of multiple compressors and chillers at full load, rather than two or more at part load.

6. Do not cool building when it is unoccupied.

7. Operate only those water pumps needed to maintain flow volume where multiple pumps are installed in parallel. This would apply to chilled water pumps and condenser water pumps.

8. Shut off the secondary hot water pumps located in the air-handling units during the spring, fall, and summer when heating is not required.

9. Use venetian blinds or drapery as interior shading devices.

10. Reduce or eliminate air leakage from duct work and from around coils.

11. To maintain an efficient system, fans should be cleaned annually.

12. Operate only the chilled water pumps and cooling tower fans necessary.

13. Elevate chilled water temperatures when humidity conditions permit.

14. Check the energy efficiency ratio (EER) of new air-conditioning units. Most older units have an EER of 5 or 6 Btu/watt, while newer units are rated at 9 Btu/watt and higher. Example: An old one-ton unit with an EER of 5 uses 2.4 kW of electricity compared to a new one-ton unit which would use only 1.3 kW. This represents a 45% reduction in electricity required for the new unit.

15. Turn on self-contained units, such as window and through-the-wall units, only when needed. Turn them off when the space is to be unoccupied for several hours.

16. Set the demand limiter on the chiller at lowest setting that will maintain the building temperature.

17. Inspect equipment for any visual changes such as oil spots on connections or on the floor under equipment.

18. Consult with manufacturer to determine if cooling equipment can be shut down when outside temperatures are below certain levels.

19. Establish what the normal operating pressures and temperatures for the system should be. Check all instrumentation frequently to ensure that design conditions are being met. Increased system pressure may be due to dirty condensers, which will decrease system's efficiency. High discharge temperatures are often caused by defective or broken compressor valves.

20. Reduce hot deck temperatures, and increase cold deck temperatures as far as humidity requirements will allow. While this will lower energy consumption, it also will reduce the system's heating and cooling capabilities as compared to current capabilities.

21. Inspect the liquid line leaving the strainer. If it feels cooler than the liquid line entering the strainer, the strainer is clogged. If it is very clogged, sweat or frost may be visible at the strainer outlet. Clean as required.

22. Inspect tension and alignment of all belts and adjust as necessary.

23. Observe the noise made by the compressor. If it seems to be excessively noisy, it may be a sign of a loose drive coupling or excessive vibration. Tighten compressor and motor on the base. If noise persists, call a mechanic.

24. Where applicable, lubricate motor bearings and all moving parts according to the manufacturer's recommendations.

25. Keep condenser coil face clean to permit proper air flow.

26. Inspect air inlet screen, spray nozzle or water distribution holes, and pump screen. Clean as necessary.

27. Follow manufacturer's guidelines for fan and pump maintenance.

28. Clean condenser shell and tubes by swabbing with a suitable brush and flushing out with clean water. Chemical cleaning also is possible, although it is suggested that a water treatment company be consulted first.

29. Perform tests to determine if solid concentrations are being maintained at an acceptable level in cooling tower.

30. Keep the cooling tower clean to minimize both air and water pressure drop.

31. Inspect spray-filled towers or distributed towers for proper nozzle performance. Clean nozzles as necessary.

32. Inspect gravity distributed tower for even water depth in distribution basins.

33. Clean evaporator and condenser coils in window units.

34. Maintain all equipment to operate as close as possible to its originally designed conditions.

35. Check voltage. Full-power voltage is essential for proper operation.

F. VENTILATION

1. Post a small sign next to each operable window instructing students and staff not to open window while the building is being heated or cooled.

2. Operate the ventilation system only when the school is occupied. Also consider shutting off the air handling units on normal heating days before school is out. If the radiators are located properly, they should be able to maintain space temperature above freezing.

3. Do not operate the ventilation units at all during the spring and fall if many of the windows in the classrooms are open during this time of the year.

4. Operate the gym outside air ventilation unit on a reduced operating schedule that coincides with occupancy of the gym. The gym fan unit should not be turned on until the first class occupies the gym and should be turned off immediately after the class leaves in the afternoon.

5. Inspect all automatic door closers to ensure that they are functioning properly. Consider adjustment to enable faster closing.

6. Place a small sign next to each door leading to the exterior or unconditioned spaces advising students and staff to keep door closed at all times when not in use.

7. In the summer when the outdoor air temperature at night is lower than indoor temperature, use full outdoor air ventilation to remove excess heat and pre-cool the structure to reduce air-conditioning load.

8. Readjust fresh air limit controllers from winter to summer earlier than the middle of May.

9. Check size and speed of exhaust fans and limit to actual needs.

10. Consider turning off electric reheat coils during the summer. With increased supply air temperature, reheat may not be necessary.

11. Clean debris from unit ventilators to permit more efficient operation.

12. Clean the filters more often to increase the overall efficiency of the air handling units.

13. Inspect filters carefully. If necessary, create a filter replacement schedule. Utilize high-efficiency, low-cost filters.

14. Consider closing outside air dampers during the first and last hours of occupancy and during peak loads.

15. Turn off humidifiers whenever a building is closed for extended periods of time, except when process and equipment requirements take precedence.

16. In mild weather, lower the cooling effect by running room cooling fans at lower speeds.

17. Inspect damper blades and linkages. Clean, oil, and adjust them on a regular basis.

18. Reduce outdoor air to the minimum acceptable level required to balance the exhaust requirements and maintain a slight positive pressure to retard infiltration of outside air.

19. Adjust outside air, return air, and mixed air damper controls in winter to raise supply air temperature to a level between 64°F and 70°F, depending on the conditions in the area served by the system.

20. Establish a ventilation operation schedule so exhaust system operates only when it is needed.

21. Adjust all VAV (variable air volume) boxes so they operate precisely. This will prevent overheating or overcooking, both of which waste energy.

22. If practical, operate the ventilation units with no outside air whenever the outside temperature is 25°F or below. There may be sufficient fresh air leakage through the dampers to provide adequate ventilation.

23. Discontinue outside air preheating where practical.

G. LIGHTING

1. Acquire energy conservation reminders such as posters and individual decals that can be located next to the light switches and on bulletin boards to alert staff that turning off lights is their responsibility.

2. Shut off lights in unoccupied rooms. Switch on large area lights by sections when cleaning.

3. Move desks and other work surfaces to a position and orientation that will use installed lighting fixtures to their greatest advantage (instead of moving light fixtures).

4. To the extent permitted by productivity requirements and related concerns, group together tasks which require approximately the same levels of lighting. This may reduce the number of areas requiring higher illumination levels and provide an opportunity to reduce the total amount of lighting needed.

5. In overlighted areas, light levels can be reduced up to 50%. In rooms or areas fitted with 2-bulb fluorescent fixtures, remove one bulb from each fixture if they are not wired in series. Disconnect ballast if possible. Consider dual bulb removal from alternate fixtures if they are wired in series. This will save energy and produce a uniform lighting level.

6. Leave the hallway lighting off in those hallways facing the interior courtyards during daylight hours, assuming a light meter reading indicates the lighting level is satisfactory.

7. Eliminate exterior lighting except where lighting is to be used for the purpose of identifying the building entrances and/or for security.

8. Lamps should be wiped clean at regular intervals to assure maximum efficiency. Lamps which are exposed to an atmosphere with substantial amounts of dirt, dust, grease, or other contaminants should be cleaned more frequently than lamps in a relatively clean atmosphere.

9. Clean ceilings, walls, and floors frequently to improve reflective qualities. In rooms or areas where natural daylight is used to maintain light levels, wash the windows frequently.

10. Consider initiating a training program to orient the gym instructors and the students in the proper operation of gym lighting so that no more than 50% to 75% of the lights are on at any one time when the gym is occupied, provided switching is available.

11. Campaign for better lighting utilization by using letters, memos, signage, and personal contact to encourage staff -- especially custodial personnel -- to use lighting only when it is needed, to use only the amount of lighting required, and to turn off lights whenever they are not being used.

12. If you have a computer room, consider reducing computer area light levels, as the room may be too bright.

H. <u>DOMESTIC HOT WATER</u>

1. Remove or turn off domestic hot water to boiler rooms and other spaces that could function without hot water.

2. Operate only one of the domestic hot water heaters. If one unit carries the load, leave the other off for standby.

3. Reduce the hot water temperature to the minimum. Because of the long lengths of hot water piping, it may not be entirely feasible to lower the temperature to 110°F because of pipe heat losses. The way to proceed is to lower the hot water temperature incrementally, say 5°F each week. Continue doing so until the students start to complain. With the first complaint, raise the temperature 5°F to that of the previous week when no one complained. This will represent practical minimum temperature for the hot water system. Realize that when reducing the hot water temperature, the capacity of the tank is an important factor.

4. If you have an electric domestic water heater, consider limiting the duty cycle to avoid adding water heating load to the building during periods of peak electrical demand.

5. If hot water is distributed through forced circulation, turn off the pump supplying areas when they are unoccupied.

I. SCHOOLS WITH KITCHENS

1. Cook with lids in place on pots and kettles. It can cut heat requirements in half.

2. Turn off infrared food warmers when no food is being warmed.

3. Thaw frozen foods in refrigerated compartments.

4. Train employees to conserve hot water. Supervise their performance and provide additional instruction and supervision as necessary.

5. Preheat ovens only for baked goods. Discourage chefs from preheating any sooner than necessary.

6. Inspect refrigeration condensers routinely to ensure that they have sufficient air circulation and that dust is cleaned off coils.

7. Walk-in or reach-in refrigerated area doors without automatic closers or tight gaskets should be inspected and repaired.

8. Keep refrigeration coils free of frost build-up.

9. Clean and maintain refrigeration on water chillers and cold drink dispensers.

10. Reduce temperature or turn off frying tables and coffee urns during off-peak periods.

11. Run the dishwasher only when it is full.

12. Fans that cool worker should be directed so they do not cool cooking equipment.

13. Provide ovens, fryers, and washers with loads all of the time they are heated and on. An oven not baking 1 hour out of 7 is an oven wasting 14% of its energy.

14. If a food preparation area exhaust hood is oversized, adjust it so no more air than necessary is exhausted. This can be done easily by blocking off a portion of the hood, or reducing fan speed, or lowering hood, or by utilizing a combination of these techniques in compliance with applicable health regulations.

CHAPTER 2

STEP-BY-STEP EXAMPLES

Now that you have examined and implemented the pertinent no-cost maintenance and operational changes in Chapter 1, you need to work your way through the energy and dollar effects of various energy conservation measures which apply to your school. A priority system must be developed to decide which measures to invest in first. Calculating the simple payback period of the suggested measures is an excellent way of establishing such a priority system.

In order to be cost effective, an energy conservation measure should return its initial cost by the savings it creates. To calculate the simple payback period, the initial cost of the measure in dollars is divided by the annual savings using today's prices. By ranking the measures in order of shortest to longest payback period, one can develop a priority system.

The problems in this chapter are designed to illustrate the method for calculating the energy savings and payback period for several energy conservation measures.

It is unlikely that your particular circumstances are identical to any of these samples, but it is very likely that the pattern of problem solving will enable you to quantify your Measures in an adequate and satisfying manner.

Before working out the step-by-step examples, you will need to complete the Energy Management Form. The directions for filling out the form are described on the following pages. It may be convenient to have your accounting or billing department or the regional administrative office fill in the necessary data. But, if all the necessary utility bills are available to you, it shouldn't take more than a few hours to fill out the entire form.

After the form is completed you will have all the energy cost data needed to work out the step-by-step examples. In some problems, a new installation rate must be obtained by calling a contractor for a price quote. Or, you may have to make a few simple measurements pertaining to the general operation of the school.

In each problem, the section for you to fill out is on the left-hand side of the page and a worked out example problem of a typical school is on the right. In each case, the boxes coincide with an underlined number in the example problem.

ENERGY MANAGEMENT FORM

Enclosed in this Chapter is a fold-out Energy Management Form. The data from the form will be used in this section of the manual to calculate the payback period for several of the recommended energy conservation measures illustrated. If you already have a similar energy bookkeeping system, you may wish to modify it to be consistent with the enclosed form. The main objective is to arrive at a common unit cost of each type of energy used in dollars per million Btu ($/MMBtu). Use your bills of last year or the last 12 months to fill in the form now.

To make it easy to use you may wish to remove it. The form is intended to be an aid for establishing a continuing energy bookkeeping procedure for your facility. If it is filled out each month, the manager or administrator of the school can get a sense of monthly and yearly energy consumption and cost. It can also be used as a base to evaluate energy savings that result from energy conservation measures.

I. NECESSARY DATA FOR FILLING IN THE ENERGY MANAGEMENT FORM

A. ELECTRICITY: The monthly electric bills for one full year.

B. FUEL OIL:

1. To calculate the monthly consumption you will need the amount of fuel oil in the tank in the beginning and the end of the month and the quantity in gallons of each delivery made during that month;
2. The price per gallon of the oil in dollars per gallon;
3. The type of fuel oil you use - #2, #4, #5 or #6 oil.

C. NATURAL GAS:

1. The monthly bills for the same full year;
2. The heat content (the number of Btu per cubic foot) of the gas if available. If it is not available, use 1030 Btu per cubic foot.

D. STEAM: If you purchase steam, you will need the monthly bills for the same full year, the quantity used and the heat content of the steam for each pound or cubic foot purchased.

E. If you use any other type of fuel (coal, wood, etc.), you will need the monthly consumption, the cost per unit, and the heat content of the fuel per unit.

F. From your local utility, weather station, or library, or State Energy Office, obtain the monthly total heating degree days and cooling degree days for your area during the same year. The daily heating degree day figure equals the number of degrees the mean temperature has fallen below 65°F. The daily cooling degree day figure equals the number of degrees the mean temperature has risen above 65°F.

II. FILLING IN THE FORM

A. Enter the monthly heating degree days in column 2 and the monthly cooling degree days in column 3.

B. ELECTRICITY - CONSUMPTION AND COST:

1. For each monthly electric bill or for each month covered by the majority of the billing period:*

   a. enter in column 4 the total number of kWh used used during the month;

   b. enter in column 5 the total cost for the month that appears on the bill;

   c. to calculate column 6, the cost per kilowatt hour (kWh), divide column 5 by column 4;

   d. to calculate the cost per million Btu ($/MMBtu) multiply column 6 by 293 and enter this in column 7.

2. After completing each month, calculate the annual totals and averages.

   a. sum column 4 and enter at the bottom of the column;

   b. sum column 5 and enter at the bottom of the column;

   c. divide the sum of column 5 by the sum of column 4 and enter in annual average at the bottom of column 6;

   d. multiply the annual average of column 6 by 293 and enter at the bottom of column 7.

---

* NOTE: The billing period may vary from 25 to 40 days. If so, you will have to adjust it to be consistent with the other types of energy on the form. Calculate the kWh per day and multiply by the number of days in the month or period you are using for oil and gas.

C. OIL - CONSUMPTION AND COST:

1. Enter in column 8 the oil consumption in gallons for each month.

2. Enter the price per gallon in column 9 in dollars per gallon. For example, if it is 35¢ per gallon, enter .35.

3. Calculate the total per month and enter in column 10. Multiply column 9 by column 8.

4. To calculate the cost per million Btu (column 11), divide column 9 by the conversion factor for your fuel listed as follows:

   No. 2 oil - divide by .139 MMBtu/gal.
   No. 4 oil - divide by .150 MMBtu/gal.
   No. 5 oil - divide by .152 MMBtu/gal.
   No. 6 oil - divide by .153 MMBtu/gal.

5. Calculate the annual total and averages:

   a. sum column 8;

   b. sum column 10;

   c. divide b. by a. and enter at the bottom of column 9;

   d. divide c. by conversion factor above (C4.) and enter at the bottom of column 11.

D. NATURAL GAS - CONSUMPTION AND COST:

1. Enter in column 12 the consumption for each month in 1000 cubic feet (MCF). If your bill is not in MCF, use the following formulas to convert:

   a. if the bill is in CCF (100 cubic feet) divide the total by 10:

      ____CCF ÷ 10 = ____MCF;

   b. if the bill is in CF (cubic feet) divide the total by 1000:

      ____CF ÷ 1000 = ____MCF;

c. if the bill is in therms, divide the total by 10.30:*

____therms ÷ 10.30 = ____MCF.

2. Enter the total cost for each month in column 13.

3. To calculate column 14, the cost per MCF, divide column 13 by column 12.

4. To calculate column 15, the cost per million Btu, divide column 14 by 1.030. Or, if you know the heat content** of your particular gas: column 14 ÷ heat content per cubic foot x 1000 = column 15.

5. Calculate the annual totals and averages:

   a. sum column 12;

   b. sum column 13;

   c. divide b. by a. and enter in the bottom of column 14;

   d. calculate the average of column 15 by using one of the following:

      - divide c. above by 1.030

        or

      - divide c. above by the heat content per cubic foot and multiply by 1000.

E. If you use any other type of fuel or energy, use the same basic reasoning with the goal of arriving at the cost per million Btu (MMBtu). You may need to set up a separate sheet for other types of fuel.

F. Column 20 is the monthly total energy cost. Sum the monthly total cost for each type of energy used. For example, if you used electricity, oil, and gas in February, add the entries in column 5, column 10, and column 13 and enter the sum in column 20.

G. After each month has been completed, sum up column 20 to calculate the energy cost for the year. Enter the total at the bottom of column 20.

---

* This figure is based on the 1977 national average of 1030 Btu per cubic foot. If you know the actual heat content of your gas, such as 1020, adjust accordingly, i.e., 10.20.

** Heat content - the amount of energy supplied by the gas in Btu per cubic foot of gas.

ENERGY MANAGEMENT FORM

BUILDING ____________________ ____________ YEAR

MONTH*	HEATING DEGREE DAYS	COOLING DEGREE DAYS	ELECTRICITY				OIL				NATURAL GAS				COAL ☐ WOOD ☐ PURCHASED STEAM ☐ OTHER ______				TOTAL ENERGY COST
			QUANTITY	COST (DOLLARS)			QUANTITY	COST (DOLLARS)			QUANTITY	COST (DOLLARS)			QUANTITY	COST (DOLLARS)			
			KWH	TOTAL $	$/KWH	$/MMBTU	GALLONS	$/GAL.	TOTAL $	$/MMBTU	MCF	TOTAL $	$/MCF	$/MMBTU	UNIT	TOTAL $	$/UNIT	$/MMBTU	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
JANUARY																			
FEBRUARY																			
MARCH																			
APRIL																			
MAY																			
JUNE																			
JULY																			
AUGUST																			
SEPTEMBER																			
OCTOBER																			
NOVEMBER																			
DECEMBER																			
ANNUAL TOTALS																			
ANNUAL AVERAGES																			

* Or comparable time period

ELECTRICITY = 3412 Btu/Kwh
GAS = 1030 Btu/CF

OIL: #2 = .139 MMBTU/gal
#4 = .150 MMBTU/gal
#5 = .152 MMBTU/gal
#6 = .153 MMBTU/gal

MCF = 1000 cubic feet of gas
MMBTU = one million Btu

The following abbreviations are used in the problems:

MMBtu	=	One Million Btu
MCF	=	1,000 Cubic Feet
kWh	=	Kilo Watt Hours
yr	=	years
hr	=	hours
mo	=	months
$	=	dollars
gal	=	gallons
ft	=	feet
in	=	inches
^{o}F	=	degrees Fahrenheit
CFM	=	cubic feet per minute
Btu/hr·10 ft	=	Btu per hour per 10 feet of pipe

PROBLEM NUMBER 1

Remove unnecessary lamps or fixture. However, do not remove fluorescent lamps without disconnecting the ballasts.

A) DATA NEEDED FOR CALCULATIONS

		EXAMPLE PROBLEM
1) Count the number of lights that you feel can be removed in the hallways or classrooms:	[ ] bulbs	50 Bulbs
	[ ] watts/bulb	75 watts/bulb
2) From the Energy Management Form obtain the average cost of electricity ($/kWh) (Average of column 6)	[ ] $/kWh	.04 $/kWh
3) The number of hours per day the lights are on:	[ ] hr/day	10 hr/day
4) The number of days per year the store is open:	[ ] days/yr	260 days/yr

B) CALLCULATIONS

1) The energy saved with lights removed:

[ ] bulbs x [ ] watts/bulb

x [ ] hr/day = [ ] watt-hr/day

2) Energy saved per year:

[ ] watt-hr/day x [ ] day/yr

÷ 1000 watt-hr/kWh = [ ] kWh/yr savings

3) Cost saved per year.

[ ] kWh/yr savings x [ ] $/kWh

= [ ] $/yr savings

Payback is immediate unless there is a charge to remove the bulbs.

EXAMPLE PROBLEM

50 bulbs x 75 watts/bulb

x 10 hr/day = 37,500 watt-hr/day

37,500 watt-hr/day x 260 days/yr

= 9750 kWh/yr savings

9750 kWh/yr savings x .04 $/kWh

= 390 $/yr savings

PROBLEM NUMBER 2

EXAMPLE PROBLEM

Connect all of the manual day-night control switches to timeclocks so that the night set-back temperatures can be achieved even if inadvertently left on "day."

A.) DATA NEEDED FOR THE CALCULATIONS

1.) The amount of energy used which is related to heating only is determined from the following curve showing the total energy usage over a full year.

2.) The values of Million Btu's per month which are used in plotting the curve are arrived at by taking the monthly usage figures from the Energy Management Form, Column 4, 8, 12 or 16 depending on the type of fuel being used. To convert these quantities into Btu's the following factors are to be used:

EXAMPLE PROBLEM

Electricity	- 1 kilowatt-hour	= 3412 Btu's
No. 2 Fuel Oil	- 1 gallon	= 0.139 Million Btu's
No. 4 Fuel Oil	- 1 gallon	= 0.150 Million Btu's
No. 5 Fuel Oil	- 1 gallon	= 0.152 Million Btu's
No. 6 Fuel Oil	- 1 gallon	= 0.153 Million Btu's
Natural Gas	- Use the higher heating value (HHV) of the gas if shown on the bill. If not, use the standard conversion factor of 1000 cubic feet = 1.030 Million Btu's	

3.) The total annual energy consumption is: (Taken from the Energy Management Form as in 2 above using the bottom line figure for the type of fuel being used. This is the total energy amount represented by the curve.)

[ ] Million Btu/yr

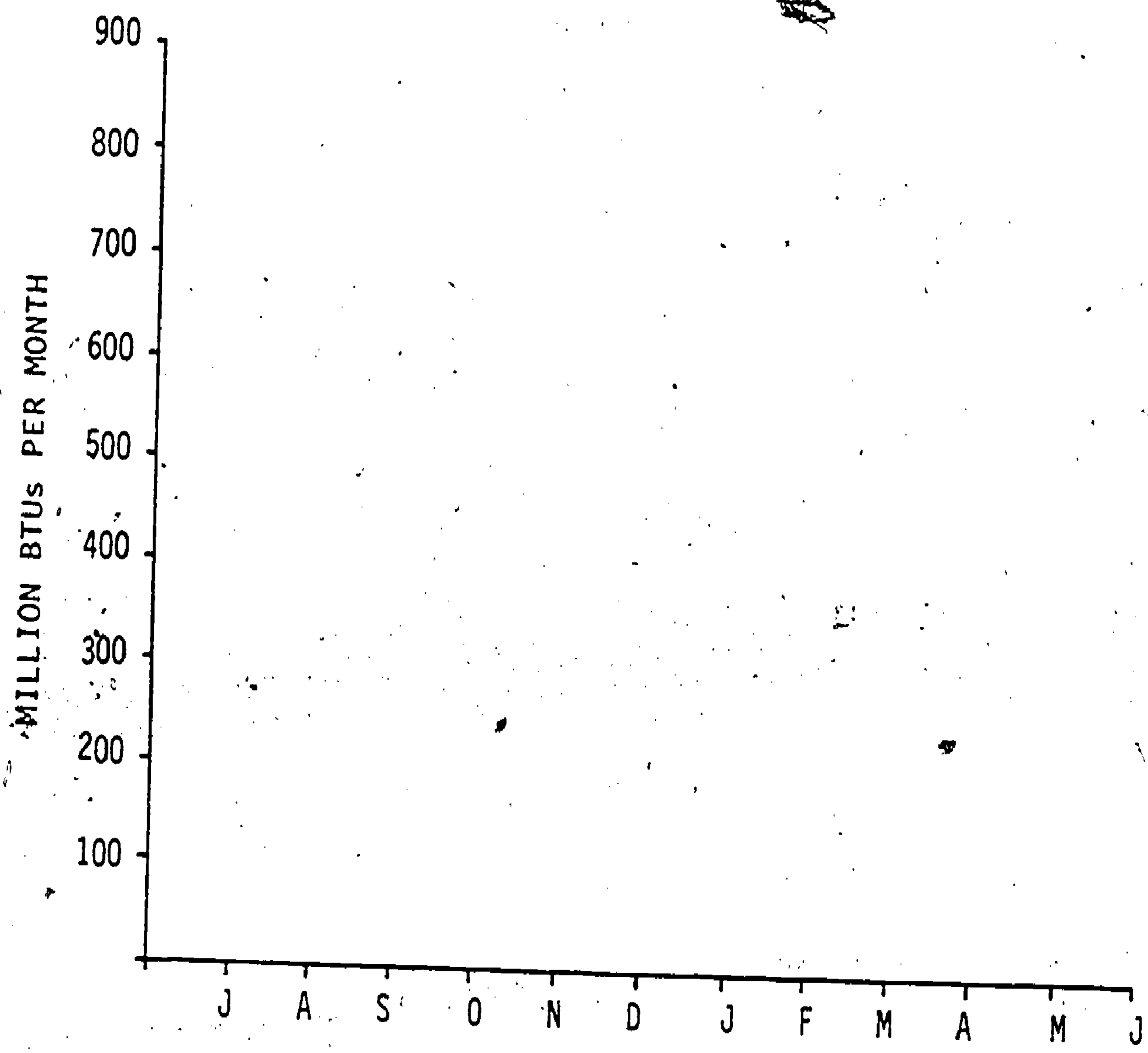
4900 Million Btu/yr

EXAMPLE PROBLEM

4.) Plot an energy consumption profile for your heating energy. Use the example curve Figure 2-1 as a guide. Plot each monthly consumption value in Million Btu against each month on the horizontal axis. Draw a smooth curve through the points. You should end up with a curve somewhat similar in shape to Figure 2-1. There should be an increase during the winter months, with a leveling off period during the summer.

5.) From this curve the "base load" can be established. The base load is energy that is not used for space heating. The base load is picked off by drawing a horizontal line between the average low points in the curve (as shown in the example). Above this line is the heating only load and below it is the base load.

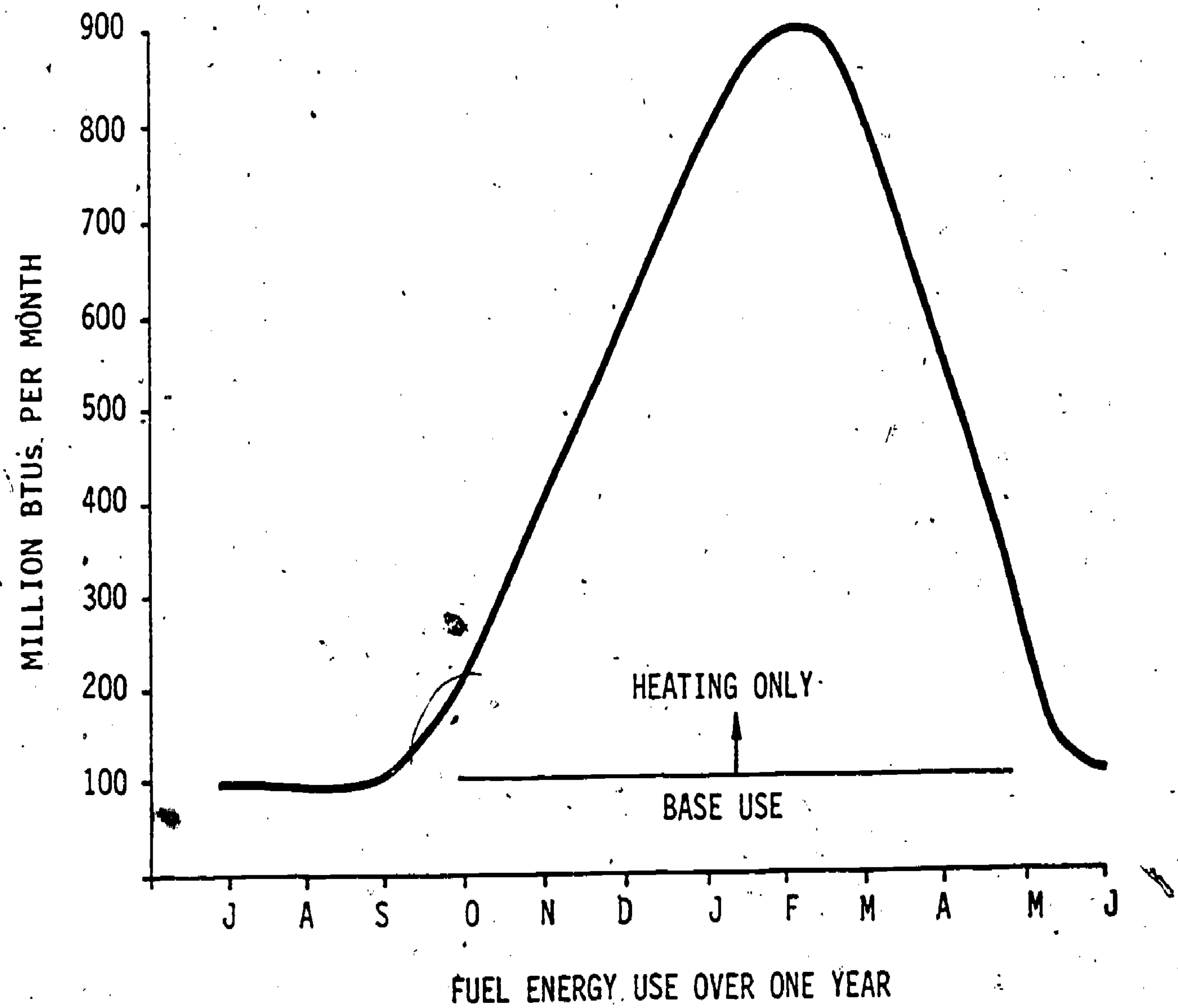
ENERGY USE PROFILE OVER ONE YEAR



FUEL ENERGY USE OVER ONE YEAR

FIGURE 2-1

EXAMPLE OF AN ENERGY USE PROFILE OVER ONE YEAR



6.) From the energy curve it will be noted that 100 Million Btu/mo is used whether the heating system is operating or not. Thus the base load is:

[ ] Million Btu/mo x [ ] mo

= [ ] Million Btu/yr

7.) The total number of heating degree days per year is:

[ ] degree days

(From Energy Management Form, Column 2)

8.) The cost of energy is taken from the Energy Management Form, Columns 7, 11, 15 or 19, depending on the type of fuel used:

[ ] $/Million Btu (annual average)

9.) The cost figure for a timeclock control switch obtained from a supplier is: [ ] $

EXAMPLE PROBLEM

100 Million Btu/mo x 12 mo

= 1200 Million Btu/yr

4560 degree days

3.10 $/Million Btu

45.00 $

B.) CALLCULATIONS

1.) From the total consumption we subtract the base load to get the energy use for space heating only.

[ ] MMBtu/yr - [ ] MMBtu/yr

= [ ] MMBtu/yr

2.) The heating load per degree day is:

$$\frac{[\ ]\ \text{MMBtu/yr}}{[\ ]\ \text{Degree days/yr}} = \frac{[\ ]\ \text{MMBtu}}{\text{Degree day}}$$

3.) If a normal set-back is [ ] degrees and we forget to set the thermostat back for [ ] days then we will use [ ] degree days/day x

[ ] days x $\frac{[\ ]\ \text{hr. set-back}}{24\ \text{hr/day}}$ x

$[\ ]\ \frac{\text{MMBtu}}{\text{Degree day}}$ = [ ] MMBtu more fuel

than if we had set back the thermostats.

EXAMPLE PROBLEM

4900 MMBtu/yr - 1200 MMBtu/yr

= 3700 MMBtu/yr

$$\frac{3700\ \text{MMBtu/yr}}{4560\ \text{Degree days/yr}} = \frac{.8114\ \text{MMBtu}}{\text{Degree day}}$$

10 degrees

2 days

10 degree days/day x

2 days x $\frac{12\ \text{hr set-back}}{24\ \text{hr/day}}$ x

$.8114\ \frac{\text{MMBtu}}{\text{Degree day}}$ = 8.114 MMBtu

4.) The value of these extra Btu's is found as follows:

[ ] \$/MMBtu x [ ] MMBtu/yr

= [ ] \$ for the two days we forgot to set back the thermostat.

5.) The payback time is:

$$\frac{\boxed{}\ \$}{\boxed{}\ \$/yr} = \boxed{}\ yrs$$

6.) If we forget to turn back for [ ] days, the payback becomes

$$\frac{\boxed{}\ yrs \times \boxed{}\ days}{\boxed{}\ days}$$

= [ ] yrs

EXAMPLE PROBLEM

3.10 \$/MMBtu x 8.114 MMBtu/yr

= 25.15 \$

$$\frac{45.00\ \$}{25.15\ \$/yr} = 1.79\ yrs$$

10 days

$$\frac{1.79\ yrs \times 2\ days}{10\ days}$$

= .36 yrs

EXAMPLE PROBLEM

PROBLEM NUMBER 3

Replace old, inefficient burners with new efficient ones.

A) DATA NEEDED FOR THE CALCULATIONS:

1) From the Energy Management Form the burner is now consuming how many gallons of fuel per year?:

[ ] gal/yr — Example: 25,000 gal/yr

2) The cost of the fuel oil from the Energy Management Form: (column 9)

[ ] $/gal — Example: .44 $/gal

3) The efficiency of the burner being used now is: (From the results of a test by a technician)

[ ] — Example: .60

4) The efficiency of a new burner would be: (From design conditions quoted by contractor) [ ] — Example: .75

5) The cost of the new efficient burner: [ ] $ — Example: 1600 $

B) CALCULATIONS:

1) The fuel savings with the more efficient burner:

$$\frac{(\square - \square) \times \square \text{ gal/yr}}{\square}$$

= [ ] gal /yr savings

2) Cost savings per year:

[ ] gal/yr saved x [ ] $/gal

= [ ] $/yr savings

3) Payback Period:

$$\frac{\square \ \$ \text{ cost of new burner}}{\square \ \$\text{/yr savings}}$$

= [ ] yr

EXAMPLE PROBLEM

$$\frac{(.75 - .60) \times 25{,}000 \text{ gal/yr}}{.75}$$

= 5000 gal/ yr savings

5000 gal/yr x .44 $/gal

= 2300 $/yr savings

$$\frac{1600 \ \$ \text{ cost}}{2200 \ \$\text{/yr savings}}$$

= .73 yr

PROBLEM NUMBER 4

EXAMPLE PROBLEM

Reduce power input to fan by decreasing air volume. Whenever heating and cooling loads are lowered, air volume requirement decreases resulting in fan energy savings. Air volume can be controlled by changing speed of fan.

A) DATA NEEDED FOR CALCULATIONS

1) School has [ ] pupils	500 pupils
2) Present ventilation rate [ ] CFM (From design specifications)	10 CFM/pupil
3) Minimum ventilation rate is: [ ] CFM/pupil (From local codes and regulations)	6 CFM/pupil
4) Power requirement to operate fan [ ] hp at the designated load from the fan name plate	7.5 hp
5) Number of days per year ventilation system is in operation is [ ] days/yr	185 days/yr
6) The cost of electricity is [ ] $/MMBtu	12.50 $/MMBtu

(From the Energy Management Form, col. 7)

7) Obtain cost of new motor from supplier [ ] dollars

EXAMPLE PROBLEM: $250

B) CALCULATIONS

1) Fan is providing a total of [ ] CFM/Pupil x [ ] pupils in school = [ ] CFM

Example: 10 CFM/pupil x 500 pupils = 5000 CFM

2) Required ventilation by code:

[ ] CFM/pupil x [ ] pupils in school = [ ] CFM

Example: 6 CFM/pupil x 500 pupils = 3,000 CFM

3) New power requirement:

$$\frac{\text{New ventilation rate } [\ \ ]^3 \text{ CFM}}{\text{Present ventilation rate } [\ \ ]^3 \text{ CFM}} \times [\ \ ] \text{ hp} = [\ \ ] \text{ hp}$$

Example:

$$\frac{(3000)^3}{(5000)^3} \times 7.5 \text{ hp} = 1.5 \text{ hp}$$

4) Energy consumption at present rate of ventilation is:

$$[\ \ ] \text{ hp} \times 2547 \frac{\text{Btu}}{\text{hp-hr}} \times [\ \ ] \frac{\text{days}}{\text{yr}} \times [\ \ ] \frac{\text{hrs}}{\text{day}} \times \frac{1}{1{,}000{,}000} = [\ \ ] \text{ MMBtu/yr}$$

Example:

$$7.5 \text{ hp} \times 2547 \frac{\text{Btu}}{\text{hp-hr}} \times 185 \frac{\text{days}}{\text{yr}} \times 7 \frac{\text{hrs}}{\text{day}} \times \frac{1}{1{,}000{,}000} = 24.7 \text{ MMBtu/yr}$$

5) Energy consumption at new rate of ventilation is:

[ ] hp of new motor x $\frac{2547\ \text{Btu}}{\text{hp - hr}}$ x

[ ] $\frac{\text{days}}{\text{yr}}$ x [ ] $\frac{\text{hrs}}{\text{day}}$ x $\frac{1}{1,000,000}$

= [ ] MMBtu/yr

6) Energy savings are:

[ ] MMBtu/yr - [ ] MMBtu/yr

= [ ] MMBtu/yr

7) Cost of electricity saved is:

[ ] MMBtu/yr x [ ] $/MMBtu

= [ ] $/yr

8) Payback period is:

$\frac{\text{cost}}{\text{savings}}$ = $\frac{[\ ]\ \$}{[\ ]\ \$/\text{yr}}$ = [ ] yr

EXAMPLE PROBLEM

1.5 hp x $\frac{2547\ \text{Btu}}{\text{hp-hr}}$ x

$\frac{185\ \text{days}}{\text{yr}}$ x $\frac{7\ \text{hrs}}{\text{day}}$ x $\frac{1}{1,000,000}$

= 4.9 MMBtu/yr

24.7 MMBtu/yr - 4.9 MMBtu/yr

= 19.8 MMBtu/yr

19.8 MMBtu/yr x 12.50 $/MMBtu

= 247 $/yr

$\frac{\$250}{247\ \$/\text{yr}}$ = 1 yr

EXAMPLE PROBLEM

PROBLEM NUMBER 5

In the previous problem we considered reduction in electricity only as a result of lowering the ventilation air quantity. Here we will consider heat saved by the same operation change. In fact, both savings occur together, but for simplicity we are looking at them one at a time.

A) DATA NEEDED FOR CALCULATIONS

1) The degree days per season are (From Energy Management Form, Col. 2) — 4560 degree days

2) The number of days in the school year the system is in operation: [ ] days — 240 days

3) From problem number 4:

Present air flow is 5000 CFM

Modified air flow is 3000 CFM

4) Hours of use per day are: [ ] hrs/day — 7 hrs/day

EXAMPLE PROBLEM

5) The average building temperature is [ ] °F — 70°F

6) The cost of energy is: (From Energy Management Form, annual average of column 7, 11, 15, or 19)

[ ] $/Million Btu — 2.78 $/Million Btu

7) Obtain efficiency reading on heating equipment from fuel supplier. If not available on the following values:

For electrical unit - 1.00

For fuel oil burner - 0.65

For natural gas burner - 0.80

[ ] efficiency — .80 efficiency

8) The cost of modification obtained from a contractor is:

[ ] — $600

B) CALCULATIONS

1) Air flow saved is:

[ ] CFM - [ ] CFM = [ ] CFM

2) [ ] degree days / [ ] days/season = [ ] °F

average below 65°F

3) Average heating season temperature is: 65° - [ ] °F =

[ ] °F

4) Average temperature difference between indoors and outdoors:

[ ] °F - [ ] °F = [ ] °F

5) The heat saved is: 1.08 x [ ] °F x

[ ] CFM x [ ] hr/day x

[ ] days/season

= [ ] Btu/season

EXAMPLE PROBLEM

5000 CFM - 3000 CFM = 2000 CFM

$\frac{4560 \text{ degree days}}{185 \text{ days}}$ = 19°F

65° - 19°F =

41°F

70°F - 41°F = 29°F

1.08 x 29°F x

2000 CFM x 7 hrs/day x

185 days/season

= 81,118,800 Btu/season

6) Cost of heat saved is:

$$\frac{[\quad]\ \text{Btu}}{1{,}000{,}000} \times \frac{[\quad]\ \$/\text{Million Btu}}{[\quad]\ \text{Efficiency}}$$

= [ ] $/season

7) Payback is $\frac{\text{cost}\ [\quad]\ \$}{\text{savings}\ [\quad]\ \$/\text{yr}}$ = [ ] yrs

EXAMPLE PROBLEM

$$\frac{81{,}118{,}800\ \text{Btu}}{1{,}000{,}000} \times \frac{2.78\ \$/\text{Million Btu}}{0.80}$$

= 282 $/season

$$\frac{\$600}{282\ \$/\text{yr}} = 2.1\ \text{yrs}$$

PROBLEM NUMBER 6

Install key-lock plastic covers over thermostats to prevent building occupants from adjusting settings.

A) DATA NEEDED FOR THE CALCULATIONS

1) Referring to Problem Number 2, the heating load is [ ] MMBtu / degree day

2) If the thermostat in one room out of [ ] rooms is turned up [ ] °F.

3) Obtain cost of protective cover from supplier.

[ ] $ each

4) The cost of energy is: (On Energy Management Form, annual average of column 7, 11, 15, or 19 depending on the type of fuel used.)

[ ] $/MMBtu

EXAMPLE PROBLEM

.8114 MMBtu / degree day

20 rooms

2°F

14.00 $ each

3.10 $/MMBtu

B) CALLCULATIONS

1) Extra heat per season per room is:

[ ] °F rise in temperature x

[ ] day, on day settings x

[ ] $\frac{\text{days}}{\text{season}}$ x [ ] $\frac{\text{MMBtu}}{\text{degree day}}$ x

$\frac{1}{[\ ]}$ total rooms = [ ] $\frac{\text{MMBtu}}{\text{season}}$

2) Cost savings:

[ ] $\frac{\text{MMBtu}}{\text{Season}}$ x [ ] $/MMBtu

= [ ] $/season savings

3) Payback Period: $\frac{[\ ]\ \$cost}{[\ ]\ \$/season\ savings}$

= [ ] years

EXAMPLE PROBLEM

2°F rise x

1/2 day x

180 $\frac{\text{days}}{\text{season}}$ x $\frac{.8114\text{MMBtu}}{\text{degree day}}$ x

$\frac{1}{20 \text{ rooms}}$ = 7.3 $\frac{\text{MBtu}}{\text{season}}$

7.3 $\frac{\text{MMBtu}}{\text{season}}$ x 3.10 $/MMBtu

= 22.6 $/season savings

$\frac{14.00\ \$\ cost}{22.63\ \$/season\ savings}$

= .62 years

PROBLEM NUMBER 7

Check the efficiency of the boiler(s). A percent loss of boiler efficiency is a percent loss of energy and dollars. It is generally worth any cost incurred to optimize the boiler operation. It is a good first step to reduce the excess air until smoke or emission violations occur. For instance, if the flue gas temperature is 400°F and excess air is changed from 100% to 50% an efficiency of 2.5% is immediately achieved.

The efficiency gain is observed clearly on Figure 2-2. The efficiency at 100 percent excess air is found at point A to be less than 82 percent and at 50 percent excess air to be greater than 84% at point B. Figures 2-2, 2-3, and 2-4 provide easy evaluations of the efficiency changes with changes in other variables.

The savings in fuel is related to the change in efficiency:

$$\frac{\text{New Efficiency} - \text{Old Efficiency}}{\text{New Efficiency}} \times \text{fuel consumption.}$$

In the above example if the oil consumption was 25,000 gallons per year at 82 percent efficiency with the increase in efficiency to 84 percent the fuel savings would be:

$$\frac{(.84 - .82)}{.84} \times 25000 \text{ gal/year} = 595 \text{ gal/year}$$

If oil cost 46 cents per gallon, the cost savings would be:

$$595 \text{ gal/year} \times .46 \text{ \$/gal} = 273 \text{ dollars per year.}$$

FIGURE 2-2 COMBUSTION EFFICIENCY vs PERCENT CO_2 OR EXCESS AIR-FUEL OIL (GRADES 2-6)

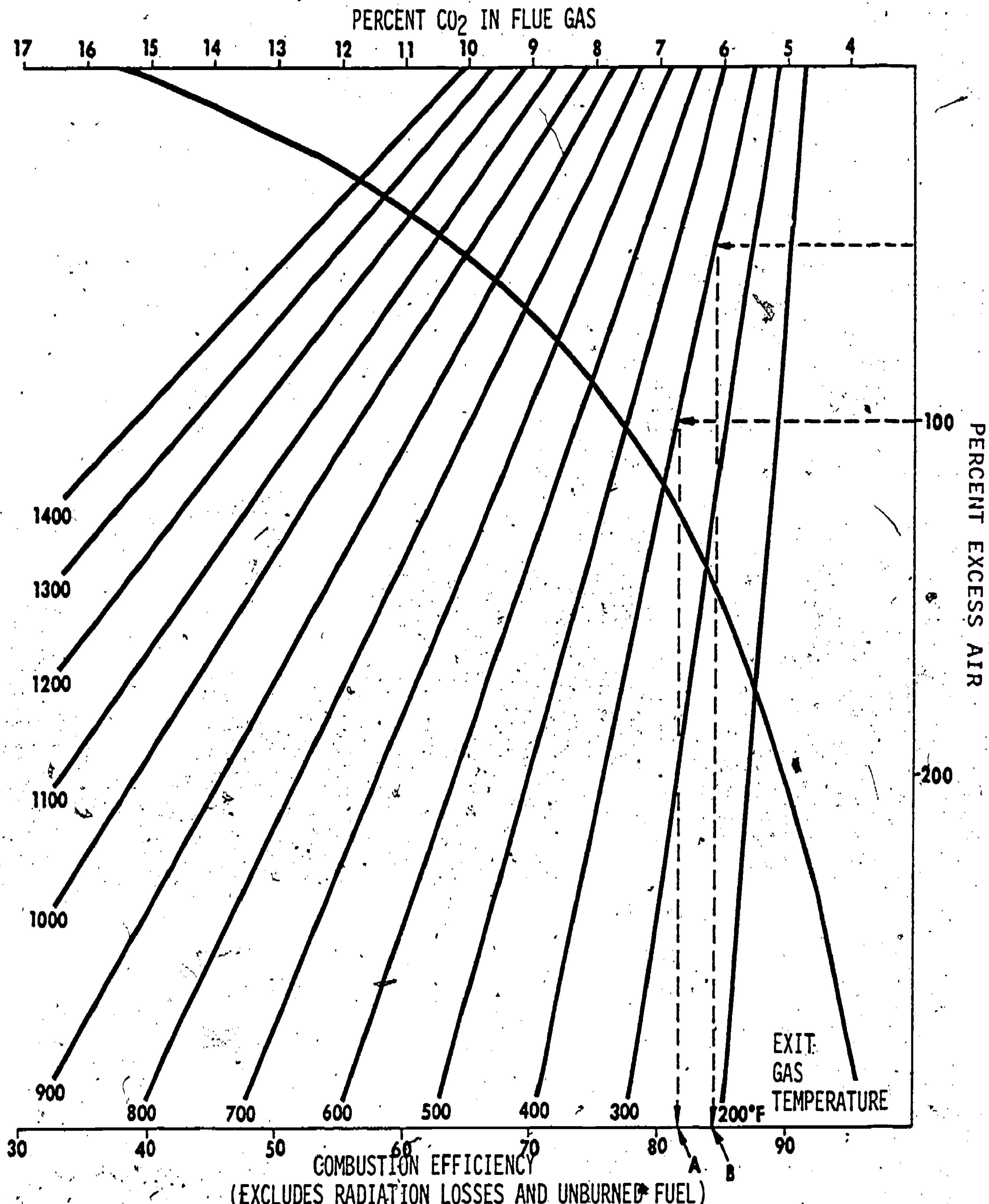


FIGURE 2-3 COMBUSTION EFFICIENCY vs PERCENT CO_2 OR EXCESS AIR-NATURAL GAS

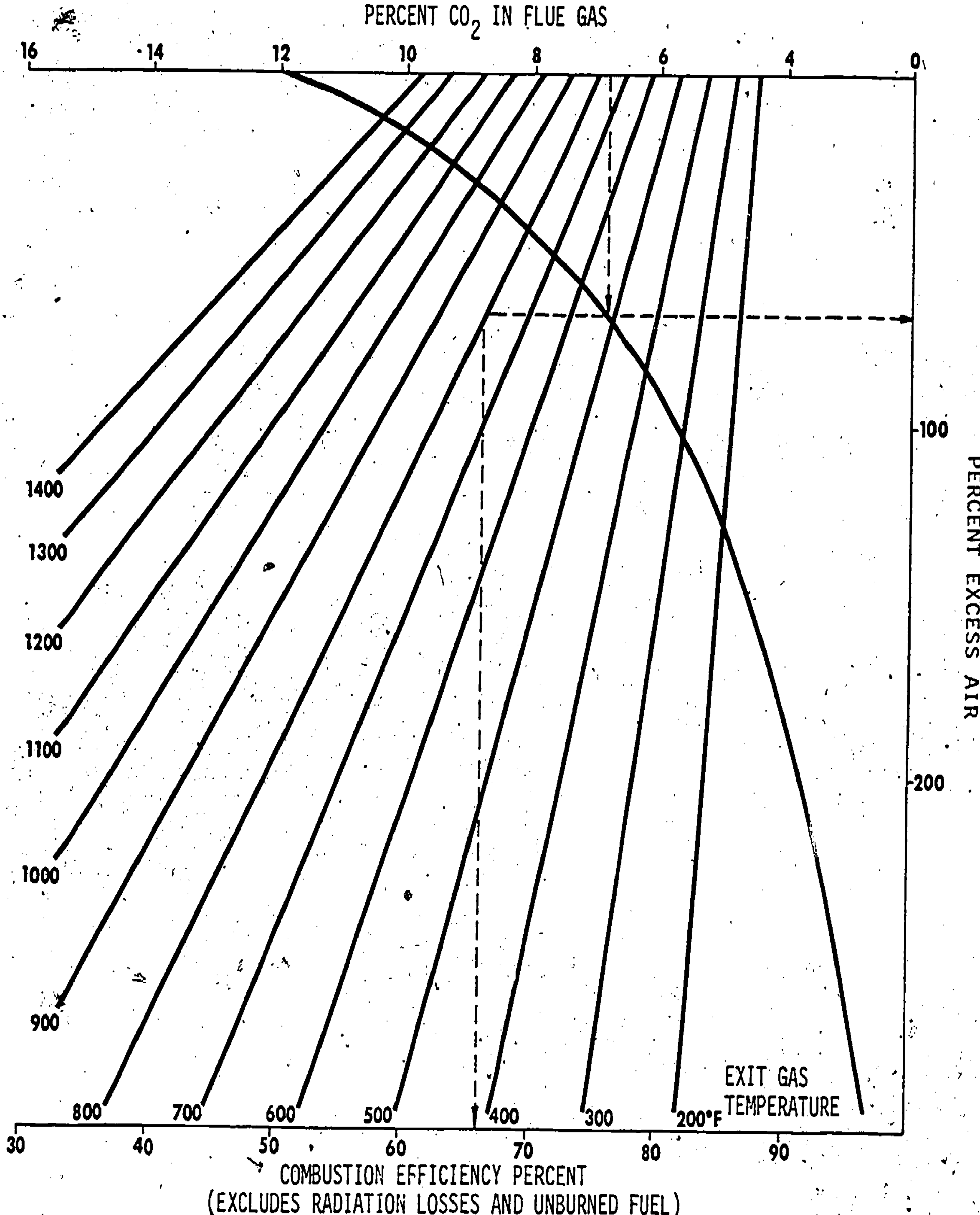
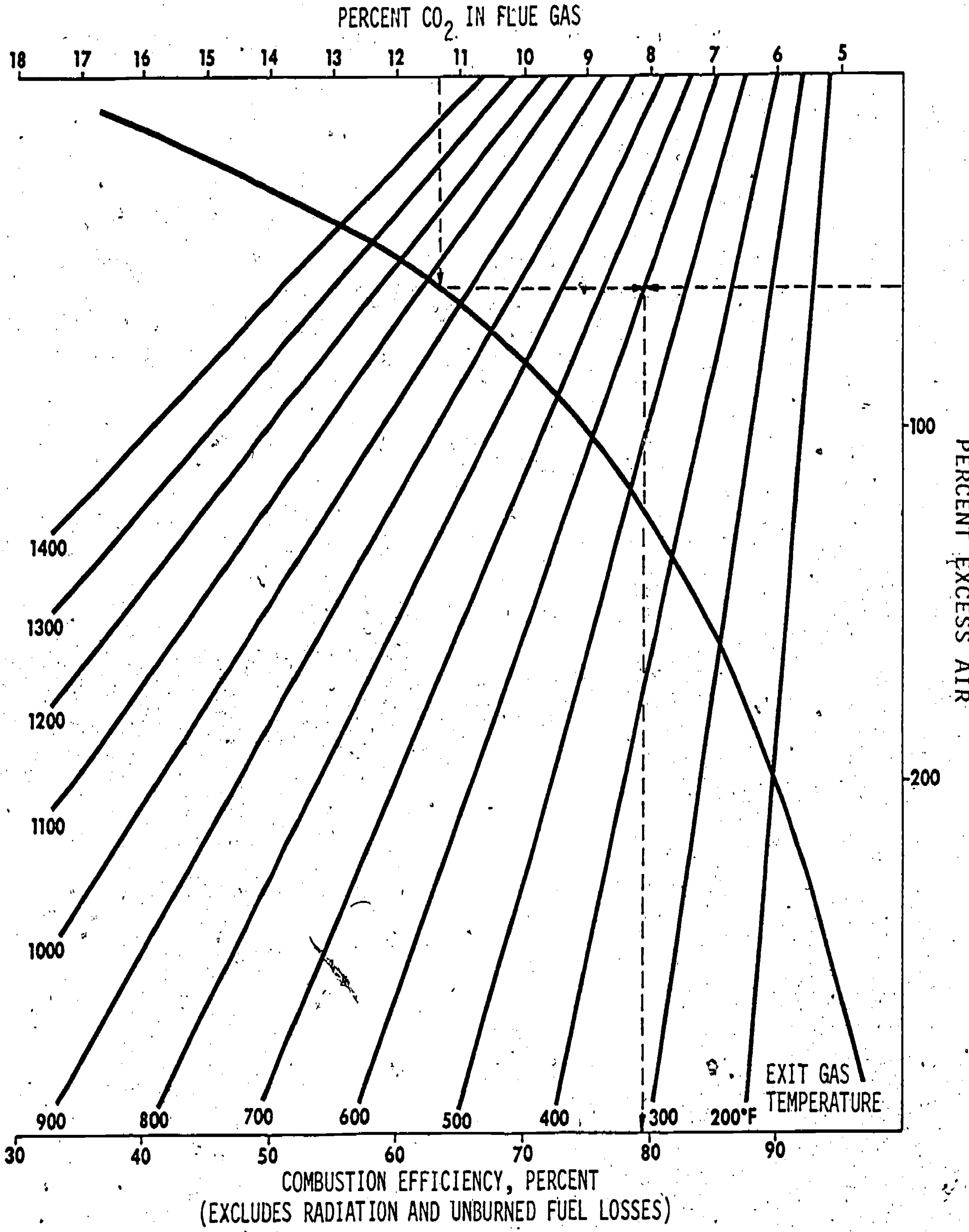


FIGURE 2-4 COMBUSTION EFFICIENCY vs PERCENT CO_2 or EXCESS AIR-BITUMINOUS COAL



PROBLEM NUMBER 8

Use photocells for turning on exterior lights. Use time clocks for turning off the exterior lights in the parking lot.

EXAMPLE PROBLEM

A.) DATA NEEDED FOR CALCULATION:

1.) The number of exterior lights:	[ ]	20 bulbs
2.) The number of watts per bulb:	[ ]	500 watts
3) Therefore, the total watts:	[ ] x [ ]	20 x 500 watts
	= [ ]	= 10,000 watts
4.) The timer is now set to turn the lights on at:	[ ] PM	4:00 PM
5.) The lights are now set to turn off at:	[ ] PM	10:00 PM
6.) The number of hours per day the lights are turned on:	[ ] hr	6 hr

	EXAMPLE PROBLEM
7.) The hours per year usage: [ ] hr/day x365	6 hr/day x 365
= [ ] hr	= 2190 hr
8.) The cost of electricity	
(from Energy Management Form annual average of column 7): [ ] $/Million Btu	= 12.5 $/Million Btu
9.) Cost to install photocells:	
(from a contractor's quote) [ ] $	= 200 $

B. CALCULATIONS

EXAMPLE PROBLEM

1.) Using table 2-1 choose the latitude closest to your school: [ ] — Example: 40 Lat.

2.) At this latitude the use time per day in January would be:

			Example
	[ ]	PM turn off time	10 PM turn off
(from table 2-1)	- [ ]	PM turn on time	- 5 PM turn on
	= [ ]	hr/day use time	= 5 hr/day use time

3.) Then for the month the total use time would be: [ ] hr X [ ] days — Example: 5 hr x 31 days

= [ ] hr — Example: = 155 hr

4.) Do this for the rest of the months using the chart on the following page.

TABLE 2-1

APPROXIMATE TIME FOR 2 FT CANDLES LIGHT LEVEL (TURN ON TIME)

Latitude	J	F	M	A	M	J	J	A	S	O	N	D
15^0S	6:30	6:30	6:00	6:00	6:30	6:00	6:00	6:00	6:00	6:30	6:30	7:00
20^0	6:00	6:00	6:00	6:30	6:30	7:00	6:30	6:30	6:00	6:00	6:00	6:00
25^0	5:30	6:00	6:00	6:30	7:00	7:00	7:00	6:30	6:00	6:00	5:30	5:30
30^0	5:30	6:00	6:00	7:00	7:00	7:00	7:00	7:00	6:00	6:00	5:30	5:00
35^0	5:00	5:00	6:00	7:00	7:00	7:00	7:00	7:00	6:00	5:30	5:00	5:00
40^0	5:00	5:30	6:00	7:00	7:30	7:30	7:30	7:30	6:00	5:30	5:00	5:00
45^0	4:30	5:30	6:00	7:00	7:30	7:30	7:30	7:00	6:00	5:30	4:30	4:30
50^0	4:30	5:00	5:30	7:00	7:30	8:00	7:30	7:00	5:30	5:30	4:30	4:00
60^0	4:00	4:30	6:00	7:30	8:30	9:00	9:00	8:30	6:30	5:00	4:00	3:30

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Usage Hours With Photocells

	hrs		days		
Jan		x		=	
Feb		x		=	
Mar		x		=	
Apr		x		=	
May		x		=	
Jun		x		=	
Jul		x		=	
Aug		x		=	
Sep		x		=	
Oct		x		=	
Nov		x		=	
Dec		x		=	

Total Hours = ☐ hr/yr

EXAMPLE PROBLEM

	hrs		days		
Jan	5	x	31	=	155
Feb	4/1/2	x	28	=	126
Mar	4	x	31	=	124
Apr	3	x	30	=	90
May	2 1/2	x	31	=	77.5
Jun	2 1/2	x	30	=	75
Jul	2 1/2	x	31	=	77.5
Aug	2 1/2	x	31	=	77.5
Sep	4	x	30	=	120
Oct	4 1/2	x	31	=	139.5
Nov	5	x	30	=	150
Dec	5	x	31	=	155

Total Hours = 1367 hr/yr

	EXAMPLE PROBLEM
5) Energy used without photocell: ____ watts total x ____ $\frac{hr}{yr}$	10,000 watts x 2190 $\frac{hr}{yr}$
= ____ watt hr/yr	= 21,900,000 watt hr/yr
6) Energy in Million Btu/yr: ____ x $\frac{3.412}{1,000,000}$	21,900,000 x $\frac{3.412}{1,000,000}$
= ____ Million Btu/yr	= 74.72 Million Btu/yr
7) Energy used with photocell: ____ watts x ____ hr/yr	10,000 watts x 1367 hr /yr
= ____ watt hr /yr	= 13,670,000 watt hr /yr
8) Energy in million Btu/yr: ____ x $\frac{3.412}{1,000,000}$	13,670,000 x $\frac{3.412}{1,000,000}$
= ____ Million Btu/yr	= 46.64 Million Btu/yr
9) Energy saved per year: ____ - ____	74.72 - 46.64
= ____ Million Btu/yr	= 28.08 Million Btu/yr

10) Cost saved per year with photocell:

[ ] x [ ] $/MMBtu cost of electricity

= [ ] $/yr

11) Payback period = cost [ ] $ / savings [ ] $/yr

= [ ] yr

EXAMPLE PROBLEM

28.08 x 12.5 $/MMBtu

= 351 $/ yr

cost 200 $ / savings 351 $ /yr

= .6 yr

EXAMPLE PROBLEM

PROBLEM NUMBER 9

Lower the domestic hot water temperature to 110°F. This should be not enough for showers, etc.

A) DATA NEEDED FOR CALCULATIONS:

1) The school is now consuming how many gallons of hot water per student per day:

(If this figure is not available use the following averages*:)

Elementary Schools = 0.6 gal/student/day

Junior and senior high schools = 1.8gal/student/day

[ ] gal/student/day

1.8 gal/student/day

* Adopted from ASHRAE, System Handbook 1973.

2) Estimate the number of students in the school:

[ ] students

3) The daily water consumption:

[ ] gal/student/day x [ ] students

= [ ] gal/day

4) Number of school day per year:

[ ] days

5) The present hot water temperature setting: [ ] °F

6) The cost of the energy to heat the hot water:

[ ] $/MMBtu

(From Energy Management Form, annual average of column 7, 11, 15, or 19 depending on the type of fuel used)

EXAMPLE PROBLEM

1000 students

1.8 x 1000

= 1800 gal/day

180 days

160 °F

12.34 $/MMBtu

B) CALCULATIONS

1) The total hot water used per year:

____ gal/day x ____ school days

= ____ gal/yr

2) The savings of heat at 110°F:

____ gal/yr x (____ °F - ____ °F)

x 8.34 ÷ 1,000,000

= ____ MMBtu/yr savings

3) The cost savings are:

____ MMBtu/yr savings x ____ $/MMBtu

= ____ $/savings

The payback is immediate since there is no initial cost to lower the hot water temperature.

EXAMPLE PROBLEM

1800 gal/day x 180 school days

= 32,400 gal/yr

32,400 gal/yr x (160°F - 110°F)

x 8.34 ÷ 1,000,000

= 13.5 MMBtu/yr savings

13.5 MMBtu/yr savings x 12.34$/MMBtu

=166.7 $/yr savings

CHAPTER 3

ENERGY MEASURES

This Chapter of the manual contains a list of energy measures that require an initial capital investment. More often than not, they will yield greater return in energy and cost savings than the no-cost maintenance and operational changes listed in Chapter 1. However, before investing any money make sure you have implemented as many of the no-cost items as practical.

Read through the list, making notes as you go along. Choose measures that are appropriate for your school. Some measures obviously require a greater investment than others; therefore, estimating the payback period of those measures which apply to your school is a convenient method of establishing your priorities. Use the basic reasoning and techniques portrayed in the problems of Chapter 2 as a guide for estimating energy savings and payback periods. For example, follow the basic methods of estimating the annual savings for a given measure. Then, obtain an installation price for that measure. To find the simple payback period, divide the installation cost by the estimated annual savings.

The following measures have been shown to produce the most dramatic savings for the least initial investment (they are also listed in their respective functional headings in this chapter):

1. Replace old, inefficient burners with new, efficient ones.
2. If you have a boiler, have a technician check the efficiency of it on a regular basis. A percent loss of boiler efficiency is a percent loss of energy and cost. It is generally worth any cost incurred to optimize the boiler operation.
3. Consider installing spring-activated hot water taps.
4. Insulate hot, bare heating pipes. Economic thicknesses can be supplied by contractors using guidelines established for FEA Conservation Paper 46, "Economic Thickness for Industrial Insulation".
5. Repair or replace leaking steam traps.
6. Install shower head restrictors in locker rooms. This may save up to 50% of the hot water consumption.
7. Where practical use waste heat for hot water heating.
8. Control exterior lighting with photo electric cells.
9. Preheat combustion air where practical.

10. Use energy conserving fluorescent lamps.

11. If you are being penalized by the electric company for a low power factor, it may be cost effective to correct it.

12. Insulate gym skylights.

PAGES 60-62 "ENERGY CONSERVATION MEASURES" REMOVED PRIOR TO BEING SHIPPED TO EDRS FOR FILMING DUE TO COPYRIGHT RESTRICTIONS.

C. SCHOOLS THAT USE BOILERS FOR SPACE HEATING OR OTHER PROCESSES

1. If the boiler is large enough to require a licensed operator, then the boiler control system is complex enough to greatly affect the efficient operation of the boiler. As the boiler control system approaches 10 years of age, the potential for defective operation from worn-out controls increases. Replacing worn-out controls with a new system could increase the efficiency of the boiler system and conserve energy.

2. Consider replacing existing boilers with modular boilers (small, independent boilers). Most boilers achieve maximum efficiency only when running at their rated output. In most cases, however, full boiler capacity is seldom required because heat load is 60% less than full load 90% of the time. As a result, large-capacity boilers in single units operate intermittently for the major part of the heating season. A modular boiler system comprised of two or more small-capacity boiler units will increase seasonal efficiency. Each module is fired at 100% of its capacity only when required. Fluctuations of load are met by firing more or less boilers. Each small-capacity boiler with low-thermal inertia (i.e., providing rapid response and low heat-up and cool-down losses) will either be running at maximum efficiency or be completely turned off. In a typical installation where single-unit, large-capacity boilers are replaced by modular boilers, boiler seasonal efficiency may be improved from 68% to 75%. This represents a 9% savings of present fuel consumption. Use of the modular approach is particularly worthwhile in cases where the present boiler plant is at or near the end of its useful life. Replacement modular boilers should be sized to meet the reduced heating load resulting from use of other measures.

3. Feel the pipe on the downstream side of steam traps. If it is excessively hot, the trap probably is passing steam. This can be caused by dirt in the trap, a valve off the stem, excessive steam pressure, or worn trap parts (especially valves and seats). If the pipe is moderately hot (as hot as a hot water pipe), it probably is passing condensate, which it should do. If it's cold, the trap is not working at all, and should be replaced or repaired.

4. Have a technician check the boiler(s). A percent loss of boiler efficiency is a percent loss of energy and money. It is generally worth any cost incurred to optimize boiler operation. A good first step is to simply reduce the excess air to the point where any further reduction would result in smoke. For instance, if the temperature of the flue gas (the gaseous products of combustion from a boiler furnace that travel to the stack through a passage known as the flue) is 400°F and excess air is changed from 100% to 50%, an efficiency increase of 3% is immediately achieved.

5. Replace inefficient boilers (e.g., single-pass tubed) and other boilers which are at or near the end of useful life. These boilers should be replaced by a modern version which is matched to current and projected needs of the installation involved. In most cases, new boilers on the market can obtain 80% efficiency. Even more efficiency can be gained by specifying multiple boilers. Replacement burners should be selected on the basis of long-term cost rather than initial cost. Increased cost of fuel, labor, and materials should be considered in developing long-term cost projections. Also consider installation of a dual-fuel system to avoid problems in the event of any shortages or curtailments.

6. Convert to a low pressure system to improve the heating system's annual operating efficiency. The installation of small steam electric boilers near the termination of some steam lines may reduce the need for piping modifications.

7. Lower steam pressure to the minimum pressure that will just satisfy needs.

8. Install a flue gas analyzer: Optimum combustion efficiency varies continuously with changing loads and stack draft. Accordingly, maintaining optimum combustion efficiency requires continuous adjustment of fuel/air ratios. This can be achieved through installation of a flue gas analyzer, which provides continuing information on flue gas temperature and CO_2 or O_2 content, thus enabling manual adjustment on a continuing basis. The specific type of flue gas analysis instrumentation required depends on the type of installation involved. Due to the increasingly more widespread need for multifuel burners, however, O_2 analysis is considered to be the single most useful measure for all fuels since the O_2 to total air ratio varies within narrow limits.

9. Most service companies will test burners for a token fee for the following:

   a. Air to fuel ratio: This must be maintained properly. In case of insufficient air, the fire will smoke and deposit soot on the water tubes of the boiler. Soot acts like insulation on the tubes, which causes waste of energy.

   b. Firing period: If it is improper, it could be a sign of faulty control.

   c. Flue gas analysis: The efficient combustion of fuel in a boiler requires burner adjustment to achieve proper stack temperature, CO_2 and excess air settings. Check settings to provide stack temperatures of not more than 150°F above steam or water temperature. There should be no carbon monoxide. For a gas-fired unit, CO_2 should be present at 9 to 10%. For #2 oil, 11.5 to 12.8%; for #6 oil, 13 to 13.8%.

10. Decrease gas or oil input rate of the boilers so that they will operate over longer periods of time. This will decrease losses incurred during the off cycle.

11. Readjust damper control to maintain proper draft under both low and high fire.

12. Install automated damper controls to provide positive draft shut-off when the boiler is not operating.

13. Inspect on a regular basis all boiler insulation, refractory (the inside lining of a furnace), brickwork, and boiler casing for hot spots and air leaks. Repair and seal as necessary.

14. Check boiler stack temperature. If it is too high (more than 150°F above steam or water temperature) clean tubes and adjust fuel burner.

15. Isolate off-line boilers: Light heating loads on a multiple boiler installation are often met by one boiler on line with the remaining boilers idling on stand-by. Idling boilers consume energy to meet stand-by losses. In many cases, these losses are increased by a continuous flow of air drawn in through the idling boilers and up the chimney. Unless a boiler is about to be used to meet an expected increase in load, it should be secured and isolated from the heating system (by closing dampers). A large boiler can be fitted with bypass valves and a regulating orifice (a small opening intended for the passage of a fluid) to allow the minimum flow required to keep the boiler warm and avoid thermal stress when it is brought on line again. If a boiler waterside is isolated, it is important to prevent back-flow of cold air through the stack, which could cause the boiler to freeze.

16. Inspect boilers for scale deposits, accumulation of sediment (the solid substance that is deposited in the bottom of a liquid), or boiler compounds on waterside surfaces. Rear portion of the boiler must be checked because it is the area most susceptible to deposits of scale. Scale reduces the efficiency of the boiler and possibly can lead to overheating of furnace, cracking of tube ends, and other problems. Have scale cleaned regularly.

17. Provide proper chemical treatment of boiler water to reduce scale build-up, protect the boiler, and help protect condensate returns.

18. Inspect insulation of all mains, risers and branches, economizers and condensate (condensed steam that is now water) receiver tanks. Repair or replace as necessary.

19. Preheat the air before it enters the combustion chamber of the boiler by the waste gases from the chimney.

20. Connect the space heating hot water pumps to the time clock so that they will operate only when the boiler is being used.

21. If possible, install a boiler stack economizer.

22. In case of leakage, replace flanged valves with weld-end valves, except at locations where frequent removal of valves is necessary.

23. Reduce blowdown losses: Some of the water is removed from the boiler by blowdown in order to control the amount of solids and salts in solution and thereby maintain the desired concentration. Blowdown results in a steady energy drain because make-up water must be heated. Energy can be saved, however, if blowdown water is not discarded but instead is used to heat make-up water.

24. Listen to steam traps to determine if they are opening and closing when they should be. If they are not, repair or replace the traps.

25. Route vents from steam system flash tanks (where the low-pressure steam is collected after the boiler has been through its blowdown cycle) back into low-pressure steam mains.

26. If practical, install turbulators in boiler tubes to increase the heat transfer from the hot gases to the waterside.

27. Inspect boiler door gaskets. Replace them if they do not provide a tight seal.

D. VENTILATION

1. Adjust outside air intake. Return air and mixed air damper controls in winter to raise supply air temperature to a level between 64°F and 70°F, depending on the conditions in the area served by the system.

2. Add a warm-up cycle to air handling units with outdoor air intake. Keep outdoor air dampers closed during morning building warm-up or cool-down so only air already in the building is conditioned. A cycle can be incorporated using a two-circuit time clock to control air damper and fan operation.

3. Consider adding variable volume valves and eliminating terminal heaters.

4. Reduce system resistance to air flow to a minimum by replacing those duct sections and fittings which impose unnecessary resistance on the system; replacing dirty filters with adequately sized filter media which have a high efficiency and low air flow resistance; removing unnecessary dampers and other obstructions from ductwork, and replacing high-resistance inlets and outlets with modern grilles and diffusers providing low resistance.

5. Inspect ductwork for air leakage. Seal all leaks by taping or caulking.

6. If possible, use permanently sealed windows to reduce infiltration in climate zones where this is a very large energy user.

7. Install storm windows throughout or double glaze windows throughout. A single 36 sq ft window will save 3.5 million Btu per year with storm windows added.

8. Replace broken or cracked window panes.

9. Inspect ductwork insulation. Condensation on air handling surface is a sign of inadequate or loose insulation. Repair or replace insulation as necessary.

10. Caulk, gasket, or otherwise weatherstrip all exterior joints, such as those between wall and foundation or wall and roof, and between wall panels.

11. Caulk, gasket, or otherwise weatherstrip all openings, such as those provided for entrance of electrical conduits, piping, through-the-wall cooling and other units, outside air louvers, etc.

12. Where practical, cover all window and through-the-wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.

13. If an exhaust hood is oversized, adjust it so no more air than necessary is exhausted. This can be done easily by blocking off a portion of the hood, or lowering the hood, or reducing fan speed, or utilizing a combination of these techniques in compliance with applicable health regulations.

14. Modify duct system and hoods to introduce unheated outdoor or return air directly to the exhaust hoods.

15. Reduce or eliminate the need for using outdoor air for odor control by installing chemical or activated charcoal-absorbing devices.

16. Consider installing new fresh air dampers. Many older ventilation systems are designed with fresh air dampers which do not provide for accurate intake control. These dampers can be replaced with high-quality, opposed blade dampers with the proper seals at the blade edges and ends. This will minimize air leaks as well as provide better fresh air intake settings.

17. Install baffles to prevent wind from blowing directly into an outdoor air intake.

18. Supply ventilated air to parking garages to levels indicated by a CO_2 monitoring system.

19. Consider installing economizer/enthalpy controls on air handling units to minimize cooling energy requirements by using proper amounts of outdoor and return air from "free cooling" when possible. Economizer controls generally are used to provide "free" cooling. Whenever the outdoor air temperature is lower than the indoor temperature, outdoor air is brought directly into conditioned spaces instead of being treated by the mechanical cooling system.

    Enthalpy controls have a similar purpose, but are more sophisticated and effective. They measure the total heat content of outdoor air and return air and utilize proper amounts of each to provide maximum energy benefits.

20. Consider installing automatic door closers on all doors leading to the exterior or unconditioned spaces.

21. Consider installing a vestibule for the front entrance of the building, where practical. It should be fitted with self-closing weatherstripped doors. It is critical that sufficient distance between doors be provided.

22. The valves of steam headers in the boiler room that supply steam to unused individual air handling units should be kept in an off position. This will reduce steam piping heat losses.

23. Acquire the services of a temperature control expert to check and adjust all system controls and to recommend modifications.

24. Change fans and pumps from steam to electric motor devices to permit reduction of steam pressure in mild weather.

25. Install individual time clocks for each fan unit.

26. Install a grille on the furnace room door to provide adequate, inside combustion air, not outside air.

27. Inspect air valves in dual-duct mixing boxes (an area in which air of different temperatures and humidities are mixed) to ensure full sealing and minimum air leakage.

28. Utilize ductwork access openings to check for any obstructions such as loosely hanging insulation (in-lined ducts), loosely turning vanes and accessories, and closed fire dampers. Adjust, repair or replace as necessary.

29. Install an automation system to operate the ventilation units so that supply air temperature and return-air/fresh-air dampers can be adjusted to maintain the desired space temperature in the room.

30. Operate exhaust fans only when needed. Consider separate time clocks for these cycles. Some pressurized buildings may not require all of the exhaust fans to operate for proper ventilation.

31. Add controls to shut down the ventilation system whenever a building is closed for an extended period of time, as during the evening, weekends, etc., except when the economizer cycle is in use.

32. Increase the ventilation unit's summer mixed air temperature to minimize the air conditioning and reheat requirements.

33. Fresh air makeup units should be designed so that the damper is closed when the unit is shut down.

34. Fresh air dampers installed in return air duct could eliminate the operation of the air conditioning (except fan) during off-peak seasons.

35. When more than 10,000 cubic feet per minute are involved, and when building configuration permits, consider installing heat recovery devices such as a rotary heat exchanger. For some climatic conditions an "enthalpy wheel," which permits recovery of some 75% of outdoor heat load during both heating and cooling cycles, will be feasible.

36. Adjust or replace all supply air temperature gauges so that accurate ventilation temperature can be read and maintained.

37. To minimize infiltration, balance mechanical ventilation and provide building static pressure (the normal pressure which exists inside that building) control so that supply air quantity equals or exceeds exhaust air quantity.

38. In existing systems where throttling is necessary to control flow, revise the fan drive or the pump to required flow with no throttling.

E. COOLING

1. Replace inefficient air conditioners. Newer units may save as much as 25% or more on the energy consumed for the same cooling.

2. Increase the supply air temperature on all air handling units during the summer to the point where at least one space served by each unit is warmer than desired.

3. Consider installing interlocks between the heating and cooling systems of each unit to prevent simultaneous heating and cooling.

4. Inspect the moisture-liquid indicator on a regular basis. If the color of the refrigerant indicates "wet," it means there is moisture in the system. This is a particularly critical problem because it can cause improper operation or costly damage. A competent mechanic should be called in to perform necessary adjustments and repairs immediately. Also, if there are bubbles in the refrigerant flow as seen through the moisture-liquid indicator, it may indicate that the system is low in refrigerant. Call in a mechanic to add refrigerant if necessary and to inspect equipment for possible refrigerant leakage.

5. Reduce air flow to all areas to minimally acceptable level.

6. When no cooling loads are present, close off cold ducts and shut down the cooling system. Reset hot deck according to heating loads and operate as a single-duct system. When no heating loads are present, follow the same procedure for heating ducts and hot deck. It should be noted that operating a dual-duct system as a single-duct system reduces air flow, resulting in increased energy savings through lowered fan speed requirements.

7. Use a leak detector to check for refrigerant and oil leaks around shaft seals, sight glasses, valve bonnets, flanges, flare connections, and the relief valve on the condenser assembly, and at pipe joints to equipment, valves, and instrumentation.

8. Look for unusual compressor operation such as continuous running or frequent stopping and starting, either of which may indicate inefficient operation. Determine the cause and, if necessary, correct.

9. Check all compressor joints for leakage. Seal as necessary.

10. Reduce secondary water flow during maximum heating and cooling periods by pump throttling or, for dual-pump systems, by operating one pump only.

11. Install insulation on all hot and chilled water pipes, fittings, and valves passing through unconditioned spaces to minimize heat losses and heat gains.

12. Use water treatment techniques if the local water supply leaves surface deposits on the coil.

13. Perform tests to determine if solid concentrations are being maintained at an acceptable level in the cooling tower.

14. Determine if there is air bypass from the tower outlet back to the inlet. If so, bypass may be reduced through the addition of baffles or higher discharge stacks.

15. Caulk openings between unit and windows or wall frames.

16. Observe the noise made by the system. Any unusual sounds could indicate a problem. Determine the cause and correct it.

17. Chillers with water-cooled condensers should have the condenser heads removed annually and the tubes and waterbox (the tank in which the tubes are immersed) cleaned. The waterside of the evaporator should be opened every three years and cleaned in the same manner as the condenser.

F. LIGHTING

1. Install a desk lamp for the instructors so that they can occupy the classroom without all the lights being on.

2. Use energy-conserving fluorescent lamps. When relamping, replace 40-watt fluorescent lamps with 35-watt lamps to achieve a reduction in electrical energy consumption. These lamps save about 15% of the fixture's electrical energy.

3. Lamp efficiency deteriorates over the life of a lamp. Light output should be checked regularly by maintenance personnel with a calibrated light meter (a meter which has been adjusted for accuracy). When the light output of a group of lamps has fallen to approximately 70% of the original light output, relamp all fixtures in the group at the same time. This is also a good time to check whether a more efficient or lower-wattage lamp is suitable.

4. Install timers on gym and fieldhouse lighting system that will automatically shut off lights after each class.

5. Consider the installation of photo-cell and timeclock to operate some of the swimming pool lights during occupied hours.

6. Luminaire efficiency can be maintained by properly cleaning the reflecting surfaces and shielding media. Replace lens shielding that has yellowed or become hazy with a clear acrylic lens with good nonyellowing properties. For some applications, a clear glass lens can be considered if it is compatible with the luminaire and does not present a safety hazard. (Caution should be used to assure that an existing luminaire will safely support and hold the glass lens.)

7. Replace outdated or damaged luminaires with modern luminaires that have good cleaning capabilities and that use lamps with good lumen maintenance characteristics.

8. Consider replacing present lamps with those of lower wattage that provides the same amount of illumination or (if acceptable for the tasks involved) a lower level of illumination. (Changing the lens or lowering the luminaire can often help facilitate this option.) This method is particularly applicable where current lighting levels are higher than recommended or where uniform lighting is the most practical due to occupant density.

9. Select lamps that are the most efficient, as measured in lumens (a unit of light output from a source) per watt, and that are compatible with the application. Compatibility with the luminaire, of course, is also essential. If some luminaire replacement is to be undertaken, determination of the lamp type involved should also be considered. In general, efficiencies of lamp types rank as follows, in descending order:

LUMENS PER WATT (INCLUDING BALLAST)

	Smaller sizes	Middle sizes	Larger sizes
High-pressure sodium	84	105	126
Metal halide	67	75	92
Fluorescent	66	74	70
Mercury	44	51	57
Incandescent	17	22	24

10. Where possible, use a single, larger incandescent lamp (a lamp in which light is produced by heating one substance to a white or red heat) rather than two or more smaller lamps. Higher-wattage general service incandescent lamps are more efficient than lower-wattage lamps.

11. Revise switch circuits to permit turning off unused or unnecessary light.

12. Avoid multilevel lamps. The efficiency of a single-wattage lamp is higher per watt than a multilevel lamp.

13. Use extended service lamps in special cases where short lamp life is a problem, such as recessed directional lights.

14. Consider using higher power factor ballasts when refitting.

15. Consider adding solid state dimming controls for incandescent luminaires in multiple-purpose spaces which require more than one level of illumination.

16. Where appropriate, consider installing lenses which provide special light distribution patterns to increase lighting effectiveness. As examples, linear batwing, radial batwing, parabolic louvers, or polarizing lenses may provide better visibility with the same or even reduced wattage. It is suggested that competent technical advice be obtained to evaluate where such lenses can be used most effectively.

17. Relocate luminaires to provide light on task areas at an angle outside the zone which causes veiling reflections if relocation of work station is impractical.

18. Consider lowering luminaires so they will provide recommended illumination levels on the task area at a reduced wattage.

19. Replace all incandescent parking lighting with H.I.D. lamps. For example, Low Pressure Sodium, High Pressure Sodium or Mercury Vapor lamps.

20. Replace the gym incandescent lighting systems with mercury vapor or other high efficiency source.

21. When natural light is available in a building, consider the use of photocell (a device which controls electricity by measuring the available light) switching to turn off banks of lighting in areas where the natural light is sufficient for the task.

22. Use photocells for turning on exterior lights; use time clocks for turning off the exterior lights.

23. Provide timers to automatically turn off lights in remote or seldom-used areas.

24. Provide selective switching: Initial cost economics and lack of knowledge about final space subdivision often lead to the use of central panel-boards as the only means of controlling large blocks of lighting. This design approach precludes the potential for turning on only the amount of lighting that is actually needed after the space has been subdivided.

G. DOMESTIC WATER

1. Meet hot water heating needs from:

   a. waste heat from incinerators or furnaces
   b. rejected heat of compression from refrigeration units
   c. waste condensate return from steam operated systems.

2. Install shower head restrictors in the gym locker rooms. This may save up to 50% of the hot water demand.

3. Inspect water supply system and repair all leaks, including those at the faucets.

4. If water pressure exceeds 40 to 50 pounds, consider having a plumber install a pressure reducing valve on the main service to restrict the amount of hot water that flows from the tap.

5. Inspect and test hot water controls to determine if they are working properly. If not, regulate, repair or replace.

6. Increase the amount of insulation installed on hot water pipes and storage tanks or replace existing insulation with a type having better thermal properties ("R" value).

7. Consider replacing existing hot water faucets with spray type faucets with flow restrictors wherever practical. Consult with a government infection control committee before making modification.

8. Use a single system to meet handwashing needs in toilets.

9. If boilers are used as the primary heat source for domestic hot water, install a boiler to match the load rather than use an oversized heating boiler all summer.

10. Install a small domestic hot water heater to maintain the desired temperature in the water storage tank. This eliminates the need for running one of the large space heater boilers at a very low efficiency during the summer months.

11. Consider arranging circulating pipework to minimize the length of dead legs connecting to faucets.

CHAPTER 4

THE ACTION PLAN

Being aware of the possibilities for saving energy and money is only the beginning step toward an energy management program. This book has presented many possible areas in schools where savings may be achieved. Now it is up to you, the administrator or maintenance manager, to get the wheels in motion and implement the applicable Maintenance and Operational changes and Energy Measures. An organized system of priorities should be established to decide where to focus your efforts. The worksheet enclosed in this chapter is designed to help you organize your list of priorities.

The first step is to examine the no-cost Maintenance and Operational Changes which fit your school. Make a list of the applicable ones, schedule them, and assign responsibility for accomplishing them. Once these no-cost items have been implemented, a monthly review and update of the Energy Management Form in Chapter 2 should be made to determine whether energy is, in fact, being saved as predicted.

Having accomplished the no-cost changes, the next step is to investigate those measures which do require a capital investment. Examine the List of Energy Measures in Chapter 3 and choose those which appear to be most suited to your school. Turn to Chapter 2 to get the approach to calculating the energy and cost savings for the measures you have chosen. Calculate these measures and determine their simple payback times. Then, arrange the list in order of shortest payback time first and longest payback time last. Assuming that budgets permit, the list should then be examined item by item to determine if any further conservation of both energy and dollars can be made.

Continue to update the Energy Management Form at regular, frequent intervals during the implementation of your energy conservation program. That way, the reduced consumption of fuel and/or electricity will become real and you will be able to demonstrate and verify the savings with your consumption measurements.

ENERGY CONSERVATION ACTION PLAN

No-Cost Maintenance And Operational Changes

CHANGE #	RESPONSIBILITY NAME & DEPT.	COMPLETION DATE & INITIAL	REMARKS

ENERGY CONSERVATION ACTION PLAN

Energy Measures

PROJECT	COST	PAYBACK PERIOD	RESPONSIBILITY	COMPLETION	REMARKS