ENERGY CONSERVATION PROGRAM GUIDE FOR INDUSTRY AND COMMERCE

NBS HANDBOOK 115
SUPPLEMENT 1

U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards
in cooperation with
FEDERAL ENERGY ADMINISTRATION/Conservation and Environment

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

[2] Located at Boulder, Colorado 80302.

Energy Conservation Program Guide for Industry and Commerce (EPIC)

SUPPLEMENT 1

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Center for Building Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

Sponsored by:

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Instructions for Inserting Supplement 1 into NBS Handbook 115 (EPIC)

Supplement 1 consists of new and revised material to be added to NBS Handbook 115. These instructions will assist you in updating your copy.

(1) Separate the pages from the binding and insert your copy of the Handbook in a 3-ring binder if you have not already done so.

(2) Separate the pages of Supplement 1 from the binding.

(3) Follow the instructions below on removing and discarding pages and inserting new pages. All new or revised material bears the legend "Supplement 1, December 1975" on the lower outer edge of the page. Where it was necessary to reprint existing pages to permit new pages to be inserted in proper sequence, the reprinted pages are without this revision legend.

Remove from original	*Insert Supplement 1 page*
	new cover (after original cover)
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	new pages iv-A and iv-B (after original page iv)
Section 2: Table of Contents and pages 2-1 through 2-4	new Section 2: Table of Contents and pages 2-1 through 2-4 and pages 2-4A through 2-4J
Section 3: Table of Contents and pages 3-1 through 3-14	new Section 3: Table of Contents and pages 3-1 and 3-2, page 3-2A, and pages 3-3 through 3-14
pages 3-17 and 3-18	new pages 3-17, pages 3-17A through 3-17G, page 3-18, and pages 3-18A through 3-18D
	new page 3-26 (after original page 3-25)
pages 3-43	new pages 3-42, 3-42A through 3-42I, 3-43 and 3-44
	new page 3-52
pages 3-59 through 3-62	new pages 3-59, 3-60, 3-60A, 3-61, pages 3-61A through 3-61C, and 3-62
Section 6: Table of Contents and pages 6-1 through 6-7	Section 6: Table of Contents and new pages 6-1 through 6-4, page 6-4A, page 6-5, page 6-5A, and pages 6-6 through 6-9
pages 7-3 through 7-5	new pages 7-3 and 7-4
	revised order blank

These instructions and the original pages removed as a result of incorporating this supplement, may be retained separately in the back of your 3-ring binder for historical reference.

FOREWORD

Supplement 1

The response of the industrial community to the publication of NBS Handbook 115 "Energy Conservation Program for Industry and Commerce (EPIC)" has indicated that it meets a need in the national energy conservation effort. Many company officials specifically mentioned that the handbook was very helpful in the development of their energy conservation programs. In addition to the use of the handbook by industrial companies, EPIC has been found applicable in educational systems, hospitals, government agencies, and in training of energy conservation personnel.

The first supplement of EPIC provides more ideas and suggestions to aid in your energy conservation efforts. The supplement includes a revised explanation of how to implement an energy conservation program, an expanded checklist of energy conservation opportunities, additional case studies, and additions and revisions to other sections of the handbook.

With the support of the Federal Energy Administration, the National Bureau of Standards will continue to assist the business community by providing information on energy conservation through additional supplements of the EPIC Handbook. Your suggestions, comments, and contributions are solicited to improve the usefulness of the EPIC program.

Please address your comments and questions to:

Office of Energy Conservation
Center for Building Technology
National Bureau of Standards
Washington, D.C. 20234

Ernest Ambler
Acting Director
National Bureau of Standards

ACKNOWLEDGMENTS

Supplement 1

The material in this supplement is based largely on the comments and suggestions of the users of the first 35,000 copies of EPIC. Helpful information has also been obtained from the use of the Handbook in several energy conservation workshops and in a college-level course in energy conservation.

Assistance in the development of this supplement was provided by Mr. J. B. Roose and his staff of the Industrial Programs Office, Federal Energy Administration, and particularly by Mr. W. M. Porter, now with the Energy Research and Development Administration. Dr. J. E. Snell, Chief, Office of Energy Conservation, and Dr. K. G. Kreider, Program Manager, Industrial Programs, both of NBS, provided additional support essential to the production of this document.

Those whose contributions have been used, but who are not directly acknowledged in the text, include Mr. W. Hung, Deltak Corporation; Mr. K. C. McNabb, Stewart Warner Corporation; Professor W. Rohrer, University of Pittsburgh; Mr. J. Barto, Occupational Safety and Health Administration; Mr. R. H. Wilder, R. H. Wilder, Inc.; Mr. P. J. Frommelt, Frommelt Industries, Inc.; Dr. W. B. Owens, Consultant; Dr. W. J. Helnhoffer, Catholic University; and the Sub-Council on Technology, National Industrial Energy Council.

NBS staff members who contributed importantly to this supplement include Mr. W. F. Druckenbrod, Dr. T. Kusuda, Mr. G. P. Lewett, Mr. W. E. Shipp, and Mr. L. A. Wood. For secretarial services, thanks are due to Mrs. A. Davis and Mrs. S. M. Mader.

The supplement was reviewed by nine members of the staff of the National Bureau of Standards, and by thirty representatives of industry, technical societies, universities, and concerned organizations of the U.S. Government.

R. G. Massey
Editor

IMPORTANT NOTICE

To receive future notices of supplements to this book, you must fill in and return the form at the end of this book, unless you did so previously.

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Conversion Table
To SI Units

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

(1) NBS SP 330, 1974 Edition, "The International System of Units"

(2) E380-74 ASTM Metric Practice Guide (American National Standard Z210.1).

The following table shows conversion factors for the units used in this handbook.

Quantity	To convert from	To	Multiply by
Length	inch	meter (m)	2.540×10^{-2}
	foot	m	3.048×10^{-1}
	mile	m	1.609×10^{3}
Area	sq in	m^2	6.452×10^{-4}
	sq ft	m^2	9.290×10^{-2}
Volume	cu in	m^3	1.639×10^{-5}
	cu ft	m^3	2.832×10^{-2}
	gallon	m^3	3.785×10^{-3}
Temperature	F	Celsius (C)	$t_C = (t_F - 32)/1.8$
T. difference	ΔF	Kelvin (K)	$\Delta K = \Delta t_F/1.8$
Mass	pound	kg	4.536×10^{-1}
	ounce	kg	2.835×10^{-2}
Pressure	psi	N/m^2	6.895×10^{3}
	in of water	N/m^2	2.488×10^{2}
	in of Hg	N/m^2	3.377×10^{3}
	mm Hg	N/m^2	1.333×10^{2}
Energy	Btu	J	1.056×10^{3}
	MBtu	J	1.056×10^{9}
	kWh	J	3.600×10^{6}
	ft lb	J	1.355×10^{0}
Power	Btu/h	W	2.931×10^{-1}
	hp	W	7.460×10^{2}
Flow	gpm	m^2/s	6.309×10^{-5}
	cfm	m^2/s	4.719×10^{-4}
Density	lb/cu ft	kg/m^3	1.602×10^{1}
	lb/gal	kg/m^3	1.198×10^{2}
Heat Capacity	Btu/lb·F	J/kg·K	4.187×10^{3}
	Btu/cu ft·F	J/M^3K	6.717×10^{4}
Conductivity	Btu·in/h·sq ft·F	W/m·K	5.192×10^{2}
Heat of Combustion	Btu/gal	J/m^3	2.790×10^{5}
	Btu/lb	J/kg	2.326×10^{3}
	Btu/cu ft	J/m^3	3.729×10^{4}
Barrel (Petroleum)	42 gal	m^3	1.590×10^{-1}

Section 2

ENERGY CONSERVATION PROGRAM IMPLEMENTATION

TABLE OF CONTENTS

2. ENERGY CONSERVATION PROGRAM IMPLEMENTATION

2.0. INTRODUCTION

This section of the Guide describes and illustrates the actions necessary to initiate and implement a successful energy conservation program. Section 2.1 is an outline of the elements of a program. It may be used as guide to design your own program, tailored to your Company's requirements and capabilities. Note that whether a company is large or small, the four important steps in the energy conservation program are:

Top management commitment and goal

Survey energy uses

Take action to save energy

Develop continuing effort

Section 2.2 discusses in some detail the essential elements common to successful programs. It suggests appropriate procedures to follow, and includes some sample forms for auditing energy conservation.

Sections 2.3 through 2.8 illustrate, by means of forms and sample memoranda based on an actual experience, how an energy conservation program might be initiated.

2.1 PROGRAM OUTLINE

	Reference Section
I. TOP MANAGEMENT COMMITMENT	
A. Inform line supervisors of:	2.3.1
1. The economic reasons for the need to conserve energy	
2. Their responsibility for implementing energy saving actions in the areas of their accountability	
B. Establish a committee having the responsibility for formulating and conducting an energy conservation program and consisting of:	2.3.1
1. Representatives from each department in the plant	
2. A coordinator appointed by and reporting to management Note: In smaller organizations, the manager and his staff may conduct energy conservation activities as part of their management duties.	
C. Provide the committee with guidelines as to what is expected of them:	2.3.1
1. Plan and participate in energy saving surveys	
2. Develop uniform record keeping, reporting, and energy accounting	
3. Research and develop ideas on ways to save energy	
4. Communicate these ideas and suggestions	
5. Suggest tough, but achievable, goals for energy saving	
6. Develop ideas and plans for enlisting employee support and participation	
7. Plan and conduct a continuing program of activities to stimulate interest in energy conservation efforts	
D. Set goals in energy saving:	
1. A preliminary goal at the start of the program	
2. Later, a revised goal based on savings potential estimated from results of surveys	
E. Employ external assistance in surveying the plant and making recommendations, if necessary	6.2
F. Communicate periodically to employees regarding management's emphasis on energy conservation action and report on progress	2.8.1, 2.3.2
II. SURVEY ENERGY USES AND LOSSES	
A. Conduct first survey aimed at identifying energy wastes that can be corrected by maintenance or operations actions, for example:	2.5.2, 2.6.1, 2.6.2, 2.6.3

	Reference Section
1. Leaks of steam and other utilities	
2. Furnace burners out of adjustment	
3. Repair or add insulation	
4. Equipment running when not needed	
5. Inefficient space utilization.	
B. Survey to determine where additional instruments for measurement of energy flow are needed and whether there is economic justification for the cost of their installation	2.5.3
C. Develop an energy balance on each process to define in detail:	2.5.3
1. Energy input as raw materials and utilities	
2. Energy consumed in waste disposal	
3. Energy credit for by-products	
4. Net energy charged to the main product	
5. Energy dissipated or wasted	
Note: Energy equivalents will need to be developed for all raw materials, fuels, and utilities, etc., in order that all energy can be expressed on the common basis of Btu's.	2.5.4
D. Analyze all process energy balances in depth:	2.5.3
1. Can waste heat be recovered to generate steam or to heat water or a raw material?	
2. Can a process step be eliminated or modified in some way to reduce energy use?	
3. Can an alternate raw material with lower energy content be used?	
4. Is there a way to improve yield?	
5. Is there justification for:	
a. Replacing old equipment with new equipment requiring less energy?	
b. Replacing an obsolete, inefficient process plant with a whole new and different process using less energy?	
E. Conduct weekend and night surveys periodically	2.7.5 2.5.2
F. Plan surveys on specific systems and equipment, such as:	2.5.3
1. Steam system	
2. Compressed air system	
3. Electric motors	
4. Natural gas lines	
5. Heating and air conditioning system	
6. Other electrical usage.	
III. IMPLEMENT ENERGY CONSERVATION ACTIONS	
A. Correct energy wastes identified in the first survey by taking the necessary maintenance or operation actions; do the simple things first	2.6.3
B. List all energy conservation projects evolving from energy balance analyses, surveys, etc. Evaluate and select projects for implementation:	
1. Calculate annual energy savings for each project	
2. Project future energy costs and calculate annual dollar savings	
3. Estimate project capital or expense cost	
4. Evaluate investment merit of projects using measures such as return on investment, etc.	
5. Assign priorities to projects based on investment merit	
6. Select conservation projects for implementation and request capital authorization	
7. Implement authorized projects	
C. Review design of all capital projects, such as new plants, expansions, buildings, etc., to assure that efficient utilization of energy is incorporated in the design.	2.7.2
Note: Include consideration of energy availability in new equipment and plant decisions.	
IV. DEVELOP CONTINUING ENERGY CONSERVATION EFFORTS	
A. Measure results:	2.5.7
1. Chart energy use per unit of production by department	2.5.6
2. Chart energy use per unit of production for the whole plant	
Note: The procedure for calculating	2.5.7

	Reference Section
energy consumption per unit of product is presented in "How to Profit by Conserving Energy"	
3. Monitor and analyze charts of Btu per unit of product, taking into consideration effects of complicating variables, such as outdoor ambient air temperature, level of production, product mix, etc.	
a. Compare Btu/product unit with past performance and theoretical Btu/product unit	
b. Observe the impact of energy saving actions and project implementation on decreasing the Btu/unit of product	
c. Investigate, identify, and correct the cause for increases that may occur in Btu/unit of product, if feasible	
B. Continue energy conservation committee activities	2.7.5
1. Hold periodic meetings	
2. Each committee member is the communications link between the committee and the department supervisors represented	
3. Periodically update energy saving project lists	
4. Plan and participate in energy saving surveys	
5. Communicate energy conservation techniques	
6. Plan and conduct a continuing program of activities and communication to keep up interest in energy conservation	
7. Develop cooperation with community organizations in promoting energy conservation	
C. Involve employees	2.7.5
1. Service on energy conservation committee	2.7.4
2. Energy conservation training course	
3. Handbook on energy conservation	2.6.4
4. Suggestion awards plan	
5. Recognition for energy saving achievements	
6. Technical talks on lighting, insulation, steam traps, and other subjects	
7. Posters, decals, stickers	
8. Publicity in plant news, bulletins	
9. Publicity in public news media	
10. Letters on conservation to homes	
11. Talks to local organizations	
D. Evaluate program	
1. Review progress in energy saving	
2. Evaluate original goals	
3. Consider program modifications	
4. Revise goals, as necessary	

2.2 ENERGY CONSERVATION PROGRAM IMPLEMENTATION PLAN

A successful energy conservation plan for any size or kind of business must incorporate certain basic elements. These are: (1) top management commitment, (2) clearly designated program responsibility, (3) defined realistic goals, and (4) means for evaluating or measuring program effectiveness. The degree of emphasis or effort required to satisfy the requirements of these elements will vary with the nature and size of your business, making it necessary for you to tailor a conservation plan to the particular characteristics of your business. It is the purpose of this section to discuss the role of these elements in an energy conservation program, but you must decide how they might best be applied to your own business.

2.2.1 TOP MANAGEMENT COMMITMENT

This is the single, most important element in the initiation of a successful energy conservation plan. Regardless of the size or nature of the organization, top management must exhibit active and continuing leadership and interest in the program. Your employees will apply their best efforts to the program only if their supervisors display a constant awareness of the energy conservation program's importance to the organization. Without complete and continuing top management support, any company energy conservation program is doomed to failure.

2.2.2 PROGRAM RESPONSIBILITY

The planning and implementation of your energy conservation program must be the clearly defined responsibility of an energy program coordinator designated by and responsible to top management. In a small business, the owner, general manager, plant engineer, or maintenance superintendent may assume this role in addition to his other duties. The mission of the energy program coordinator is to develop and implement an energy conservation program capable of achieving the program goal. The energy program coordinator must have top management support to successfully carry out the program for which he is responsible. The assistance of a professionally trained consultant may be of great help to the coordinator in identifying potential energy and cost savings.

2.2.3 PROGRAM GOALS

To provide a target for your energy conservation program, an energy saving goal should be specified. You may wish to initially establish a preliminary goal which might later be revised on the basis of a more thorough analysis of your energy savings potential as determined by surveys of your energy consumption. Your energy program goal should be communicated frequently and clearly to your employees and the goal should offer sufficient incentives to make achievement a challenge. Some suggestions for stimulating and maintaining employee participation in your energy conservation program may be found in Section 8 of this Guide.

2.2.4 PROGRAM IMPLEMENTATION

After your program coordinator has been designated and at least a tentative program goal has been established, the following actions should be taken:

a. **Tabulate your energy consumption** over the preceding twelve months. The Form A, entitled "Monthly Energy Use," Figure 1, is an example of a format which might serve this purpose. Energy quantities may be recorded in any units compatible with the way in which your purchase your energy. To correlate equivalent units from one type of fuel to another, however, Btu's are recommended as the common denominator. Factors for converting the units of various types of fuels to Btu's are contained in Section 4 of this Guide.

b. **Survey your usage of energy** to identify obvious wastes. In a retail or commercial type of business, this survey will be limited to the use of energy for primarily housekeeping functions, such as, space conditioning, hot water and lighting. In an industrial type of business such as manufacturing or processing, this survey should, in addition to the normal housekeeping functions, cover such items as leaking utility lines, damaged insulation, equipment being permitted to idle when it could be turned off, or other instances of improper operation or maintenance. These surveys for wasted energy should be conducted at frequent intervals during both working and non-working hours. For the kinds of energy wastes to look for, consult the energy conservation opportunities (ECO) listed in the checklist, Section 3.1, under "Suggestions for Immediate Action." The Form B, "Energy Saving Survey," Figure 2, is an example of a format which might be used to record the conditions causing your energy wastes.

c. Action should be taken to **correct the energy wastes** found in the above surveys. Most of these conditions can be eliminated by procedural changes. They seldom require capital investment and can result in savings of from 5 to 20 per cent.

d. **More comprehensive surveys,** particularly of manufacturing or process operations, to identify inefficient uses of energy should be conducted. The kinds of energy conservation opportunities you are looking for are those listed under "Other Suggested Actions" in Section 3.1 of this Guide. The objective of these surveys is to analyze your actual energy consumption down to a single process, manufacturing step, or product, and to evaluate these measurements with respect to more efficient use of energy which could be attained by procedural and/or equipment changes in your operation. Depending upon the technical capabilities of your personnel, you may require assistance from your utility company or an outside consultant for these surveys. You may also find it desirable to install additional metering equipment in your plant. Section 9 of this Guide contains some information on various kinds of measuring equipment.

Figures 3, 4, 5, and 6 are examples of forms for tabulating monthly department (or function) use of raw materials and utilities, for computing Btu equivalent of these quantities, and for determining the total Btu/unit output.

These forms provide a means for subdividing energy use in a plant by department or activity for a more detailed analysis of plant energy distribution. The inclusion in Figure 5 of the energy content in the raw material, i.e., the energy used to produce the raw material up to the point the material enters your process provides a total energy content for your products. If these values are not readily available, you may choose to neglect this energy cost. In this case, the processing energy may be used as the raw material energy content in a multi-step operation or as the final energy cost used in calculating the Btu's per unit of production.

Collecting the data on Figures 3, 4, and 5, and plotting the results on Figure 6 will result in a graphic presentation of the progress of your Energy Conservation Program.

In using these forms, or similar ones, it is important to use conversion factors that are meaningful in terms of energy actually used, including unavoidable wastage in boilers and generating plants. For example, the number of Btu's in a pound of steam should be the energy value of the fuel actually used in your boiler to produce that steam. It should take into account the efficiency of the boiler. Similarly, the energy value assigned to a kilowatt hour should be expressed in terms of the fuel used in producing it. This value varies, of course, from one area to another, and even from hour to hour in a given utility. We have chosen 10,000 Btu per kWh as being a reasonably representative figure for the average power plant.

A copy of the do-it-yourself kit "How to Profit by Conserving Energy" developed by the Sub-Council on Technology of the National Industrial Energy Council is shown in Section 2.5.7, page 2-25. The instructions in the kit, page 2-27, detail a suggested procedure for calculating the energy content of a product. Figure 7, "Industrial Plant Survey," is another example of a format for relating energy consumption of specific equipment and processes. This form was developed by a gas utility for its industrial customers.

e. The correction of inefficient uses of energy found during these comprehensive surveys will in many cases require the expenditure of capital for improvements and/or new equipment. Review the case histories of energy use problems similar to yours, which are contained in Section 3 of this Guide, as a basis for estimating the benefits and cost of planned improvements or new equipment.

2.2.5 SUMMARY

In summary, the elements of top management commitment, a designated energy conservation program coordinator, clearly defined goals, and a well conceived and executed conservation evaluation plan are essential. At the same time your employees must be educated in and kept continually aware of the need for efficient use of energy in your business so that the result is a complete plant-wide cooperative effort to achieve more effective use of energy.

Form A

MONTHLY PLANT ENERGY USE

	ELECTRIC POWER			NATURAL GAS			FUEL OIL			COAL			TOTAL Btu	Number of Units Produced	Btu Per Unit of Production
1973	kWh	Btu/kWh	Btu	k cu ft	Btu/k cu ft	Btu	gal	Btu/gal	Btu	TONS	Btu/lb	Btu			
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															
1974															
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															

FIGURE 1

Form B

ENERGY SAVING SURVEY

Department: ____________

Date: ____________

Surveyed by: W.D. SMITH
A.B. JONES

Fuel Gas or Oil Leaks	Steam Leaks	Compressed Air Leaks	Condensate Leaks	Water Leaks	Damaged or Lacking Insulation	Excess Lighting	Excess Utility Usage	Equipment Running & Not Needed	Burners Out of Adjustment	Leaks of or Excess of HVAC	Location	Date Corrected
		near #1 furnace									Furnaces	
					#2 furnace lining						Furnaces	
						Parts Storage					Shop	
										Broken Window	Shop	
									#1 furnace		Heat Treating	
#3 furnace											Heat Treating	
								#2 furnace			Heat Treating	
								#1 conveyor			Assembly	
	Bldg. Heater Trap										Assembly	
						Storage Area					Shipping	
										Doors need weatherstrip	Shipping	
								Man cooler fan			Receiving	
						Above Shelves					Receiving	
								Fume hood fan			Laboratory	
				safety shower							Laboratory	
						Chemical Storage					Laboratory	
	#1 boiler										Utilities	
					#2 steam line						Utilities	
		#2 compressor									Utilities	
	#1 reboiler										Chemicals	
			#2 reboiler								Chemicals	
							steam jets				Chemicals	
						Hallways					Administration Building	
										reheat air condition	Administration Building	
				Men's rm. faucet							Administration Building	

FIGURE 2

Form C

DEPARTMENT ______________

MONTHLY DEPARTMENT ENERGY USE

	ELECTRIC POWER			NATURAL GAS			FUEL OIL			COAL			COMPRESSED AIR		
1973	kWh	Btu/kWh	Btu	k cu ft	Btu/k cu ft	Btu	gal	Btu/gal	Btu	TONS	Btu/lb	Btu	k cu ft	Btu/k cu ft	Btu
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															
1974															
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															

FIGURE 3

Form D

DEPARTMENT ____________

MONTHLY DEPARTMENT ENERGY USE

	psig STEAM			psig STEAM			CONDENSATE USED OR LOST			WATER			TOTAL CONVERSION Btu	NUMBER OF UNITS PRODUCED	CONVERSION Btu PER UNIT OF PRODUCTION
1973	k lb	Btu/k lb	Btu	k lb	Btu/k lb	Btu	k lb	Btu/k lb	Btu	k lb	Btu/k lb	Btu			
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															
1974															
Jan.															
Feb.															
Mar.															
Apr.															
May															
June															
July															
Aug.															
Sep.															
Oct.															
Nov.															
Dec.															

FIGURE 4

Form E

DEPARTMENT ____________

MONTHLY DEPARTMENT ENERGY USE

	RAW MATERIAL "A"			RAW MATERIAL "B"			RAW MATERIAL "C"			Total Raw Material Btu	Raw Material Btu Per Unit of Production	Total Conversion & Raw Material Btu Per Unit of Production
1973	k lb	Btu/k lb	Btu	k lb	Btu/k lb	Btu	k lb	Btu/k lb	Btu			
Jan.												
Feb.												
Mar.												
Apr.												
May												
June												
July												
Aug.												
Sep.												
Oct.												
Nov.												
Dec.												
1974												
Jan.												
Feb.												
Mar.												
Apr.												
May												
June												
July												
Aug.												
Sep.												
Oct.												
Nov.												
Dec.												

FIGURE 5

Form F

Tracking Chart

Energy Use Per Unit of Production

Attachment C

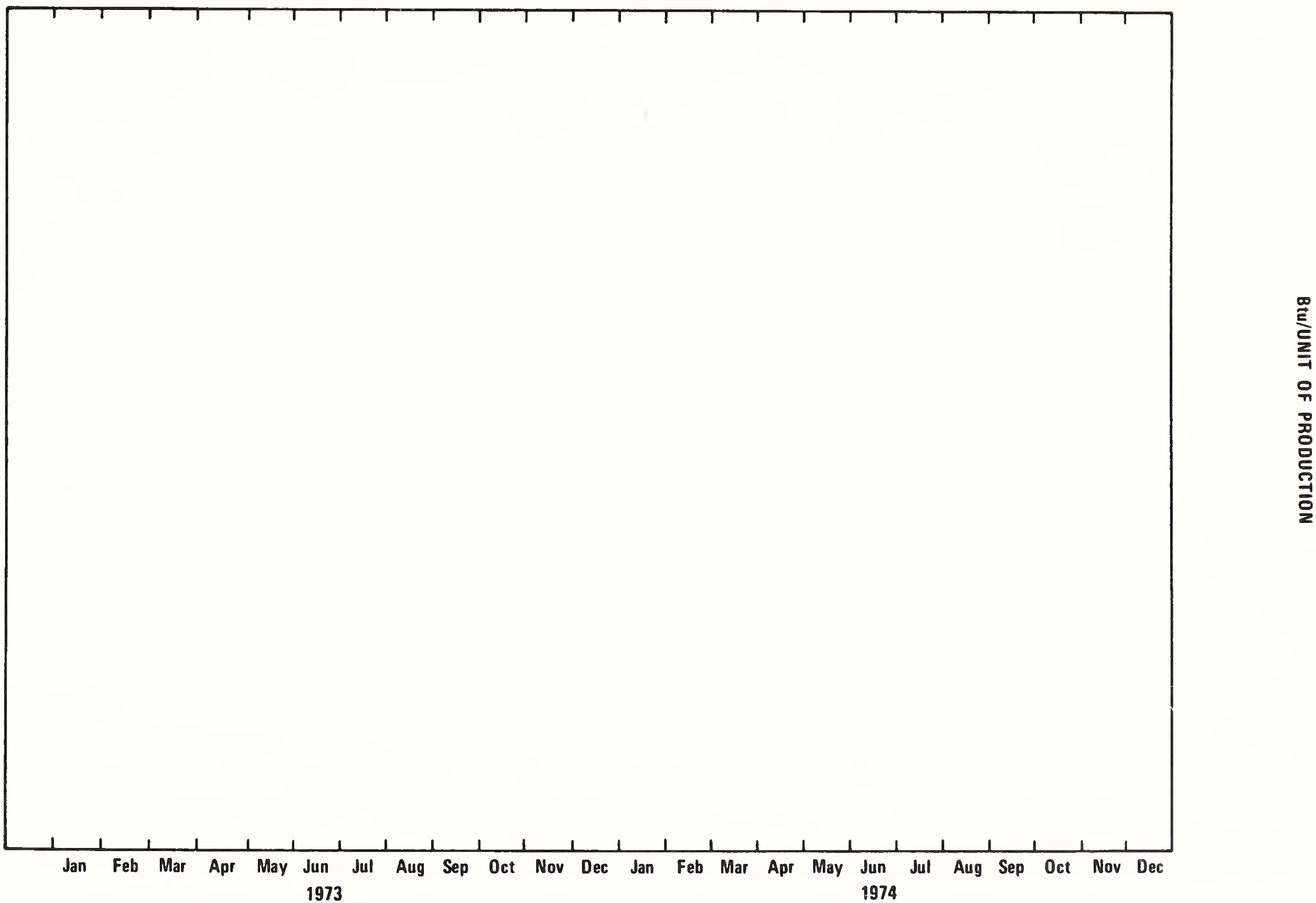


FIGURE 6

INDUSTRIAL PLANT SURVEY

1\.

DATE OF SURVEY ____________ SURVEY MADE BY ____________

PLANT NAME ____________ LOCATION ____________

ADDRESS ____________

____________ MAJOR PRODUCT ____________

PHONE ____________ SIC CODE ____________

CONTACTS

2\.

NAME	TITLE

3\.

TOTAL HOURLY DEMAND ____________ MCFH HOURLY HEATING DEMAND ____________ MCFH

SERVICE LINE SIZE ________ L. S. # ____________ LINE # ____________ SIZE ____________

METERMAKE ____________ SIZE ____________

LINE PRESSURE ____________ MEASURING PRESSURE ____________ DELIVERY PRESSURE ____________

GAS-FIRED SPACE HEAT

4\.

U. H. -- UNIT HEATER W.A.F. -- WARM AIR FURNACE I.R. -- INFRA RED M.U.A. -- MAKE UP AIR S -- SALAMANDER

TYPE	NUMBER OF UNITS	TOTAL INPUT MCFH	TOTAL MCF/DAY (0°F)

BOILER - GAS FIRED

5\.

SIZE HP OR LBS/HR	NO. OF BURNERS	TOTAL INPUT MCFH		OPERATING SCHEDULE			USE %		ALT. FUEL
		RATED	ACTUAL	HRS/DAY	DAY/WK	WKS/YR	HEAT	PROCESS	

BOILER - OTHER FUELS

(OTHER THAN BY-PRODUCT)

6\.

SIZE HP OR LBS/HR	FUEL	FUEL RATE		OPERATING SCHEDULE			USE %	
		RATED	ACTUAL	HRS/DAY	DAY/WK	WKS/YR	HEAT	PROCESS

FIGURE 7

INDUSTRIAL PLANT SURVEY

ALTERNATE FUEL

7.

TYPE OF FUEL	STORAGE CAPACITY		MAX. RATE OF FUEL USAGE	REPLACEMENT CAPABILITY DAYS
	EXISTING	PLANNED		

TOTAL ELECTRIC USE

8. ANNUAL USE ______________________ KWH BILLING DEMAND ______________________ KW OR KVA

PROCESS - GAS FIRED

9.

EQUIPMENT OR PROCESS	NO. OF BURNERS	TOTAL INPUT MCFH		OPERATING SCHEDULE			HOLDING GAS MCF/DAY	ALT FUEL	SURVEYOR'S SUGGESTION C OR NC
		RATED	ACTUAL	HRS/DAY	DAY/WK	WKS/YR			

PROCESS - OTHER FUELS

10.

EQUIPMENT OF PROCESS	FUEL RATE		OPERATING SCHEDULE			FUEL
	RATED	ACTUAL	HRS/DAY	DAY/WK	WKS/YR	

FIGURE 7a

2.3 PROGRAM PLAN ILLUSTRATION

This section illustrates, by a series of memoranda and internal correspondence, the important steps in establishing an energy conservation program in a large size company. Many of these communications could be accomplished verbally at staff or committee meetings and then be documented in minutes. All of your needs may not be anticipated and some of the actions illustrated may not be necessary or appropriate for your management structure, but you will find illustrated in this section most of the necessary communications. Suggested methods and forms for recording and reporting plant survey data and for tracking the progress of the program are included.

Throughout this section, the letters, reports, forms, and meeting agendas are in time sequence. Where appropriate, there are comments or explanations which relate to the following memoranda.

Energy costs and cost projections, quantities of energy, and equivalent energy factors for utilities have been left as blanks, rather than stated numerically, in order to avoid any implication that the figures are typical. Such numbers will vary from industry to industry, plant to plant, and region to region. Each plant must make its own determination of these figures.

Names of individuals and of the company are, of course, fictitious.

The plant manager has decided that energy conservation must become a specific part of the company management program. He takes action by appointing an energy conservation coordinator and requesting the head of each department to select someone to work with the coordinator. His actions are expressed in the following memoranda.

Section 3

ENERGY CONSERVATION OPPORTUNITIES (ECO's)

TABLE OF CONTENTS

3. ENERGY CONSERVATION

3.0 INTRODUCTION

Energy Conservation Opportunities (ECOs) are reported in this section. Section 3.1 is a checklist of such opportunities and Sections 3.2 through 3.13 contain case descriptions of specific applications of ECOs. When a case report is included in EPIC, the checklist item to which it pertains is followed by a subsection number identifying the case report. The checklist and the case reports are categorized in the same manner. One case report may be shown as an example of more than one checklist item.

All of the ECO cases reported are either based on a specific industrial and commercial experience or representative of several experiences. The reports include graphs, tables and sample calculations, as well as a brief description of the circumstances and the action. The calculations are intended to illustrate key steps in estimating energy savings potential and associated cost savings. They are not complete engineering analyses of the application. The cases have been checked for internal consistency but do not contain all of the factors which will affect your decision to implement an ECO.

3.0.1 ENERGY COSTS

It will be noted that costs of fuel, steam, and electric power vary from case to case. In some instances, low energy costs were reported because the projects were actually implemented two or three years ago. The energy costs in hypothetical examples were chosen arbitrarily to reflect current trends. Even so, it is recognized that energy costs vary widely from region to region. When applying a particular ECO appropriate local unit costs must be used to revise the cost calculation. Recent increases in the price of energy indicate that consideration should be given to including energy escalation costs. This will result in a shorter payback period.

3.0.2 ECO SELECTION

The ECOs have been reported from many different sources and where appropriate both the contributor and the company which supplied the case are listed. Even though all ECOs won't apply to your industry, the ideas may help you formulate ECOs applicable to your particular business. The Checklist (Section 3.1.4) may also be used to find ideas for ECOs applicable to your circumstances.

Some of the most profitable areas to check for energy conservation are reported to be waste water, stack gas and exhaust ventilation air containing energy that may be recoverable with heat exchangers. The higher the temperature of the water or the gas, the more energy available for recovery. However, temperature measurement and flow rate surveys must be made (see Section 9) followed by analysis to determine exactly how much energy is available and the practicality of recovering the energy.

3.0.3 SUPPLEMENTS

It is planned that this section of EPIC, the Checklist and case studies, will be expanded in future supplements. You will be notified of the availability of these supplements if you will return the form located in the back of the Handbook or the supplements.

PLEASE NOTE THAT ALL ECO'S USE THE FOLLOWING SYMBOLS:

k = thousand or kilo
M = million or mega

3.1 ENERGY CONSERVATION OPPORTUNITY CHECKLIST

3.1.1 FACTORS TO CONSIDER IN EVALUATING ECO's

The ECO's in the checklist are suggested possibilities for conserving energy. However, any ECO requires careful evaluation for a specific application. For instance, the possibility that under certain circumstances an ECO could be counterproductive needs to be determined for the application.

In some cases existing equipment will have operating limits which must be considered. For example, excessive insulation on a furnace roof can confine too much heat, overheat the refractory, and cause failure of the roof.

Other factors to be considered are listed in the form, ""Energy Conservation Project Evaluation Summary" in Section 2.7.3. Information on financial analysis and safety and pollution considerations appears in Section 5 and Section 7 respectively.

3.1.2 BUILDINGS AND GROUNDS

Suggestions for Immediate Action

	REFERENCE RELATED ECO
Reduce Ventilation Air	3.2.1
Increase Light Reflectance of Walls and Ceilings	
Shut Off Air Conditioning in Winter Heating Season	
Eliminate Unused Roof Openings or Abandoned Stacks	
Reduce Building Exhausts and Thus Make-Up Air	
Reduce Glazed Areas in Buildings	
Reduce Temperature of Service Hot Water	
Shut Down Air Conditioning During Non-Working Hours	3.2.2
Reduce Heating Level When Building Is Not in Use	3.2.5
Install Timers on Light Switches in Little Used Areas	
Close Holes and Openings in Buildings Such as Broken Windows, Unnecessary Louvers and Dampers, Cracks Around Doors and Windows	
Repair Faulty Louvers and Dampers	
Conserve Energy by Efficient Use of Water Coolers and Vending Machines	3.2.3
Schedule Use of Elevators to Conserve Energy	3.2.4
Use Cold Water for Clean Up Whenever Possible	
Analyze Pipe and Duct Insulation—Use Amount Necessary to Accomplish Task	
Clean or Replace Air Filters Regularly	
Centralize Control of Exhaust Fans to Ensure Their Shutdown	
Mix Hot Air Near the Ceiling with Outside Air, Then Recirculate	
Plant Trees or Shrubs Near Windows to Shield From Sunlight	
Change Zone Reheat Coils to Low Pressure Variable Air Volume Boxes	
Replace High Resistance Ducts, Pipes, and Fittings	
Close Outdoor Air Dampers During Warm-up or Cool-down Periods Each Day	

Other Suggested Actions

	REFERENCE RELATED ECO
Reduce Air Conditioning Load by Evaporating Water from Roof	
Convert to Fluorescent, Mercury, Sodium, or High Intensity Direct Lighting	
Insulate Walls, Ceilings, and Roofs	
Install Timers on Air Conditioning for Summer Operation	
Periodically Calibrate the Sensors Controlling Louvers and Dampers on Buildings	
Eliminate Inefficient Electric Lamps from Plant Stocks and Catalogs	3.3.2
Clean Air Conditioning Refrigerant Condensers to Reduce Compressor Horsepower — Check Cooling Water Treatment	
Use "Heat Wheel" or Other Heat Exchanger to Cross-Exchange Building Exhaust Air with Make-up Air	
Use Photocell Control on Outdoor Lights	
Use Building Materials Which Require Less Energy to Produce	
Size Air Handling Grills, Ducts, and Coils to Minimize Air Resistance	
Recover Heat in Waste Service Hot Water	
Avoid Introducing High Moisture Exhaust Air Into Air Conditioning System	
Air Condition Only Space in Use	
Shade Windows from Summer Sun	
Use Direct Air Supply to Exhaust Hoods	
Use Exhaust Heat from Buildings for Snow and Ice Removal from Walks, Driveways, Parkways, Parking Lots, etc.	
Use Separate Switches on Perimeter Lighting Which May be Turned Off When Natural Light is Available	

	REFERENCE RELATED ECO
Use Double or Triple Glazed Windows to Maintain Higher Relative Humidity and to Reduce Heat Losses	
Heat Water During Off-Peak Periods and Store for Later Use	
Use Heat Pump for Space Conditioning	
Heat Service Hot Water with Air Conditioning Compressor Exhaust	
Use Radiant Heater for Spot Heating Rather than Heating Entire Area	
Reduce or Eliminate General Lighting Where Natural Light Provides Sufficient Illumination. Limit Higher Lighting Levels to Task Areas Only	
Reduce Exterior Buildings and Grounds Illumination to Minimum Safe Level	3.13.1

	REFERENCE RELATED ECO
Interlock Heating and Air Conditioning Systems to Prevent Simultaneous Operation	
Recycle Air for Heating, Ventilation and Air Conditioning to Maximum Extent	
Minimize Use of Outside Make-Up Air for Ventilation Except When Used for Economizer Cycle	
Lower Light Fixtures in High Ceiling Areas	
Reduce General Illumination to Minimum Necessary for Safety	3.2.6
Replace Air Curtain Doors with Solid Doors	
Reduce Heat Gain by Window Tinting	3.2.8
Minimize Water Use in Lavatories by Choosing Appropriate Fixtures and Valves	
Recover Heat in Domestic Hot Water Going to Drain	
Install Storm Windows and Doors	

3.1.3 ELECTRICAL POWER

	REFERENCE RELATED ECO
Other Suggested Actions	
Use Combined Cycle Gas Turbine Generator Sets with Waste Heat Boilers Connected to Turbine Exhaust	
Replace Steam Jets on Vacuum Systems with Electric Motor Driven Vacuum Pumps	
Size Electric Motors for Peak Operating Efficiency—Use Most Efficient Type of Electric Motors	
Use Power During Off-Peak Periods —Store Heated/Cooled Water for Use During Peak Demand Periods	
Use Steam Pressure Reduction to Generate Power	
Use Immersion Heating in Tanks, Melting Pots, etc.	
Reduce Load on Electric Conductors to Reduce Heating Losses	
Increase Electrical Conductor Size to Reduce Distribution Losses	
Optimize Plant Power Factors	
Use By-Product Heat from Transformers for Service Water Heating	3.3.3
De-energize Excess Transformer Capacity	
Provide Proper Maintenance and Lubrication of Motor Driven Equipment	
Consider Energy Efficiency When Purchasing New Equipment	
Consider Power Loss as Well as Initial Loads and Load Growth in Sizing Transformers	
Schedule to Minimize Electrical Demand Charge	3.3.1
Use Multiple Speed Motors or Variable Speed Drives for Variable Pump, Blower and Compressor Loads.	
Check for Accuracy of Power Meter	
Optimize Motor Size with Load to Improve Power Factor and Efficiency	

3.1.4 STEAM

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Turn Off Steam Tracing During Mild Weather	
Maintain Steam Jets Used for Vacuum System	
Repair Leaks in Lines and Valves	3.4.5
Repair Insulation on Condensate Lines	
Repair Faulty Insulation on Steam Lines	
Repair or Replace Steam Traps	3.4.6
Eliminate Leaks in High Pressure Reducing Stations	
Cover Condensate Storage Tanks	
Other Suggested Actions	
Consider Replacing Electric Motors with Back Pressure Steam Turbines and Use Exhaust Steam for Process Heat	
Operate Distillation Columns at Minimum Quality Requirements	
Operate Distillation Columns at Near Flooding Conditions for Maximum Separation Efficiency	
Determine Correct Feed Plate Location on Distillation Columns to Increase Efficiency and Minimize Steam Consumption	
Consider Switching Selected Steam Stripping Distillation Units from Direct (Live) Steam to Indirect (Dry) Stripping	
Use Heat Exchange Fluids Instead of Steam in Pipeline Tracing Systems	3.12.2
Clean Steam Coils in Processing Tanks	

	REFERENCE RELATED ECO
Use Correct Size Steam Traps	
Flash Condensate to Produce Lower Pressure Steam	3.4.4
Evaluate Replacing Condensing Steam Turbine Rotating Equipment Drives with Electric Motors, If Your Plant Has a Power Generating Capability	
Add Traps to a Distillation Column to Reduce the Reflux Ratio	
Insulate Condensate Lines	
Minimize Boiler Blowdown with Better Feedwater Treatment	
Insulate Steam Lines	3.4.1
Install Steam Traps	3.4.2
Return Steam Condensate to Boiler Plant	3.4.3
Use Minimum Steam Operating Pressure	
Use Waste Heat Low Pressure Steam for Absorption Refrigeration	
Replace Barometric Condensers with Surface Condensers	
Shut Off Steam Traps on Superheated Steam Lines When Not in Use	
Optimize Operation of Multi-Stage Vacuum Steam Jets	
Use Optimum Thickness Insulation	
Use Reflux Ratio Control or Similar Control Instead of Flow Control on Distillation Towers	
Substitute Hot Process Fluids for Steam	
Use Steam Sparging or Injections in Place of Indirect Heating	3.12.3
Use Steam Condensate for Hot Water Supply (Non Potable)	

3.1.5 OTHER UTILITIES

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Clean Fouling from Water Lines Regularly	
Shut Off Cooling Water When Not Required	
Reduce Business Travel By Using Telephone When Possible	
Conduct Monthly Audit of Water Meters for Early Leak Detection	
Clean or Replace Air Filters Regularly	
Remove Unneeded Service Lines to Eliminate Potential Leaks	
Eliminate Leaks in Combustible Gas Lines	3.5.1
Eliminate Leaks in Inert Gas and Compressed Air Lines and Valves	3.5.3
Eliminate Leaks in Water Lines and Valves	
Shut Off All Laboratory Fume Hoods When Not In Use	
Other Suggested Actions	
Install Adequate Dryers on Air Lines to Eliminate Blowdown	
Install Compressor Air Intakes in Coolest Locations	3.5.4
Recover and Reuse Cooling Water	
Do Not Use Compressed Air for Personal Cooling	3.5.5
Use Flow Control Valves on Equipment to Optimize Water Use	
Evaluate Water Cooling vs. Air Cooling for Specific Situations	
Check for Accuracy of Utility Meters	
Eliminate or Reduce Compressed Air Used for Cooling Product, Equipment, or for Agitating Liquids	

	REFERENCE RELATED ECO
Replace Water Cooling on Processes with Air Cooling Where Possible	
Recover Heat from Compressed Air Dryers	
Eliminate Cooling of Process Streams Which Subsequently Must Be Heated and Vice Versa	
Shut Off Cooling If Cold Outside Air Will Cool Process	
Use Cascade System of Recirculating During Cold Weather to Avoid Sub-Cooling	
Operate Cooling Towers at Constant Outlet Temperature to Avoid Sub-Cooling	
Use Minimum Cooling Water to Bearings	
Increase the Level of the Water in a Drainage Ditch To Reduce the Pumping Head and Horsepower Required Where Drainage Water Must be Pumped Over a Levee for Disposal	
Reduce Sewer Liquid Volume Which Reduces Treatment Energy by Returning Steam Condensate to Boilers	
Replace Over-Size Motors and Pumps with Optimum Size	
Reduce the Pressure of Compressed Air to the Minimum Required	3.5.2
Reduce Hot Water Temperature to the Minimum Required	
Recycle Treated Water	
Eliminate Compressed Air Drives from Permanent Installations	

3.1.6 HEAT RECOVERY

Other Suggested Actions

Action	REFERENCE RELATED ECO
Use the Overhead Condenser to Generate Steam From Condensates in a Distillation Process	
Use Hot Flue Gases in Radiant Heater for Space Heating, Ovens, Dryers, etc.	
Use Heat in Flue Gases to Preheat Products or Material Going into Ovens, Dryers, etc.	
Use Hot Process Fluids to Preheat Incoming Process Fluids	
Use Hot Flue Gases to Preheat Wastes for Incinerator Boiler	
Use Waste Heat from Hot Flue Gases to Generate Steam for Processes or Consider Selling Excess Steam	3.6.3
Use Waste Heat from Hot Flue Gases to Heat Space Conditioning Air	3.6.1
Use Waste Heat from Hot Flue Gases to Preheat Combustion Air	3.6.7
Use Engine Exhaust Heat to Make Steam	3.6.2
Recover Heat from Hot Waste Water	3.6.9
Use Oven Exhaust to Preheat Air	3.6.10
Recover Fuel Value in Polluted Exhaust Air	3.6.11
Recover Fuel Value in Waste By-Product	3.6.4, 3.6.5
Use Flue Gases to Heat Process or Service Water	3.6.6
Use Oven Exhaust for Space Heating	3.6.8
Recover Heating or Cooling Effect from Ventilation Exhaust Air to Precondition Incoming Ventilation Air	
Use Recovered Heat from Lighting Fixtures for Useful Purpose, i.e., to Operate Absorption Cooling Equipment	3.2.5
Use Flue Gas Heat to Preheat Boiler Feedwater	3.6.1
Use Cooling Air Which Cools Hot Work Pieces for Space Heating or Make-Up Air in Cold Weather	

3.1.7 HEAT CONFINEMENT	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Repair Faulty Insulation in Furnaces, Boilers, etc.	
Other Suggested Actions	
Use Economic Thickness of Insulation for Low Temperatures	
Increase Insulation Thickness	
Cover Open Tanks with Floating Insulation to Minimize Energy Losses	3.7.1
Use Soft Insulation in Cycling Furnaces to Facilitate Heating Up and Cooling Down	
Use Minimum Safe Oven Ventilation	
Upgrade Insulation and Linings in Furnaces, Boilers, etc.	
Repair Furnaces and Oven Doors So That They Seal Efficiently	

3.1.8 COMBUSTION

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Calculate and Plot Boiler Efficiency Daily	3.8.4
Establish Burner Maintenance Schedule	
Adjust Burners for Efficient Operation	
Other Suggested Actions	
Improve Combustion Control Capability	3.8.1; 3.8.2
Heat Oil to Proper Temperature for Good Atomization	3.8.3
Keep Boiler Tubes Clean (Fireside)	3.8.7
Keep Boiler Tubes Clean (Waterside)	3.4.7
Analyze Flue Gas for Proper Air/Fuel Ratio	
Eliminate Combustible Gas in Flue Gas	3.8.5
Reduce Combustion Air Flow to Optimum	3.8.6
Convert Combustion to More Efficient Fuel	
Replace Obsolete Burners with More Efficient Ones	
Use Waste and By-Products as Fuel	
Limit and Control Secondary Combustion Air in Furnace Operations to the Amount Required for Proper Furnace Operation	

3.1.9 SCHEDULING	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Shut Down Process Heating Equipment When Not in Use	3.9.2
Other Suggested Actions	
Locate Causes of Electrical Power Demand Charges, and Reschedule Plant Operations to Avoid Peaks	3.3.1
Reduce Temperature of Process Heating Equipment When on Standby	3.9.1
Use Most Efficient Equipment at It's Maximum Capacity and Less Efficient Equipment Only When Necessary	
Use Drying Oven (Batch Type) on Alternate Days or Other Optimum Schedule to Run Equipment with Full Loads	

	REFERENCE RELATED ECO
Heat Treat Parts Only to Required Specifications or Standards	3.9.3
Schedule Routine Maintenance During Non-Operating Periods	
Consider Three or Four Days Around-the-Clock Operation Rather Than One or Two Shifts Per Day	
Minimize Operation of Equipment Required to be Maintained in Standby Condition	
Reduce Operating Time of Equipment to That Actually Required	3.9.4
Optimize Production Lot Sizes and Inventories	

3.1.10 MATERIALS HANDLING

REFERENCE RELATED ECO

Suggestions for Immediate Action

Turn Off Conveyors, Lift Trucks, etc. When Not In Use

Recharge Batteries on Materials Handling Equipment During Off-Peak Demand Periods

Adjust and Maintain Fork Lift Trucks for Most Efficient Operation

Shut Down Diesel Construction Equipment When Not Needed

Other Suggested Actions

Use Optimum Size and Capacity Equipment

Upgrade Conveyors

Use Gravity Feeds Wherever Possible

Improve Lubrication Practices — 3.10.1

3.1.11 SHIPPING, DISTRIBUTION, AND TRANSPORTATION

Suggestions for Immediate Action

	REFERENCE RELATED ECO
Schedule Regular Maintenance to Maintain Efficiency of Truck Engines	
Shut Down Truck Engines While Loading, Unloading, or Waiting	
Keep Loading Dock Doors Closed When Not In Use	
Turn Off Equipment During Lunch Breaks	
Consider Intermediate or Economy Size Autos and Trucks for Company Sales and Plant Fleets	
Change to Lower Energy Content Packaging	
Use Only Amount of Packaging Material Necessary	
Consider Use of Bulk Materials Where Possible	
Add Air Shields to Long Distance Trucks to Increase Fuel Mileage	

Other Suggested Actions

	REFERENCE RELATED ECO
Size Trucks to Job	
Reduce Delivery Schedules	
Consolidate Deliveries	
Eliminate Lighting on Top of Stacked Material	
Install Air Seals Around Truck Loading Dock Doors	
Optimize Routing of Delivery Trucks to Minimize Mileage	3.11.1
Evaluate Energy Use in Packaging	3.11.2

3.1.12 PROCESS CHANGES

Other Suggested Actions

	REFERENCE RELATED ECO
Schedule Baking Times of Small and Large Components to Minimize Use of Energy	3.9.3
Use Vapor Recompression Design in Distillation Processes	
Use "Side Draw" Principle in Distillation Column Design	
Use Continuous Equipment Which Retains Process Heating Conveyors Within the Heated Chamber	
Use Direct Flame Impingement or Infrared Processing for Chamber Type Heating	
Convert from Indirect to Direct Firing	
Use Batch Firing with Kiln "Furniture" Designed Specifically for the Job	
Salvage and Re-Use Process Waste	
To Drive Off Combustible Solvents, Use Only Amount of Air Necessary to Prevent Explosion Hazard and to Protect Personnel	
Increase Use of Re-Cycled Material	
Use Small Number of High Output Units Instead of Many Small Inefficient Units	
Avoid Cooling of Process Streams or Materials That Must Subsequently be Heated	
Reschedule Plant Operation to Minimize Electric Power Demand Peaks	
Convert from Batch to Continuous Operation	
Use Shaft Type Furnaces for Preheating Incoming Material	
Convert Liquid Heaters from Underfiring to Immersion or Submersion Heating	
Minimize Unessential Material in Heat Treatment Process	3.12.1
Change Product Design to Reduce Processing Energy Requirements	
Reduce Scrap Production	
Upgrade Obsolete or Little Used Equipment	

3.1.13 COMMERCIAL PRACTICES

	REFERENCE RELATED ECO
Suggestions for Immediate Action	
Shut-Down Air Conditioning During Non-Working Hours	3.2.2
Reduce Heating Level When Building is Not in Use	3.2.5
Air Condition Only Space in Use	
Reduce Business Travel by Using Telephone When Possible	
Turn Off Lights, Electric Typewriters and Other Such Equipment When Not in Use	3.2.6, 3.2.7
Replace Broken Windows and/or Window Sash	
Maintain Space Temperature Lower During the Winter Season and Higher During the Summer Season	
Reduce Interior Lighting to Minimum Necessary Level	
Reduce Hot Water Temperature in Washrooms to 120F	
Avoid Electrically-Powered Animated Displays	
Urge Customers to Take Merchandise with Them	
Reduce Lighting of Used-Car Lots After Midnight	
Eliminate or Reduce Lighting of Outdoor Displays and Signs	
Utilize Daylight Whenever Possible in Lieu of Artificial Light	
Add Area Lighting Switches to Allow Smaller Areas to be Darkened When Not in Use	
Use Computer Programs, for Example, an Enthalpy Optimization Program to Reduce Heating and Mechanical Cooling Requirements of HVAC Equipment	

	REFERENCE RELATED ECO
Delay Turning on Heating and Air Conditioning Equipment Until Necessary	
Revise Conference Room Ventilation System to Shut Off When Room is Not in Use	
Install Timers on Light Switches in Little Use Areas	
Keep Doors and Windows Shut to Retain Heated or Air Conditioned Air	
Overlap the Work Hours of Custodial Services with Normal Day Hours	
Turn On Display Merchandise, Such as Radios, TV Sets, Washers, Dryers, Power Tools, etc., for Demonstration Only When Requested by Customer	
Consolidate Freight Shipments and/or Deliveries	
Other Suggested Actions	
Shade Windows From Summer Sun	
Reduce Exterior Buildings and Grounds Illumination to Minimum Safe Level	3.13.1
Clean or Replace Air Filters Regularly	
Use More Efficient Light Sources, i.e. Fluorescent Lamps for Incandescent Bulbs	
Use Light Color Finishes on Ceilings, Walls, Floors and Furnishings	
Keep Lamps and Reflectors Clean	
Reduce Illumination to Minimum Necessary Level Except Where Custodial Work is Actually Being Performed	

REDUCE WAREHOUSE VENTILATION

Energy savings may be realized by reducing forced ventilation in buildings to a lesser but still adequate amount required to provide safe conditions.

The air flow from a centrifugal fan varies directly as its rotational speed. Thus, the amount of ventilation can be reduced by decreasing fan speed. Figure 1 shows the air flow from a centrifugal fan versus the power required to drive it, both as percent of full rating.

EXAMPLE

A new 150,000 cubic foot warehouse was constructed with provision for five air changes per hour. This required a 10 hp motor (with a fan load of 9.83 hp) driving a 24 inch centrifugal fan at 915 rpm to deliver air at the rate of 12,500 cfm. Later information showed that only four changes per hour would be adequate, or 80% of the original design. Pulley changes were made, therefore, to reduce the fan speed to 915 × 0.80, or 732 rpm.

Reference to Figure 1 shows that with the fan speed reduced to 80% of full rating, the power required to drive it is only 50% of full load. Assuming a motor efficiency of 80% at full load,

Power at full load = 9.83 hp × 0.746 kW/hp × 1/0.80
= 9.166 kW

Assuming a drop in motor efficiency to 77%,

Power at 50% load = 9.83 hp × 0.50 × 0.746 kW/hp × 1/0.77
= 4.762 kw

Elec. Power saving = (9.166 − 4.762)kW × 8760 h/yr
= 38,600 kWh/yr

If the utility consumes 10,000 Btu of fuel/kWh generated,

Annual energy savings = 38,600 kWh/yr × 10,000 Btu/kWh
= 386 MBtu per year

If the cost of electric power is $0.02 per kWh,

Annual cost saving = 38,600 kWh/yr × 0.02 $k/Wh
= $770 per year

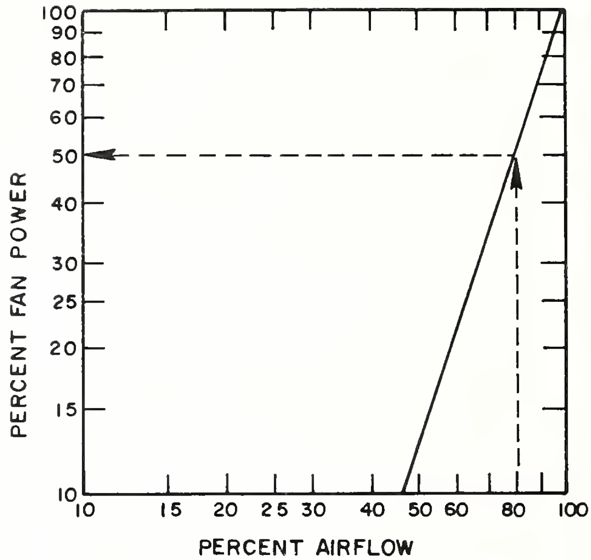


FIGURE 1. *Decrease in horsepower accomplished by reducing fan speed (based on laws of fan performance).*

SUGGESTED ACTION

Determine whether the number of air changes provided by your ventilation system can be reduced and still maintain safe conditions.

Fan speed can be reduced, and energy saved, merely by changing pulleys. If the motor operates at less than 50% of its rated load, however, its efficiency may be very poor and its power factor unduly high. In such cases, consult the motor manufacturer to determine electric efficiencies and power factors at low loads. In some cases a smaller motor rated for the job will produce greater savings.

(Note: Reducing ventilation may also reduce the energy requirements for heating and cooling.)

REFERENCE

Heating, Refrigerating, Ventilating and Air Conditioning Guide and Data Book—Equipment—1972
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
345 E. 47th Street
New York, New York 10017

SOURCE Based on J. R. Kernan—"Examples of Energy Conservation," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

EXAMPLE

Elevators are a common source of energy loss, particularly when used in lieu of stairs for one or two floor trips. Elevator lighting is also an area of energy waste. Elevators often have 300 or more watts of fluorescent lighting when only 30 watts are needed. These lights burn for 24 hours a day, 365 days a year in many installations. This alone is a waste of 2370 kilowatt hours per year per elevator ($71.00) in electrical energy. The following table presents the electrical energy consumption data and its annual cost for four typical elevators used for 600 one floor trips per year.

SUGGESTED ACTION

Energy savings can be realized very quickly by several methods. First, when there are two elevators (or more) side by side serving a building, one (or more) may be shut down. This will force more passengers per load. Educate your employees by the use of memos and signs to use the stairs for short up and down trips. As an additional savings measure, lighting in the elevators being used should be reduced to minimum required for safety.

SOURCE Based on D. Rudawitz—"Reports on Energy Conservation in Industry," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

ENERGY USAGE CHARACTERISTICS FOR FOUR TYPICAL ELEVATORS

Type	Weight Capacity	fpm Average	watts	sec/ floor	600 one floor trips/d
Hydraulic Type I	1500	100	10 kW	8	13 kWh/d 65 kWh/wk 3380 kWh/yr ($101/yr)*
Electric Type I	2000	250	12 kW	5	10 KWh/d 50 kWh/wk 2600 kWh/yr ($78/yr)*
Hydraulic Type II	2000	125	12 kW	7	14 kWd/d 70 kWh/wk 3640 kWh/yr ($109/yr)*
Electric	2500	350	16 kW	3	8 kWh/d 40 kWh/wk 2080 kWh/yr ($62/yr)*

Based on information from Otis Elevator Company and Dover Elevator Company.

*Using an assumed average cost per kilowatt-hour of $.03.

REDUCE SPACE HEATING DURING NON-WORKING HOURS

EXAMPLE

An oppprtunity to conserve energy and save \$3130 per year was identified as a reduction in space heating in a fabric slip-cover plant. The plant consists of a 4800 sq ft office building attached to a 100,000 sq ft production building. Both areas are electrically heated and were maintained at a constant temperature of 68 F throughout the entire heating season. This required some supplemental heat from lighting for the production area in extreme winter weather. The plant operates only one eight-hour shift per day, five days per week. The heat required to maintain a constant 68 F was calculated to be 533,590 Btu/h at the average outside air temperature of 53 F during the heating season.

Reduction of all space temperatures to 58 F during all non-working hours (includes weekends and holidays) throughout the heating season has resulted in savings of 417,500 kWh for heating. This allows for use of 75 kW of lighting for a total of 686 hours to supplement heating in the operating area in extreme weather. Net savings is about \$3130 per heating season.

An estimate of the savings resulting from reducing the heating schedule can be made as follows:

Total hours = 258 d/yr × 24 h/d
= 6192 h/yr

Non-working hours = 258d/yr × 1 wk/7d
× (168 − 40)h/wk
+ (4 holidays × 24 h/d)
= 4813 h/yr

Working hours = 6192 h/yr − 4813 h/yr
= 1379 h/yr

Energy required to maintain 68 F for the total heating season,

Annual heating energy = 533,590 Btu/h × 6192 h/yr
= 3300 MBtu/yr

Energy required by the reduced heating schedule,

During working hours = 533,590 Btu/h × 1379 h/yr
= 736 MBtu/yr

Non-working hours = (58–52)F/(68–52)F × 533,490 Btu/h × 4813 h/yr
= 963 MBtu/yr

Total energy required = 736 MBtu/yr + 963 MBtu/yr
= 1700 MBtu/yr

Heat saved per season = (3300 – 1700) MBtu/yr
= 1600 MBtu/yr

Electricity saved = 1600 MBtu/yr × 1 kWh/3412 Btu
= 469,000 kWh/yr

Extra lighting required = 686 h/yr × 75 kW
= 51,500 kWh/yr

Net electrical savings = (469,000–51,500) kWh/yr
= 417,500 kWh/yr

If the utility uses 10,000 Btu fuel/kWh,

Annual energy savings = 417,500 kWh/yr × 10,000 Btu/kWh
= 4175 MBtu per year

For electric power at a cost of \$0.0075/kWh,

Annual cost saving = 417,500 kWh/yr × 0.0075\$/kWh
= \$3130 per year

SUGGESTED ACTION

Evaluate your space heating requirements. Maintain 68 F during periods that your plant is occupied and the lowest practical temperature during unoccupied periods. Savings will become more and more important as the cost of energy increases.

SOURCE Reported by Carolina Power and Light Company for Reeves Manufacturing Company at Kenansville, N.C.

REDUCE NON-ESSENTIAL LIGHTING

EXAMPLE

Energy may be conserved by reducing non-essential lighting. Such an opportunity to reduce costs by almost $7800 per year was identified by a fabric slip-cover plant that operates one eight-hour shift per day, five days per week. The plant consists of a 4800 sq ft office building attached to a 100,000 sq ft manufacturing building. Both buildings are lighted by a total of 2,200 eight-foot long fluorescent lamps (110 watt plus 10 watt ballast per lamp). The normal practice of this plant was to leave all lights burning Monday through Friday, 24 hours per day, 50 weeks per year.

A lighting plan was instituted for non-operating hours which provided illumination only for required maintenance and security. The elimination of non-essential lighting resulted in a lighting plan equivalent to burning all lights only 10 hours per day, 250 days per year.

An annual power saving of $7090 was achieved, plus a reduction in lamp replacement cost of $710, for a total saving of $7800 per year.

The electrical energy saving by the new plan is calculated as follows:

Annual Power Saving = (24 − 10) h/d × 250 d/yr × 120 w/lamp × 2200 lamps = 924,000 kWh per year

At a cost for electricity of $0.007677 kWh
Annual Power Cost Saving = 924,000 kWh/yr × 0.007677 $/kWh = $7090 per year

If the utility consumes 10,000 Btu of fuel per kWh,

Annual Energy Saving = 924,000 kWh/yr × 10,000 Btu/kWh = 9240 MBtu/yr

In addition to power costs for the two different schedules, one must consider lamp replacement costs. This depends, among other things, on the actual operating cycle. The annual replacement cost for fluorescent lamps may be estimated as follows:

Annual Replacement Cost

$$= (P + h) \times (C\ d/L) \times n$$

Where,

P = price of replacement lamp
h = labor cost of replacing lamps
C = lamp life hours consumed by each operating period (hours per start) as estimated from Figure 1
d = number of operating periods per year
L = average lamp life at 3 hours per start
n = number of lamps

For this case the labor cost (h) is $2.00, and the price ($P$) is $1.42 per lamp with average life (L) of 12,000 hours. As stated previously, there are 2200 lamps (n).

For the old plan, there were 5 × 24 = 120 hours per operating period; hence from Figure 1, C = approx. 60 h. There were 50 operating periods (d) per year.

Replacement cost (old) = (2.00 + 1.42) $/lamp × 60 h/period × 50 periods × 2200 lamps/ 12000 h = $1880 per year

For the new plan there are 250 periods (d) of 10 hours each; C from Figure 1 is 7.5 h.

Replacement cost (new) = (2.00 + 1.42) $/lamp × 7.5 h/period × 250 periods × 2200 lamps/ 12000 h = $1170 per year

Replacement saving (net) = $1880 − $1170 = $710 per year

Total annual saving = $7090 + $710 = $7800 per year

Electrical costs higher than rate used here will obviously result in higher savings.

SUGGESTED ACTION

Review your lighting practices and eliminate all nonessential lighting during working hour. During nonworking hours, operate only those lights that are required for plant security and the performance of janitorial services. If possible, schedule all janitorial services to be accomplished simultaneously by area to minimize the use of lights throughout the plant for long periods of time. Install more switches to increase control of lighting. Consult your utility company, lighting consultant, manufacturer for recommendations.

REFERENCE "Fluorescents — ON/OFF," *Lighting Design and Application* Jan. 1973, p. 38.

SOURCE Reported by Carolina Power and Lighting Company for Reeves Brothers Manufacturing Company at Kenansville, N.C.

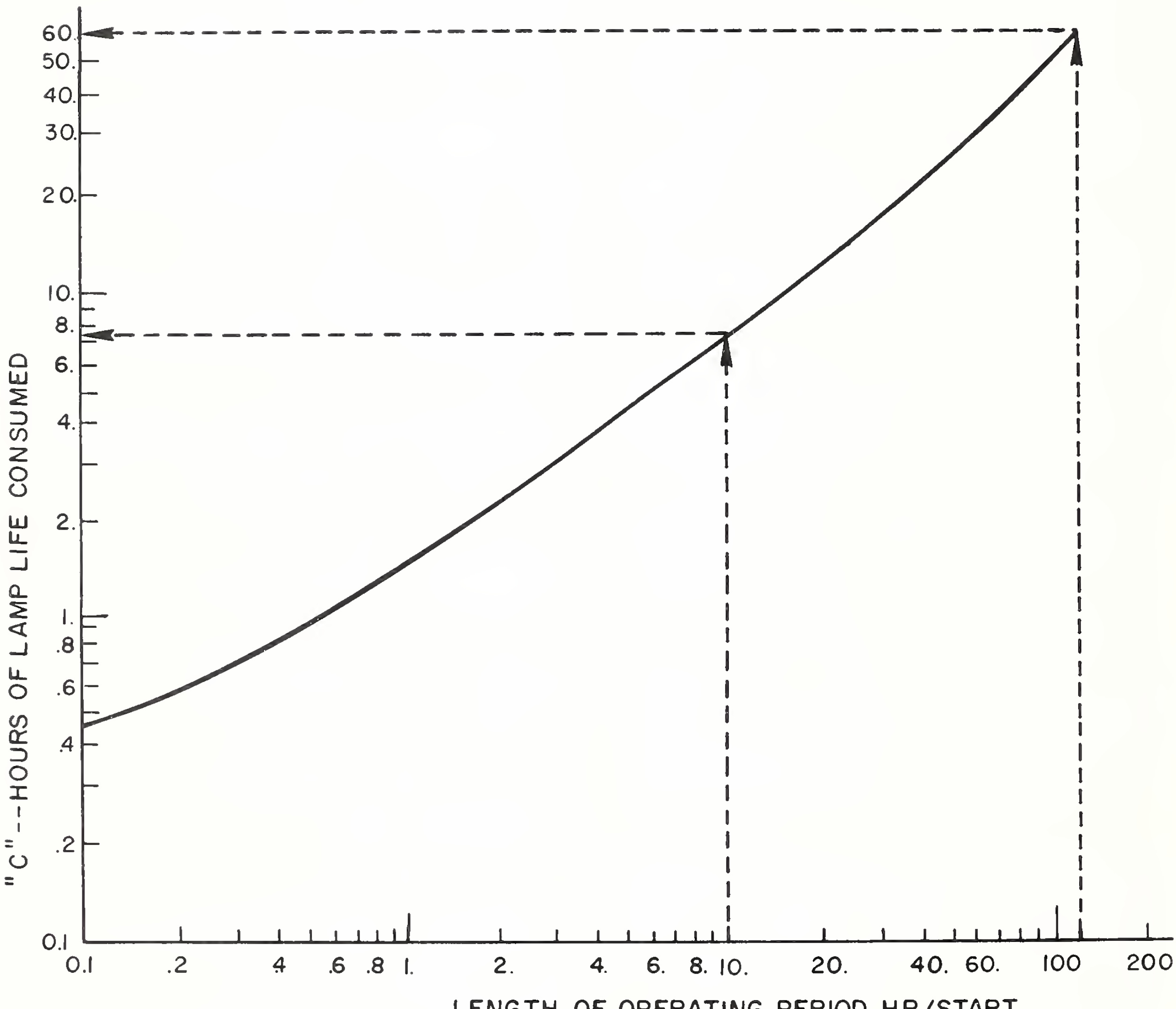


FIGURE 1. *Lamp life hours consumed for each operating period from reference 1.*

TURN OFF FLUORESCENT LIGHTS

An annual cost savings of $548 per year was realized by turning off fluorescent lights during a 1 hour lunch break. Turning off lights will save electrical power and energy; however, consideration must be given to replacement cost since more frequent starts shorten the lamp life. An important consideration in deciding whether or not to turn off fluorescent lights for short durations is to evaluate the breakeven time, which is a balance between the electrical power savings and the cost of shorter lamp life.

EXAMPLE

Consider an industrial plant which is lighted by 1000 110 watt fluorescent lights that are used 10 hours per day 250 days per year. Calculations are based on an electric energy cost of $0.02/kWh and a labor replacement cost of $2.00/lamp. Typical lamp parameters are shown in the following Table:

Lamp Rating Watts	Lamp & Ballast Watts	P (list price) Per Lamp	Average Lamp Life Hours
40	46	$1.20	18,000
75	82	2.45	12,000
110	120	2.95	12,000

Power Savings

Turning the lights off during a 1 hour lunch break results in

Power Savings = 1 hour/day × 250 day/year × 1000 lamps × 120 watts/1000 watts/kW
= 30,000 kWh/yr

Energy Savings

Assuming 10,000 Btu to produce 1 kWh

Energy Savings = 300 MBtu/yr
Cost Savings = 30,000 kWh/yr × $0.02/kWh
= $600 per year

Replacement Cost

The daily cost of replacing a lamp is given by

$$= (P + h)\ (C_1 + C_2)/L$$

where

P is the price of a replacement lamp,
h is the labor cost for replacing a lamp,
L is the average lamp life at 3 hour per operating period, and
C_1, C_2 are the lamp life hours consumed for each daily operating time period (hours/operating period). These can be evaluated approximately from Figure 1.

For continuous 10 hour operation with the lights left on during the lunch break, C_1 = 7.5 (from Figure 1) and C_2 = O.

Replacement Cost = (2.95 + 2.00) (7.5 + 0)/12000
= $0.003094/lamp-d
= $0.003094/lamp-d × 1000 lamps × 250 d/yr
= $773/year

Suppose the lights are burned for 4.5 hours (C_1 = 4), turned off for 1 hour, and then burned for 4.5 hours (C_2 = 4)

Replacement Cost = (2.95 + 2.00) (4 + 4)/12,000
= $0.0033/lamp-d
= $0.0033/lamp-d × 1000 lamps × 250 d/y
= $825/year

Therefore the additional cost of replacement can be estimated:

Additional Cost = $825 − $773
= $52 per year

Total cost savings (energy − additional replacement cost)
= $600 − $52
= $548 per year

SUGGESTED ACTION

Review lighting schedules and eliminate nonessential lighting during extended breaks. If possible, schedule breaks to permit reducing lighting throughout particular areas of the plant whenever feasible.

REFERENCE

"Fluorescents—ON/OFF," *Lighting Design and Application, January* 1973, p. 38.

SOURCE An equipment manufacturer

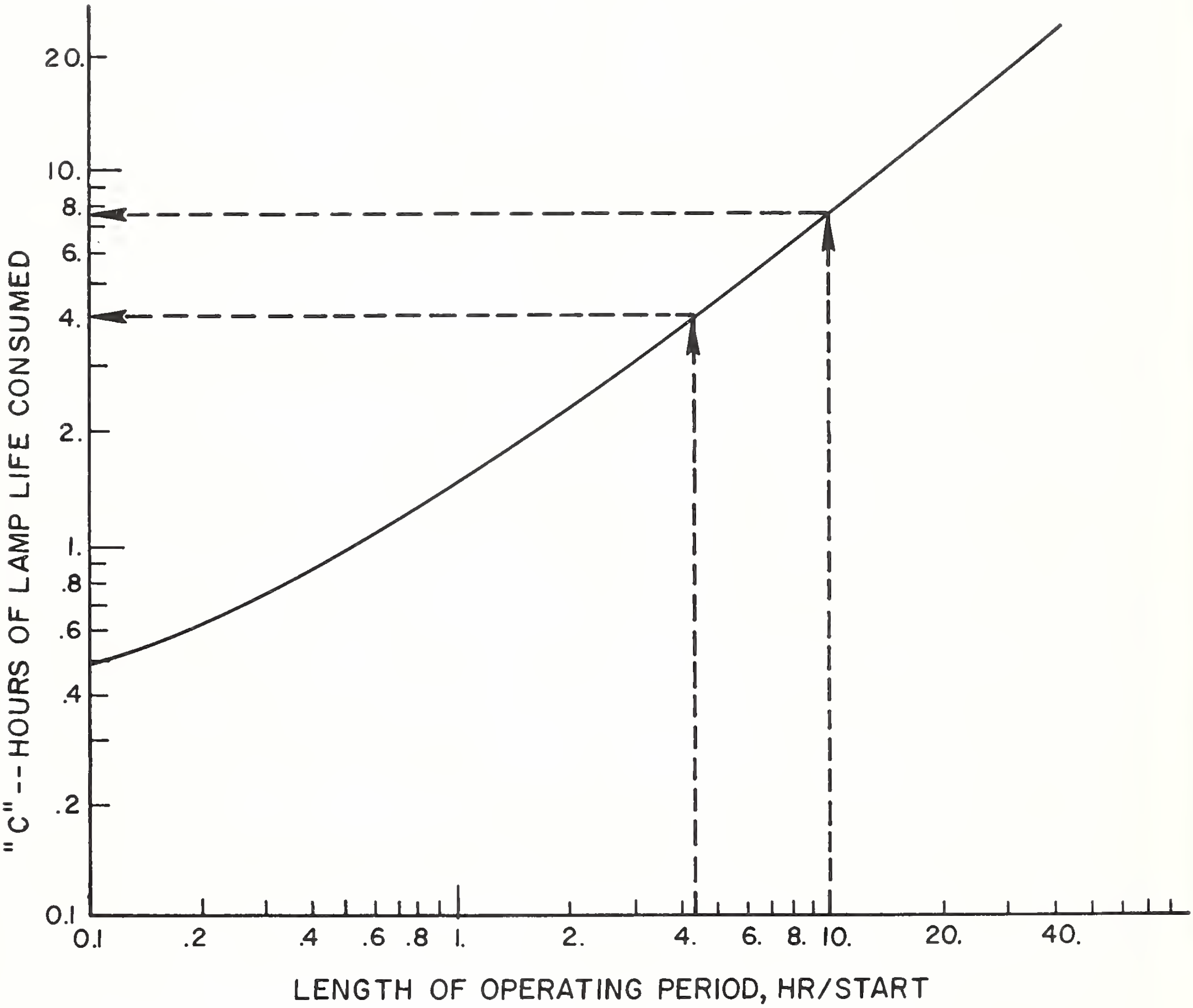


FIGURE 1. *Lamp life hours consumed for each operating period.*

Source: 'Fluorescents—on/of' Lighting Design and Application, January 1973.

ENERGY SAVINGS THROUGH THE USE OF WINDOW TINTING

Window tinting with the use of plastic films is often an effective method of conserving energy. The films used for the tinting inhibit the transmission of solar energy while still transmitting visible light permitting visual communication. This can reduce solar heat gain up to 75 per cent in summer thereby reducing air conditioning load. The films also reduce glare and fading due to ultra violet radiation.

EXAMPLE

A building in Ft. Worth, Texas, has a north-south orientation. The building has 100 ft by 6 ft of glass area on the east and west facades and 50 ft x 6 ft of glass area on the south facade. The application of window tinting resulted in a seasonal reduction of 10,458 kWh for air conditioning. This saving estimate is based on the seasonal cooling load (due only to windows) during the months of May thru September, and calculated by the following equation:

Seasonal Cooling Load (SCL) =

$$[SHGF \times CCF \times SC] + \frac{[U \times (To - 75) \times H]}{12{,}000}$$

Where:

SHGF = Average clear sky seasonal Solar Heat Gain in Ton-Hours/ft^2 for given latitude (Table II)

CCF = Average seasonal Cloud Cover Factor for given locality (Table I)

SC = Shading Coefficient for particular tinting values (Table III)

U = Overall heat transfer coefficient which is 1.06 Btu/hr. sq ft F for a single glazing window

To = Average seasonal daytime outdoor temperature for given locality city (Table I)

H = Total daylight hours in the season for given latitude (Table II)

The appropriate values for Ft. Worth, Texas (nearest latitude – 32°) are obtained from Tables I, II, and III. Substituting in the above equation:

The seasonal cooling load with plain glass:

For east facade:

$$SCL_{E/sq\ ft} = [14.05 \times .72 \times 1.00] + \frac{[1.06 \times (83.3 - 75) \times 1999]}{12.000}$$

$$= 10.12 + 1.46$$

$$= 11.58 \text{ ton h/sq ft}$$

$$SCL_{E\ TOT} = 11.58 \text{ ton h/sq ft} \times 100 \text{ ft} \times 6 \text{ ft}$$

$$= 6948 \text{ ton h}$$

For west facade *(same value of SHGF):*

$$SCL_{W\ TOT} = 6{,}948 \text{ ton} - \text{h}$$

For south facade:

$$SCL_{S/sq\ ft} = [8.34 \times .72 + 1.00] + \frac{[1.06 \times (83.5 - 75) \times 1999]}{12{,}000}$$

$$= 6.00 + 1.46$$

$$= 7.46 \text{ ton h/sq ft}$$

$$SCL_{S\ TOT} = 7.45 \text{ ton h/sq ft} \times 50 \text{ ft x } 6 \text{ ft}$$

$$= 2238 \text{ ton h}$$

The seasonal cooling load with tinted glass:

$$SCL_{E/sq\ ft} = [14.05 \times .72 \times .25] + \frac{[1.06 \times (83.3 - 75) \times 1999]}{12{,}000}$$

$$= 2.53 + 1.46$$

$$= 3.99 \text{ ton h/sq ft}$$

$$SCL_{E\ TOT} = 3.99 \text{ ton h/sq ft} \times 600 \text{ sq ft}$$

$$= 2.394 \text{ ton h}$$

TABLE I

	Lat°	*Avg. Seasonal CCF	Avg. Seasonal T_o °F
Atlanta, Ga.	34°	0.62	79.1°
Schenectady, N.Y.	43°	.53	69.5°
Washington, D.C.	39°	.60	74.8°
Lamont, Ill.	42°	.62	69.4°
Cleveland, Ohio	42°	.62	71.1°
Ft. Worth Texas	33°	.72	83.5°
San Antonio, Texas	30°	.70	84.4°
Gainesville, Fla.	30°	.61	82.5°
Columbia, Mo.	39°	.67	75.0°
Los Angeles, Calif.	34°	.72	72.9°
Lexington, Ky.	38°	.71	74.9°
Nashville, Tenn.	36°	.64	78.6°
Madison, Wis.	43°	.61	69.7°
Lake Charles, La.	30°	.65	69.7°
New York, N.Y.	41°	.58	72.4°
Phoenix, Ariz.	33°	.82	88.9°
Astoria, Ore.	46°	.60	60.5°
Seattle, Wash.	48°	.61	64.8°
St. Cloud, Minn.	46°	.63	67.2°

*The cloud cover factors were estimated by K_T/0.87, where the values of K_T were obtained from an ASHRAE article entitled, "Availability of Solar Energy for Flat-Plate Solar Heat Collectors," by B. Y. H. Liu and R. C. Jordan, Low Temperature Engineering Application of Solar Energy, 1967 ASHRAE Symposium Bulletin.

$SCL_{W\ TOT}$ = 2394 ton h
$SCL_{S\ TOT}$ = 2.96 ton h/sq ft × 300 sq ft
= 888 ton h

The total SCL for the entire building with tinted glass = 5676 ton h

The seasonal cooling load saving is then:

Seasonal cooling load, plain glass	16.134 ton h
Seasonal cooling load, tinted glass	5.676 ton h
Seasonal Savings	10,458 ton h

If the power cost for air conditioning is $0.03/kWh:
Seasonal cost savings
= 10,458 Ton h × 1 kWh/Ton h × $0.03 kWh
= $313 per season

If the cost of installing the plastic tint is $1.50/sq ft,
Investment cost
= 1500 sq ft × $1.50
= $2,250

Although this installation requires 7.2 years to pay off the original investment, other possible savings are the reduction of fading and deterioration, plus the safety factor provided by the film if a window is broken. (The film tends to hold the window pieces together like safety glass.)

SUGGESTED ACTION

If your plant has a large amount of glass area exposed to direct sunlight, evaluate the possibility of applying window tinting treatment. In your evaluation, also consider some of the indirect benefits of such a treatment. Window tinting reduces useful solar radiation for heating, which also should be considered.

Note that the "Seasonal Cooling Load" calculated by this method is only that heat load which is radiated or conducted through the window glass. It does not include the heat load caused by fresh air input, conduction through walls and ceilings, or the heat generated by people and equipment.

SOURCE

1. Handbook of Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Tables 1–6, Chapter 22—Air Conditioning Cooling Load, 1972.
2. Low Temperature Engineering Application of Solar Energy, 1967 ASHRAE Bulletin, Table 1–1 "Availability of Solar Energy for Flat-Plate Solar Heat Collectors" by B.Y.H. Liu and R. C. Jordan.

TABLE II
*Average Seasonal Clear Sky Solar Heat Gain (SHGF) Ton — Hrs./ft²

	N	NE	E	SE	S	SW	W	NW	HOR	Hours In Season
24°	5.4	10.58	13.85	9.68	6.36	9.68	13.85	10.58	26.89	1989
32°	5.67	9.84	14.05	12.56	8.34	12.56	14.05	9.84	26.29	1999
40°	4.76	9.19	14.15	14.15	10.98	14.15	14.15	9.19	25.32	2173
48°	4.80	8.90	14.42	15.70	13.80	15.70	14.42	8.9	23.83	2419
56°	4.85	8.66	14.55	17.03	16.23	17.03	14.55	8.66	21.86	2479

*Obtained from data contained in Tables 1 through 6, Chapter 22, Air Conditioning Cooling Load, *Handbook of Fundamentals*, 1972. American Society of Heating, Refrigeration, and Air Conditioning Engineers.

TABLE III
Shading Coefficients

Shading Device	Shading Coefficient
Single strength glass (plain)	1
Typical grey glass	0.67
Typical bronze glass	.67
Typical green flow-on coating	.70
Tinting film on Single strength glass	0.25–42—Depending on the film used
Tinting on typical ¼″ grey glass	.35–.43
Tinting on typical ¼″ bronze glass	.31–.41
Tinting on typical ¼″ insulating glass	.13–.31

Estimated from Multiple Sources.

SCHEDULE USE OF ELECTRICAL EQUIPMENT TO MINIMIZE PEAK DEMAND

ECO 3.3.1

Reschedule the use of electrical equipment to lower the demand peak. This action will not reduce the amount of electrical energy used, assuming the same equipment is continued in operation, but will reduce the "surcharge" (demand charge) paid to the power company to provide, in effect, the standby equipment that must be maintained to meet your *peak* demand for power. Theoretically, if you and your community reduce the peak demand, this reduces the standby capacity required, which in turn may postpone the power company's need to install additional capacity to meet an increasing load on its systems. While the individual industrial power consumer's contribution to the utility-wide demand peak may be small, reducing his peak demand can be rewarding.

EXAMPLES

1. A plant operates a group of twelve 30 kW resistance heated furnaces. Each furnace draws its full load of 30 kW for two hours after being turned on and then falls back to a temperature holding rate of 10 kW. All furnaces go through one cycle of heating up, holding, and cooling every 24 hours. By scheduling their use so that no more than two furnaces are on heat-up simultaneously, the following savings in electrical demand charge can be achieved.

Where all 12 furnaces heat-up simultaneously:

Peak demand = 12 furnaces $\times$ 30 kW/furnace
= 360 kW

Where 2 furnaces heat-up simultaneously and the remaining 10 furnaces are on hold:

Peak demand = (2 furnaces $\times$ 30 kW/furnace) + (10 furnaces $\times$ 10 kW/furnace)
= 160 kW

Peak demand Reduction = 360 kw — 160kW = 200 kW

Annual demand charge cost saving = 200 kW $\times$ 1.50 \$/kW mo $\times$ 12 mo/yr
= <u>\$3600</u> per year

2. A small city utilitiy uses an 800 hp pump for eight hours out of each 24. By operating the pump only at night, an off-peak rate reduction of \$1.40/kW mo in the demand charge results in the following annual savings.

Annual demand charge cost savings = 800 hp $\times$ 0.746 kW/hp $\times$ 1.40 \$/kW mo $\times$ 12 mo/yr
= <u>\$10,000</u> per year

SUGGESTED ACTION

A plot of demand versus time is helpful in evaluating the possibilities for savings. If one is not available, your local power company will usually cooperate in preparing such a plot. If the plot shows some high cyclical peaks, usually some savings are possible by altering equipment use or possibly scheduling the use of equipment during off-peak hours.

SOURCE Based on L. A. Wood—"Energy Conservation Through Scheduling and Process Changes," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

UPGRADE EFFICIENCY OF INCANDESCENT LIGHT SOURCES

Energy savings of 10% to more than 30% may be possible in a conventional incandescent lighting system by merely replacing old bulbs with more efficient ones.

EXAMPLE

(1) Standard bulbs filled with krypton gas instead of the conventional argon are available which yield the same lumen output and bulb life at 10% less power input.

POWER RATING
(at same light output)

Conventional	Krypton Filled
60	54
100	90
150	135

(2) In an installation using reflector type flood lamps the older R type lamps can be replaced with the newer PAR types which are much more efficient.

Comparison of "R" vs "PAR" Reflector Bulbs

R-40 Floods		PAR-38 Floods	
Wattage	Beam Candle Power	Wattage	Beam Candle Power
100	800	75	1300
150	1200	100	2230
200	1600	150	3450
300	2450	200	4560
500	3600	250	5850

The replacement of a 500 watt R-40 bulb with a 250 watt PAR-38 constitutes a 50% saving in electrical power demand, and a definite cost saving.

Assuming operation for 4000 hours per year, and 2.5¢ per kWh,

Annual Cost Savings

$$= (500 - 250)\text{W} \times 1\ \text{kW}/1000\ \text{W} \times 4000\ \text{h/yr} \times 0.025\ \$/\text{kWh}$$

$$= \$25 \text{ per year for each bulb replaced}$$

SUGGESTED ACTION

If your lighting system uses incandescent bulbs, consider the use of more efficient bulbs for replacement purposes.

Consultation with your lamp supplier, or a lighting consultant, may help determine the most efficient replacement for your particular system. The examples listed above are not an exhaustive list.

SOURCE Herbert Anderson, "An Efficient Selection of Modern Energy-Saving Light Sources Can Mean Savings of 10% to 30% in Power Consumption," *Electrical Consultant,* April, 1974, p. 32–33.

CORRECT LOW POWER FACTORS

The penalty charge for a low electrical power factor can easily be saved by installing capacitors. The installation will normally pay for itself in one or two years.

EXAMPLE

Consider the case of a plant with a maximum demand of 350 kW, and operating with a power factor of 0.65. Since the power contract has a penalty clause for power factors of less than 0.85, the monthly demand charge is

$$\begin{aligned}\text{Original Demand Cost} &= 350\ \text{kW} \times 0.85\ \text{PF}/0.65\ \text{PF} \times 1.67\ \$/\text{kW} \\ &= \$764\ \text{per month}\end{aligned}$$

Reference to Figure 1 shows that by installing capacitors rated at 0.55 kvar for each kilowatt of demand, the power factor could be improved to 0.85. Assuming an installed cost of $15 per kvar,

$$\begin{aligned}\text{Cost of Capacitors} &= 350\ \text{kW} \times 0.55\ \text{kvar/kW} \times 15\ \$/\text{kvar} \\ &= \$2900\end{aligned}$$

At the improved power factor of 0.85,

$$\begin{aligned}\text{New Demand Cost} &= 350\ \text{kW} \times 0.85/0.85 \times 1.67\ \$/\text{kW} \\ &= \$585\ \text{per month}\end{aligned}$$

$$\begin{aligned}\text{Annual Cost Saving} &= (764 - 585)\ \$/\text{mo} \times 12\ \text{mo/yr} \\ &= \underline{\$2150}\ \text{per year}\end{aligned}$$

BRIEF EXPLANATION

Every inductive device (e.g., electric motors, transformers, magnetic vibrators, solenoids, etc.) has one or more magnetic coils through which flow two different components of electric power.

One component, measured in kilowatts (kW), does the useful work and is the quantity recorded by a watt meter. It is approximately proportional to the amount of fuel burned by the electric utility.

The second component, reactive kilovolt-amperes (kvar), represents the current needed to produce the magnetic field for the operation of a motor, etc. This component does no useful work, is not registered on a watt meter, but does some heating of generators, tranformers, and transmission lines. Thus it constitutes an energy loss.

The relative amount of the kvar component in an electrical system is designated by the power factor (*PF*).

$$\begin{aligned}PF &= \text{Useful power/Total power} \\ &= \text{kw/(kW + kvar)}\end{aligned}$$

A light bulb or an electric heater, both non-inductive devices, has a power factor of 1.0. A motor on the other hand, will typically have a power factor of 0.3 to 0.9 as shown in Figure 2.

Electric utilities assume a power factor of 0.85 or more in their rate structure. If the overall power factor of a commercial customer is less than 0.85, they add a penalty in the demand charge. The usual formula,

$$\text{Monthly Demand Billing} = \text{Maximum demand} \times 0.85/\text{Measured power factor} \times \$/\text{kW}$$

The usual cure for a low power factor is to install a capacitor in parallel with the offending machine, or across the line feeding a group of such machines. If the capacitor is properly sized, the kvar currents will not flow between motor and power plant, but will only shuttle back and forth between motor and capacitor. Figure 1 shows the correct size capacitor, in kvar, for different power factor conditions. It is important that the capacitor be as near the correct size as possible.

SUGGESTED ACTION

Determine whether or not your plant is paying a penalty charge for a lower power factor. If so, consider installing corrective capacitors. The advice of an electrical consultant or an engineer from your utility will be helpful in planning an installation.

REFERENCES

1. "A Guide to Power Factor Correction for the Plant Engineer" Sprague Electric Company, North Adams, Massachusetts.
2. Presentation by Edra Maxcy, Supervisor, Electrical Demonstrations, Tennessee Valley Authority, Nashville, Tennessee.

SOURCE Sprague Electric Company and Tennessee Valley Authority

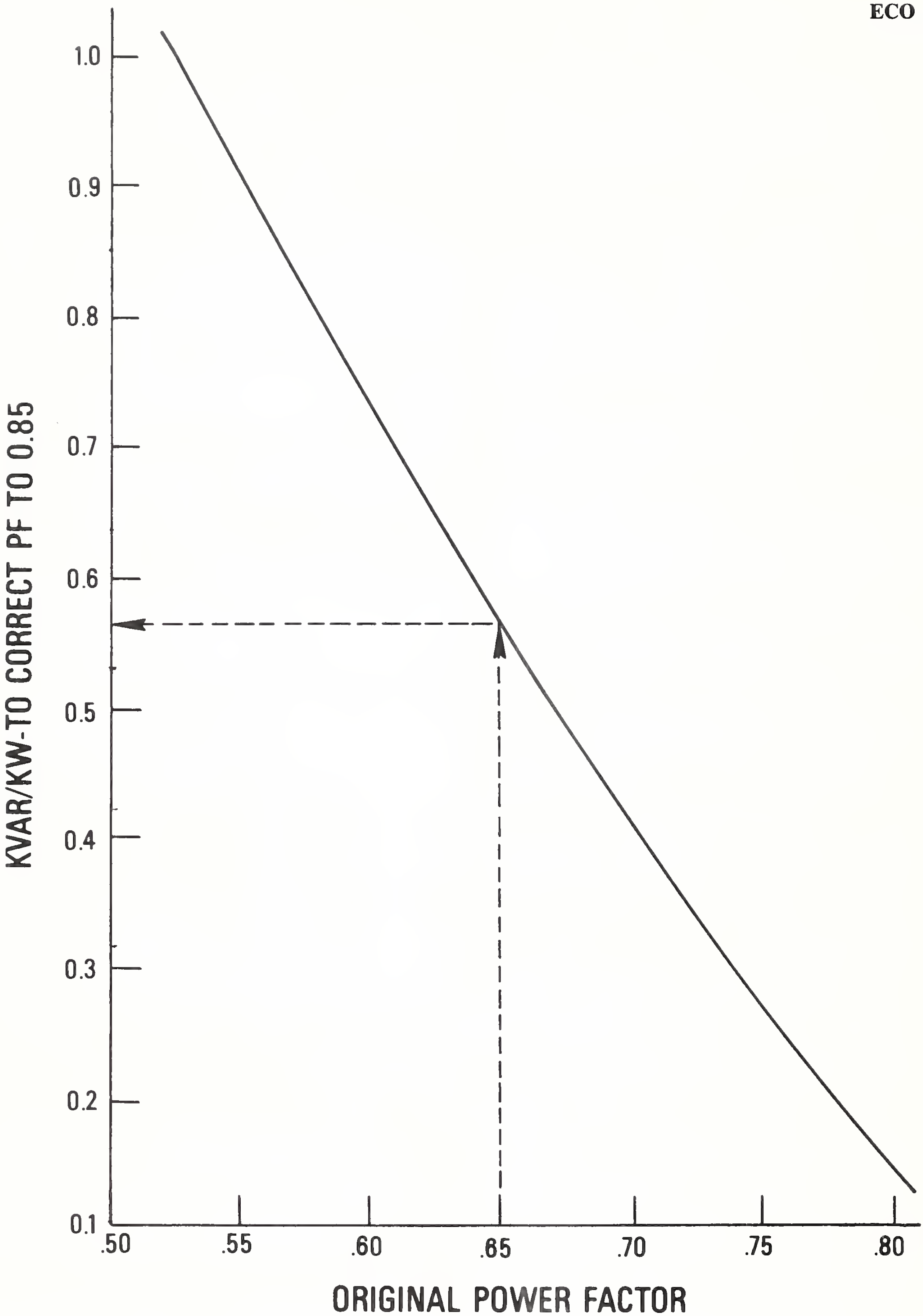
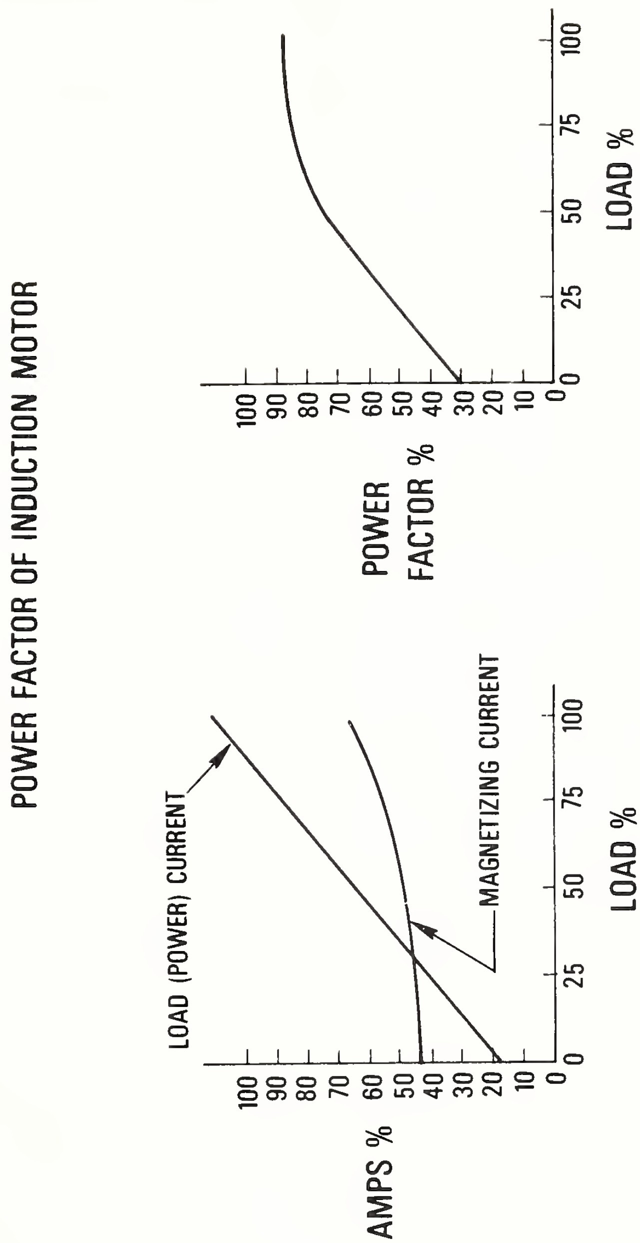

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
KVAR/KW-TO CORRECT PF TO 0.85
.50
.55
.60
.65
.70
.75
.80
ORIGINAL POWER FACTOR

FIGURE 1



FROM REFERENCE (2)

FIGURE 2.

KEEP BOILER TUBES CLEAN (WATER SIDE)

The prevention of scale formation, even on a small 500 hp boiler, can produce energy savings up to \$30,000 per year. For an individual case the potential saving depends on the scale thickness and on its chemical composition.

EXAMPLE

Consider a small 500 hp boiler in use at its 100% rating of 16.74 MBtu/h into steam, or approximately 16,700 lb steam/h. At its rated 75% efficiency, and operating 8000 h/yr:

Annual energy input = 16.74 MBtu × 8000 h/yr × 1/0.75
= 178,560 MBtu

Condition A: If scale 1/32″ thick is allowed to form on the tubes, and the scale is of "normal" composition (salts of Ca and Mg), reference to Figure 1 indicates an energy loss of 2%. Under these conditions,

Annual energy loss = 178,560 MBtu × 0.02
= 3570 MBtu per year

If the scale is cleaned out and prevented from reforming, and assuming the fuel oil used has a heating value of 144,000 Btu/gal and costs 35¢ per gal, there will be an

Annual cost saving = 3570 MBtu × 1/0.144 MBtu/gal × \$0.35/gal
= \$8,680 per year

Condition B: If scale the same thickness forms, but of a composition high in iron and silica, the graph indicates an energy loss of 7%.

Annual energy loss = 178,560 MBtu × 0.07
= 12,500 MBtu per year

Removing the scale and preventing its reforming with the same assumptions as to fuel oil:

Annual cost savings = 12,500 MBtu × 1/0.144 MBtu/gal × \$0.35/gal
= \$30,400 per year

SUGGESTED ACTION

Check boiler tubes visually for scale while the boiler is shut down for maintenance. Operating symptoms which may be due to scale include reduced steam output, excessive fuel use, and increased stack temperature.

If scale is present, consider modifying the feedwater treatment and/or the schedule of chemical additives. The cost of modification can vary widely, depending on such factors as the type of treatment facilities already available and the chemical problems presents if any. The advice of a consultant or of a vendor of water treatment chemicals can be helpful.

SOURCE "How to Control Boiler Iron Deposits," Joseph V. Phelan and Leonard R. Gelosa, *Chemical Engineering*, 3/3/75, p. 174–178.

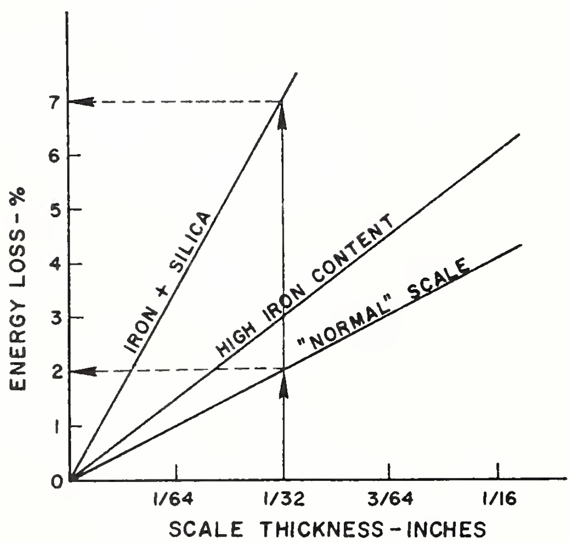


FIGURE 1. *Energy loss from scale deposits. Based on data from the reference.*

WASTE HEAT RECOVERY FROM INCINERATOR FLUE GAS

EXAMPLE

A potential saving of \$45,000 annually was identified in the recovery of waste heat from an incinerator of an asphalt roofing plant to produce 15,000 lb/h of steam at 150 psig.

An asphalt roofing plant disposes of 16,000 scfm of asphalt-saturated air by burning the mixture in an incinerator at 1400 F. The normal procedure was to discharge the incinerator flue gas to the atmosphere. At the same time, the plant purchases 15.000 lb/h of process steam at 150 psig from a neighboring steam plant. A brief study showed that a waste heat boiler installed in the incinerator stack could produce the required steam, and more if needed.

The plant has 200 F feedwater available. To produce 1 lb of 150 psig saturated steam (366 F) from 1 lb of 200 F water requires 1036 Btu. Heat (q) to produce 15,000 lb/h of steam.

$$q = 1036 \text{ Btu/lb} \times 15{,}000 \text{ lb/h} = 15.54 \text{ MBtu/h}$$

Flue gas flow rate (m) at a gas density of 0.0763 lb/cu ft at standard conditions,

$$m = 16.000 \text{ scfm} \times .0763 \text{ lb/cu ft} \times 60 \text{ min/hr} = 73{,}248 \text{ lb/hr}$$

With a 2% heat loss and with C_p = 0.28 Btu/lb F, the required temperature drop in the flue gas is

$$\Delta T = \frac{15.54 \text{ MBtu/h}}{0.28 \text{ Btu/lb F} \times 73{,}248 \text{ lb/h} \times (1 - 0.02)} = 773 \text{ F}$$

Therefore, the flue gas need only be cooled to 1400 − 773 = 627 F to produce the required 15000 lb/h of 150 psig steam. At a cost of \$1.00 per 1000 lbs of steam and operating 3000 hours per year, the cost savings if waste heat is recovered is

$$\text{Cost Savings} = 15000 \text{ lb/h} \times \$1.00/1000 \text{ lb} \times 3000 \text{ h/yr} = \underline{\$45{,}000 \text{ per year}}$$

If the flue gas were cooled to a lower temperature, say around 400 F, instead of 627 F, a total of 19,400 lb/h of 150 psig steam could be generated with a cost savings of \$58,200/yr.

At an installed cost of approximately \$37,000, the first year savings paid for the boiler, even at the lower steam output.

SUGGESTED ACTION

Evaluate plant exhaust streams with temperatures higher than 300 F as potential sources of heat for steam generation. Consider selling unneeded steam to a neighboring plant. Consult waste heat boiler equipment manufacturers for recommendations.

CAUTION

Flue gas containing condensible components must be kept above the dew point temperature to minimize corrosion problems. Usually the flue gas temperature should not be cooled below 300 F.

SOURCE Allied Materials Corporation
P.O. Box 12340
Oklahoma City, Okla.

RECOVER HEAT FROM WASTE BY-PRODUCTS

EXAMPLE

A chemical manufacturing firm will save $240,000 per year by burning a liquid chemical by-product to generate 64,000 lb/yr of 300 psig process steam, which is presently produced by burning purchased fuel oil. Use of the by-product as a fuel also eliminated a disposal problem for an environmentally objectionable material. The cost of the boiler, with special design features for corrosion and soot deposits, is approximately $400,000, and the cost of installation and accessories is approximately $300,000.

The by-product has an average heating value of 6000 Btu/lb and is completely oxidized at 1800 F. A total of 200,000 cfm of flue gas will be produced and quenched to 200 F before passing through a scrubber into the stack.

The flue gas flow rate corresponding to 200,000 cfm at 1800 F is 170,000 lb/h. The specific heat of the flue gas is 0.30 Btu/lb F and the saturation temperature of 300 psig steam is 422 F. The waste heat boiler was designed to have an exit flue gas temperature of 500 F. Therefore the energy available from the flue gas, is:

$$\begin{aligned}\text{Energy available} &= 170{,}000\ \text{lb/h} \times 0.30\ \text{Btu/lb F} \\ &\quad \times (1800 - 500)\text{F} \\ &= 66.3\ \text{Btu/h}\end{aligned}$$

If the feedwater is at 220 F, the heat required to produce saturated 300 psig steam is 1027 Btu/lb. Allowing for 1% heat loss,

$$\begin{aligned}\text{Steam production} &= 66.3\ \text{MBtu/h} \times \\ &\quad 1\ \text{lb}/1027\ \text{Btu} \times 0.99 \\ &= 63{,}900\ \text{lb/h}\end{aligned}$$

The company was paying $1.25 per 1000 lb of steam when it was produced from fuel oil. Based on 3000 hours per year operation,

$$\begin{aligned}\text{Annual cost savings} &= 63{,}900\ \text{lb steam/h} \times \$1.25/1000\ \text{lb steam} \times 3000\ \text{h/yr} \\ &= \underline{\$240\,000}\ \text{per year}\end{aligned}$$

SUGGESTED ACTION

Liquid by-products and solvents should be considered as fuel sources for steam generation, space heating, etc. If your fuel oil costs are higher than the approximate 18¢/gal in this example, annual savings will accrue at a faster rate. Consult manufactures of boilers and waste heat recovery equipment for recommendations.

SOURCE An equipment manufacturer.

RECOVER FUEL VALUE IN WASTE BY-PRODUCT

EXAMPLE

Recovering waste heat from the combustion of H_2S rich gas produced 27,835 lbs/hr of 175 psig steam providing an estimated saving of $133,000 per year. An oil refinery has an acid gas by-product that contains a high percentage of hydrogen sulfide (H_2S). Because of pollution requirements, the gas could not be vented to the atmosphere without being properly treated. The H_2S rich gas is mixed with air and burned at 2500 F (no additional fuel supply is required). The combustion gas is cooled to 650 F in a waste heat recovery boiler before it enters a converter which extracts sulfur from the gas. A total of 39,140 lb/h of flue gas is formed in the furnace.

From the combustion gas,

$$\text{Energy available} = 39{,}140 \text{ lb gas/hr} \times 0.366 \text{ Btu/lb F} \times (2500 - 650) \text{ F} = 26.5 \text{ MBtu/h}$$

At a feedwater temperature of 300 F, the energy required to produce 1 lb of steam at 175 psig from water at 300 F is 933 Btu/lb (from steam table). With a 2% heat loss,

$$\text{Steam flow rate} = 26.5 \text{ MBtu/h} \times 1/933 \text{ lb/Btu} \times (1 - .02) = 27{,}800 \text{ lb/h}$$

Based on a cost of $1.20 per 1000 lb of steam and 4000 hour per year operation,

$$\text{Annual savings} = 27{,}800 \text{ lb/hr} \times 1.20 \text{ \$/1000 lb} \times 4000 \text{ h/yr} = \underline{\$133{,}000} \text{ per year}$$

SUGGESTED ACTION

Evaluate waste products as energy sources to supply heat for the production of steam, for space heating, and other plant requirements. Often this action can be used to eliminate pollution problems. Consult manufacturers of boilers and waste heat recovery equipment for recommendations.

SOURCE An equipment manufacturer

HEAT PROCESS WATER WITH FLUE GAS HEAT

EXAMPLE

The installation of a waste heat recovery system in two steam boilers, and the use of the 1.17 MBtu/h of recovered energy to heat process water, offered a candy plant an opportunity to save $14,000 annually.

The plant operates two oil-fired boilers to generate 150 psig steam; each boiler exhausts 7500 lb/h of flue gas at a temperature of 600 F. The installation of a heat recovery system to cool these gas streams to 300 F would make available energy for other uses.

$$\text{Energy recoverable} = 7500\ \text{lb/h} \times 2\ \text{boilers} \times 0.26\ \text{Btu/lb F} \times (600 - 300)\ \text{F} = 1.17\ \text{MBtu/h}$$

The plant also operates an oil fired hot water heater to heat 50 gpm of water from 50 F to 180 F.

$$\text{Energy used} = 50\ \text{gpm} \times 8.34\ \text{lb/gal} \times 60\ \text{min/h} \times (180 - 50)\ \text{F} \times 1\ \text{Btu/lb F} = 3.253\ \text{MBtu/h}$$

If this energy input were reduced by 1.17 MBtu/h, to 2.083 MBtu/h, the temperature of the water stream would be increased to only 133 F.

$$\text{Temperature increase} = 130\ \text{F} \times 2.083/3.253 = 83\ \text{F}$$

$$\text{Output temperature} = 50\ \text{F} + 83\ \text{F} = 133\ \text{F}$$

Passing this stream of warm water through the heat recovery system on the steam boilers would add 1.17 MBtu/h to stream and increase the water temperature to the required 180 F.

Assuming 6000 h/yr operation, and a fuel cost of $2.00/MBtu

$$\text{Annual savings} = 1.17\ \text{MBtu/h} \times 6000\ \text{h/yr} \times 2\ \$/\text{MBtu} = \underline{\$14{,}000}\ \text{per year}$$

SUGGESTED ACTION

Review waste flue gas heat as a possible method of producing hot water.

In order to keep away from corrosion problems, the flue gas should not be cooled below 300 F, and the water entering the heat exchanger should have a minimum temperature of 125 F.

SOURCE An equipment manufacturer

PREHEAT COMBUSTION AIR WITH WASTE PROCESS HEAT

EXAMPLE

A company in southeastern United States manufactures kaolin powder which is a base material for paint. By recovering waste heat from the kaolin, 7950 scfm of combustion air is preheated to 1140 F, thus avoiding a fuel cost of $67,000. The process involves a gas fired furnace that supplies hot air which is mixed with clay from a calcinator. The clay-air mixture is at a temperature of 1450 F and has a flow rate of 41,000 lb/hr. The mixture is cooled to 400 F in a heat exchanger before it goes through baghouses where the kaolin powder is collected. The heat recovered from the clay-air mixture is used to preheat 7950 scfm of combustion air for the furnace.

$$\text{Recovery heat} = 41{,}000 \text{ lb/h} \times 0.308 \text{ Btu/lb F} \times (1450 - 400)\text{F} = 13.3 \text{ MBtu/h}$$

Based on a typical 70% recovery of heat by means of the heat exchanger, the 7950 scfm, or 36,400 lb/h, of combustion air at an ambient temperature of 80 F can be preheated to a temperature (t) of,

$$t = 80\text{ F} + \left[\frac{0.70 \times 13.3 \text{ MBtu/h}}{36{,}400 \text{ lb/h} \times 0.24 \text{ Btu/lb F}}\right] = 1140 \text{ F}$$

As a result of the higher temperature of the combustion air, less fuel is required to heat this air. For 6000 h/yr operation,

$$\text{Annual energy saving} = 0.7 \times 13.3 \text{ MBtu/h} \times 6000 \text{ h/yr} = \underline{55{,}860} \text{ MBtu per year}$$

If the fuel cost is $1.20/MBtu,

$$\text{Annual cost saving} = 55{,}860 \text{ MBtu/yr} \times 1.20 \text{ \$/MBtu} = \underline{\$67{,}000} \text{ per year}$$

At an installed heat exchanger cost of $90,000 the investment is recovered in less than 2 years.

SUGGESTED ACTION

Examine all sources of waste heat for preheating combustion air, and for other possible uses.

SOURCE Burgess Pigment Co.
P.O. Box 349
Sandersville, Georgia 31082

RECOVERY OF OVEN EXHAUST FOR SPACE HEATING

By recovering heat from an oven exhaust using a heat wheel, an annual cost saving of over $4100 was estimated for an installation cost of about $5600. The waste heat from the oven was used for space heating.

EXAMPLE

A survey of a drying oven located in a midwestern plant showed a significant amount of heat was being lost in the 10,000 scfm of air being exhausted at a temperature of 300 F. A prime use for this heat was determined to be space heating using a heat wheel as a heat exchanger.

For the size heat wheel required, the typical heat recovery efficiency was 78% and for heating average ambient air from 39 F, the heat recovery was estimated as:

$$\text{Heat recovered} = 10{,}000 \text{ scfm} \times 0.0763 \text{ lb/cf} \times .24 \text{ Btu/lb F} \times 0.78 \times (300 - 39) \text{ F} \times 60 \text{ min/h} = 2.24 \text{ MBtu/h}$$

If a natural gas heater with a fuel efficiency of 70% were used to provide this amount of heat for the average 6588 degree days per year,

$$\text{Annual fuel required} = 2.24 \text{ MBtu/h} \times 8 \text{ h/d} \times 6588 \times 1/(65 - 39) \text{ F} \times 1/0.70 = 6490 \text{ MBtu/yr}$$

If the fuel cost is $0.65/MBtu,

$$\text{Annual saving} = 6490 \text{ MBtu/yr} \times 0.65 \text{ \$/MBtu} = \$4220 \text{ per year}$$

Using a heat wheel eliminates the fuel cost, but requires power to operate a fan. If 4 hp is required for the fan, at $0.0125/kWh,

$$\text{Fan power cost} = 4 \text{ hp} \times 0.746 \text{ kW/hp} \times 8 \text{ h/d} \times 6588 \text{ F d/yr} \times 1/65 - 39) \text{ F} \times \$.0125/\text{kW} = \$75/\text{yr}$$

$$\text{Annual cost savings} = \$4220 - \$75 = \$4145 \text{ per year}$$

This saving would recover the $5600 investment in about 1.4 years. If costs of energy increase, the payoff time becomes correspondingly shorter.

SUGGESTED ACTION

Investigate the possibility of recovering heat from hot exhaust systems. This heat can be utilized for space heating to either reduce or eliminate the need for space heater units. Consider also the possibility of preheating the air to the oven.

SOURCE An equipment manufacturer

RECOVERY OF HEAT FROM HOT WASTE WATER

EXAMPLE

An opportunity to save $34,000 per year while conserving 10 MBtu per hour was identified by a large textile company by recovering heat from hot waste water. A major source of hot water discharge in the textile industry is the griege preparation ranges which perform a continuous fabric washing operation.

For this particular application, the discharge of waste water from the griege preparation ranges is 360 gpm at 160 F. Rather than discharging this hot water to a drain, it was decided to preheat the 360 gpm of cold inlet water having a yearly average temperature of 63.3 F, by passing it through a counterflow heat exchanger with automatic back flushing to reduce fouling (characteristic of textile processes).

Based on a heat recovery factor of 58%, and operation 4440 hours per year,

$$\text{Annual energy saving} = 360\ \text{gal/min} \times 8.34\ \text{lb/gal} \times (160\ \text{F} - 63.3\ \text{F}) \times 60\ \text{min/h} \times 4440\ \text{h/yr} \times 1\ \text{Btu/lb F} \times 0.58 = \underline{44900}\ \text{MBtu}$$

Using an energy cost of $0.90 per MBtu,

$$\text{Annual energy cost savings} = 44{,}900\ \text{MBtu/yr} \times 0.90\ \text{\$/MBtu} = \underline{\$40{,}400}\ \text{per year}$$

Assuming a 5 year capital recovery period, the estimated annual amortization cost of the 10 MBtu/h heat exchanger plus the installation cost is $6,000 per year.

$$\text{Net cost savings} = 40{,}400\ \text{\$/yr} - 6{,}000\ \text{\$/yr} = \underline{\$34{,}400}\ \text{per year}$$

These savings will, of course, increase if energy costs become greater.

SUGGESTED ACTION

Evaluate the feasibility of heat recovery from all hot waste streams. Selection of proper counterflow heat exchange equipment for a particular system is very important. Recognize the potential of excessive maintenance due to fouling problems.

SOURCE Based on J. R. Kernan—"Examples of Energy Conservation," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II.

RECOVER HEAT FROM HOT AIR EXHAUST STREAMS

A heat recovery system in the exhaust stream of a tenter frame of a textile plant cost $22,750 installed and resulted in an energy savings of 14,145 million Btu per year and a cost savings of $10,500 per year. A major source of waste heat discharge in textile fabric finishing plants is the exhaust from tenter frames which are used for either finishing or heat setting (preshrinking) fabric. Finishing operations typically run at 275 F while heat setting requires about 400 F. Actual tests were performed in a finishing plant on tenter frames used for heat setting to determine the feasibility of recovering heat from the exhaust air stream.

EXAMPLE

Natural gas was used to heat outside air to a temperature of 400 F for heat setting in a tenter frame. The exhaust air which was typically 30 F to 60 F lower than the inlet temperature was exhausted to the atmosphere. A waste heat recovery system was installed to preheat outside air using the tenter frame exhaust.

Tests were conducted using a heat wheel equipped with a pre-filter. Figure 1 indicates the possible energy savings from a heat recovery system as a function of the standard volumetric flow rate and the temperature entering the recovery system (or the process exhaust temperature). This Figure is based on an outdoor air temperature of 60 F and a heat recovery efficiency of 65%. With an air flow rate of 11,000 scfm and an exhaust air temperature of 355 F, from Figure 1,

Heat Recovery = 2.3 MBtu/h

Equipment costs were obtained from a manufacturer and installation costs were estimated.

Cost of Heat Wheel	=	$13,750
Filter Modification and Estimated Installation Cost	=	$ 9,000
Total Equipment and Installation Cost	=	$22,750

If the energy cost is $0.74 MBtu and the system is used 6150 hours per year,

Annual Cost Savings = 2.3 MBtu/h × $0.74/MBtu × 6150 h/yr
= $10,500 per year

Annual Energy Savings = 2.3 MBtu/h × 6150 h/yr
= 14,145 MBtu per year

SUGGESTED ACTION

Heat from drying operations can be utilized for heating makeup water for boilers, for other wet process operations, or for preheating air. Consider recovery of waste heat from all exhaust air streams.

SOURCE Based on J. R. Kernan, "Examples of Energy Conservation," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II.

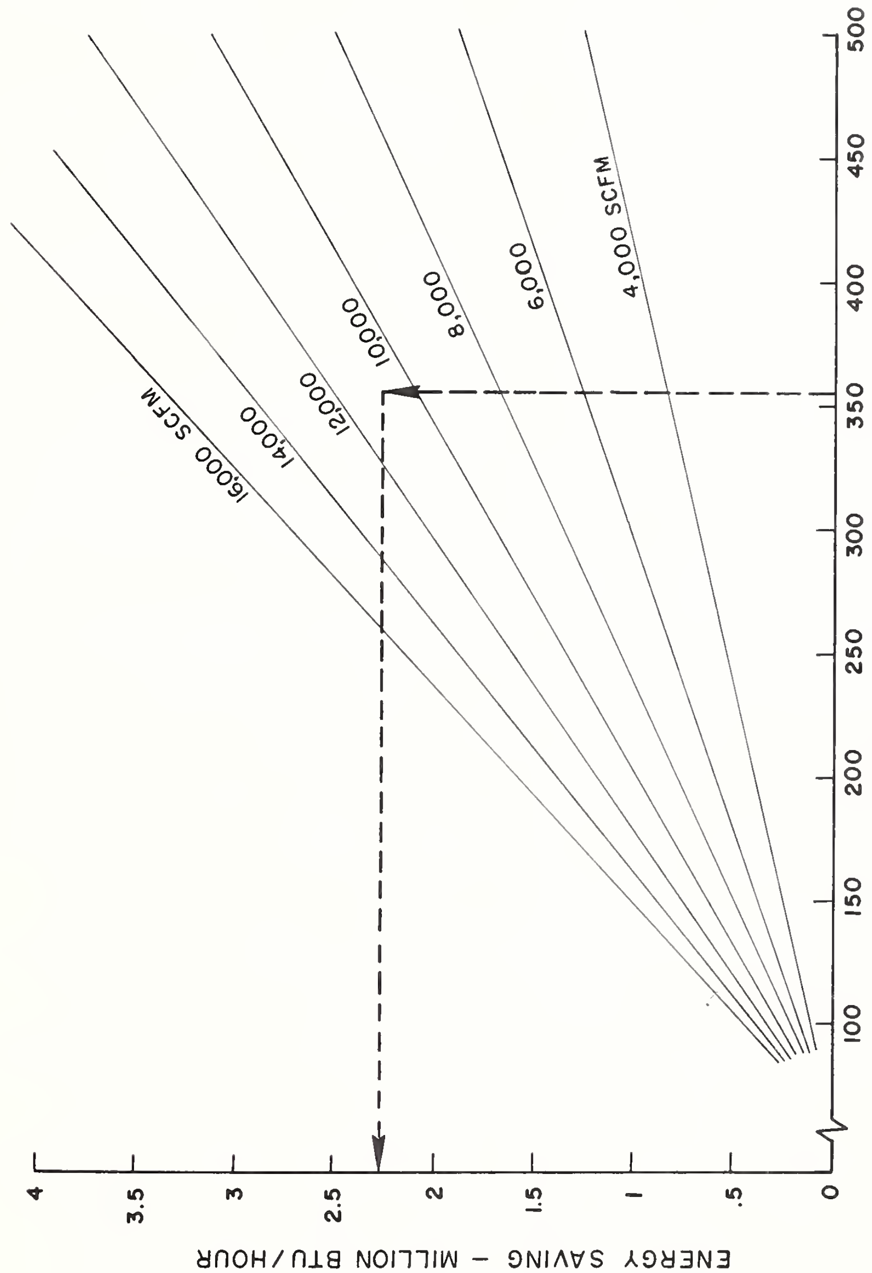


FIGURE 1. *Energy savings as a function of the temperature entering the heat recovery system.*

The outside temperature was 60 F and the heat recovery efficiency was 65 percent.

USE WASTE HEAT FROM POLLUTION CONTROL EQUIPMENT

EXAMPLE

A metal finishing plant added an incineration unit to a large paint curing oven in order to discharge only clean air to the atmosphere. Utilizing only 50% of the waste heat generated resulted in a saving of approximately \$120,000 per year.

The unit is designed to accept up to 28,000 scfm of exhaust gas from the finishing oven at a temperature of 700 F. In the incinerator the temperature is raised to 1400 F, effectively oxidizing all the hydrocarbons from the paint solvents. The energy required is furnished partly by natural gas and partly by the heat of combustion of the solvent vapor.

Instead of exhausting this hot clean air, it is first passed to a heat exchanger to raise the temperature of oven exhaust before this exhaust enters the incinerator. This reduces the amount of natural gas needed for incineration.

On leaving the heat exchanger, the clean air is sent to a waste heat boiler, producing 50 psi steam for general plant use. The total energy utilized is about 50% of that generated by the incinerator, 40% in the heat exchanger and 10% in the boiler.

Assuming operation of the incinerator at 75% of the design capacity,

Total energy added = 28,000 scfm × 0.0807 lb/scf × 60 min/h × (1400 − 700)F × .28 Btu/lb F × 0.75
= 20 MBtu/h

At 50% utilization of this waste heat,

Annual energy saving = 20 MBtu/h × 6000 h/yr × 0.50
= 60,000 MBtu

At a cost of \$2.00 per MBtu,

Annual cost saving = 60,000 MBtu × 2 \$/MBtu
= <u>\$120,000</u> per year

SUGGESTED ACTION

Clean air requirements may make more widespread the installation of equipment to recover or destroy solvent vapors from finishing ovens and spray booths. If incineration is the chosen technique, look for methods to recover what is otherwise waste heat.

SOURCE Anon. "Industrial Heating", Vol. **41,** No. 6, June 1974, p. 74–76, 78–79.

REDUCE VAPOR LOSS FROM OPEN PROCESSING TANKS

EXAMPLE

A small chrome plating plant realized a significant reduction in energy lost through evaporation by covering the exposed liquid surface of its plating tanks with small (2″ × 2″) expanded polystyrene chips. The plant operates four open top, rectangular tanks with an area of 18 sq ft each. Three of the tanks contain either copper, nickel, or chromium solutions necessary for chrome plating, and the fourth tank contains water for rinsing. The four tanks are heated for 8 hours a day, 4 days a week by electric immersion heaters (total capacity 36 kW) to temperatures ranging from 100 to 150 F. Loss of heat through evaporation from the liquid surface in the tanks is increased by the necessity for agitation in one of the tanks during plating and by forced ventilation in the plating area. The heat loss before the expanded polystyrene chips were placed on the liquid surfaces amounted to about 450 watts per square foot. The expanded polystyrene chips reduced this to about 35 watts per square foot.

$$\begin{aligned}\text{Annual power savings} &= 72 \text{ sq ft} \times (450-35) \text{ W/sq ft} \times 1 \text{ kW}/1000 \text{ W} \times 32 \text{ h/wk} \times 50 \text{ wk/yr} \\ &= 48{,}000 \text{ kWh per year}\end{aligned}$$

Assuming electrical power at \$0.02 per kWh,

$$\begin{aligned}\text{Annual cost savings} &= 48{,}000 \text{ kWh} \times 0.02 \text{ \$/kWh} \\ &= \$960 \text{ per year}\end{aligned}$$

If a utility consumes fuel at the rate of 10,000 Btu/kWh,

$$\begin{aligned}\text{Annual energy savings} &= 48{,}000 \text{ kWh} \times 10{,}000 \text{ Btu/kWh} \\ &= \underline{480} \text{ MBtu per year}\end{aligned}$$

Additional savings may be made during heat-up periods.

SUGGESTED ACTION

Consider the possibility of reducing evaporation losses from any heated, open top vessel by covering the surface of the liquid with a floating inert material. Make sure the covering material does not contaminate or degrade the process or the end product. Many types of foam material and/or small hollow beads are available.

SOURCE Based on J. R. Kernan—"Examples of Energy Conservation", Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II.

IMPROVE FURNACE INSULATION

EXAMPLE

The amount of gas consumed by a gas fired glass bending furnace was substantially reduced for an annual cost reduction of $1000 when the furnace was re-insulated with a low density ceramic felt insulating material. The furnace, which is 45 feet long by 6 feet wide, was converted from a suspended crown and side wall construction of refractory and red brick to a construction of sheet metal and a low density ceramic fiber insulation. This furnace normally operates 16 hours per day for 210 days per year and is cycled one time per working day. The gas consumption characteristics of the furnace before and after it was re-insulated are shown below:

	Original Furnace	After New Insulation
Heat up time	2½ h	½ h
Heat up gas used	3650 cu ft	530 cu ft
Gas used normal running	1190 cu ft/h	1110 cu ft/h
Gas used/16 h day	22,700 cu ft	18,300 cu ft
Gas saved/d = 4400 cu ft		

Total annual gas saved = 4400 cu ft/d × 210 d/yr = 924,000 cu ft/yr

Annual energy saving = 924,000 cu ft/yr × 1000 Btu/cu ft = 924 MBtu/yr

At a cost of $1.00/kcf for gas,
Annual cost saving = 924,000 cu ft/yr × 1.00 $/1000 cu ft = $924

The total cost for the furnace conversion project was about $1750. Increasing gas costs will make the savings even greater.

Other advantages obtained included 10% production increase due to faster heat-up, improved working environment as a result of lowered heat loss through furnace walls, and more uniform distribution of heat across the width of the bending furnace for a lowered breakage factor.

SUGGESTED ACTION

Check the condition of the insulation in your furnace(s). When replacement of the insulation is indicated, investigate the possibility of replacing the existing type of insulation with ceramic fiber refractories. These materials permit faster heat up and eliminate many disadvantages of conventional firebrick.

SOURCE Behrenberg Glass Company, reported by Peoples Natural Gas Company, Pittsburgh, Penn.

CONSERVE FUEL BY KEEPING BOILER TUBES CLEAN

EXAMPLE

An opportunity to save \$8,350 per year by utilizing an automatic tube cleaner was identified by a can manufacturing company. The accumulation of soot on the surface of boiler tubes acts as a thermal insulator which reduces the overall boiler efficiency. The normal procedure is to periodically (weekly or biweekly) shut-down the boiler and manually clean each tube. With the installation of the automatic tube cleaning system, each tube is cleaned at least every 30 minutes by adjustable timed blasts of compressed air. A catalyst is also automatically injected into the tube area to reduce soot and smoke emissions to the atmosphere.

This plant installed automatic tube cleaners on two fire tube boilers in September 1967. One boiler was rated at 400 hp (13.4 MBtu/h) and the other was rated at 500 hp (16.7 MBtu/h). The following table shows the actual fuel oil consumption and the number of degree days for the year preceding the installation of the automatic tube cleaner and for two heating seasons following the installation.

Season	No. 6 Fuel Oil Consumption, gal	Degree Day	Gal/ degree-d
1966–67	373,062	4147	89.96
Automatic tube cleaner installed September 1967			
1967–68	349,773	4196	83.36
1968–69	327,712	3942	83.13

For the 1967–68 and 1968–69 heating seasons, the

$$\begin{aligned}\text{Avg gal/degree-d} &= (83.36 + 83.13)/2 \\ &= 83.25 \text{ gal/degree-d}\end{aligned}$$

Average percent savings in fuel with the automatic tube cleaner installed is

$$\begin{aligned}\text{Percent savings} &= \frac{89.96 - 83.25}{89.96} \times 100\% \\ &= 7.46\% \\ \text{Annual fuel savings} &= 373{,}062 \text{ gal/yr} \times .0746 \\ &= 27{,}830 \text{ gal/yr}\end{aligned}$$

Assuming the No. 6 fuel oil has a heating value of 152,000 Btu/gal

$$\begin{aligned}\text{Annual energy savings} &= 152{,}000 \text{ Btu/gal} \times 27{,}830 \text{ gal/yr} \\ &= 4230 \text{ MBtu per year}\end{aligned}$$

Based on a fuel oil cost of \$0.30 per gallon

$$\begin{aligned}\text{Annual cost savings} &= 27{,}830 \text{ gal/yr} \times 0.30\ \$/\text{gal} \\ &= \$8{,}350 \text{ per year} \\ \text{Installed equipment cost} &= \$9{,}550\end{aligned}$$

In addition to the fuel cost savings of \$8,350 per year resulting from cleaner tubes, a substantial savings in the labor required to hand clean the tubes on a periodic basis (the 400 hp unit has 273 tubes and the 500 hp unit has 293 tubes) was realized. This plant has recently changed to No. 2 fuel oil for environmental reasons.

SUGGESTED ACTION

Consider installing automatic tube cleaners in both fire tube and water tube boilers as a means of saving fuel and labor. A fast check on the efficiency of the boiler can be made by installing a thermometer in the stack gas as close as possible to the last set of tubes. If this temperature exceeds the steam/water temperature by more than 100 F, fuel savings can be realized.

SOURCE American Can Company
Baltimore, Md.

IMPROVE LUBRICATION PRACTICES

The installation of modern automatic lubrication systems can produce major savings in the amount of lubricant used. This represents a cost saving as well as an energy saving in the petroleum used to prepare the lubricants.

The following two examples from a cement plant total an annual material cost saving of \$20,000, and an annual energy saving of at least 1000 MBtu.

EXAMPLE

(1) Three grinding equipment gear trains were formerly manually sprayed with gear compound every two hours using 4350 gallons of lubricant per year. An automatic oil-mist system now uses only 150 gal/yr. Assuming an energy content of 140,000 Btu/gal.

$$\text{Annual equivalent energy saving} = (4350 - 150)\ \text{gal/yr} \times 0.140\ \text{MBtu/gal} = 600\ \text{MBtu per year}$$

At a cost of 27¼¢/lb for the gear lubricant,

$$\text{Annual cost saving} = (4350 - 150)\ \text{gal/yr} \times 8\ \text{lb/gal} \times 0.2725\ \$/\text{lb} = \underline{\$9100}\ \text{per year}$$

(2) Automatic lubrication on a group of seven clinker breakers reduced consumption from 3600 gal/yr to less than 200 gal/yr.

$$\text{Annual equivalent energy saving} = (3600 - 200)\ \text{gal/yr} \times 0.140\ \text{MBtu/gal} = 475\ \text{MBtu per year}$$

At a lubricant cost of 40¢/lb,

$$\text{Annual cost saving} = (3600 - 200)\ \text{gal/yr} \times 8\ \text{lb/gal} \times 0.40\ \$/\text{lb} = \underline{\$10{,}900}\ \text{per year}$$

SUGGESTED ACTION

Review lubrication procedures, and consider updating lubrication systems. In addition to material savings, major savings are possible in labor, in equipment life, and in maintenance.

SOURCE An equipment manufacturer

AIR LOCKS FOR LOADING DOORS

A substantial loss of energy occurs in factories and warehouses where loading doors are open to the outside with no means of preventing heat escape from the building interior during loading and unloading operations. This energy loss may be reduced by installing an air lock at the loading door. An air lock is a structure or device which prevents the unloading door from being directly exposed to the outside when open.

EXAMPLE

A large warehouse has a 20 ft × 17.5 ft loading door through which railroad cars enter the building for loading and leave the building when loaded. The door is open for 10 minutes an average of 12 times per day, five days per week. The inside building temperature (T^i) is 70 F and the heating season is from October through April during which time the average outside temperature (T^o) is 38.4 F.

Assuming an air flow velocity through the open door of 500 fpm, (about 6 mph) the approximate heat loss is:

Air entering door = 500 fpm × 20 ft × 17.5 ft
= 175,000 cfm

Heat loss = 175,000 cfm × 0.0183 Btu/cu ft F × (70 − 38.4)F
= 102,000 Btu/min

Using steam for heating that supplies 960 Btu/lb and costs $1.86/1000 lb, the cost of heating this air is:

Heating cost per minute of door opening = 102,000 Btu/min × 1 lb steam/960 Btu × 1.86 $/1000 lb steam
= $0.20/min

Annual cost saving = $0.20/min × 12 openings/d × 10 min/opening × 5 d/wk × 30 wk/yr
= $3600 per year

Annual energy saving = 102,000 Btu/min × 12 openings/d × 10 min/opening × 5 d/wk × 30 wk/yr
= 1836 MBtu per year

At an estimated installation cost of $20,000 for an air lock of this size, the return on investment would be 18%. Note that in any specific installation the savings will vary widely with prevailing winds, the length and severity of the heating season, the size of the opening, and the cost of energy for space heating.

SUGGESTED ACTION

Consider the installation of an air lock at loading doors which are open frequently or for extended periods of time.

SOURCE Westinghouse Electric Corporation
East Pittsburgh, Pennsylvania

INSTALL DOCK SHELTERS ON LOADING DOCKS

The use of a loading dock shelter to reduce cold air flow into a heated area while a truck is loading or unloading can, under some conditions, pay for itself in a single heating season.

EXAMPLE

The following calculations concern a plant at a latitude of 43° north, such as Buffalo or Syracuse, New York, and use the list of assumptions below:

1. Dock door—8 ft wide by 12 ft high
2. Truck door—8 ft wide by 10 ft high
3. Gap, building to truck, 6 in. (Open area for air flow, 26 sq ft)
4. Air velocity through dock door—500 fpm
5. Heating season—40 weeks
6. Door open—4 hours per day, 6 days per week
7. Average temperatures—inside 65 F, outside 40 F
8. Specific heat of air—0.0183 Btu/cu ft F

$$\begin{aligned}\text{Energy Loss} &= 26 \text{ sq ft} \times 500 \text{ fpm} \times 40 \text{ wk/yr} \\ &\quad \times 6 \text{ d/wk} \times 4 \text{ h/d} \times 60 \text{ min/h} \\ &\quad \times 0.0183 \text{ Btu/cu ft F} \times \\ &\quad (65 - 40)\text{F} \\ &= 340 \text{ MBtu per year}\end{aligned}$$

Assuming 85% efficiency in energy saving by a dock shelter,

$$\begin{aligned}\text{Annual Energy} &= 340 \text{ MBtu/yr} \times 0.85 \\ \text{Savings} &= \underline{290 \text{ MBtu}} \text{ per year}\end{aligned}$$

Assuming a cost of $2.00 per MBtu for space heating,

$$\begin{aligned}\text{Annual Energy} &= 290 \text{ MBtu/yr} \times 2.00 \text{ \$/MBtu} \\ \text{Saving} &= \underline{\$580} \text{ per year}\end{aligned}$$

The typical cost for such a shelter, delivered and installed, is about $600—$650.

SUGGESTED ACTION

Estimate the amount of energy lost through loading dock doors, particularly if your location has a long and severe heating season. Dock shelters come in a variety of designs, and of course a variety of prices. Consult with a manufacturer of dock shelters.

SOURCE An equipment manufacturer

Large amounts of energy can be saved if furnace or kiln firing schedules are held to the minimum time necessary, and if the supporting kiln furniture is designed for minimum heat capacity.

EXAMPLE

Such process changes were implemented by a firm to reduce the energy requirement for firing computer memory cores from 120 kWh per million cores to slightly less than 0.9 kWh per million. Exact data are not available, but since the computer industry uses between 100 and 200 billion cores per year, the total yearly savings potential is 10 million to 20 million kWh, or 100,000 to 200,000 MBtu based on 10,000 Btu/kWh.

The original process consisted of spreading out the small (.030" o.d.) green cores on heavy aluminum oxide plates, loading a stack of such plates into a large batch type furnace, and firing for 18 to 24 hours. Although the cores themselves required only a second or two at some precise temperature, usually about 1000 C, the long cycle was necessitated by the characteristics of the furnaces and of the plates which supported the cores. First, it was difficult to be sure that the cores reached the right temperature without any over-shoot; second, the plates were sensitive to temperature shock and had to be heated and cooled slowly.

In the improved process the cores were spread on a woven belt of platinum wire which carried them continuously through a small tube furnace about four feet long. The cores were exposed to high temperature for only 15 to 20 seconds.

The continuous process permitted frequent sample testing of the cores, with feed-back of information for any desired adjustment in temperature, oxygen content of the furnace atmosphere, etc. As a result, the yield of good cores at the final 100% test station was more than doubled.

SUGGESTED ACTION

(1) Keep firing schedules as short as possible.
(2) Reduce to the minimum the amount of heat lost through heating and cooling kiln furniture.
(3) Use continuous firing where possible.

SOURCE Based on L. A. Wood—"Energy Conservation Through Scheduling and Process Changes," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

USE HEAT TRANSFER FLUID IN TRACING SYSTEMS

A heat transfer system using ethylene glycol in place of conventional steam tracing can save a significant amount of energy. Such a system may also substantially reduce maintenance costs because with conventional steam tracing the lines often freeze in winter while a 50% aqueous solution of the heat transfer fluid will not freeze until the temperature reaches −34 F. One installation saved 30,000 MBtu/yr, or about $36,000/yr.

EXAMPLE

An organic chemical plant converted a 32,000 linear ft steam tracing system to a heat transfer system using ethylene glycol. The original steam tracing system used plant steam which could maintain the heated product at 365 F, whereas it was required to maintain the product at only 248 F. Tests showed that an average of 23.3 lb/h of steam was consumed per 100 ft of line when using steam tracing while as little as 8 lb/h, depending upon the particular process conditions, was required to heat the fluid to 248 F in the heat transfer system.

$$\text{Potential annual steam savings} = (23.3 - 8.0)\ \text{lb/100 ft h} \times 8760\ \text{h/yr} \times 32{,}000\ \text{ft} = \underline{42.9}\ \text{M lb/yr}$$

This amounts to a potential energy savings of about 43 billion Btu/yr. The actual saving attained was 30 billion Btu/yr because of losses due to process and ambient condition variation.

The cost of the shell and tube heat exchanger for heating the fluid was approximately the same as the cost of steam traps, check valves, thermostatic air vents, drains, and fittings in a conventional steam tracing system.

SUGGESTED ACTION

Consider the possibility of converting steam tracing systems to another type of heating system. The potential savings are greatest when the required temperature in the process line is considerably less than that conveniently maintained by steam tracers. In other words, the lower the temperature, the greater the saving.

SOURCE Seifer, W., "Heat-Transfer Fluid Conserves 30 Billion Btu in Tracing System," Chemical Engineering, Vol. 81, No. 18, Sept. 2, 1974, p. 61.

USE DIRECT STEAM INJECTION FOR HEATING WATER

There is always some unavoidable loss of energy in steam condensate return lines. When heating water or aqueous solutions this loss can be avoided completely by using direct steam injection rather than heating coils and steam traps.

EXAMPLE

Assume a demand for 30 gpm of water heated from 60 F to 160 F for 4000 h/yr. Assume also, that by the time condensate from a heating coil was returned to the boiler it would have cooled to 120 F.

Referring to Figure 1, under these conditions the use of steam injection will save 14.5 Btu for each pound of hot water produced. This saving is in fuel, assuming a boiler efficiency of 75%.

Annual Energy Saving = 30 gpm × 8.34 lb/gal × 60 min/h × 4000 h/yr × 14.5 Btu/lb
= 870 MBtu/yr

Assuming a fuel cost of $2.00 per MBtu,

Annual Cost Saving = 870 MBtu/yr × 2 $/MBtu
= $1740 per year

NOTES

(1) The data in Figure 1 assumes steam at 45 psig and cold water at 60 F. Changes in steam pressure of plus or minus 25 psi will affect the indicated savings only slightly; major changes in incoming water temperature (more than plus or minus 10 F) would suggest the need for new calculations.

(2) If steam injection is used for heating an aqueous solution, allowance must be made for the diluting effect of the condensed steam.

(3) Extensive use of steam injection requires treatment and additional make-up water. This treatment cost must be considered.

SUGGESTED ACTION

Consider the use of steam injection. In addition to saving energy, it saves the installation and maintenance of heat exchangers, traps, and condensate returns.

REFERENCE Steam tables

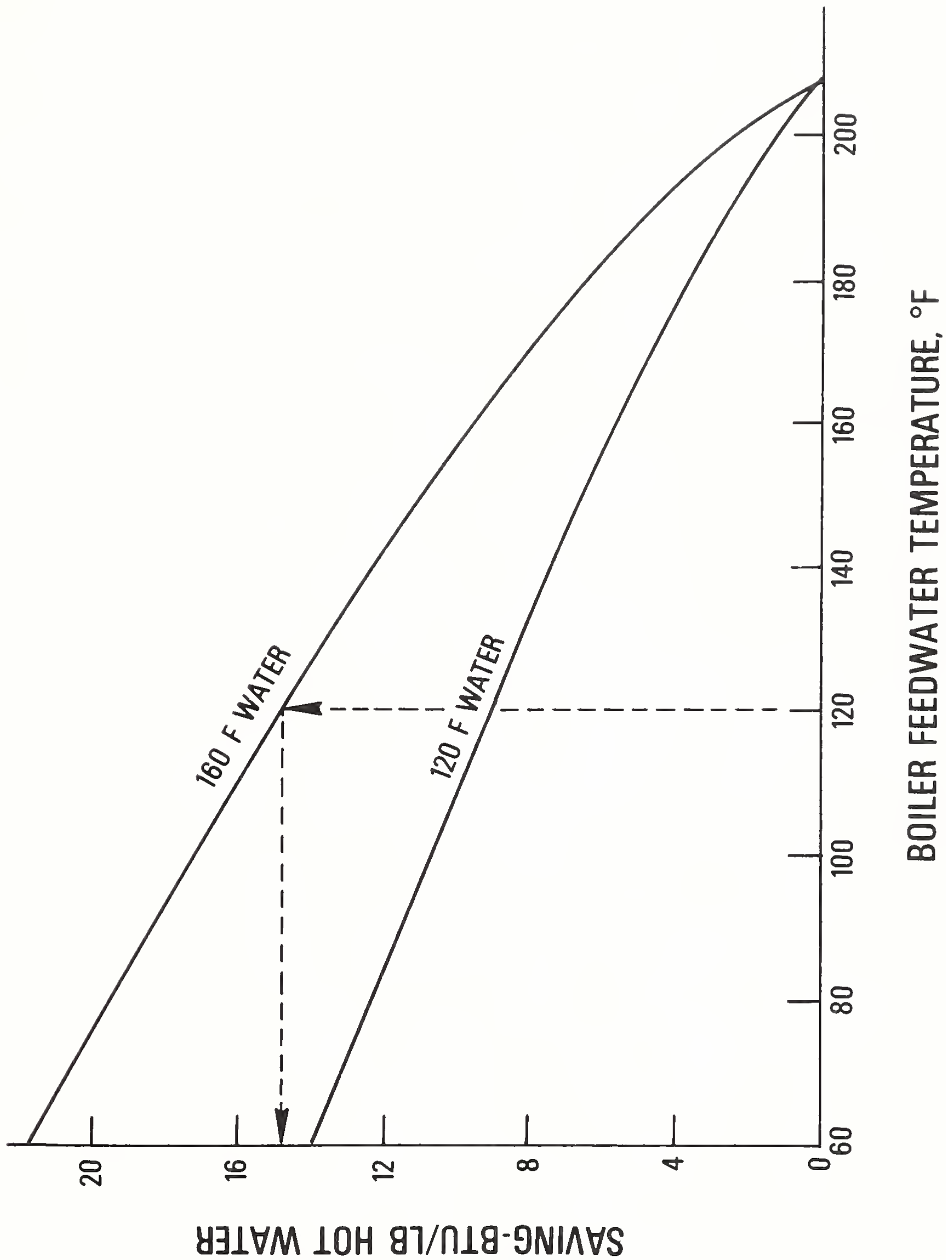


FIGURE 1. *Steam injection for heating water.*

EXAMPLE

By rescheduling the way in which its outdoor lights were used, a shopping center realized a reduction in electric power usage of 56,600 kWh per month which was equivalent to a cost savings of $350 per month.

The shopping center includes a total of 83 acres of which approximately 67 are used for outside customer parking and material and equipment storage. The outside area has a total of 2250 lights, ranging in type from floodlights to 35 foot pole lights. The existing lights were the subject of a thorough study over a considerable period of time which considered such factors as the distribution of the lights, which lights were wired on time clocks, which on photo-cells, which were wired singly, in pairs, or in clusters. As a result of this study, only 1401 of the total 2250 lights are now normally used. Of these 1401 lights; 1230 operate from dusk until 10:00 PM, a half hour after the shops close; 38 operate to 11:00 PM; and 133 operate all night. This plan provides adequate, but not uniform, lighting for night time operation and security. There have been no complaints from customers or merchants nor has there been an increase in accident frequency or vandalism.

Method for Calculating Lighting Requirements

The amount of light received from any arrangement of standard lighting fixtures and known wattage can be calculated as follows:

$$F = \frac{N \times L \times D}{A}$$

where: F = foot-candles of illumination
N = number of lighting units of same type and wattage
L = light in lumens for a given type and wattage lighting unit (refer to "IES Lighting Handbook" —1972)
D = depreciation factor for installed lights—use 0.7
A = lighted area, sq. ft.

Power Usage (kWh)

$$= \frac{N \times W \text{ (watts)} \times \text{Usage (hours)}}{1000 \text{ watts/kW}}$$

Power Cost ($) = usage (kWh) $\times$ unit cost from local rate schedule ($/kWh)

Recommended illumination for parking lots is 1 to 2 foot-candles (Ref. Figure 9–80, "IES Lighting Handbook"—1972).

SUGGESTED ACTION

1. Analyze your outdoor lighting to determine whether use of some lights can be eliminated, or rescheduled, without going below adequate, safe lighting levels.
2. Consult your power company or lighting consultant.

REFERENCE IES Lighting Handbook—1972—5th Edition
Illuminating Engineering Society
345 E. 47th Street
New York, N.Y. 10017

SOURCE Based on J. R. Kernan—"Examples of Energy Conservation," Energy Conservation Through Effective Energy Utilization, National Bureau of Standards Special Publication No. 403, Vol. II

Section 6

SOURCES OF ASSISTANCE

TABLE OF CONTENTS

6. SOURCES OF ASSISTANCE

6.0 INTRODUCTION

The individuals listed with the national organizations in Table 1 (Trade, Business and Commercial Associations) and Table 2 (Technical Societies) have volunteered to serve in a "steering role." That is, if contacted, they will supply information on energy conservation available from their organization and/or they may provide names of other organizations and/or individuals who can be contacted regarding specific problems. The local or regional chapter addresses can be furnished through the national contact.

The Field and Regional Offices of the Department of Commerce and the Federal Energy Administration are listed in Tables 3 and 4, respectively.

In addition to those organizations listed by name there are many other sources of assistance that may be contacted in seeking guidance in energy conservation methods. For example, your local utility company, is one such source of assistance. Many of these utilities have expertise in this area and have developed programs for helping their customers to improve their energy management. Beyond that, the utility—either individually or through the industrial association to which they belong—probably can offer you a wealth of educational materials and services, that can be invaluable aids in developing your energy conservation programs.

State energy offices as well as the universities in your area may provide short-term engineering help on specific conservation problems or referrals to specialists, consultants, and suppliers as needed. Some have developed Energy Speakers Bureaus available to talk to civic and professional organizations. They have in some instances developed video tapes and workshops on various energy conservation topics. Many can provide information and assistance on how to set up internal energy conservation programs.

Many major manufacturers are prepared to offer you valuable assistance, often without charge. Don't hesitate to call on them for advice. Look also to your mechanical or specialty contractor who designed or installed your environmental system. He would have first-hand knowledge of your installation and how it is supposed to perform and will be able to bring the system back to design performance as well as offering suggestions for improvement of its performance.

Several large companies have had such a tremendous success with their energy conservation programs that they have established energy consultation services whereby they are now selling energy conservation services to small and medium business clients. These consultants, professionals, have proven themselves firsthand on their own and can now share these experiences with you; they know how to go about conserving energy. Remember professional competence is not cheap but can save you money in the long run.

We have made an attempt to list the major sources of assistance, however, this listing is by no means complete. You are sure to come up with others in your geographic area that are capable of responding to your specific question or need.

6.1 TRADE, BUSINESS AND COMMERCIAL ASSOCIATIONS

TABLE 1.

American Concrete Pipe Association
Cyril I. Malloy, Jr.
Director of Public Affairs
1501 Wilson Boulevard, Suite 908
Arlington, VA 22209
(703) 524–3939

American Dry Milk Institute
John T. Walsh
Executive Director
130 North Franklin Street
Chicago, IL 60606
(312) 782–4888

American Gas Association
Robert A. Modlin
Manager, Industrial and Commercial Marketing
1515 Wilson Boulevard
Arlington, VA 22209
(703) 524-2000

American Hotel & Motel Association
Albert E. Kudrle
Director of Public Relations
888 Seventh Avenue
New York, NY 10019
(212) 265-4506

American Institute of Food Distribution, Incorporated
John F. Rengstorff
Executive Vice President
P.O. Box 523
Fair Lawn, NJ 07410
(201) 791–5570

American Institute of Timber Construction
Paul R. Beattie
Executive Vice President
333 West Hampden Avenue
Englewood, CO 80110
(303) 761–3212

American Petroleum Institute
Ms. Barbara J. Bland
Senior Manager Public Communications
1801 K Street, N.W.
Washington, DC 20006
(202) 833–5756

American Plywood Association
L. A. Whitman
Treasurer
119 A Street
Tacoma, WA 98401
(206) 272–2283

American Textile Manufacturers Institute, Incorporated
St. Clair J. Tweedie
Secretary, Energy Policy Committee
1150 17th St., N.W., Suite 1001
Washington, DC 20036
(202) 833–9420

American Trucking Association's Inc.
Edward V. Kiley
Vice President, Research and Technical Service Division
1616 P Street, N.W.
Washington, DC 20036
(202) 797–5221

Brick Institute of America
A. H. Yorkdale, P.E.
Director, Engineering & Research
175'0 Old Meadow Road
McLean, VA 22101
(703) 893-4010

Chemical Specialities Manufacturers Association
Ralph Engel
Executive Director
1001 Connecticut Avenue, N.W.
Washington, DC 20036
(202) 872–8110

Concrete Reinforcing Steel Institute
Paul F. Rice
Technical Director
180 N. LaSalle Street, Room 2110
Chicago, IL 60601
(312) 372–5059

Forging Industry Association
George W. Weinfurtner
Director of Engineering and Manufacturing
55 Public Square
Cleveland, OH 44113
(216) 781–6260

Independent Battery Manufacturers Association, Incorporated
Dan O. Noe
Executive Secretary
100 Larchwood Drive
Largo, FL
(813) 584–5540

International Association of Business Communicators
Henry Bachrach, Chairman
Energy Communication Advisory Committee
3135 Eastern Turnpike
Fairfield, CT 06431
(203) 373–2245

International Association of Ice Cream Manufacturers and/or Milk Industry Foundation
Robert M. Mulligan
Administrative Assistant
910 17th Street, N.W.
Washington, DC 20006
(202) 296–4250

International Mobile Air Conditioning Association, Incorporated
L. T. Merrill, Secretary-Manager
616 North Central Expressway, Suite 909
Dallas, TX 75206
(214) 361–7014

Manufacturing Jewelers and Silversmiths of America
Bernard W. Russian
Chairman, Energy Committee
236 Chapman Street
Providence, RI 02905
(401) 467–5800

Metal Powder Industries Federation
Kempton H. Roll
Executive Director
Box 2054
Princeton, NJ 08540
(609) 799–3300

Motor and Equipment Manufacturers Association
Ronald M. Landau
Coordinator of Technical Services
222 Cedar Lane
P.O. Box 439
Teaneck, NJ 07666
(201) 836-9500

National Asphalt Pavement Association
Charles R. Foster
Director of Engineering & Research
6811 Kenilworth Avenue, Suite 620
P.O. Box 517
Riverdale, MD 20840
(301) 779–4880

National Association of Building Manufacturers
William T. Eggbeer
Vice President/Technical Services
1619 Massachusetts Avenue, N.W.
Washington, DC 20036
(202) 234–1374

National Association of Food Chains
Mr. Thomas K. Zaucha
Director of Public Affairs
1725 I Street, N.W., Room 210
Washington, DC 20006
(202) 331–7822

National Association of Photographic Manufacturers, Inc.
Thomas J. Dufficy
600 Mamaroneck Avenue
Harrison, NY 10528
(914) 698–7603

National Association of Engine and Boat Manufacturers
George Rounds
Secretary
Box 5555
Grand Central Station
New York, NY 10017
(212) 697–1100

National Association of Recycling Industries, Incorporated
Howard Ness
Technical Vice President
330 Madison Avenue
New York, NY 10017
(212) 867–7330

National Automatic Laundry and Cleaning Council
Julius Hovany
National Legislative Director
7 South Dearborn Street, Room 1038
Chicago, IL 60603
(312) 263–3368

National Canners Association
R. P. Farrow
Vice President and Director
Western Research Laboratory
1950 Sixth Street
Berkley, CA 94710
(415) TH 3–9762

National Carwash Council
Mr. Julius Hovany
National Legislative Director
7 South Dearborn Street, Room 1038
Chicago, Illinois 60603
(312) 263–3368

National Clay Pipe Institute
E. J. Newbould
Vice President—Government Relations
1130 17th Street, N.W.
Washington, DC 20036
(202) 296–5270

National Crushed Stone Association
F. A. Renninger
Vice President—Operations
1415 Elliot Place, N.W.
Washington, DC 20007
(202) 333–1536

National Electrical Manufacturers Association
Robert Stuart Smith
Director of Public Relations
155 East 44th Street
New York, NY 10017
(212) 682–1500

National Environmental Systems Contractors Association
James P. Norris
Executive Manager
1501 Wilson Boulevard
Arlington, VA 22209
(703) 527–0678

National Federation of Independent Business
Wilson S. Johnson
President
150 West 20th Avenue
San Mateo, CA 94403
(415) 341–7441

National LP-Gas Association
John Hartzell
Manager, Public Information Department
79 West Monroe Street
Chicago, IL 60603
(312) 372–5484

National Oil Fuel Institute
Robert Nespeco
Staff Engineer
60 East 42nd Street
New York, NY 10017
(212) 867–0260

National Roofing Contractors' Association
Dr. Edwin Mertz
Technical Services Manager
1515 North Harlem Avenue
Oak Park, IL 60302
(312) 383–9513

National Soft Drink Association
Thomas A. Daly
Legal Counsel
1101 Sixteenth Street, N.W.
Washington, DC 20036
(202) 833–2450

National Tool, Die and Precision Machining Association
Tom Poturalski
National Coordinator
9300 Livingston Road
Washington, DC 20022
(303) 248–6200 x62

Optical Manufacturers Association
Eugene A. Keeney
Executive Director
1730 North Lynn St.
Arlington, VA 22209
(703) 525–3514

Pharmaceutical Manufacturers Association
John G. Adams
Vice President, Office of Scientific and Professional Relations
1155 Fifteenth Street, N.W.
Washington, DC 20005
(202) 296–2440

Portland Cement Association
Max D. Moore
Director
Industry Communications Department
Old Orchard Road
Skokie, IL 60076
(312) 966–6200

Screen Manufacturers Association
Frank S. Fitzgerald
Executive Director
410 North Michigan Avenue
Chicago, IL 60611
(312) 321–1646

The Asphalt Institute
Duane E. Edge
Director of Education
College Park, MD 20740
(301) 927–0422

The Fertilizer Institute
W. C. White
Vice President
Member Services
1015 18th Street, N.W.
Washington, DC 20036
(202) 466–2700

U. S. Brewers Association
Henry B. King
President
1750 K Street, N.W.
Washington, DC 20006
(202) 466–2400

Welded Steel Tube Institute
Robert Boeddener
522 Westgate Tower
Cleveland, OH 44116
(216) 333–4550

Whey Product Institute
John T. Walsh
Executive Director
130 North Franklin Street
Chicago, IL 60606
(312) 782–5455

6.2 TECHNICAL SOCIETIES

TABLE 2

American Ceramic Society
R. S. Sheldon
Technical Secretary
65 Ceramic Drive
Columbus, OH 43214
(614) 268–8645

American Chemical Society
Dr. Stephen T. Quigley
Director, Department of Chemistry & Public Affairs
1155 16th Street, N.W.
Washington, D.C. 20036
(202) 872–4474

American Consulting Engineers Council
Bruce E. Vogelsinger
Assistant Director, Governmental Affairs
1155 15th Street, N.W.
Suite 713
Washington, D.C. 20005
(202) 296–1780

American Institute of Chemical Engineers
Gerald L. Decker
2339 Peale Drive
Saginaw, MI 48640
(517) 636–1000

American Institute of Mining, Metallurgical, & Petroleum Engineers
Frederick C. Motts
Assistant for Public Affairs—AIME
345 East 47th Street
New York, NY 10016
(212) 644-7677

American Institute of Plant Engineers
Walter A. Schaw
Executive Director
1021 Delta Avenue
Cincinnati, OH 45208
(503) 321–9412

American Society of Agricultural Engineers
Russell H. Hahn
Assistant Secretary of Technical Activities
2950 Niles Road
St. Joseph, MI 49085
(616) 983–6521

American Society of Heating, Refrigerating & Air Conditioning Engineers
Andrew T. Boggs, III
Secretary & Executive Director
345 East 47th Street
(616) 983–6521
New York, NY 10017
(212) 644-7940

American Society of Mechanical Engineers
A. Bruce Conlin
Director, Public Program
345 East 47th Street
New York, NY 10017
(212) 644-7737

American Society of Sanitary Engineers
Morton H. Lerner, P.E., L.A.
Chairman of Fuel Energy and Conservation Committee
2401 Architects Building
117 South 17th Street
Philadelphia, PA 19103
(215) 568–5677 or 568–3242

Illuminating Engineering Society
John E. Kaufman
Technical Director
345 East 47th Street
New York, NY 10017
(212) 644-7917

Instrument Society of America
Glenn F. Harvey
Director, Publications and Standards
400 Stanwix Street
Pittsburgh, PA 15222
(412) 281–3171

Society of Automotive Engineers, Incorporated
Joseph Gilbert
General Manager
400 Commonwealth Drive
Warrendale, PA 15096
(412) 776–4841

Society of Manufacturing Engineers
Peter L. Blake
Manager, Technical Activities Department
20501 Ford Road
Dearborn, MI 48128
(313) 271–1500

Society of Petroleum Engineers of AIME
Granville Dutton
Chairman, Technical Information Committee
c/o Sun Oil Company
P. O. Box 2880
Dallas, TX 75221
(214) 744–4411

U.S. National Committee of World Energy
Conference
c/o Engineers Joint Council
345 East 47th Street
New York, NY 10017
(212) 644-7848

6.3 U.S. DEPARTMENT OF COMMERCE FIELD OFFICES

TABLE 3

Address listed is the local Director, Domestic and International Business Administration. Hours shown are local time.

Department of Commerce
Office of Energy Programs
Washington, D.C. 20230
(202) 967–3535

Alabama, Birmingham
8:30 a.m.—5 p.m.
Suite 200, 908 S. 20th St.
35205 Tel (205) 325–3327

Alaska, Anchorage
8:30 a.m.—5 p.m.
Room 412 Hill Bldg., 632 Sixth Ave.
99501 Tel (907) 272–6531

Arizona, Phoenix
8:30 a.m.—5 p.m.
508 Greater Arizona Savings Bldg.
112 N. Central Ave.
85004 Tel (602) 261–3285

California, Los Angeles
8:30 a.m.—5 p.m.
11th Fl. Federal Office Bldg.
11000 Wilshire Blvd.
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2120 Capitol Avenue
82001 Tel (307) 778-2151

6.4 FEDERAL ENERGY ADMINISTRATION REGIONAL OFFICES

TABLE 4

Individual listed is the Regional Administrator of the Federal Energy Administration Regional Offices.

Federal Energy Administration
Technology Transfer
Industrial Programs Office
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(202) 254–9627

Region I
Robert Mitchell
Room 700
150 Causeway Street
Boston, Massachusetts 02114
(617) 223–3703

Region II
Alfred Kleinfeld
Room 3206
26 Federal Plaza
New York, New York 10007
(212) 264–1021

Region III
J. A. LaSala
Room 1001
1421 Cherry Street
Philadelphia, Pennsylvania 19102
(215) 597–9066

Region IV
Kenneth Dupuy
8th Floor
1655 Peachtree Street, N.E.
Atlanta, Georgia 30309
(404) 875–8261

Region V
N. Allen Andersen
Room A–333
Federal Office Building
175 West Jackson Boulevard
Chicago, Illinois 60604
(312) 591–6025

Region VI
Delbert Fowler
Room 1720
Corrigan Towers
212 North St. Paul Street
Dallas, Texas 75201
(214) 749–7345

Region VII
James Newman
Federal Office Building
P.O. Box 15000
112 East 12th Street
Kansas City, Missouri 64106
(816) 374-2064

Region VIII
Dudley Faver
P.O. Box 26247—Belmar Branch
1075 South Yukon Street
Lakewood, Colorado 80226
(303) 234–2420

Region IX
William Arntz
Barclay Bank Boulevard
111 Pine Street
San Francisco, California 94111
(415) 556–7216

Region X
Jack Robertson
Room 1151
Federal Office Building
909 First Avenue
Seattle, Washington 98174
(206) 442–7280

either additional surface or lower cooling fluid temperatures.

D. REPLACE BAROMETRIC CONDENSERS WITH SURFACE CONDENSERS

Although this is definitely recommended as a water pollution control step as well as an energy conservation measure, it can introduce an air pollution problem. Most barometric condensers act as scrubbers for the non-condensible gases in the stream. They usually remove soluble gases, odors, and some particulates. The conditions of a surface condenser may be such that the condensing fluid may not have sufficient capacity to dissolve some of the components in the non-condensible gases. An additional treatment step on the gases might be required. An analysis of the specific conditions existing in the condensing stream is required to determine if problems of this type are likely.

E. CLEAN FOULING FROM WATER LINES REGULARLY

This is of course good practice. Care must be taken, however, that the cleaning compounds used are compatible with the waste treatment system, and that the treatment system will not be overloaded or adversely affected by discharging large amounts of cleaning solutions at one time.

F. RECOVER AND REUSE COOLING WATER

If the installation of a cooling tower will require that the water be treated to inhibit corrosion and fouling, the blowdown from the tower will contain dissolved salts and the treatment chemicals, and a permit will be required if the blowdown is discharged to a stream. Although this does not present a severe problem the application for a new discharge permit from EPA for this stream shouldn't be overlooked.

G. USE WASTE AND BY-PRODUCTS AS FUEL

Significant benefits to the environmental control program can result from the successful burning of waste products as fuel. There are air pollution pitfalls in doing this, however, and the problems associated with efficiently burning wastes should not be minimized. For instance heavy metals, such as mercury and cadmium, occur in many waste products and during the incineration process these are sometimes dispersed into the effluent. Another important factor to remember is the variability of many liquid wastes in comparison to fuels. The oxygen requirements for efficient burning of many wastes will vary radically depending on fuel properties and the incinerator operation must be controlled to respond to these changes. In addition hydrochloric acid or other corrosive combustion products may be formed from wastes containing chlorinated hydrocarbons. Other halides such as fluorine compounds also occur in some modern waste materials. Combustion of these wastes can have a rapid deleterious impact on boiler surfaces causing repair costs which may more than offset any savings in fuel costs. The proper scrubbing and/or particulate control systems must be included on the boiler or incinerator. In addition many of the toxic substances require a minimum flame temperature to completely destroy their toxic properties. It is important for the incinerator or boiler to have refractory material which can withstand both the high temperature and the corrosive materials.

H. OPERATE 3 OR 4 DAYS AROUND THE CLOCK RATHER THAN ONE OR TWO SHIFTS PER DAY

For plants which have their own waste biological treatment system this change in operating schedule may affect the performance of the treatment plant unless special provisions are made. The treatment plant will be faced with an increased load over the period of continuous operation and substantially no load for about one half the time. Although a moderate amount of flow equalization will allow most waste treatment plants to operate satisfactorily on a 1-2 shift per day cycle, a 3 or 4 day continuous operating cycle may require considerable equalization capacity so that food will be available to the biomass during the down time.

I. CONVERT FROM INDIRECT TO DIRECT FIRING

Direct firing means that the combustion gases will be contacting the process materials. There is the possibility of new materials being added to the combustion gases which could become air pollutants. The dilution effect of the combustion will tend to sweep process materials into the stack. This possibility should be carefully evaluated for air pollution potential before converting to direct firing. For example, direct contact evaporation of black liquor in paper mills is largely responsible for the odor problems associated with this industry.

7.4 GENERAL SAFETY CONSIDERATIONS

As energy conservation proceeds, operating and maintenance procedures may be changed for existing equipment and new equipment or modifications may be installed. If this represents an increase in the tempo of such changes it would be appropriate to step up activities normally associated with the plant safety program.

Plant safety engineers or others responsible for identifying unsafe conditions have experience in viewing the plant in a critical manner. For example, a warehouse storing flammable materials is designed for a certain number of air changes per hour which has been arrived at after consideration of health and safety requirements involving a company's insurance carrier, local and state labor department regulations, and state and federal OSHA and MESA requirements, among others. It would be a serious error to arbitrarily reduce the ventilation capacity in any warehouse or manufacturing area to save energy without a plant safety engineer taking all these factors into consideration. The safety engineer may see the operation in a way which helps to spot undesirable features which might be overlooked by one who identifies those features with their contribution to the plant processes. This point of view may be valuable in identifying opportunities for energy conservation.

By including plant safety personnel on the energy conservation team there may be a double advantage, the benefit of having personnel experienced in plant inspection and of including the consideration of plant safety early in the planning for each energy conserving change.

7.5 SPECIAL SAFETY AND HEALTH CONSIDERATION

Certain energy conservation actions could result in a conflict with safety and health standards issued by the Department of Labor, Occupational Safety and Health Administration (OSHA). Most of these actions concern possible reduction in the amount of ventilation for specific categories of materials and operations. OSHA at this time has issued no regulations concerning heating or illumination in industry, except the implied one of satisfying personal efficiency and comfort.

Following is a list of applicable regulations on the subject of ventilation:

1910.93 Air Contaminants

This standard details the maximum permissible rates of exposure to a wide variety of industrial materials, ranging from acetone to ozone to zirconium. Handling procedures are included for a long list of carcinogens.

1910.94 Ventilation

Detailed ventilation requirements are listed for (a) abrasive blasting, (b) grinding, polishing, and buffing operations, (c) spray finishing, and (d) open surface tanks.

1910.106 Flammable and Combustible Liquids

This specifies procedures for storing and handling flammable liquids, including the ventilation requirements.

1010.107 Spray Finishing Using Flammable and Combustible Materials

This details construction and operational requirements for spray finishing operations, including detailed ventilation specifications.

1910.108 Dip Tanks Containing Flammable or Combustible Liquids

Construction, operation, and ventilation specifications, covering tanks for the purpose of coating, finishing, treating and the like.

1910.252 Welding, Cutting, and Brazing

This covers operational requirements for welding, including detailed specifications for ventilation.

The above regulations were published in the *Federal Register,* Vol. 39, No. 125—Thursday, June 27, 1974. They are available as a booklet, *General Industry Safety and Health Regulations,* Part 1910. It is essential to read these regulations in detail to determine their applicability to any specific energy conservation proposal. A consultant may be of assistance in such an analysis.

More regulations may, of course, be released in the future covering other subjects bearing on energy conservation actions.

References

(1) *General Industry Safety and Health Regulations, Part 1910* June 1974. OSHA #2206.

(2) *Construction Safety and Health Regulations, Part 1926* June 1974. OSHA #2207.

Both are available from the Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Prices: (1) $3.85, (2) $1.55.

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