ENERGY MANAGEMENT OPPORTUNITIES

CALCULATION MANUAL

prepared by

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submitted to

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Preface

Industry and Commerce, which account for over one-half of the national use of energy, have tremendous opportunity for energy management.

The adequacy of America's energy supply has become one of the most frequently discussed subjects in the business and professional communities. Though most of us may not be involved in global decisions that will affect U.S. future use of the various available energy sources, many of us are involved in important energy decisions affecting individual business and industries. Energy use decisions made this year may well determine the survival or failure of a company and the employment status of hundreds or thousands of people next year and beyond. Decisions this important require the fullest possible availability of readily usuable information from both public and private sources. But - this kind of information is not always easy to obtain.

The vast body of energy-related material produced by government and private agencies contains enormous amounts of raw, unorganized information which is not readily available to or easily assimilated by the people involved in this area.

Keeping this difficulty in view, this EMO Energy Calculation Manual has been designed and prepared in a fashion that accomplishes the task of summarizing and standardizing a rather comprehensive list of ECOs (Energy Conservation Opportunities) in an organized, systematic and easy-to-use format.

This could have been done in various ways but in the interest of being consistent with the classification of *EPIC ECO Category Code, I have chosen to identify and designate the variety of ECOs by the same code.

In appendix   a reproduction of the "Directory of Industrial Energy Conservation Opportunities - DIECO" has been provided which the reader can go through to understand the mechanics of EPIC ECO Codes. These codes have been used to identify and designate ECOs.

In this Manual, section 1 is an introduction to EADC and a discussion on the research objectives. In section 2 standardization of ECO formats is discussed with guidelines for the users of the standard ECO Formats. Section 3 is the main content of this Manual wherein fourteen Standardized ECO Formats have been designed and example calculations have been worked. The order in which these forms have been set up is that the each ECO has an instruction sheet of its own followed by example calculations. Finally, the blank forms for the

* EPIC = Energy Conservation Program Guide for Industry and Commerce. NBS Handbook 115

ECO are given.

In section 4, some discussion on the scope of further research is included to indicate what future work can be done on this topic. Section 5 is a short summary followed by an Appendix and References.

I believe the information and guidelines presented in the Manual will help today's energy decision maker to meet the critical challenge of current and long term Energy Management.

Gholam Mustafa
Dec. 2, 1982

1. INTRODUCTION

1.1 What is EADC?

The Oklahoma State University Energy Analysis and Diagnostic Center (EADC) is the name of a project funded by the U.S. Department of Energy through the University City Science Center of Philadelphia, Pennsylvania as prime contractor.

The objective of the Center is to identify and evaluate, through visits to industrial sites, opportunities for energy conservation. The evaluation process is based on the data gathered during a one day site visit by an audit team. An energy audit report is then mailed within two weeks to the plant engineer of the plant by the audit team. The report contains a list of ECOs which are specifically identified and evaluated for that plant. A follow up letter is also then sent to the management after about six months so as to get feedback regarding their response to the suggested ECOs.

1.2 Background of the Research

A need was perceived for an EMO Calculation Manual. A large list of ECOs has been developed and are being developed by EADC for which costs and savings have already been calculated so there existed a need to summarize and standardize these in a format that would be useful for later analyses. By designing standardized ECO formats much time and effort could be saved.

1.3 Objectives of the Research

The major objectives are:

(i) To improve the quality of EADC energy audit reports mailed to the various industries where the audit takes place.

(ii) To summarize and standardize the most frequently encountered ECOs in an organized, systematic and easy-to-use format.

(iii) To maintain a consistent and unified approach in the calculation of costs and savings for various ECOs.

(iv) To eliminate the repetition of work and research on the same type of ECO by different members of EADC thereby improving the productivity of the organization as a whole.

(v) To provide the users of this Manual with a broad outline for development of future ECOs.

2. STANDARDIZATION OF ECO FORMATS

2.1 Format Discussion

The contents of all the fourteen samples of the standardized ECO formats have essentially the following seven major parts or items:

(1) EPIC ECO Code
(2) Title
(3) Executive Summary
(4) Required Data
(5) Calculations (for energy and $ savings)
(6) Calculations (for implementation cost)
(7) Calculations (for simple payback)

The aspects of design and layout of each of the above items for all of the formats have been discussed in Section 2.2.

2.2 Aspects of Design and Layout

(1) EPIC ECO Code:

Each ECO format begins with an EPIC Code number which is essentially a code number given for the name of that ECO. The reader of this manual, at this point, can make a reference to the Appendix "A" which is actually a complete set of "Directory of Industrial Energy Conservation Opportunities - DIECO" in order to understand the mechanics of the coding for a variety of ECOs.

(2) Title

This is accomplished with a short sentence (preferably of one line) for the name of the ECO which specifies its type and nature like "optimize plant power factor".

(3) Executive Summary

This is, of course, an important part of format in the sense that it explains the nature of the ECO and all the important and necessary information in brief. Brevity is important because executives are always constrained by time-factor. Therefore, it is important that the information presented is precise.

Enough information should be provided in the Executive Summary to state what is being done and why. Specific process machines should be named when necessary.

(4) Required Data

This part contains the necessary data for the cost/benefit analysis of the ECO. The audit team must supply all the data listed in the "Required Data" part of the format.

Most of the data are collected from the site either by measurement or by the records and information available at the site. However, sometimes some of the data are assumed either for the sake of simplifying the calculations or because of the unavailability of needed data. This, of course, requires judgement on the part of the analyst. The cost data are usually based on market research, and therefore, should be latest as far as possible.

(5) Calculations (for energy and $ savings)

This is the first calculation part of the ECO formats in which the energy and dollar savings are calculated. This information becomes a necessary part of the calculations for the simple payback period.

(6) Calculations (for implementation cost)

Since all of the ECOs require some capital expense (whether minimal or significant), the implementation cost for the ECO is evaluated in this part.

(7) Calculations (for simple payback)

In this last part of the calculation, the simple payback period is determined as a ratio of (total investment cost in $) to (total net annual $ savings) in order to evaluate the economic attractiveness of the ECO. A payback period up to 3 years is usually regarded as economically justifiable depending upon the nature and type of ECO

2.3 Guidelines for the Users of the ECO Formats

The design of the standard forms is such that they can be readily used as "fill-in-the-blanks." Some minor modifications might be required in case of a very typical situation. However, in general they can be used as is.

Care should be taken to be sure all data is provided accurately. Once this is done, calculations are made for energy and dollar savings and finally the payback period is calculated to evaluate the economic justification for the project.

Most of the ECOs have their own attached charts and figures to which references are to be made for calculation purposes.

In order to explain the procedures for filling out the formats, an instruction sheet and an example calculation for each of the ECOs has been provided.

The data used in the example calculations are taken from audits previously done by EADC audit teams for various industries in Oklahoma. Hence, the data are not fabricated and, therefore, reflect real world situations.

In example calculations, all the information (words or data) with which the formats are filled out are in handwriting so that they are prominently visible to the readers.

The reason for using separate instruction sheet for every ECO is the fact that every ECO has its own characterisitcs and own figures and charts to use.

INSTRUCTION SHEET FOR ECO #1

Title: Reduce Combustion Air Flow to Optimum

How To Use This ECO Format

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from the EADC audit report (Report #D6) prepared for Canadian Valley, Oklahoma City. When the reader goes through this example calculation, probably he/she would like to understand the use of Figure 1 because the rest of the materials are almost self explanatory.

Use of Figure 1

This curve is typical for hydrocarbon gaseous fuels such as natural gas. It shows the effect of reducing excess air for a hydrocarbon gaseous fuel. To use this figure, note that the curve "A" relates to %O_2 content in the flue gas to the corresponding % excess air. Hence, the broken arrows (in red ink) shows that for 7% O_2 in flue gas the corresponding % excess air is 45%. To find the fuel savings that will result from reducing the 0_2 content to an optimum value of 2%, simply find the intersection of the given O_2 level of 7% with the flue stack temperature of 360 F. The fuel savings is read as 2% directly to the left ordinate.

Handbook

Figures are available in Energy Management Handbook and Instructions for Energy Auditors for other fuels.

Note: The figures for cost of implementation should always be up to date as far as possible.

ECO # 1
(EPIC ECO CODE 11.12)

TITLE: Reduce Combustion Air Flow to Optimum

EXECUTIVE SUMMARY:

Fuel savings can be realized by reducing combustion air flow to the required optimum level. Natural gas fired furnaces need enough oxygen to support combustion. This is supplied by atmospheric air being fed into the flame. The energy content of the air must be raised to the desired furnace temperature. Therefore, any excess air drawn into the system is heated from room temperature to stack temperature having no useful purpose served and is, therefore, lost heat. By controlling the amount of air flow to the optimum level for complete combustion, less fuel will be needed to maintain the desired temperature. This can be done easily by an investment in a flue gas analyzer that helps monitor and adjust the levels of O_2 and CO_2 in the flue gases.

REQUIRED DATA:

Given:

Firing Unit Heat Output	: 3,608,500 BTU/hr.
Operating Hours	: 420 Hrs/year
Number of Burners	:
Average Fuel Cost	: $ 2.62 /MCF

Measured:

% O_2 in Flue Gases	: 7%
% CO_2 in Flue Gases	:
Stack Temperature	: 360 °F

CALCULATIONS (for energy and $ savings):

(1) Your present system has 7 % of O_2 in the flue gases at 360 °F for which Fig. (1) gives a corresponding value of 45 % excess air.

(2) You can improve your system by reducing the excess air or oxygen from the operating condition of 7 % to an optimum value of 2% oxygen, corresponding to 10% excess air for natural gases.

(3) For this action if taken, Fig. (1) shows that a fuel saving of 2 % will be achieved.

(4) % efficiency of your natural gas firing unit is determined as 82 % from Fig. (2) (existing condition).

(5) Savings in fuel = (Output heat capacity) x (1/% efficiency of firing unit) x (% Load) x (Operating hours) x (% Fuel saving)

= (3608500BTU/hr.) x (100/82) x (90/100) x (4200 Hrs./yr.) x (2 /100)

$= 333 \times 10^6$ BTU/yr.

(6) Savings in \$ = (Fuel savings) x (Fuel cost)

= (333×10^6 BTU/yr.) x (1 MCF/10^6 BTU) x (\$ 2.62/MCF)

= \$ 872.46 /year.

CALCULATIONS (for implementation cost):

(1) Material cost: The % O_2 can be monitored and adjusted by incorporating a Fyrite Analyzer to the system at an approximate cost of \$ 450.

(2) Oper. Cost: The Fyrite Analyzer can be operated by employing a maintenance personnel at the rate of \$ 10/hr. It can be assumed that he/she would spend 30 minutes every month for checking % O_2 in flue gases.

CALCULATIONS (for payback):

(1) Annual net savings = (Total \$ savings/yr.) – (Operational cost/yr.)

= \$(872.46) - \$(60.00)

= \$ 812.46 /yr.

(2) Simple payback = (Total Cost) ÷ (Annual net saving)

= (\$450) ÷ (\$812.46 /yr.)

= 0.55 yrs.

REDUCING ENERGY LOSSES IN UTILITY AND PROCESS OPERATIONS

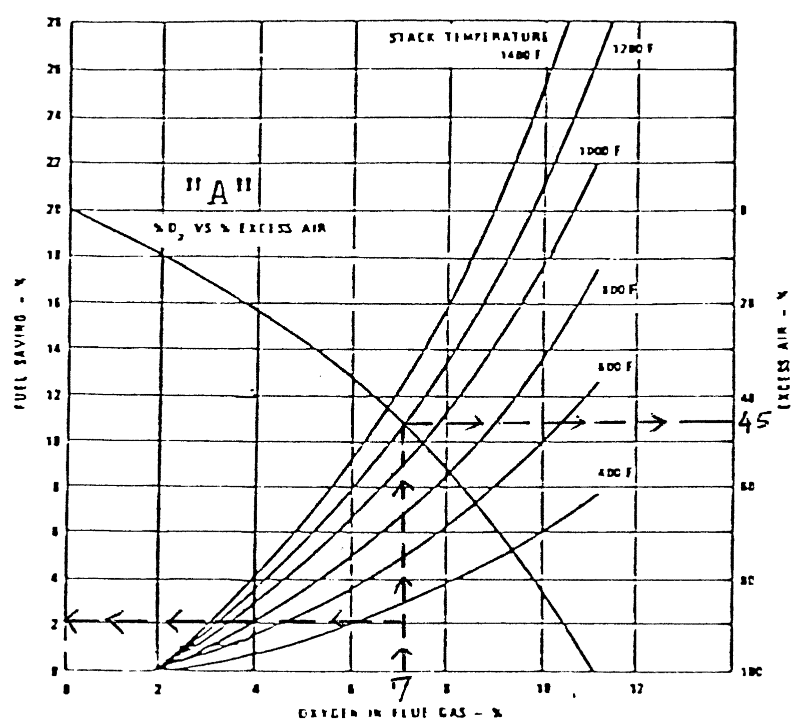


Fig. 1. The effect of reducing excess air for a hydrocarbon gaseous fuel. (Adapted from the NBS Handbook 115.)

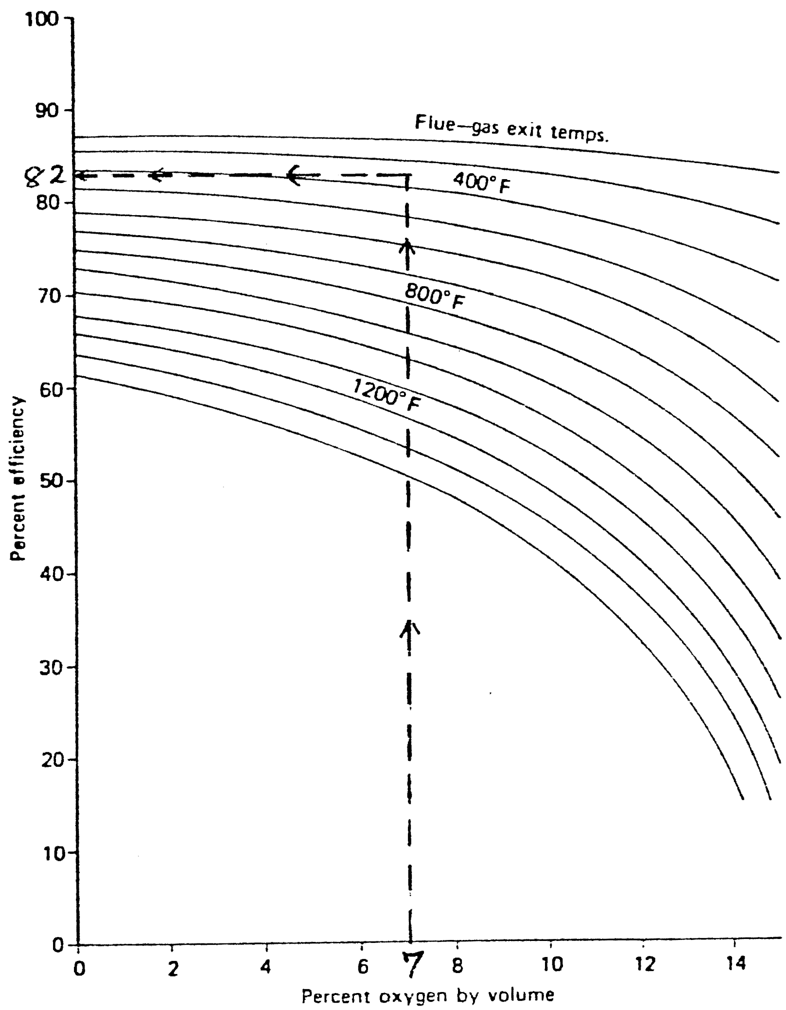


Fig. 2. Natural gas efficiency.

ECO #
(EPIC ECO CODE 11.12)

TITLE: Reduce Combustion Air Flow to Optimum

EXECUTIVE SUMMARY:

Fuel savings can be realized by reducing combustion air flow to the required optimum level. Natural gas fired furnaces need enough oxygen to support combustion. This is supplied by atmospheric air being fed into the flame. The energy content of the air must be raised to the desired furnace temperature. Therefore, any excess air drawn into the system is heated from room temperature to stack temperature having no useful purpose served and is, therefore, lost heat. By controlling the amount of air flow to the optimum level for complete combustion, less fuel will be needed to maintain the desired temperature. This can be done easily by an investment in a flue gas analyzer that helps monitor and adjust the levels of O_2 and CO_2 in the flue gases.

REQUIRED DATA:

Given:
Firing Unit Heat Output: ________ BTU/hr.
Operating Hours : ________ Hrs/year
Number of Burners : ________
Average Fuel Cost : $________ /MCF

Measured:
% O_2 in Flue Gases : ________
% CO_2 in Flue Gases : ________
Stack Temperature : ________ °F

CALCULATIONS (for energy and $ savings):

(1) Your present system has   % of O_2 in the flue gases at   °F for which Fig. (1) gives a corresponding value of   % excess air.

(2) You can improve your system by reducing the excess air or oxygen from the operating condition of   % to an optimum value of 2% oxygen, corresponding to 10% excess air for natural gases.

(3) For this action if taken, Fig. (1) shows that a fuel saving of   % will be achieved.

(4) % efficiency of your natural gas firing unit is determined as   % from Fig. (2) (existing condition).

(5) Savings in fuel = (Output heat capacity) x (1/% efficiency of firing unit) x (% Load) x (Operating hours) x (% Fuel saving)

= (BTU/hr.) x (100/   ) x (/100) x (Hrs./yr.) x (/100)

=   BTU/yr.

(6) Savings in $ = (Fuel savings) x (Fuel cost)

= (BTU/yr.) x (1 MCF/10^6 BTU) x ($ /MCF)

= $ /year.

CALCULATIONS (for implementation cost):

(1) Material cost: The % O_2 can be monitored and adjusted by incorporating a Fyrite Analyzer to the system at an approximate cost of $.

(2) Oper. Cost: The Fyrite Analyzer can be operated by employing a maintenance personnel at the rate of $ /hr. It can be assumed that he/she would spend 30 minutes every month for checking % O_2 in flue gases.

CALCULATIONS (for payback):

(1) Annual net savings = (Total $ savings/yr.) – (Operational cost/yr.)

= $(   ) - $(   )

= $ /yr.

(2) Simple payback = (Total Cost)÷ (Annual net saving)

= ($) ÷ ($ /yr.)

=   yrs.

REDUCING ENERGY LOSSES IN UTILITY AND PROCESS OPERATIONS

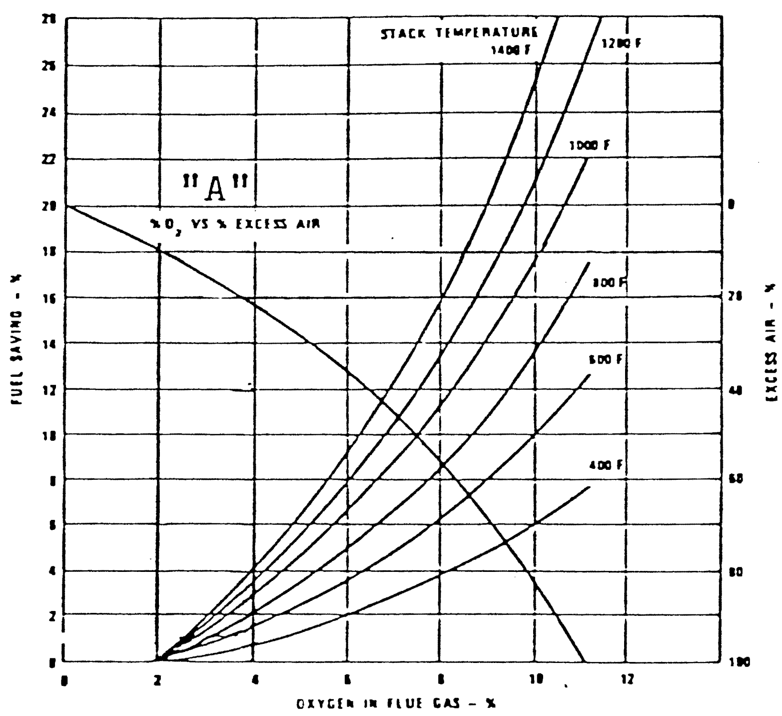
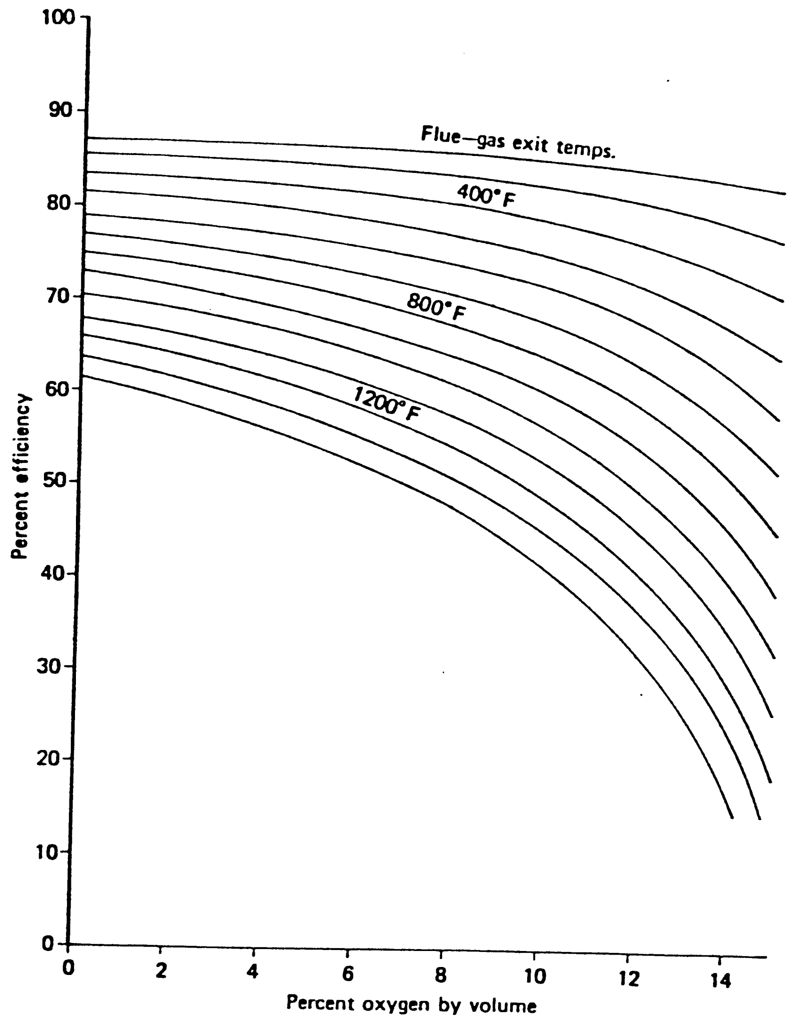


Fig. 1. The effect of reducing excess air for a hydrocarbon gaseous fuel. (Adapted from the NBS Handbook 115.)


Flue–gas exit temps.
400°F
800°F
1200°F
Percent efficiency
Percent oxygen by volume
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14

INSTRUCTION SHEET FOR ECO #2

Title: Install Compressor Air Intakes in Coolest Location

How To Use this ECO Format

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from the EADC audit report (Report #C4) prepared for Boardman Company, Oklahoma City, Oklahoma.

In this ECO, Figure 1 gives zero percent HP savings corresponding to an air intake temperature of 70°F and at this temperature the intake volume required to deliver 1000 cu.ft. of free air is also 1000 cu.ft., but for other air intake temperatures, the intake volumes required to deliver 1000 cu.ft. of free air are different and they are increasing with the increase in air intake temperatures.

Further, note that the intake volume corresponding to air intake temperature of 95 F is 1050 ft^3 which has been calculated from Figure 1 by interpolation.

For example, the intake volume corresponding to 88 F (air intake temperature) can be interpolated as follows:

$$1020 + \frac{(1040 - 1020)}{90 - 80} \times (88 - 80) = 1036 \text{ cu.ft}$$

Note: The figures for cost of implementation should always be up to date as far as possible.

ECO # 2
(EPIC ECO CODE 32.21)

TITLE: Install Compressor Air Intakes in Coolest Locations.

EXECUTIVE SUMMARY:

By installing the intake duct for an air compressor in the coolest locations, one can have H.P. savings thereby reducing the consumption of the energy for the prime mover. Usually it is the saving in electrical energy of the motors driving the compressor. This energy saving potential is due to the fact that the compressor is required to do less work in order to compress a certain amount of air at a lower temperature having a smaller volume than to compress the same amount of air at a higher temperature having a larger volume. This can be done easily by installing an air intake duct at the compressor intake leading it to the outside cooler atmosphere.

REQUIRED DATA:

Given:

Average inside air temp. (T_1)	: 95	°F
Average outside air temp. (T_2)	: 60	°F
Compressor size	: 50	Hp.
Operation Hours	: 2500	Hrs./yr.
Electricity cost	: $ 0.02812	/KWH
% Load on compressor	: 50	%

Measured:

Duct-work length	: 4	ft.

CALCULATIONS (for energy and $ savings):

(1) Referring to Fig. (1) under the second column (with the heading: Intake volume required to deliver 1000 ft^3 of free air at 70°F), the corresponding volumes of air can be found at T_1 = 95°F and T_2 = 60 °F as 1050 ft^3 and 981 ft^3 respectively.

(2) Savings in energy = [(Intake vol. at T_1 - Intake vol. at T_2)/(Intake vol. at T_1)] x 100%
= [(1050 - 981)/(1050)] x 100%
= 6.57 % Hp saving.

(3) Savings in KWH: = (% Hp saving) x (% Load) x (Compressor size) x (0.746 KW/hp) x (Operating hrs./yr.)
= (6.57 /100) x (50 /100) x (50 hp) x (0.746 KW/hp.) x (2500 hrs./yr.)
= 3063 KWH/yr.

(4) Savings in BTU: = (3063 KWH/yr.) x (3412 BTU/KWH)
= 10.5×10^6 BTU/yr.

(5) Savings in $: = (KWH/yr. saved) x (Electricity cost)
= (3063 KWH/yr.) x ($ 0.02812/KWH)
= $ 86.13 /yr.

CALCULATIONS (for implementation cost):

(1) Material cost: For the air intake duct work, insulated flexible duct with vinyl coated spring steel (or aluminum) can be used which costs abour $ 3.00 /linear ft.
And 2 grille would cost $ 50 approximately @ $25/grille.

(2) Labor cost: For the installation of the duct, 2 persons may be employed @ $ 10 /hr. for about 2 hours.

(3) Hence Total cost = Material cost + Labor cost

= (duct cost/linear ft) x (Total linear ft) + (# grilles) x (Cost of grille) + (# of labors) x (# of hrs. worked) x (wage/hr.)

= $ 3.00 /linear ft) x (4 ft.) + (2 grilles) x ($ 25/grille) + (2 labors) x ($ 10 /hr) x (2 hrs)

= $ 102.00

CALCULATION (for payback):

(1) Simple payback = $\frac{\text{Total cost \$}}{\text{Annual \$ savings}}$

= 102.00/86.13

= 1.18 yrs.

Note: In some cases a damper is required so that inside air is used in the summer if it is cooler than outside. In your case such a damper is also recommended.

Figure 1

Temperature of Air Intake, F	Intake Volume Required to Deliver 1000 cu.ft. of Free Air at 70 F	% HP Saving or Increase Relative to 70 F Intake
30	925	7.5 Saving
40	943	5.7 Saving
50	962	3.8 Saving
60	981	1.9 Saving
70	1000	0
80	1020	1.9 Increase
90	1040	3.8 Increase
100	1060	5.7 Increase
110	1080	7.6 Increase
120	1100	9.5 Increase

64	DUCTWORK Incl. fittings, joints, supports, allowance for							
002	flexible connections. No insulation included.							
010	(139) Aluminum, alloy 3003-H14, under 500 lb.	Q-10	80	Lb	1.95	4.69	6.64	8.95
016	Over 2000 lb.		130		1.34	2.89	4.23	5.65
050	Galvanized steel, under 500 lb.		240		.76	1.56	2.32	3.10
052	500 to 1000 lb.		255		.57	1.47	2.04	2.75
054	1000 to 2000 lb.		265		.48	1.42	1.90	2.57
056	2000 to 5000 lb.		275		.45	1.36	1.81	2.47
058	Over 5000 lb.		285		.39	1.32	1.71	2.33
100	Stainless steel, type 304, under 400 lb.		165		1.96	2.27	4.23	5.45
106	Over 2000 lb.		225		1.24	1.67	2.91	3.77
110	For medium pressure ductwork, add					15%		
120	For high pressure ductwork, add					40%		
130	Flexible duct, vinyl coated spring steel or aluminum,							
140	pressure to 10" (WG) UL-181.							
150	Non-insulated, 3" diameter	Q-9	400	L.F.	.48	.60	1.08	1.40
154	5" diameter		320		.66	.75	1.41	1.82
156	6" diameter		280		.76	.86	1.62	2.08
158	7" diameter		240		.86	1.01	1.87	2.40
160	8" diameter		200		1.02	1.21	2.23	2.87
164	10" diameter		160		1.32	1.51	2.83	3.63
166	12" diameter		120		1.61	2.01	3.62	4.68
190	Insulated, 4" diameter		340		1.75	.71	2.46	2.95
192	5" diameter		300		1.22	.80	2.02	2.50
194	6" diameter		260		1.32	.93	2.25	2.79
196	7" diameter		220		1.44	1.10	2.54	3.17
198	8" diameter		180		1.62	1.34	2.96	3.72
202	10" diameter		140		1.91	1.72	3.63	4.59
204	12" diameter		100		2.34	2.41	4.75	6.05
300	Rigid fiberglass, round, .003" foil scrim jacket							
310	4" diameter	Q-9	310	L.F.	1.21	.78	1.99	2.46
312	5" diameter		275		1.39	.88	2.27	2.80
314	6" diameter		240		1.52	1.01	2.53	3.13
316	7" diameter		220		1.77	1.10	2.87	3.53
318	8" diameter		180		2.03	1.34	3.37	4.17
322	10" diameter		140		2.47	1.72	4.19	5.20
324	12" diameter		100		3.15	2.41	5.56	6.95
350	Rectangular, (no additional insulation required)	Q-10	350	SF Surf	.88	1.07	1.95	2.52

55	GRILLES							
002	Aluminum							
100	Air return, 6" x 6"	1 Shee	26	Ea.	5.05	5.15	10.20	13
102	10" x 6"		24		5.45	5.60	11.05	14.05
108	16" x 8"		22		7.45	6.10	13.55	17
110	12" x 12"		22		7.45	6.10	13.55	17
112	24" x 12"		18		11.15	7.45	18.60	23
122	24" x 18"		16		17.80	8.40	26.20	32
128	36" x 24"		14		42	9.55	51.55	60
300	Filter grille with filter, 12" x 12"		24		11.25	5.60	16.85	20
302	18" x 12"		20		14.50	6.70	21.20	26
304	24" x 18"		18		26	7.45	33.45	39
306	24" x 24"		16		37	8.40	45.40	53
600	For steel grilles instead of aluminum, in above deduct				10%			

For expanded coverage of these items see Means' *Mechanical & Electrical Cost Data 1981*

ECO #
(EPIC ECO CODE 32.21)

TITLE: Install Compressor Air Intakes in Coolest Locations.

EXECUTIVE SUMMARY:

By installing the intake duct for an air compressor in the coolest locations, one can have H.P. savings thereby reducing the consumption of the energy for the prime mover. Usually it is the saving in electrical energy of the motors driving the compressor. This energy saving potential is due to the fact that the compressor is required to do less work in order to compress a certain amount of air at a lower temperature having a smaller volume than to compress the same amount of air at a higher temperature having a larger volume. This can be done easily by installing an air intake duct at the compressor intake leading it to the outside cooler atmosphere.

REQUIRED DATA:

Given:

Average inside air temp. (T_1) : ________ °F
Average outside air temp. (T_2): ________ °F
Compressor size : ________ Hp.
Operation Hours : ________ Hrs./yr.
Electricity cost : $________ /KWH
% Load on compressor : ________ %

Measured:

Duct-work length : ________ ft.

CALCULATIONS (for energy and $ savings):

(1) Referring to Fig. (1) under the second column (with the heading: Intake volume required to deliver 1000 ft^3 of free air at 70°F), the corresponding volumes of air can be found at T_1 = °F and T_2 = °F as ft^3 and ft^3 respectively.

(2) Savings in energy = [(Intake vol. at T_1 - Intake vol. at T_2)/ (Intake vol. at T_1)] x 100%

= [(−)/( )] x 100%

= % Hp saving.

(3) Savings in KWH: = (% Hp saving) x (% Load) x (Compressor size) x (0.746 KW/hp) x (Operating hrs./yr.)

= (/100) x (/100) x (hp) x (0.746 KW/hp.) x (hrs./yr.)

= KWH/yr.

(4) Savings in BTU: = (KWH/yr.) x (3412 BTU/KWH)

= BTU/yr.

(5) Savings in $: = (KWH/yr. saved) x (Electricity cost)

= (KWH/yr.) x ($ /KWH)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) Material cost: For the air intake duct work, insulated flexible duct with vinyl coated spring steel (or aluminum) can be used which costs abour $ /linear ft.
And grille would cost $ approximately @ $ /grille.

(2) Labor cost: For the installation of the duct, persons may be employed @ $ /hr. for about hours.

(3) Hence Total cost = Material cost + Labor cost

= (duct cost/linear ft) x (Total linear ft) + (# grilles) x (Cost of grille) + (# of labors) x (# of hrs. worked) x (wage/hr.)

= $ /linear ft) x (ft.) + (grilles) x ($ grille) + (labors) x ($ /hr) x (hrs)

= $.

CALCULATION (for payback):

(1) Simple payback = $\frac{\text{Total cost \$}}{\text{Annual \$ savings}}$

=

= yrs.

Note: In some cases a damper is required so that inside air is used in the summer if it is cooler than outside. In your case

Figure 1

Temperature of Air Intake, F	Intake Volume Required to Deliver 1000 cu.ft. of Free Air at 70 F	% HP Saving or Increase Relative to 70 F Intake
30	925	7.5 Saving
40	943	5.7 Saving
50	962	3.8 Saving
60	981	1.9 Saving
70	1000	0
80	1020	1.9 Increase
90	1040	3.8 Increase
100	1060	5.7 Increase
110	1080	7.6 Increase
120	1100	9.5 Increase

64	DUCTWORK Incl. fittings, joints, supports, allowance for							
002	flexible connections. No insulation included.							
010	(139) Aluminum, alloy 3003-H14, under 500 lb	Q-10	80	Lb	1.95	4.69	6.64	8.95
016	Over 2000 lb.		130		1.34	2.89	4.23	5.65
050	Galvanized steel, under 500 lb.		240		.76	1.56	2.32	3.10
052	500 to 1000 lb.		255		.57	1.47	2.04	2.75
054	1000 to 2000 lb.		265		.48	1.42	1.90	2.57
056	2000 to 5000 lb.		275		.45	1.36	1.81	2.47
058	Over 5000 lb.		285		.39	1.32	1.71	2.33
100	Stainless steel, type 304, under 400 lb		165		1.96	2.27	4.23	5.45
106	Over 2000 lb.		225		1.24	1.67	2.91	3.77
110	For medium pressure ductwork, add					15%		
120	For high pressure ductwork, add					40%		
130	Flexible duct, vinyl coated spring steel or aluminum,							
140	pressure to 10" (WG) UL-181.							
150	Non-insulated, 3" diameter	Q-9	400	L.F.	.48	.60	1.08	1.40
154	5" diameter		320		.66	.75	1.41	1.82
156	6" diameter		280		.76	.86	1.62	2.08
158	7" diameter		240		.86	1.01	1.87	2.40
160	8" diameter		200		1.02	1.21	2.23	2.87
164	10" diameter		160		1.32	1.51	2.83	3.63
166	12" diameter		120		1.61	2.01	3.62	4.68
190	Insulated, 4" diameter		340		1.75	.71	2.46	2.95
192	5" diameter		300		1.22	.80	2.02	2.50
194	6" diameter		260		1.32	.93	2.25	2.79
196	7" diameter		220		1.44	1.10	2.54	3.17
198	8" diameter		180		1.62	1.34	2.96	3.72
202	10" diameter		140		1.91	1.72	3.63	4.59
204	12" diameter		100		2.34	2.41	4.75	6.05
300	Rigid fiberglass, round, .003" foil scrim jacket							
310	4" diameter	Q-9	310	L.F.	1.21	.78	1.99	2.46
312	5" diameter		275		1.39	.88	2.27	2.80
314	6" diameter		240		1.52	1.01	2.53	3.13
316	7" diameter		220		1.77	1.10	2.87	3.53
318	8" diameter		180		2.03	1.34	3.37	4.17
322	10" diameter		140		2.47	1.72	4.19	5.20
324	12" diameter		100		3.15	2.41	5.56	6.95
350	Rectangular, (no additional insulation required)	Q-10	350	SF Surf	.88	1.07	1.95	2.52

55	GRILLES							
002	Aluminum							
100	Air return, 6" x 6"	1 Shee	26	Ea.	5.05	5.15	10.20	13
102	10" x 6"		24		5.45	5.60	11.05	14.05
108	16" x 8"		22		7.45	6.10	13.55	17
110	12" x 12"		22		7.45	6.10	13.55	17
112	24" x 12"		18		11.15	7.45	18.60	23
122	24" x 18"		16		17.80	8.40	26.20	32
128	36" x 24"		14		42	9.55	51.55	60
300	Filter grille with filter, 12" x 12"		24		11.25	5.60	16.85	20
302	18" x 12"		20		14.50	6.70	21.20	26
304	24" x 18"		18		26	7.45	33.45	39
306	24" x 24"		16		37	8.40	45.40	53
600	For steel grilles instead of aluminum, in above deduct				10%			

For expanded coverage of these items see Means' *Mechanical & Electrical Cost Data 1981*

INSTRUCTION SHEET FOR ECO #3

Title: Eliminate Leaks in Compressed Air

How To Use This ECO Format

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from EADC audit report (Report #C10) prepared for Neece Steel Corporation, Claremore, Oklahoma.

Table 1 of this ECO furnishes values of "free air wasted by the air leaks" corresponding to different leak sizes at different air pressure of compressor. It also furnishes the corresponding values of fuel wasted (in KWH/yr and BTU/yr). However, in cases of air pressure other than 120, 110, 100 and 90 psig, interpolation would be required. For example, if the compressor air pressure were 105 psig then the fuel wasted (in BTU/yr) corresponding to a leak size of 1/16 inch would be:

$$= 21.5 \times 10^6 - \frac{(21.5 \times 10^6 - 19.8 \times 10^6)}{110 - 100} \times (110 - 105)$$

$$= 20.65 \times 10^6 \text{ BTU/yr.}$$

Note: The figures for cost of implementation should always be up to date as far as possible.

ECO # 3
(EPIC ECO CODE 32.31)

TITLE: Eliminate Leaks in Compressed Air.

EXECUTIVE SUMMARY:

Compressed air leaks are quite expensive and they are a direct loss of the dollars put into the energy required to compress the air. You can realize savings in energy and thereby in $s by establishing a maintenance schedule to inspect air hoses, pipelines, valves and fittings at regular intervals to detect leaks. Since the hissing sound of air leaks often becomes inaudible due to excessive plant noise, it is, therefore, a common way of detecting leaks in air pipelines by swabbing soapy water around the joints. Even very small leaks will make their presence known by blowing bubbles. For your system of compressed air leaks, calculations have been made to show the savings.

REQUIRED DATA:

Given:

Air compressor discharge pressure	: 100 psig
Cost of electricity (including fuel adj.)	: $ 0.029 /KWH
Hrs. of operation/yr.	: 4250 Hrs./yr.

Measured/Estimated:

Compressed air leak sizes (in terms of their equivalent diameters)	: (a) 1/16 inch
	: (b) 1/8 inch
	: (c) 1/4 inch
Corresponding number of leaks	: (a) 4
	: (b) 3
	: (c) 1

CALCULATIONS (for energy and $ savings):

(1) Some of the air leaks are actually cracks/holes/gaps etc. of irregular shape. But, however, for calculation purposes they have been rounded off to their approximate equivalent diameter.

(2) For your present system, Tables (1) shows that for your air compressor discharge pressure of 100 psig, you have the following amount of waste of free air and fuel:

Number of Leaks	Estimated Diameter (inch)	Free air wasted cu.ft./yr.	Fuel wasted BTU/yr.
4	1/16	4 x 2,222,000	$4 \times 19.8 \times 10^6$
3	1/8	3 x 8,880,000	$3 \times 78.8 \times 10^6$
1	1/4	1 x 35,500,000	$1 \times 315.6 \times 10^6$

Total: 7.1×10^6 cu ft/yr. Total 631.2×10^6 BTU/yr.

(3) Fuel (BTU) Savings: (Total fuel wasted/yr.) x $\frac{\text{(Hrs. of operation/yr.)}}{\text{24 x 365 Hrs./yr.}}$

$= (631.2 \times 10^6 \text{ BTU/yr}) \times \left(\frac{4250 \text{ Hrs./yr.}}{8760 \text{ Hrs./yr.}}\right)$

$= 306 \times 10^6$ BTU/yr.

(4) KWH Savings: (BTU savings/yr.) x (1 KWH/3412 BTU)

$= (306 \times 10^6$ BTU/yr.) x (1 KWH/3412 BTU)

= 89752 KWH/yr.

(5) $ Savings: = (KWH savings/yr.) x (Electricity cost)

= (89752 KWH/yr.) x ($0.029 /KWH)

= $2603 /yr.

CALCULATIONS (for implementation cost):

(1) Material cost: This cost will be the replacement cost of the bad portion of the hoses and cost of fittings/unions etc.

(2) Labor cost: For the repair work, 1 persons may be employed at the rate of $10 /hr. for about 0.5 hr./hole.

(3) Total cost = Material cost + Labor cost

= [(Hose cost) + (2 parts) x (Union/fitting cost per part)] + [(Wage rate) x $\frac{\text{(Repair time)}}{\text{hole}}$ x (Number of holes)]

= ($20) + 2($2.00/part) x (8 holes) + ($10 /hr.)(0.5 hr./hole) x (8 holes)

= $92.00

CALCULATIONS (for payback):

Simple payback = $\frac{\text{Total cost}}{\text{Annual \$ savings}} = \frac{92.00}{2603}$

= 0.035 years

= 0.42 months.

TABLE 1

COMPRESSED AIR LEAKS

Hole Diameter (In.)	Free Air Wasted By the Air Leak (cu.ft./yr.)	Fuel Wasted KWH/YR	Fuel Wasted BTU/YR (1×10^6)
	@ 120 PSI		
3/8	94,369,800	248,190	846.8
1/4	41,900,190	110,200	376.0
1/8	10,475,050	27,550	94.0
1/16	2,623,480	6,900	23.5
1/32	632,300	1,660	5.7
	@ 110 PSI		
3/8	86,834,000	226,100	771.5
1/4	38,580,800	100,500	342.9
1/8	9,638,600	25,100	85.6
1/16	2,412,200	6,300	21.5
1/32	601,000	1,600	5.5
	@ 100 PSI		
3/8	79,900,000	208,100	710.0
1/4	35,500,000	92,500	315.6
1/8	8,880,000	23,100	78.8
1/16	2,220,000	5,800	19.8
1/32	553,000	1,400	4.8
	@ 90 PSI		
3/8	72,967,000	190,000	648.3
1/4	33,133,000	86,300	294.4
1/8	8,107,000	21,100	72.0
1/16	2,027,000	5,300	18.1
1/32	505,000	1,300	4.4

ECO #
(EPIC ECO CODE 32.31)

TITLE: Eliminate Leaks in Compressed Air.

EXECUTIVE SUMMARY:

Compressed air leaks are quite expensive and they are a direct loss of the dollars put into the energy required to compress the air. You can realize savings in energy and thereby in $s by establishing a maintenance schedule to inspect air hoses, pipelines, valves and fittings at regular intervals to detect leaks. Since the hissing sound of air leaks often becomes inaudible due to excessive plant noise, it is, therefore, a common way of detecting leaks in air pipelines by swabbing soapy water around the joints. Even very small leaks will make their presence known by blowing bubbles. For your system of compressed air leaks, calculations have been made to show the savings.

REQUIRED DATA:

Given:

Air compressor discharge pressure	: ________	psig
Cost of electricity (including fuel adj.)	: $ ________	/KWH
Hrs. of operation/yr.	: ________	Hrs./yr.

Measured/Estimated:

Compressed air leak sizes		
(in terms of their equivalent diameters)	: (a) ________	inch
	: (b) ________	inch
	: (c) ________	inch
Corresponding number of leaks	: (a) ________	
	: (b) ________	
	: (c) ________	

CALCULATIONS (for energy and $ savings):

(1) Some of the air leaks are actually cracks/holes/gaps etc. of irregular shape. But, however, for calculation purposes they have been rounded off to their approximate equivalent diameter.

(2) For your present system, Tables (1) shows that for your air compressor discharge pressure of   psig, you have the following amount of waste of free air and fuel:

Number of Leaks	Estimated Diameter (inch)	Free air wasted cu.ft./yr.	Fuel wasted BTU/yr.
		Total: cu ft/yr.	Total BTU/yr.

(3) Fuel (BTU) Savings: (Total fuel wasted/yr.) x $\frac{\text{(Hrs. of operation/yr.)}}{\text{24 x 365 Hrs./yr.}}$

= (BTU/yr) x $\left(\frac{\text{Hrs./yr.}}{\text{8760 Hrs./yr.}}\right)$

= BTU/yr.

(4) KWH Savings: (BTU savings/yr.) x (1 KWH/3412 BTU)

= (BTU/yr.) x (1 KWH/3412 BTU)

= KWH/yr.

(5) $ Savings: = (KWH savings/yr.) x (Electricity cost)

= (KWH/yr.) x ($. /KWH)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) Material cost: This cost will be the replacement cost of the bad portion of the hoses and cost of fittings/unions etc.

(2) Labor cost: For the repair work, persons may be employed at the rate of $ /hr. for about 0.5 hr./hole.

(3) Total cost = Material cost + Labor cost

= [(Hose cost) + (2 parts) x (Union/fitting cost per part)] + [(Wage rate) x $\frac{\text{(Repair time)}}{\text{hole}}$ x (Number of holes)]

= ($) + 2($ /part) + ($ /hr.)(0.5 hr./hole) x (holes)

= $

CALCULATIONS (for payback):

Simple payback = $\frac{\text{Total cost}}{\text{Annual \$ savings}}$

= years

TABLE 1

COMPRESSED AIR LEAKS

Hole Diameter (In.)	Free Air Wasted By the Air Leak (cu.ft./yr.)	Fuel Wasted KWH/YR	Fuel Wasted BTU/YR (1×10^6)
	@ 120 PSI		
3/8	94,369,800	248,190	846.8
1/4	41,900,190	110,200	376.0
1/8	10,475,050	27,550	94.0
1/16	2,623,480	6,900	23.5
1/32	632,300	1,660	5.7
	@ 110 PSI		
3/8	86,834,000	226,100	771.5
1/4	38,580,800	100,500	342.9
1/8	9,638,600	25,100	85.6
1/16	2,412,200	6,300	21.5
1/32	601,000	1,600	5.5
	@ 100 PSI		
3/8	79,900,000	208,100	710.0
1/4	35,500,000	92,500	315.6
1/8	8,880,000	23,100	78.8
1/16	2,220,000	5,800	19.8
1/32	553,000	1,400	4.8
	@ 90 PSI		
3/8	72,967,000	190,000	648.3
1/4	33,133,000	86,300	294.4
1/8	8,107,000	21,100	72.0
1/16	2,027,000	5,300	18.1
1/32	505,000	1,300	4.4

INSTRUCTION SHEET FOR ECO #4

Title: Reduce the Pressure of Compressed Air to the Minimum

<u>How To Use This ECO Format</u>

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from EADC audit report (Report #C9) prepared for Pawhuska Manufacturing, Pawhuska, Oklahoma.

There are two figures in this ECO. Figure 1 should be used for single stage reciprocating and rotary screw type compressors, whereas Figure 2 is to be used for two stage reciprocating and centrifuged compressors. The abscissas of both the figures are meant for lowered (recommended) discharge pressure and the curves are for different initial discharge pressure. The ordinates give the approximate decrease in BHP (Brake Horse Power) in percentage.

ECO #

EPIC ECO CODE 32.11

TITLE: Reduce the pressure of compressed air to the minimum required.

EXECUTIVE SUMMARY:

The audit team feels that your air pressure could be lowered without causing operating problems. A reduction in air pressure to the minimum required level reduces consumption of energy of the electrical motor driving the compressor. In your case, we recommend you go from 110 psig to 100 psig, for which calculations have been made to show the savings.

REQUIRED DATA:

Given:

(1) Present air compressor discharge pressure	: 110 psig
(2) Type of compressor	: Single Stage Reciprocating
(3) Size (HP) of compressor	: 10 HP
(4) Operating hrs./yr.	: 700 hrs./yr.
(5) Cost of electricity	:$ 0.03798 /KWH
(6) Fuel adjustment cost factor charge	:$ 0.00639 /KWH
(7) Recommended air compressor discharge pressure	: 100 psig

CALCULATIONS (for energy and $ savings):

(1) For a recommended air compressor discharge pressure of 100 psig (i.e., a reduction of (110 - 100 = 10 psig), Fig. (1) gives a reduction in base horsepower of 5 %.

(2) Effective cost of electricity:

= (cost of electricity) + (fuel adjustment cost factor charge)

= ($0.03798 /KWH) + ($0.00639/KWH)

= $0.04437/KWH

(3) Savings in energy (KWH):

= (% HP savings/100) x (compressor HP) x (operating hrs./yr.) x (conversion factor for HP to KW)

= (5 /100) x (10 hp) x (700 hrs./yr.) x (0.746 KW/hp)

= 261.1 KWH/yr.

(4) Savings in energy (BTU):

= (savings in KWH/yr.) x (conversion factor)

= (261.6 KWH/yr.) x (3412 BTU/KWH)

= 0.9×10^6 BTU/yr.

(5) Savings in $:

= (savings in KWH) x (effective cost of electricity)
= (261.1 KWH/hr.) x ($ 0.04437/KWH)
= $ 11.59/yr.

CALCULATIONS (for implementation cost):

Since there is no cost of implementation, the payback is immediate.

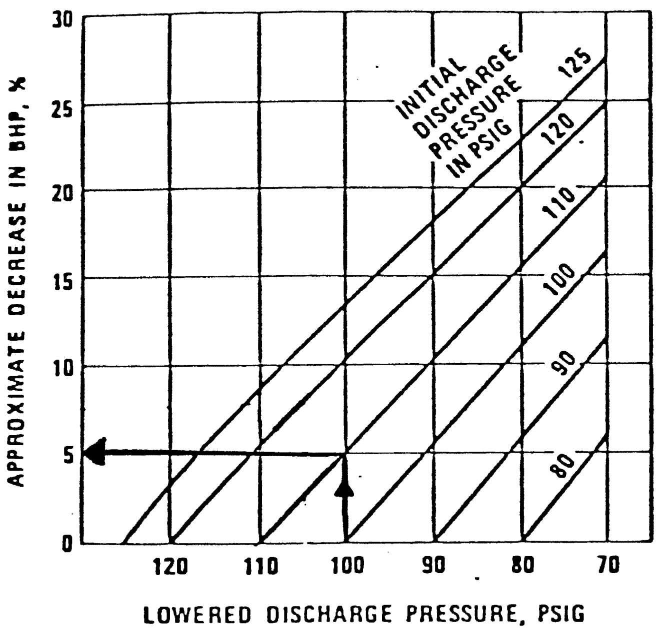


Figure 1 – Single Stage Reciprocating and Rotary Screw Compressors

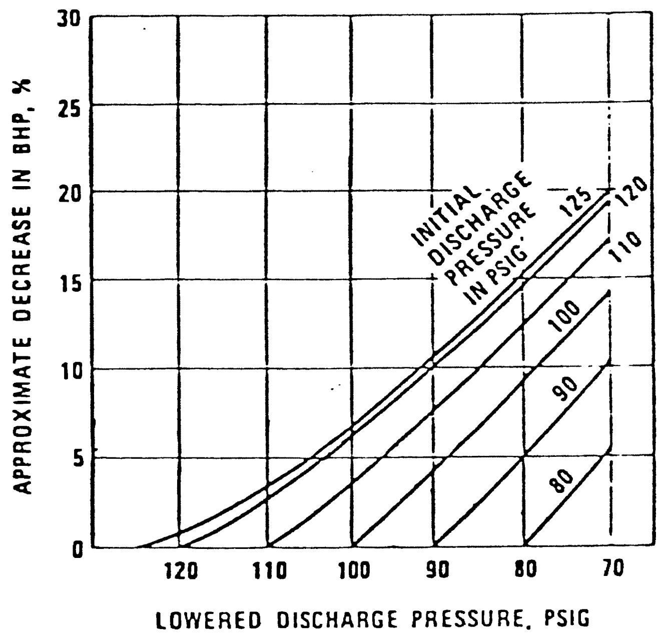


Figure 2 – Two Stage Reciprocating and Centrifugal Compressors

Source: Energy Conservation Program Guide for Industry and Commerce, NBS Handbook 115 (US Dept. of Commerce/National Bureau of Standards).

ECO #

EPIC ECO CODE 32.11

TITLE: Reduce the pressure of compressed air to the minimum required.

EXECUTIVE SUMMARY:

The audit team feels that your air pressure could be lowered without causing operating problems. A reduction in air pressure to the minimum required level reduces consumption of energy of the electrical motor driving the compressor. In your case, we recommend you go from psig to psig, for which calculations have been made to show the savings.

REQUIRED DATA:

Given:

(1) Present air compressor discharge pressure	:	psig
(2) Type of compressor	:	
(3) Size (HP) of compressor	:	HP
(4) Operating hrs./yr.	:	hrs./yr.
(5) Cost of electricity	:$	/KWH
(6) Fuel adjustment cost factor charge	:$	/KWH
(7) Recommended air compressor discharge pressure	:	psig

CALCULATIONS (for energy and $ savings):

(1) For a recommended air compressor discharge pressure of psig (i.e., a reduction of (- = psig), Fig. ( ) gives a reduction in base horsepower of %.

(2) Effective cost of electricity:

= (cost of electricity) + (fuel adjustment cost factor charge)

= ($ /KWH) + ($ /KWH)

= $ /KWH

(3) Savings in energy (KWH):

= (% HP savings/100) x (compressor HP) x (operating hrs./yr.) x (conversion factor for HP to KW)

= (/100) x (hp) x (hrs./yr.) x (0.746 KW/hp)

= KWH/yr.

(4) Savings in energy (BTU):

= (savings in KWH/yr.) x (conversion factor)

= (KWH/yr.) x (3412 BTU/KWH)

= BTU/yr.

(5) Savings in $:

= (savings in KWH) x (effective cost of electricity)
= (KWH/hr.) x ($ /KWH)
= $ /yr.

CALCULATIONS (for implementation cost):

Since there is no cost of implementation, the payback is immediate.

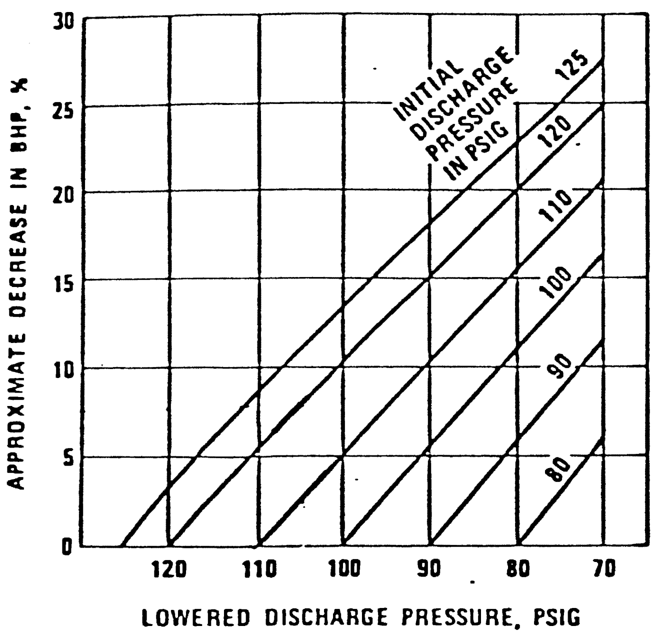


Figure 1 – Single Stage Reciprocating and Rotary Screw Compressors

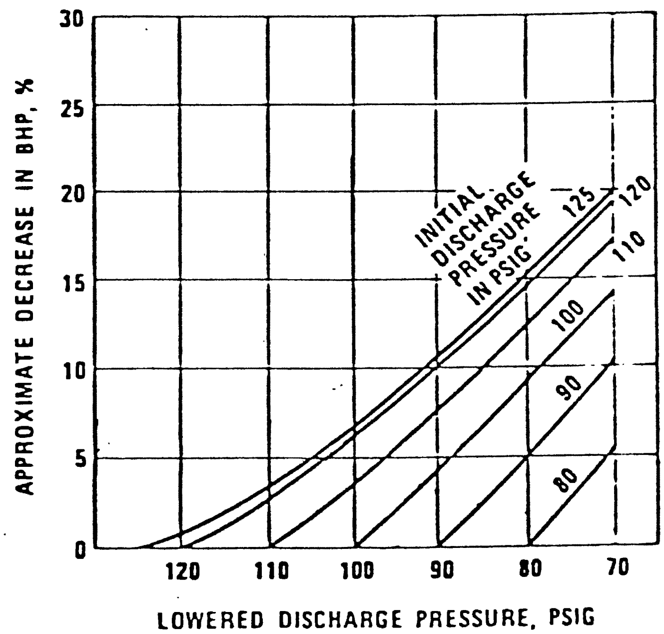


Figure 2 – Two Stage Reciprocating and Centrifugal Compressors

Source: Energy Conservation Program Guide for Industry and Commerce, NBS Handbook 115 (US Dept. of Commerce/National Bureau of Standards).

INSTRUCTION SHEET FOR ECO #5

Title: Optimize Plant Power Factor

How To Use This ECO Format

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from EADC audit report prepared for Moore Business Forms, Stillwater, Oklahoma.

In this format, in the portion of "Calculations (for savings in energy and $)" there has been left about one page of blank space because savings calculations depend on billing procedure. Therefore, the pattern for the calculations for $ savings has not been standardized. However, an example calculation based on a typical billing procedure has been given in the ECO format (in handwriting) under the heading "(7) Dollar ($) Savings in Utility Bills".

How To Calculate The Cost of Capacitor

Since declining block pricing mechanics is used by the manufacturers for the capacitors of higher KVAR ratings, so the calculated size of 450 KVAR capacitor can be split up into three of 150 KVAR sizes (600 voltage rating). The price tag for these capacitors can be looked up into the table for the listing of prices for capacitors of different ratings. In this case, the price is $3837 for each of 150 KVAR capacitors. But since the discount sheet DE-1 suggests a discount factor of 40%, hence the net price for 450 KVAR stands as:

$$3 \times \$3837 \times 0.60 = \$6906.6$$

ECO #

(EPIC CODE #31.11)

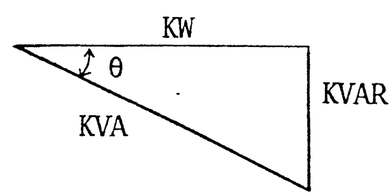
TITLE: Optimize Plant Power Factor

EXECUTIVE SUMMARY:

Electrical systems of industrial plants normally have a lagging power factor. A main reason for this is the general use of induction motors, which may have a rather low power factor at part load. Every inductive device (e.g. electric motors, transfomers, 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, transformers, 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) as

$$PF = \frac{\text{USEFUL POWER}}{\text{TOTAL POWER}}$$

$$= \frac{\text{Kilowatt}}{\text{Kilovolt-ampere}} = \frac{KW}{KVA} = \cos\theta$$



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 around 0.3 to 0.9. Electric utilities penalize customers for low power factor.

For your electrical system, calculations have been made to show the savings for improving your power factor to 90 %.

REQUIRED DATA:

Given:

Average Power Factor in Year 1980	: 78.4 %
Average KW Demand/Month in Year 1980	: 1353 KW/month
Electrical Demand Charge	:$ 1.92/KW-month
Surcharge Tax	: 6 %
Desired Power Factor by the Utility Supplying Power	: 85 %

CALCULATIONS (for savings in energy and $):

(1) The usual cure for a low power factor is to install a capacitor in parallel with the offending machines, or across the line feeding a group of such machines. Capacitors supply the kilovolt-ampere reactive or magnetizing power required for reactive loads. The size of the capacitor is determined as follows.

(2) Since PF = (demand in KW) ÷ (kilovolt-ampere)

∴ KVA = KW ÷ PF = 1353 ÷ 0.784 = 1725.8

(3) From the power triangle:

$$KVA^2 = KW^2 + KVAR^2$$

$$\therefore \text{Existing KVAR} = (KVA^2 - KW^2)^{1/2}$$

$$= (1725.8^2 - 1353^2)^{1/2}$$

$$= 1071.34 \text{ existing KVAR}$$

(4) After correction of power factor to 90%,

New KVA = (demand in KW) ÷ (desired PF)

= (1353) ÷ (0.90)

= 1503.34 new KVA

(5) Now new KVAR = $(\text{new } KVA^2 - KW^2)^{1/2}$

$$= (1503.34^2 - 1353^2)^{1/2}$$

$$= 655.3 \text{ new KVAR}$$

(6) Difference in KVAR = Existing KVAR - new KVAR

= (1071.34) - (655.3)

= 416.04 KVAR

= 450 KVAR (rounded off to standard size of capacitors)

(7) Dollar ($) Savings in Utility Bills:

Since Monthly demand Billing =

$$(\text{Max. demand}) \times \frac{\text{Desired PF}}{\text{Existing PF}} \times (\text{Demand charge})$$

Therefore original demand cost =

$$(1353 \text{ KW}) \times \frac{90\%}{78.4\%} \times (\$1.92/\text{kw-month})$$

= $2982.12 /month.

And at the improved power factor of 90%;
the New Demand Cost =

$$(1353\ \text{KW}) \times \frac{90\%}{90\%} \times (\$1.92/\text{KW-month})$$

$$= \$2597.76/\text{month}.$$

Now Annual Dollar ($) Savings in Utility Bills:

= (Original Demand Cost − New Demand cost) × (conversion factor)

$$= (\$2982.12/\text{month} - \$2597.76/\text{month}) \times (12\ \text{months/yr.})$$

$$= \$4612.32/\text{yr.}$$

CALCULATIONS (for simple payback):

(1) The required size of the capacitor has been determined as 450 KVAR.

(2) Therefore, the cost of the capacitor would be $ 6906.6 (see attached).

(3) Installation cost may be assumed to be $ 200 .

(4) Hence, implementation cost =

Cost of capacitor + cost of installation

= $ 6906.6 + $ 200 .

= $ 7106.6

(5) Payback period = $\frac{\text{Total cost of implementation}}{\text{Total \$ savings/yr}}$

= 7106.6 / 4612.32

= 1.54 yrs.

Note: The primary purpose of capacitors is to reduce the power consumption. Once the size of capacitors is determined, the next selection is where to connect them on the customer's electrical system. The capacitors must, of course, be for the voltage where applied, but the user has a choice of three possible places to connect the capacitors:

(1) Connect all together at any point past the utility metering (usually at the service entrance switch gear).

(2) Divide the total capacitor requirement in selected amounts and connect to the system about the electrical center of power feeders.

(3) Connect a large number of small capacitors on the terminals of each motor and switch motor and capacitor.

Choice 1 is often called the cheap and dirty way. Capacitors connected at any point past the utility metering does eliminate customer reactive current from the utility system, thus releasing additional utility system capacity for other customers. However, all inductive reactive current in the customer system and switch gear still circulates between the low power factor causing devices and the capacitors. Electrical losses in the user system, although comparatively small, are not reduced.

Choice 2, sometimes combined with Choice 3, is the usual and most satisfactory method for applying capacitors. Location of capacitors in banks is by far the most economical procedure as far as implementation cost is concerned. Usually, an industrial plant or a commercial building has several to a large number of power feeders. Thus, the total capacitors required for improvement can be divided into standard KVAR sizes to be connected at approximately the electrical centers of the feeders serving the loads.

Reactive current from electrical devices will still circulate between the devices and the capacitor bank connected to the feeder. However, such current is eliminated from going through the feeder breaker or switch, and with the bank connected at the electrical center to the feeder, is partially eliminated from sections of the feeder. Thus, additional loads may possibly be added without exceeding the ampacity of the feeder conductors and the protective switch gear. In addition to savings in power billing, savings can occur due to added capacity in existing lines.

Choice 3 is seldom economically desirable but it offers the maximum improvement in the power factor. Reactive current circulates only in the very short connection between the motor and the capacitor. Unfortunately, this is also almost always by far the most expensive method. Dollar per KVAR for small capacitors is considerably more than dollars per KVAR for large capacitors banks. In practice, PF improvement by this method is usually for motors 50 HP or larger with the addition of feeder bank capacitors to take care of smaller motors.

Low Voltage Power Capacitors

The inexpensive, efficient way to provide power factor correction

Benefits of Power Factor Improvement

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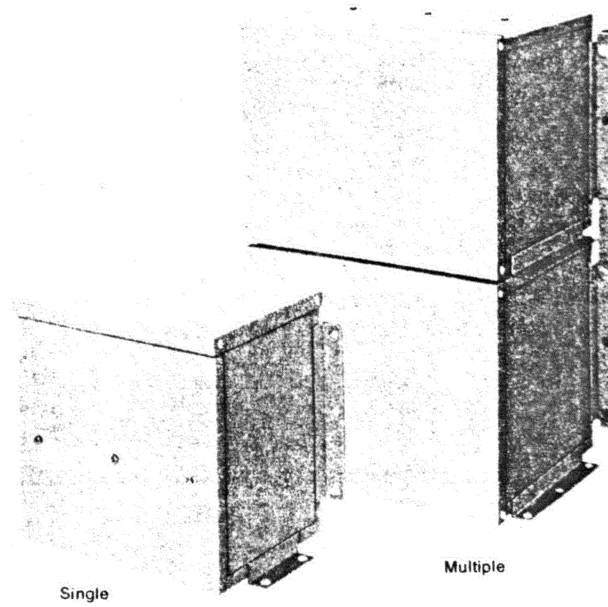
- System capacity is increased.
- Voltage is improved and power losses reduced.

These UL listed devices utilize a metallized polypropylene dielectric system with "self healing" properties to restore the dielectric to an acceptable condition should a breakdown in the dielectric occur during operation. Each capacitor cell has a pressure sensitive interrupter which eliminates the need for internal protective fusing.

Enclosures are fabricated from heavy duty steel and are supplied without knockouts. They are finished with gray enamel and are suitable for either indoor or outdoor use. They are designed for installation in accordance with Article 460 of the 1981 National Electrical Code and can be either wall or floor mounted.



240 VOLT• 3 PHASE/60 HZ

KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
					H	W	D
2.5	PFC2002	$ 395.	6	#14-6 CU	10⅞	12¾	8¼
5	PFC2005	448.	12	#14-6 CU	10⅞	12¾	8¼
7.5	PFC2007	500.	18	#14-6 CU	10⅞	12¾	8¼
10	PFC2010	632.	24.1	#8-2 CU	10⅞	12¾	8¼
15	PFC2015	869.	36.1	#8-2 CU	10⅞	12¾	11
20	PFC2020	1079.	48.1	#2-1/0 CU	10⅞	15½	11
25	PFC2025	1264.	60.1	#2-1/0 CU	10⅞	17⅞	11

•For 208 volt operation derate KVAR and current to 75% of tabulated value.

600 VOLT♦ 3 PHASE/60 HZ

KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
					H	W	D
2.5	PFC6002	$ 340.	2.4	#14-6 CU	10⅞	12¾	8¼
5	PFC6005	353.	4.8	#14-6 CU	10⅞	12¾	8¼
7.5	PFC6007	406.	7.2	#14-6 CU	10⅞	12¾	8¼
10	PFC6010	453.	9.6	#14-6 CU	10⅞	12¾	8¼
12.5	PFC6012	511.	12	#14-6 CU	10⅞	12¾	8¼
15	PFC6015	558.	14.4	#14-6 CU	10⅞	12¾	8¼
20	PFC6020	669.	19.2	#14-6 CU	10⅞	12¾	8¼
25	PFC6025	706.	24.1	#8-2 CU	10⅞	12¾	11
30	PFC6030	753.	28.9	#8-2 CU	10⅞	12¾	11
35	PFC6035	856.	33.7	#8-2 CU	10⅞	15½	11
40	PFC6040	906.	38.5	#8-2 CU	10⅞	15½	11
45	PFC6045	995.	43.3	#8-2 CU	10⅞	17⅞	11
50	PFC6050	1043.	48.1	#2-1/0 CU	10⅞	17⅞	11

480 VOLT 3 PHASE/60 HZ

KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
					H	W	D
1.5	PFC4001	$ 335.	1.8	#14-6 CU	10⅞	12¾	8¼
2.5	PFC4002	340.	3	#14-6 CU	10⅞	12¾	8¼
3	PFC4003	343.	3.6	#14-6 CU	10⅞	12¾	8¼
4	PFC4004	348.	4.8	#14-6 CU	10⅞	12¾	8¼
5	PFC4005	353.	6	#14-6 CU	10⅞	12¾	8¼
6	PFC4006	377.	7.2	#14-6 CU	10⅞	12¾	8¼
7.5	PFC4007	406.	9	#14-6 CU	10⅞	12¾	8¼
10	PFC4010	453.	12	#14-6 CU	10⅞	12¾	8¼
12.5	PFC4012	511.	15	#14-6 CU	10⅞	12¾	8¼
15	PFC4015	558.	18	#14-6 CU	10⅞	12¾	8¼
18	PFC4018	643.	21.7	#8-2 CU	10⅞	12¾	8¼
20	PFC4020	669.	24.1	#8-2 CU	10⅞	12¾	8¼
22.5	PFC4022	690.	27.1	#8-2 CU	10⅞	12¾	8¼
25	PFC4025	706.	30.1	#8-2 CU	10⅞	12¾	8¼
30	PFC4030	753.	36.1	#8-2 CU	10⅞	12¾	11
35	PFC4035	856.	42.1	#8-2 CU	10⅞	15½	11
40	PFC4040	906.	48.1	#2-1/0 CU	10⅞	15½	11
45	PFC4045	995.	54.1	#2-1/0 CU	10⅞	17⅞	11
50	PFC4050	1043.	60.1	#2-1/0 CU	10⅞	17⅞	11

MULTIPLE UNITS♦ FOR LARGER KVAR RATINGS 3 PHASE/60 HZ

Voltage Rating	KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
						H	W	D
240	40	PFC2040	$2579.	96.2	#4-3/0 CU	22	15½	11⅞
	50	PFC2050	2974.	120	2/0-4/0 CU	22	18¼	11⅞
	60	PFC2060	3816.	144	2/0-4/0 CU	33	15½	11⅞
	75	PFC2075	4395.	180	1/0-350 MCM CU	33	18¼	11⅞
480	60	PFC4060	1190.	72.2	#2-1/0 CU	22	12¾	11⅞
	70	PFC4070	2048.	84.2	#4-3/0 CU	22	12¾	11⅞
	75	PFC4075	2185.	90.2	#4-3/0 CU	22	15½	11⅞
	80	PFC4080	2316.	96.2	#4-3/0 CU	22	15½	11⅞
	90	PFC4090	2448.	108	#4-3/0 CU	22	15½	11⅞
	100	PFC4100	2579.	120	2/0-4/0 CU	22	15½	11⅞
	125	PFC4125	3395.	150	1/0-350 MCM CU	22	18¼	11⅞
	150	PFC4150	3837.	180	1/0-350 MCM CU	33	18¼	11⅞
600	60	PFC6060	1190.	57.8	#2-1/0 CU	22	12¾	11⅞
	100	PFC6100	2579.	96.2	#4-3/0 CU	22	18¼	11⅞
	125	PFC6125	3395.	120	2/0-4/0 CU	33	18¼	11⅞
	150	PFC6150	3837.	144	2/0-4/0 CU	33	18¼	11⅞

♦Order only. Not stocked in PDS.

USER OR CONSUMER DISCOUNTS

Applies To Distribution Equipment Published List Prices

NET PRICES: When figuring net prices on a quantity of one style, multiply the list price of one device by the desired number of devices, then apply the appropriate multiplier to this total, rounding the resulting fractions of cents to the nearest whole number.

TYPE OF EQUIPMENT	Discount Schedule	QUANTITY OR VOLUME	SUGGESTED TRADE DISCOUNTS Discounts	Multiplier
Safety Switches Industrial Circuit Breaker Devices and Enclosures Wireway and Posts Miscellaneous	A1-1 A1-2 A1-3 A1-4	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
QO-Q1 Plug-On Circuit Breakers Unit Molded Case Breakers Panelboard Circuit Breakers (except QO-QOB) QOB-Q1B Bolt-On Circuit Breakers	B1-1 B1-2 B1-3 B1-4	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
QO Load Center Devices Metering Equipment Fusible Service Equipment	C1-1 C1-2 C1-3	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
I-Line Busway Listed stock components only Plug-In Units Except units for 100A. Busway	E1	Any Quantity	40%	.60
I-Line Busway Non-stock components 100A. Busway and Plug-In Units	E2	Any Quantity	40%	.60
Load Interrupter Switches (15 KV Max.) I.C.C.B. Switchgear (600V.) Package Substations Metal Frame Cir. Bkr. Switchgear (600V.) Substation Transformers Load Interrupter Switchgear (38 KV Max.) Metal Clad Switchgear (15 KV Max.)	F F3 F4 F5 F6 F7 F8	Any Quantity	50% 3% 3% 3% 25% 25% 3%	.50 .97 .97 .97 .75 .75 .97
Panelboards Unassembled Type NQO/NQOB, NEHB, I-Line and QMB (including Motor Starter) Switchboards Unassembled Type Speed-D Telephone Cabinets - Standard	G1-1 G1-2 G1-3	Any Quantity	40%	.60
Panelboards (all other not in G1) Switchboards (all other not in G1) Enclosed Bolt-Loc Switches Equipment GFP — Ground-Censor (GA, GC, GP)	G2 G2 G2 G2	Any Quantity	40%	.60
Repair Parts	H	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
Dry Type Transformers Hospital Isolating Panels	J1 J2	Any Quantity	25%	.75
Qwik-Gard Receptacles and accessories	P	Any Quantity	40%	.60
Earli-Gard Smoke Detectors	S	Any Quantity	40%	.60
Cable Tray	T	Any Quantity	40%	.60
Service Fittings for Underfloor Duct	U1	Any Quantity	40%	.60
Underfloor Duct, Header Duct, Trench Duct and all accessories (Except Service Fittings in U1)	U2	Any Quantity	40%	.60

PAYMENT TERMS: 2% - 10th, net 25th on all Discount Schedules except for Discount Schedules F (all), J1 and J2 which are net 30 days after invoice date.

16.5 POWER SYSTEMS & CAPACITORS		CREW	DAILY OUTPUT	UNIT	BARE COSTS MAT.	BARE COSTS INST.	BARE COSTS TOTAL	TOTAL INCL O&P
05	CAPACITORS Indoor, dustproof. Fuses incl. for 2.5 KVAR							
002	and larger, 240 volts, single & 3 phase, 0.5 KVAR	1 Elec	2.70	Ea.	54	52	106	135
010	1.0 KVAR		2.70		78	52	130	160
015	2.5 KVAR		2		210	70	280	330
020	5.0 KVAR		1.80		280	77	357	420
025	7.5 KVAR		1.60		330	87	417	485

16.5 POWER SYSTEMS & CAPACITORS		CREW	DAILY OUTPUT	UNIT	BARE COSTS MAT.	BARE COSTS INST.	BARE COSTS TOTAL	TOTAL INCL O&P
[illegible]30	10 KVAR	1 Elec	1.50	Ea.	385	93	478	555
[illegible]35	15 KVAR		1.30		505	105	610	710
[illegible]40	20 KVAR		1.10		610	125	735	850
[illegible]45	25 KVAR		1		720	140	860	990
[illegible]0	480 volts, single & 3 phase, 1 KVAR		2.70		54	52	106	135
[illegible]	2 KVAR		2.70		72	52	124	155
[illegible]10	5 KVAR		2		215	70	285	335
[illegible]15	7.5 KVAR		2		240	70	310	365
[illegible]20	10 KVAR		2		250	70	320	375
[illegible]25	15 KVAR		2		275	70	345	400
[illegible]30	20 KVAR		1.60		310	87	397	465
[illegible]35	30 KVAR		1.50		380	93	473	550
[illegible]40	40 KVAR		1.20		485	115	600	700
[illegible]45	50 KVAR		1.10		580	125	705	820

Source: Mean's Mechanical & Electrical Cost Data, 1981.

ECO #

(EPIC CODE #31.11)

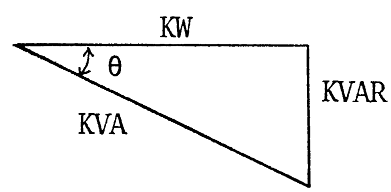
TITLE: Optimize Plant Power Factor

EXECUTIVE SUMMARY:

Electrical systems of industrial plants normally have a lagging power factor. A main reason for this is the general use of induction motors, which may have a rather low power factor at part load. Every inductive device (e.g. electric motors, transfomers, 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, transformers, 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) as

$$PF = \frac{\text{USEFUL POWER}}{\text{TOTAL POWER}}$$

$$= \frac{\text{Kilowatt}}{\text{Kilovolt-ampere}} = \frac{KW}{KVA} = \cos\theta$$



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 around 0.3 to 0.9. Electric utilities penalize customers for low power factor.

For your electrical system, calculations have been made to show the savings for improving your power factor to %.

REQUIRED DATA:

Given:

Average Power Factor in Year 198	:	%
Average KW Demand/Month in Year 198	:	KW/month
Electrical Demand Charge	:$	/KW-month
Surcharge Tax	:	%
Desired Power Factor by the Utility Supplying Power	:	%

CALCULATIONS (for savings in energy and $):

(1) The usual cure for a low power factor is to install a capacitor in parallel with the offending machines, or across the line feeding a group of such machines. Capacitors supply the kilovolt-ampere reactive or magnetizing power required for reactive loads. The size of the capacitor is determined as follows.

(2) Since PF = (demand in KW) ÷ (kilovolt-ampere)

$\therefore$ KVA = KW ÷ PF

(3) From the power triangle:

$$KVA^2 = KW^2 + KVAR^2$$

$\therefore$ Existing KVAR = $(KVA^2 - KW^2)^{1/2}$

= (- $)^{1/2}$

=   existing KVAR

(4) After correction of power factor to   %,

New KVA = (demand in KW) ÷ (desired PF)

= (   ) ÷ (   )

=   new KVA

(5) Now new KVAR = (new $KVA^2 - KW^2)^{1/2}$

= (- $)^{1/2}$

=   new KVAR

(6) Difference in KVAR = Existing KVAR - new KVAR

= (   ) - (   )

=   KVAR

=   KVAR (rounded off to standard size of capacitors)

(7) Dollar ($) Savings in Utility Bills:

CALCULATIONS (for simple payback):

(1) The required size of the capacitor has been determined as KVAR.

(2) Therefore, the cost of the capacitor would be $
(see attached).

(3) Installation cost may be assumed to be $.

(4) Hence, implementation cost -

Cost of capacitor + cost of installation

= $ + $.

= $.

(5) Payback period = $\frac{\text{Total cost of implementation}}{\text{Total \$ savings/yr}}$

=

= yrs.

Note: The primary purpose of capacitors is to reduce the power consumption. Once the size of capacitors is determined, the next selection is where to connect them on the customer's electrical system. The capacitors must, of course, be for the voltage where applied, but the user has a choice of three possible places to connect the capacitors:

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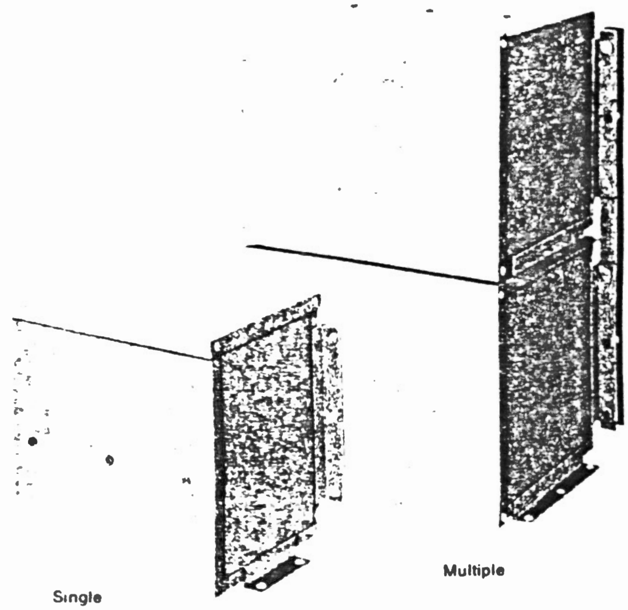

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7.5	PFC2007	500.	18	#14-6 CU	10⅞	12¾	8¼
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15	PFC2015	869.	36.1	#8-2 CU	10⅞	12¾	11
20	PFC2020	1079.	48.1	#2-1/0 CU	10⅞	15½	11
25	PFC2025	1264.	60.1	#2-1/0 CU	10⅞	17⅞	11

•For 208 volt operation derate KVAR and current to 75% of tabulated value

480 VOLT 3 PHASE/60 HZ

KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
					H	W	D
1.5	PFC4001	$ 335.	1.8	#14-6 CU	10⅞	12¾	8¼
2.5	PFC4002	340.	3	#14-6 CU	10⅞	12¾	8¼
3	PFC4003	343.	3.6	#14-6 CU	10⅞	12¾	8¼
4	PFC4004	348.	4.8	#14-6 CU	10⅞	12¾	8¼
5	PFC4005	353.	6	#14-6 CU	10⅞	12¾	8¼
6	PFC4006	377.	7.2	#14-6 CU	10⅞	12¾	8¼
7.5	PFC4007	406.	9	#14-6 CU	10⅞	12¾	8¼
10	PFC4010	453.	12	#14-6 CU	10⅞	12¾	8¼
12.5	PFC4012	511.	15	#14-6 CU	10⅞	12¾	8¼
15	PFC4015	558.	18	#14-6 CU	10⅞	12¾	8¼
18	PFC4018	643.	21.7	#8-2 CU	10⅞	12¾	8¼
20	PFC4020	669.	24.1	#8-2 CU	10⅞	12¾	8¼
22.5	PFC4022	690.	27.1	#8-2 CU	10⅞	12¾	8¼
25	PFC4025	706.	30.1	#8-2 CU	10⅞	12¾	8¼
30	PFC4030	753.	36.1	#8-2 CU	10⅞	12¾	11
35	PFC4035	856.	42.1	#8-2 CU	10⅞	15½	11
40	PFC4040	906.	48.1	#2-1/0 CU	10⅞	15½	11
45	PFC4045	995.	54.1	#2-1/0 CU	10⅞	17⅞	11
50	PFC4050	1043.	60.1	#2-1/0 CU	10⅞	17⅞	11

600 VOLT◆ 3 PHASE/60 HZ

KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
					H	W	D
2.5	PFC6002	$ 340.	2.4	#14-6 CU	10⅞	12¾	8¼
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7.5	PFC6007	406.	7.2	#14-6 CU	10⅞	12¾	8¼
10	PFC6010	453.	9.6	#14-6 CU	10⅞	12¾	8¼
12.5	PFC6012	511.	12	#14-6 CU	10⅞	12¾	8¼
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35	PFC6035	856.	33.7	#8-2 CU	10⅞	15½	11
40	PFC6040	906.	38.5	#8-2 CU	10⅞	15½	11
45	PFC6045	995.	43.3	#8-2 CU	10⅞	17⅞	11
50	PFC6050	1043.	48.1	#2-1/0 CU	10⅞	17⅞	11

MULTIPLE UNITS◆ FOR LARGER KVAR RATINGS 3 PHASE/60 HZ

Voltage Rating	KVAR Rating	Catalog Number	Price	Rated Current Amperes	Terminal Lug Wire Size	Dimensions (Inches)		
						H	W	D
240	40	PFC2040	$2579.	96.2	#4-3/0 CU	22	15½	11⅞
	50	PFC2050	2974.	120	2/0-4/0 CU	22	18¼	11⅞
	60	PFC2060	3816.	144	2/0-4/0 CU	33	15½	11⅞
	75	PFC2075	4395.	180	1/0-350 MCM CU	33	18¼	11⅞
480	60	PFC4060	1190.	72.2	#2-1/0 CU	22	12¾	11⅞
	70	PFC4070	2048.	84.2	#4-3/0 CU	22	12¾	11⅞
	75	PFC4075	2185.	90.2	#4-3/0 CU	22	15½	11⅞
	80	PFC4080	2316.	96.2	#4-3/0 CU	22	15½	11⅞
	90	PFC4090	2448.	108	#4-3/0 CU	22	15½	11⅞
	100	PFC4100	2579.	120	2/0-4/0 CU	22	15½	11⅞
	125	PFC4125	3395.	150	1/0-350 MCM CU	22	18¼	11⅞
	150	PFC4150	3837.	180	1/0-350 MCM CU	33	18¼	11⅞
600	60	PFC6060	1190.	57.8	#2-1/0 CU	22	12¾	11⅞
	100	PFC6100	2579.	96.2	#4-3/0 CU	22	18¼	11⅞
	125	PFC6125	3395.	120	2/0-4/0 CU	33	18¼	11⅞
	150	PFC6150	3837.	144	2/0-4/0 CU	33	18¼	11⅞

◆Order only. Not stocked in PDS.

USER OR CONSUMER DISCOUNTS

Applies To Distribution Equipment Published List Prices

NET PRICES: When figuring net prices on a quantity of one style, multiply the list price of one device by the desired number of devices, then apply the appropriate multiplier to this total, rounding the resulting fractions of cents to the nearest whole number.

TYPE OF EQUIPMENT	Discount Schedule	QUANTITY OR VOLUME	SUGGESTED TRADE DISCOUNTS	
			Discounts	Multiplier
Safety Switches Industrial Circuit Breaker Devices and Enclosures Wireway and Posts Miscellaneous	A1-1 A1-2 A1-3 A1-4	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
QO-Q1 Plug-On Circuit Breakers Unit Molded Case Breakers Panelboard Circuit Breakers (except QO-QOB) QOB-Q1B Bolt-On Circuit Breakers	B1-1 B1-2 B1-3 B1-4	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
QO Load Center Devices Metering Equipment Fusible Service Equipment	C1-1 C1-2 C1-3	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
I-Line Busway Listed stock components only Plug-In Units Except units for 100A. Busway	E1	Any Quantity	40%	.60
I-Line Busway Non-stock components 100A. Busway and Plug-In Units	E2	Any Quantity	40%	.60
Load Interrupter Switches (15 KV Max.) I.C.C.B. Switchgear (600V.) Package Substations Metal Frame Cir. Bkr. Switchgear (600V.) Substation Transformers Load Interrupter Switchgear (38 KV Max.) Metal Clad Switchgear (15 KV Max.)	F F3 F4 F5 F6 F7 F8	Any Quantity	50% 3% 3% 3% 25% 25% 3%	.50 .97 .97 .97 .75 .75 .97
Panelboards Unassembled Type NQO/NQOB, NEHB, I-Line and QMB (including Motor Starter) Switchboards Unassembled Type Speed-D Telephone Cabinets - Standard	G1-1 G1-2 G1-3	Any Quantity	40%	.60
Panelboards (all other not in G1) Switchboards (all other not in G1) Enclosed Bolt-Loc Switches Equipment GFP — Ground-Censor (GA, GC, GP)	G2 G2 G2 G2	Any Quantity	40%	.60
Repair Parts	H	Less than $100.00 List $100.00 List and Over	35% 40%	.65 .60
Dry Type Transformers Hospital Isolating Panels	J1 J2	Any Quantity	25%	.75
Qwik-Gard Receptacles and accessories	P	Any Quantity	40%	.60
Earli-Gard Smoke Detectors	S	Any Quantity	40%	.60
Cable Tray	T	Any Quantity	40%	.60
Service Fittings for Underfloor Duct	U1	Any Quantity	40%	.60
Underfloor Duct, Header Duct, Trench Duct and all accessories (Except Service Fittings in U1)	U2	Any Quantity	40%	.60

PAYMENT TERMS: 2% - 10th, net 25th on all Discount Schedules except for Discount Schedules F (all), J1 and J2 which are net 30 days after invoice date.

SQUARE D COMPANY
ELECTRICAL EQUIPMENT

(405) 234-6525 807 W. MAINE ENID, OKLAHOMA 73701

April 30, 1982

Mr. Gholam Mustafa
39-10 South University Place
Stillwater, Oklahoma 74074

Dear Mr. Mustafa:

Subject: Power Factor Correction Capacitors

Attached is pricing information for the subject devices. The catalog sheet has list prices which should be multiplied by the discount given on discount sheet DE-1. The 240 Volt and 480 Volt Capacitors are items that we stock in warehouses, while the 600 Volt and Multiple Unit Capacitors are special built items. Any of these items can be bought by O.S.U. through one of our local distributors, such as American Electric in Ponca City.

I am also attaching some literature concerning other energy-saving devices that Square D manufactures. If it would be of aid to you, I would be glad to bring you further information on these devices or a catalog digest, which lists most of the items that Square D sells.

Please feel free to contact me.

Very truly yours,

SQUARE D COMPANY

Larry Vinson

Larry Vinson
Branch Manager

LV:ch
Enclosures

16

16.5	POWER SYSTEMS & CAPACITORS	CREW	DAILY OUTPUT	UNIT	BARE COSTS MAT.	BARE COSTS INST.	BARE COSTS TOTAL	TOTAL INCL O&P
05	CAPACITORS Indoor, dustproof. Fuses incl. for 2.5 KVAR							
002	and larger, 240 volts, single & 3 phase, 0.5 KVAR	1 Elec	2.70	Ea.	54	52	106	135
010	1.0 KVAR	↓	2.70	↓	78	52	130	160
015	2.5 KVAR		2		210	70	280	330
020	5.0 KVAR		1.80		280	77	357	420
025	7.5 KVAR		1.60		330	87	417	485

16.5	POWER SYSTEMS & CAPACITORS	CREW	DAILY OUTPUT	UNIT	BARE COSTS MAT.	BARE COSTS INST.	BARE COSTS TOTAL	TOTAL INCL O&P
30	10 KVAR	1 Elec	1.50	Ea.	385	93	478	555
35	15 KVAR	↓	1.30	↓	505	105	610	710
40	20 KVAR		1.10		610	125	735	850
45	25 KVAR		1		720	140	860	990
00	480 volts, single & 3 phase, 1 KVAR		2.70		54	52	106	135
05	2 KVAR		2.70		72	52	124	155
10	5 KVAR		2		215	70	285	335
15	7.5 KVAR		2		240	70	310	365
20	10 KVAR		2		250	70	320	375
25	15 KVAR		2		275	70	345	400
30	20 KVAR		1.60		310	87	397	465
35	30 KVAR		1.50		380	93	473	550
40	40 KVAR		1.20		485	115	600	700
45	50 KVAR	↓	1.10	↓	580	125	705	820

Source: Mean's Mechanical & Electrical Cost Data, 1981.

Instruction Sheet for ECO #6

Title: Night Setback

How to use this Eco format?

In the example calculations for this ECO form, the information for the required data have been taken from the EADC audit report (Report #C8) prepared for Labarge Steel, Tulsa, Oklahoma.

In this example calculation, the present annual energy consumption for space heating (= 380 x 10^6 Btu/yr) has been calculated from their natural gas consumption graph which is enclosed herewith.

The graph shows that the cold months (of November, December, January, February, March, April) have a significantly higher consumption of gas due to space heating load. The average monthly heating load above the regular base load of approximately 6 x 10^6 Btu/month are 47 x 10^6, 72 x 10^6, 83 x 10^6, 117 x 10^6, 64 x 10^6 and 33 x 10^6 for November, December, January, February, March and April respectively. Therefore the annual energy consumption for space heating read from the graph is = (41 + 66 + 77 + 111 + 58 + 27) x 10^6 = 380 x 10^6 Btu/yr.

Moreover, the annual energy saving due to reduced gas consumption is read from Figure 1. The arrows show how to use this figure.

ECO #

EPIC CODE #62.44

TITLE: Night-Setback

EXECUTIVE SUMMARY:

Energy and thereby $ savings can be realized by having a night setback. This can be done easily by installing a seven day 24 hours/day programmable automatic night setback timer to control the thermostats. During the heating season, the timer can be set at 68 °F for normal working (or occupied hours) and at 50°F (or lower) during unoccupied hours (evenings & weekends). Since the air handling units would be heating to a lower temperature, less energy would be used.

Moreover, during hot days of summer, the temperature can be set for air conditioners at the normal 78°F for working/occupied hours and at some temperature higher than 78°F for unoccupied hours. However, the selection for this higher temperature is sometimes dependent upon factors like degree of humidity requirement, etc. The savings would be directly proportional to the setting of this temperature chosen for the summer.

For your system of present operating conditions, calculations have been made to show the savings only during the heating season. However, total savings would be even greater, depending upon the set-up temperature chosen for summer.

REQUIRED DATA:

Given:

(1) Your existing level of temp. for space heating	:	68 °F
(2) Heating Unit efficiency	:	80 %
(3) Heating degree days for your area (Tulsa)	:	3680
(4) Natural gas cost	:	$3.0859/MCF
(5) Your total covered plant area	:	15,000 ft^2
(6) Your total area for conditioned space	:	13,610 ft^2

CALCULATIONS (for energy and $ savings):

(1) From your natural gas consumption graph (provided in the beginning of this report), the present energy used for your space heating has been read as 380×10^6 BTU/yr.

(2) Your present average heating consumption per square ft.

= (Energy used for space heating) ÷ (Conditioned space area)

= (380×10^6 BTU/yr.) ÷ (13,610 ft^2)

= 27920.65 BTU/yr.-ft^2

(3) For 3680 heating degree days and $(68-50^\circ F) = 18^\circ F$ of setback and for your present average heating consumption per ft^2 of 27920.65 BTU/yr.-ft^2; the graph of Fig. (1) reads an energy saving of 16800 BTU/ft^2-yr.

(4) Your actual annual energy savings would, therefore, be

= (Energy savings read from graph) x (conditioned space area)

÷ (Heating unit efficiency)

= (16800 BTU/ft^2-yr.) x (13,610 ft^2) ÷ (0.80)

= 285×10^6 BTU/yr.

(5) Savings in natural gas

= (Savings in BTU) x (conversion factor)

= (286×10^6 BTU/yr.) x (1 MCF/10^6 BTU)

= 286 MCF/yr.

(6) Savings in $

= (~~BTU~~ Gas savings) x (Gas cost)

= (286 ~~BTU~~ MCF/yr.) x ($3.0859/MCF)

= $882.57/yr.

CALCULATIONS (for implementation cost):

(1) Instrument cost: For your system a night setback sequences 7 day programmable Eight channel version would cost you approximately $550

(2) Labor cost: For installation purposes, some material and labor would be required which is estimated to be approximately $240

(3) Total cost = Instrument cost + Labor cost

= $ 550 + $ 240

= $ 790.00

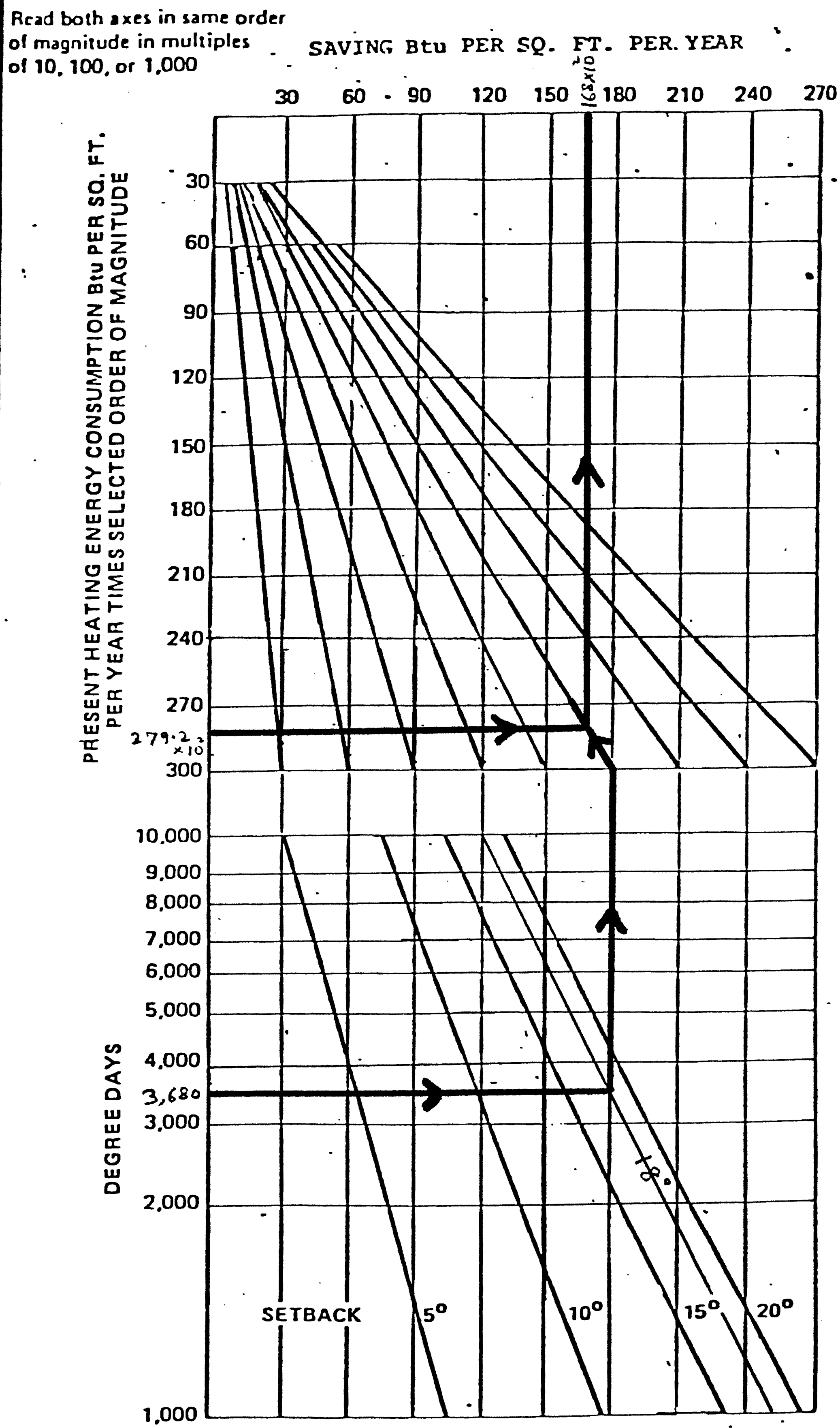
CALCULATIONS (for payback):

Simple payback = (Total cost in $) ÷ (Annual $ savings)

= ($ 790.00) ÷ ($882.57/yr.)

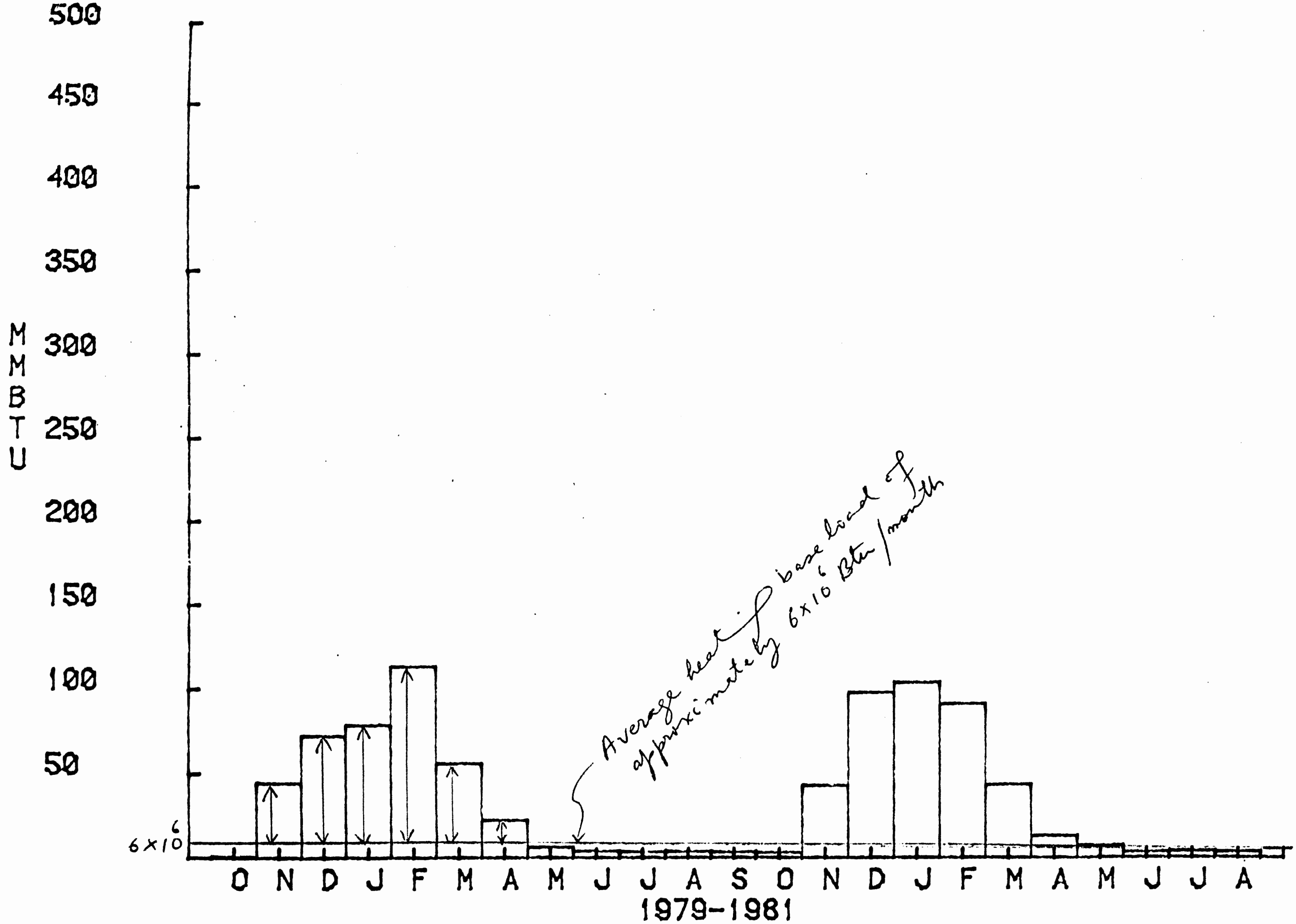
= 0.9 yrs.. = 10.8 months.

NOTE: The calculated payback period would become even less if we added the savings in the cooling season to the annual dollar savings.



Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975.

Figure 1 HEATING ENERGY SAVED BY NIGHT SETBACK



NATURAL GAS CONSUMPTION

(for Labarge Steel)

ECO #

EPIC CODE #62.44

TITLE: Night-Setback

EXECUTIVE SUMMARY:

Energy and thereby $ savings can be realized by having a night setback. This can be done easily by installing a seven day 24 hours/day programmable automatic night setback timer to control the thermostats. During the heating season, the timer can be set at 68 °F for normal working (or occupied hours) and at 50°F (or lower) during unoccupied hours (evenings & weekends). Since the air handling units would be heating to a lower temperature, less energy would be used.

Moreover, during hot days of summer, the temperature can be set for air conditioners at the normal 78°F for working/occupied hours and at some temperature higher than 78°F for unoccupied hours. However, the selection for this higher temperature is sometimes dependent upon factors like degree of humidity requirement, etc. The savings would be directly proportional to the setting of this temperature chosen for the summer.

For your system of present operating conditions, calculations have been made to show the savings only during the heating season. However, total savings would be even greater, depending upon the set-up temperature chosen for summer.

REQUIRED DATA:

Given:

(1) Your existing level of temp. for space heating	:		°F
(2) Heating Unit efficiency	:		%
(3) Heating degree days for your area	:		
(4) Natural gas cost	:	$	/MCF
(5) Your total covered plant area	:		ft^2
(6) Your total area for conditioned space	:		ft^2

CALCULATIONS (for energy and $ savings):

(1) From your natural gas consumption graph (provided in the beginning of this report), the present energy used for your space heating has been read as BTU/yr.

(2) Your present average heating consumption per square ft.

= (Energy used for space heating) ÷ (Conditioned space area)

= (BTU/yr.) ÷ (ft^2)

= BTU/yr.- ft^2

(3) For heating degree days and °F of setback and for your present average heating consumption per ft^2 of BTU/yr.-ft^2; the graph of Fig. (1) reads an energy saving of BTU/ft^2-yr.

(4) Your actual annual energy savings would, therefore, be

= (Energy savings read from graph) x (conditioned space area)

÷ (Heating unit efficiency)

= (BTU/ft^2-yr.) x (ft^2) ÷ ( )

= BTU/yr.

(5) Savings in natural gas

= (Savings in BTU) x (conversion factor)

= (BTU/yr.) x (1 MCF/10^6 BTU)

= MCF/yr.

(6) Savings in $

= (BTU savings) x (Gas cost)

= (BTU/yr.) x ($ /MCF)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) Instrument cost: For your system a night setback sequences 7 day programmable channel version would cost you approximately $

(2) Labor cost: For installation purposes, some material and labor would be required which is estimated to be approximately $

(3) Total cost = Instrument cost + Labor cost

= $ + $

= $

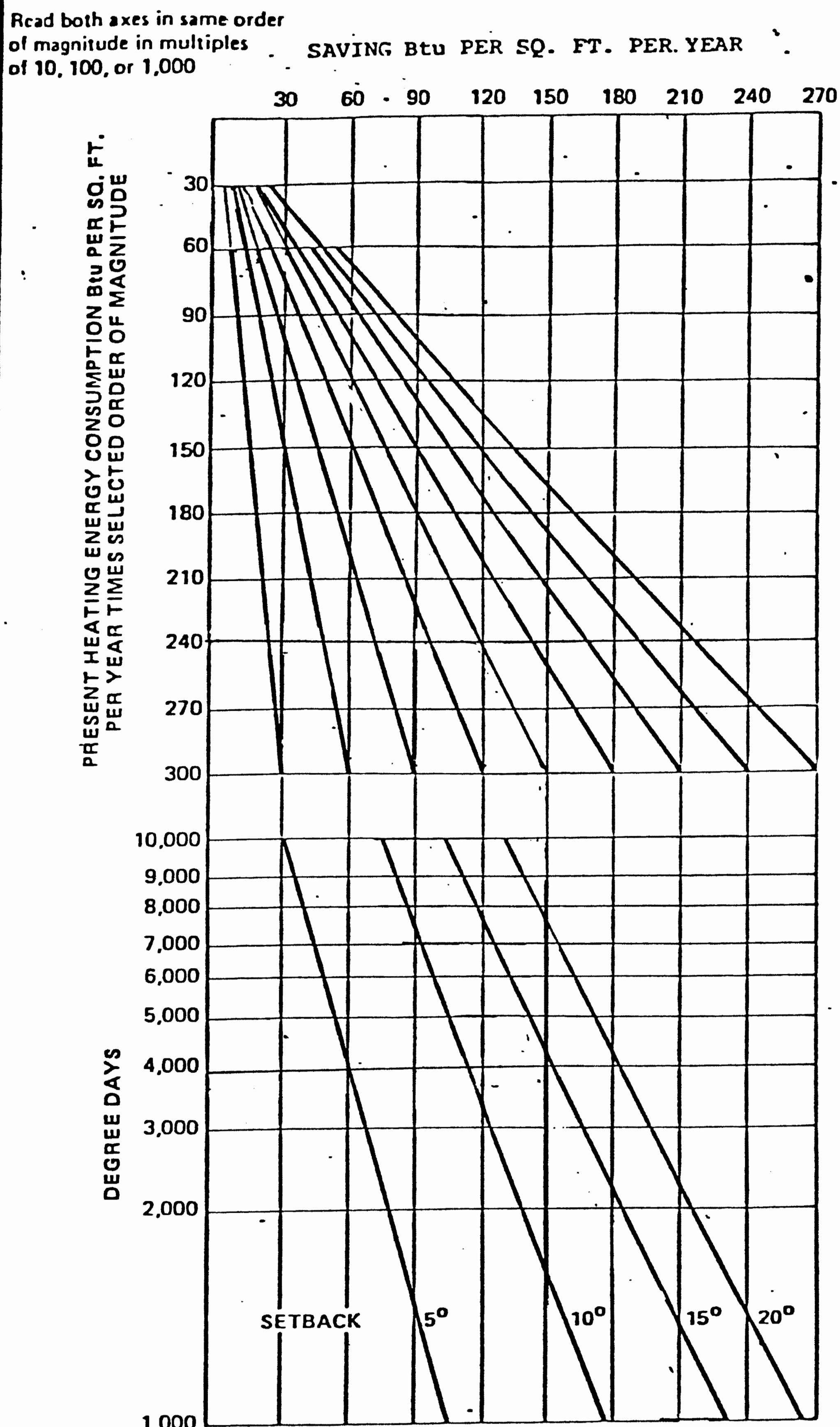
CALCULATIONS (for payback):

Simple payback = (Total cost in $) ÷ (Annual $ savings)

= ($) ÷ ($ /yr.)

= yrs.

NOTE: The calculated payback period would become even less if we added the savings in the cooling season to the annual dollar savings.



Source: Guidelines for Saving Energy in Existing Buildings, ECM-1, FEA, 1975.

Figure 1 HEATING ENERGY SAVED BY NIGHT SETBACK

INSTRUCTION SHEET FOR ECO #7

Title: Turn Off Air Conditioning Unit(s) at Night During Non-Working Hours

How To Use This ECO Format

In this example calculations for this ECO attached herewith, the set of relevant data were picked up from EADC audit report (Report #C4) prepared for Boardman Company, Oklahoma City, Oklahoma. However, these data were not exactly related to this ECO but have been adapted to make them applicable to this ECO.

In this ECO, probably the important thing is how to figure out the approximate average annual air conditioning load from the electrical consumption graph of the consumer.

Enclosed herewith is the electrical consumption graph for the year 1980 of Boardman Company. The graph shows that the hot months (of June, July, August and September) have a higher consumption of electrical energy due to A/C load. The average monthly A/C load above the regular electrical base load of approximately 600 x 10^6 BTU/yr are 80 x 10^6, 80 x 10^6, 100 x 10^6 and 90 x 10^6 BTU/yr for the hot months of June, July, August and September, respectively. Note that the annual A/C load read from the graph is therefore:

$$= (80 + 80 + 100 + 90) \times 10^6 = 250 \times 10^6 \text{ BTU/yr.}$$

ECO # 7

(EPIC ECO CODE 62.43)

TITLE: Turn off air conditioning unit(s) at night and during non working hours.

EXECUTIVE SUMMARY:

By turning off air conditioning at night a substantial savings in electric power (kilo watt-hours) consumed by the air conditioning unit(s) can be realized in the normal cooling season.

There are a number of ways of controlling time of operation, one of which is by using timers. It is rare to find a situation where a timer has a simple payback of more than several weeks when used on an air-handling system. There are a wide variety of inexpensive options available with time clocks enabling on and off settings at different hours and times everyday of the week, and overrides. For your present system, calculations have been made to show the savings that can be realized by turning off the A/C during non working hours. The cost figures are for installing a timer, but you could also do it manually. We recommend that air conditioning be controlled as follows:

Area	Shut Off Times
Building A (9595 ft^2)	From 7 p.m. to 7 a.m
Building P (940 ft^2)	From 7 p.m to 7 a.m.

REQUIRED DATA:

Given:
Present Operating Hours of A/C Units: 2160 hrs./yr.
Cost of Electricity :$0.02173/KWH
Fuel Adjustment Cost Factor Charge :$0.00637/KWH

CALCULATIONS (for energy and $ savings):

(1) From your electric consumption graph (provided in the beginning of this report), your average annual air conditioning load has been figured out as approximately 100 MMBTU/yr. i.e., 100×10^6 BTU/yr. (above the average regular electrical base load).

(2) By turning off the A/C at night, the operation load on A/C will be reduced from the present operating condition of 2160 hrs./yr. to 1080 hrs./yr. which will result in a reduction of the annual KWH energy consumption of the electrical equipment running the A/C unit(s).

(3) Effective cost of electricity:

= (cost of electricity) + (fuel adjustment cost factor charge)

= ($0.02173/KWH) + ($0.00639/KWH)

= $0.02812/KWH.

(4) Savings in energy:

= (annual A/C load read from graph) x (conversion factor from BTU to KWH) x (% reduction in operating hrs/yr) x (effectiveness factor)

= (250 x 10^6 BTU/yr) x (1 KWH/3412 BTU) x [(present 2160 hrs./yr.) - (proposed 1080 hrs./yr)]/(present 2160 hrs./yr.) x (0.7)

= 25645 KWH/yr.

(5) Savings in $:

= (savings in KWH/yr.) x (effective cost of electricity)

= (25645 KWH/yr.) x ($0.02812/KWH)

= $ 721 /yr.

CALCULATIONS (for implementation cost):

(1) A timer can be used for automatic control on A/C shut off at night, which would not cost you more than $ 100 (installed).

(2) Hence, total cost of implementation = $100 .

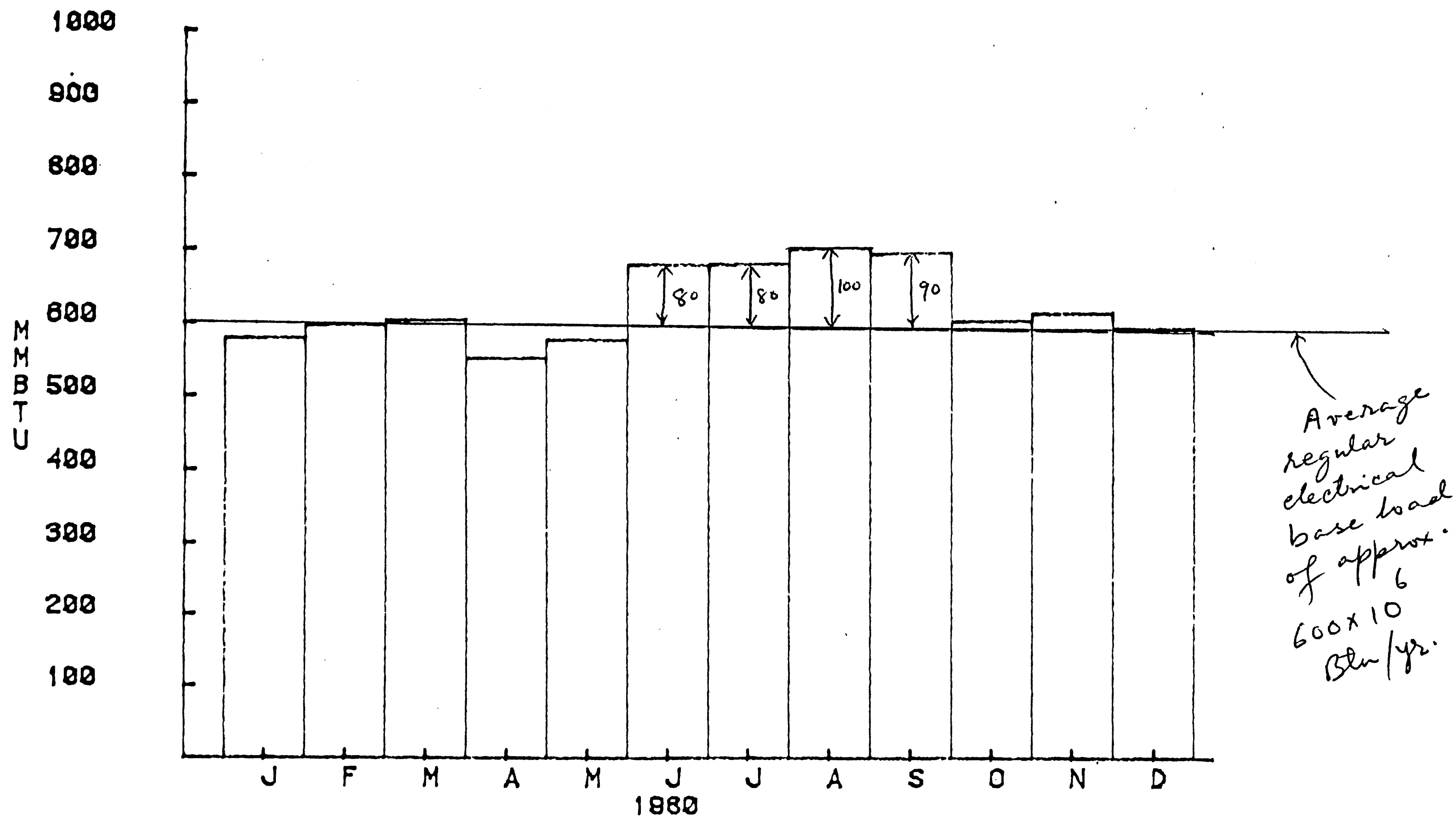
CALCULATIONS (for simple payback):

Payback = (total cost of implementation) ÷ (savings in $/yr.)

= ($100) ÷ ($ 721 /yr.)

= 0.14 yr.

= 1.7 months.



ELECTRICAL CONSUMPTION

(for Boardman Company).

ECO #

(EPIC ECO CODE 62.43)

TITLE: Turn off air conditioning unit(s) at night and during non working hours.

EXECUTIVE SUMMARY:

By turning off air conditioning at night a substantial savings in electric power (kilo-watt-hours) consumed by the air conditioning unit(s) can be realized in the normal cooling season.

There are a number of ways of controlling time of operation, one of which is by using timers. It is rare to find a situation where a timer has a simple payback of more than several weeks when used on an air-handling system. There are a wide variety of inexpensive options available with time clocks enabling on and off settings at different hours and times everyday of the week, and overrides. For your present system, calculations have been made to show the savings that can be realized by turning off the A/C during non working hours. The cost figures are for installing a timer, but you could also do it manually. We recommend that air conditioning be controlled as follows:

Area	Shut Off Times

REQUIRED DATA:

Given:
Present Operating Hours of A/C Units: hrs./yr.
Cost of Electricity :$ /KWH
Fuel Adjustment Cost Factor Charge :$ /KWH

CALCULATIONS (for energy and $ savings):

(1) From your electric consumption graph (provided in the beginning of this report), your average annual air conditioning load has been figured out as approximately MMBTU/yr. i.e., x 10^6 BTU/yr. (above the average regular electrical base load).

(2) By turning off the A/C at night, the operation load on A/C will be reduced from the present operating condition of hrs./yr. to hrs./yr. which will result in a reduction of the annual KWH energy consumption of the electrical equipment running the A/C unit(s).

(3) Effective cost of electricity:

= (cost of electricity) + (fuel adjustment cost factor charge)

= ($ /KWH) + ($ /KWH)

= $ /KWH.

(4) Savings in energy:

= (annual A/C load read from graph) x (conversion factor from BTU to KWH) x (% reduction in operating hrs/yr) x (effectiveness factor)

= ($\times 10^6$ BTU/yr) x (1 KWH/3412 BTU) x [(present hrs./yr.) - (proposed hrs./yr)]/(present hrs./yr.) x (0.7)

= KWH/yr.

(5) Savings in $:

= (savings in KWH/yr.) x (effective cost of electricity)

= (KWH/yr.) x ($ /KWH)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) A timer can be used for automatic control on A/C shut off at night, which would not cost you more than $ (installed).

(2) Hence, total cost of implementation = $.

CALCULATIONS (for simple payback):

Payback = (total cost of implementation) ÷ (savings in $/yr.)

= ($) ÷ ($ /yr.)

= yr.

Instruction sheet for ECO #8

Title: Insulation of ceiling.

How to use this ECO format?

In the example calculations for this ECO form, the information for the required data have been taken from the EADC audit report prepared for Hudson Refining Co., Cushing, Oklahoma 74074.

Since the design of this ECO format is such that it is self explanatory every step need not be explained explicitly. However, the resistance values for a variety of building and insulating materials have not been exhaustively covered by table - D. In case of unavailability of such required data the user of this form can refer to Ref.[5], page (138-157).

Moreover, on the page of Table D, the relationship:

$$R = \frac{d}{K} = \frac{1}{U} = \frac{1}{C}$$

is important for calculating the resistances for a variety of building and insulating materials. In the above relationship, "d" stands for the thickness of such material.

It should further be noted that this ECO format can only be used to evaluate economic justification for any type of building insulation (walls, ceilings, etc.) but it cannot be used for the calculations of reducing energy losses of equipment and piping by installing insulation on them. For such calculations, principles of Heat Transfer should be applied for the specific situation.

ECO # 8
(EPIC ECO CODE)

TITLE: Insulation of ceiling

EXECUTIVE SUMMARY:

Thermal insulation plays a key role in the overall energy management picture. It is interesting to consider that by using insulation, the entire energy requirements of a system are reduced. Most insulation systems reduce the unwanted heat transfer, either loss or gain, by at least 90% as compared to uninsulated systems.

Since the insulation system is so vital to energy-efficient operations, the proper selection and application of that system is very important.

Sophisticated techniques using computer programming are available to find the economic insulation thickness for various situations, however, for your system of 4824 ft² of uninsulated area, calculations have been made to show the result savings taking into account the economic trade-offs between insulation costs and energy savings.

Specifically, we recommend you insulate above existing suspended ceiling by installing Batt insulation. 3" Fibre glass insulation has been recommended.

REQUIRED DATA:

Given:
(1) Total area needing insulation: 4824 ft²
(2) Heating unit efficiency : 0.75
(3) Cooling unit efficiency (COP): 2.00
(4) Cost of electricity : $0.02893/KWH
(5) Fuel cost adjustment charge : $0.00639/KWH
(6) Cost of natural gas : $ 2.41 /MCF
(7) Demand charge : $ 2.40 /KW-month

*(8) Installed costs of insulations:

Insulation size (inches)	Material cost ($/ft²)	Labor cost ($/ft²)	Unit-Resistance (R) (Hr - ft² - °F)/BTU
3" Fiberglass	$ 0.14	$ 0.08	11
6" Fiberglass	$ 0.25	$ 0.10	19

*The cost data are market-research based.

CALCULATIONS (for energy & savings):

(1) For the present 4824 ft^2 of insulated area, the overall coefficient of transmission (U) i.e. BTU/(hr-ft^2 -°F) is calculated as:

$$U = 1/[(R_1 + R_2 + R_3 + \cdots + R_N) + (R_i + R_0)]$$

	R - values (Hr-ft^2-°F)/BTU	Description of Resistance type	References
R_i	0·61	Inside still air film	Table - C
R_0	0·17	Outside air film (15 mph)	Table - C
R_1	(·84+1·31)/2 = 1·06	Air space 3/4"	Table - C
R_2	5/8 ÷ 0·8 = 0·78	Plywood deck 5/8"	Table - D
R_3	0·44	Asphalt Shingle Roofing	Table -
R_4	0·06	Building paper	Table -
R_5			Table -

∴ Existing R-value = ΣR = 0·61 + 0·17 + 1·06 + 0·78 + 0·44 + 0·06
= 3·12 (Hr-ft^2 -°F)/BTU

and U (Existing) = 1/ΣR
= 1/(3·12)
= 0·321 BTU/(Hr-ft^2-°F)

(2) Enclosed herewith are two information sheets for weather data from Tinker Air Force Base - Oklahoma City, which have been used and adapted to prepare table-A and table-B to facilitate the Heat-loss and Heat-gain calculations for heating and cooling seasons respectively by "Temperature Bin Calculation Method".

(3) U(with proposed 3" insulation):

= 1/[(Existing R-value) + (R-value for 3" insulation)]

= 1/[(3·12) + (11·00)]

= 0·071 BTU/(hr-ft^2-°F)

(4) U(with proposed 6" insulation):

= 1/[(Existing R-value) + (R-value for 6" insulation)]

= 1/[(3·12) + (19)]

= 0·045 BTU/(hr-ft^2-°F)

(5) ΔU(for 3" insulation):

= U(Existing) - U(with proposed 3" insulation)

= (0.321) - (0.071)

= 0.25 BTU/(hr-ft^2-°F)

(6) ΔU(for 6" insulation):

= U(Existing) - U(for 6" insulation)

= (0.321) - (0.045)

= 0.276 BTU/(hr-ft^2- °F)

(7) Savings in heating energy (BTUs):
(Due to 3" insulation in heating season)

= (Area to be insulated) x ΔU(for 3" insulation) x [$\Sigma(\Delta t$ x hrs.) from table A] ÷ (Heating unit efficiency)

= (4824 ft^2) x (0.25 BTU/hr-ft^2-°F) x (94,614 °F-hrs/yr) ÷ (0.75)

= 152×10^6 BTU/yr.

(8) Savings in gas consumption:
(Due to 3" insulation in heating season)

= (BTUs saved due to 3" insulation) x (conversion factor for BTU to MCF)

= (152×10^6 BTU/yr) x (1 MCF/10^6BTU)

= 152 MCF/yr.

(9) Resulting $ savings:

= (savings in gas consumption) x (cost of natural gas)

= (152 MCF/yr) x ($2.41 /MCF)

= $366.32/yr.

(10) Now savings in electrical energy (KWHs):
(Due to 3" insulation in cooling season)

= (Area to be insulated) x ΔU(for 3" insulation) x [$\Sigma(\Delta t$ x hrs.) from table B] x (conversion factor for BTU to KWH) ÷ (cooling unit efficiency)

= (4824 ft^2) x (0.25 BTU/hr-ft^2-°F) x (13,406 °F - hrs/yr) x (1KWH/3412 BTU) ÷ (2.00).

= 2369.23 KWH/yr.

(11) Resulting \$ savings:

= (Savings in KWH/yr) x (effective cost of electricity)

= (2369.23 KWH/yr) x (\$0.03532/KWH)

= \$ 83.68 /yr.

(12) Savings in demand charge:

There will be a demand saving, but the calculations are complicated. Hence, none are claimed.

(13) Hence total annual \$ savings:
(Due to 3" insulation both for heating and cooling seasons)

= (\$savings for reduced gas consumption) + (\$savings for reduced KWH consumption by A/C units)

= (\$366.32/yr) + (\$ 83.68/yr)

= \$ 450 /yr.

(14) Now savings in heating energy (BTUs):
(Due to 6" insulation in heating season)

= (Area to be insulated)x ΔU(for 6" insulation) x [$\Sigma(\Delta t$ x hrs) from table A] ÷ (Heating unit efficiency

= (4824 ft^2) x (0.276 BTU/hrs-ft^2-°F) x (94,614 °F-hrs/yr) ÷ (0.75).

= 168×10^6 BTU/yr.

(15) Savings in gas consumption:
(Due to 6" insulation in heating season)

= (BTUs saved due to 6" insulation) x (conversion factor for BTU to MCF)

= (168×10^6 BTU/yr) x (1MCF/10^6BTUs)

= 168 MCF/yr.

(16) Resulting $ savings:

= (Savings in gas consumption) x (cost of natural gas)

= (168 MCF/yr) x ($ 2.41 /MCF)

= $ 404.88/yr.

(17) Savings in electrical energy (KWHs):
(Due to 6" insulation in cooling season)

= (Area to be insulated) x ΔU(for 6" insulation) x [Σ(Δt x hrs) from table B) x (conversion factor for BTU to KWH) ÷ (cooling unit efficiency)

= (4824 ft^2) x (0.276 BTU/hr-ft^2-°F) x (13,466 °F - hrs/yr) x (1KWH/3412 BTUs) ÷ (2.00).

= 2615.63 KWH/yr.

(18) Resulting $ savings:

= (Savings in KWH/yr) x (Effective cost of electricity)

= (2615.63 KWH/yr) x ($0.03532/KWH)

= $ 92.38/yr.

(19) Hence total annual $ savings:
(Due to 6" insulation both for heating and cooling season)

= ($ savings for reduced gas consumption) + ($ savings for reduced KWH consumption by A/C units)

= ($ 404.88/yr) + ($ 92.38 /yr)

= $497.26/yr.

CALCULATIONS (for implementation cost):

(1) Cost for 3" insulation:

= (Area to be insulated) x [(Material cost) + (Labor cost)]

= (4824 ft^2) x [($0.14 /ft^2) + ($0.08 /ft^2)]

+ $1061.28

(2) Cost for 6" insulation:

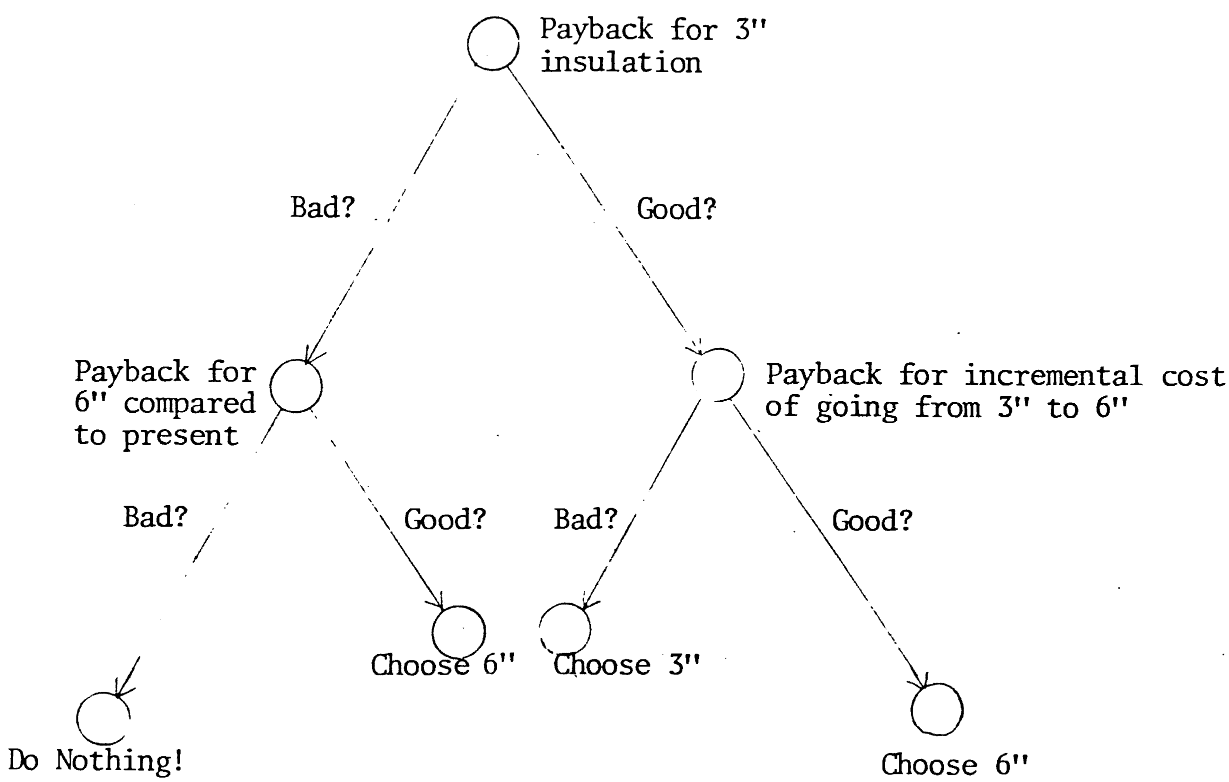
= (Area to be insulated) x [(Material cost) + (Labor cost)]

= (4824 ft^2) x [($0.25 /ft^2) + ($ 0.10 /ft^2)]

= $1688.40

CALCULATIONS (for simple payback):

The simple payback period can be calculated based on the following decision tree: -



(1) Payback for 3" insulation:

Payback period = (Total cost for 3" insulation) ÷ (Total annual \$ savings for 3" insulation)

= (\$1061.28) ÷ (\$ 450 /yr)

= 2.36 yrs.

(2) Payback for 6" insulation:

Payback period = (Total cost for 6" insulation) ÷ (annual \$ savings for 6" insulation)

= (\$1688.40) ÷ (\$ 497.26/yr)

= 3.40 yrs.

(3) Payback period for incremental cost of going from 3" to 6"

Payback period = (Total cost for 6" insulation - Total cost for 3" insulation) ÷ (Incremental annual \$ savings for going from 3" to 6")

= (\$ 1688.40 - \$1061.28) ÷ (\$497.26/yr - \$ 450.00/yr)

= 13.27 yrs.

CONCLUSION:

The decision tree model suggests to go for 3 inch insulation based on the above analysis.

Table A

HEATING SEASON T = 65°F				
Bins	Midpoint	Δt	Hours in Bin	Δt(Hrs.)
0/4	2	63	9	567
5/9	7	58	18	1,044
10/14	12	53	49	2,597
15/19	17	48	84	4,032
20/24	22	43	184	7,912
25/29	27	38	278	10,564
30/34	32	33	425	14,025
35/39	37	28	531	14,868
40/44	42	23	595	13,685
45/49	47	18	599	10,782
50/54	52	13	595	7,735
55/59	57	8	598	4,784
60/64	62	3	673	2,019
		Σ (Δt x Hrs)		= 94,614 °F - hrs/yr

Table B

COOLING SEASON T = 78°F				
Bins	Midpoint	Δt	Hours in Bin	Δt(Hrs.)
80/84	82	4	639	2,556
85/89	87	9	434	3,906
90/94	92	14	279	3,906
95/99	97	19	124	2,356
100/104	102	24	26	624
105/109	107	29	2	58
		Σ (Δt x Hrs)		= 13,406 °F - hrs/yr

TINKER AFB OKLAHOMA

Mean Frequency of Occurrence of Dry Bulb Temperature (°F) With Mean Coincident Wet Bulb Temperature (°F) For Each Dry Bulb Temperature Range

COOLING SEASON

Temperature Range (°F)	MAY Obsn/Hour Gp 02 to 09	MAY Obsn/Hour Gp 10 to 17	MAY Obsn/Hour Gp 18 to 01	MAY Total Obsn	MAY Mean Coincident Wet Bulb (°F)	JUNE Obsn/Hour Gp 02 to 09	JUNE Obsn/Hour Gp 10 to 17	JUNE Obsn/Hour Gp 18 to 01	JUNE Total Obsn	JUNE Mean Coincident Wet Bulb (°F)
105/109										
100/104							0	0	0	73
95/99		1		1	68		8	1	9	74
90/94		8	1	9	71		40	7	47	74
85/89		33	5	38	70	2	64	25	91	72
80/84	1	58	21	80	68	14	61	53	128	71
75/79	13	51	46	110	66	50	36	70	156	69
70/74	53	40	62	155	64	86	17	51	154	67
65/69	72	29	55	156	61	62	10	24	96	63
60/64	55	17	32	104	58	20	3	8	31	60
55/59	33	9	20	62	53	5	1	1	7	55
50/54	15	2	5	22	48	1	0		1	49
45/49	5	0	1	6	43					
40/44	1		0	1	40					
35/39	0			0	35					
30/34										
25/29										

Temperature Range (°F)	JULY Obsn/Hour Gp 02 to 09	JULY Obsn/Hour Gp 10 to 17	JULY Obsn/Hour Gp 18 to 01	JULY Total Obsn	JULY Mean Coincident Wet Bulb (°F)	AUGUST Obsn/Hour Gp 02 to 09	AUGUST Obsn/Hour Gp 10 to 17	AUGUST Obsn/Hour Gp 18 to 01	AUGUST Total Obsn	AUGUST Mean Coincident Wet Bulb (°F)
105/109		0		0	72		2	0	2	73
100/104		7	0	7	72		15	2	17	73
95/99		51	8	59	74	0	37	7	44	73
90/94	1	70	26	97	74	1	63	20	84	73
85/89	11	53	43	107	73	7	64	39	110	72
80/84	34	35	73	142	71	29	88	70	187	71
75/79	90	20	55	165	70	82	20	64	166	69
70/74	83	10	34	127	68	84	7	37	128	67
65/69	26	2	9	37	65	37	2	8	47	63
60/64	3		0	3	60	7	0	1	8	58
55/59	0			0	57	1			1	55
50/54										
45/49										
40/44										
35/39										
30/34										
25/29										

Temperature Range (°F)	SEPTEMBER Obsn/Hour Gp 02 to 09	SEPTEMBER Obsn/Hour Gp 10 to 17	SEPTEMBER Obsn/Hour Gp 18 to 01	SEPTEMBER Total Obsn	SEPTEMBER Mean Coincident Wet Bulb (°F)	OCTOBER Obsn/Hour Gp 02 to 09	OCTOBER Obsn/Hour Gp 10 to 17	OCTOBER Obsn/Hour Gp 18 to 01	OCTOBER Total Obsn	OCTOBER Mean Coincident Wet Bulb (°F)
105/109										
100/104		0		0	72					
95/99		11	0	11	71		0		0	61
90/94		30	4	34	71		6		6	64
85/89	1	48	13	62	70		14	1	15	66
80/84	7	43	35	85	69		30	5	35	65
75/79	30	42	56	128	67	2	39	14	55	63
70/74	67	33	48	148	65	13	44	37	94	62
65/69	53	18	46	117	62	35	46	50	131	59
60/64	45	11	26	82	57	54	34	53	141	55
55/59	27	3	8	38	53	49	21	48	118	51
50/54	7	1	4	12	49	48	8	27	83	47
45/49	3	0		3	46	29	4	13	46	42
40/44						12	1	3	16	38
35/39						4	1	1	6	34
30/34						1		1	2	29
25/29						1		0	1	26

HEATING SEASON

Temperature Range (°F)	NOVEMBER					DECEMBER					JANUARY					FEBRUARY					MARCH					APRIL					ANNUAL (ALL MONTHS)				
	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 01 to 09	Obsn/Hour Gp 10 to 17	Obsn/Hour Gp 18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)
105/109																																2	0	2	73
100/104																																23	3	26	73
95/99																															0	108	16	124	73
90/94																											2		2	65	3	219	57	279	70
85/89							0		0	60							0		0	62		1	0	1	58		10	1	11	66	20	288	128	434	70
80/84							0		0	59							1	0	1	60		4	1	5	61	0	20	5	25	64	85	292	262	639	66
75/79		7		7	60		0		0	56							3	0	3	57	0	10	2	12	59	1	32	15	48	63	269	259	322	850	64
70/74	2	25	4	31	60		2	0	2	53		1		1	56		7	1	8	57	0	15	5	20	56	10	41	33	84	61	398	245	314	957	61
65/69	6	26	14	46	57		7	1	8	51		7	1	8	53	0	12	4	16	54	4	24	13	41	54	31	38	39	108	58	326	219	265	810	58
60/64	11	30	22	63	53	1	17	3	21	51	2	13	4	19	52	2	15	7	24	52	10	30	21	61	51	39	33	41	113	54	250	204	219	673	55
55/59	19	35	29	83	49	7	27	14	48	49	4	17	8	29	49	7	22	15	44	49	15	30	28	73	48	41	26	37	104	49	207	188	203	598	51
50/54	29	38	42	109	46	11	37	24	72	46	7	29	18	54	46	9	29	23	61	45	24	33	36	93	45	41	19	30	90	45	192	195	208	595	46
45/49	43	34	40	117	42	23	40	39	102	41	11	34	24	69	41	26	26	33	85	42	36	29	38	103	41	35	13	22	70	42	210	180	209	599	42
40/44	39	20	32	91	37	38	38	45	121	38	29	38	43	110	37	32	30	39	101	38	45	28	42	115	35	26	4	12	42	38	223	159	213	595	38
35/39	43	14	31	88	33	46	30	41	117	33	36	31	42	109	33	37	32	32	101	33	42	21	28	91	34	12	1	4	17	35	221	132	178	531	34
30/34	26	7	14	47	29	49	20	34	103	29	52	28	35	115	29	41	18	29	88	29	36	13	20	69	29	3			3	30	207	85	133	425	29
25/29	10	3	9	22	24	32	14	22	68	25	39	19	26	84	25	29	13	22	64	26	21	7	9	37	25	1	1	1	3	26	132	57	89	278	26
20/24	10	1	3	14	20	23	10	14	47	20	24	14	23	61	20	23	11	13	47	20	10	2	3	15	20						90	38	56	184	20
15/19	1	0	0	1	15	8	4	7	19	15	19	7	10	36	16	12	4	5	21	16	2	1	1	4	16						42	17	25	84	16
10/14	1			1	10	7	2	4	13	11	13	7	7	27	11	5	1	1	7	12	2	0	1	3	11						27	9	13	49	11
5/9						3	0	0	3	7	5	3	5	13	6	1			1	7	1	0		1	8						10	3	5	18	6
0/4						0		0	0	3	8	0		8	2						0			0	4						7	0	2	9	2
−5/−1											1	0		1	−2																1	0		1	−2

TABLE C Thermal Resistances for Surface Films and Air Spaces.

Medium & Position	Direction of Heat Flow	Building Materials: wood, paper, glass, masonry $\epsilon = 0.90$	Galvanized Steel $\epsilon = 0.20$	Aluminum Foil $\epsilon = 0.05$
A. Surface Films		R	R	R
1. Still Air				
a) Horizontal	Up	0.61	1.10	1.32
b) Horizontal	Down	0.92	2.70	4.55
c) Vertical	Horizontal	0.68	1.85	1.70
2. Moving Air				
a) 15 mph Wind (Winter)	Any	0.17	–	–
b) 7.5 mph Wind (Summer)	Any	0.25	–	–
B. Air Space 3/4"		$\epsilon = 0.82$	$\epsilon = 0.20$	$\epsilon = 0.05$
1. Air Mean Temp. 90°F/0°F.**		R	R	R
a) Horizontal	Up	0.76/1.02*	1.63/1.78	2.26/2.16
b) Horizontal	Down	0.84/1.31	2.08/2.88	3.25/4.04
c) Slope 45°	Up	0.81/1.13	1.90/2.13	2.81/2.71
d) Slope 45°	Down	0.84/1.31	2.09/2.88	3.24/4.04
e) Vertical	Horizontal	0.84/1.28	2.10/2.73	3.28/3.76

*Assume an average ΔT of 10°F.

**For resistance at temperatures other than 90°F or 0°F, interpolate between the two values–typical.

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TABLE D Heat Transfer Coefficients of Building Materials.*

MATERIAL	DESCRIPTION	CONDUCTIVITY K#	CONDUCTANCE C +
BUILDING BOARDS	ASBESTOS-CEMENT BOARD	4.0	
	GYPSUM OR PLASTER BOARD...1/2 IN		2.25
	PLYWOOD	0.80	
	PLYWOOD...3/4 IN		1.07
	SHEATHING (IMPREGNATED OR COATED)	0.38	
	SHEATHING (IMPREGNATED OR COATED) 25/32 IN		0.49
	WOOD FIBER—HARDBOARD TYPE	1.40	
INSULATING MATERIALS	BLANKET AND BATT		
	MINERAL WOOL FIBERS (ROCK, SLAG, OR GLASS)	0.27	
	WOOD FIBER	0.25	
	BOARDS AND SLABS		
	CELLULAR GLASS	0.39	
	CORKBOARD	0.27	
	GLASS FIBER	0.25	
	INSULATING ROOF DECK ..2 IN.		0.18
MASONRY MATERIALS	LOOSE FILL		
	MINERAL WOOL (GLASS, SLAG, OR ROCK)	0.27	
	VERMICULITE (EXPANDED)	0.46	
	CONCRETE:		
	CEMENT MORTAR	5.0	
	LIGHTWEIGHT AGGREGATES, EXPANDED SHALE, CLAY, SLATE, SLAGS; CINDER, PUMICE, PERLITE; VERMICULITE	1.7	
	SAND AND GRAVEL OR STONE AGGREGATE	12.0	
	STUCCO	5.0	
	BRICK, TILE, BLOCK, AND STONE		
	BRICK, COMMON	5.0	
	BRICK, FACE	9.0	
	TILE, HOLLOW CLAY, 1 CELL DEEP, 4 IN.		0.90
	TILE, HOLLOW CLAY, 2 CELLS, 8 IN.		0.54
	BLOCK, CONCRETE, 3 OVAL CORE		
	SAND & GRAVEL AGGREGATE...4 IN.		1.40
	SAND & GRAVEL AGGREGATE...8 IN		0.90
	CINDER AGGREGATE ....4 IN		0.90
	CINDER AGGREGATE ....8 IN.		0.58
	STONE, LIME OR SAND	12.50	
PLASTERING MATERIALS	CEMENT PLASTER, SAND AGGREGATE	5.0	
	GYPSUM PLASTER:		
	LIGHTWEIGHT AGGREGATE ..1/2 IN..		3.12
	LT. WT. AGG. ON METAL LATH...3/4 IN.		2.13
	PERLITE AGGREGATE	1.5	
	SAND AGGREGATE	5.6	
	SAND AGGREGATE ON METAL LATH 3/4 IN		7.70
	VERMICULITE AGGREGATE	1.7	
ROOFING	ASPHALT ROLL ROOFING		6.50
	BUILT-UP ROOFING ..3/8 IN..		3.00
SIDING MATERIALS	ASBESTOS-CEMENT, 1/4 IN. LAPPED		4.76
	ASPHALT INSULATING (1/2 IN BOARD)		0.69
	WOOD, BEVEL, 1/2 x 8, LAPPED		1.23
WOODS	MAPLE, OAK, AND SIMILAR HARDWOODS	1.10	
	FIR, PINE, AND SIMILAR SOFTWOODS	0.80	
	FIR, PINE & SIM. SOFTWOODS 25/32 IN.		1.02

$$R = \frac{d}{K} = \frac{1}{U} = \frac{1}{C}$$

*Extracted with permission from ASHRAE Guide and Data Book, 1965.
#Conductivity given in Btu in. per hr sq ft F
+Conductance given in Btu per hr sq ft F

Courtesy of the Trane Company.

ECO #
(EPIC ECO CODE)

TITLE: Insulation of

EXECUTIVE SUMMARY:

Thermal insulation plays a key role in the overall energy management picture. It is interesting to consider that by using insulation, the entire energy requirements of a system are reduced. Most insulation systems reduce the unwanted heat transfer, either loss or gain, by at least 90% as compared to uninsulated systems.

Since the insulation system is so vital to energy-efficient operations, the proper selection and application of that system is very important.

Sophisticated techniques using computer programming are available to find the economic insulation thickness for various situations, however, for your system of ft^2 of uninsulated area, calculations have been made to show the result savings taking into account the economic trade-offs between insulation costs and energy savings.

Specifically, we recommend you insulate

REQUIRED DATA:

Given:
(1) Total area needing insulation: ft^2
(2) Heating unit efficiency :
(3) Cooling unit efficiency (COP):
(4) Cost of electricity : $ /KWH
(5) Fuel cost adjustment charge : $ /KWH
(6) Cost of natural gas : $ /MCF
(7) Demand charge : $ /KW-month

*(8) Installed costs of insulations:

Insulation size (inches)	Material cost ($/ft^2)	Labor cost ($/ft^2)	Unit-Resistance (R) (Hr - ft^2 - °F)/BTU
3" Fiberglass			11
6" Fiberglass			19

*The cost data are market-research based.

CALCULATIONS (for energy & savings):

(1) For the present ft² of insulated area, the overall coefficient of transmission (U) i.e. BTU/(hr-ft² -°F) is calculated as:

$$U = 1/[(R_1 + R_2 + R_3 + \cdots + R_N) + (R_i + R_0)]$$

	R - values (Hr-ft²-°F)/BTU	Description of Resistance type	References
R_i		Inside still air film	Table -
R_0		Outside air film (15 mph)	Table -
R_1		Air space	Table -
R_2			Table -
R_3			Table -
R_4			Table -
R_5			Table -

∴ Existing R-value = ΣR
= (Hr-ft² -°F)/BTU

and U (Existing) = $1/\Sigma R$
= 1/( )
= BTU/(Hr-ft²-°F)

(2) Enclosed herewith are two information sheets for weather data from Tinker Air Force Base - Oklahoma City, which have been used and adapted to prepare table-A and table-B to facilitate the Heat-loss and Heat-gain calculations for heating and cooling seasons respectively by "Temperature Bin Calculation Method".

(3) U(with proposed 3" insulation):

= 1/[(Existing R-value) + (R-value for 3" insulation)]

= 1/[( ) + ( )]

= BTU/(hr-ft²-°F)

(4) U(with proposed 6" insulation):

= 1/[(Existing R-value) + (R-value for 6" insulation)]

= 1/[( ) + ( )]

= BTU/(hr-ft²-°F)

(5) ΔU(for 3" insulation):

= U(Existing) - U(with proposed 3" insulation)

= ( ) - ( )

= BTU/(hr-ft^2-°F)

(6) ΔU(for 6" insulation):

= U(Existing) - U(for 6" insulation)

= ( ) - ( )

= BTU/(hr-ft^2- °F)

(7) Savings in heating energy (BTUs):
(Due to 3" insulation in heating season)

= (Area to be insulated) x ΔU(for 3" insulation) x [$\Sigma(\Delta t$ x hrs.) from table A] ÷ (Heating unit efficiency)

= (ft^2) x (BTU/hr-ft^2-°F) x (°F-hrs/yr) ÷ ( )

= BTU/yr.

(8) Savings in gas consumption:
(Due to 3" insulation in heating season)

= (BTUs saved due to 3" insulation) x (conversion factor for BTU to MCF)

= (BTU/yr) x (1 MCF/10^6BTU)

= MCF/yr.

(9) Resulting $ savings:

= (savings in gas consumption) x (cost of natural gas)

= (MCF/yr) x ($ /MCF)

= $ /yr.

(10) Now savings in electrical energy (KWHs):
(Due to 3" insulation in cooling season)

= (Area to be insulated) x ΔU(for 3" insulation) x [$\Sigma(\Delta t$ x hrs.) from table B] x (conversion factor for BTU to KWH) ÷ (cooling unit efficiency)

= (ft^2) x (BTU/hr-ft^2-°F) x (°F - hrs/yr) x (1KWH/3412 BTU) ÷ (   ).

=   KWH/yr.

(11) Resulting $ savings:

= (Savings in KWH/yr) x (effective cost of electricity)

= (KWH/yr) x ($ /KWH)

= $ /yr.

(12) Savings in demand charge:

There will be a demand saving, but the calculations are complicated. Hence, none are claimed.

(13) Hence total annual $ savings:
(Due to 3" insulation both for heating and cooling seasons)

= ($savings for reduced gas consumption) + ($savings for reduced KWH consumption by A/C units)

= ($ /yr) + ($ /yr)

= $ /yr.

(14) Now savings in heating energy (BTUs):
(Due to 6" insulation in heating season)

= (Area to be insulated)x ΔU(for 6" insulation) x [$\Sigma(\Delta t$ x hrs) from table A] ÷ (Heating unit efficiency

= (ft^2) x (BTU/hrs-ft^2-°F) x (°F-hrs/yr) ÷ (   ).

=   BTU/yr.

(15) Savings in gas consumption:
(Due to 6" insulation in heating season)

= (BTUs saved due to 6" insulation) x (conversion factor for BTU to MCF).

= (BTU/yr) x (1MCF/10^6BTUs)

= MCF/yr.

(16) Resulting $ savings:

= (Savings in gas consumption) x (cost of natural gas)

= (MCF/yr) x ($ /MCF)

= $ /yr.

(17) Savings in electrical energy (KWHs):
(Due to 6" insulation in cooling season)

= (Area to be insulated) x ΔU(for 6" insulation) x [$\Sigma(\Delta t$ x hrs) from table B) x (conversion factor for BTU to KWH) ÷ (cooling unit efficiency)

= (ft^2) x (BTU/hr-ft^2-°F) x (°F - hrs/yr) x (1KWH/3412 BTUs) ÷ ( ).

= KWH/yr.

(18) Resulting $ savings:

= (Savings in KWH/yr) x (Effective cost of electricity)

= (KWH/yr) x ($ /KWH)

= $ /yr.

(19) Hence total annual $ savings:
(Due to 6" insulation both for heating and cooling season)

= ($ savings for reduced gas consumption) + ($ savings for reduced KWH consumption by A/C units)

= ($ /yr) + ($ /yr)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) Cost for 3" insulation:

= (Area to be insulated) x [(Material cost) + (Labor cost)]

= (ft²) x [($ /ft²) + ($ /ft²)]

+ $.

(2) Cost for 6" insulation:

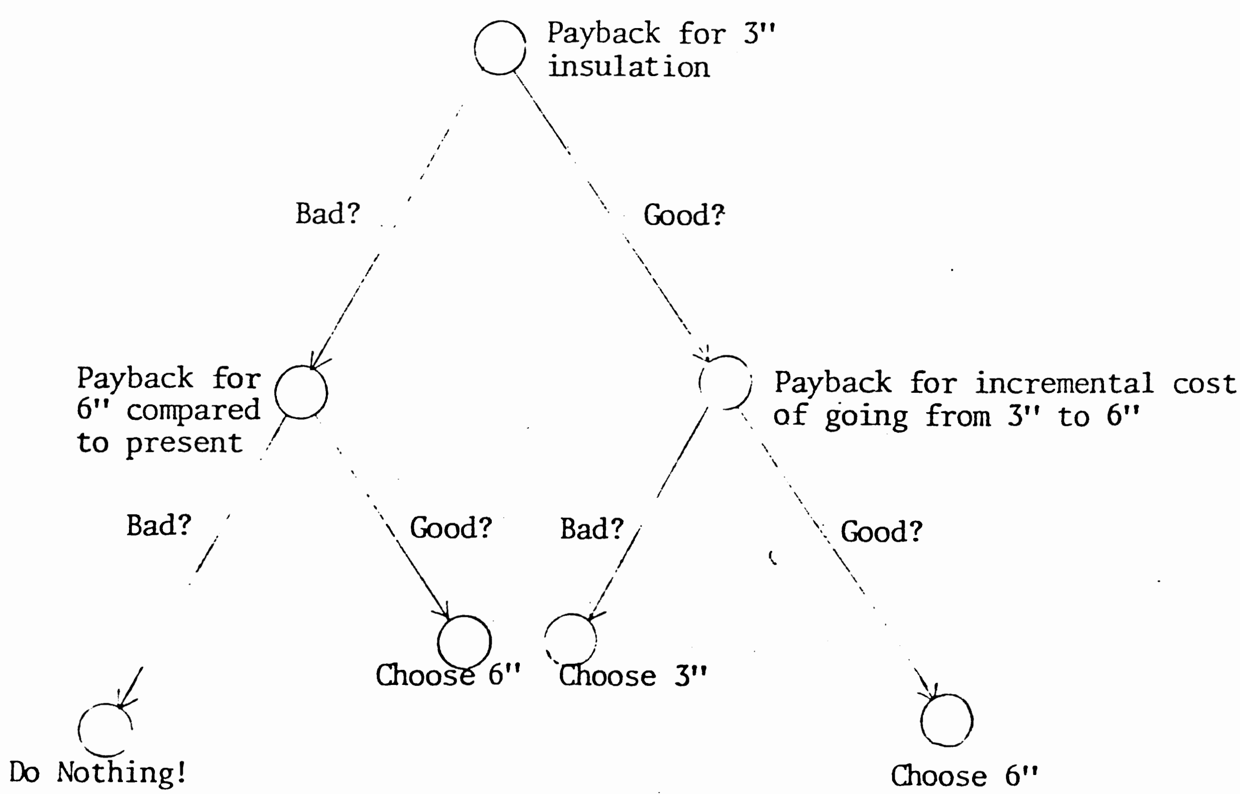
= (Area to be insulated) x [(Material cost) + (Labor cost)]

= (ft²) x [($ /ft²) + ($ /ft²)]

= $.

CALCULATIONS (for simple payback):

The simple payback period can be calculated based on the following decision tree: -



(1) Payback for 3" insulation:

Payback period = (Total cost for 3" insulation) ÷ (Total annual $ savings for 3" insulation)

= ($) ÷ ($ /yr)

= yrs.

(2) Payback for 6" insulation:

Payback period = (Total cost for 6" insulation) ÷ (annual $ savings for 6" insulation)

= ($) ÷ ($ /yr)

= yrs.

(3) Payback period for incremental cost of going from 3" to 6"

Payback period = (Total cost for 6" insulation - Total cost for 3" insulation) ÷ (Incremental annual $ savings for going from 3" to 6")

= ($ - $) ÷ ($ /yr - $ /yr)

= yrs.

CONCLUSION:

The decision tree model suggests to go for inch insulation based on the above analysis.

Table A

HEATING SEASON T = 65°F				
Bins	Midpoint	Δt	Hours in Bin	Δt(Hrs.)
0/4	2	63	9	567
5/9	7	58	18	1,044
10/14	12	53	49	2,597
15/19	17	48	84	4,032
20/24	22	43	184	7,912
25/29	27	38	278	10,564
30/34	32	33	425	14,025
35/39	37	28	531	14,868
40/44	42	23	595	13,685
45/49	47	18	599	10,782
50/54	52	13	595	7,735
55/59	57	8	598	4,784
60/64	62	3	673	2,019
		Σ (Δt x Hrs)		= 94,614 °F - hrs/yr

Table B

COOLING SEASON T = 78°F				
Bins	Midpoint	Δt	Hours in Bin	Δt(Hrs.)
80/84	82	4	639	2,556
85/89	87	9	434	3,906
90/94	92	14	279	3,906
95/99	97	19	124	2,356
100/104	102	24	26	624
105/109	107	29	2	58
		Σ (Δt x Hrs)		= 13,406 °F - hrs/yr

TINKER AFB OKLAHOMA

Mean Frequency of Occurrence of Dry Bulb Temperature (°F) With Mean Coincident Wet Bulb Temperature (°F) For Each Dry Bulb Temperature Range

COOLING SEASON

Temperature Range (°F)	MAY Obsn/Hour Gp 01 to 09	MAY 10 to 17	MAY 18 to 01	MAY Total Obsn	MAY Mean Coincident Wet Bulb (°F)	JUNE Obsn/Hour Gp 01 to 09	JUNE 10 to 17	JUNE 18 to 01	JUNE Total Obsn	JUNE Mean Coincident Wet Bulb (°F)	JULY Obsn/Hour Gp 01 to 09	JULY 10 to 17	JULY 18 to 01	JULY Total Obsn	JULY Mean Coincident Wet Bulb (°F)
105/109												0		0	72
100/104							0	0	0	73		7	0	7	72
95/99		1		1	68		8	1	9	74		51	8	59	74
90/94		8	1	9	71		40	7	47	74	1	70	26	97	74
85/89		33	5	38	70	2	64	25	91	72	11	53	43	107	73
80/84	1	58	21	80	68	14	61	53	128	71	34	35	73	142	71
75/79	13	51	46	110	66	50	36	70	156	69	90	20	55	165	70
70/74	53	40	62	155	64	86	17	51	154	67	83	10	34	127	68
65/69	72	29	55	156	61	62	10	24	96	63	26	2	9	37	65
60/64	55	17	32	104	58	20	3	8	31	60	3		0	3	60
55/59	33	9	20	62	53	5	1	1	7	55	0			0	57
50/54	15	2	5	22	48	1	0		1	49					
45/49	5	0	1	6	43										
40/44	1		0	1	40										
35/39	0			0	35										
30/34															
25/29															

Temperature Range (°F)	AUGUST Obsn/Hour Gp 01 to 09	AUGUST 10 to 17	AUGUST 18 to 01	AUGUST Total Obsn	AUGUST Mean Coincident Wet Bulb (°F)	SEPTEMBER Obsn/Hour Gp 01 to 09	SEPTEMBER 10 to 17	SEPTEMBER 18 to 01	SEPTEMBER Total Obsn	SEPTEMBER Mean Coincident Wet Bulb (°F)	OCTOBER Obsn/Hour Gp 01 to 09	OCTOBER 10 to 17	OCTOBER 18 to 01	OCTOBER Total Obsn	OCTOBER Mean Coincident Wet Bulb (°F)
105/109		2	0	2	73										
100/104		15	2	17	73		0		0	72					
95/99	0	37	7	44	73		11	0	11	71		0		0	61
90/94	1	63	20	84	73		30	4	34	71		6		6	64
85/89	7	64	39	110	72	1	48	13	62	70		14	1	15	66
80/84	29	88	70	187	71	7	43	35	85	69		30	5	35	65
75/79	82	20	64	166	69	30	42	56	128	67	2	39	14	55	63
70/74	84	7	37	128	67	67	33	48	148	65	13	44	37	94	62
65/69	37	2	8	47	63	53	18	46	117	62	75	46	50	111	59
60/64	7	0	1	8	58	45	11	26	82	57	54	34	53	141	55
55/59	1			1	55	27	3	8	38	53	49	21	43	113	51
50/54						7	1	4	12	49	48	8	27	83	47
45/49						3	0		3	46	29	4	13	46	42
40/44											12	1	3	16	38
35/39											4	1	1	6	34
30/34											1		1	2	29
25/29											1		0	1	26

HEATING SEASON

Temperature Range (°F)	NOVEMBER					DECEMBER					JANUARY					FEBRUARY					MARCH					APRIL					ANNUAL (ALL MONTHS)				
	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)	Obsn/Hour Gp 02 to 09	10 to 17	18 to 01	Total Obsn	Mean Coincident Wet Bulb (°F)
105/109																																2	0	2	73
100/104																																23	3	26	73
95/99																															0	108	16	124	73
90/94																											2		2	65	3	219	57	279	70
85/89							0		0	60							0		0	62		1	0	1	58		10	1	11	66	20	286	128	434	70
80/84							0		0	59							1	0	1	60		4	1	5	61	0	20	5	25	64	85	292	262	639	66
75/79		7		7	60		0		0	55							3	0	3	57	0	10	2	12	59	1	32	15	48	63	269	259	322	850	64
70/74	2	25	4	31	60		2	0	2	53		1		1	56		7	1	8	57	0	15	5	20	56	10	41	33	84	61	398	245	314	957	61
65/69	6	26	14	46	57		7	1	8	51		7	1	8	53	0	12	4	16	54	4	24	13	41	54	31	38	39	108	58	326	219	265	810	58
60/64	11	30	22	63	53	1	17	3	21	51	2	13	4	19	52	2	15	7	24	52	10	30	21	61	51	39	33	41	113	54	250	204	219	673	55
55/59	19	35	29	83	49	7	27	14	48	49	4	17	8	29	49	7	22	15	44	49	15	30	28	73	48	41	26	37	104	49	207	188	203	598	51
50/54	29	38	42	109	46	11	37	24	72	46	7	29	18	54	46	9	29	23	61	46	24	33	36	93	45	41	19	30	90	45	192	195	208	595	46
45/49	43	34	40	117	42	23	40	39	102	41	11	34	24	69	41	26	26	33	85	42	36	29	38	103	41	35	13	22	70	42	210	180	209	599	42
40/44	39	20	32	91	37	38	38	45	121	38	29	38	43	110	37	32	30	39	101	38	45	28	42	115	35	26	4	12	42	38	223	159	213	595	38
35/39	43	14	31	88	33	46	30	41	117	33	36	31	42	109	33	37	32	32	101	33	42	21	28	91	34	12	1	4	17	35	221	132	178	531	34
30/34	26	7	14	47	29	49	20	34	103	29	52	28	35	115	29	41	18	29	88	29	36	13	20	69	29	3			3	30	207	85	133	425	29
25/29	10	3	9	22	24	32	14	22	68	25	39	19	26	84	25	29	13	22	64	25	21	7	9	37	25	1	1	1	3	26	132	57	89	278	25
20/24	10	1	3	14	20	23	10	14	47	20	24	14	23	61	20	23	11	13	47	20	10	2	3	15	20						90	38	56	184	20
15/19	1	0	0	1	15	8	4	7	19	16	19	7	10	36	16	12	4	5	21	16	2	1	1	4	16						42	17	25	84	16
10/14	1			1	10	7	2	4	13	11	13	7	7	27	11	5	1	1	7	12	2	0	1	3	11						27	9	13	49	11
5/9						3	0	0	3	7	5	3	5	13	6	1			1	7	1	0		1	8						10	3	5	18	6
0/4						0		0	0	3	8	0		8	2						0			0	4						7	0	2	9	2
−5/−1											1	0		1	−2																	0		1	−2

TABLE C Thermal Resistances for Surface Films and Air Spaces.

Medium & Position	Direction of Heat Flow	Building Materials: wood, paper, glass, masonry $\epsilon = 0.90$	Galvanized Steel $\epsilon = 0.20$	Aluminum Foil $\epsilon = 0.05$
A. Surface Films		*R*	*R*	*R*
1. Still Air				
a) Horizontal	Up	0.61	1.10	1.32
b) Horizontal	Down	0.92	2.70	4.55
c) Vertical	Horizontal	0.68	1.85	1.70
2. Moving Air				
a) 15 mph Wind (Winter)	Any	0.17	–	–
b) 7.5 mph Wind (Summer)	Any	0.25	–	–
B. Air Space 3/4"		$\epsilon = 0.82$	$\epsilon = 0.20$	$\epsilon = 0.05$
1. Air Mean Temp. 90°F/0°F.**		*R*	*R*	*R*
a) Horizontal	Up	0.76/1.02*	1.63/1.78	2.26/2.16
b) Horizontal	Down	0.84/1.31	2.08/2.88	3.25/4.04
c) Slope 45°	Up	0.81/1.13	1.90/2.13	2.81/2.71
d) Slope 45°	Down	0.84/1.31	2.09/2.88	3.24/4.04
e) Vertical	Horizontal	0.84/1.28	2.10/2.73	3.28/3.76

*Assume an average ΔT of 10°F.

**For resistance at temperatures other than 90°F or 0°F, interpolate between the two values–typical.

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TABLE D Heat Transfer Coefficients of Building Materials.*

MATERIAL	DESCRIPTION	CONDUCTIVITY k#	CONDUCTANCE C +
BUILDING BOARDS	ASBESTOS-CEMENT BOARD	4.0	
	GYPSUM OR PLASTER BOARD ..1/2 IN		2.25
	PLYWOOD	0.80	
	PLYWOOD ..3/4 IN		1.07
	SHEATHING (IMPREGNATED OR COATED)	0.38	
	SHEATHING (IMPREGNATED OR COATED) 25/32 IN		0.49
	WOOD FIBER—HARDBOARD TYPE	1.40	
INSULATING MATERIALS	BLANKET AND BATT		
	MINERAL WOOL FIBERS (ROCK, SLAG, OR GLASS)	0.27	
	WOOD FIBER	0.25	
	BOARDS AND SLABS		
	CELLULAR GLASS	0.39	
	CORKBOARD ..	0.27	
	GLASS FIBER	0.25	
	INSULATING ROOF DECK ..2 IN		0.18
MASONRY MATERIALS	LOOSE FILL		
	MINERAL WOOL (GLASS, SLAG, OR ROCK)	0.27	
	VERMICULITE (EXPANDED)	0.46	
	CONCRETE:		
	CEMENT MORTAR	5.0	
	LIGHTWEIGHT AGGREGATES, EXPANDED SHALE, CLAY, SLATE, SLAGS; CINDER, PUMICE, PERLITE; VERMICULITE	1.7	
	SAND AND GRAVEL OR STONE AGGREGATE	12.0	
	STUCCO	5.0	
	BRICK, TILE, BLOCK, AND STONE		
	BRICK, COMMON	5.0	
	BRICK, FACE .	9.0	
	TILE, HOLLOW CLAY, 1 CELL DEEP, 4 IN		0.90
	TILE, HOLLOW CLAY, 2 CELLS, 8 IN		0.54
	BLOCK, CONCRETE, 3 OVAL CORE		
	SAND & GRAVEL AGGREGATE ..4 IN		1.40
	SAND & GRAVEL AGGREGATE 8 IN		0.90
	CINDER AGGREGATE ... .4 IN		0.90
	CINDER AGGREGATE ....8 IN		0.58
	STONE, LIME OR SAND	12.50	
PLASTERING MATERIALS	CEMENT PLASTER, SAND AGGREGATE	5.0	
	GYPSUM PLASTER:		
	LIGHTWEIGHT AGGREGATE 1/2 IN.		3.12
	LT. WT. AGG. ON METAL LATH...3/4 IN		2.13
	PERLITE AGGREGATE	1.5	
	SAND AGGREGATE	5.6	
	SAND AGGREGATE ON METAL LATH 3/4 IN		7.70
	VERMICULITE AGGREGATE	1.7	
ROOFING	ASPHALT ROLL ROOFING ...		6.50
	BUILT-UP ROOFING .3/8 IN		3.00
SIDING MATERIALS	ASBESTOS-CEMENT, 1/4 IN. LAPPED		4.76
	ASPHALT INSULATING (1/2 IN BOARD)		0.69
	WOOD, BEVEL, 1/2 x 8, LAPPED		1.23
WOODS	MAPLE, OAK, AND SIMILAR HARDWOODS	1.10	
	FIR, PINE, AND SIMILAR SOFTWOODS	0.80	
	FIR, PINE & SIM. SOFTWOODS 25/32 IN.		1.02

$$R = \frac{d}{K} = \frac{1}{U} = \frac{1}{C}$$

*Extracted with permission from ASHRAE Guide and Data Book, 1965.
#Conductivity given in Btu in per hr sq ft F
+Conductance given in Btu per hr sq ft F

Courtesy of the Trane Company.

Instruction Sheet for ECO #9

Title: Switching to more efficient light sources.

How to use this ECO format?

In the example calculations for this ECO form, the information for the required data have been taken from the EADC audit report (Report #C10) prepared for Neece Steel Corp., Claremore, Oklahoma.

In this ECO format the present illumination level is obtained by multiplying the number of lamps in use with the lumens per lamp i.e., 17 lamps x 29,000 lumens/lamp = 493,000 lumens. The number of lamps recommended is calculated by dividing the present illumination level by the lumens per lamp of the proposed lamps, i.e., (493,000 lumens) ÷ (37,000 lumens/lamp) = 13.32 = 14 lamps (rounded off to the nearest integer).

The rest of the materials in the example calculation are almost self-explanatory.

However, for longer payback periods, the calculations for simple payback of the format can be modified by the following tabular form of cash flow diagram to show the economic analysis and to calculate the payback period.

End of year	Savings in energy charge (A)	Savings in demand charge (B)	Annual replacement cost (C)	Total D = A+B−C (D)	Unrecovered balance
0	0	0	0	0	−
1	+	+	−	+	−
2	+	+	−	+	−
3	+	+	−	+	−
.	+	+	−	+	−
.	+	+	−	+	−
.	+	+	−	+	−
.	+	+	−	+	−

The payback period is calculated from the point where the unrecovered balance changes its sign from negative to positive.

ECO #

EPIC ECO CODE 61.32

TITLE: Switching to more efficient light sources.

EXECUTIVE SUMMARY:

Switching from one light source to more efficient source is always recommended if economically justified because this results in both energy and demand charge savings in addition to improved general lighting condition. Enclosed, herewith, is a table which gives you a comparative pictorial of the most commonly used light sources and their various characteristics. These factors do enter into consideration whenever a decision is made to switch from one source of light to a more efficient one to be used for a particular location.

However, in general, the high pressure sodium lamps have the highest lamp efficiency and also have excellent lumen maintenance over life. Although the high pressure sodium lamp first found its principal use in street and outdoor lighting, it now is a readily accepted light source in industrial plants.

It is, therefore, recommended that your present system of lamp be relamped by HPS lamps for which calculations have been made to show the resulting savings.

REQUIRED DATA:

<u>Given:</u>

Cost of electricity	:$ 0.029/KWH
Fuel adjustment cost factor charge	:$0.006455/KWH
Demand charge	:$ 2.39 /KW-month
Hours of operation	: 10 Hrs/day
	365 days/yr.

<u>Present system of lighting:</u>

Type of light source in use	: Tungsten Halogen Lamps
Wattage/lamp	: 1500 watts/lamp
Total input wattage/fixture	: watts/fixture
Number of lamps in use	: 17
Life/lamp	: 3000 hrs./lamp
Lumen/lamp	: 29,000 lumen/lamp
Cost/lamp	:$ 27.00/lamp
Cost/fixture	:$ — /fixture
Area illuminated	: — ft^2
Present illumination level	: 493000 lumens

Proposed system of lighting:
Type of light source recommended: High Pressure Sodium lamps.
Wattage/lamp : 250 watts/lamp
Total input wattage/fixture : 310 watts/fixture
Number of lamps and fixtures recommended : 14 each
Lumen/lamp : 37000 lumen/lamp
Life/lamp : 24,000 hrs./lamp
Cost/lamp :$ 60.00/lamp
Cost/fixture (installed) :$ 300.00/fixture
Proposed illumination level :518000 lumens

CALCULATIONS (for $ and energy savings):

(1) Effective cost of electricity:

= (cost of electricity) + (cost of fuel adjustment factor charge)
= ($0.029/KWH) + ($0.006455/KWH)
= $0.035455/KWH.

(2) Savings in energy charge:

= [(# of existing lamps) x (total input wattage/fixture)] - (# of proposed lamps) x (total input wattage/fixture)] x (conversion factor for watts to KW) x (operation hrs./yr.) x (effective cost of electricity)
= [(17) x (1500 watts/fixture) - (14) x (310 watts/fixture)] (1 KW/1000 watts) x (3650 hrs./yr.) x ($0.035455/KWH)
= $ 3139.5/yr.

(3) Savings in demand charge:

= [(# of existing lamps) x (total input wattage/fixture) - (# of proposed lamps) x (total input wattage/fixture)] x (conversion factor for watts to KW) x (conversion factor for months to yr.) x (demand charge)
= [(17) x (1500 watts/fixture) - (14) x (310 watts/fixture)] x (1 KW/1000 watts) x (12 months/yr.) x ($2.39 /KW-month)
= $ 606.85 /yr.

(4) Savings in energy (KWH):

= (savings in energy charge) ÷ (effective cost of electricity)
= ($3139.5/yr.) ÷ ($0.035455/KWH)
= 88548.87 KWH/yr.

(5) Savings in energy (BTUs):

= (savings in KWH/yr) x (conversion factor)
= (88548.87 KWH/yr.) x (3412 BTU/KWH)
= 302×10^6 BTU/yr.

CALCULATIONS (for implementation cost):

(1) Incremental annual cost for lamp replacement:

= [(# of existing lamps) x (cost/lamp) x (1/lamp life) - (# of proposed lamps) x (cost/lamp) x (1/lamp life)] x (operation hrs. per year per lamp)
= [(17) x ($ 27 /lamp) x (1 lamp/3000 hrs.) - (14) x ($ 60 /lamp) x (1 lamp/24000 hrs.)] x (3650 hrs./yr. - lamp)
= $430.7/yr.

(2) One time investment cost for fixtures:

= (# of new fixtures recommended) x (cost/fixture)
= (14 fixtures) x ($ 300 /fixture)
= $ 4200

CALCULATIONS (for simple payback):

(1) Total net annual $ savings:

= (annual $ savings in energy charge) + (annual $ savings in demand charge) - (incremental annual cost for lamp replacement)
= ($3139.5/yr.) + ($606.85/yr.) – ($ 430.7 /yr.)
= $3315.65/yr.

(2) Simple payback period:

= (total investment cost for fixtures) ÷ (total net annual $ savings)
= ($ 4200) ÷ ($ 3315.65/yr.)
= 1.27 yrs.

NOTE:

The audit team further recommends that a lamp maintenance program be initiated if there does not exist any at present. It is worth mentioning that cleaning dirt off the light lamps and reflectors on periodic intervals increases the lighting level from 5 to 15%.

Table Light Source Characteristics

	Incandescent, Including Tungsten Halogen	Fluorescent	High-Intensity Discharge: Mercury Vapor (Self-Ballasted)	High-Intensity Discharge: Metal Halide	High-Intensity Discharge: High-Pressure Sodium (Improved Color)	Low-Pressur Sodium
Wattages (lamp only)	15–1500	15–219	40–1000	175–1000	70–1000	35–180
Life* (hr)	750–12,000	7500–24,000	16,000–15,000	1500–15,000	24,000 (10,000)	18,000
Efficacy* (lumens/W) lamp only	15–25	55–100	50–60 (20–25)	80–100	75–140 (67–112	Up to 180
Lumen maintenance	Fair to excellent	Fair to excellent	Very good (good)	Good	Excellent	Excellent
Color rendition	Excellent	Good to excellent	Poor to excellent	Very good	Fair (very good)	Poor
Light direction control	Very good to excellent	Fair	Very good	Very good	Very good	Fair
Source size	Compact	Extended	Compact	Compact	Compact	Extended
Relight time	Immediate	Immediate	3–10 min	10–20 min	Less than 1 min	Immediate
Comparative fixture cost	Low: simple fixtures	Moderate	Higher than incandescent and fluorescent	Generally higher than mercury	High	High
Comparative operating cost	High: short life and low efficacy	Lower than incandescent	Lower than incandescent	Lower than mercury	Lowest of HID types	Low
Auxiliary equipment needed	Not needed	Needed: medium cost	Needed: high cost	Needed: high cost	Needed: high cost	Needed: high c

* Life and efficacy ratings subject to revision. Check manufacturers' data for latest information.

Information Sheet

The following table provides a typical total input wattage/fixture (i.e., the wattage consumed by the lamp and ballast together) for three different light sources for their different lamp wattage ratings:

High Pressure Sodium

Lamp Wattage	Total Input Wattage/Fixture
75 watts	95 watts
100 watts	135 watts
150 watts	200 watts
250 watts	310 watts
400 watts	475 watts

Metal Halide

Lamp Wattage	Total Input Wattage/Fixture
175 watts	210 watts
250 watts	300 watts
400 watts	460 watts

Mercury Vapor

Lamp Wattage	Total Input Wattage/Fixture
100 watts	120 watts
175 watts	205 watts
250 watts	285 watts
400 watts	445 watts

ECO #

EPIC ECO CODE 61.32

TITLE: Switching to more efficient light sources.

EXECUTIVE SUMMARY:

Switching from one light source to more efficient source is always recommended if economically justified because this results in both energy and demand charge savings in addition to improved general lighting condition. Enclosed, herewith, is a table which gives you a comparative pictorial of the most commonly used light sources and their various characteristics. These factors do enter into consideration whenever a decision is made to switch from one source of light to a more efficient one to be used for a particular location.

However, in general, the high pressure sodium lamps have the highest lamp efficiency and also have excellent lumen maintenance over life. Although the high pressure sodium lamp first found its principal use in street and outdoor lighting, it now is a readily accepted light source in industrial plants.

It is, therefore, recommended that your present system of lamp be relamped by HPS lamps for which calculations have been made to show the resulting savings.

REQUIRED DATA:

Given:

Cost of electricity	:$	/KWH
Fuel adjustment cost factor charge	:$	/KWH
Demand charge	:$	/KW-month
Hours of operation	:	Hrs/day
		days/yr.

Present system of lighting:

Type of light source in use	:	
Wattage/lamp	:	watts/lamp
Total input wattage/fixture	:	watts/fixture
Number of lamps in use	:	
Life/lamp	:	hrs./lamp
Lumen/lamp	:	lumen/lamp
Cost/lamp	:$	/lamp
Cost/fixture	:$	/fixture
Area illuminated	:	ft^2
Present illumination level	:	lumens

Proposed system of lighting:

Type of light source recommended:		
Wattage/lamp	:	watts/lamp
Total input wattage/fixture	:	watts/fixture
Number of lamps and fixtures recommended	:	each
Lumen/lamp	:	lumen/lamp
Life/lamp	:	hrs./lamp
Cost/lamp	:$	/lamp
Cost/fixture (installed)	:$	/fixture
Proposed illumination level	:	lumens

CALCULATIONS (for $ and energy savings):

(1) Effective cost of electricity:

= (cost of electricity) + (cost of fuel adjustment factor charge)

= ($ /KWH) + ($ /KWH)

= $ /KWH.

(2) Savings in energy charge:

= [(# of existing lamps) x (total input wattage/fixture)] - (# of proposed lamps) x (total input wattage/fixture)] x (conversion factor for watts to KW) x (operation hrs./yr.) x (effective cost of electricity)

= [( ) x (watts/fixture) - ( ) x (watts/fixture)] (1 KW/1000 watts) x (hrs./yr.) x ($ /KWH)

= $ /yr.

(3) Savings in demand charge:

= [(# of existing lamps) x (total input wattage/fixture) - (# of proposed lamps) x (total input wattage/fixture)] x (conversion factor for watts to KW) x (conversion factor for months to yr.) x (demand charge)

= [( ) x (watts/fixture) - ( ) x (watts/fixture)] x (1 KW/1000 watts) x (12 months/yr.) x ($ /KW-month)

= $ /yr.

(4) Savings in energy (KWH):

= (savings in energy charge) ÷ (effective cost of electricity)

= ($ /yr.) ÷ ($ /KWH)

= KWH/yr.

(5) Savings in energy (BTUs):

= (savings in KWH/yr) x (conversion factor)

= (KWH/yr.) x (3412 BTU/KWH)

= BTU/yr.

CALCULATIONS (for implementation cost):

(1) Incremental annual cost for lamp replacement:

= [(# of existing lamps) x (cost/lamp) x (1/lamp life) - (# of proposed lamps) x (cost/lamp) x (1/lamp life)] x (operation hrs. per year per lamp)

= [( ) x ($ /lamp) x (1 lamp/ hrs.) - ( ) x ($ /lamp) x (1 lamp/ hrs.)] x (hrs./yr. - lamp)

= $ /yr.

(2) One time investment cost for fixtures:

= (# of new fixtures recommended) x (cost/fixture)

= (fixtures) x ($ /fixture)

= $

CALCULATIONS (for simple payback):

(1) Total net annual $ savings:

= (annual $ savings in energy charge) + (annual $ savings in demand charge) - (incremental annual cost for lamp replacement)

= ($ /yr.) + ($ /yr.) – ($ /yr.)

= $ /yr.

(2) Simple payback period:

= (total investment cost for fixtures) ÷ (total net annual $ savings)

= ($) ÷ ($ /yr.)

= yrs.

NOTE:

The audit team further recommends that a lamp maintenance program be initiated if there does not exist any at present. It is worth mentioning that cleaning dirt off the light lamps and reflectors on periodic intervals increases the lighting level from 5 to 15%.

Information Sheet

The following table provides a typical total input wattage/fixture (i.e., the wattage consumed by the lamp and ballast together) for three different light sources for their different lamp wattage ratings:

High Pressure Sodium

Lamp Wattage	Total Input Wattage/Fixture
75 watts	95 watts
100 watts	135 watts
150 watts	200 watts
250 watts	310 watts
400 watts	475 watts

Metal Halide

Lamp Wattage	Total Input Wattage/Fixture
175 watts	210 watts
250 watts	300 watts
400 watts	460 watts

Mercury Vapor

Lamp Wattage	Total Input Wattage/Fixture
100 watts	120 watts
175 watts	205 watts
250 watts	285 watts
400 watts	445 watts

Table Light Source Characteristics

	Incandescent, Including Tungsten Halogen	Fluorescent	High-Intensity Discharge: Mercury Vapor (Self-Ballasted)	High-Intensity Discharge: Metal Halide	High-Intensity Discharge: High-Pressure Sodium (Improved Color)	Low-Pressure Sodium
Wattages (lamp only)	15–1500	15–219	40–1000	175–1000	70–1000	35–180
Life[a] (hr)	750–12,000	7500–24,000	16,000–15,000	1500–15,000	24,000 (10,000)	18,000
Efficacy[a] (lumens/W) lamp only	15–25	55–100	50–60 (20–25)	80–100	75–140 (67–112	Up to 180
Lumen maintenance	Fair to excellent	Fair to excellent	Very good (good)	Good	Excellent	Excellent
Color rendition	Excellent	Good to excellent	Poor to excellent	Very good	Fair (very good)	Poor
Light direction control	Very good to excellent	Fair	Very good	Very good	Very good	Fair
Source size	Compact	Extended	Compact	Compact	Compact	Extended
Relight time	Immediate	Immediate	3–10 min	10–20 min	Less than 1 min	Immediate
Comparative fixture cost	Low: simple fixtures	Moderate	Higher than incandescent and fluorescent	Generally higher than mercury	High	High
Comparative operating cost	High: short life and low efficacy	Lower than incandescent	Lower than incandescent	Lower than mercury	Lowest of HID types	Low
Auxiliary equipment needed	Not needed	Needed: medium cost	Needed: high cost	Needed: high cost	Needed: high cost	Needed: high cost

[a] Life and efficacy ratings subject to revision. Check manufacturers' data for latest information.

INSTRUCTION SHEET FOR ECO #10

Title: Switching to Ellipsoidal Reflector Lamps

How To Use This ECO Format

In the example calculations for this ECO format, most of the information for the required data has been taken from the EADC audit report prepared for Koehring Speedstar Division, Enid, Oklahoma. In this example calculation, the contents need not be explained explicitly because they are almsot self explanatory.

ECO # 10

(EPIC ECO Code 61.31)

TITLE: Switching to Ellipsodial Reflector Lamps

EXECUTIVE SUMMARY:

Incandescent lamps are available in a variety of shapes and sizes. Reflector lamps (which are incandescent lamps) are classified as both flood lamps and spot lamps. A flood lamp has a wide beam, while the spot light concentrates its light output in a more narrow beam. For most applications, spot lamps are preferred over flood lamps. Most flood lamp fixtures block a large portion of light beam and also result in unwanted heating of the bulb housing. However, a spot lamp gets more light out of the fixtures and concentrates it where you need it -- on the target. In many cases, you can replace a flood lamp with a spot lamp using half the wattage and get the same light where you need it. The ER-type lamp (ellipsodial reflector) is a relatively new type of spot lamp which has been designed to be effective in getting light out of the baffled or recessed fixtures.

We, therefore, recommend you to relamp your flood lamps with Ellipsodial Recessed flood lamps in your ~~office~~ hallways. area for which the resulting savings in energy and dollars have been provided below.

REQUIRED DATA:

Given:
(1) For your present system of flood lamps:

Wattage : 150 watts/lamp
Total Number: 30
Cost/Lamp :$ 4.05 /lamp

Proposed:
(2) For your proposed system of ellipsodial reflector lamps:

Wattage : 75 watts/lamp
Total Number: 30
Cost/Lamp :$ 5.15/lamp

(3) Cost of Electricity :$0.0153/KWH
(4) Demand Charge :$ 2.39 /KW-month
(5) Fuel Cost Adjustment Charge:$0.006455/KWH
(6) Operating Hours : 3375 Hrs./Yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= (cost of electricity) + (fuel cost adjustment factor charge)

= ($0.0153/KWH) + ($0.006455/KWH)

= $0.021755/KWH.

(2) Savings in energy charge:

= [(# of present flood lamps) x (corresponding wattage) - (# of proposed ellipsodial reflector lamps) x (corresponding wattage)] x (operating hrs./yr.) x (effective cost of electricity)

= [(30) x (150 watts)/1000 - (30) x (75 watts/1000] x (3375 hrs./yr) x ($0.021755/KWH)

= $165.20/yr.

(3) Savings in demand charge:

= [(# of present flood lamps) x (corresponding wattage) - (# of proposed ellipsodial reflector lamps) x (corresponding wattage)] x (demand charge) x (conversion factor)

= [(30) x (150 watts)/1000 - (30) x (75 watts/1000] x ($ 2.39 /KW-month) x (12 months/yr.)

= $ 64.53 /yr.

(4) Savings in KWH:

= (savings in energy charge/yr.) ÷ (effective cost of electricity)

= (165.20 KWH/yr.) ÷ ($0.021755/KWH)

= 7593.66 KWH/yr.

CALCULATIONS (for implementation cost):

(1) The implementation cost for this ECO is based on incremental cost.

Total incremental replacement cost

= (Total # of proposed lamps) x (their incremental cost of purchasing)

= (30) x [($ 5.15 /proposed lamp) − ($ 4.05 / present lamp)]

= $ 33.00 .

(2) Total annual $ savings:

= (savings in energy charge) + (savings in demand charge)

= ($ 165.20 /yr.) + ($ 64.53/yr.)

= $229.73 /yr.

CALCULATIONS (for simple payback):

Payback = (total incremental replacement cost) ÷ (total annual $ savings)

= ($ 33.00) ÷ ($ 229.73/yr.)

= 0.14 yrs.

= 1.7 months.

ECO #

(EPIC ECO Code 61.31)

TITLE: Switching to Ellipsodial Reflector Lamps

EXECUTIVE SUMMARY:

Incandescent lamps are available in a variety of shapes and sizes. Reflector lamps (which are incandescent lamps) are classified as both flood lamps and spot lamps. A flood lamp has a wide beam, while the spot light concentrates its light output in a more narrow beam. For most applications, spot lamps are preferred over flood lamps. Most flood lamp fixtures block a large portion of light beam and also result in unwanted heating of the bulb housing. However, a spot lamp gets more light out of the fixtures and concentrates it where you need it -- on the target. In many cases, you can replace a flood lamp with a spot lamp using half the wattage and get the same light where you need it. The ER-type lamp (ellipsodial reflector) is a relatively new type of spot lamp which has been designed to be effective in getting light out of the baffled or recessed fixtures.

We, therefore, recommend you to relamp your flood lamps with Ellipsodial Recessed flood lamps in your area for which the resulting savings in energy and dollars have been provided below.

REQUIRED DATA:

<u>Given:</u>

(1) For your present system of flood lamps:

Wattage : watts/lamp
Total Number:
Cost/Lamp :$ /lamp

<u>Proposed:</u>

(2) For your proposed system of ellipsodial reflector lamps:

Wattage : watts/lamp
Total Number:
Cost/Lamp :$ /lamp

(3) Cost of Electricity :$ /KWH
(4) Demand Charge :$ /KW-month
(5) Fuel Cost Adjustment Charge:$ /KWH
(6) Operating Hours : Hrs./Yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= (cost of electricity) + (fuel cost adjustment factor charge)

= ($ /KWH) + ($ /KWH)

= $ /KWH.

(2) Savings in energy charge:

= [(# of present flood lamps) x (corresponding wattage) - (# of proposed ellipsodial reflector lamps) x (corresponding wattage)] x (operating hrs./yr.) x (effective cost of electricity)

= [( ) x (watts)/1000 - ( ) x (watts/1000] x (hrs./yr) x ($ /KWH)

= $ /yr.

(3) Savings in demand charge:

= [(# of present flood lamps) x (corresponding wattage) - (# of proposed ellipsodial reflector lamps) x (corresponding wattage)] x (demand charge) x (conversion factor)

= [( ) x (watts)/1000 - ( ) x (watts/1000] x ($ /KW-month) x (12 months/yr.)

= $ /yr.

(4) Savings in KWH:

= (savings in energy charge/yr.) ÷ (effective cost of electricity)

= (KWH/yr.) ÷ ($ /KWH)

= KWH/yr.

CALCULATIONS (for implementation cost):

(1) The implementation cost for this ECO is based on incremental cost.

Total incremental replacement cost

= (Total # of proposed lamps) x (their incremental cost of purchasing)

= ( ) x [($ /proposed lamp) − ($ /present lamp)]

= $.

(2) Total annual $ savings:

= (savings in energy charge) + (savings in demand charge)

= ($ /yr.) + ($ /yr.)

= $ /yr.

CALCULATIONS (for simple payback):

Payback = (total incremental replacement cost) ÷ (total annual $ savings)

= ($) ÷ ($ /yr.)

= yrs.

INSTRUCTION SHEET FOR ECO #11

Title: Switching to LPS for Security Lights

How To Use This ECO Format

In the example calculations for this ECO format, most of the information for the required data has been taken from the EADC audit report prepared for Labarge Steel, Tulsa, Oklahoma.

In this example calculation, the contents need not be explained explicitly because they are almost self explanatory.

ECO #

(EPIC ECO Code 61.32)

TITLE: Switching to LPS Lamps for Security Lights

EXECUTIVE SUMMARY:

The low pressure sodium (LPS) lamp is the most efficient of all the available light sources, providing up to 183 lumens/watt. However, its monochromatic yellow light has limited its application to areas where color identification is not a matter of concern. That is why the primary use of LPS lamps is currently for street and highway lighting as well as outdoor area and security lighting.

We recommend that your present security lighting systems be relamped by higher efficiency and lower wattage low pressure sodium lamps. Since LPS lamps have wider dispersement of light output, relocation of the new fixtures might improve the overall security lighting in addition to giving you the benefits of energy and dollar savings. Calculations for savings have been provided below.

REQUIRED DATA:

Given:

(1) For your present floodlights lamps for security lighting:

*Wattage/Lamp	Total Number	Lumens per Lamp	Life Per Lamp	Cost Per Lamp
150 watts	7		2000 hrs/lamp	$3.00/lamp.

(2) For your proposed LPS lamps for security lighting:

*Wattage/Fixture	Total Number	Lumens per Lamp	Life Per Lamp	Cost per Lamp	Cost per Fixture
30 watts/fixture	7		10,000 hrs/lamp	$27.00 per lamp	$67.00 per fixture.

*Ballast wattage is added to the wattage rating per lamp to get the total wattage/fixture

(3) Cost of Electricity :$0.050235/KWH
(4) Fuel Cost Adjustment Factor Charge:$0.006455/KWH
(5) Operating Hrs./Yr. : 4562.5 Hrs./Yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= (cost of electricity) + (fuel cost adjustment factor charge)
= ($0.050235/KWH) + ($0.006455/KWH)
= $0.05669 /KWH

(2) Savings in energy (KWH):

= [(# of present lamps) x (corresponding wattage/lamp)
- (# of proposed LPS lamps) x (corresponding wattage/fixture)]
x (operating hrs./yr.)
= [(7 lamp) x (150 watts/lamp)/1000 - (7 fixtures)
x (30 watts/fixture)/1000] x (4562.5 hrs./yr.)
= 3832.5 KWH/yr.

(3) Savings in energy (BTUs):

= (savings in KWH/yr.) x (conversion factor)
= (3832.5 KWH/yr.) x (3412 BTU/KWH)
= 13.1×10^{6} BTU/yr.

(4) Savings in energy charge:

= (savings in KWH/yr.) x (effective cost of electricity)
= (3832.5 KWH/yr.) x ($0.05669/KWH)
= $217.26 /yr.

CALCULATIONS (for implementation cost):

(1) Annual incremental cost for lamp replacement:

= [(# of proposed lamps) x (1/lamp life) x (cost/lamp)
- (# of present LPS lamps) x (1/lamp life) x (cost/lamp)]
x (operating hrs. per year per lamp)
= [(7 lamps) x (lamp/2,000 hrs.) x ($ 3.00/lamp)
- (7 lamps) x (lamp/10,000 hrs.) x ($27.00/lamp)]
x (4562.5 hrs./yr.-lamp)
= $ 38.33/yr.

(2) One-time investment cost for fixtures:

= (# of proposed LPS fixtures for lamps) x (cost per fixture)

= (7 fixtures) x ($67 /fixture)

= $469.00 .

(3) Net annual $ savings:

= (annual $ savings in energy charge) – (annual incremental cost for lamp replacement)

= ($217.26/yr.) – ($38.33/yr.)

= $178.93/yr.

CALCULATIONS (for simple payback):

Payback period = (investment cost for fixtures) ÷ (net annual $ savings)

= ($469.00) ÷ ($178.93/yr.)

= 2.62 yrs.

TYPICAL CHARACTERISITCS OF COMMON INDUSTRIAL LAMPS

Lamp Type	Availability Size Range, watts	Lamp Efficacy, lumens per watt Initial	Mean	Average Rated Life, hr
Low-pressure sodium	35 to 180	137 to 183	122 to 164	18,000
High-pressure sodium	50 to 1000	83 to 140	75 to 127	24,000
Metal halide	175 to 1000	80 to 125	62 to 92	7500 to 20,000
Mercury	50 to 1000	32 to 63	25 to 48	16,000 to 24,000+
Fluorescent	40 to 215	74 to 100	49 to 88	12,000 to 20,000+
Incandescent	60 to 1500	15 to 24	14 to 23	750 to 4000

1. Efficacy and life rating ranges are given over the range of sizes in which lamps are offered. In general (but not necessarily for all lamp types), higher-wattage lamps have higher initial efficacy and lower mean efficacies than lower-wattage lamps, specific lamp color (clear, phosphored, or diffuse) also affects efficacy. High-wattage lamps usually have shorter life than low-wattage lamps, but some low-wattage HID lamps have shorter life than their mid-sized counterparts. Extended-life incandescent lamps typically have lower efficacies than standard (750 hr) lamps.

2. Initial efficacy is usually considered to be the efficacy after a 100 hr burning-in period. Mean efficacy is the mean efficacy over the rated life of the lamp.

3. Rated life is based on the point at which 50 percent of the lamps in a representative sample can be expected to have failed.

4. Life ratings given for high-pressure sodium lamps are for standard lamps operated on HPS ballasts. Interchangeable (retrofit) lamps have life ratings ranging from 12,000 to 18,000 hr.

The selection of light source should never be based on a single factor such as high efficacy, long life, or low lamp and fixture cost. The luminaire in which the lamp must be applied and the room geometry affect the selection of lamp/luminaire combination that will result in the most light delivered to the work plane for the money.

Source: Plant Engineering, July 24, 1980.

ECO #

(EPIC ECO Code 61.32)

TITLE: Switching to LPS Lamps for Security Lights

EXECUTIVE SUMMARY:

The low pressure sodium (LPS) lamp is the most efficient of all the available light sources, providing up to 183 lumens/watt. However, its monochromatic yellow light has limited its application to areas where color identification is not a matter of concern. That is why the primary use of LPS lamps is currently for street and highway lighting as well as outdoor area and security lighting.

We recommend that your present security lighting systems be relamped by higher efficiency and lower wattage low pressure sodium lamps. Since LPS lamps have wider dispersement of light output, relocation of the new fixtures might improve the overall security lighting in addition to giving you the benefits of energy and dollar savings. Calculations for savings have been provided below.

REQUIRED DATA:

Given:

(1) For your present lamps for security lighting:

*Wattage/Lamp	Total Number	Lumens per Lamp	Life Per Lamp	Cost Per Lamp

(2) For your proposed LPS lamps for security lighting:

*Wattage/Fixture	Total Number	Lumens per Lamp	Life Per Lamp	Cost per Lamp	Cost per Fixture

*Ballast wattage is added to the wattage rating per lamp to get the total wattage/fixture

(3) Cost of Electricity :$ /KWH
(4) Fuel Cost Adjustment Factor Charge:$ /KWH
(5) Operating Hrs./Yr. : Hrs./Yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= (cost of electricity) + (fuel cost adjustment factor charge)
= ($ /KWH) + ($ /KWH)
= $ /KWH

(2) Savings in energy (KWH):

= [(# of present lamps) x (corresponding wattage/lamp)
- (# of proposed LPS lamps) x (corresponding wattage/fixture)]
x (operating hrs./yr.)
= [(lamp) x (watts/lamp)/1000 - (fixtures)
x (watts/fixture)/1000] x (hrs./yr.)
= KWH/yr.

(3) Savings in energy (BTUs):

= (savings in KWH/yr.) x (conversion factor)
= (KWH/yr.) x (3412 BTU/KWH)
= BTU/yr.

(4) Savings in energy charge:

= (savings in KWH/yr.) x (effective cost of electricity)
= (KWH/yr.) x ($ /KWH)
= $ /yr.

CALCULATIONS (for implementation cost):

(1) Annual incremental cost for lamp replacement:

= [(# of proposed lamps) x (1/lamp life) x (cost/lamp)
- (# of present LPS lamps) x (1/lamp life) x (cost/lamp)]
x (operating nrs. per year per lamp)
= [(lamps) x (lamp/ hrs.) x ($ /lamp)
- (lamps) x (lamp/ hrs.) x ($ /lamp)]
x (hrs./yr.-lamp)
= $ /yr.

(2) One-time investment cost for fixtures:

= (# of proposed LPS fixtures for lamps) x (cost per fixture)

= (fixtures) x ($ /fixture)

= $.

(3) Net annual $ savings:

= (annual $ savings in energy charge) – (annual incremental cost for lamp replacement)

= ($ /yr.) - ($ /yr.)

= $ /yr.

CALCULATIONS (for simple payback):

Payback period = (investment cost for fixtures) ÷ (net annual $ savings)

= ($) ÷ ($ /yr.)

= yrs.

TYPICAL CHARACTERISITCS OF COMMON INDUSTRIAL LAMPS

Lamp Type	Availability Size Range, watts	Lamp Efficacy, lumens per watt Initial	Mean	Average Rated Life, hr
Low-pressure sodium	35 to 180	137 to 183	122 to 164	18,000
High-pressure sodium	50 to 1000	83 to 140	75 to 127	24,000
Metal halide	175 to 1000	80 to 125	62 to 92	7500 to 20,000
Mercury	50 to 1000	32 to 63	25 to 48	16,000 to 24,000+
Fluorescent	40 to 215	74 to 100	49 to 88	12,000 to 20,000+
Incandescent	60 to 1500	15 to 24	14 to 23	750 to 4000

1. Efficacy and life rating ranges are given over the range of sizes in which lamps are offered. In general (but not necessarily for all lamp types), higher-wattage lamps have higher initial efficacy and lower mean efficacies than lower-wattage lamps; specific lamp color (clear, phosphored, or diffuse) also affects efficacy. High-wattage lamps usually have shorter life than low-wattage lamps, but some low-wattage HID lamps have shorter life than their mid-sized counterparts. Extended-life incandescent lamps typically have lower efficacies than standard (750 hr) lamps.

2. Initial efficacy is usually considered to be the efficacy after a 100 hr burning-in period. Mean efficacy is the mean efficacy over the rated life of the lamp.

3. Rated life is based on the point at which 50 percent of the lamps in a representative sample can be expected to have failed.

4. Life ratings given for high-pressure sodium lamps are for standard lamps operated on HPS ballasts. Interchangeable (retrofit) lamps have life ratings ranging from 12,000 to 18,000 hr.

The selection of light source should never be based on a single factor such as high efficacy, long life, or low lamp and fixture cost. The luminaire in which the lamp must be applied and the room geometry affect the selection of lamp/luminaire combination that will result in the most light delivered to the work plane for the money.

Source: Plant Engineering, July 24, 1980.

Instruction Sheet for ECO #12

Title: Use higher efficiency, lower wattage fluorescent lamps in existing fixtures

How to use this ECO format?

In the example calculations for this ECO format, the information for the required data has been taken from the EADC audit report prepared for Labarge Steel, Tulsa, Oklahoma.

In this example, all calculations are self-explanatory.

ECO # 12

EPIC CODE # 61.31

TITLE: Use higher efficiency, lower wattage fluorescent lamps in existing fixtures.

EXECUTIVE SUMMARY:

Energy efficient fluorescent bulbs are available as replacements for the standard bulbs. They consume considerably less energy but yield approximately the same light levels. The energy efficient lamps are direct replacements and need no modification or adjustments in their fixtures. This ECO can be easily implemented by replacing your regular fluorescent lamps at the end of their life by their equivalent energy efficient ones. The incremental cost of buying the new ones are not at all high but the savings in energy and dollars are quite attractive. The payback period is short.

REQUIRED DATA:

Given:

(1) For your present system of regular fluorescent lighting:

Present Types of Lamps

	F40CW (40 watts)	F96/T12/CW (75 watts)
Total Number	200	184
Life	20,000 hrs	20,000 hrs
Lumen/lamp	lumens/lamp	lumens/lamp
Cost/lamp	$ 1.20/lamp	$ 2.90/lamp

(2) For the proposed system of energy efficient fluorescent lighting:

Proposed Types of Lamps

	F40/CW/RS/SS (35 watts)	F96/T12/CW/SS (60 watts)
Total Number	200	184
Life	20,000 hrs	20,000 hrs
Lumen/lamp	lumens/lamp	lumens/lamp
Cost/lamp	$ 1.60/lamp	$ 3.10/lamp

(3) Cost of electricity :$ 0.050235/KWH

(4) Demand charge :$ 2.39 /KW-month

(5) Fuel cost adjustment factor charge:$0.006455/KWH

(6) Operating hrs./yr. : 2750 Hrs./yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= KWH consumption charge + fuel cost adjustment factor charge

= ($0.050235/KWH) + ($0.006455/KWH)
= $0.05669/KWH

(2) Savings in energy charge:

= [(# of 40 watts lamps) x (Their corresponding KW savings) + (# of 75 watts lamps) x (Their corresponding KW savings)] x (operating hrs./yr.) x (effective cost of electricity)

= $[(200) \times (\frac{40 - 35}{1000}) + (184) \times (\frac{75 - 60}{1000})]$ x (2750 hrs./yr.) x ($0.05669/KWH)

= $586.17 /yr.

(3) Savings in demand charge:

= [(# of 40 watts lamps) x (Their corresponding KW demand savings) + (# of 75 watts lamps) x (Their corresponding KW demand savings)] x (Monthly demand charge) x (Conversion factor)

= $[(200) \times (\frac{40 - 35}{1000}) + (184) \times (\frac{75 - 60}{1000})]$ x ($2.39 /KW-month) x (12 months/yr.)

= $17.97 /yr.)

(4) Total $ savings:

= (savings in energy charge/yr.) + (savings in demand charge/yr.)
= ($586.17/yr.) + ($17.97 /yr.)
= $604.14/yr.

(5) Savings in KWH:

= ($ savings in energy charge) ÷ (effective cost of electricity)
= ($586.17/yr.) ÷ ($0.05669/KWH)
= 10339.9 KWH/yr.

(6) Savings in BTUs:

= (KWH savings/yr.) x (conversion factor)
= (10339.9 KWH/yr.) x (3412 BTU/KWH)
= 35.3×10^{6} BTU/yr.

CALCULATIONS (for implementation cost):

(1) The implementation cost for this ECO is based on incremental cost basis. Your purchasing department can take care of this by ordering energy efficient lamps instead of the regular fluorescent ones as your existing bulbs fail and need replacement.

(2) Total incremental cost of replacement:

= (# of 35 watts lamps) x (Their incremental cost of purchasing) + (# of 60 watts lamps) x (Their incremental cost of purchasing)

= (200 lamps) x (\$1.60/lamp - \$1.20/lamp) + (184 lamps) x (\$3.10/lamp - \$2.90/lamp)

= \$116.80

CALCULATIONS (for simple payback):

Payback period = Total incremental cost of replacement / Total \$ savings/yr.

= 116.80/604.14

= 0.19 yrs.

= 2.3 months.

ECO #

EPIC CODE # 61.31

TITLE: Use higher efficiency, lower wattage fluorescent lamps in existing fixtures.

EXECUTIVE SUMMARY:

Energy efficient fluorescent bulbs are available as replacements for the standard bulbs. They consume considerably less energy but yield approximately the same light levels. The energy efficient lamps are direct replacements and need no modification or adjustments in their fixtures. This ECO can be easily implemented by replacing your regular fluorescent lamps at the end of their life by their equivalent energy efficient ones. The incremental cost of buying the new ones are not at all high but the savings in energy and dollars are quite attractive. The payback period is short.

REQUIRED DATA:

Given:
(1) For your present system of regular fluorescent lighting:

Present Types of Lamps

	F40CW (60 watts)	F96/T12/CW (75 watts)
Total Number		
Life	hrs	hrs
Lumen/lamp	lumens/lamp	lumens/lamp
Cost/lamp	$ /lamp	$ /lamp

(2) For the proposed system of energy efficient fluorescent lighting:

Proposed Types of Lamps

	F40/CW/RS/SS (35 watts)	F96/T12/CW/SS (60 watts)
Total Number		
Life	hrs	hrs
Lumen/lamp	lumens/lamp	lumens/lamp
Cost/lamp	$ /lamp	$ /lamp

(3) Cost of electricity :$ /KWH
(4) Demand charge :$ /KW-month
(5) Fuel cost adjustment factor charge:$ /KWH
(6) Operating hrs./yr. : Hrs./yr.

CALCULATIONS (for energy and $ savings):

(1) Effective cost of electricity:

= KWH consumption charge + fuel cost adjustment factor charge

= ($ /KWH) + ($ /KWH)

= $ /KWH

(2) Savings in energy charge:

= [(# of watts lamps) x (Their corresponding KW savings) + (# of watts lamps) x (Their corresponding KW savings)] x (operating hrs./yr.) x (effective cost of electricity)

$$= [(\quad) \times (\frac{\quad - \quad}{1000}) + (\quad) \times (\frac{\quad - \quad}{1000})]$$

x (hrs./yr.) x ($ /KWH)

= $ /yr.

(3) Savings in demand charge:

= [(# of watts lamps) x (Their corresponding KW demand savings) + (# of watts lamps) x (Their corresponding KW demand savings)] x (Monthly demand charge) x (Conversion factor)

$$= [(\quad) \times (\frac{\quad - \quad}{1000}) + (\quad) \times (\frac{\quad - \quad}{1000})]$$

x ($ /KW-month) x (12 months/yr.)

= $ /yr.)

(4) Total $ savings:

= (savings in energy charge/yr.) + (savings in demand charge/yr.)

= ($ /yr.) + ($ /yr.)

= $ /yr.

(5) Savings in KWH:

= ($ savings in energy charge) ÷ (effective cost of electricity)

= ($ /yr.) ÷ ($ /KWH)

= KWH/yr.

(6) Savings in BTUs:

= (KWH savings/yr.) x (conversion factor)

= (KWH/yr.) x (3412 BTU/KWH)

= BTU/yr.

CALCULATIONS (for implementation cost):

(1) The implementation cost for this ECO is based on incremental cost basis. Your purchasing department can take care of this by ordering energy efficient lamps instead of the regular fluorescent ones as your existing bulbs fail and need replacement.

(2) Total incremental cost of replacement:

= (# of watts lamps) x (Their incremental cost of purchasing) + (# of watts lamps) x (Their incremental cost of purchasing)

= (lamps) x ($ /lamp - $ /lamp) +
(lamps) x ($ /lamp - $ /lamp)

= $

CALCULATIONS (for simple payback):

$$\text{Payback period} = \frac{\text{Total incremental cost of replacement}}{\text{Total \$ savings/yr.}}$$

=

= yrs.

Instruction Sheet for ECO #13

Title: Recover and reuse cooling water

How to use this ECO format?

In this example calculations for this ECO form, the information for the required data have been taken from the EADC audit report (Report #B14) prepared for Adams-Millis Corporation, Edmond, Oklahoma.

In general cooling water discharged from any system (like an air compressor) can be recovered and reused. The double attraction for such a conservation technique is the fact that if some process (like dye operation) is using city water at normal temperature, (usually cooler than cooling water discharged from any system) it can be replaced by cooling water after some in-house treatment thereby eliminating or reducing the requirements for water and gas consumption.

In the example calculation, the source of cooling water is the air compressor whose discharge rate is 8208 gallons/day at a steady state temperature of 90°F. In the same plant they were using city water at an average temperature of 55°F at the rate of 3960 gallons per day for the dye operation process water requirement. In such a situation the recommended waste heat recovery technique in addition to Water Conservation is really a "good resource management".

Most of the steps in the example calculation are self-explanatory and therefore need not be explained.

ECO # 13

EPIC ECO CODE 33.31

TITLE: Recover and reuse cooling water

EXECUTIVE SUMMARY:

Recovering and reusing cooling water discharge for some other heating process is an example of waste heat recovery. For your present system of dye operation, calculations have been made to show how you can take advantage of the waste heat contained in the cooling water discharge by reusing it after in-house treatment for the purpose of dying operation in place of city water. This could result in savings in heating energy required to raise the temperature of the city water to the temperature required for the dying operation process water. Moreover, this would cut down the cost of water because the same cooling water is reused and also it would reduce sanitary sewer cost.

REQUIRED DATA:

Given:

(1)	Cooling water discharge rate	: 8208 gals./day
(2)	Temperature of discharge	: 102°F
(3)	Steady state discharge temperature (assumed)	: 90°F
(4)	Dye operation process water requirement	: 3960 gals./day
(5)	Average city water temperature	: 55°F
(6)	Cost of water	:$ 0.60/1000 gal.
(7)	Cost of sanitary sewer	:$ 0.30/1000 gal.
(8)	Firing unit efficiency (assumed)	: 70%
(9)	Days of operation/yr.	: 250 days/yr.
(10)	Natural gas cost	:$ 2.597/MCF
(11)	Length of pipe work	: 50 ft. (1" dia.)

CALCULATIONS (for savings in energy and $):

(1) Savings in energy consumption:

= (rate of water reused/day) x (days of operation/yr.) x (8.32 lbm/gal.) x (1 BTU/lbm °F) x (steady state cooling water discharge temperature - average city water temperature)

= (3960 gals./day) x (250 days/yr.) x (8.32 lbm/gal.) x (1 BTU/lbm °F) x (90°F - 55°F)

= 288.3×10^6 BTU/yr.

(2) Savings in gas consumption:

= (savings in energy consumption) x (1 MCF of natural gas/ 10^6 BTU) x (1/firing unit efficiency)

= (2883×10^6 BTU/yr.) x (1 MCF/10^6 BTU) x (1/0.70)

= 411.86 MCF/yr.

(3) Savings in water consumption:

= (rate of water reused/day) x (days of operation/yr.)

= (3960 gals./day) x (250 days/yr.)

= 990,000 gals./yr.

(4) Savings in $ (for energy):

= (savings in gas consumption) x (gas cost)

= (411.86 MCF/yr.) x ($2.597/MCF)

= $1069.6/yr.

(5) Savings in $ (for water):

= (savings in water consumption) x (water cost)

= (990000 gals./yr.) x ($ 0.60 /1000 gal.)

= $ 594 /yr.

(6) Savings in $ (for sanitary sewer):

= (rate of process water consumption) x (cost of sanitary sewer)

= (990000 gals./yr.) x ($ 0.30 /1000 gal.)

= $ 297 /yr.

(7) Total annual $ savings:

= ($ savings for energy) + ($ savings for water) + ($ savings for sewer)

= $ 1069.60 + $ 594.00 + $ 297.00

= $1960.60/yr.

CALCULATIONS (for implementation cost):

(1) Since the cooling water discharge is through one inch pipe, a total of 50 ft. of one inch pipe would be required to bring it to the location needed at a cost of $ 200.00 @ $ 4.00 /linear ft.

(2) Assume an installation cost of $ 200.00 together with some miscellaneous items like limit switch control etc.

(3) Total cost of implementation:

= Sum of the above costs
= (\$ 200) + (\$ 200)
= \$ 400.00

CALCULATIONS (for simple payback):

Payback period = (total cost) ÷ (total annual \$ savings)
= (\$ 400.00) ÷ (\$1960.6 /yr.)
= 0.20 yrs.
= 2.4 months.

ECO #

EPIC ECO CODE 33.31

TITLE: Recover and reuse cooling water

EXECUTIVE SUMMARY:

Recovering and reusing cooling water discharge for some other heating process is an example of waste heat recovery. For your present system of , calculations have been made to show how you can take advantage of the waste heat contained in the cooling water discharge by reusing it for the purpose of in place of city water. This could result in savings in heating energy required to raise the temperature of the city water to the temperature required for the operation process water. Moreover, this would cut down the cost of water because the same cooling water is reused and also it would reduce sanitary sewer cost.

REQUIRED DATA:

Given:

(1)	Cooling water discharge rate	:	gals./day
(2)	Temperature of discharge	:	°F
(3)	Steady state discharge temperature (assumed)	:	°F
(4)	process water requirement	:	gals./day
(5)	Average city water temperature	:	°F
(6)	Cost of water	:$	/1000 gal.
(7)	Cost of sanitary sewer	:$	/1000 gal.
(8)	Firing unit efficiency (assumed)	:	%
(9)	Days of operation/yr.	:	days/yr.
(10)	Natural gas cost	:$	/MCF
(11)	Length of pipe work	:	ft.

CALCULATIONS (for savings in energy and $):

(1) Savings in energy consumption:

= (rate of water reused/day) x (days of operation/yr.) x (8.32 lbm/gal.) x (1 BTU/lbm °F) x (steady state cooling water discharge temperature - average city water temperature)

= (gals./day) x (days/yr.) x (8.32 lbm/gal.) x (1 BTU/lbm °F) x (°F- °F)

= BTU/yr.

(2) Savings in gas consumption:

= (savings in energy consumption) x (1 MCF of natural gas/ 10^6 BTU) x (1/firing unit efficiency)

= (BTU/yr.) x (1 MCF/10^6 BTU) x (1/)

= MCF/yr.

(3) Savings in water consumption:

= (rate of water reused/day) x (days of operation/yr.)

= (gals./day) x (days/yr.)

= gals./yr.

(4) Savings in $ (for energy):

= (savings in gas consumption) x (gas cost)

= (MCF/yr.) x ($ /MCF)

= $ /yr.

(5) Savings in $ (for water):

= (savings in water consumption) x (water cost)

= (gals./yr.) x ($ /1000 gal.)

= $ /yr.

(6) Savings in $ (for sanitary sewer):

= (rate of process water consumption) x (cost of sanitary sewer)

= (gals./yr.) x ($ /1000 gal.)

= $ /yr.

(7) Total annual $ savings:

= ($ savings for energy) + ($ savings for water) + ($ savings for sewer)

= $ + $ + $

= $ /yr.

CALCULATIONS (for implementation cost):

(1) Since the cooling water discharge is through inch pipe, a total of ft. of inch pipe would be required to bring it to the location needed at a cost of $ @ $ /linear ft.

(2) Assume an installation cost of $ together with some miscellaneous items like limit switch control etc.

(3) Total cost of implementation:

= Sum of the above costs

= ($) + ($)

= $

CALCULATIONS (for simple payback):

Payback period = (total cost) ÷ (total annual $ savings)

= ($) ÷ ($ /yr.)

= yrs.

INSTRUCTION SHEET FOR ECO #14

Title: Install Insulation On condensate return Lines

<u>How To Use This ECO Format</u>

In the example calculations for this ECO attached herewith, the set of relevant data were picked up from the EADC audit report (report #C15) prepared for Musingwear, Inc., Pawnee, Oklahoma.

For this ECO format it is to be noted that it has flexibility and can also be used for ECOs other than "Installing Insulation on Condensate Return Lines". As for example, it can also be used for ECOs like "Installing Insulation On Any Bare Line Carrying Hot or Cold Fluids".

The abscissa of Figure 1 gives both the saturation pressure and temperature of the fluid in the base line (in psig and degree Fahrenheit, respectively). The ordinate gives the corresponding amount of heat loss in million BTU/yr per 100 feet of bare line. The different curves are for different pipe sizes.

In the example calculation the fluid is steam; however, the fluid could have been any hot fluid.

ECO # 14

EPIC ECO CODE 21.23

TITLE: Install insulation on condensate return lines.

EXECUTIVE SUMMARY:

Thermal insulation plays a key role in the overall energy management picture. In fact, the use of insulation is mandatory for the efficient operation of any hot or cold system. Most insulation systems reduce the unwanted heat transfer, either loss or gain, by at least 90% as compared to bare surfaces.

For your present system of condensate return lines, there are approximately 200 ft. of uninsulated lines. Insulation of these lines will prevent unwanted heat loss to the environment. This will also minimize a drop down in the temperature of the fluid in the line.

REQUIRED DATA:

<u>Given/Measured:</u>

(1)	Total length of bare lines	: 200 ft.
(2)	Size (diameter) of the bare lines	: 1.5 inch
(3)	Temperature of the fluid	: 280 °F
(4)	Corresponding saturation pressure of: the fluid (if necessary)	: 34.5 psig
(5)	Hours of operation	: 1000 hrs./yr.
(6)	Cost of gas	:$ 2.39 /MCF

CALCULATIONS (for energy and $ savings):

(1) For your present system of bare condensate return lines, the fluid at a saturation pressure of 34.5 psig (corresponding to a temperature of 280°F) in the carrier pipe of 1.5 inch diameter, Fig. (1) shows a heat loss of 0.38×10^6 BTU/yr. per 100 ft. of bare line.

(2) Present resistance heat loss without insulation:

$$= (\text{heat loss/yr. read from graph}) \times (\text{linear ft. of return line/100 ft.}) \times \frac{(\text{hours of operation/yr.})}{24 \times 365 \text{ hrs./yr.}}$$

= (.38×10^6 BTU/yr.) x (200 ft/100 ft.)
x (1000 hrs./yr.)/(8760 hrs./yr.)
= 8 7 x 10^6 BTU/yr.

(3) Assume 85 % reduction in heat loss after insulation.

(4) Proposed resistance heat loss with insulation:

= (reduced fraction of the total heat loss) x (total heat loss without insulation)

$= \frac{(100 - 85\%)}{100} \times (8.7 \times 10^6 \text{ BTU/yr.})$

$= 1.31 \times 10^6$ BTU/yr.

(5) Now annual savings in heat (BTUs):

= (total heat loss/yr. without insulation) – (reduced fraction of total heat loss per year with insulation)

$= (8.7 \times 10^6$ BTU/yr.) - $(1.31 \times 10^6$ BTU/yr.)

$= 7.39 \times 10^6$ BTU/yr.

(6) Assume firing unit efficiency as 70 %.

(7) Then the annual savings in natural gas consumption:

= (annual savings in BTU) x (100/firing unit efficiency) x (conversion factor)

$= (7.39 \times 10^6$ BTU/yr.) x (100%/70%) x (1 MCF/10^6 BTU)

= 105.60 MCF of natural gas/yr.

(8) Annual savings in \$:

= (annual savings in natural gas) x (gas cost)

= (105.6 MCF/yr.) x (\$ 2.39 /MCF)

= \$252.4/yr.

CALCULATIONS (for implementation cost):

(1) The cost of insulating material at the rate of approximately \$ 2.50/ft. would be \$ 500 for a pipe size of 1.5 inch.

(2) Labor cost may be estimated to be approximately \$100 .

(3) Total cost of investment:

= (material cost) + (labor cost)

= \$ 500 + \$100

= \$ 600.00

CALCULATIONS (for simple payback):

Payback = (total cost) ÷ (annual \$ savings)

= (\$600) ÷ (\$ 252.4/yr.)

= 2.37 yr.

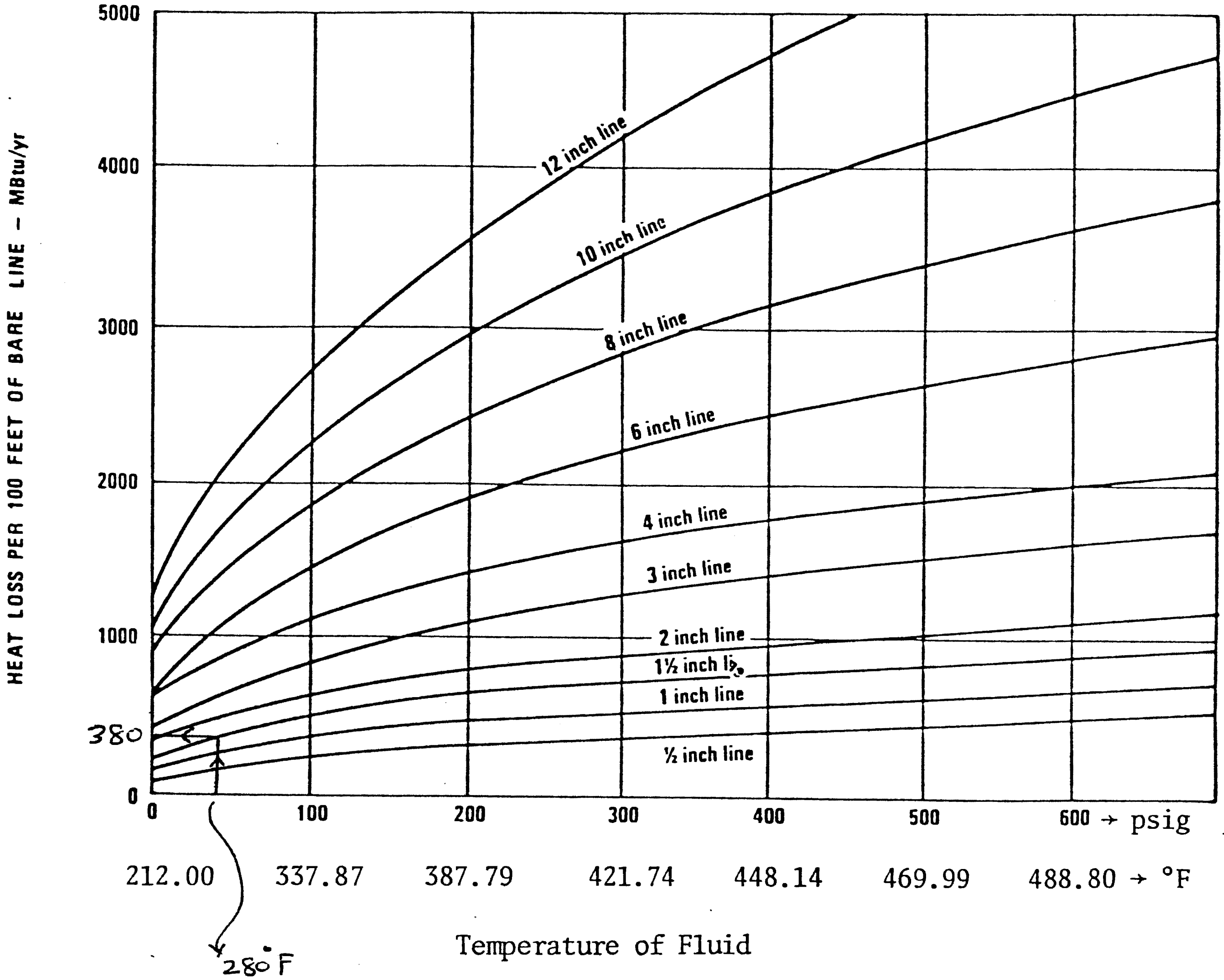

Figure 1 – Heat Loss From Bare Lines
(Based on data from the reference)

ECO #

EPIC ECO CODE 21.23

TITLE: Install insulation on lines.

EXECUTIVE SUMMARY:

Thermal insulation plays a key role in the overall energy management picture. In fact, the use of insulation is mandatory for the efficient operation of any hot or cold system. Most insulation systems reduce the unwanted heat transfer, either loss or gain, by at least 90% as compared to bare surfaces.

For your present system of lines, there are approximately ft. of uninsulated lines. Insulation of these lines will prevent unwanted heat loss to the environment. This will also minimize a drop down in the temperature of the fluid in the line.

REQUIRED DATA:

Given/Measured:

(1) Total length of bare lines	:	ft.
(2) Size (diameter) of the bare lines	:	inch
(3) Temperature of the fluid	:	°F
(4) Corresponding saturation pressure of: the fluid (if necessary)	:	psig
(5) Hours of operation	:	hrs./yr.
(6) Cost of gas	:$	/MCF

CALCULATIONS (for energy and $ savings):

(1) For your present system of bare lines, the fluid at a saturation pressure of psig (corresponding to a temperature of °F) in the carrier pipe of inch diameter, Fig. (1) shows a heat loss of BTU/yr. per 100 ft. of bare line.

(2) Present resistance heat loss without insulation:

$$= (\text{heat loss/yr. read from graph}) \times (\text{linear ft. of return line/100 ft.}) \times \frac{(\text{hours of operation/yr.})}{24 \times 365 \text{ hrs./yr.}}$$

= (BTU/yr.) x (ft/100 ft.) x (hrs./yr.)/(8760 hrs./yr.)

= BTU/yr.

(3) Assume % reduction in heat loss after insulation.

(4) Proposed resistance heat loss with insulation:

= (reduced fraction of the total heat loss) x (total heat loss without insulation)

= $\frac{(100 - \quad \%)}{100}$ x (BTU/yr.)

= BTU/yr.

(5) Now annual savings in heat (BTUs):

= (total heat loss/yr. without insulation)
- (reduced fraction of total heat loss per year with insulation)

= (BTU/yr.) - (BTU/yr.)

= BTU/yr.

(6) Assume firing unit efficiency as %.

(7) Then the annual savings in natural gas consumption:

= (annual savings in BTU) x (100/firing unit efficiency) x (conversion factor)

= (BTU/yr.) x (100%/ %) x (1 MCF/10^6 BTU)

= MCF of natural gas/yr.

(8) Annual savings in $:

= (annual savings in natural gas) x (gas cost)

= (MCF/yr.) x ($ /MCF)

= $ /yr.

CALCULATIONS (for implementation cost):

(1) The cost of insulating material at the rate of approximately $ /ft. would be $ for a pipe size of inch.

(2) Labor cost may be estimated to be approximately $.

(3) Total cost of investment:

= (material cost) + (labor cost)

= $ + $

= $

CALCULATIONS (for simple payback):

Payback = (total cost) ÷ (annual $ savings)

= ($) ÷ ($ /yr.)

= yr.

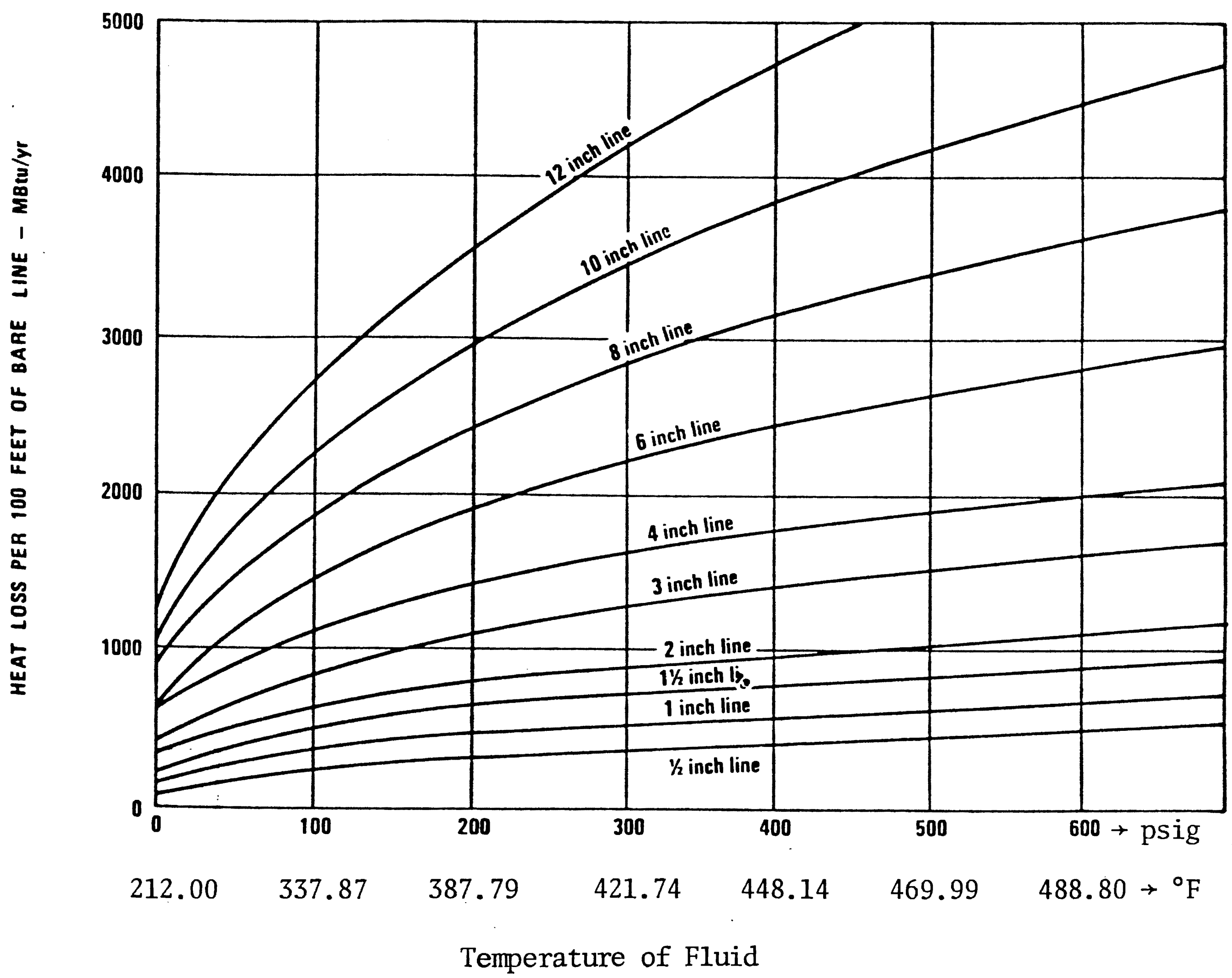

Figure 1 – Heat Loss From Bare Lines
(Based on data from the reference)

Further Research

This "Energy Management Opportunities Calculation Manual" explains the use and design of standardized ECO formats. This work is not an end itself rather it opens the avenue for more research. More ECOs can be standardized based on the same or even an improved pattern.

As a matter of fact, the standard ECO forms designed in this Manual can be better standardized through computerization. Programs can be written to make the computers do the energy calculations for the user in addition to giving the printouts of the ECO forms thereby reducing a number of steps which would further save time. These computer printouts can directly go to EADC Energy Audit Reports giving them a more professional look. Some other research that needs to be done related to this topic are listed as follows:

(1) Compiling a comprehensive list of Energy Management Opportunites which are more attractive in terms of Btu savings but less attractive in terms of $ savings and vice versa.

(2) Compiling a comprehensive list of Energy Management Opportunites which are quite attractive in terms of Btu and/or $ savings but less or not attractive in terms of payback period. Also list the reasons and factors that could change the scenerio. For example, switching to High Pressure Sodium lighting can be easily justified with two or more shifts of operations but it is difficult to justify with one shift.

(3) Compiling a list of ECOs which have been proven to be economically justifiable in about all the cases.

(4) Use of computer simulation technology to identify the best alternative among a possible combination of ECOs.

(5) Some standardization of Btu Accounting Techniques in a similar fashion.

(6) More and better use of computer graphics in this area.

(7) Incorporating of more rigorous methods of engineering economic analysis for ECOs.

Summary

As energy costs continue to escalate, rewards for saving energy will escalate, too. Now the days of simply worrying about materials and labor are over. Energy has become the third dimension.

Energy Conservation Opportunities (ECOs) are numerous but it is important that they first be identified and then justified economically combined with other considerations in order to make it suitable for a particular situation. The intent of this EMO Calculation Manual is to show:

(1) How energy calculations are made for economic justification of ECOs.

(2) How ECO formats can be standardized for other ECOs.

APPENDIX

Appendix.

DIRECTORY OF INDUSTRIAL ENERGY CONSERVATION OPPORTUNITIES

DIECO

Prepared under the Energy Analysis and Diagnostic Center program for the Department of Energy under Contract No. DE-AC-01-78CS-40091.

by

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FOREWORD

This Directory has been assembled to systematize the collection, computerized storage, and analysis of energy conservation opportunities (ECOs) for the Energy Analysis and Diagnostic Center (EADC) program.

Many of listed ECOs are drawn from NBS Handbook 115 (September, 1974) and Handbook 115 Supplement 1 (December, 1975), Energy Conservation Program Guide for Industry and Commerce (EPIC), produced by the National Bureau of Standards. Other ECOs have been added by the staff of the Center for Energy Management and Economic Development to reflect experience gained under the EADC program since its inception in 1976.

The DIECO system is intended to group ECOs logically for easy reference and access, minimize redundant ECO listings, organize ECOs hierarchically to allow data analysis at several levels of detail, and cross-reference similar ECOs which may refer to different areas of industrial energy usage.

DIRECTORY OF INDUSTRIAL ENERGY CONSERVATION OPPORTUNITIES

PREFACE

Energy Conservation Opportunities (ECOs) are organized into major groups, subgroups, and ECO type. Each major group is labeled with a two-digit number, ending in zero; each subgroup is also labeled with a two-digit number, beginning with the same digit as the associated major group. Each ECO type carries a four-digit number, of which the first two are the same as the code of the associated subgroup, and the fourth is a zero. Each ECO listed is labeled with a four-digit code, of which the first three are the same as the first three digits of the associated ECO type. The four-digit ECO code represents the major group (first digit), subgroup (second digit), and ECO type (third digit) under which the ECO is classified. For example,

Major group:		10 Combustion
Subgroup	:	13 Combustion Heat Recovery
ECO Type	:	13.10 Heat recovery from flue gases for boiler operations
ECO	:	13.11 Use waste heat from hot flue gases to preheat combustion air

TABLE OF CONTENTS

10 Combustion

See 53.10 for process combustion equipment ECOs

11 Equipment Efficiency: Operational

11.10 Boiler air/fuel ratio controls

11.11 Adjust (tune) burners for optimal air/fuel ratio

11.12 Monitor boiler efficiency and improve control capability; or add automatic (O_2-trim) controls

11.20 Warmest air for combustion air

11.21 Use warmest room air for combustion air

11.22 Preheat combustion air with waste process heat

11.23 Preheat boiler makeup water with exchange from waste process heat

11.30 Fuel atomization improvements

11.31 Heat oil to proper temperature for good atomization

11.32 Use air instead of steam for oil atomization

11.40 Miscellaneous boiler efficiency improvements

11.41 Install turbulator

11.42 Minimize boiler blowdown with better feedwater treatment

12 Equipment Maintenance and Replacement

12.10 Boiler Maintenance

12.11 Establish burner maintenance schedule

12.12 Keep boiler tubes clean, both fireside and waterside

12.20 Replace and upgrade equipment
(see also 90. - Alternate Fuels)

12.21 Replace obsolete burners with more efficient ones

12.22 Replace obsolete boiler

13 Combustion Heat Recovery (See also 53, changes to ovens, kilns, and furnaces; and 54, Process heat recovery)

13.10 Heat recovery from flue gases for boiler operations

13.11 Use waste heat from hot flue gases to preheat combustion air

13.12 Use waste heat from hot flue gases to preheat boiler feed water

13.13 Use waste heat from hot flue gases to preheat wastes for incinerator

13.20 Heat recovery from flue gases for process heat
(See also 90 - Alternate Fuels)

13.21 Install waste heat boiler to provide direct shaft power (See also 92.31)

13.22 Install waste heat boiler for process steam, or consider selling excess steam

13.23 Use waste heat from hot flue gases to preheat products or materials going into oven, dryers, etc.

13.24 Use waste heat from hot flue gases to heat process or service hot water

13.30 Heat recovery from flue gases for HVAC

13.31 Install waste heat boiler to produce steam for space heating

13.32 Recover heat from hot flue gases for space heating

13.40 Boiler blowdown heat recovery

13.41 Recover heat from boiler blowdown to preheat boiler feed water

<u>14 Combustion Heat Confinement</u> (See also 53.10)

14.10 Insulation of boilers, burners, etc.

14.11 Repair faulty insulation in boilers, furnaces, etc.

14.12 Install boiler insulation, or upgrade to optimal thickness

14.13 Use soft insulation in cycling furnaces to facilitate heating up and cooling down

14.20 Furnace openings

14.21 Reduce size of charging openings, slots, doors, etc., or add a movable cover or door

14.22 Repair furnace and oven doors so that they seal efficiently

14.23 Install automatic stack damper

20 Steam

21 Steam System Equipment Upgrade/Repair

21.10 Steam trap upgrading/repair

21.11 Install steam traps

21.12 Use correct size steam traps

21.13 Repair or replace faulty or leaky steam traps

21.14 Shut off steam traps on superheated steam lines when not in use

21.20 Condensate return system
(See also 22.20)

21.21 Increase amount of condensate returned; e.g., increase pressure, repair leaks, etc.

21.22 Cover condensate storage tanks

21.23 Install, upgrade, or repair insulation on condensate lines

21.30 Steam lines and distribution systems

21.31 Install, upgrade or repair insulation on steam lines

21.40 Steam system leaks

21.41 Repair and eliminate leaks in steam lines and valves

21.42 Repair and eliminate steam leaks at high-pressure reducing stations

21.43 Repair and eliminate steam leaks at process equipment

22 Steam System Changes (See also 50 - Process Equipment and changes)

22.10 Steam distillation
(See also 53.50, 54.25)

22.11 Operate distillation columns at minimum quality requirements

22.12 Operate distillation columns near flooding conditions for maximum separation efficiency

22.13 Determine correct feed plate locations on distillation columns to increase efficiency and minimize steam consumption

22.14 Consider switching selected steam stripping distillation units from direct (live) steam to indirect (dry) stripping

22.15 Use reflux ratio control or similar control instead of flow control on distillation towers

22.16 Add steam traps to a distillation tower to reduce the reflux ratio (See also 53.50, 54.25)

22.20 Use of steam condensate

22.21 Return steam condensate to boiler plant

22.22 Flash condensate to produce lower-pressure steam

22.23 Use steam condensate for non-potable hot water supply

22.30 Steam distribution system and tracing

22.31 Use minimum necessary operating steam pressure

22.32 Substitute hot process water or other fluids for steam

22.33 Turn off steam tracing during mild weather

22.34 Use heat exchange fluids instead of steam in pipeline tracing systems

22.40 Miscellaneous steam system improvements

22.41 Use surface condensate in place of barometric condenser

22.42 Clean steam coils in processing tanks

22.43 Maintain steam jets used for vacuum system

22.44 Optimize operation of multi-stage vacuum steam jets

30 Other Utilities

31 Electricity

31.10 **Demand charge reduction**
(See 41.40 for rescheduling to avoid peaks)

31.11 Optimize plant power factors

31.12 Install demand controller/load shedder

31.13 Install power factor controllers on motors

31.20 **Reduction in other electric utility charges**

31.21 De-energize excess transformer capacity to avoid utility charges

31.22 Check accuracy of power meter

31.23 Restructure rate schedules

31.30 **Motors: electrical use efficiency**

31.31 Optimize motor size with load; size motors for peak operating efficiency

31.32 Use multiple-speed motors or variable-speed drives for variable pump, blower, and compressor loads

31.40 **Transformers, conductors, and other electricity-handling equipment**

31.41 Reduce load on electric conductors to reduce heat losses

31.42 Increase electrical conductor size to reduce distribution losses

31.43 Consider power loss as well as initial loads and growth in sizing transformers

32 Compressed Air

32.10 **Reductions in use of compressed air**

32.11 Reduce the pressure of compressed air system to the minimum required

32.12 Shut off cooling when outside air will cool process streams/equipment

32.13 Reduce use of compressed air to minimum for cooling product, cooling equipment, or agitating liquids

32.14 Eliminate permanently the use of compressed air for cooling product, cooling equipment, or agitating liquids; do not use for personal cooling

32.15 Replace compressed air cooling with water cooling

32.20 Coolest air to compressor intake

32.21 Install compressor air intakes in coolest locations

32.22 Use heat exchange to cool air intake to compressor

32.30 Leaks in compressed air system

32.31 Eliminate leaks in lines and valves carrying compressed air or other gases

32.32 Remove or close off unneeded compressed air lines to eliminate potential le

32.40 Miscellaneous air compressor system improvements

32.41 Install adequate dryers on air lines to eliminate blowdown (See 54.20 for heat recovery from air compressor)

33 Water

(See also 53.40)

33.10 Cooling water reduction

33.11 Use minimum cooling water to bearings, and for other process cooling

33.12 Shut off cooling water when not required

33.13 Replace water cooling of processes with ambient or outdoor air cooling where possible

33.30 Recovery of water

33.31 Recover and reuse cooling water - cooling tower, etc.

33.32 Recycle treated water

(See 54.12, 62,23 for heat recovery from hot waste water)

33.40 Water recycling operations

33.41 Use cascade system of recirculating during cold weather to avoid sub-cooling

33.42 Operate cooling towers at constant outlet temperature to avoid sub-cooling

33.43 Use lake water as a heat sink

33.50 Water leaks and distribution

33.51 Eliminate leaks in water lines and valves

33.52 Remove or close off unneeded water lines to avoid potential leaks and freezing

33.53 Use flow control valves on equipment to optimize water use

33.54 Clean fouling from water lines regularly

33.55 Minimize water use in lavatories by using appropriate fixtures and valves

33.60 Monitoring of water use

33.61 Conduct periodic audits of water meters, for early leak detection

33.62 Check for accuracy of utility meters

33.63 Meter waste water

40 Scheduling and Shipping/Handling

41 Equipment Scheduling

41.10 Equipment shutdown

41.11 Shut down process heating equipment when not in use; shut down boilers on weekends, holidays, etc.

41.12 Reduce operating time of electrical equipment to the minimum required; turn off during lunch breaks and other idle periods

41.13 Turn off conveyors when not in use

41.14 Shut down diesel construction equipment when not needed

41.20 Efficient equipment use scheduling

41.21 Use most efficient equipment at its maximum capacity and less efficient equipment only when necessary

41.22 Schedule to run equipment with full loads, use batch type drying ovens or other equipment on optimum schedule

41.23 Optimize production lot sizes and inventories

41.24 Schedule use of elevators to conserve energy

41.25 Schedule baking times of small and large components to minimize energy use

41.30 Standby equipment operation

41.31 Reduce temperature of process heating equipment when on standby

41.32 Minimize operation of equipment required to be kept in standby condition

41.33 Shut off pilot in standby boiler or other equipment

41.40 Electrical equipment scheduling
(See also 31.10,53)

41.41 Locate causes of electrical demand charges and reschedule operations to avoid peaks

41.42 Recharge batteries (fork trucks, etc.) during off-peak demand periods

41.43 Heat water during off-peak periods and store for later use

42 Plant Scheduling

42.10 Plant operation schedule changes

42.11 Consider three- or four-day 24-hour operation rather than one or two shifts per day

42.12 Consider shifting from daytime to nighttime operation

42.20 **Maintenance scheduling**

42.21 Schedule routine equipment maintenance during non-operating periods

42.22 Overlap custodial work hours with normal day hours

43 Packing, shipping, handling, and transportation

43.10 **Packaging**

43.11 Use minimum necessary packaging material

43.12 Evaluate energy use in packaging process; change to less energy-intensive procedures

43.20 **Materials Handling**

43.21 Upgrade or repair and maintain conveyors

43.22 Use gravity feed wherever possible

43.23 Consider use of bulk materials where possible

43.24 Adjust and maintain fork lift trucks for most efficient operation

43.30 **Trucking Operations**

43.31 Optimize routing of delivery trucks to minimize mileage; consolidate deliveries, reduce delivery schedules

43.32 Size truck to job; consider replacing sales and delivery fleets with intermediate or economy cars and trucks

43.33 Add air shields to long distance trucks to reduce fuel consumption

43.34 Shut off truck engines while loading, unloading, or waiting

43.35 Maintain truck engines regularly for maximum efficiency

50 Process Equipment and Process Changes

51 Equipment Maintenance, Repair, and Replacement General

51.10 Equipment replacement

51.11 Consider energy efficiency when purchasing new equipment

51.12 Upgrade obsolete or little-used equipment
(See also 31.30, electrical motors, and 92, alternate fuels)

51.20 Equipment maintenance and repair

51.21 Establish equipment maintenance schedule for process equipment
(See also 62.47 for B & G equipment)

51.22 Improve lubrication practices for motor-driven equipment

51.23 Adjust vents on process equipment to minimize energy usage

51.24 Keep outside process equipment clean to improve heat transfer

52 Operations and Process Design: General

52.10 Process design

52.11 Redesign process flow for minimum mass transfer length

52.12 Redesign process to improve heat transfer gradient

52.13 Avoid cooling process streams which subsequently must be heated and vice versa

52.14 Reduce flow rate of process fluids (e.g., drying air)
(See also 41.22,42.10)

52.15 Change product design to reduce processing energy requirements

52.16 Use optimum size and capacity equipment

52.17 Use steam sparging or injection in place of indirect heating

52.20 Operations modifications
(See also major group 40: Scheduling)

52.21 Convert from batch to continuous operation

52.22 Use small number of high-output units instead of many small inefficient units

52.23 Salvage and re-use process waste

52.24 Reduce scrap production

53 Techniques Specific to Certain Processes

53.10 Ovens, furnaces, and kilns
(See also 10, Combustion; 20, Steam; 54, Heat Recovery; 55, Heat Confinement; and 52.12)

53.11 Use minimum safe oven ventilation

53.12 Minimize nonessential material in heat treatment process

53.13 In batch firing, use kiln "furniture" designed specifically for the job

53.14 Convert from indirect to direct firing in ovens, furnaces, or kilns

53.15 Use continuous equipment which contains process heating conveyors within the heated chamber

53.16 Use direct flame impingement or infrared processing for chamber type heating

53.17 Use hot flue gases in radiant heaters for preheating air to ovens, dryers, etc.
(See also 62.26)

53.18 Use shaft type furnaces for preheating incoming material

53.19 Heat treat parts or products only to required standards

53.20 Textiles

53.21 Modify dye beck for efficiency improvement

53.22 Improve textile dryers

53.30 Refrigeration and cold storage

53.31 Use optimum thickness insulation for low temperatures

53.32 Cool smallest space necessary for refrigerated storage

53.33 Repair refrigerator door seals

53.34 Use outside air for product freezer during winter
(See 52.24 for heat recovery)

53.40 Hot water
(See also subgroup 33, water as a utility)

53.41 Reduce temperature of service or domestic hot water

53.42 Use cold water for cleanup whenever possible

53.50 Miscellaneous specific equipment/process changes

53.51 Use vapor recompression in distillation process

53.52 Use "side draw" principle in distillation column
(See also 22.20 for other measures related to distillation)

53.53 Convert liquid heaters from underfiring to immersion or submersion heating

53.54 Add temperature control and cutoff to steam heated tanks or exchangers

54 Process Heat Recovery (See 13.20 for recovery from boilers for process heat)

54.10 Heat recovery from exhaust or effluent streams for process use

54.11 Use hot process effluents or cooling system to preheat incoming process fluids or for other process heat

~~54.13~~ Recover heat from hot waste water (See also, 62.23)

54.12 Recover heat from hot waste water (See also 62.23)

54.13 Recycle hot process exhaust air, or exchange heat with incoming air

54.14 Use exhaust steam for process heat

54.15 Heat service or domestic water with exhaust from refigeration or air conditioner

54.20 Recovery of heat from equipment for process use

54.21 Use engine exhaust heat to make steam

54.22 Recover heat from air compressor

54.23 Recover heat from compressed air dryers

54.24 Recover heat from refrigeration condensers

54.25 Use product condensers to generate steam from condensates in a distillation process (See also 22.20)

54.26 Recover by-product heat from transformers to heat service water

54.30 Heat recovery for space heat from process effluent or equipment
(See 62.20 for B&G heat recovery)

54.31 Exchange hot process effluents for space heat

54.32 Use oven exhaust for direct space heat

54.33 Exchange oven exhaust to preheat makeup air

54.34 Use cooling air which cools hot pieces for space heating or make-up air

54.35 Exchange hot process exhaust air for space heat

55 Process Heat Confinement

55.10 Equipment insulation

(See also 20, Steam; 14, Combustion, and 62, B&G)

55.11 Insulate bare tanks, vessels, lines, and process equipment

55.12 Increase insulation thickness on process tanks, vessels, lines, and equipment

55.13 Cover open tanks with floating insulation

55.14 Cover and seal open tanks

55.20 Process ventilation reduction

(See also 62.30, B&G; and 53.11)

55.21 Use minimum necessary ventilation to drive off combustible solvents or other unwanted vapors

55.22 Revise smoke cleanup from production operations (e.g., welding, etc.)

55.23 Use outside air instead of conditioned air for process purposes - drying, dryer combustion air, etc. (See also 62.20, Building and Grounds ventilation)

60 Buildings and Grounds

61 Lighting

61.10 **Reduction in general lighting**

61.11 Disconnect fixtures, remove lamps, or use lower-output lamps to achieve minimum necessary light levels

61.12 Reduce lighting where natural light supplements indoor lighting

61.13 Reduce exterior lighting to minimum safe level

61.14 Disconnect ballasts

61.15 Provide strong lighting only where tasks are performed

61.16 Improve reflectance of walls, ceilings, etc. to permit use of lower output lamps (e.g., light color paints, tile)

61.17 Clean light fixtures regularly to permit use of lower output lamps

61.18 Lower light fixtures to permit use of lower output lamps

61.20 **Reduction of extraneous lighting**

61.21 Install timers on lights in little-used areas

61.22 Rewire to permit turning off lights in little-used areas, while other lights remain on

61.23 Rewire to permit turning off lights where natural light is sometimes sufficient

61.24 Manually turn off lights in areas not in use

61.25 Eliminate lighting above high storage stacks

61.26 Use photocell control in outdoor lights

61.30 **Efficiency of light source**

61.31 Use higher efficiency, lower wattage lamps in existing fixtures

61.32 Convert to more efficient light source; e.g., fluorescent for incandescent, metal halide or H.I.D. where acceptable, etc.

61.33 Eliminate inefficient lamps from plant stocks and catalogues

62 Space Heating and Cooling

62.10 **Building infiltration reduction**

62.11 Close doors, windows, and loading doors in heated or air conditioned areas

62.12 Repair or replace broken windows, sashes, doors, etc., and cracks surrounding

62.13 Seal unnecessary dampers, flues, louvres , and other roof and wall openings

62.14 Install weather stripping on loose-fitting windows and doors

62.15 Install doorseals or plastic strip doors at loading dock doors

62.16 Periodically calibrate sensors controlling louvres and dampers; repair faulty louvres and dampers

62.20 Space heating heat recovery
(See also 54.30,13.30)

62.21 Use "heat wheel" or other heat exchange techniques to precondition incoming air with exhaust air

62.22 Recover heat from lighting fixtures (e.g., for absorption cooling equipment)

62.23 Recover heat from domestic hot water or hot waste water for space heating (See also, 54.12)

62.26 Exchange hot flue gases in radiant heaters for space heating (See also 53.17)

62.27 Recover waste heat from air conditioning (computer room, etc.) for space heat or domestic hot water (See also 54.20)

62.28 Use building exhaust heat for outdoor snow and ice removal

62.30 Ventilation

62.31 Reduce use of outside make-up air for ventilation, except as used for economizer cycle; recycle HVAC air to maximum extent

62.32 Reduce ventilation air to minimum safe levels, especially little-used areas; reduce building exhausts and thus make-up air

62.33 Use destratification fans or other methods to improve interior air circulation

62.34 Use direct outside air supply to exhaust hoods, welding smoke clean-up, etc.

62.35 Avoid introducing high-moisture exhaust air into air conditioning system

62.36 Clean or replace air filters regularly

62.37 Replace high resistance grills, coils, ducts, pipes and fittings with proper size to minimize resistance

62.38 Centralize control of exhaust fans to ensure their shutdown, or establish program to ensure manual shutdown

62.39 Use building exhaust air to temper air at chemical removal hoods, smoke cleanup, etc. (See also 55.20)

62.40 **HVAC controls and operations**

62.41 Keep space temperature lower in heating season, higher during cooling season, or both

62.42 Air condition only space in use, or smallest areas necessary

62.43 Reduce heating level and shut off air conditioning, when building is not in use

62.44 Install timers on thermostats for automatic adjustment of heating and air conditioning

62.45 Interlock heating and air conditioning systems to prevent simultaneous operation

62.46 Close outdoor air dampers during warm-up or cool-down periods

62.47 Establish HVAC equipment maintenance schedules (See also 51.21 for process equipment)

62.48 Install computer system to control HVAC, including automatic shutdown, enthalpy optimization, etc., to reduce equipment loads

62.50 **HVAC systems or equipment changes**

62.51 Use enthalpy control instead of temperature control on air conditioning equipment

62.52 Reduce air conditioning load by evaporating water from roof

62.53 Use heat pump for space conditioning

62.54 Use radiant heaters for spot heating rather than heating entire area

62.55 Install or upgrade insulation on HVAC distribution systems (hot water pipes, airducts, etc.) (See also 21.31, 55.11)

62.56 Change zone reheat coils to low-pressure variable air volume boxes

62.57 Lower ceiling to reduce heated and cooled space

62.58 Install flexible strip door or partition between cooler and warmer areas

62.60 **Building envelope improvements**

62.61 Use proper thickness of insulation on walls, ceilings, roofs, and doors

62.62 Reduce glazed areas

62.63 Use double- or triple-glazed windows

62.64 Install storm windows and doors, translucent window insulation, or plastic sheets over windows for heating season

62.65 Reduce summer heat gain through windows with awnings, trees and shrubs, window tinting, or window shades

62.70 Miscellaneous space heating and cooling

62.71 Route steam lines to avoid heating air conditioned areas (See also 52.13)

62.72 Turn off steam or hot water lines leading to space heating units during mild weather

63 Miscellaneous Buildings and Grounds

63.10 Miscellaneous buildings and grounds

63.11 Replace air curtain doors with solid doors

63.12 Clean air conditioning refrigerant condensers to reduce compressor horsepower

63.13 Use water coolers and vending machines efficiently

63.14 Use building materials which require less energy to produce

90 Alternate Fuels

91 Waste and by-products as fuels

91.10 Process heat supplied by alternate fuels

91.11 Burn waste paper for process heat

91.12 Install solid waste incinerator for process heat

91.13 Burn wood by-products for process heat

91.20 Space heat supplied by alternate fuels

91.21 Burn waste paper for space heat

91.22 Install solid waste incinerator for space heat

91.23 Burn wood by-products for space heat

92 Conversion to more efficient or more economical fuel source

92.10 Conversion to combustion of a different fuel

92.11 Convert oil-burning boilers to natural gas combustion

92.12 Convert oil or gas burner to combustion of coal

92.20 Replacement of electrical equipment with equipment burning fossil fuels

92.21 Replace electrically operated process heating equipment with fossil fuel combustion equipment

92.22 Replace electrically operated domestic or service water heater with one using fossil fuel

92.23 Replace electrically operated space-heating system with one burning fossil fuel

92.30 Increased use of electrical equipment

92.31 Replace steam jets on vacuum equipment with electric-motor driven vacuum pumps

92.32 Use electric immersion heating in tanks, melting pots, etc.

92.33 Replace fossil fuel furnace with electric induction furnace

92.34 Replace hydraulic or pheumatic hand tools or other equipment with electric equipment

92.40 Waste heat recovery to displace an energy source

92.41 Replace electric motors with back-pressure steam turbines and use exhaust steam for process heat

92.42 Use waste heat from low pressure steam for absorption refrigeration

93 Cogeneration

93.10 Cogeneration of electricity with existing steam capacity

93.11 Use existing excess steam capacity to cogenerate electricity

93.12 Use combined cycle gas turbine generator sets with waste heat boilers connected to turbine exhaust to cogenerate electricity

93.13 Replace condensing steam turbine rotating equipment drives with electrical motors, and use existing steam capacity to generate electricity

93.20 Cogeneration of electricity and steam using alternate fuel sources

93.21 Burn waste wood to supply process steam and electricity

94 Solar Energy

94.10 Solar heat

94.11 Use solar heat to heat make-up ventilation air

94.12 Use solar heat to heat domestic or service hot water

94.13 Use solar heat for process heat

References

1) Arthur Young, paper presented on "Lighting Energy Management" sponsored by the Oklahoma Dept. of Energy; Energy Information Centre, 4400 Lincoln Boulevard, Oklahoma City, OK 73105.

2) Kane, Les A., "Process Control & Optimazation Handbook for the Hydrocarbon Processing Industries", Gulf Publishing Co., 1980.

3) McRae, Alexander, Janice L. Dudas & Howard Rowland, "The Energy Source Book", A publication of the Centre for Compliance Information; A ASPEN publication, 1977.

4) Philips, James M., "Improving Profits in Oklahoma Industries Through Self Energy Management", Wayne C. Turner (Director) Oklahoma Industrial Energy Management Program, School of Industrial Eng. and Mgmt., Oklahoma State University, Stillwater, Oklahoma 74074.

5) Thumann, Albert, P. E., "Plant Engineers and Managers Guide to Energy Conservation", Van Nostrand Reinhold Company, 1977.

6) Turner, Wayne C., "Energy Management Handbook", John Wiley and Sons, 1982.

SOURCES OF INFORMATION ON ENERGY MANAGEMENT

Here follows a list of sources from whom further information on energy management may be obtained.

1. **Societies, Associations, & Institutes**

- Air-Conditioning and Refrigeration Institute, 1815 N. Ft. Myer Dr., Arlington, VA 22209
- Air Cooling Institute, P.O. Box 2121, Wichita Falls, TX 76301
- Air Diffusion Council, 435 N. Michigan Ave., Chicago, IL 60611
- Air Distribution Institute, 221 N. LaSalle St., Chicago, IL 60601
- Air Moving and Conditioning Association, 30 W. University Dr., Arlington Heights, IL 60004
- American Boiler Manufacturers Association, 1500 Wilson Blvd., Suite 317, Arlington, VA 22209
- American Consulting Engineers Council, 1155 15th St., N.W., Rm. 713, Washington, DC 20005
- American Gas Association, 1515 Wilson Blvd., Arlington, Va. 22209
- American Industrial Hygiene Association, 210 Haddon Ave., Westmont, NJ 08108
- American Institute of Architects, 1735 New York Ave., N.W., Washington, DC 20006
- American Institute of Consulting Engineers (See American Consulting Engineers Council)
- American Institute of Plant Engineers, 1021 Delta Ave., Cincinnati, OH 45208
- American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018
- American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc., 345 E. 47th St., New York, NY 10017
- American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017
- American Society of Plumbing Engineers, 16161 Ventura Blvd., Suite 105, Encino, CA 91316
- American Society for Testing and Materials, 1916 Race St., Philadelphia PA 19103
- Associated Air Balance Council, 2146 Sunset Blvd., Los Angeles, CA 90026
- Associated General Contractors of America, 1957 E. St., N.W., Washington, DC 20006
- Better Heating-Cooling Council, 35 Russo Pl., Berkeley Heights, NJ 07922
- BRAB Building Research Institute, 2101 Constitution Ave., Washington, DC 20418
- Building Owners & Managers Association International, 1221 Massachusetts Ave., N.W., Washington, D.C.
- Building Research Advisory Board, National Research Council, National Academy of Sciences-National Academy of Engineering, 2101 Constitution Ave., N.W., Washington, DC 20418
- Construction Specifications Institute, 1150 Seventeenth St., N.W., Suite 300, Washington DC 20036
- Conveyor Equipment M[illegible]facturers, 1000 Vermont Ave., N.W., Washington, DC 20005
- Cooling Tower Institute, 3003 Yale St., Houston, TX 77018
- Edison Electric Institute, 90 Park Ave., New York, NY 10016
- Electrical Apparatus Service Association, Inc., 7710 Carondelet Ave., St. Louis, MO 63105
- Electrification Council, The, 90 Park Ave., New York, NY 10016
- Heat Exchange Institute, 122 E. 42nd St., New York, NY 10017
- Hydronics Institute, 35 Russo Pl., Berkeley Heights, NJ 07922
- Illuminating Engineering Society, 345 E. 47th St., New York, NY 10017
- Institute of Electrical & Electronics Engineers, Inc., 345 E. 47th St., New York, NY 10017
- Instrument Society of America, Stanwix St., Pittsburgh, PA 15222
- International District—Heating Association, 5940 Baum Sq., Pittsburgh, PA 15206
- Mechanical Contractors Association of America, Inc., 5530 Wisconsin Ave., Suite 750, Washington, DC 20015
- National Association of Oil Heating Service Manager, Inc., 60 E. 42nd St., New York, NY 10017
- National Association of Plumbing, Heating & Cooling Contractors, 1016 20th St., N.E., Washington, DC 20036
- National Association of Power Engineers, Inc., 176 W. Adams St., Suite 1411, Chicago, IL 60603
- National Association of Refrigerated Warehouses, 1210 Tower Bldg., 1401 K St., N.W., Washington, DC 20005
- National Coal Association, Coal Bldg., 1130 17th St., N.W., Washington, DC 20036
- National Electrical Contractors Association, 7315 Wisconsin Ave., Washington, DC 20014
- National Electrical Manufacturers Association, 155 E. 44th St., New York, NY 10017
- National Environmental Systems Contractors Association, 221 N. LaSalle St., Chicago, IL 60601
- National Insulation Contractors Association, 8630 Fenton St., Suite 506, Silver Spring, MD 20910
- National LP-Gas Association, 79 W. Monroe St., Chicago, IL 60603
- National Mineral Wool Insulation Association, Inc., 211 E. 51st St., New York, NY 10022
- National Oil Fuel Institute, Inc., 60 E. 42nd St., New York, NY 10017
- National Society of Professional Engineers, 2020 K St., N.W., Washington, DC 20006
- Producers' Council, Inc., 1717 Massachusetts Ave., Washington, DC 20036
- Refrigeration Service Engineers Society, 2720 Des Plaines Ave., Des Plain[illegible]18
- Society of American Value Engineers (SAVE), 2550 Hargrave Dr., Smyrna, Ga. 30080
- Standards Engineers Society, P.O. Box 7507, Philadelphia, PA 19101
- Steam Heating Equipment Manufacturers Assoc., c/o Samuel J. Reid, Barnes & Jones, Inc., P.O. Box 207, Newtonville, MA 02160

- Thermal Insulation Manufacturers Association, Inc., 7 Kirby Plaza, Mt. Kisco, NY 10549
- Underwriters' Laboratories, Inc., 333 Pfingsten Rd., Northbrook, IL 60062
- Water Conditioning Foundation, 1780 Maple St., P.O. Box 194, Northfield, IL 60093

2. Local Sources

- Chapters of above mentioned societies, associations and institutions
- Utilities
- Chambers of Commerce
- Construction industry organizations
- Building code authorities
- Libraries
- Architectural engineers, contractors, suppliers and others with whom you work on a regular basis.

2. U.S. Government Sources

- Federal Energy Administration, Office of Energy Conservation and Environment, 12th & Pennsylvania, N.W., Washington, D.C. 20461
- Department of Commerce, Office of Energy Programs, 14th & Constitution Ave., Washington, D.C. 20230
- General Services Administration, Public Building Service, 18th & F St., N.W., Washington, D.C. 20405
- National Bureau of Standards, Office of Energy Conservation, Building 226, Rm. B114, Washington, D.C. 20234