Saving Money with Energy Conservation:

ECONOMIC ANALYSIS

OF CONSERVATION MEASURES

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For additional assistance contact your State Energy Office.

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SAVING MONEY WITH ENERGY CONSERVATION

Energy Conservation means saving energy and saving money. Ten, twenty, even thirty percent savings in utility bills are possible when zero and low cost conservation measures are adopted. Conservation measures which create more savings than they cost without sacrificing working conditions are generally attractive investment opportunities. Profit minded managers everywhere are looking for ways to reduce their utility bills. It's just good business.

Many conservation measures require little more than changing operating procedures. They call for negligible initial cost. Removing unneeded light tubes or turning back the thermostat fall into this category. For such measures, analysis of costs and savings are unnecessary. For other measures, however, initial costs might be significant and an analysis of such investments is in order. The purpose of this workbook is to review the basic tools for performing simple economic analyses of energy conservation measures.

As with other investment opportunities, economic analysis of energy conservation is sound business practice. The value of conservation must be viewed in comparison to other investment opportunities because money spent here can't be invested elsewhere. With the fast rising cost of energy, many conservation measures look very good in such a comparison. Only when the expected rate of return is greater than that for other opportunities should a measure be implemented. For lack of a better standard, we suggest the rate of return be at least 15 percent.

In reality, criteria other than simple rates of return are used to evaluate investment opportunities. The availability of funds, and income taxes should be reviewed.

The potential loss if the measure fails to work should also be considered. These criteria are, however, situation specific and will not be covered here.

In the next part of the booklet, utility bills will be reviewed to suggest ways of analyzing your energy unit costs. Part 2 will introduce ways to calculate the payback period, return on investment and present worth of energy conservation measures. Several economic analysis examples will be given to show how these calculations are made. Finally, in part 3, a discussion of the inflation, depreciation, and income tax ramifications of energy conservation will be offered. Taken as a whole, this booklet should prepare you quite well for analyzing most measures. If, however, the measure is costly and the impact on energy consumption complex, it would be wise to consider employing a professional energy auditor/engineer.

**You can argue all day — but
wasted energy is wasted money.**

PART 1
ENERGY ACCOUNTING

The purpose of energy accounting is to establish energy utilization patterns and performance goals. Energy usage patterns help identify the relation between consumption and facility use. Such patterns indicate the times of day, days of the week, and seasons of the year which require the most energy. The calculation of a performance index (i.e. KWH/day or BTU/sq ft) allows for comparing one facility with another. Changes in the performance index over time are useful in measuring the effect of your conservation program.

Energy accounting is used to keep records of and control energy utilization and costs. Financial accounting deals with the ongoing monitoring of meters and utility bills. Financial accounting is used to verify whether you are being charged properly. They can lead to suggestions of changes in metering or business practice which could significantly reduce the utility bills.

How to Read Your Utility Bill

Your utility bill is a critical source of information for beginning your energy conservation program. It will provide you with much of the

data necessary to determine if your program is working to reduce the number of energy units you are using.

Your utility bill will show several items dealing with units of consumption. For electric bills, these include KWH, which is your consumption of electricity in kilowatt-hours. Each KWH represents 1000 watts used for a period of one hour. One KWH yields approximately 3413 British Thermal Units (BTU's) of heating value. A BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. Another unit of consumption is KW, the peak load or peak demand and is the maximum number of kilowatts averaged over any fifteen minute period since the meter was last read and the demand reset. The consumption figures for natural gas are therms, MCF or CCF. One therm of gas is enough to give 100,000 BTU's of heating value. An MCF is 1000 cubic feet and a CCF is 100 cubic feet and they yield approximately 1,000,000 BTU's and 100,000 BTU's respectively. Probably the most important figure to you on your bill is the amount due. However, for keeping track of energy saved, it will not be as useful as the units of consumption. This is because the cost of energy is growing so fast conservation may not reduce the amount you pay. Instead, it will reduce the amount you would have paid had you not conserved. Dividing the KWH, MCF or other units used into the amount due gives the dollar per unit due. If you multiply the units saved from one time period to the next by the new dollars per unit, you will have an estimate of the true dollars saved by conservation.

The utility bill actually begins with the meter, which records the energy units used over time. You can take some of the mystery out of

utility bills with a daily visit to your meter. You should take time to become familiar with your meter, because it can provide you with a daily energy unit count, a yardstick to measure energy-saving progress, and a reminder that keeps you motivated to save. The meter is read periodically, usually every month, by a utility company meter reader and you are billed for the energy units used during this time period. So the first thing reading your own meter can do is guard against overcharging which result from utility company errors.

When reading your electric meter, there are three pieces of data to be captured: the kilowatt hour reading, the peak kilowatt to date reading (called demand) and the multiplier. A typical meter is shown in the figure below.

Kilowatt-hours of consumption are read off of the five dials at the top. Reading left to right, the first dial is between the 2 and 3, its reading is 2 in the 10,000th place. Similarly, dials 2 through 5 are read 4, 2, 9 and 4 in the 1000, 100, 10, and 1's place, respectively. Thus the dial reading is 24294. This figure must be multiplied by the multiplier which in this example is 30. Thus the actual kilowatt hours indicated on the meter is $24294 \times 30 = 728820$ KWH.

As mentioned previously, the peak kilowatts of demand is the maximum number of kilowatts averaged over any fifteen minute period since the meter was last read. Essentially, it represents the average consumption when the demand for energy was the greatest. The greater your peak demand, the higher your bill. In the example above, the needle to the right indicates the peak to date which is $37.5 \times 30 = 1125$ kilowatts.

Reading your natural gas meter is not unlike reading the electric meter. There is, however, only one bit of data to be read. That is the thousands of cubic feet (MCF) of gas consumed. Consider the following example:

The reading in this example is 4279 MCF or 4,279,000 cubic feet. Your utility bill is given in therms of natural gas rather than cubic feet, a conversion factor is: 1 therm = 100 cubic feet.

When meters are understood, they become tools for economy. Recording usage from meter readings at various times of the day and for various days of the week can be quite informative. It is recommended that meters be read at 8 a.m., 12 noon and 4 p.m. every day for two or three weeks. This should be done during each of the four seasons. It should be repeated every year. Based on this data, one can calculate averages for each period of the day, day of the week, and season of the year. The result can lead to probing questions. For example, you might find that nearly as much electricity is used between 4 p.m. and 8 a.m. as is used during the daytime hours. Why? Perhaps too many lights are left on all night. Another example of what one might find is that the daily consumption of gas is as high on weekends as during the week. Why? Perhaps the building is being heated unnecessarily when no one is there. Knowing when energy is used is a large part of knowing where it is wasted.

**Kicking the habit of wasting energy
is well worth the effort.**

PART 2

INTRODUCTION TO ECONOMIC ANALYSIS

In this part of the workbook, we introduce three methods for economic analysis. Six examples are provided to illustrate the computations and appropriate applications of each measure.

The first two measures, payback period (PP) and return on investment (ROI) are useful for quick analysis of simple low cost conservation measures. If, however, the measure requires large initial investment, with corresponding large future savings, then the third measure, present worth (PW) is suggested.

The payback and return on investment methods can be used to quickly reject measures because of the long time needed to pay back the investment or because the return is too low to justify the investment.

The data needed to use the PP or ROI methods are:

- FC - First Cost required to implement the measure; Purchasing equipment, the installation labor costs, and direct income tax credits, for example.
- AOC - Annual Operating Costs required to operate the measure. Yearly maintenance for example.
- AES - Annual Energy Savings resulting from the measure. This might be in KWH of electricity, KW of peak electricity, MCF of natural gas, GAL of fuel oil or LBS of steam.
- PEC - Projected Energy Costs are the forecasted average unit cost of the energy saved.
- EL - Estimated Life of the investment is the expected time before the equipment will wear out and have to be replaced.
- CEC - That portion of the first cost required for capital equipment.
- TR - Estimated income tax rate to be paid by the company in next year.

At this point, the expected annual savings (S) of a measure can be defined. This value should be calculated for every measure, even those which cost nothing. The results will allow you to compare savings for changes in the operation of the building.

EXPECTED ANNUAL SAVINGS

$$S = (AES \times PEC) - AOC$$

(It should be noted that expected annual savings could also include the tax savings resulting from depreciating any capital equipment required to implement the conservation measure. These tax savings equal the depreciation cost multiplied by the company's income tax rate, $DC \times TR$.)

The payback period (PP) of an investment is the simple ratio of the first cost divided by the expected annual savings.

PAYBACK PERIOD

$$PP = \frac{FC}{(AES \times PEC) - AOC}$$

The payback period is then compared to the expected lifetime of the investment. A payback period of less than one-half the lifetime of an investment would generally be considered profitable where the lifetime is ten years or less.

The payback period as a measure of performance gives rise to problems, however. For instance, dollars saved in future years are credited the same as dollars saved in current years and comparisons between alternative investment opportunities of different lifetimes cannot be made.

Return on Investment (ROI) is considered superior to payback period because it considers the depreciation of the equipment over its expected lifetime. Depreciation is taken in equal amounts for each year and equals the ratio of capital equipment cost divided by the equipments estimated life. That is

DEPRECIATION OF EQUIPMENT COST

$$DC = \frac{CEC}{EL}$$

Return on investment as a fraction is the ratio of annual savings less depreciation divided by the first cost.

RETURN ON INVESTMENT

$$\begin{aligned} \text{ROI} &= \frac{S - DC}{FC} \\ &= \frac{(\text{AES} \times \text{PEC}) - \text{AOC} - \text{DG}}{FC} \end{aligned}$$

Expressing the ROI as a percentage, one need only multiply the fraction by 100.

PERCENT RETURN ON INVESTMENT

$$\text{ROI}\% = \frac{S - DC}{FC} \times 100$$

The return on investment is then compared to other opportunities for investing money. Generally speaking ROI%'s greater than 25% to 35% are reasonable for small investments. For larger investments, the desired return is typically reduced.

If, however, the first cost is quite large or if the potential annual costs and savings are complex or if the expected life is long, then neither payback period or return on investment are recommended.

More exact measures of performance are those which incorporate an allowance for the time value of money, generally in the form of a discount factor. Because of alternative investment opportunities, a dollar held today is worth more than a dollar held in some future time period. The internal rate of return on typical investment alternatives is generally considered to be the appropriate discount rate for evaluating new investment opportunities, unless this rate is below the cost of

borrowing when a new investment needs to be financed. In this case, the discount rate must be at least as high as the borrowing rate. This discount rate is called the Minimum Attractive Rate of Return or MARR.

While appropriate discount rates may differ widely in different industries and even among firms within the same industry, corporate discount rates usually run between 10 to 20% or higher. For the example in this workbook we shall use a figure of 15% for the MARR. This, again, is equivalent to saying that such a return can be realized elsewhere and thus for a new investment to be justified it must yield a return somewhat greater than this. It should be noted that profits generated by energy savings are generally taxed at the same rate as profits earned elsewhere within or outside of the firm, affirming the need for an equivalent discount rate for energy saving projects.

Several second-level measurements for evaluating conservation measures are available. In this workbook, we shall present only one, the Present Worth (PW) method. A conservation measure with a present worth of one thousand dollars is said to be equivalent to the immediate receipt of \$1000. The thousand dollar receipt and the measure are economically identical if the money could be invested today at a return equal to the MARR.

In order to calculate the present worth (PW) of a measure, one must convert each income and expense associated with the measure to its equivalent present worth. This is done by multiplying future income and expense cash flows by discount factors. We shall use two such

factors; the single payment factor and the uniform series factor. Tables of the single payment and uniform series present worth factors for different values of n and i are presented in the appendix.

SINGLE PAYMENT PRESENT WORTH FACTOR

$$(P/F, i, n)$$

This factor converts a payment of F dollars, expected in n years in the future if the rate of return is i . For example, what is the equivalent present worth of \$10,000 which will be available in 8 years, if $i = 15$ percent?

$$\begin{aligned} PW &= 10000 (P/F, 15\%, 8) \\ &= 10000 \times .3269 \\ &= \$3269 \end{aligned}$$

Thus, \$3269 invested today at 15% interest, will be worth \$10,000 in eight years.

UNIFORM SERIES PRESENT WORTH FACTOR

$$(P/A, i, n)$$

This factor converts equal payments of A dollars in each of the next n years if the rate of return is i . For example, what is the equivalent present worth of an energy savings of \$250 a year for 6 years if $i = 15$ percent?

$$\begin{aligned} PW &= 250 (P/A, 15\%, 6) \\ &= 250 \times 3.284 \\ &= \$821 \end{aligned}$$

Or, a project which will return \$250 each year for six years is equivalent to \$821 invested today at a 15% interest rate for the same period.

When performing a present worth analysis, each expected income and expense are estimated along with the year in which they will occur. For convenience, the present is called year zero. All cash flows after the first costs which occur during the first 12 months of the measure's life are said to occur in year one. All cash flows in the second 12 months occur in the second year and so forth. Thus, the cash flows are grouped in the year in which they occur. They can then be converted using the following equation to present worth all at the same time.

$$PW = (AES \times PEC - AOC + DC \times TR)(P/A, i, n) - FC$$

All measures with positive present worths may be good investments. However, since capital available for investing is limited, only those with the greatest present worths should be implemented.

Because one can't implement all possible measures, they should be rank ordered. One should only rank order measures using the same economic analysis method. If that analysis method is payback, then those measures with shorter payback periods are better. If the method is return on investment, then those measures with greater returns are better. Finally, if the method is present worth, then those measures with greater present worths are better. Looking at the ranked conservation measures and the availability of capital, one can select which measures to implement.

To better understand these principles, six example problems follow.* A brief description of each conservation opportunity is given, followed by a section showing how to calculate the costs and savings associated with the example. Finally, the payback, return on investment

and present worth values are worked out to show which approach is best. A review of these examples should prepare you to do economic studies in your own organization.

*Note: Several of these examples were inspired by case problems shown in the following documents:

1. U.S. Dept. of Commerce, Federal Energy Administration, "Energy Conservation Program Guide for Industry and Commerce," NBS Handbook 115, Sept. 1974.
2. U.S. Dept. of Energy, "Saving Money With Energy Conservation," An Energy Audit Workbook for Warehouses," DOE/CS-0138, July 1980.
3. U.S. Dept. of Energy, "Saving Money With Energy Conservation, An Energy Audit Workbook for Hotels/Motels," DOE CS-0140 July 1980.
4. U.S. Dept. of Energy, "Saving Money With Energy Conservation, An Energy Audit Workbook for Office Buildings," DOE/CS-0137 July 1980.
5. New Mexico Energy and Minerals Dept., "TEEM, Total Effective Energy Management," No. 76-160A, 1978.
6. Texas Industrial Commission, "Energy Conservation for the Meat Processing Industry."

A. REDUCING PARKING LOT LIGHTING

The manager of a neighborhood shopping center decided his parking lot was overlighted, especially after the stores were closed. The lot was using thirty 300 watt flood lights. The lights were timed to go on at 5 p.m. and off at 5 a.m., seven days a week. The first decision was to reset the timer to turn the lights off at 10 p.m. when the stores closed and leave them off entirely on Sunday. During the 5 to 10 p.m. period, it was decided to cut the lighting in half. Two options were open; to remove half the 300 watt bulbs or to replace all 30 bulbs with 150 watt floods. The manager decided the first option would not sufficiently spread the light and would give an appearance of poor maintenance. The questions were, how much would the reduced hours save and how economical would the bulb replacement be?

Data Collection

1. Energy savings from reduced hours.

	30	flood lights
x	300	watts/flood light
	9000	watts
X	54	hours saved (7 hours x 6 days + 12 hours on Sunday)
	486000	watt hours/week
÷	1000	watts/kilowatt
	486	kilowatt hours (KWH)
x	52	weeks/year
	25272	KWH saved/year

2. Additional Energy Savings from Bulb Replacement.

	30	flood lights
x	150	watts saved/flood light (300 watts - 150 watts)
	4500	watts saved/year
x	30	hours/week
	135000	watt hours/week
÷	1000	watts/kilowatt
	135	KWH
x	52	weeks/year
	7020	KWH saved/year

3. Cost to replace bulbs

\$	5.40	bulb cost
+	5.00	labor cost
\$	10.40	cost to replace each bulb
x	30	flood lights
\$	312.00	cost to replace bulbs

4. Savings per KWH of energy

From utility bill

0.055 dollars/KWH

5. Expected life of bulbs

—	5000	hours (from vendor brochure)
÷	1560	hours/year (5 hours/day x 6 days/wk x 52 wks/year)
—	3.2	years
		Approx. 3 years

Economic Analysis

First Costs	FC = \$312
Capital Equipment Cost	CEC = 0
Annual Energy Savings (from bulb replacement)	AES ₁ = 7020 KWH/year
Annual Energy Savings (from reduced hours)	AES ₂ = 25272 KWH/year
Annual Operating Costs	AOC = 0
Projected Energy Costs	PEC = .055 \$/KWH
Estimated Life	EL = 3 years

1. Calculating savings from reduced hours

$$\begin{aligned}\text{Annual Savings} &= \text{AES}_2 \times \text{PEC} - \text{AOC} \\ &= 25272 \times .055 \\ &= \$1390\end{aligned}$$

2. Calculating payback period (PP) for replacement

$$\begin{aligned}\text{PP} &= \frac{\text{FC}}{(\text{AES}_1 \times \text{PEC}) - \text{AOC}} \\ &= \frac{312}{7020 \times .055} \\ &= .81 \text{ years} \\ \text{PP} &= \underline{10 \text{ months}}\end{aligned}$$

3. Calculating Return on Investment (ROI) for replacement

$$\begin{aligned} \text{ROI} &= \frac{(\text{AES}_1 \times \text{PEC}) - \text{AOC} - \text{DC}}{\text{FC}} \\ &= \frac{7020 \times .055 - 0 - 0}{312} \\ &= 1.23 \end{aligned}$$

$$\text{ROI} = 123\%$$

4. Calculating present worth for replacement

Minimum Attractive Rate of Return	MARR = .15
Approximate Estimated Life	EL = 3 years
Present worth factor (from Appendix)	(P/A,.15,3) = 2.283

$$\begin{aligned} \text{PW} &= (\text{AES}_1 \times \text{PEC} - \text{AOC} + \text{DC} \times \text{TR})(\text{P/A}, .15, 3) - \text{FC} \\ &= (7020 \times .055)(2.283) - 312 \end{aligned}$$

$$\text{PW} = \underline{\$569}$$

Conclusion

Thus the decision to reduce the hours of lighting will save \$1390 a year. Further the decision to replace the 300 watt bulbs with 150 watt bulbs will pay off in 10 months which is equivalent to a return of 123 percent or a present worth of \$569 savings over the life of the bulbs.

B. REDUCING INDOOR LIGHTING

The manager of an office building observed that many indoor areas were way over lighted. In selected hallways and working areas he cut the lighting in half by removing fluorescent tubes. After a period he asked the people using those areas if they thought the new light levels were sufficient. The response led him to decide to cut the light levels throughout the building by half. Three options existed; first, he could simply have his maintenance staff remove half the tubes; second, he could hire an electrician to remove tubes and their ballasts and third, he could have his staff replace all tubes with a lower wattage energy saving variety. The question is; which option is the most economical?

Data Collection

1. Energy Savings for Option A (remove half the tubes)

	225	tubes (half the total tubes)
x	40	watts/tube
	9000	watts
x	3120	hours/year (12 hrs/day x 5 days/wk x 52 wk/yr)
	28080000	watt hours/year
÷	1000	watts/kilowatt
	28080	KWH/year

2. Replacement Savings for Option A (fewer tubes to wear out)

	225	tubes
÷	2.0	years (life expectancy of a bulb)
	113	tubes/year
x \$	2.76	cost to replace tubes (\$.76/tube + \$2 for labor)
	\$312.00	replacement savings/year

3. Cost to remove tubes for Option A

	225	tubes
x \$	2	cost/tube ($\frac{1}{4}$ hr/tube x \$8/hr)
\$	550	cost to remove tubes

4. Energy Savings for Option B (remove tubes and ballast)

	28080	KWH saved/year
+	2808	KWH (add 10% for ballast removal)
	20888	KWH saved/year

5. Cost to remove tubes and ballasts for Option B

Bid from local electrician	\$1200
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6. Energy Savings for Option C (energy savers)

	450	tubes
x	5	watts saved/tube (40 watts - 35 watts)
	2250	watts saved
x	3120	hours/year (12 hrs/day x 5 days/wk x 52 wks/yr)
	7020000	watt hours
÷	1000	watts/kilowatt
	7020	KWH/year

7. Cost to implement Option C

	450	tubes
x\$	3.02	cost to replace tubes (\$1.02/tube + \$2 for labor)
	\$1359.00	cost to replace tubes

8. Projected energy cost

From utility bill	0.055 dollars/KWH
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9. Estimated life of idea

Since the manager believes he will use lower lighting permanently, he placed a long life of 20 years on the idea.	20 years
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10. Capital Equipment Cost

The capital equipment cost for each option is zero.

Economic Analysis

Option A

First Cost	FC = 550
Annual Energy Savings	AES = 28,080
Annual Operating Cost*	AOC = - 312
Projected Energy Cost	PEC = 0.055
Estimated Life	EL = 20

Option B

First Cost	FC = 1200
Annual Energy Savings	AES = 30888
Annual Operating Cost*	AOC = - 312
Projected Energy Cost	PEC = 0.055
Estimated Life	EL = 20

Option C

First Cost	FC = 1359
Annual Energy Savings	AEC = 7020
Annual Operating Cost	AOC = 0
Projected Energy Cost	PEC = 0.055
Estimated Life	EL = 20

*Note that a negative annual operating cost represents an annual operating savings due to fewer tube replacements.

1. Calculate payback for Option A

$$\begin{aligned} PP_A &= \frac{FC}{(AES \times PEC) - AOC} \\ &= \frac{550}{(28,080 \times .055) + 312} \\ &= .296 \text{ years} \\ PP_A &= \underline{3.5 \text{ months}} \end{aligned}$$

2. Calculate payback for Option B

$$\begin{aligned} PP_B &= \frac{1200}{(30888 \times .055) + 312} \\ &= .597 \text{ years} \\ PP_B &= \underline{7.2 \text{ months}} \end{aligned}$$

3. Calculate payback for Option C

$$PP_C = \frac{1359}{(7020 \times .055) - 0}$$

$$= 3.5 \text{ years}$$

$$PP_C = 42.2 \text{ months}$$

4. Calculate return on investment for Option A

$$ROI_A = \frac{(AES \times PEC) - AOC - DC}{FC}$$

$$= \frac{28080 \times .055 + 312 - 0}{550}$$

$$= 3.38$$

$$ROI_A = 338\%$$

5. Calculate return on investment of Option B

$$ROI_B = \frac{30888 \times .055 + 312 - 0}{1200}$$

$$= 1.67$$

$$ROI_B = 167\%$$

6. Calculating return on investment for Option C

$$ROI_C = \frac{7020 \times .055 - 0}{1359}$$

$$= .28$$

$$ROI_C = 28\%$$

7. Calculating present worth for Option A

$$\begin{aligned}PW_A &= (AES \times PEC - AOC)(P/A, 15, 20) - FC \\&= (28080 \times .055 + 312) \times 6.259 - 550 \\&= \$11,069\end{aligned}$$

8. Calculating present worth for Option B

$$\begin{aligned}PW_B &= (30888 \times .055 + 312) \times 6.259 - 1200 \\&= \$11,386\end{aligned}$$

9. Calculating present worth for Option C

$$\begin{aligned}PW_C &= (7020 \times .055 - 0.0) \times 6.259 - 1359 \\&= \$1058\end{aligned}$$

Conclusion

The decision in this situation is between Option A, to remove half the tubes without removing their ballasts and Option B, to remove half the tubes and the ballasts. The figures are

	<u>Option A</u>	<u>Option B</u>	<u>Option C</u>
Payback Period	3.5 mths	7.2 mths	42.2 mths
Return on Inv.	338%	167%	28%
Present Worth	\$11,069	\$11,386	\$1,058

In the long run (20 years) Option B is the more attractive alternative but only by 317 dollars. In the shorter term, Option A is best with a payback of only 3.5 months and an equivalent rate of return of percent. The decision to implement Option A is worth \$11,069 to the manager.

C. ADDING STORM WINDOWS

A school principal has received complaints that classrooms are cold near the windows and too warm away from the windows. The windows are well weatherstripped so he decides to look into storm windows. A vendor has quoted \$52 per window. The vendor said the "U"* value for the present window is 1.13 and with storm windows it would be reduced by .57. The question is one of convincing the school board of the cost effectiveness of the idea.

Data Collection

1. Energy Savings from the Storm Windows

As demonstrated in the example on the next page, to determine heat conserved, you need to know:

1. The "U" values of the two alternatives (obtain from vendor).
2. The area in sq. ft. of the surface affected (obtain from measurements).
3. The average daily temperature during the period in question (obtain from weather bureau).
4. The number hours per day of heating.
5. The efficiency of the heating system (obtained from the HVAC contractor).

*Note: The "U" value is the coefficient of heat transfer (air to air) expressed in BTU's per square foot per hour per degree F. The "U" value applies to combinations of different materials used in series along the heat path flow, including air spaces, and surface air films on both sides.

The local weather bureau stated that the area averages 260 days of heating season (days where average temperature is below 65°F) and that the average daily temperature during this season is 44°F. Because the classrooms were set at 68°F the difference in temperature is 24°F.

$$\begin{array}{rcl} & 36 & \text{sq.ft. (average window area)} \\ \times & 110 & \text{windows} \\ \hline & 3960 & \text{sq.ft. (total window area)} \end{array}$$

$$\begin{array}{rcl} & 260 & \text{heating days} \\ \times & 24 & \text{hours/day} \\ \hline & 6240 & \text{heating hours} \end{array}$$

$$\begin{array}{rcl} & 68^{\circ}\text{F} & \text{room temperature} \\ - & 44^{\circ}\text{F} & \text{average daily temperature} \\ \hline & 24^{\circ}\text{F} & \text{difference} \end{array}$$

BTU Savings = change in "U" value x area affected x number of heating hours x degree F change.

$$= .57 \times 3960 \times 6240 \times 24$$

$$= 338,000,000 \text{ BTU/year (saved in the classroom)}$$

To determine how much gas will be saved, divide the BTU saved (or used) in the classroom (338 million BTU) by the system efficiency (.65). System efficiency is a measure of how well the system converts the energy it consumes into useful heat. The remaining energy is lost during conversion or transmission. In this case, the .65 efficiency means that

only 65% of the heating value of the gas heats the school --
the remaining 35% is lost in the furnace or in the vents.
Thus to supply 338 million BTU to the schoolrooms, you must
burn enough additional gas to make up for the losses:

BTU's required x system efficiency = BTU's supplied

or

BTU's required = BTU's supplied ÷ system efficiency

BTU's required = 338 ÷ .65
= 520 million BTU's

Next, convert to amount of gas used. This is a simple conversion since 1 MCF (1000 cubic feet) of gas produces 1 million BTU. So, Annual Energy Savings is: 520 MCF

2. Expected cost of energy

From utility company \$3.80 MCF

3. Cost to install windows and capital equipment cost

From vendor	110 windows
x \$ 52	cost per window
\$ 5720	cost to install windows

4. Expected life of windows

From vendor 10 years

Economic Analysis

First Cost	FC = 5720
Capital Equipment Cost	CEC = 5720
Annual Operating Cost	AOC = 0
Annual Energy Savings	AES = 520
Projected Energy Cost	PEC = 3.80
Expected Life	EL = 10
Expected Income Tax Rate	TR = .50

1. Calculate Payback Period (PP)

$$\begin{aligned} PP &= \frac{FC}{(AES \times PEC) - AOC} \\ &= \frac{5720}{520 \times 3.80} \\ &= 2.89 \text{ years} \end{aligned}$$

2. Calculate return on investment

$$\begin{aligned} ROI &= \frac{(AES \times PEC) - AOC - DC}{FC} \\ &= \frac{520 \times 3.80 - 5720/10}{5720} \\ &= .25 \\ &= 25\% \end{aligned}$$

3. Calculate present worth for investment

$$\begin{aligned} PW &= (AES \times PEC - AOC + DC \times TR)(P/A, 15, 10) - FC \\ &= (520 \times 3.80 + 572 \times .50)(5.019) - 5720 \\ &= \$5633 \end{aligned}$$

Conclusions

Thus the addition of storm windows is a good investment indeed. For a \$5720 initial outlay, the school system will receive utility bill savings worth several times that amount over the next ten years. The initial outlay will be recouped in 2.89 years and the return on this investment will be 25 percent. These figures should have a positive

impact on the school board provided \$5720 is available for energy conservation. Since money can be borrowed from a bank for far less than 25 percent, the board would save money even if it had to borrow the funds to install the windows.

Energy savings can help profits go up by keeping costs down.

D. REDUCING VENTILATION FAN RUNNING TIME

The energy programs manager for a school district counted 34 ventilation fans in the school system that ran all the time. He decided that 10 hours a day, 5 days a week would be enough. This reduced the usage by 118 hours a week. He had his maintenance chief total the horsepower of the fan motors. The total was 102 hp. The questions were, how much would be saved if the custodial staff turned the fans off and would it be wise to install timers to automatically turn the fans off.

Data Collection

1. Energy Saved by reduced fan time

	102	horsepower(hp) saved
x	.746	kilowatts/hp
	76	kilowatts
x	6136	hrs/yr (118 hrs/week x 52 wks/yr)
	466901	KWH/yr

2. Energy cost for electricity

From Utility bills	.055 \$/KWH
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3. Cost of timers installed

\$ 15.00	cost of timer
+ 12.50	labor/timer
\$ 27.50	cost/timer and installation
x 34	timers needed
\$ 935.00	cost of timers installed

4. Capital Equipment Cost

\$ 15.00	cost of timer
x 34	timers
\$ 510.00	capital equipment cost

5. Labor cost to manually turn off fans

	1/6	hour/fan/day (estimated time)
x \$	8.75	cost of staff/hour
	\$ 1.46	cost/fan/day
x	34	fans
	49.58	cost/day
x	260	days (5 dys/wk x 52 wks/yr)
	\$12892.00	cost of labor/year

6. Estimated life of timers

From vendor 5 years

7. Estimated life of idea

(In order to compare two options, we use the same life). 5 years

Economic Analysis

Option A (Manual turn off)

First Cost	FC = 0
Capital Equipment Cost	CEC = 0
Annual Energy Savings	AES = 466,901
Annual Operating Costs	AOC = 12,892
Projected Energy Costs	PEC = 0.055
Expected Life	EL = 5

Option B (Timer turn off)

First Cost	FC = 935
Capital Equipment Cost	CEC = 510
Annual Energy Savings	AES = 466,901
Annual Operating Costs	AOC = 0
Projected Energy Costs	PEC = 0.055
Expected Life	EL = 5
Expected Income Tax Rate	TR = .50

1. Calculate payback for Option A

$$PP_A = \frac{FC}{AES \times PEC - AOC}$$

Since there is no first cost, the payback period for Option A is zero and has no meaning.

2. Calculate payback for Option B

$$PP_B = \frac{935}{466901 \times 0.055 - 0}$$

$$= .036 \text{ years}$$

$$= .4 \text{ months (about 2 weeks)}$$

3. Calculate return on investment for Option A

$$ROI_A = \frac{(AES \times PEC) - AOC - DC}{FC}$$

Since there is no first cost, the return on investment for Option A is infinite and has no meaning.

4. Calculate return on investment for Option B

$$\begin{aligned} ROI_B &= \frac{466901 \times 0.055 - 510/5}{935} \\ &= 27.36 \\ &= 2736\% \end{aligned}$$

5. Calculate present worth for Option A

$$PW_A = (AES \times PEC - AOC + DC \times TR)(P/A, 15, 5) - FC$$

Even though the life of Option A is forever, in order to compare apples to apples the two options must be compared at equal lives. Thus we assume 5 years for both options.

$$\begin{aligned} &= (466901 \times 0.055 - 12892) \\ &= \$ 12,788 \end{aligned}$$

6. Calculate present worth for Option B

$$\begin{aligned} PW_B &= (AES \times PEC - AOC + DC \times TR)(P/A, 15, 5) - FC \\ &= (466901 \times 0.055 + 102 \times .50)(3.352) - 935 \\ &= 85,314 \end{aligned}$$

Conclusions

The payback period and return on investment analyses proved meaningless in this case because there was no first cost in Option A. Thus, it was not possible to compare the two options using PP or ROI methods. However, the present worth analysis method showed that the investment of 935 dollars

in timers was well worth it. The savings over five years for Option A was equivalent to getting \$12,788 today. For Option B, the present worth of the five years savings was \$85,314. The fact that Option B resulted in nearly 6.7 times the present worth of Option A means that the timers are an excellent investment. Surely the school board would authorize \$935 to save an additional \$75,526

One might argue that the custodians time is going to be paid with or without the duty to turn off fans. Nonetheless, they are being paid to do other things which will have to be foregone if the fans switches need to be switched.

Cutting energy waste cuts energy cost

E. RECYCLING BOILER CONDENSATE

The facilities engineer of a factory noted that the condensate from a boiler is being poured down the drain. Using a thermometer he determined that the dumped condensate water averaged 180°F while the makeup water averaged 60°F. The boiler was running at 168 gallons of water per hour. The boiler itself is rated at 80% efficiency. The records indicated that the boiler was being used for 48 hours a week. Obviously, recycling the condensate water would reduce the natural gas needed to operate the boiler. The recycling would require a 2 hp pump and some piping. The question was would the energy savings be worth the change?

Data Collection

1. Energy savings from recycling

$$\begin{array}{rcl} & 168 & \text{gallons/hour} \\ \times & 8.33 & \text{lbs. of water/gallon} \\ \hline & 1400 & \text{lbs/hour} \\ \times & 120 & ^\circ\text{F temperature difference (180}^\circ\text{F} - 60^\circ\text{F)} \\ \hline 168000 & \text{lbs } ^\circ\text{F/hr} & \end{array}$$

Since 1 BTU is define as the energy needed to raise one pound of water one degree F,
168000 lbs $^\circ\text{F}$ =

$$\begin{array}{rcl} 168000 & \text{BTU/hr} & \\ \div & .80 & \text{efficiency of boiler} \\ \hline 210000 & \text{BTU/hr} & \\ \times & 2496 & \text{hrs/yr (48 hrs/wk x 52 wks/yr)} \\ \hline 524160000 & \text{BTU/yr} & \\ \div & 1000000 & \text{BTU/MCF} \\ \hline 524 & \text{MCF/yr} & \end{array}$$

2. Projected Cost of Energy

From the utility bill 3.80 dollars/MCF

3. Cost to implement the idea

\$	85	cost of pump and motor
	15	cost of piping
+	75	cost of labor
	<u>175</u>	cost to implement the idea

4. Capital Equipment Cost

\$	85	cost of pump
+	15	cost of piping
	<u>\$ 100</u>	capital equipment cost

5. Cost to operate recycling system

	2	horsepower (HP) of pump
x	.746	KW/HP
	<u>1.495</u>	KW
÷	.80	motor efficiency
	<u>1.865</u>	KW
x	2496	hrs/yr
	<u>4655</u>	KWH/yr
x \$	.055	price per KWH (taken from utility bill)
	<u>\$ 256</u>	cost to operate recycling system/yr

6. Estimated life of boiler and pump

From pump vendor 4 years

Economic Analysis

First Cost	FC = 175
Capital Equipment Cost	CEC = 100
Annual Energy Savings	AES = 524
Annual Operating Cost	AOC = 256
Projected Energy Cost	PEC = 3.8
Expected Life	EL = 4
Expected Income Tax Rate	TR = .50

1. Calculate payback period

$$PP = \frac{FC}{AES \times PEC - AOC}$$

$$= \frac{175}{524 \times 3.8 - 256}$$

$$= .10 \text{ years}$$

$$= 1.2 \text{ months}$$

2. Calculate return on investment

$$ROI = \frac{(AES \times PEC) - AOC - DC}{FC}$$

$$= \frac{524 \times 3.8 - 256 - 100/4}{175}$$

$$= 9.77$$

$$= 977\%$$

3. Calculate present worth

$$PW = (AES \times PEC - AOC + DC \times TR)(P/A, 15, 4) - FC$$

$$= (524 \times 3.8 - 256 + 25 \times .50)(3.170) - 175$$

$$= \$5365$$

Conclusions

The idea seems well worth the \$175 to install the pump. The cost of the pump will be returned with 1.2 months of savings. The investment in a pump will payback at a rate of 977 percent. The total idea over a period of 4 years is equivalent to \$5365 in present worth.

Not managing your heating and air conditioning systems is like blowing money out the door.

F. SHIFTING ELECTRICAL DEMAND PEAK

A grocery store chain operated 52 outlets. Each store had four 3 horsepower cooler compressors. Although the compressors ran only 20 percent of the time, it was not uncommon for 3 to be running simultaneously. An energy auditor suggested using a timer mechanism to cycle the compressors so that no more than one would be on at a time. The electric utility was charging \$5.20 per peak kilowatt. The question was, would the idea pay off?

Data Collection

1. Kilowatt savings

Because other electrical usage was fairly constant, an occurrence of 3 compressors on at once caused the peak. If only one were allowed on then the peak savings is equivalent to 2 compressors.

	2	compressors
x	3	HP/compressor
	6	HP
x	.746	KW/HP
	4.476	KW/store
x	52	stores
	233	KW/month
x	12	billing periods/year
	2796	KW/year

2. Cost of energy

from utility 5.20 dollars/KW

3. Cost to implement

bid from electrical contractor 143 dollars/store
x52
7436 dollars

4. Expected life of timers

from electrical contractor

10 years

Economic Analysis

First Cost	FC = 7436
Capital Equipment Cost	CEC = 7436
Annual Energy Savings	AES = 2796
Annual Operating Cost	AOC = 0
Projected Energy Cost	PEC = 5.20
Expected Life	EL = 10
Expected Income Tax Rate	TR = .50

1. Calculate payback period

$$\begin{aligned} PP &= \frac{FC}{AES \times PEC - AOC} \\ &= \frac{7436}{2796 \times 5.20 - 0} \\ &= .51 \text{ years} \\ &= 6 \text{ months} \end{aligned}$$

2. Calculate return on investment

$$\begin{aligned} ROI &= \frac{(AES \times PEC) - AOC - DC}{FC} \\ &= \frac{2796 \times 5.20 - 7436/10}{7436} \\ &= 1.86 \\ &= 186 \text{ percent} \end{aligned}$$

3. Calculate present worth

$$\begin{aligned} PW &= (AES \times PEC - AOC + DC \times TR)(P/A, 15, 10) - FC \\ &= (2796 \times 5.20 + 743.6 \times .50)(5.847) - 7436 \\ &= 79,778 \end{aligned}$$

Conclusions

The installation of timer circuits to cycle the compressors is a very good idea. The initial investment will pay for itself in about 6 months. The return on investment will be 186 percent. If the system operates for 10 years, the energy savings will total to a figure equivalent to 79,778 dollars in present worth.

**Look High *and* low—there *are*
ways to save money on energy**

PART 3
INFLATION, DEPRECIATION AND TAXES

Inflation:

Everyone knows that inflation creates severe cost consequences. The double-digit inflation of the past few years has increased the price of everything. This means that energy conservation investments that you can afford today will cost a lot more if you wait next year. In addition, energy saved today will represent greater dollar savings next year. Therefore, if you have the money, it is probably worth your while to implement conservation measures as soon as you can.

In order to estimate the impact of inflation on costs, consider the following table.

Inflation Factor Table *

Energy Inflation Rate	Years							
	1	2	3	4	5	10	15	20
10%	1.05	2.21	3.50	4.92	6.49	17.18	34.82	63.89
15%	1.08	2.33	3.79	5.48	7.45	23.21	56.58	127.24
20%	1.11	2.46	4.11	6.13	8.59	31.95	95.43	267.99
25%	1.14	2.59	4.47	6.87	9.96	44.73	166.08	589.65

*This table assumes energy costs inflate continuously throughout the year.

These figures represent cost increase factors for 1, 2, 3, 4, 5, 10, 15 and 20 years into the future should the inflation rate be 10, 15, 20 or 25 percent. For example, if energy cost inflation averages 20 percent over the next 5 years, then the total utility bills over the five years will be 8.59 times what they are today. Conversely, if your utility bills for the past 12 months total \$2500 and a conservation program will save 20 percent or \$500 based on last year's costs, then over the next five years, the total savings will be $500 \times 8.59 = \$4295$.

When looking at investment opportunities, the true impact of inflation comes when different costs inflate at different rates. We have seen, for example, that the cost of some energy saving equipment is increasing at a much slower rate than the consumer price index. This is due to the economy of scale and the commercialization of new technologies. It's hard to envision the cost of solar equipment going down, but the more the nation adopts this technology, the slower the cost increases will be. On the other hand, since 1973, the cost of energy itself is increasing faster than the consumer price index. These costs are increasing because the price of oil and natural gas are going up faster than the price of other commodities. All indications suggest that energy costs will continue to inflate at a faster rate.

What does this all mean when you're analyzing an energy conservation measure. Suppose a measure involves three cost items; 1) a need to buy a piece of equipment which is inflating slower than normal; 2) a reduction in energy consumption the cost of which is inflating faster than normal; and 3) a change in the cost of labor and materials which are

inflating at the normal rate. Then, when we project the cost of these items to future years, they will all change at different rates. If the differences in these inflation rates is significant we should consider them in projecting costs. If this is the case in your company, it would be wise to consult your tax accountant or a local energy auditor/engineer.

Depreciation

Depreciation is an accounting mechanism used to describe the "consumption" of capital equipment. United States tax law, as well as various state laws, realize that part of a business's income should be set aside to replace worn-out equipment. Thus depreciation reduces the company's income tax liability. Obviously, any money invested in equipment to conserve energy offers an additional savings due to reduced income taxes.

A second reason for considering depreciation is to keep the account books up-to-date. Since no equipment will last forever, it is necessary that funds be gradually accounted for as though they were being set aside to replace the equipment when it wears out. In fact, these funds enter a general pool for additional capital investment.

The method for calculating depreciation and the equipment qualification requirements are not simple. The determination of allowable depreciation for energy conservation equipment should likely be referred to your tax accountant.

Income Tax Credits

In addition to the normal depreciation write-offs for energy conservation equipment, the IRS and most states offer direct income tax credits. That is to say, the federal and state governments are willing to pay part of the cost to purchase energy saving equipment. Thus the initial cost to implement certain measures is reduced for you, the business.

Tax credits from the Federal IRS come in two categories. First is the general business investment tax credit. Any investment, including energy saving opportunities, can receive a tax credit writeoff. The 1980 Federal Tax Manual requires that the capital item be depreciable and have a life of three or more years. For such items, you may be able to write off 10 percent of the initial cost.

A second tax credit category is for energy conservation equipment only. Any conservation equipment which uses an energy source other than hydroelectric, coal, oil, or natural gas qualifies for this write-off. Thus equipment to make use of solar, wind, recycled materials or the like can qualify. The tax credit offered in The 1980 Federal Tax Manual is for 10 percent of the initial cost. To learn what the total allowable tax credit is in your state, contact your tax accountant or the Federal and State Tax Offices.

Let us summarize this part of the workbook. A number of points have been discussed which can affect the economic benefits inherent in energy conservation. As noted, these benefits should be fully explored with your tax accountant. Inflation rates in energy costs are greater than the consumer price index. This fact makes it wise to invest in

energy conservation as soon as you can afford to do so. Depreciation of energy saving capital equipment will increase the savings you realize by reducing the tax liability of your business. Finally, federal and state tax laws allow direct tax credits which reduce the initial cost of conservation investment. These tax issues make it cheaper to attain meaningful energy savings.

**You can wrangle more dollars in savings by having an
on-going energy management program**

APPENDIX

Value for the Single Payment Present Worth Factor ($P/F, i, n$) and the Uniform Series Present Worth Factor ($P/A, i, n$) for various values of n and i .

	$i = .10$		$i = .12$		$i = .15$		$i = .20$	
<u>n</u>	<u>P/F, i, n</u>	<u>P/A, i, n</u>	<u>P/F, i, n</u>	<u>P/A, i, n</u>	<u>P/F, i, n</u>	<u>P/A, i, n</u>	<u>P/F, i, n</u>	<u>P/A, i, n</u>
1	0.9091	0.909	0.8929	0.893	0.8696	0.870	0.8333	0.833
2	0.8264	1.736	0.7972	1.690	0.7561	1.626	0.6944	1.528
3	0.7513	2.487	0.7118	2.402	0.6575	2.283	0.5787	2.106
4	0.6830	3.170	0.6355	3.037	0.5718	2.855	0.4823	2.589
5	0.6209	3.791	0.5674	3.605	0.4972	3.352	0.4019	2.991
6	0.5645	4.355	0.5066	4.111	0.4323	3.784	0.3349	3.326
7	0.5132	4.868	0.4523	4.564	0.3759	4.160	0.2791	3.605
8	0.4665	5.335	0.4039	4.968	0.3269	4.487	0.2326	3.837
9	0.4241	5.759	0.3606	5.328	0.2843	4.772	0.1938	4.031
10	0.3855	6.144	0.3220	5.650	0.2472	5.019	0.1615	4.192
11	0.3505	6.495	0.2875	5.938	0.2149	5.234	0.1346	4.327
12	0.3186	6.814	0.2567	6.194	0.1869	5.421	0.1122	4.439
13	0.2897	7.103	0.2292	6.424	0.1625	5.583	0.0935	4.533
14	0.2633	7.367	0.2046	6.628	0.1413	5.724	0.0779	4.611
15	0.2394	7.606	0.1827	6.811	0.1229	5.847	0.0649	4.675
16	0.2176	7.824	0.1631	6.974	0.1069	5.954	0.0541	4.730
17	0.1978	8.022	0.1456	7.120	0.0929	6.047	0.0451	4.775
18	0.1799	8.201	0.1300	7.250	0.0808	6.128	0.0376	4.812
19	0.1635	8.365	0.1161	7.366	0.0703	6.198	0.0313	4.844
20	0.1486	8.514	0.1037	7.469	0.0611	6.259	0.0261	4.870