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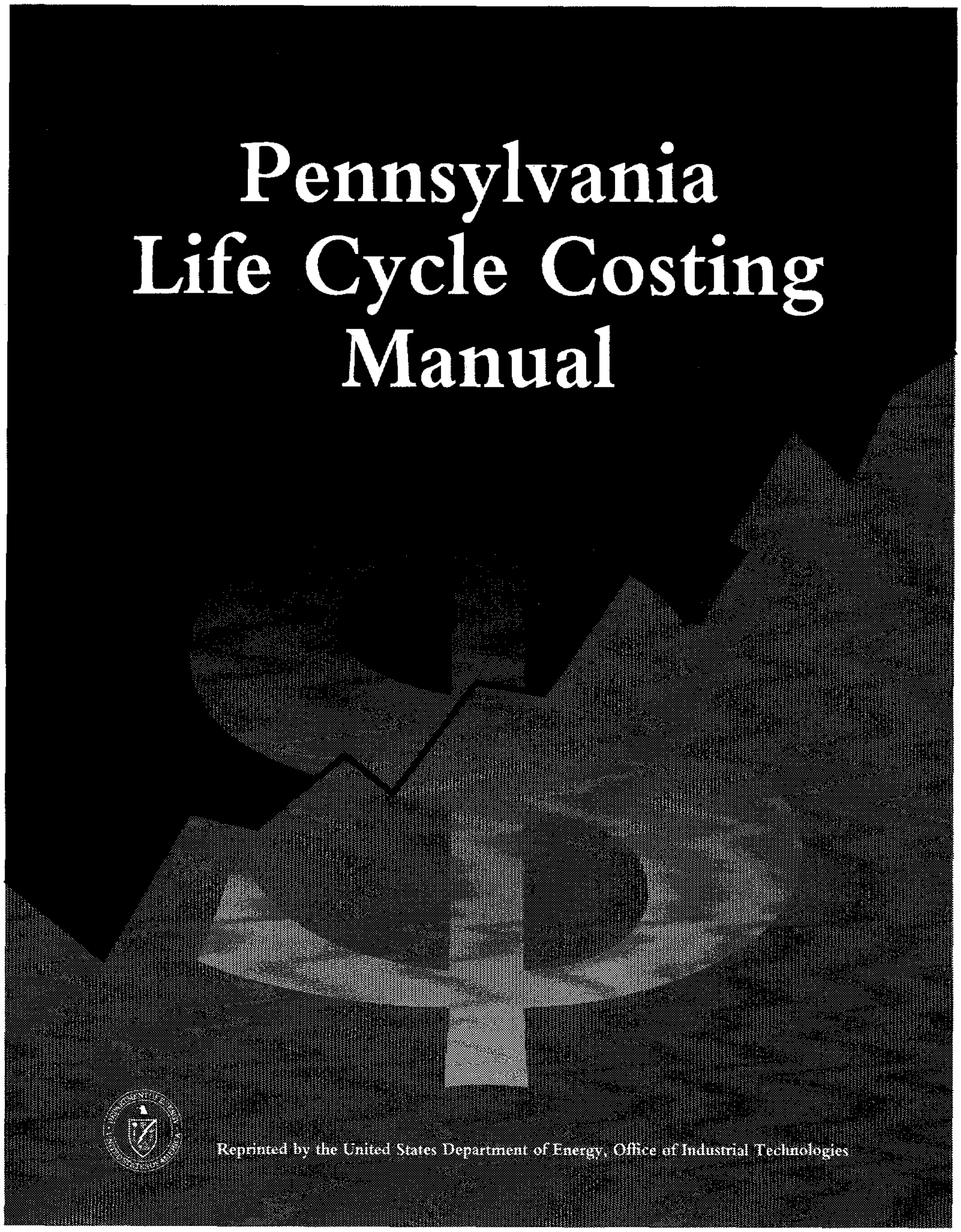

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Department of Energy
Washington, DC 20585

Dear Energy Professional:

The Department of Energy is pleased to reprint the *Pennsylvania Life Cycle Costing Manual*. This manual was designed to help companies evaluate their expenditures by factoring purchase and operating costs over the life of new equipment. The Pennsylvania State Energy Office originally published this document and diskette in June 1992. In the summer of 1995 the energy office was closed and some of their responsibilities were absorbed by other State offices. The Environmental Protection Agency, Bureau of Energy Services gave reprinting rights, for this publication, to the United States Department of Energy, Office of Industrial Technologies (OIT) which promotes energy-efficiency in industry. OIT is also working with partners to develop energy-efficient technology focusing on seven energy-intensive industries; aluminum, chemicals, forest products, glass, metal casting, refining, and steel.

If you need additional information or assistance, please contact the Department of Energy Regional Support Office nearest you. These offices can be found by contacting the **E**nergy Efficiency and **R**enewable **E**nergy **C**learinghouse (EREC) at 1-800-DOE-EREC. The clearinghouse also maintains a library of free publications on energy efficiency, renewable energy, and pollution prevention. You can reach the EREC bulletin board system with a computer modem at 1-800-273-2955. The bulletin board contains these Lotus worksheet files and portions of this instruction manual. You may also contact OIT's World Wide Web site on the Internet at http://www.eren.doe.gov/industry/

Sincerely,

Denise F. Swink

Denise F. Swink
Deputy Assistant Secretary
for Industrial Technologies
Energy Efficiency and Renewable Energy

Printed with soy ink on recycled paper

Printed in the United States of America.

The information contained in this publication was originally prepared by Hansen Associates, Inc., and BENATECH under contract with the Pennsylvania Energy Office. Any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the PEO or the U.S. Department of Energy.

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BACKGROUND

Until the 1970s, it was commonplace for institutions and governments to purchase equipment based on lowest initial (first) costs. Recurring costs such as operational, maintenance, and energy costs often were not considered in the purchase decision. If an agency wanted to buy something, it published specifications and requested bids from several manufacturers. Often, the lowest bidder who met the specifications won the job, with no consideration given to the economic life of the equipment or yearly recurring costs such as energy and maintenance costs.

The practice of purchasing based on lowest initial costs probably did not make good economic sense prior to 1970, and it certainly does not make good sense now. The wise person will consider all costs and benefits associated with a purchase, both initial and post-purchase, in order to make procurement decisions that are valid for the life of the equipment.

The method of financial analysis that considers all pertinent costs is life cycle costing (LCC). In LCC, all of the following factors are considered for the life of the equipment:

- Initial costs--including freight and installation
- Training costs--to prepare people to use the particular equipment
- Energy costs--annual energy costs
- Operation and maintenance costs--annual labor, parts, technical service
- Salvage value--may be an expense for removal or a deduction of costs if it can be converted into cash through sale
- Escalation rates--estimated inflation rates of costs (may be different rates for different costs)
- Discount rate--the rate at which future cash flows are brought back to the present to compare present values of costs and savings.

PAYBACK METHOD

Before detailing life cycle costing, let's consider a common method of investment analysis known as the payback method (payback period) or simple payback method (simple payback period). This is a relatively simple and widely used method that gives the number of years required to recoup the initial investment.

Example 1

Consider two alternative heating, ventilating and air conditioning (HVAC) systems which could possibly replace an inefficient HVAC system. The costs and savings of each system are shown below:

	System A		**System B**	
Initial Cost	$10,000		$20,000	
Annual Energy Cost Savings	Yearly Savings (A)	Cumulative Savings (A)	Yearly Savings (B)	Cumulative Savings (B)
Year 1	2,000	2,000	3,000	3,000
Year 2	2,300	4,300	3,450	6,450
Year 3	2,650	6,950	3,950	10,400
Year 4	3,050	**10,000**	4,450	14,850
Year 5	3,500	13,500	5,150	**20,000**
Year 6	4,025	17,525	5,900	25,900
Year 7	4,625	22,150	6,800	32,700
Year 8	--	22,150	7,800	40,500
Year 9	--	22,150	9,000	49,500
Year 10	--	22,150	10,300	59,800
(There are no savings for years 8-10 for System A because its expected life is 7 years; B's life is 10 years. Also, the above energy costs are escalated at approximately 15% per year.)				

Selection of a system based solely on first cost would indicate System A. Selection based on payback would still indicate A, because it pays for itself in four years while B pays for itself after five years.

This can lead to a poor decision since there are several factors that are not considered in the payback method that are crucial to making the most cost effective decision. First, note that System A will have to be replaced after seven years while B will have three more years of useful life, with additional energy savings accruing to the owner during those years. Second, there has been no mention of maintenance costs for either system. Third, the time value of money has not been recognized.

LIFE CYCLE COSTING

The economic analysis method that takes into account most of the shortcomings of the payback method is known as life cycle costing (LCC). As its name implies, LCC is simply a method of calculating the total cost incurred with the ownership, lease or rental of a facility or equipment over its lifetime.

There are several different methods of LCC analysis that the professional can use to make a purchase decision. (Although leasing and rental are also options for a building, it is assumed that the facility will use a financial advisor to evaluate ownership, leasing, and rental options.) The purpose of this LCC primer is to acquaint building owners and managers with basic life cycle costing methodology, so they can evaluate the financial viability of typical energy conservation measures. For illustrative purposes, a purchase situation will be considered throughout the primer. A specific LCC example will be considered later, but first it is necessary to understand the concept of "time value of money" (TVOM).

TIME VALUE OF MONEY

In analyzing any cost, investment, or stream of cash flows, it is extremely important to recognize that money has a time value. As an illustration, consider the option of receiving a $100 bill now or $100 bill one year from now. Most people would rather have the $100 bill now because they can invest it and earn a return on their investment. For example, $100 invested now will earn $15 in one year if invested at a 15 percent rate of return. The investor will have a total of $115 at the end of one year. Even with zero inflation, money in the future is worth less than the same amount of money now. Again, this is because money can be invested now to earn a return on the investment for the investor.

Similarly, cash in the future can be "discounted" to the present through the use of discount formulas and tables that are the inverse of the familiar compound interest formulas and tables. This allows us to determine the present value of a future amount of money (such as might be saved annually by an energy conservation measure). These discount tables allow money to be moved from the future to the present to compare the present value of future cash flows (e.g., energy cost savings) with the present value of any initial investment. It is extremely important to compare "apples to apples" or present values to present values to determine if an energy conservation investment makes sense.

The present value discount table on the following page shows the different discount factors versus the number of years the cash flow is to be discounted. An example will explain the use of this table.

PRESENT VALUE DISCOUNT FACTOR TABLE

Formula: Discount Factor = $1/(1+i)^n$

Where: i = Discount rate in decimal form
n = period in number of years

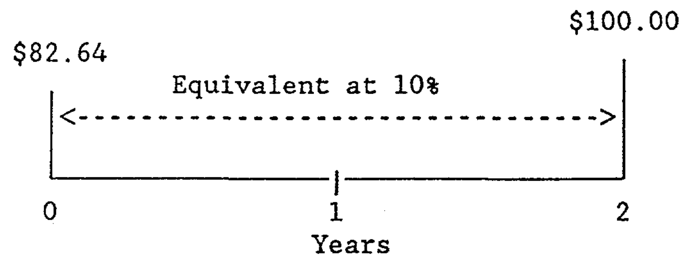
DISCOUNT RATE PERCENT

PERIOD (YEARS)	0%	2%	4%	5%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	25%
1	1.0000	.9804	.9615	.9524	.9434	.9259	.9091	.8929	.8772	.8696	.8621	.8475	.8333	.8197	.8000
2	1.0000	.9612	.9246	.9070	.8900	.8573	.8264	.7972	.7695	.7561	.7432	.7182	.6944	.6719	.6400
3	1.0000	.9423	.8890	.8638	.8396	.7938	.7513	.7118	.6750	.6575	.6407	.6086	.5787	.5507	.5120
4	1.0000	.9238	.8548	.8227	.7921	.7350	.6830	.6355	.5921	.5718	.5523	.5158	.4823	.4514	.4096
5	1.0000	.9057	.8219	.7835	.7473	.6806	.6209	.5674	.5194	.4972	.4761	.4371	.4019	.3700	.3277
6	1.0000	.8880	.7903	.7462	.7050	.6302	.5645	.5066	.4556	.4323	.4104	.3704	.3349	.3033	.2621
7	1.0000	.8706	.7599	.7107	.6651	.5835	.5132	.4523	.3996	.3759	.3538	.3139	.2791	.2486	.2097
8	1.0000	.8535	.7307	.6768	.6274	.5403	.4665	.4039	.3506	.3269	.3050	.2660	.2326	.2038	.1678
9	1.0000	.8368	.7026	.6446	.5919	.5002	.4241	.3606	.3075	.2843	.2630	.2255	.1938	.1670	.1342
10	1.0000	.8203	.6756	.6139	.5584	.4632	.3855	.3220	.2697	.2472	.2267	.1911	.1615	.1369	.1074
11	1.0000	.8043	.6496	.5847	.5268	.4289	.3505	.2875	.2366	.2149	.1954	.1619	.1346	.1122	.0859
12	1.0000	.7885	.6246	.5568	.4970	.3971	.3186	.2567	.2076	.1869	.1685	.1372	.1122	.0920	.0687
13	1.0000	.7730	.6006	.5303	.4688	.3677	.2897	.2292	.1821	.1625	.1452	.1163	.0935	.0754	.0550
14	1.0000	.7579	.5775	.5051	.4423	.3405	.2633	.2046	.1597	.1413	.1252	.0985	.0779	.0618	.0440
15	1.0000	.7430	.5553	.4810	.4173	.3152	.2394	.1827	.1401	.1229	.1079	.0835	.0649	.0507	.0352
16	1.0000	.7284	.5339	.4581	.3936	.2919	.2176	.1631	.1229	.1069	.0930	.0708	.0541	.0415	.0281
17	1.0000	.7142	.5134	.4363	.3714	.2703	.1978	.1456	.1078	.0929	.0802	.0600	.0451	.0340	.0225
18	1.0000	.7002	.4936	.4155	.3503	.2502	.1799	.1300	.0946	.0808	.0691	.0508	.0376	.0279	.0180
19	1.0000	.6864	.4746	.3957	.3305	.2317	.1635	.1161	.0829	.0703	.0596	.0431	.0313	.0229	.0144
20	1.0000	.6730	.4564	.3769	.3118	.2145	.1486	.1037	.0728	.0611	.0514	.0365	.0261	.0187	.0115
21	1.0000	.6598	.4388	.3589	.2942	.1987	.1351	.0926	.0638	.0531	.0443	.0309	.0217	.0154	.0092
22	1.0000	.6468	.4220	.3418	.2775	.1839	.1228	.0826	.0560	.0462	.0382	.0262	.0181	.0126	.0074
23	1.0000	.6342	.4057	.3256	.2618	.1703	.1117	.0738	.0491	.0402	.0329	.0222	.0151	.0103	.0059
24	1.0000	.6217	.3901	.3101	.2470	.1577	.1015	.0659	.0431	.0431	.0284	.0188	.0126	.0085	.0047
25	1.0000	.6095	.3751	.2953	.2330	.1460	.0923	.0588	.0378	.0378	.0245	.0160	.0105	.0069	.0038

Example 2

What is the present value of $100 two years from now discounted to the present at (a) 10%?, (b) 15%?, (c) 20%?

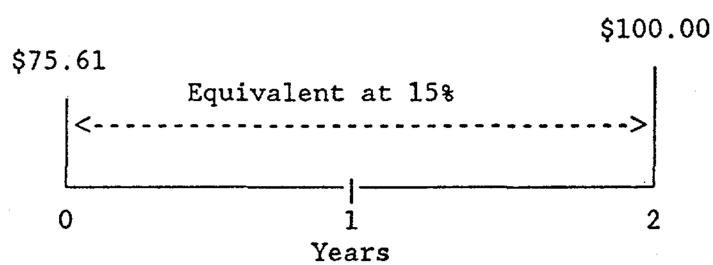
(a) Enter the discount table at 10 percent and two years and identify the present value factor (or present worth factor) .8264. Now multiply $100 by .8264 to obtain $82.64 as the present or discounted value of $100 two years from now. This can be illustrated by a cash flow diagram as shown below:



What this means is that if you could earn 10 percent on your money for two years and you were offered $82.64 now or $100 two years from now, you would be neutral as to which you would accept. If you were offered $90 now or $100 two years from now and you could earn 10 percent on your money, you would opt for the $90 now. Similarly, if you were offered $80 now and you could earn 10 percent on your money, you would take the $100 two years from now.

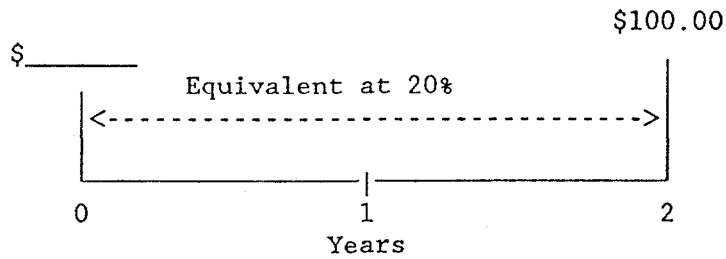
(b) At 15 percent, the discount factor is .7561. So $100 two years from now is worth ($100) (.7561) = $75.61 now (present value).

The cash flow diagram is:



Would you rather have $80 now or $100 two years from now if you could earn 15% on your money? How about $70 now versus $100 two years from now at 15%?

(c) Try this one. It's as easy as the other two.



Because investment in energy conservation equipment involves cash outlay now with benefits in the form of energy and dollar savings occurring in the future, it is necessary to use life cycle costing techniques combined with time value of money techniques to make valid energy conservation decisions. As was the case previously, this can best be illustrated through an example.

Example 3

Three electric hot water heaters are functioning well, but at $.06/KWH there is concern about excessive hot water heating costs for the building. You are considering different options for reducing these costs, including heat pump water heaters (HPWHs). You have determined that a currently available HPWH can be installed for $800/year ($2400 for three). Your energy analysis (or that of a reputable energy management consultant or contractor) has estimated a monthly energy savings of 400 KWH per water heater. The HPWHs will function for ten years with an annual maintenance cost of $50 per heater. The salvage value of the HPWHs is zero. Energy prices are expected to escalate 10 percent per year. If your agency's cost of money (capital) is 12 percent, should you purchase the HPWHs?

Solution to Example 3

The first step is to determine yearly cash flows.

Year 0 (Now)

-Purchase three HPWHs for $800 each $800/HPWH x 3 HPWH = $2400.

Annual Cash Flows

-Annual Energy Costs Savings:

400 KWH/month/HPWH x 12 months/year x HPWH = 14,400 KWH/year saved.

14,400 KWH/year saved x $.06/KWH = $864 saved in the first year.

(Note: Energy and cost savings will occur throughout the year, but for analysis purposes, we will assume they occur at the end of each year. This allows us to use the standard Present Value Discount Table presented previously. Results based on this assumption are typically well within the accuracy range necessary for making a decision.)

These savings increase at the rate of 10 percent per year because of energy price escalation of 10 percent per year:

Years	1	2	3	4	5	6	7	8	9	10
Energy Cost Savings	$864	950	1045	1150	1265	1391	1531	1684	1852	2037

The above steps can be combined to yield the following cash flow table:

	Years										
	0	1	2	3	4	5	6	7	8	9	10
Initial Cost	$2400										
Energy Cost Savings		$864	950	1045	1150	1265	1391	1531	1684	1852	2037
Less O&M Costs		-150	-150	-150	-150	-150	-150	-150	-150	-150	-150
Change in Cash Flow	($2400)	$714	800	895	1000	1115	1241	1381	1534	1702	1887

With the cash flows now determined, we use the discount factors to determine the net present value (NPV) of this investment. The NPV of an investment is equal to the present value (PV) of the savings minus the present value (PV) of the initial investment. To determine NPV, each cash flow must be brought back to the present through the use of the appropriate discount factor at 12 percent for each year. NPV is determined by subtracting the PV (initial cost or investment) from the PV (savings), or NPV = PV (savings) - PV (cost or investment). If the NPV is greater than zero at 12 percent, the investment will be acceptable; if the NPV is less than zero, we will reject the investment.

From the discount factor table, the 12 percent discount factors for each year are:

Years	1	2	3	4	5	6	7	8	9	10
Discount Factor	.8929	.7972	.7118	.6355	.5674	.5066	.4523	.4039	.3606	.3220

Multiplying the above factor by the corresponding yearly cash flow savings, we obtain the following present values:

Year 0 (Now)
Present Value Cost: $2400 x 1.000 = $2400
(Discount factor is 1)

Energy Cost Savings		Disc. Factor		PV Savings
Year 1 PV = 714	x	.8929	=	$ 638
Year 2 PV = 800	x	.7972	=	638
Year 3 PV = 895	x	.7118	=	637
Year 4 PV = 1000	x	.6355	=	636
Year 5 PV = 1115	x	.5674	=	633
Year 6 PV = 1241	x	.5066	=	629
Year 7 PV = 1381	x	.4523	=	625
Year 8 PV = 1534	x	.4039	=	620
Year 9 PV = 1702	x	.3606	=	614
Year 10 PV = 1887	x	.3220	=	608
Total PV savings			=	$6,278

Net Present Value = PV (Savings) - PV (Investment or Cost)

NPV = $6278 - $2400 = $3,878

Since the NPV is positive, the HPWHs should be purchased. It's like someone wrote you a check for $3,878 in today's dollars!

It is important to note several critical aspects of the NPV procedure:

1. The correct savings (and all other estimates) must be calculated by a competent individual using realistic assumptions. If this is not done properly, the remaining analysis may lead to an invalid decision.

2. The facility's cost of capital must be known or estimated.

3. The above analysis illustrates the net present value technique of LCC. Other valid methodologies are also available for use. This analysis shows that the HPWHs are an acceptable investment. It does not indicate it is the best investment. Other options should be analyzed to see if they might be even better (have a higher NPV).

INTERNAL RATE OF RETURN

The time value of money concept can be taken a step further by asking the question. "What is the actual return on my investment if I purchase the HPWHs?" The answer is the discount rate yielding a net present value of zero. This discount rate is called the project's Internal Rate of Return (IRR). It is equivalent to the interest rate you would earn if you placed your money (for Example 3, $2,400) in a bank account earning the IRR interest rate. It is determined through a trial and error procedure where different discount rates are used to compute NPV. When the NPV is approximately zero, the discount rate that made it zero is the project's IRR. For Example 3, the RR is approximately 37 percent.

CONCLUSION

The purpose of this primer is not to create a financial or engineering economy expert. Rather, it is to illustrate the necessity for considering all relevant factors in a purchase decision so that the professional can make a decision based on valid assumptions and decision criteria. For a more complete discussion of life cycle costing and engineering economy, the bibliography at the end of this section may be helpful. Each of these references has been used in discussing with LCC analyses.

LIFE CYCLE COSTING REFERENCES

1. Grant, Eugene L., W.G. Ireson, and Richard S. Leavenworth, *Principles of Engineering Economy*, 7th Ed., John Wiley & Sons, New York, 1982.

2. Brown, Robert J., Rudolph R. Yanuck, *Life Cycle Costing*, Fairmont Press, Atlanta, 1980. (Note: This is a good source of LCC; however, the original printing had several errors in examples and calculations. Ensure you have appropriate errata for the book or a revised edition that has corrected these errors.)

3. U.S. Department of Commerce/National Bureau of Standards, *Energy Conservation in Buildings: An Economic Guidebook for Investment Decisions (NBS Handbook 132)*, Washington, D.C., 1980.

4. Benator, Barry I., "Microcomputer Applications in Energy Management", *Journal of Microcomputer Applications*, Vol. 10, No. 1, pp. 1-9, 1987.

LIFE CYCLE COSTING EXAMPLE
ENERGY EFFICIENT FLUORESCENT LAMPS

It is time to relamp 1,000 lamps in your building and you are evaluating the use of 34 watt energy efficient fluorescent lamps vs. standard 40 watt lamps. Each type of lamp has a 20,000 hour life. The 34 watt lamp puts out 3%-5% less lumens (light) than the 40 watt lamp, but a lighting survey has revealed that the building is roughly 10% overlit, so the loss of 3%-5% light will still maintain the building within code requirements.

The building's operating hours are 7:00 a.m. to 5:00 p.m., Monday-Friday; 8:00 a.m. to 1:00 p.m. on Saturday; and closed on Sunday. The cost of the standard 40 watt lamp is $1.00 per lamp. The cost of the 34 watt lamp is $1.50 per lamp. Local electrical rate is $.06/KWH (including demand charges). Electrical rate increases are expected to average 5%/year. The agency's discount rate is 10%. O&M costs (e.g., cleaning) are not expected to be different for the two types of lamps.

Should you purchase the 34 watt lamps or the 40 watt lamps if you want to obtain the lowest life cycle cost lamps for your building?

Solution

First, we need to compute how much energy we will save each year by the energy efficient 34 watt lamps. This is done by the following equation:

KWH Saved/Yr =	Watts saved/lamp x no. of lamps x hrs. of operation per year x .001 KWH/WH.

Watts saved = 40 - 34 watts = 6 watts saved per lamp (6 watts/lamp)

Hours of operation per year determined by:

Weekdays: 7 a.m. - 5 p.m. = 10 hours/day or 50 hours/week
Saturday: 8 a.m. - 1 p.m. = 5 hours/day or 5 hours/week

Total hours of operation per week = 55 hrs/wk x 52 wks/yr = 2,860 hrs/yr

Annual KWH savings = 6 watts/lamp x 1,000 lamps x 2,860 hrs/yr x .001 KWH/WH = 17,160 KWH/yr

Next, we need to determine the first year dollar savings. This is done by the following equation:

First year dollar savings = No. KWH/yr. x $/KWH

First year dollar savings = 17,160 KWH/yr x $.06/KWH = $1,030 saved in the first year

Economic Life:

The life of the energy conservation measure is determined by dividing the life of lamps (20,000 hours) by the hours of operation per year, or:

Life = 20,000 hours / 2,860 hours of operation/yr = 7 years

We now develop the cash flow table:

Year 0 (Now)

Purchase 1,000 34 watt lamps. The difference in cost between the 34 watt lamps and the 40 watt lamps is $0.50/lamp. For 1,000 lamps, the cost difference is:

Cost Difference = 1,000 lamps x $0.50/lamp = $500

Annual Cash Flows

First Year Energy Cost Savings = $1,030

(Note: Energy and cost savings will occur through the year, but for analysis purposes, we will assume they occur at the end of each year. This allows us to use the standard end-of-year Present Value Discount Table presented previously. Results based on this assumption are typically well within the accuracy range necessary for making a decision.)

These savings increase at the rate of 5 percent per year because of energy price escalation of 5 percent per year.

Years	1	2	3	4	5	6	7
Energy Cost Savings	$1030	1082	1136	1193	1253	1316	1382

Annual Operations and Maintenance Costs:

There are no additional O&M costs from using the 34 watt lamps, so annual maintenance costs (i.e., the difference in maintenance costs between the 34 watt lamps and the 40 watt lamps) are zero.

The above steps can be combined to yield the following cash flow table:

	Years							
	0	1	2	3	4	5	6	7
Initial Cost	$500							
Energy Cost Savings		$1030	1082	1136	1193	1253	1316	1382
Less O&M Costs		-0	-0	-0	-0	-0	-0	-0
Change in Cash Flow	($500)	$1030	1082	1136	1193	1253	1316	1382

With the cash flows now determined, we use the discount factors to determine the net present value (NPV) of this investment. The NPV of an investment is equal to the present value (PV) of the savings minus the present value (PV) of the initial investment. To determine NPV, each cash flow must be brought back to the present through the use of the appropriate discount factor at 10 percent for each year. NPV is determined by subtracting the PV (initial cost or investment) from the PV (savings), or NPV = PV (savings) - PV (cost or investment). If the NPV is greater than zero at 10 percent, the investment will be acceptable; if the NPV is less than zero, we will reject the investment.

From the discount factor table, the 10 percent discount factors for each year are:

Years	1	2	3	4	5	6	7
Discount Factor	.9091	.8264	.7513	.6830	.6209	.5645	.5132

Multiply the above factor by the corresponding yearly cash flow savings, we obtain the following present values:

Year 0 (Now)
Present Value Cost: $500 x 1.000 = $500
(Discount factor is 1)

Energy Cost Savings		Disc. Factor		PV Savings
Year 1 PV = $1030	x	.9091	=	$ 936
Year 2 PV = 1082	x	.8264	=	894
Year 3 PV = 1136	x	.7513	=	853
Year 4 PV = 1193	x	.6830	=	815
Year 5 PV = 1253	x	.6209	=	778
Year 6 PV = 1316	x	.5645	=	743
Year 7 PV = 1382	x	.5132	=	709
Total PV savings			=	$5728

Net Present Value = PV (Savings) - PV (Investment or Cost)

NPV = $5728 - $500 = $5228

Since the NPV is positive, the energy efficient lamps would be purchased. For this example, the Internal Rate of Return is approximately 210 percent.

Modification

Suppose you had just installed 1,000 standard 40 watt lamps, but after attending an energy seminar you were considering pulling out all the lamps and replacing them with 34 watt energy efficient lamps. Should you do so?

The analysis of this problem is quite straightforward. All the hard work is done. The only cash flow item that has changed is the initial cost. Instead of $500 initial cost, the amount is $1,500 (1,000 lamps times $1.50/lamp = $1,150).

The cash flow diagram is:

	Years							
	0	1	2	3	4	5	6	7
Initial Cost	$1500 (Only item that has changed)							
Energy Cost Savings		$1030	1082	1136	1193	1253	1316	1382
Less O&M Costs		-0	-0	-0	-0	-0	-0	-0
Change in Cash Flow	($1500)	$1030	1082	1136	1193	1253	1316	1382

With the cash flows now determined, we use the discount factors to determine the net present value (NPV) of this investment. The NPV of an investment is equal to the present value (PV) of the savings minus the present value (PV) of the initial investment. To determine NPV, each cash flow must be brought back to the present through the use of the appropriate discount factor at 10 percent for each year. NPV is determined by subtracting the PV (initial cost or investment) from the PV (savings), or NPV = PV (savings) - PV (cost or investment). If the NPV is greater than zero at 10 percent, the investment will be acceptable; if the NPV is less than zero, we will reject the investment.

From the discount factor table, the 10 percent discount factors for each year are:

Years	1	2	3	4	5	6	7
Discount Factor	.9091	.8264	.7513	.6830	.6209	.5645	.5132

Multiplying the above factor by the corresponding yearly cash flow savings, we obtain the following present values:

Year 0 (Now)

Present Value Cost: $1500 x 1.000 = $1500 (Discount factor is 1)

Energy Cost Savings		Disc. Factor		PV Savings
Year 1 PV = $1030	x	.9091	=	$ 936
Year 2 PV = 1082	x	.8264	=	894
Year 3 PV = 1136	x	.7513	=	853
Year 4 PV = 1193	x	.6830	=	815
Year 5 PV = 1253	x	.6209	=	778
Year 6 PV = 1316	x	.5645	=	743
Year 7 PV = 1382	x	.5132	=	709
Total PV savings			=	$5728

Net Present Value = PV (Savings) - PV (Investment or Cost)

NPV = $5728 - $1500 = $4228

Since the NPV is positive, the energy efficient lamps would be purchased. For this example, the Internal Rate of Return is approximately 71 percent.

CHART A

Annual Life Cycle Cost Analysis Heat Pump

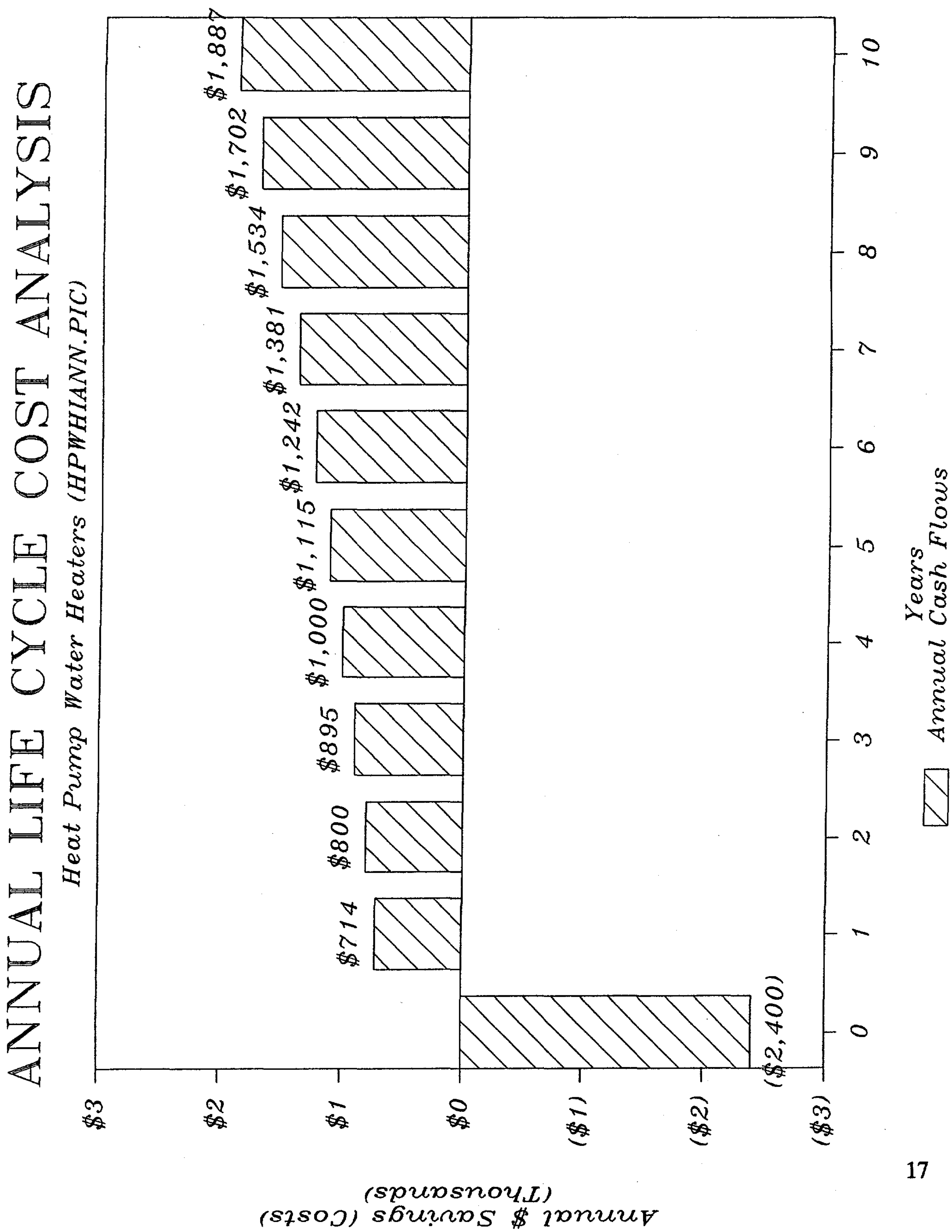


CHART B

Cumulative Life Cycle Heat Pump

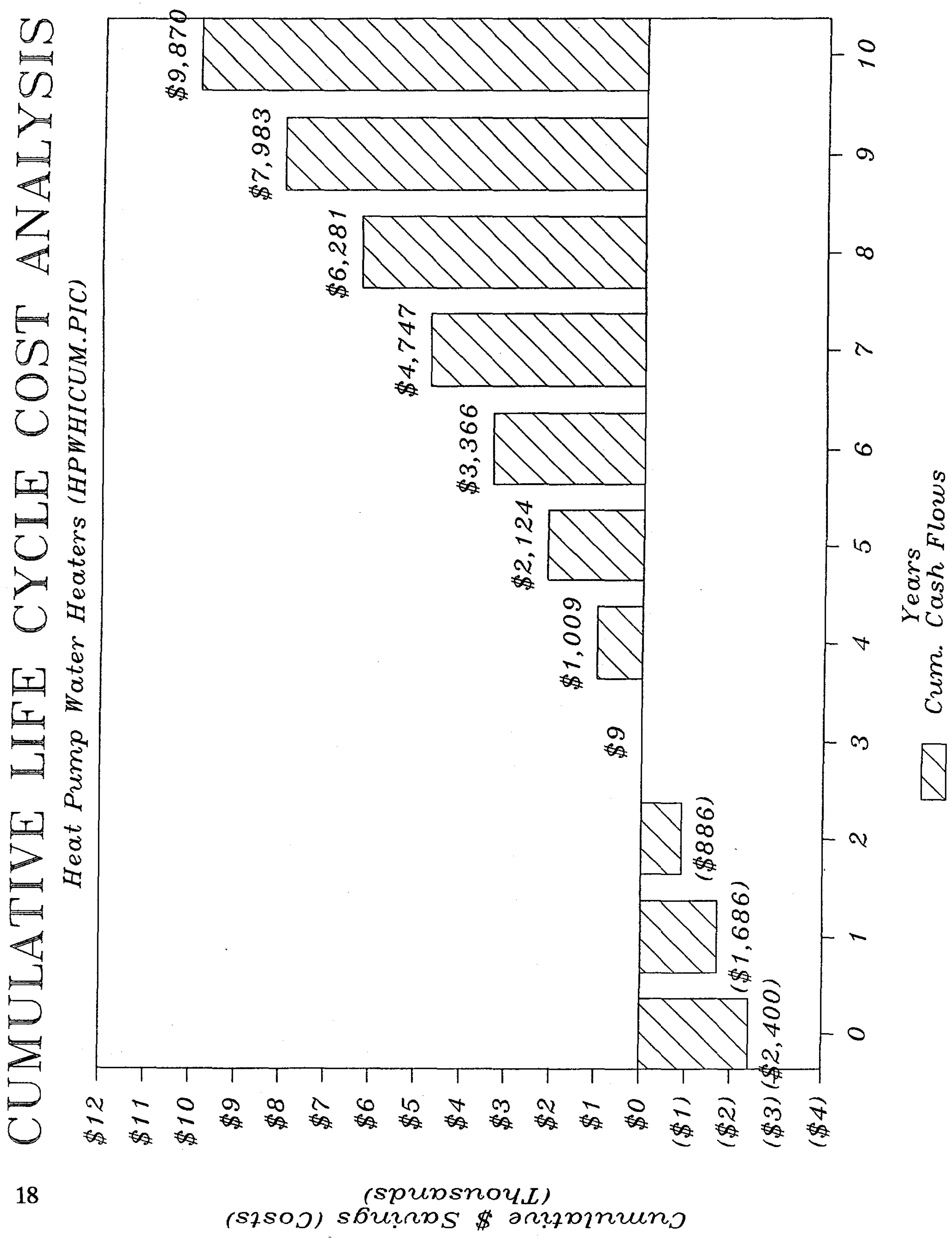


CHART C

Annual Life Cycle Cost Analysis
Fluorescent

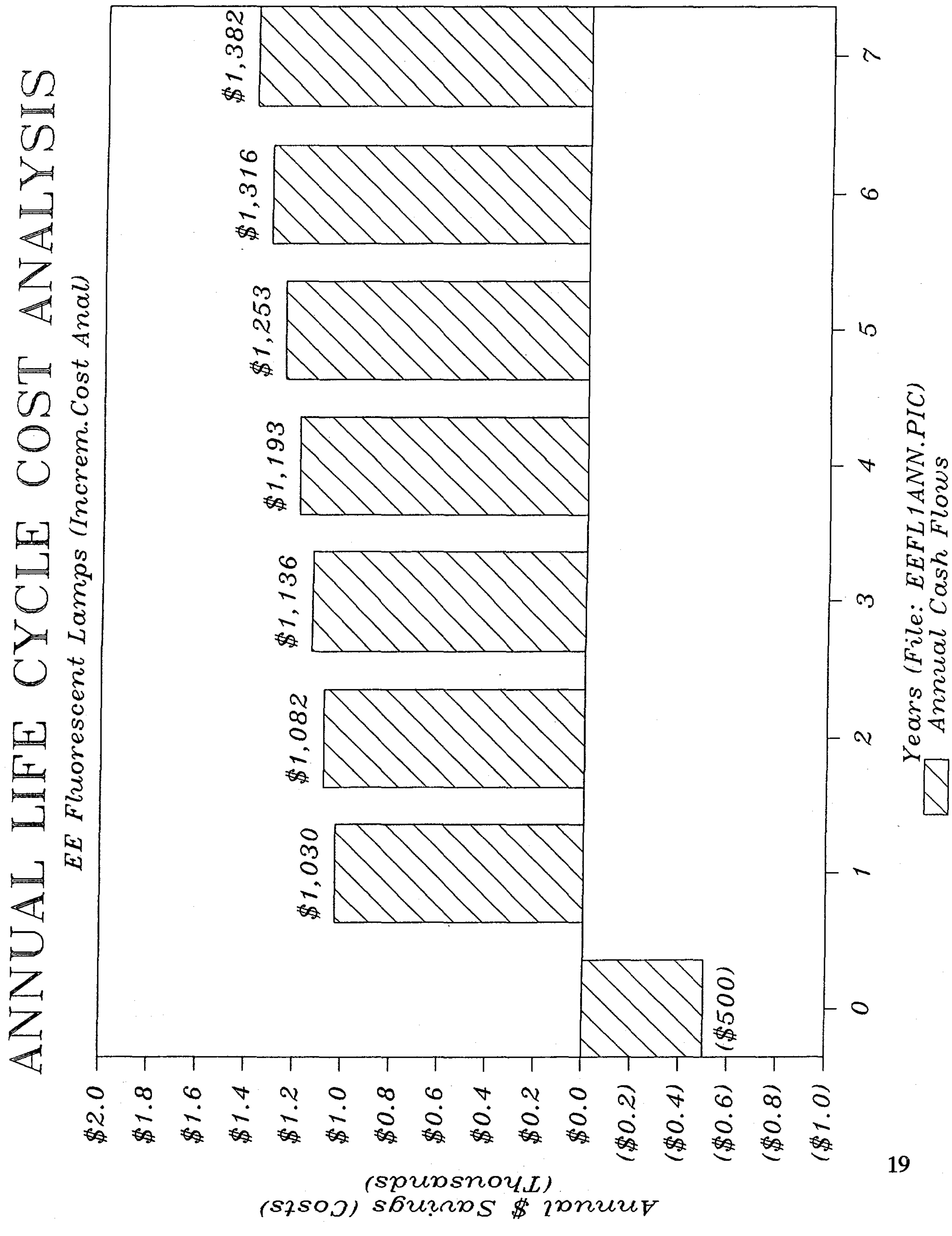
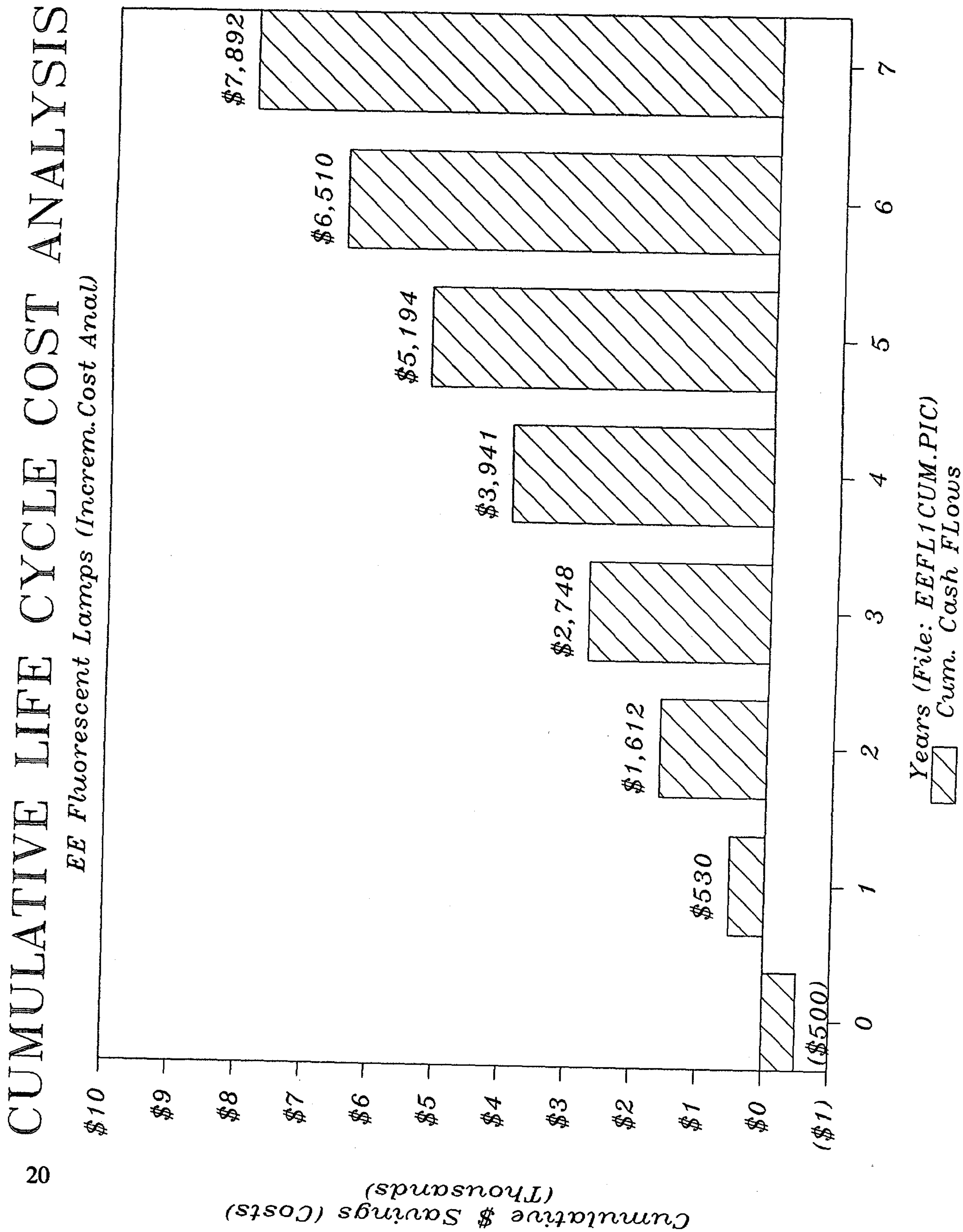


CHART D

Cumulative Life Cycle
Fluorescent



FINANCIAL ANALYSIS SOFTWARE

PROGRAM DESCRIPTION

The enclosed data disk contains several Lotus 1-2-3 compatible spreadsheets that will help you analyze the financial aspects of energy conservation measures (ECMs). There are two types of spreadsheets on the disk--life cycle costing (LCC) spreadsheets and a cash flow spreadsheet.

Using the life cycle costing spreadsheets, you will be able to separate those ECMs that are truly beneficial to your institution from those that may look good but do not pass the financial test of positive net present value (NPV). By using the cash flow spreadsheet, you will be able to determine the cash flow to your institution as a result of implementing a particular ECM or group of ECMs.

Both the life cycle costing spreadsheets and the cash flow spreadsheet are fast and highly flexible. You can input ECM costs, energy cost savings, O&M costs, miscellaneous costs, and financing interest rate (or discount rate for LCC analysis) and see the results right on the screen. You can plot graphs of the results to compare different projects and financing methods. In addition, you can save each analysis under its own file name and look at it again at a later date.

As you gain experience with microcomputer spreadsheets, you can take the ones we have provided for illustration purposes and modify them to meet your exact needs.

PROGRAM REQUIREMENTS

System Requirements:

IBM Personal Computer or compatible
Display: Color or monochrome
Disk capacity: two 360k double-sided disk drives
Memory size: 256K
Maximum usable memory size: 640K
Operating system: PC DOS/MS DOS Version 2.0 or higher
Other hardware: color/graphics adapter, printer, plotter

Software Requirements:

Lotus 1-2-3 Version 2.01 or Lotus 1-2-3 macro compatible spreadsheet program.

Operator Requirements:

Ability to use computer and simplest 1-2-3 commands. Basic understanding of Lotus 1-2-3's addition, subtraction, multiplication and division functions.

Data Required:

Amount Financed
Projected Annual Energy Savings
Period of Analysis
Interest Rate/Discount Rate
Life of ECM

Optional Data:

Owner's O&M (+ or -)
Salvage Value
Construction and/or General Inflation

OPERATING PROCEDURES

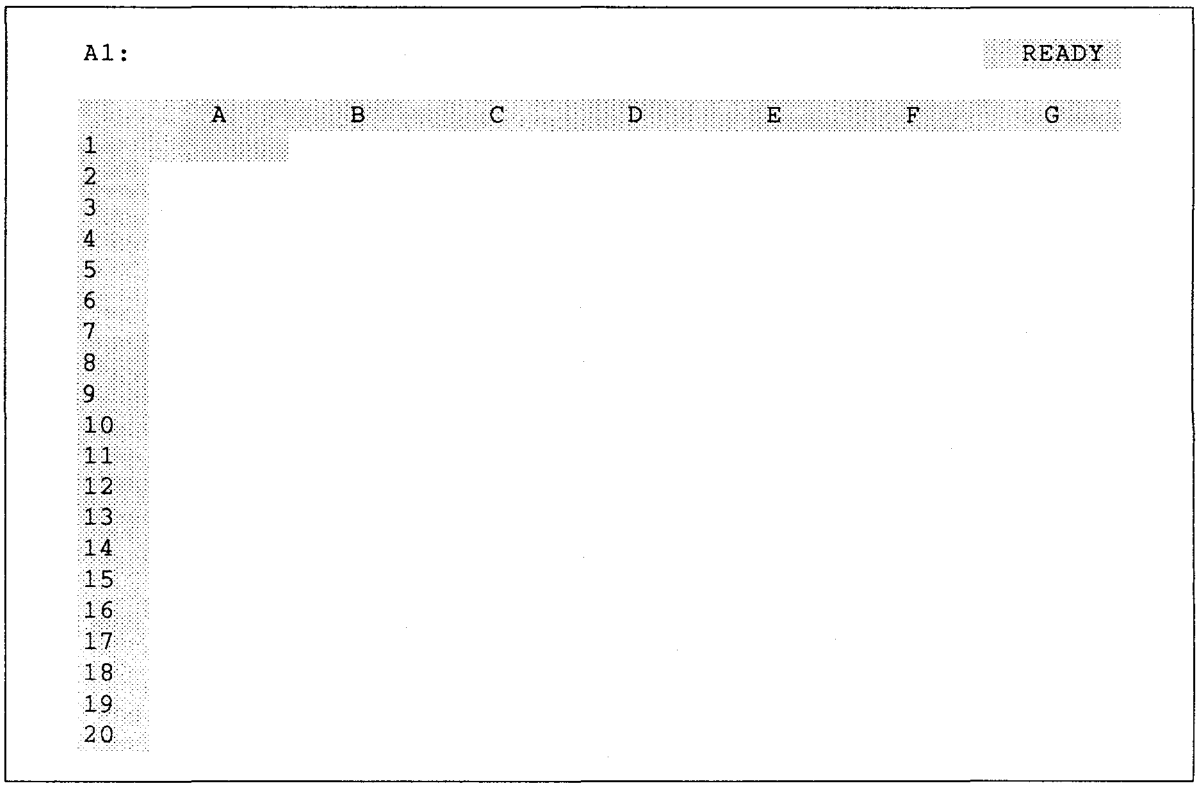
(Computers with 2 Disk Drives)

STEP 1

Turn on your computer with your DOS disk in drive A. After the A> appears on the screen, put the Lotus System Disk in drive A and your handout data disk in drive B. Load 1-2-3 by typing Lotus after the A> as shown:

A>Lotus

Touch enter or return and follow the instructions on the screen until you have a blank spreadsheet similar to the one shown below.



Set your directory to drive B within Lotus and proceed to step 2. To set up your directory to drive B, just:

Bring up menu	[/]	Select DEFAULT	[D]	Type	[a:\]
Select WORKSHEET	[W]	Select DIRECTORY	[D]	Touch	[ENTER]
Select GLOBAL	[G]	Touch ESCAPE	[ESC]	Select QUIT	[Q]

STEP 2

Now you can bring up any of the WK1 files on the data disk. Let's bring up (load) EXAM_CF5.WK1 and look at it. Just:

Bring up menu	[/]
Select FILE	[F]
Select RETRIEVE	[R]

Highlight EXAM_CF5.WK1 and touch enter or return. The spreadsheet that loads is a cash flow spreadsheet that allows you to compare cash flows associated with a term loan, a bond, and a performance contracting agreement.

Below is the primary input area for the loan analysis portion of the spreadsheet.

LOAN CASH FLOW ANALYSIS

===================

Saved as: **EXAM_CF5.WK1**

ECM: **Energy Management System** ECM Cost/Loan Princ: **$500,000**

ECM Life: **10** Years (Period of Analysis)

First Year Energy Cost Savings: **$200,000**

Annual Energy Price Escalation: 5%/year

Initial O&M Savings (Costs): **($25,000)** for 1st year

Annual O&M Escalation: 5%/year

Finance Rate: **10%**/year Loan Term: **5** years

The inputs you can provide are shown in **bold** print. The values shown are for a sample project: an Energy Management System (EMS). The spreadsheet assumes the entire ECM cost of $500,000 will be financed by either a loan, a bond, an ESCO or other lender. The output of the spreadsheet is shown in the data below the input area.

The entire Loan-Based spreadsheet is presented on the following page. After that, the Bond-Based and Performance Contracting-Based Spreadsheets are presented.

LOAN CASH FLOW ANALYSIS

==================

Saved as: **EXAM_CF5.WK1**

ECM: **Energy Management System** ECM Cost/Loan Princ: **$500,000**

ECM Life: **10** Years (Period of Analysis)

First Year Energy Cost Savings: **$200,000**

Annual Energy Price Escalation: **5%**/year

Initial O&M Savings (Costs): **($25,000)** for 1st year

Annual O&M Escalation: **5%**/year

Finance Rate: **10%**/year Loan Term: **5** years

****

Simple Payback Period: 2.5 years

YEAR	ANNUAL COST SAVINGS AFTER ECM	ANNUAL LOAN PMT.	ANNUAL O&M COSTS	ANNUAL CASH	CUMULATIVE CASH FLOW
Now	$0				
1	200000	($131899)	($25000)	$43101	$43101
2	210000	(131899)	(26250)	51851	94952
3	220500	(131899)	(27563)	61038	155990
4	231525	(131899)	(28941)	70685	226675
5	243101	0	(30388)	80814	307489
6	255256	0	(31907)	223349	530838
7	268019	0	(33502)	234517	765355
8	281420	0	(35177)	246243	1011598
9	295491	0	(36936)	258555	1270153
10	310266	0	(38783)	271483	1541636
11	0	0	0	0	1541636
12	0	0	0	0	1541636
13	0	0	0	0	1541636
14	0	0	0	0	1541636
15	0	0	0	0	1541636
16	0	0	0	0	1541636
17	0	0	0	0	1541636
18	0	0	0	0	1541636
19	0	0	0	0	1541636
20	0	0	0	0	1541636

Net cumulative cash benefit over the 10 year life of the ECM is $1,541,636.

BOND CASH FLOW ANALYSIS

==================

Saved as: EXAM_CF5.WK1

ECM: Energy Management System ECM Cost/Loan Princ: $500,000

ECM Life: 10 Years (Period of Analysis)

First Year Energy Cost Savings: $200,000

Annual Energy Price Escalation: 5%/year

Initial O&M Savings (Costs): ($25,000) for 1st year

Annual O&M Escalation: 5%/year

Finance Rate: 7%/year Bond Term: 10 years

****

Simple Payback Period: 2.5 years

YEAR	ANNUAL COST SAVINGS AFTER ECM	ANNUAL LOAN PMT.	ANNUAL O&M COSTS	ANNUAL CASH	CUMULATIVE CASH FLOW
===	======	=====	=====	=======	====
Now	$0				
1	200000	($71189)	($25000)	$103811	$103811
2	210000	(71189)	(26250)	112561	216372
3	220500	(71189)	(27563)	121748	338120
4	231525	(71189)	(28941)	131395	469515
5	243101	(71189)	(30388)	141524	611039
6	255256	(71189)	(31907)	152160	763199
7	268019	(71189)	(33502)	163328	926527
8	281420	(71189)	(35177)	175054	1101581
9	295491	(71189)	(36936)	187366	1288947
10	310266	(71189)	(38783)	200294	1489241
11	0	0	0	0	1489241
12	0	0	0	0	1489241
13	0	0	0	0	1489241
14	0	0	0	0	1439241
15	0	0	0	0	1439241
16	0	0	0	0	1439241
17	0	0	0	0	1439241
18	0	0	0	0	1439241
19	0	0	0	0	1439241
20	0	0	0	0	1439241

Net cumulative cash benefit over the 10 year life of the ECM is $1,489,241.

PERFORMANCE CONTRACTING CASH FLOW ANALYSIS

Saved as: EXAM_CF5.WK1

ECM: Energy Management System   ECM Cost/Bond Princ: $500,000

ECM Life: 10 Years (Period of Analysis)

First Year Energy Cost Savings: $200,000

Annual Energy Price Escalation: 5%/year

Annual ESCO Service Cost: 18% of ECM $ = $90,000

Risk-Guarantee of Savings (% of ECM) 5%/year

Finance Rate: 10%/year   Loan Term: 10 years

Simple Payback Period: 2.5 years

YEAR	ANNUAL COST SAVINGS AFTER ECM	ESCO "SERVICE PAYMENT"	GUAR. PAYMENT TO ESCO	ANNUAL LOAN PAYMENT	CUMULATIVE CASH FLOW
Now	$0				
1	200000	($90000)	($25000)	($81373)	$0
2	210000	(90000)	(25000)	(81373)	3627
3	220500	(90000)	(25000)	(81373)	17254
4	231525	(90000)	(25000)	(81373)	41381
5	243101	(90000)	(25000)	(81373)	76533
6	255256	(90000)	(25000)	(81373)	123261
7	268019	(90000)	(25000)	(81373)	182144
8	281420	(90000)	(25000)	(81373)	253790
9	295491	(90000)	(25000)	(81373)	338837
10	310266	(90000)	(25000)	(81373)	437955
11	0	(90000)	(25000)	(81373)	551848
12	0	0	0	0	551848
13	0	0	0	0	551848
14	0	0	0	0	551848
15	0	0	0	0	551848
16	0	0	0	0	551848
17	0	0	0	0	551848
18	0	0	0	0	551848
19	0	0	0	0	551848
20	0	0	0	0	551848

Net cumulative cash benefit over the 10 year life of the ECM is $551,848.

STEP 3

When you are ready to enter your own data, just go to the top part of the spreadsheet and input your data. The answers will appear in the bottom part of the spreadsheet. You can think of the cumulative cash flow column as the total amount of money you have saved since the ECM was implemented. Conversely, it is also the Cost of Delay (COD) for not acting on valid energy conservation measures. The COD figures for the loan option are presented below the loan-based cash flow spreadsheet.

STEP 4

Let's look at a visual representation of the data on the sample spreadsheet. Just touch:

MENU	[/]
GRAPH	[G]
NAME	[N]
USE	[U]

Now use cursor arrow keys (<-- or -->) to highlight CUMCF5 to see cumulative cash flows. Touch enter or return to call up the graph. The graph is shown on the next page. You can do the same thing with your own facility's data.

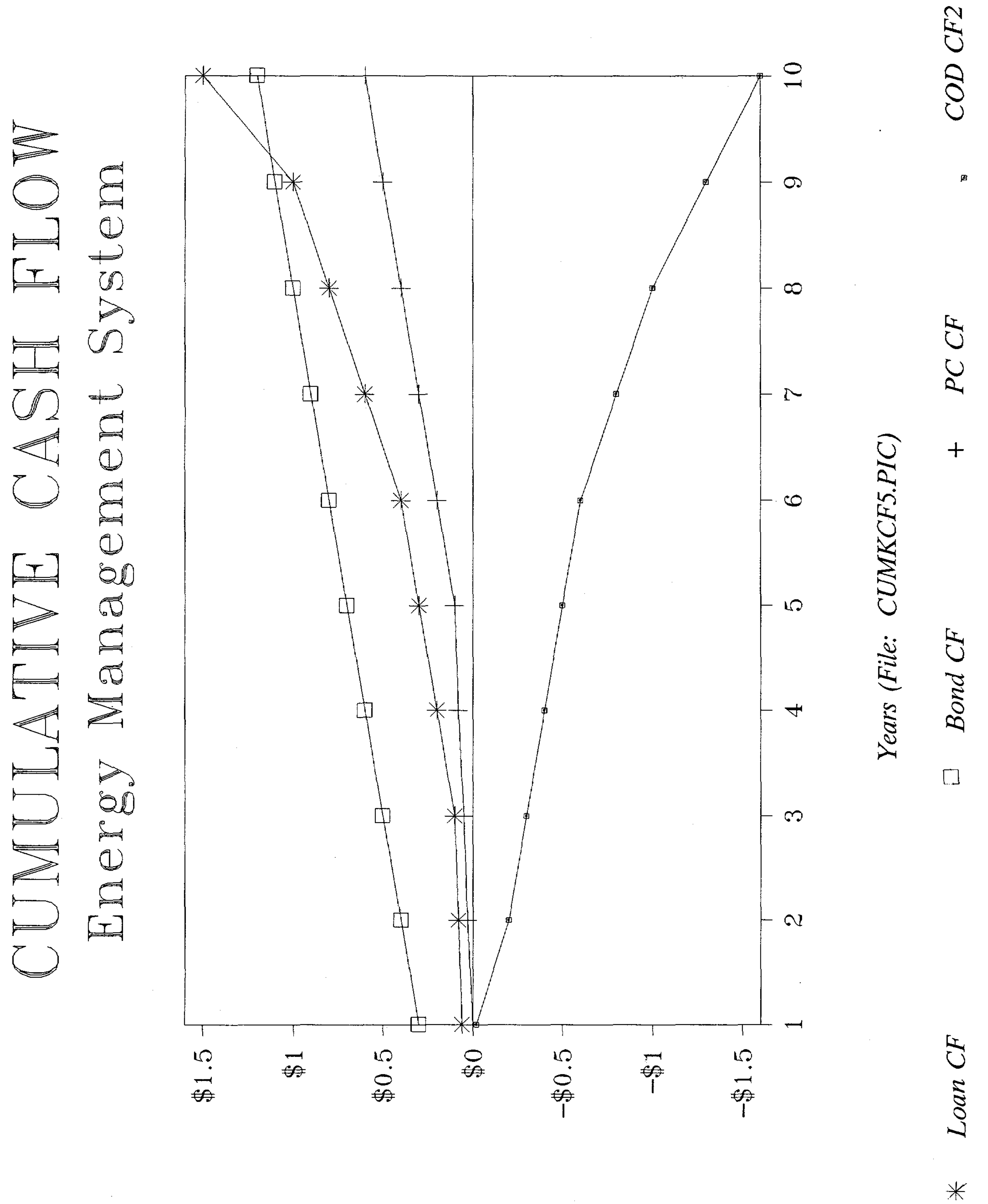
SOFTWARE ASSUMPTIONS AND USER OPTIONS

The cash flow and life cycle costing spreadsheets were developed under the following assumptions:

- Equipment life of up to and including 20 years. (Period of analysis cannot be greater than the equipment life.)
- For both the cash flow and LCC spreadsheets, you have the ability to escalate energy and O&M savings/costs at different rates.
- Ability to select different discount rates and loan/bond rates.
- For the LCC spreadsheets, you can enter miscellaneous costs/benefits for each individual year.
- For the LCC spreadsheets, you can determine Internal Rate of Return (IRR) of a potential investment with a quick iterative procedure.

Chart E

Cumulative Cash Flow
EMS



LIFE CYCLE COST ANALYSIS

ECM: Energy Management System   ECM Cost: $500,000

ECM Life: 10 years   Saved as: LCCEMS2.WK1

First Year Energy Cost Savings: $200,000

Energy Escalation Rate: 5%/year

O&M Savings (Costs): ($25,000) first year

O&M Escalation Rate: 5%/year

Discount Rate: 10%

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
ECM Cost	($500000)										
Energy Cost Savings		200000	210000	220500	231525	243101	255256	268019	281420	295491	310266
Less O&M Costs		(25000)	(26250)	(27563)	(28941)	(30388)	(31907)	(33502)	(35177)	(36936)	(38783)
Misc. Benefits/ Costs		--	--	--	--	--	--	--	--	--	--
Net Cash Flow	(500000)	175000	183750	192937	202584	212713	223349	234517	246243	258555	271483
Cum. Cash Flow	(500000)	(325000)	(141250)	51687	254271	466984	690333	924850	1171093	1429648	1701131

Discount Rate: 10%   Simple Payback: 2.5 years

Present Value Savings: $1,302,967

Net Present Value (NPV) $801,967

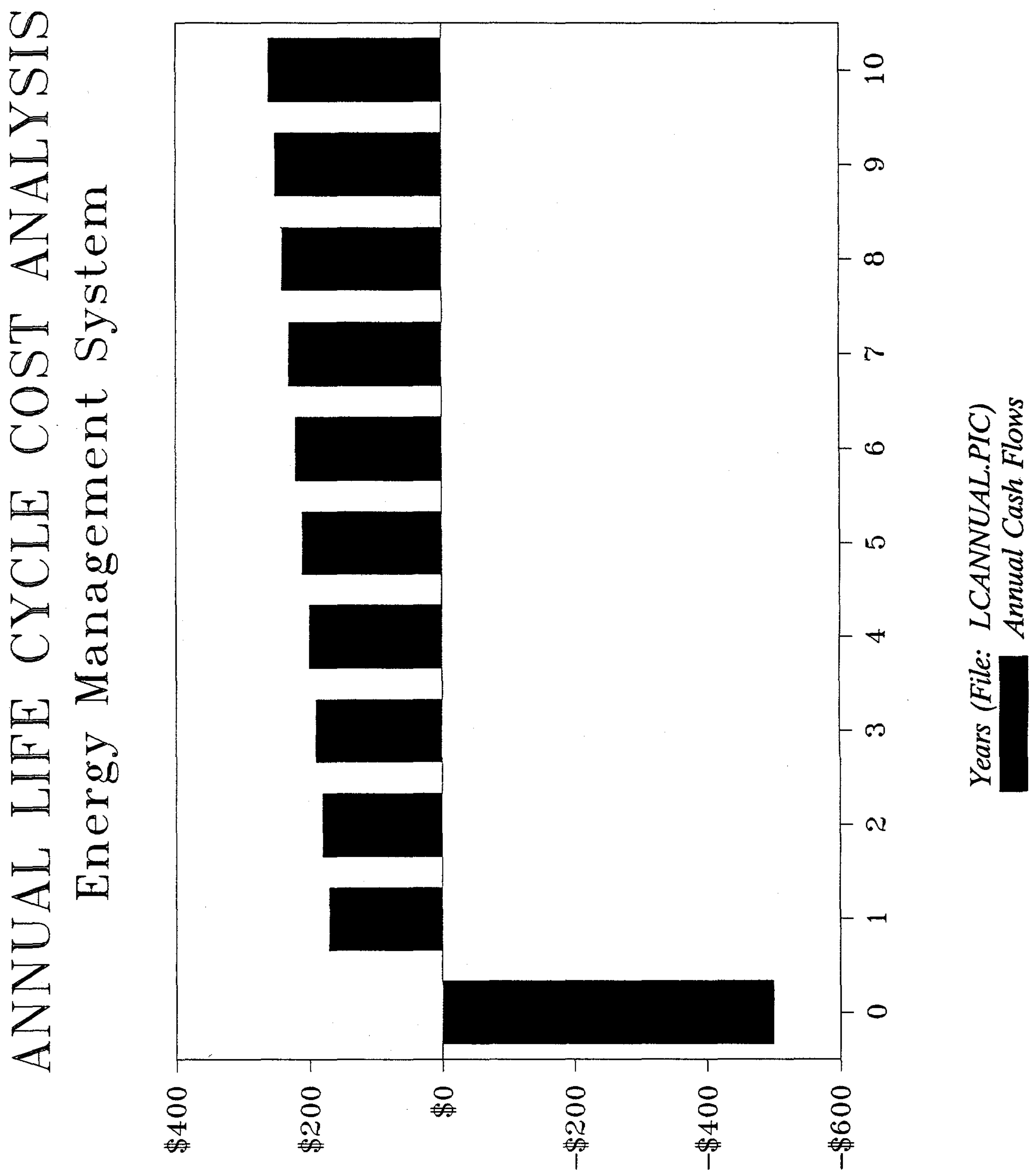
Savings to Investment Ratio: 2.60

Internal Rate of Return (IRR): 38% (Trial Till NPV approx. = Zero)

Trial NPV for IRR Calcs: $874

Chart F

Annual Life Cycle
EMS



Annual $ Savings (Costs)
(Thousands)

Chart G

Cumulative Life Cycle
EMS