State of Illinois
Capital Development Board

LIFE CYCLE COST

ANALYSIS

MANUAL

July 1991

TABLE OF CONTENTS

INTRODUCTION

1. **Authority**. Life cycle cost estimates are required by an amendment to the Capital Development Board Act of 1972. Section 10.02 of the Act was amended by the Comprehensive Solar Energy Act of 1977 and states that CDB is "To prepare or cause to be prepared, general plans, drawings, and estimates, **including the life cycle cost estimate of** energy systems, for public buildings and improvements to be erected for any State agency."

2. **Scope**. This manual prescribes requirements for life cycle cost analysis of energy systems for projects under the jurisdiction of the Capital Development Board.

3. **Definitions**. Terminology commonly used with regard to life cycle cost analysis.

   Life Cycle Cost Analysis. An economic examination of alternative allocation of capital resources that considers all significant costs of ownership over the economic life of the alternatives and considers the cost of the capital.

   Initial Costs. The owner's cost of acquiring the proposed alternative in a fully operational state. For the purposes of this manual, this is the construction cost of the energy systems.

   Operation and Maintenance Costs. Costs incurred annually for the regular care and upkeep of the alternative (energy system). These costs include the salary of maintenance personnel, consumable supplies, service contracts, etc.

   Renewal Costs. Cost incurred for the renewal or replacement of elements or systems components whose useful life is less than the economic life considered for the entire energy systems.

   Cost of Capital. The cost of capital is the time value of money to the owner, the taxpayers. It must be commensurate with the lost opportunity to invest the funds with similar risks. Approximates general long term interest investment rates.

   Energy Systems. The components of the facility that provide environmental conditions consistent with the intended use of the facility. This excludes energy consumed to perform functions such as process equipment, communications, food preparation.

4. **Applicability**. This manual is a supplement to, and part of, the agreement between the Architect-Engineer and the Capital Development Board. Life cycle cost estimates prescribed herein shall be prepared by the A/E for all CDB projects.

5. **Submittal Requirements**. Life cycle cost estimates for the energy systems shall be submitted at the preliminary design phase unless otherwise directed. A life cycle cost estimate shall be prepared for each alternative energy system for each schematic design.

6. **Computation Models**. This document provides one method of preparing life cycle cost estimates. This computation model is not complex but will provide valid results. The analyst preparing the estimates may prefer to use a computation model or procedure developed by his firm or others. Prior to using a model or procedure other than that prescribed herein, it should be submitted to CDB for review and approval. CDB reserves the right to reject any computation method not in accord with sound life cycle cost analysis principles.

7. **Use of the Analysis**. The A/E shall consider the results of the LCC analysis in selecting energy systems. The life cycle cost analysis shall serve as only one criterium in this selection process, not the exclusive criterium.

   CDB shall consider the results of the life cycle cost analysis in the review of the design alternatives and their associated energy systems.

8. **Non-monetary Considerations**. Each alternative may have characteristics that cannot be reduced to monetary terms. When possible, these characteristics should be quantified by other evaluation techniques. Non-monetary considerations may be considered in the selection of the "best" energy system.

INSTRUCTIONS FOR FORM LCC-1

1. **Form LCC-1**. These instructions pertain to the computation model outlined on CDB's Life Cycle Cost Estimate Form LCC-1. An Excel file of this model, including Tables 1-5, is available on CDB's website in the Reference Library (Life Cycle Cost Workbook).

2. **Base Parameters**. The computation model is based on a 25 year economic life and a time value of money to the taxpayers (cost of capital). The use of these parameters is mandatory in the preparation of LCC estimates for CDB. Appendix B lists other parameters to be used in the analysis. Appendix B will be updated as economic conditions and forecasts are revised. Included are the rates and factors for cost of capital, bond rate, fuel costs and their escalation rates, as well as a general escalation rate for plant and O & M. Other factors such as fuel costs, bond rates, general inflation rates and fuel escalation rates will be reviewed and published by CDB as appropriate.

3. **Costs**. There are five costs to be calculated for each alternate energy system:

   a. Initial or construction costs.
   b. Energy costs, annual.
   c. Operating and maintenance costs, annual.
   d. Renewal costs, as required.
   e. Other, annual.

   The A/E shall estimate the present value for each category for each alternative.

4. **Construction Costs (Line 1)**. The cost of the construction of the energy systems. This includes the cost of any special building requirements. Include design fees and reimbursables (10%).

5. **Annual Energy Costs (Line 2).** The first year's cost of energy consumed by the systems is to be determined.

6. **Operation and Maintenance Costs (Line 3)**. Forecast the cost of the first year's cost to operate and maintain only those costs unique to the option. Do not include, for example, the O & M costs for gas heating plants, electric chillers, and lighting. Consider that they are equivalent and will offset each other. Include only high O & M items such as particulate and ash removal equipment & steam equipment.

7. **Renewal Costs (Line 4)**. The useful equipment service life of various types of equipment is provided in Appendix A. The A/E may also consult with equipment suppliers for this information. Indicate source of data if different than Appendix A.

   List the equipment to be renewed, the year it will occur, and the cost of replacement at current prices.

8. **Other Costs (Line 5)**. This section is reserved for other annual costs that are pertinent to the analysis. These may be "ripple" or associated costs or **savings** that are generated by the alternate energy system.

9. **Accumulative Present Value Factor (APV)**. A factor is applied to each line item to determine total present value in current dollars. The factor considers the cost of capital, price escalation, and for annual costs, accumulates the discounted costs for each year of the economic life. The factors are provided in the Tables included in the back of this manual and are included on Form LCC-1.

10. **Construction Cost APV Factor**. The accumulative present value factor for the construction cost is not 1.000 as one would expect. The cost of capital to the owners, the taxpayers is 10%. Since these capital improvements are funded by State bonds, the cost of these borrowed funds is lower than the 10% cost of capital. This creates a positive leverage. Since the bonds are retired in the future at a lower rate, the construction costs incurred today are discounted. As an example, for an effective bond rate of 7% and a cost of capital of 10%, the discount factor is 0.8089 (See Table 5). The discount factor from Appendix B is used for the accumulative present value factor on Line 1.

11. **Energy Costs APV Factors**. The APV factors for the energy costs consider the fact that these costs are escalating. The APV factor accounts for this escalation as well as discounting each of these yearly costs to its present value and sums the present values.

    For various fuel types, the appropriate APV factors are included in Appendix B. These factors are to be used in the "APV Factor" column for Line 2 if CDB's forecasts of energy cost escalation are followed.

12. **Operations & Maintenance APV Factor**. The determination of the accumulative present value factor for operations and maintenance costs is similar to that for energy costs. It discounts the annual costs that are escalating for each year and also totals them. This factor is taken from Appendix B and should be entered in the APV Factor column under Item 3 on Form LCC-1.

13. **Renewal Cost APV Factor**. The present value factors for the renewal costs are given in Table 4 of this manual. Find the present value factor for each year a replacement cost will occur. Enter these factors in the APV column under Item 4 against the respective replacement cost.

14. **APV Factors for Other Costs**. The APV factors to be used for other costs are dependent upon the type of costs considered. The preparer must know the characteristics of the costs, e.g. if it is a single payment, and if so, the year it occurs and how much it will escalate. If the costs occur annually, the number of years they occur and the annual escalation must be determined. Once these characteristics are known, the Tables and their instructions will guide in the determination of the appropriate APV factor.

15. **Non-Standard Factors**. The use of CDB's forecasts of escalation rates is strongly encouraged but not mandatory. The use of different rates must be noted and the justification for such deviation(s) provided with the LCC estimates.

USE OF THE TABLES

1. **Purpose.** These tables provide factors that consider the time value of money to determine the equivalency of funds accruing at different points in time.

2. **Table 1 - Present Value Factors**. Provides factors to determine the equivalent or present value of a single payment to be expended or received at some point in the future considering the time value of money. In other words, how much is needed today to realize a certain sum in "n" numbers of years if invested at an interest rate, "i", per annum.

$$SPVF = \left[\frac{1}{(1+i)^n} \right]$$

Where SPVF = Present Value Factor of a single payment to be received in the future.

i = interest rate per interest period
n = number of interest periods (usually annually)

Therefore, the Present Value of a sum, F, to be spent or received in "*n*" number of years from today at an interest rate of "*i*" annually is determined by:

$$PV = F \bullet \left[\frac{1}{(1+i)^n} \right]$$

In preparing the LCC estimates, Table 1 would most likely be used in determining the present value of a renewal cost that occurs in the future.

3. **Table 2 - Compound Amount Factors.** This table provides the factors for determining the future value of a sum invested today at a given rate of interest. The factors also determines the future single payment cost of an item whose current costs are known and escalated at a fixed annual rate. The equation for this factor is:

$$CAF = (1+i)^n$$

where CAF is the compound amount factor for a single amount invested today at a rate "i" for "n" periods.

i = interest rate per interest period (usually per annum)
n = number of interest periods (usually years)

Therefore, if an amount *P* is invested today, the future equivalent value is:

$$F = P\ (1+i)^n$$

In preparing life cycle estimates, these factors would be useful in determining the present value of "other costs" or renewal costs where exception is taken with CDB's forecasted rate of escalation. For example, a replacement of a component is forecasted to occur in 14 years. Its current cost is $2,000 and this cost is expected to escalate at 9% per year. The amount required at the time the component is replaced is:

$$F = \$2000 \bullet (CAF \text{ for } i = 9\%, n = 14)$$
$$F = \$2000 \bullet (3.3417)$$
$$F = \$6,683.40$$

4. **Composite Factors.** Tables 1 and 2 enable the user to compute a composite factor to determine the present value of renewal costs that are affected by escalation.

For example, suppose a renewal cost will occur in the sixteenth year, its current value is $3,000 and costs are anticipated to escalate at 8% per annum. The cost of capital to the owner is 10% and he desires to know the present value of that future expense.

First the actual cost in the sixteenth year could be determined by using Table 2. The compound amount factor for interest rate of 8% and sixteen years is 3.4259. The actual cost to be incurred then is:

$$F = P \bullet CAF$$
$$F = 3000 \bullet 3.4259$$
$$F = \$10,277.70$$

The renewal cost will be $10,277.70 when it occurs sixteen years hence. But the owner wants to invest a sum at 10% today in order to meet that cost. Table 1 provides the factor to apply to the $10,277.70 to determine that amount.

$$P = F \bullet SAPV$$
$$= 10,27.70\ (0.2176)$$
$$= \$2,236.43$$

In other words $2,236.43 invested today at 10% would provide the funds to cover a renewal cost worth $3,000 today but escalating 8% per year and needed in 16 years.

Alternately, the computation could be made directly by determining the product of the single payment present value factor for the cost of capital and the compound amount factor for the escalation rate, the number of years being equal for both. That is:

$$\text{composite factor} = SAPV \bullet CAF$$
$$= (3.4259)(0.2176)$$
$$= 0.7455$$

For the above example:

$$\text{Present~value} = 3000 \bullet (0.7456)$$
$$= 2,236.43$$

For renewal costs that do not escalate at the rate suggested by CDB, this composite factor is entered under the APV column. The escalation rate used must be noted and the current cost of capital rate used must be 10%. If single occurring costs are included in Other Costs, the APV factors used are also determined by this method and must also be entered on the appropriate line on Form LCC-1.

5. **Table 3 - Present Value Factors for an Escalating Annual Amount.** This table provides present value factors for annual amounts which are escalating at a uniform rate. This table is broken down by escalation rates and all factors as based on a current 10% cost of capital. Each succeeding year's amount is higher than the previous year's by the amount of escalation. The factors also cumulate the total of the present values of each year's escalated amount. The equation for these factors is:

$$EAPF = \frac{\left[\frac{1-e}{1+i}\right]\left[\left(\frac{1+e}{1+i}\right)^{n}-1\right]}{\left(\frac{1+e}{1+1}\right)-1}$$

where e = *escalation rate*
i = *interest rate, cost of capital*
n = *number of interest periods, years*

The present value of an escalating annual amount then is:

$$PV = A \bullet EAPF$$

For example, the annual cost of electricity for an energy system is calculated to be $5,000 at today's rates. These rates are forecasted to escalate at 7% per annum. The time value of money to the owner of the facility is 10%. What is the present value of the electric costs over the 25 year economic life of the facility? From Table 3 under the 7% escalation rate column, the present value factor for an escalating annual amount for 25 years is 17.8002. Therefore, the present value of the electric cost for the life of the systems is:

PV = $ 5,000 x 17.8002
= $89, 001

Table 3 could be used in the preparation of LCC estimate in two ways:

1. When escalation rates for annual costs, energy or O & M, are different from those suggested by CDB.

2. For other costs the analyst feels are pertinent and are annual and escalating.

6. **Table 4.** This table lists factors similar to the composite factors addressed in Paragraph 4. They are for a particular case of a single expenditure in the future whose today's cost is known and escalating at various percents and discounted at the current cost of capital of 10%. These are CDB's parameters for the APV factors for renewal costs. They could be used for other costs that occur once in the future.

These factors are the product of the compound amount factor (CAF) and the single payment present value factor (SPVF). It combines the future value of an amount known today and escalating at a rate of "e" per year with the discount factor. In other words, it takes the amount out to the future at one rate (escalation) and brings it back at another rate (discounted).

$$\text{Factor} = \text{CAF} \times \text{SPVF}$$

$$= (1+e)^n \text{ x} \left[\frac{1}{(1+i)^n} \right]$$

where e = escalation rate

i = discount rate

L C C - 1

LIFE CYCLE COST ESTIMATE

DATE:

For Proposed Energy Systems

Project Name:
Project Number:
Location:

A/E:
Project Manager:
Gross Square Footage

Alternative Number:

	Initial Cost, $	APV Factor	Present Value
1. CONSTRUCTION COSTS		x 0.81 = $	0

2. ENERGY COSTS	Escalation Rate	1st Yr. Cost	APV Factor (Table 3)	Present Value
a. Electric	7%	$ x 17.8000 = $		0
b. Natural Gas	11%	$ x 28.1800 = $		0
c. Fuel Oil	9%	$ x 22.2500 = $		0
d. Coal	8%	$ x 19.8700 = $		0
e. Other		$ x = $		0
Subtotal Energy Costs			$	0

3. OPERATIONS & MAINTENANCE (see Instructions)	Escalation Rate	1st Yr. Cost	APV Factor (Table 3)	Present Value
a. Extra Shift Personnel (No.)	5%	$ x 14.4400 = $	$	0
b. Disposal Costs	7%	$ x 17.8000 = $		0
c. Special Maintenance Contracts	7%	$ x 17.8000 = $	$	0
d.		$ x = $		0
e.		$ x = $		0
Subtotal O & M			$	0.00

4. OTHER ANNUAL COSTS	Escalation Rate	1st Yr. Cost		APV Factor (Table 3)		Present Value
a.		$	x		= $	0.00
b.		$	x		= $	0.00
c.		$	x		= $	0.00
d.		$	x		= $	0.00
		Subtotal Other Annual Costs			$	0.00

5.RENEWAL COSTS	Year Replaced	Present Cost		APV Factor (Table 4)		Present Value
a. Plant Equipment		$	x		= $	0
b.		$	x		= $	0
c.		$	x		= $	0
d.		$	x		= $	0
		Subtotal Renewal Costs			$	0
		Total Present Value			**$**	**0**

Brief Desciption of Energy Systems and Other Related Factors

Provide, separate sheets if necessary, calculations, energy consuption, fuel rates, etc. that support the annual costs, renewal costs, etc. that are used in this analysis.

TABLE NO. 1
PRESENT VALUE FACTORS

WHAT $1, SINGLE PAYMENT, IN THE FUTURE IS WORTH TODAY

	DISCOUNT RATES PER PERIOD					
Period	7.00%	7.50%	8.00%	9.00%	10.00%	11.00%
1	0.9346	0.9302	0.9259	0.9174	0.9091	0.9009
2	0.8734	0.8653	0.8573	0.8417	0.8264	0.8116
3	0.8163	0.8050	0.7938	0.7722	0.7513	0.7312
4	0.7629	0.7488	0.7350	0.7084	0.6830	0.6587
5	0.7130	0.6966	0.6806	0.6499	0.6209	0.5935
6	0.6663	0.6480	0.6302	0.5963	0.5645	0.5346
7	0.6227	0.6028	0.5835	0.5470	0.5132	0.4817
8	0.5820	0.5607	0.5403	0.5019	0.4665	0.4339
9	0.5439	0.5216	0.5002	0.4604	0.4241	0.3909
10	0.5083	0.4852	0.4632	0.4224	0.3855	0.3522
11	0.4751	0.4513	0.4289	0.3875	0.3505	0.3173
12	0.4440	0.4199	0.3971	0.3555	0.3186	0.2858
13	0.4150	0.3906	0.3677	0.3262	0.2897	0.2575
14	0.3878	0.3633	0.3405	0.2992	0.2633	0.2320
15	0.3624	0.3380	0.3152	0.2745	0.2394	0.2090
16	0.3387	0.3144	0.2919	0.2519	0.2176	0.1883
17	0.3166	0.2925	0.2703	0.2311	0.1978	0.1696
18	0.2959	0.2720	0.2502	0.2120	0.1799	0.1528
19	0.2765	0.2531	0.2317	0.1945	0.1635	0.1377
20	0.2584	0.2354	0.2145	0.1784	0.1486	0.1240
21	0.2415	0.2190	0.1987	0.1637	0.1351	0.1117
22	0.2257	0.2037	0.1839	0.1502	0.1228	0.1007
23	0.2109	0.1895	0.1703	0.1378	0.1117	0.0907
24	0.1971	0.1763	0.1577	0.1264	0.1015	0.0817
25	0.1842	0.1640	0.1460	0.1160	0.0923	0.0736
26	0.1722	0.1525	0.1352	0.1064	0.0839	0.0663
27	0.1609	0.1419	0.1252	0.0976	0.0763	0.0597
28	0.1504	0.1320	0.1159	0.0895	0.0693	0.0538
29	0.1406	0.1228	0.1073	0.0822	0.0630	0.0485
30	0.1314	0.1142	0.0994	0.0754	0.0573	0.0437
31	0.1228	0.1063	0.0920	0.0691	0.0521	0.0394
32	0.1147	0.0988	0.0852	0.0634	0.0474	0.0355
33	0.1072	0.0919	0.0789	0.0582	0.0431	0.0319
34	0.1002	0.0855	0.0730	0.0534	0.0391	0.0288
35	0.0937	0.0796	0.0676	0.0490	0.0356	0.0259
36	0.0875	0.0740	0.0626	0.0449	0.0323	0.0234
37	0.0818	0.0688	0.0580	0.0412	0.0294	0.0210
38	0.0765	0.0640	0.0537	0.0378	0.0267	0.0190
39	0.0715	0.0596	0.0497	0.0347	0.0243	0.0171
40	0.0668	0.0554	0.0460	0.0318	0.0221	0.0154

TABLE NO. 2
COMPOUND AMOUNT FACTORS

WHAT $1, SINGLE PAYMENT, INVESTED TODAY IS WORTH IN THE FUTURE

	DISCOUNT RATES PER PERIOD				
Period	7.00%	7.50%	8.00%	9.00%	10.00%
1	1.0700	1.0750	1.0800	1.0900	1.1000
2	1.1449	1.1556	1.1664	1.1881	1.2100
3	1.2250	1.2423	1.2597	1.2950	1.3310
4	1.3108	1.3355	1.3605	1.4116	1.4641
5	1.4026	1.4356	1.4693	1.5386	1.6105
6	1.5007	1.5433	1.5869	1.6771	1.7716
7	1.6058	1.6590	1.7138	1.8280	1.9487
8	1.7182	1.7835	1.8509	1.9926	2.1436
9	1.8385	1.9172	1.9990	2.1719	2.3579
10	1.9672	2.0610	2.1589	2.3674	2.5937
11	2.1049	2.2156	2.3316	2.5804	2.8531
12	2.2522	2.3818	2.5182	2.8127	3.1384
13	2.4098	2.5604	2.7196	3.0658	3.4523
14	2.5785	2.7524	2.9372	3.3417	3.7975
15	2.7590	2.9589	3.1722	3.6425	4.1772
16	2.9522	3.1808	3.4259	3.9703	4.5950
17	3.1588	3.4194	3.7000	4.3276	5.0545
18	3.3799	3.6758	3.9960	4.7171	5.5599
19	3.6165	3.9515	4.3157	5.1417	6.1159
20	3.8697	4.2479	4.6610	5.6044	6.7275
21	4.1406	4.5664	5.0338	6.1088	7.4002
22	4.4304	4.9089	5.4365	6.6586	8.1403
23	4.7405	5.2771	5.8715	7.2579	8.9543
24	5.0724	5.6729	6.3412	7.9111	9.8497
25	5.4274	6.0983	6.8485	8.6231	10.8347
26	5.8074	6.5557	7.3964	9.3992	11.9182
27	6.2139	7.0474	7.9881	10.2451	13.1100
28	6.6488	7.5759	8.6271	11.1671	14.4210
29	7.1143	8.1441	9.3173	12.1722	15.8631
30	7.6123	8.7550	10.0627	13.2677	17.4494
31	8.1451	9.4116	10.8677	14.4618	19.1943
32	8.7153	10.1174	11.7371	15.7633	21.1138
33	9.3253	10.8763	12.6760	17.1820	23.2252
34	9.9781	11.6920	13.6901	18.7284	25.5477
35	10.6766	12.5689	14.7853	20.4140	28.1024
36	11.4239	13.5115	15.9682	22.2512	30.9127
37	12.2236	14.5249	17.2456	24.2538	34.0039
38	13.0793	15.6143	18.6253	26.4367	37.4043
39	13.9948	16.7853	20.1153	28.8160	41.1448
40	14.9745	18.0442	21.7245	31.4094	45.2593

TABLE NO. 3
PRESENT VALUE FACTORS FOR AN ESCALATING ANNUAL AMOUNT
FOR A COST OF CAPITAL OF 10.00%

		ESCALATION RATES PER YEAR				
YEAR	7.00%	7.50%	8.00%	9.00%	10.00%	11.00%
1	0.9727	0.9773	0.9818	0.9909	1.0000	1.0091
2	1.9189	1.9323	1.9458	1.9728	2.0000	2.0274
3	2.8393	2.8657	2.8922	2.9458	3.0000	3.0549
4	3.7346	3.7778	3.8215	3.9099	4.0000	4.0917
5	4.6055	4.6692	4.7338	4.8653	5.0000	5.1380
6	5.4526	5.5404	5.6295	5.8120	6.0000	6.1938
7	6.2766	6.3918	6.5090	6.7500	7.0000	7.2592
8	7.0782	7.2238	7.3725	7.6796	8.0000	8.3343
9	7.8579	8.0369	8.2203	8.6007	9.0000	9.4192
10	8.6163	8.8315	9.0526	9.5134	10.0000	10.5139
11	9.3540	9.6080	9.8698	10.4178	11.0000	11.6186
12	10.0716	10.3669	10.6722	11.3140	12.0000	12.7333
13	10.7697	11.1086	11.4600	12.2021	13.0000	13.8581
14	11.4487	11.8334	12.2334	13.0821	14.0000	14.9932
15	12.1092	12.5417	12.9928	13.9540	15.0000	16.1386
16	12.7517	13.2340	13.7384	14.8181	16.0000	17.2944
17	13.3766	13.9105	14.4704	15.6743	17.0000	18.4607
18	13.9845	14.5716	15.1892	16.5227	18.0000	19.6376
19	14.5759	15.2177	15.8948	17.3634	19.0000	20.8252
20	15.1511	15.8491	16.5876	18.1965	20.0000	22.0236
21	15.7106	16.4662	17.2679	19.0220	21.0000	23.2330
22	16.2548	17.0692	17.9357	19.8399	22.0000	24.4533
23	16.7842	17.6586	18.5914	20.6505	23.0000	25.6846
24	17.2992	18.2345	19.2352	21.4537	24.0000	26.9272
25	17.8002	18.7973	19.8673	22.2495	25.0000	28.1811
26	18.2874	19.3474	20.4879	23.0382	26.0000	29.4464
27	18.7614	19.8850	21.0972	23.8196	27.0000	30.7232
28	19.2225	20.4103	21.6954	24.5940	28.0000	32.0116
29	19.6709	20.9237	22.2828	25.3613	29.0000	33.3117
30	20.1072	21.4254	22.8595	26.1217	30.0000	34.6236
31	20.5315	21.9158	23.4257	26.8751	31.0000	35.9475
32	20.9443	22.3950	23.9816	27.6217	32.0000	37.2833
33	21.3458	22.8633	24.5274	28.3615	33.0000	38.6314
34	21.7364	23.3209	25.0632	29.0946	34.0000	39.9917
35	22.1163	23.7682	25.5893	29.8210	35.0000	41.3643
36	22.4859	24.2053	26.1059	30.5408	36.0000	42.7494
37	22.8453	24.6324	26.6131	31.2541	37.0000	44.1472
38	23.1950	25.0499	27.1110	31.9609	38.0000	45.5576
39	23.5351	25.4578	27.5999	32.6612	39.0000	46.9808
40	23.8660	25.8565	28.0799	33.3552	40.0000	48.4170

TABLE NO. 4
PRESENT VALUE FACTORS FOR RENEWAL COSTS

FOR A COST OF CAPITAL OF 10.00%

Renewal Year	ESCALATION RATES PER YEAR					
	5.00%	6.00%	7.00%	8.00%	9.00%	10.00%
1	0.9545	0.9636	0.9727	0.9818	0.9909	1.0000
2	0.9112	0.9286	0.9462	0.9640	0.9819	1.0000
3	0.8697	0.8948	0.9204	0.9464	0.9730	1.0000
4	0.8302	0.8623	0.8953	0.9292	0.9641	1.0000
5	0.7925	0.8309	0.8709	0.9123	0.9554	1.0000
6	0.7564	0.8007	0.8471	0.8957	0.9467	1.0000
7	0.7221	0.7716	0.8240	0.8795	0.9381	1.0000
8	0.6892	0.7435	0.8015	0.8635	0.9295	1.0000
9	0.6579	0.7165	0.7797	0.8478	0.9211	1.0000
10	0.6280	0.6904	0.7584	0.8324	0.9127	1.0000
11	0.5995	0.6653	0.7377	0.8172	0.9044	1.0000
12	0.5722	0.6411	0.7176	0.8024	0.8962	1.0000
13	0.5462	0.6178	0.6980	0.7878	0.8881	1.0000
14	0.5214	0.5954	0.6790	0.7735	0.8800	1.0000
15	0.4977	0.5737	0.6605	0.7594	0.8720	1.0000
16	0.4751	0.5529	0.6425	0.7456	0.8641	1.0000
17	0.4535	0.5328	0.6250	0.7320	0.8562	1.0000
18	0.4329	0.5134	0.6079	0.7187	0.8484	1.0000
19	0.4132	0.4947	0.5913	0.7057	0.8407	1.0000
20	0.3944	0.4767	0.5752	0.6928	0.8331	1.0000
21	0.3765	0.4594	0.5595	0.6802	0.8255	1.0000
22	0.3594	0.4427	0.5443	0.6679	0.8180	1.0000
23	0.3430	0.4266	0.5294	0.6557	0.8105	1.0000
24	0.3274	0.4111	0.5150	0.6438	0.8032	1.0000
25	0.3125	0.3961	0.5009	0.6321	0.7959	1.0000

SHADED AREA INDICATES ESCALATION RATE FOR RENEWAL PLANT COST RECOMMENDED BY CDB

TABLE NO. 5

Calculation of the Accumulative Present Value Factor for Construction Costs

Amount Bonded	$1,000,000.00
Bond Rate	7%
Cost of Capital	10%
Present Value of Bond Retirement Payments Discounted at the Cost of Capital Rate	$ 808,924.50
Accumulative Present Value for Construction Cost	**0.81**

Year	Bond Retirement Payments	Outstanding Balance	Discounted Amount
1	$ 110,000.00	$960,000.00	$ 100,000.00
2	$ 107,200.00	$920,000.00	$ 88,595.04
3	$ 104,400.00	$880,000.00	$ 78,437.27
4	$ 101,600.00	$840,000.00	$ 69,394.17
5	$ 98,800.00	$800,000.00	$ 61,347.03
6	$ 96,000.00	$760,000.00	$ 54,189.50
7	$ 93,200.00	$720,000.00	$ 47,826.34
8	$ 90,400.00	$680,000.00	$ 42,172.27
9	$ 87,600.00	$640,000.00	$ 37,150.95
10	$ 84,800.00	$600,000.00	$ 32,694.07
11	$ 82,000.00	$560,000.00	$ 28,740.50
12	$ 79,200.00	$520,000.00	$ 25,235.56
13	$ 76,400.00	$480,000.00	$ 22,130.36
14	$ 73,600.00	$440,000.00	$ 19,381.18
15	$ 70,800.00	$400,000.00	$ 16,948.96
16	$ 68,000.00	$360,000.00	$ 14,798.78
17	$ 65,200.00	$320,000.00	$ 12,899.47
18	$ 62,400.00	$280,000.00	$ 11,223.19
19	$ 59,600.00	$240,000.00	$ 9,745.08
20	$ 56,800.00	$200,000.00	$ 8,442.96
21	$ 54,000.00	$160,000.00	$ 7,297.05
22	$ 51,200.00	$120,000.00	$ 6,289.71
23	$ 48,400.00	$80,000.00	$ 5,405.22
24	$ 45,600.00	$40,000.00	$ 4,629.57
25	$ 42,800.00	$0.00	$ 3,950.27

Table 5 Equipment Service Life [a]

Equipment Item	Median Years
Air conditioners	
Window Unit	10
Residential single or split package	15
Commercial through-the-wall	15
Water-cooled package	15
Heat Pumps	
Residential air-to-air	15 [b]
Commercial air-to-air	15
Commercial water-to-air	19
Roof-top air conditioners	
Single-zone	15
Multizone	15
Boilers, hot water (steam)	
Steel water-tube	24 (30)
Steel fire-tube	25 (25)
Cast iron	35 (30)
Electric	15
Burners	21
Furnaces	
Gas- or oil-fired	18
Unit heaters	
Gas or electric	13
Hot water or steam	20
Radiant heaters	
Electric	10
Hot water or steam	25
Air terminals	
Diffusers, grilles, and registers	27
Induction and fan-coil units	20
VAV and double-duct boxes	20
Air washers	17
Duct work	30
Dampers	20
Fans	
Centrifugal	25
Axial	20
Propeller	15
Ventilating roof-mounted	20
Coils	
DX, water, or steam	20
Electric	15
Heat Exchangers	
Shell-and-tube	24
Reciprocating compressors	20
Package chillers	
Reciprocating	20
Centrifugal	23
Absorption	23
Cooling towers	
Galvanized metal	20
Wood	20
Ceramic	34
Air-cooled condensers	20
Evaporative condensers	20
Insulation	
Molded	20
Blanket	24
Pumps	
Based-mounted	20
Pipe-mounted	10
Sump and well	10
Condensate	15
Reciprocating engines	20
Steam turbines	30
Electric motors	18
Motor starters	17
Electric transformers	30
Controls	
Pneumatic	20
Electric	16
Electronic	15
Valve actuators	
Hydraulic	15
Pneumatic	20
Self-contained	10

[a] Obtained from a nation-wide survey conducted by ASHRAE TC 1.8 (Akalin 1978). Data changed by TC 1.8 in 1986.

[b] See Lovvorn and Hiller (1985) and Easton Consultants (1986) for further information.

Reprinted by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers from the 1987 ASHRAE Handbook—HVAC Systems and Applications.

APPENDIX A (cont'd.)

EQUIPMENT SERVICE LIFE

Light Fixtures	**20 years**
Solar Film	**3 years**
Direct Fired Gas A/C Equipment	**20 years**
Field Erected Boilers	**40 years**

APPENDIX B

ILLINOIS CAPITAL DEVELOPMENT BOARD
LIFE CYCLE COST ANALYSIS MANUAL
CURRENT ESCALATION RATES AND ECONOMIC FACTOR
EFFECTIVE: APRIL 1991

THE FOLLOWING ARE RATES AND FACTORS TO BE USED FOR CDB'S LIFE CYCLE COST ANALYSIS.

COST OF CAPITAL (DISCOUNT RATE)		10%
BOND RATE		7%
FUEL ESCALATION RATES:		
GAS, NATURAL		11%
ELECTRIC		7%
COAL		8%
GAS, LPG		11%
FUEL OIL		9%
PLANT EQUIPMENT		7%
OPERATING & MAINTENANCE COST		7%
RENEWAL COSTS		7%
CONSTRUCTION COST ACCUMULATIVE PRESENT VALUE FACTOR (COST OF CAPITAL 10% AND BOND RATE 7%)		0.8089