Economic Calculations for the ASHRAE Handbook

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ECONOMIC ANALYSIS TECHNIQUES

Definitions of terms:

C_e	= cost of energy to operate the system for one period
$C_{s,assess}$	= initial assessed system value
$C_{s,salv}$	= system salvage value at the end of its useful life in constant dollars
$C_{s,init}$	= initial system cost
C_y	= annualized system cost in constant dollars
$D_{k,sl}$ or $D_{k,SD}$	= amount of depreciation at the end of period k depending on the type of depreciation schedule used, where $D_{k,sl}$ is the straight line depreciation method and $D_{k,SD}$ represents the sum-of-digits depreciation method in constant dollars
F	= future value of a sum of money
i_d	= discount rate
i_m	= market mortgage rate (real rate + general inflation rate)
$i_m P_k$	= interest charge at the end of period k
i'	= $(i_d - j)/(1+j)$ = effective discount rate adjusted for energy inflation j, sometimes called the real discount rate
i''	= $(i_d - j_e)/(1+j_e)$ = effective discount rate adjusted for energy inflation j_e
I	= annual insurance costs
ITC	= investment tax credit for energy efficiency improvements, if applicable
j	= general inflation rate per period
j_e	= general energy rate per period
k	= end if period(s) in which replacement(s), repair(s), depreciation, or interest is calculated
M	= periodic maintenance cost
n	= number of period(s) under consideration
P	= a sum of money at the present time, *i.e.*, its present value
P_k	= outstanding principle of the loan for $C_{s,init}$ at the end of period k in current dollars
R_k	= net replacement(s), repair cost(s), or disposals at the end of period k in constant dollars
T_{inc}	= (state tax rate + federal tax rate) – (state tax rate X federal tax rate) where tax rates are based on the last dollar earned, *i. e.*, the marginal rates
T_{prop}	= property tax rate
T_{salv}	= tax rate applicable to salvage value of the system

For any proposed capital investment, the capital and interest costs, salvage costs, replacement costs, energy costs, taxes, maintenance costs, insurance costs, interest deductions,

depreciation allowances, and other factors must be weighed against the value of the services provided by the system.

Single Payment

A common method for analyzing the impact of a future payment is to reduce it to its present value or present worth. The primary underlying principle is that all monies (those paid now and in the future) should be evaluated according to their present purchasing power. This approach is known as discounting.

The future value F of a present sum of money P over n periods with compound interest rate i is:

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

The present value or present worth P or a future sum of money F is given by:

$$P = F/(1+i)^n = F \times \mathrm{PWF}(i,n) \tag{2}$$

where PWF(i,n) the worth factor, is defined by:

$$\mathrm{PWF}(i,n) = 1/(1+i)^n \tag{3}$$

Example 2: Calculate the future value of a system presently valued at \$10,000, in 10 years, at 10% interest.

$$F = P(1+i)^n = \$10,000 \times (1+0.10)^{10} = \$10,000 \times 2.593742 = \$25,937.42$$

Example 3: Using the present worth factor PWF($i = 0.10$, $n = 10$), calculate the present value of a future sum of money valued at \$10,000.

$$P = F \times \mathrm{PWF}(i,n) = 10,000 \times 1/(1+0.1)^{10} = \$3,855.43$$

Accounting for Varying Inflation Rates

Inflation, which accounts for the rise in costs of a commodity over time, is a separate issue from the time value of money – the basis for discounting. Inflation must often be accounted for in

an economic evaluation. Further complexities are added when one considers that different economic goods inflate at different rates. One way to account for this is to use effective interest rates that account for varying rates of inflation.

The effective interest rate i', sometimes called the real rate, accounts for the general inflation rate j and the discount rate i_d, and can be expressed as follows (Kreith and Kreider 1978, Kreider and Kreith 1982):

$$i' = \frac{1+i_d}{1+j} - 1 = \frac{(i_d - j)}{(1+j)} \tag{4}$$

Such an expression can be adapted to account for energy inflation by considering the general discount rate i_d and the energy inflation rate j_e, thus:

$$i'' = \frac{1+i_d}{1+j_e} - 1 = \frac{(i_d - j_e)}{(1+j_e)} \tag{5}$$

The discount equations(1) through (3) can be revised to consider the effects of varying inflation rates. The future value F, using constant currency of an invested sum P with a discount rate i_d under inflation j during n periods now becomes:

$$F = P[1+i_d/1+j]^n = P(1+i')^n \tag{6}$$

The present worth P, in constant dollars, of a future sum of money F with discount rate i_d under inflation rate j during n periods is then expressed as:

$$P = F/\left[(1+i_d)/(1+j)\right]^n \tag{7}$$

In constant currency, the present worth P of a sum of money F can be expressed with an effective interest rate i' which is adjusted for inflation by:

$$P = F/(1+i')^n = F \times \mathrm{PWF}(i', n) \tag{8}$$

where the effective present worth factor is given by:

$$\mathrm{PWF}(i', n) = 1/(1+i')^n \tag{9}$$

Example 4: Calculate the effective interest rate taking into consideration a discount rate i_d of 10% and a general inflation rate j of 5%.

$$i' = (i_d - j) = (1+j) = (0.1 - 0.05)/(1+0.05) = 0.04762 = 4.62\%$$

Example 5: Using the effective interest rate in **Example 4**, calculate the future value of $10,000 10 years from now.

$$F = P(1+i')^n = \$10,000(1+0.04762)^{10} = \$15,923.47 \text{ (constant dollars)}$$

Recovering Capital as a Series of Payments

Another important economic concept is the recovery or acquisition of capital as a series of uniform payments – the capital recovery factor. The capital recovery factor is commonly used to describe periodic uniform mortgage or loan payments. It is the ratio of the periodic payment to the total sum being repaid. The discounted sum S of such an annual series of payments P_{ann} invested over n periods with interest rate i is given by:

$$S = P_{ann}\left[1-(1+i)^{-n}\right]/i \tag{10}$$

This series of uniform annual payments P_{ann} over n periods is equivalent to the present value sum S divided by the capital recovery factor, with interest rate i expressed as:

$$P_{ann} = Si/\left[1-(1+i)^{-n}\right] \tag{11}$$

This multiplier is the capital recovery CRF(i,n), which can be expressed as:

$$\text{CRF}(i,n) = i/\left[1-(1+i)^{-n}\right] = i(1+i)^n/\left[(1+i)^n-1\right] \tag{12}$$

Example 6: Calculate the discounted sum of ten periodic payments of $1,000 with a discount rate of 10%.

$$S = P_{ann}S = P_{ann}\left[1-(1+i)^{-n}\right]/i = 1000\left[1-(1+0.10)^{-10}\right]/0.10 = \$6144.57$$

Example 7: Calculate the capital recovery factor for Example 6.

$$\text{CRF}(i,n) = i/\left[1-(1+i)^{-n}\right] = 0.10/1-(1+0.10)^{-10} = 0.162745$$

Annualized Costs

The economic analysis methods presented to this point have included only single cash flows or a simple series of payments that were adjusted for inflation. A detailed cash flow analysis of a mechanical system should consider all positive and negative cash flow through the life of the system, including single payments, series of payments, and increasing or decreasing payments, and

must also consider varying inflation rates. Such analysis should take into account taxes, tax credits, mortgage payments, and all other costs associated with a particular system. One convenient way of accomplishing this is to use annualized system costs as presented by Kreith and Kreider (1978, 1982) and Kreider (1979).

Total annualized mechanical system costs depend on initial investments, salvage values, replacement costs, energy costs, property taxes, property tax deductions, interest tax deductions, maintenance costs, replacement costs, and insurance costs. Such a representation lends itself to optimization of system costs and can be applied to residential and commercial systems.

Annualized mechanical system owning, operating, and maintenance costs (for a profit-making firm) can be expressed in constant currency as:

C_y = – capital and interest + salvage value – replacements (or disposals) – operating energy – property tax – maintenance – insurance + interest tax deduction + depreciation (for commercial systems) (13)

where

$(\mathrm{CRF}_{s,init} - \mathrm{ITC})\mathrm{CRF}(i',n)$ = capital and interest

$C_{s,salv}\mathrm{PWF}(i',n)\mathrm{CRF}(i',n)(1-T_{salv})$ = salvage value

$\sum_{k=1}^{n}[R_k\mathrm{PWF}(i',k)]\mathrm{CRF}(i',n)(1-T_{inc})$ = replacements or disposals

$C_e[\mathrm{CRF}(i',n)/\mathrm{CRF}(i'',n)](1-T_{inc})$ = operating energy

$C_{s,assess}T_{prop}(1-T_{inc})$ = property tax

$M(1-T_{inc})$ = maintenance

$I(1-T_{inc})$ = insurance

$T_{inc}\sum_{k=1}^{n}[i_m P_{k-1}\mathrm{PWF}(i_d,k)]\mathrm{CRF}(i',n)$ = interest tax deduction

$T_{inc}\sum_{k=1}^{n}[D_k\mathrm{PWF}(i_d,k)]\mathrm{CRF}(i',n)$ = depreciation (for commercial systems)

The outstanding principle P_k during year k at market mortgage rate i_m is given by:

$$P_k = (C_{s,init} - \mathrm{ITC})\left[(1+i_m)^{k-1} + \frac{(1+i_m)^{k-1}-1}{(1+i_m)^{-n}-1}\right] \quad (14)$$

Note: P_k is in current dollars and must, therefore, be discounted by the discount rate i_d not i'.

Likewise, the summation term for interest deduction can be expressed as:

$$\sum_{k=1}^{n}\left[i_m P_k/(1+i_d)^k\right]=\left[\frac{\mathrm{CRF}(i_m,n)}{\mathrm{CRF}(i_d,n)}+\frac{1}{(1+i_m)}\frac{i_m-\mathrm{CRF}(i_m,n)}{\mathrm{CRF}(i_d-i_m)/(1+i_m),n}\right]\times(C_{s,init}-\mathrm{ITC}) \quad (15)$$

and if $i_d = i_m$,

$$\sum_{k=1}^{n}\left[i_m P_k/(1+i_d)^k\right]=\left[1+\frac{n}{(1+i_m)}\left[i_m-\mathrm{CRF}(i_m,n)\right]\right](C_{s,init}-\mathrm{ITC}) \quad (16)$$

Depreciation terms commonly used include depreciation calculated by the straight line depreciation method, which is:

$$D_{k,SL}=(C_{s,init}-C_{s,salv})/n \quad (17)$$

and the sum-of-digits depreciation method:

$$D_{k,SD}=(C_{s,init}-C_{s,salv})[2(n-k+1)]/n(n+1) \quad (18)$$

Riggs (1977) and Grant *et al.* (1982) present further information on advanced depreciation methods. Certified accountants may also be consulted for information regarding accelerated methods allowed by the IRS.

Example 8: Calculate the annualized system costs using constant dollars for a $10,000 system considering the following factors: a 5-year life, a salvage value of $1,000 at the end of the 5 years, ignore investment tax credits, a $500 replacement in year 3, a discount rate i_d of 10%, a general inflation rate j of 5%, a fuel inflation rate j_e of 8%, a market mortgage rate i_m of 10%, an annual operating cost for energy of $500, a $100 annual maintenance cost, a $50 annual insurance cost, straight line depreciation, an income tax rate of 50%, a property tax rate of 1% of assessed value, an assessed system value equal to 40% of the initial system value, and a salvage tax rate of 50%.

Effective interest rate i'

$$i'=(i_d-j)/(1+j)=(0.10-0.05)/(1+0.05)=0.047619$$

Effective interest rate i''

$$i''=(i_d-j_e)/(1+j_e)=(0.10-0.08)/(1+0.08)=0.018519$$

Capital recovery factor CRF(i',n)

$$\text{CRF}(i',n) = i' / \left[1-(1+i')^{-n}\right] = 0.047619 / \left[1-(1.047619)^{-5}\right] = 0.229457$$

Capital recovery factor CRF(i'',n)

$$\text{CRF}(i'',n) = i'' / \left[1-(1+i'')^{-n}\right] = 0.018519 / \left[1-(0.018519)^{-5}\right] = 0.211247$$

Capital recovery factor CRF(i_m,n)

$$\text{CRF}(i_m,n) = i_m / \left[1-(1+i_m)^{-n}\right] = 0.10 / \left[1-(1.10)^{-5}\right] = 0.263797$$

Present worth factor PWF$(i_d,$ years 1 to 5$)$

$$\text{PWF}(i_d,1) = 1/(1.10)^1 = 0.909091$$
$$\text{PWF}(i_d,2) = 1/(1.10)^2 = 0.826446$$
$$\text{PWF}(i_d,3) = 1/(1.10)^3 = 0.751315$$
$$\text{PWF}(i_d,4) = 1/(1.10)^4 = 0.683013$$
$$\text{PWF}(i_d,5) = 1/(1.10)^5 = 0.620921$$

Present worth factor PWF$(i',$ years 1 to 5$)$

$$\text{PWF}(i',1) = 1/(1.047619)^1 = 0.954545$$
$$\text{PWF}(i',2) = 1/(1.047619)^2 = 0.911157$$
$$\text{PWF}(i',3) = 1/(1.047619)^3 = 0.869741$$
$$\text{PWF}(i',4) = 1/(1.047619)^4 = 0.830207$$
$$\text{PWF}(i',5) = 1/(1.047619)^5 = 0.792471$$

Capital and interest

$$(C_{s,init} - \text{ITC})\text{CRF}(i',n) = (\$10,000 - \$0)0.0229457 = \$2,294.57$$

Salvage value

$$C_{s,salv}\text{PWF}(i',n)\text{CRF}(i',n)(1-T_{salv}) = \$1,000 \times 0.792471 \times 0.229457 \times 0.5 = \$90.92$$

Replacements or disposals

$$\sum_{k=1}^{n}\left[R_k\text{PWF}(i',k)\right]\text{CRF}(i',n)(1-T_{inc}) = \$500 \times 0.869741 \times 0.229457 \times 0.5 = \$49.89$$

Operating energy

$$C_e\left[\text{CRF}(i',n)/\text{CRF}(i'',n)\right](1-T_{inc}) = 500[0.229457/0.211247]0.5 = \$271.55$$

Property tax

$$C_{s,assess}T_{prop}(1-T_{inc}) = \$10,000 \times 0.40 \times 0.01 \times 0.05 = \$20.00$$

Maintenance

$$M(1-T_{inc}) = 100(1-.5) = \$50$$

Insurance

$$I(1-T_{inc}) = 50(1-.5) = \$25$$

Interest tax deduction

$$T_{inc}\sum_{k=1}^{n}\left[i_m P_{k-1}\mathrm{PWF}(i_d,k)\right]\mathrm{CRF}(i',n) = \ . \ . \ .$$

Table 5 Interest Deduction Summary

Year	Payment Amount (Current $)	Interest Payment (Current $)	Principal Payment (Current $)	Outstanding Principal (Current $)	PWF(i_d,k)	Discounted Interest (discounted $)	Discounted Payment (discounted $)
0	--	--	--	$10,000	--	--	--
1	2637.97	1000.00	1637.97	8362.02	0.909091	909.09	2398.17
2	2637.97	836.20	1801.77	6560.26	0.826446	691.07	2180.14
3	2637.97	656.03	1981.95	4578.31	0.751315	492.89	1981.95
4	2637.97	457.83	2180.14	2398.17	0.683013	312.70	1801.77
5	2637.97	239.82	2398.17	0	0.620921	148.91	1637.97
Total	--	3189.88	10,000.00	--	--	2554.66	10.000.00

Annual payment amounts, interest payments, principal payments, outstanding principal payments, present worth factor PWF(i_d,k), discounted interest, and discounted payment are shown in table 5. Annual payments are the product of the initial system costs $C_{s,init}$ and the capital recovery factor CRF(i_m,5).

Note: Equation (15) can be used to calculate the total discounted interest deduction directly.

Next, apply the capital recovery factor CRF(i',5) and tax rate T_{inc} to the total of the discounted interest sum.

$$\$2554.66\ \mathrm{CRF}(i',5)T_{inc} = \$2554.66 \times 0.229457 \times 0.05 = \$293.09$$

Depreciation

$$T_{inc}\sum_{k=1}^{n}\left[D_k \mathrm{PWF}(i_d,k)\right]\mathrm{CRF}(i',n) \ . \ . \ .$$

Use the straight line depreciation method to calculate depreciation.

$$D_{k,SL} = \left(C_{s,init} - C_{s,salv}\right) / n = (\$10,000 - \$1,000) / 5 = \$1800.00$$

Next, discount the depreciation.

Year	$D_{k,SL}$	PWF(i_d,k	Discounted Depreciation
1	\$1800.00	0.909091	\$1636.36
2	\$1800.00	0.826446	\$1487.60
3	\$1800.00	0.751315	\$1353.37
4	\$1800.00	0.683013	\$1229.42
5	\$1800.00	0.620921	\$1117.66
Total	--	--	\$6823.42

Finally, the capital recovery factor and tax are applied.

$$\$6823.42 \ \mathrm{CRF}(i', n) T_{inc} = \$6823.42 \times 0.229457 \times 0.05 = \$782.84$$

Summary of terms:

Capital and interest	–\$2294.57
Salvage value	+\$90.92
Replacements or disposal	–\$49.89
Operating costs	–\$271.55
Property tax	–\$20.00
Maintenance	–\$50.00
Insurance	–\$25.00
Interest deduction	+\$293.09
Depreciation deduction	+782.84
Total annualized cost	–\$1544.00

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TC1.8 HANDBOOK EX #1

VALUES	
System Cost=	$10,000
Invest.Tax Credit=	$0
Life=	5
Salvage value=	$1,000
Salvage Year =	5
Replacement/disposal	$500
Replace/disposal Yr	3
id=	10%
j=	5%
je=	8%
im=	10%
Fuel=	$500
Maintenance=	$100
Insurance=	$50
Depreciation =	S.L.
Inc.Tax=	50%
Prop.Tax=	1%
% of system cost=	40%
Salvage Tax=	50%

CALCULATIONS	
Effective int.(i')=	0.0476
Effective int.(i'')=	0.0185
CRF(i',n) =	0.2295
CRF(i'',n) =	0.2112
CRF(im,n) =	0.2638
PWF(id,1) =	0.9091
PWF(id,2) =	0.8264
PWF(id,3) =	0.7513
PWF(id,4) =	0.6830
PWF(id,5) =	0.6209
PWF(id,6) =	0.5645
PWF(id,7) =	0.5132
PWF(id,8) =	0.4665
PWF(id,9) =	0.4241
PWF(id,10) =	0.3855
PWF(i',1) =	0.9545
PWF(i',2) =	0.9112
PWF(i',3) =	0.8697
PWF(i',4) =	0.8302
PWF(i',5) =	0.7925
PWF(i',6) =	0.7564
PWF(i',7) =	0.7221
PWF(i',8) =	0.6892
PWF(i',9) =	0.6579
PWF(i',10) =	0.6280
Capitol & interest =	$2,295
Salvage Value =	$91
Replacement Costs =	$50
Operating Energy =	$272
Property Tax =	$20
Maintenance =	$50
Insurance =	$25

Year	Payment Amount	Interest Payment	Princ Payment	Outstand Princ	PWF(id,k)	Disc Inter	Disc Payment
0				$10,000			
1	$2,638	$1,000	$1,638	$8,362	0.9091	$909	$2,398
2	$2,638	$836	$1,802	$6,560	0.8264	$691	$2,180
3	$2,638	$656	$1,982	$4,578	0.7513	$493	$1,982
4	$2,638	$458	$2,180	$2,398	0.6830	$313	$1,802
5	$2,638	$240	$2,398	$0	0.6209	$149	$1,638
6	$0	$0	$0	$0	0.0000	$0	$0
7	$0	$0	$0	$0	0.0000	$0	$0
8	$0	$0	$0	$0	0.0000	$0	$0
9	$0	$0	$0	$0	0.0000	$0	$0
10	$0	$0	$0	$0	0.0000	$0	$0
TOTAL		$3,190	$10,000			$2,555	$10,000

Next apply the capital recovery factor & tax rate to total discounted int.sum.

$293

Calculate the depreciation...first calculate depreciation

$1,800

Next, discount the depreciation and sum...

Year	Dk,SL	PWF(id,k)	Disc.Depr
1	$1,800	0.9091	$1,636
2	$1,800	0.8264	$1,488
3	$1,800	0.7513	$1,352
4	$1,800	0.6830	$1,229
5	$1,800	0.6209	$1,118
6	$0	0.0000	$0
7	$0	0.0000	$0
8	$0	0.0000	$0
9	$0	0.0000	$0
10	$0	0.0000	$0
TOTAL			$6,823

Summarize the terms...

Capital & Interest =	($2,295)
Salvage value =	$91
Replacements	($50)
Operating Costs =	($272)
Property tax =	($20)
Maintenance =	($50)
Insurance =	($25)
Interest deduction =	$293
Depreciation deduction =	$783
TOTAL	($1,544)

Now apply the capital recovery factor and tax...

$783

TC1.8 HANDBOOK EX #2

VALUES	
System Cost=	$10,000
Invest.Tax Credit=	$500
Life=	10
Salvage value=	$0
Salvage Year =	10
Replacement/disposal	$1,000
Replace/disposal Yr	10
id=	15%
j=	5%
je=	10%
im=	8%
Fuel=	$400
Maintenance=	$150
Insurance=	$35
Depreciation =	S.L.
Inc.Tax=	35%
Prop.Tax=	2%
% of system cost=	60%
Salvage Tax=	35%

CALCULATIONS	
Effective int.(i')=	0.0952
Effective int.(i'')=	0.0455
CRF(i',n) =	0.1594
CRF(i'',n) =	0.1267
CRF(im,n) =	0.1490
PWF(id,1) =	0.8696
PWF(id,2) =	0.7561
PWF(id,3) =	0.6575
PWF(id,4) =	0.5718
PWF(id,5) =	0.4972
PWF(id,6) =	0.4323
PWF(id,7) =	0.3759
PWF(id,8) =	0.3269
PWF(id,9) =	0.2843
PWF(id,10) =	0.2472
PWF(i',1) =	0.9130
PWF(i',2) =	0.8336
PWF(i',3) =	0.7612
PWF(i',4) =	0.6950
PWF(i',5) =	0.6345
PWF(i',6) =	0.5794
PWF(i',7) =	0.5290
PWF(i',8) =	0.4830
PWF(i',9) =	0.4410
PWF(i',10) =	0.4026
Capitol & interest =	$1,515
Salvage Value =	$0
Replacement Costs =	$42
Operating Energy =	$327
Property Tax =	$78
Maintenance =	$98
Insurance =	$23

Year	Payment Amount	Interest Payment	Princ Payment	Outstand Princ	PWF(id,k)	Disc Inter	Disc Payment
0				$10,000			
1	$1,490	$800	$690	$9,310	0.8696	$696	$1,296
2	$1,490	$745	$746	$8,564	0.7561	$563	$1,127
3	$1,490	$685	$805	$7,759	0.6575	$450	$980
4	$1,490	$621	$870	$6,889	0.5718	$355	$852
5	$1,490	$551	$939	$5,950	0.4972	$274	$741
6	$1,490	$476	$1,014	$4,936	0.4323	$206	$644
7	$1,490	$395	$1,095	$3,841	0.3759	$148	$560
8	$1,490	$307	$1,183	$2,658	0.3269	$100	$487
9	$1,490	$213	$1,278	$1,380	0.2843	$60	$424
10	$1,490	$110	$1,380	($0)	0.2472	$27	$368
TOTAL		$4,903	$10,000			$2,881	$7,479

Next apply the capital recovery factor & tax rate to total discounted int.sum.

$161

Calculate the depreciation...first calculate depreciation

$1,000

Next, discount the depreciation and sum...

Year	Dk,SL	PWF(id,k)	Disc.Depr
1	$1,000	0.8696	$870
2	$1,000	0.7561	$756
3	$1,000	0.6575	$658
4	$1,000	0.5718	$572
5	$1,000	0.4972	$497
6	$1,000	0.4323	$432
7	$1,000	0.3759	$376
8	$1,000	0.3269	$327
9	$1,000	0.2843	$284
10	$1,000	0.2472	$247
TOTAL			$5,019

Summarize the terms...

Capital & Interest =	($1,515)
Salvage value =	$0
Replace/disposal=	($42)
Operating Costs =	($327)
Property tax =	($78)
Maintenance =	($98)
Insurance =	($23)
Interest deduction =	$161
Depreciation deduction =	$280
TOTAL	($1,641)

Now apply the capital recovery factor and tax...

$280

Example that has a disposal cost in year 10.

Calculate the annualized system cost using constant dollars for a $10,000 system considering the following factors: a 10 ye a disposal cost of $1,000 at the end of the 10 years, a $500 investment tax credit for energy efficiency, no replacements, a discount rate id of 15%, a general inflation rate of 5%, a fuel inflation rate je of 10%, a market mortgage im of 8%, an annual operating cost for energy of $400, a $150 annual maintenance cost, a $35 insurance cost, straight line depreciation, an income tax of 35%, a property tax of 2% of assessed value, an assessed system value of equal to 60% of the system value, an a salvage tax rate of 35% (if positive salvage

TC1.8 HANDBOOK EX #3

VALUES	
System Cost=	$0
Invest.Tax Credit=	$0
Life=	10
Salvage value=	$0
Salvage Year =	10
Replacement/disposal	$1,000
Replace/disposal Yr	5
id=	15%
j=	5%
je=	10%
im=	8%
Fuel=	$1,800
Maintenance=	$300
Insurance=	$35
Depreciation =	S.L.
Inc.Tax=	35%
Prop.Tax=	2%
% of system cost=	60%
Salvage Tax=	35%

CALCULATIONS	
Effective int.(i')=	0.0952
Effective int.(i'')=	0.0455
CRF(i',n) =	0.1594
CRF(i'',n) =	0.1267
CRF(im,n) =	0.1490
PWF(id,1) =	0.8696
PWF(id,2) =	0.7561
PWF(id,3) =	0.6575
PWF(id,4) =	0.5718
PWF(id,5) =	0.4972
PWF(id,6) =	0.4323
PWF(id,7) =	0.3759
PWF(id,8) =	0.3269
PWF(id,9) =	0.2843
PWF(id,10) =	0.2472
PWF(i',1) =	0.9130
PWF(i',2) =	0.8336
PWF(i',3) =	0.7612
PWF(i',4) =	0.6950
PWF(i',5) =	0.6345
PWF(i',6) =	0.5794
PWF(i',7) =	0.5290
PWF(i',8) =	0.4830
PWF(i',9) =	0.4410
PWF(i',10) =	0.4026
Capitol & interest =	$0
Salvage Value =	$0
Replacement Costs =	$66
Operating Energy =	$1,473
Property Tax =	$0
Maintenance =	$195
Insurance =	$23

Year	Payment Amount	Interest Payment	Princ Payment	Outstand Princ	PWF(id,k)	Disc Inter	Disc Payment
0				$0			
1	$0	$0	$0	$0	0.8696	$0	$0
2	$0	$0	$0	$0	0.7561	$0	$0
3	$0	$0	$0	$0	0.6575	$0	$0
4	$0	$0	$0	$0	0.5718	$0	$0
5	$0	$0	$0	$0	0.4972	$0	$0
6	$0	$0	$0	$0	0.4323	$0	$0
7	$0	$0	$0	$0	0.3759	$0	$0
8	$0	$0	$0	$0	0.3269	$0	$0
9	$0	$0	$0	$0	0.2843	$0	$0
10	$0	$0	$0	$0	0.2472	$0	$0
TOTAL		$0	$0			$0	$0

Next apply the capital recovery factor & tax rate to total discounted int.sum.

$0

Calculate the depreciation...first calculate depreciation

$0

Next, discount the depreciation and sum...

Year	Dk,SL	PWF(id,k)	Disc.Depr
1	$0	0.8696	$0
2	$0	0.7561	$0
3	$0	0.6575	$0
4	$0	0.5718	$0
5	$0	0.4972	$0
6	$0	0.4323	$0
7	$0	0.3759	$0
8	$0	0.3269	$0
9	$0	0.2843	$0
10	$0	0.2472	$0
TOTAL			$0

Now apply the capital recovery factor and tax...

$0

Summarize the terms...

Capital & Interest =	$0
Salvage value =	$0
Replace/disposal=	($66)
Operating Costs =	($1,473)
Property tax =	$0
Maintenance =	($195)
Insurance =	($23)
Interest deduction =	$0
Depreciation deduction =	$0
TOTAL	($1,756)

Retrofit example...part one...

Calculate the annualized system cost using constant dollars for an existing system considering the following factors: a 10 a replacement cost of $1,000 at the end of the 5 years, no investment tax credits, a $1,000 replacement in year 5, a discount rate id of 15%, a general inflation rate of 5%, a fuel inflation rate je of 10%, a market mortgage im of 8%, an annual operating cost for energy of $1,800, a $30 annual maintenance cost, a $35 insurance cost, straight line depreciation, an income tax of 35%, a property tax of 2% of assessed value, an assessed system value of equal to 60% of the system value, an a salvage tax rate of 35% (if positive salvage

TC1.8 HANDBOOK EX #4

VALUES	
System Cost=	$5,000
Invest.Tax Credit=	$0
Life=	10
Salvage value=	$0
Salvage Year =	10
Replacement/disposal	$0
Replace/disposal Yr	5
id=	15%
j=	5%
je=	10%
im=	8%
Fuel=	$1,200
Maintenance=	$150
Insurance=	$35
Depreciation =	S.L.
Inc.Tax=	35%
Prop.Tax=	2%
% of system cost=	60%
Salvage Tax=	35%

CALCULATIONS	
Effective int.(i')=	0.0952
Effective int.(i'')=	0.0455
CRF(i',n) =	0.1594
CRF(i'',n) =	0.1267
CRF(im,n) =	0.1490
PWF(id,1) =	0.8696
PWF(id,2) =	0.7561
PWF(id,3) =	0.6575
PWF(id,4) =	0.5718
PWF(id,5) =	0.4972
PWF(id,6) =	0.4323
PWF(id,7) =	0.3759
PWF(id,8) =	0.3269
PWF(id,9) =	0.2843
PWF(id,10) =	0.2472
PWF(i',1) =	0.9130
PWF(i',2) =	0.8336
PWF(i',3) =	0.7612
PWF(i',4) =	0.6950
PWF(i',5) =	0.6345
PWF(i',6) =	0.5794
PWF(i',7) =	0.5290
PWF(i',8) =	0.4830
PWF(i',9) =	0.4410
PWF(i',10) =	0.4026
Capitol & interest =	$797
Salvage Value =	$0
Replacement Costs =	$0
Operating Energy =	$982
Property Tax =	$39
Maintenance =	$98
Insurance =	$23

Year	Payment Amount	Interest Payment	Princ Payment	Outstand Princ	PWF(id,k)	Disc Inter	Disc Payment
0				$5,000			
1	$745	$400	$345	$4,655	0.8696	$348	$648
2	$745	$372	$373	$4,282	0.7561	$282	$563
3	$745	$343	$403	$3,880	0.6575	$225	$490
4	$745	$310	$435	$3,445	0.5718	$177	$426
5	$745	$276	$470	$2,975	0.4972	$137	$370
6	$745	$238	$507	$2,468	0.4323	$103	$322
7	$745	$197	$548	$1,920	0.3759	$74	$280
8	$745	$154	$592	$1,329	0.3269	$50	$244
9	$745	$106	$639	$690	0.2843	$30	$212
10	$745	$55	$690	($0)	0.2472	$14	$184
TOTAL		$2,451	$5,000			$1,440	$3,740

Next apply the capital recovery factor & tax rate to total discounted int.sum.

$80

Calculate the depreciation...first calculate depreciation

$500

Next, discount the depreciation and sum...

Year	Dk,SL	PWF(id,k)	Disc.Depr
1	$500	0.8696	$435
2	$500	0.7561	$378
3	$500	0.6575	$329
4	$500	0.5718	$286
5	$500	0.4972	$249
6	$500	0.4323	$216
7	$500	0.3759	$188
8	$500	0.3269	$163
9	$500	0.2843	$142
10	$500	0.2472	$124
TOTAL			$2,509

Summarize the terms...

Capital & Interest =	($797)
Salvage value =	$0
Replace/disposal=	$0
Operating Costs =	($982)
Property tax =	($39)
Maintenance =	($98)
Insurance =	($23)
Interest deduction =	$80
Depreciation deduction =	$140
TOTAL	($1,718)

Now apply the capital recovery factor and tax...

$140

Retrofit example...part two...

Calculate the annualized system cost using constant dollars for an new $5,000 system considering the following: a 10 year l no replacements, no investment tax credits, a discount rate id of 15%, a general inflation rate of 5%, a fuel inflation rate je of 10%, a market mortgage im of 8%, an annual operating cost for energy of $1,200, a $15 annual maintenance cost, a $35 insurance cost, straight line depreciation, an income tax of 35%, a property tax of 2% of assessed value, an assessed system value of equal to 60% of the system value, an a salvage tax rate of 35% (if positive salvage

Energy Systems Laboratory
Mechanical Engineering

INSTALLATION GUIDE:

The floppy disk that accompanies the "Economic Calculations for the ASHRAE Handbook..." contains several Lotus 123 spreadsheet templates that are an electronic version of the last 4 pages of this document. To use this software you will need to have an MSDOS compatible computer with Lotus 123 Version 2x or some other spreadsheet that can convert Lotus 123 Version 2x files such as Excel, or Quatro Pro. The remainder of this document assumes that the reader is familiar with MSDOS and Lotus 123 commands.

To install the 123 templates in your MSDOS computer select the appropriate directory into which you want to copy the templates (let's assume that this is called c:\TEMP. Check to make sure that you do not have any .WK1 Lotus templates (or anything else) named ASHRAE01.WK1 through ASHRAE04.WK1. Place the floppy disk in the A: drive, then type:

CD C:\TEMP	...this will put you in C:\TEMP
COPY a:*.WK1 *.*	...this copies everything named *.WK1 into the C:\TEMP directory

Next, you will need to start Lotus 123. Depending upon whether or not you have declared the directory containing the 123.EXE file to be on your path, you may need to change directories to the C:\LOTUS directory. Then start Lotus with:

LOTUS followed by 123

or simply

123

Once Lotus 123 is running the ASHRAE01.WK1 template can then be retrieved with the following command:

/FILE RETRIEVE C:\TEMP\ASHRAE01.WK1

This assumes that ASHRAE01.WK1 is indeed in C:\TEMP.

The template should come alive in column 1, row 1 and display the text 'ASHRAE HANDBOOK EX#1. The other ASHRAE templates have a similar title only contain EX#2, EX#3, and EX#4 respectively.

Cells C3 ... C21 are the only cells that need to be changed by the user. All other cells are displaying the results of calculations and should not require any adjustments. You

are free to look a the equations by simply moving around the spreadsheet to view the formulas.

The cells E1 ... K15 display the Table 5 contained in the write-up.

The final answer can be found in cells J27 ... M39.

This economic analysis is only valid for 1 to 10 years. For an economic analysis of greater than 10 years, cells E1 ... K15 will need to be expanded. It is suggested that you simply move the cells immediately below this to another location on the spreadsheet, move the totalizing row, copy down the last row of the block until the proper number of years appears, adjust the "year" column, and recalculate.

After any new value has been entered you will need to hit the F9 or RECALCULATE function key. It is advised that after each new value is entered a print is made of the spreadsheet to serve as a handy reference to what has been done.

Unfortunately, this spreadsheet only fits nicely into a landscape mode of printing. To make this adjustment one needs to reset the 123 printer setup command. For example using an HP Laserjet III this would be as follows:

/ PRINT PRINTER OPTIONS SETUP \027&l1o5.45C\027Cs0p16.67H

Other printers have different set up commands.

If you have any questions about the use of these templates feel free to contact the author.