Economic Calculations for the ASHRAE Handbook

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ECONOMIC ANALYSIS TECHNIQUES

Definitions of terms:

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

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:

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

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

$$ P = F/(1+i)^n = F \times PWF(i,n) \quad (2) $$

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

$$ PWF(i,n) = 1/(1+i)^n \quad (3) $$

**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.

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

**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):

$$i' = \frac{1+i_d}{1+j} - 1 = \frac{(i_d - j)}{(1+j)}$$  \hspace{1cm} (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:

$$i'' = \frac{1+i_d}{1+j_e} - 1 = \frac{(i_d - j_e)}{(1+j_e)}$$  \hspace{1cm} (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:

$$F = P \left[ \frac{1+i_d}{1+j} \right]^n = P(1+i')^n$$  \hspace{1cm} (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:

$$P = F / \left[ \frac{(1+i_d)}{(1+j)} \right]^n$$  \hspace{1cm} (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:

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

where the effective present worth factor is given by:

$$\text{PWF}(i', n) = 1 / (1+i')^n$$  \hspace{1cm} (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 \( P_{\text{ann}} \) invested over \( n \) periods with interest rate \( i \) is given by:

\[ S = P_{\text{ann}} \left[ \frac{1-(1+i)^{-n}}{i} \right] \]

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

\[ P_{\text{ann}} = S \frac{i}{(1+i)^n} \]

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

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

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

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

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:

\[
C_y = - \text{capital and interest} + \text{salvage value} - \text{replacements (or disposals)} - \text{operating energy} - \text{property tax} - \text{maintenance} - \text{insurance} + \text{interest tax deduction} + \text{depreciation (for commercial systems)}
\]

\[
(\text{CRF}_{s,\text{init}} - \text{ITC})\text{CRF}(i', n)
\]

\[
C_{s,\text{salv}}\text{PWF}(i', n)\text{CRF}(i', n)(1 - T_{s,\text{salv}})
\]

\[
\sum_{k=1}^{n} [R_k \text{PWF}(i', k)]\text{CRF}(i', n)(1 - T_{s,\text{inc}})
\]

\[
C_e[\text{CRF}(i', n) / \text{CRF}(i''', n)](1 - T_{s,\text{inc}})
\]

\[
C_{s,\text{access}}T_{prop}(1 - T_{s,\text{inc}})
\]

\[
M(1 - T_{s,\text{inc}})
\]

\[
I(1 - T_{s,\text{inc}})
\]

\[
T_{s,\text{inc}} \sum_{k=1}^{n} [i_m P_{k-1} \text{PWF}(i, k)]\text{CRF}(i', n)
\]

\[
T_{s,\text{inc}} \sum_{k=1}^{n} [D_i \text{PWF}(i, k)]\text{CRF}(i', n)
\]

where

\[
(\text{CRF}_{s,\text{init}} - \text{ITC})\text{CRF}(i', n)
\] = capital and interest

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

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

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

\[
C_{s,\text{access}}T_{prop}(1 - T_{s,\text{inc}})
\] = property tax

\[
M(1 - T_{s,\text{inc}})
\] = maintenance

\[
I(1 - T_{s,\text{inc}})
\] = insurance

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

\[
T_{s,\text{inc}} \sum_{k=1}^{n} [D_i \text{PWF}(i, k)]\text{CRF}(i', n)
\] = depreciation (for commercial systems)

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

\[
P_k = (C_{s,\text{init}} - \text{ITC})\left[ (1 + i_m)^{k-1} + \frac{(1 + i_m)^{k-1} - 1}{(1 + i_m)^n - 1} \right]
\]
Depreciation terms commonly used include depreciation calculated by the straight line method, which is:

\[ A^* = \frac{C_u - O}{i} \]  

and the sum-of-digits depreciation method:

\[ D_{KS} = \frac{(C_u - O)[2(n^2 + n)]}{n(n + 1)} \]  

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 \( j_f \) 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** \( i' \)

\[ i' = \frac{(i_d - j)}{1 + j} = \frac{0.10 - 0.05}{1 + 0.05} = 0.047619 \]

**Effective interest rate** \( i'' \)

\[ i'' = \frac{(i_d - j_f)}{1 + j_f} = \frac{0.10 - 0.08}{1 + 0.08} = 0.018519 \]
Capital recovery factor $CRF(i', n)$

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

Capital recovery factor $CRF(i'', n)$

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

Capital recovery factor $CRF(i_m, n)$

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

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

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

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

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

Capital and interest

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

Salvage value

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

Replacements or disposals

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

Operating energy

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

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

\[ T_{inc} \sum_{k=1}^{n} [i_m P_k - PWF(i', k)] \cdot \text{CRF}(i', n) = \ldots \]

Annual payment amounts, interest payments, principal payments, outstanding principal payments, present worth factor \( PWF(i_a k) \), 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 \( \text{CRF}(i_m'5) \).

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

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

\[ \$2554.66 \cdot \text{CRF}(i', 5) \cdot T_{inc} = \$2554.66 \times 0.229457 \times 0.05 = \$293.09 \]

Depreciation

\[ T_{inc} \sum_{k=1}^{n} [D_k \cdot PWF(i_a k)] \cdot \text{CRF}(i', n) = \ldots \]
Use the straight line depreciation method to calculate depreciation.

\[ D_{k,SL} = \frac{(C_{s,init} - C_{s,vol})}{n} = \frac{($10,000 - $1,000)}{5} = $1800.00 \]

Next, discount the depreciation.

<table>
<thead>
<tr>
<th>Year</th>
<th>( D_{k,SL} )</th>
<th>PWF( (i, k) )</th>
<th>Discounted Depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1800.00</td>
<td>0.909091</td>
<td>$1636.36</td>
</tr>
<tr>
<td>2</td>
<td>$1800.00</td>
<td>0.826446</td>
<td>$1487.60</td>
</tr>
<tr>
<td>3</td>
<td>$1800.00</td>
<td>0.751315</td>
<td>$1353.37</td>
</tr>
<tr>
<td>4</td>
<td>$1800.00</td>
<td>0.683013</td>
<td>$1229.42</td>
</tr>
<tr>
<td>5</td>
<td>$1800.00</td>
<td>0.620921</td>
<td>$1117.66</td>
</tr>
<tr>
<td>Total</td>
<td>--</td>
<td>--</td>
<td>$6823.42</td>
</tr>
</tbody>
</table>

Finally, the capital recovery factor and tax are applied.

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

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
REFERENCES


BIBLIOGRAPHY


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%
j = 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'') = 0.0183
CRF (i', n) = 0.2295
CRF (i'', n) = 0.2112
CRF (i', m) = 0.2638
PW(i, d) = 0.0909
PW(id, 1) = 0.8264
PW(id, 3) = 0.7513
PW(id, 4) = 0.6830
PW(id, 5) = 0.6209
PW(id, 6) = 0.5654
PW(id, 7) = 0.5132
PW(id, 8) = 0.4665
PW(id, 9) = 0.4241
PW(id, 10) = 0.3855
PW(id, 11) = 0.3545
PW(id, 12) = 0.3261
PW(id, 13) = 0.3002
PW(id, 14) = 0.2760
PW(id, 15) = 0.2536
PW(id, 16) = 0.2328
PW(id, 17) = 0.2135
PW(id, 18) = 0.1956
PW(id, 19) = 0.1791
PW(id, 20) = 0.1639
Capital & Interest = ($2,959)
Salvage value = $91
Replacements = ($50)
Operating Costs = ($272)
Property tax = ($20)
Maintenance = ($50)
Insurance = ($25)
Interest deduction = ($293)
Depreciation deduction = $783
TOTAL ($1,544)

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 Summarize the terms...

<table>
<thead>
<tr>
<th>Year</th>
<th>Dk, SL</th>
<th>PWF(id, k)</th>
<th>Disc. Depr</th>
<th>Summarize the terms...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1,800</td>
<td>0.9091</td>
<td>$1,636</td>
<td>Capital &amp; Interest = ($2,959)</td>
</tr>
<tr>
<td>2</td>
<td>$1,800</td>
<td>0.8264</td>
<td>$1,488</td>
<td>Salvage value = $91</td>
</tr>
<tr>
<td>3</td>
<td>$1,800</td>
<td>0.7513</td>
<td>$1,332</td>
<td>Replacements = ($50)</td>
</tr>
<tr>
<td>4</td>
<td>$1,800</td>
<td>0.6830</td>
<td>$1,199</td>
<td>Operating Costs = ($272)</td>
</tr>
<tr>
<td>5</td>
<td>$1,800</td>
<td>0.6209</td>
<td>$1,118</td>
<td>Property tax = ($20)</td>
</tr>
<tr>
<td>6</td>
<td>$0</td>
<td>0.0000</td>
<td>$0</td>
<td>Maintenance = ($50)</td>
</tr>
<tr>
<td>7</td>
<td>$0</td>
<td>0.0000</td>
<td>$0</td>
<td>Insurance = ($25)</td>
</tr>
<tr>
<td>8</td>
<td>$0</td>
<td>0.0000</td>
<td>$0</td>
<td>Interest deduction = ($293)</td>
</tr>
<tr>
<td>9</td>
<td>$0</td>
<td>0.0000</td>
<td>$0</td>
<td>Depreciation deduction = $783</td>
</tr>
<tr>
<td>10</td>
<td>$0</td>
<td>0.0000</td>
<td>$0</td>
<td>TOTAL ($1,544)</td>
</tr>
</tbody>
</table>

TOTAL $6,823

Now apply the capital recovery factor and tax...

$783
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 year 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 base 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 equal to 60% of the system value, an a salvage tax rate of 35% (if positive salvage

TC1.8 HANDBOOK EX #2
VALUES

| System Costs | $10,000 |
| Invest.Tax Credit | $500 |
| Life | 10 |
| Salvage value | $0 |
| Salvage Year | 10 |
| Replacement/disposal | $1,000 |
| Replace/disposal Yr | 10 |
| id | 15% |
| je | 5% |
| 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.(f) | 0.0952 |
| Effective int.(f/10) | 0.0545 |
| CRF(1/10) | 0.1594 |
| CRF(1/10,1) | 0.1267 |
| CRF(1/10,2) | 0.1490 |
| PWF(d,1) | 0.8696 |
| PWF(d,2) | 0.7561 |
| PWF(d,3) | 0.6575 |
| PWF(d,4) | 0.5718 |
| PWF(d,5) | 0.4972 |
| PWF(d,6) | 0.4323 |
| PWF(d,7) | 0.3759 |
| PWF(d,8) | 0.3269 |
| PWF(d,9) | 0.2843 |
| PWF(d,10) | 0.2472 |
| PWF(d,11) | 0.2131 |
| PWF(d,12) | 0.1836 |
| PWF(d,13) | 0.1576 |
| PWF(d,14) | 0.1342 |
| PWF(d,15) | 0.1129 |
| PWF(d,16) | 0.0934 |
| PWF(d,17) | 0.0749 |
| PWF(d,18) | 0.0575 |
| PWF(d,19) | 0.0440 |
| PWF(d,20) | 0.0326 |

Capital & Interest = $1,515
Salvage Value = $0
Replacement Costs = $42
Operating Energy = $327
Property Tax = $78
Maintenance = $98
Insurance = $23

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...

<table>
<thead>
<tr>
<th>Year</th>
<th>Dk,Sl</th>
<th>PWF(id,k)Disc.</th>
<th>Summarize the terms...</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$1,000</td>
<td>0.8696</td>
<td>$870 Capital &amp; Interest = ($1,515)</td>
</tr>
<tr>
<td>1</td>
<td>$1,000</td>
<td>0.7561</td>
<td>$756 Salvage value = $0</td>
</tr>
<tr>
<td>2</td>
<td>$1,000</td>
<td>0.6575</td>
<td>$658 Replace/disposal = ($42)</td>
</tr>
<tr>
<td>3</td>
<td>$1,000</td>
<td>0.5718</td>
<td>$572 Operating Costs = ($327)</td>
</tr>
<tr>
<td>4</td>
<td>$1,000</td>
<td>0.4972</td>
<td>$497 Property tax = ($78)</td>
</tr>
<tr>
<td>5</td>
<td>$1,000</td>
<td>0.4323</td>
<td>$432 Maintenance = ($98)</td>
</tr>
<tr>
<td>6</td>
<td>$1,000</td>
<td>0.3759</td>
<td>$376 Insurance = ($23)</td>
</tr>
<tr>
<td>7</td>
<td>$1,000</td>
<td>0.3269</td>
<td>$327 Interest deduction = $161</td>
</tr>
<tr>
<td>8</td>
<td>$1,000</td>
<td>0.2843</td>
<td>$284 Depreciation deduction = $280</td>
</tr>
<tr>
<td>9</td>
<td>$1,000</td>
<td>0.2472</td>
<td>$247 TOTAL</td>
</tr>
<tr>
<td>10</td>
<td>$1,000</td>
<td>0.2131</td>
<td>$213 TOTAL ($1,641)</td>
</tr>
</tbody>
</table>

Now apply the capital recovery factor and tax...

$280
Calculate the annualized system cost using constant dollars for an existing system considering the following factors: a $1,000 replacement cost at the end of the 5 years, no investment tax credits, a $1,000 replacement in year 5, a discount rate of 15%, a general inflation rate of 5%, a fuel inflation rate of 8%, an annual operating cost for energy of $1,800, a $30 annual maintenance cost, a $50 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, and a salvage tax rate of 35% (if positive salvage value).

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

Calculate the depreciation... first calculate depreciation

Next, discount the depreciation and sum...

Summarize the terms...

Now apply the capital recovery factor and tax...
Calculate the annualized system cost using constant dollars for a new $5,000 system considering the following: a 10 year life, 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 value).

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...

<table>
<thead>
<tr>
<th>Year</th>
<th>Dk,SL</th>
<th>PWF(id,k)Disc.Depr</th>
<th>Summarize the terms...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$500</td>
<td>0.8696</td>
<td>Capital &amp; Interest = ($797)</td>
</tr>
<tr>
<td>2</td>
<td>$500</td>
<td>0.7561</td>
<td>Salvage value = $0</td>
</tr>
<tr>
<td>3</td>
<td>$500</td>
<td>0.6575</td>
<td>Replace/disposal= $0</td>
</tr>
<tr>
<td>4</td>
<td>$500</td>
<td>0.5718</td>
<td>Operating Costs = ($982)</td>
</tr>
<tr>
<td>5</td>
<td>$500</td>
<td>0.4972</td>
<td>Property tax = ($39)</td>
</tr>
<tr>
<td>6</td>
<td>$500</td>
<td>0.4323</td>
<td>Maintenance = ($98)</td>
</tr>
<tr>
<td>7</td>
<td>$500</td>
<td>0.3269</td>
<td>Insurance = ($23)</td>
</tr>
<tr>
<td>8</td>
<td>$500</td>
<td>0.2843</td>
<td>Interest deduction = $50</td>
</tr>
<tr>
<td>9</td>
<td>$500</td>
<td>0.2472</td>
<td>Depreciation deduction = $140</td>
</tr>
<tr>
<td>10</td>
<td>$500</td>
<td>0.2157</td>
<td>TOTAL = ($1,718)</td>
</tr>
</tbody>
</table>

TOTAL = $2,509

Now apply the capital recovery factor and tax...

$140
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:*.* 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 at 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&llo5.45C\027Cs0pl6.67H
```

Other printers have different set up commands.

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