Appendix J
Cost Effective Analysis

I.   GENERAL GUIDELINES

The purpose of the cost-effectiveness analysis is to determine a benefit-to-cost ratio (BCR) and net present value (NPV) for each ECM and an entire package of ECMs. The cost-effectiveness analysis is designed to be comprehensive enough to compare different system types fairly, yet allow for simple comparison of ECMs. The figures referred to in this section are on Pages J-3 through J-6. The tables referred to are on Pages J-20 through J-22.

1.   The benefit-to-cost ratio (BCR) indicates the relative cost effectiveness of various ECMs. If a BCR exceeds 1.0, the ECM is considered to be cost-effective. In some cases, an ECM costs less than the baseline system. When the cost is negative, a measure is cost-effective as long as there is a positive saving. When comparing individual ECMs, a higher BCR is more cost-effective. The BCR is calculated as follows:

$$BCR = \frac{\text{Present Value measure savings (PVS)}}{\text{Present Value measure incremental cost (PVC)}}$$

Where: PVS is the present value of the savings of the ECM or ECM package, and includes:
   a.   The energy savings
   b.   Other annual operating and maintenance savings
   c.   For complex ECMs:
       •   Avoided baseline system replacements adjusted for salvage value
       •   Avoided baseline periodic maintenance

And: PVC is the present value of the incremental cost of the ECM or ECM package, and includes:
   a.   Construction labor, material, and equipment costs
   b.   Any increase in agency supervision and administration
   c.   Any increase in design costs
   d.   Any increase in annual operating or maintenance costs
   e.   For complex ECMs:
       •   Added ECM system replacements adjusted for salvage value
       •   Added ECM periodic maintenance
   f.   The cost of SEED Program participation may be included at the agency's option in the cost-effectiveness analysis of a package of ECMs, but not in the cost-effective analysis of individual ECMs.

2.   The net present value (NPV) of the ECM's savings is the present value savings minus the present value costs. The NPV must be positive for a measure to be

considered cost effective. The NPV represents the total net savings for an ECM over its life expressed in today's dollars. When comparing alternative ECMs or ECM packages, a NPV indicates a larger benefit or savings. The net present value can be calculated as follows:

$$\text{NPV} = \text{PV Measure Savings (PVS)} - \text{PV Measure Costs (PVC)}$$

Where: PVS and PVC are as defined above for the BCR.

When calculating present values, the analysis period for each ECM shall be the ECM useful life. For ECM packages, the life used shall be the cost-weighted life of all included ECMs. Use the expected useful lifetimes for equipment provided in Table 1.

3. For buildings where extensive remodeling is expected, shorter equipment lives may be selected to reflect early removal of equipment during remodeling. Short equipment life should be used for both the baseline and ECM systems and only where equipment life will be affected by remodeling.

4. Present-value discount factors are included in Table 2. Select the appropriate table values based on the fuel types and select equipment lifetimes listed in Table 1. The Department of Energy determines the present value discount factors biannually and updates the *SEED Program Guidelines* accordingly. See notes in table 2 for the explanation of assumptions.

5. The cost-effectiveness analysis shall be a real-dollar analysis based on a discount rate as shown in table 2, which represents the state's cost of bonded money minus inflation. The cost of all project replacements, maintenance, and initial costs shall be expressed in today's real dollars without any addition for inflation. Electricity and fuel price escalation assumptions are included in the notes in table 2.

6. When selecting between mutually exclusive (independent) ECMs, select the ECM with a higher NPV except in the following situations:
    a. The ECM with the lower NPV is preferred for non-economic reasons
    b. The ECM with the higher NPV is not cost-effective after interaction in an ECM package and an alternative ECM with a lower NPV is cost-effective after interaction

A sample ECM Cost-Effectiveness Analysis is on Pages J-9 and J-10. A sample package analysis is on Page J-15. The energy analyst should use the Cost-Effectiveness Analysis worksheets included in Appendix G for ECM and ECM package evaluation. Electronic versions of the worksheets are available on the web.

II.   ECM COST-EFFECTIVENESS ANALYSIS WORKSHEET INSTRUCTIONS

All ECMs shall be analyzed for cost effectiveness using the *Preliminary ECM Cost-Effectiveness Analysis* worksheet. Prepare a worksheet as discussed below for each ECM:

1. **Heading**

   Identify the building, the person completing the analysis, the agency, the ECM number from the *ECM Checklist*, and the ECM name.

   ECM life in years – Enter the ECM life. Table 1 below lists expected useful lifetimes for various system types.

2. **ECM Description**

   List items in the baseline building that would change as a result of the ECM and the specific change the ECM would provide. For example, indicate the wall insulation R-value of the baseline model versus the R-value for the ECM or list the type of fixture, lamp, and ballast included in the baseline model and the type of fixture, lamp, and ballast included in the ECM. The description should give a clear picture of the baseline conditions and the changes that will be implemented within the scope of the ECM.

3. **ECM Operation and Maintenance Costs and Savings**

   Determine the annual amount of non-energy operating costs that recur annually on a uniform basis. Operating costs for the baseline or ECM do not need to include all costs, as long as significant differences between the baseline cost and the ECM cost are explained. If the baseline and ECM systems require about the same amount and type of maintenance, don't enter the difference in costs. Follow these steps:

   a. Put operation and maintenance cost savings associated with the ECM in the Annual Savings column. An example of maintenance cost savings is a baseline system with an oil boiler that requires regular cleaning, burner maintenance, and chemical treatment. An ECM with gas furnaces or heat pumps would have lower maintenance costs. Another example is lower lamp-replacement costs for fluorescent lighting versus incandescent lighting.

   b. Put the operation and maintenance cost increase associated with the ECM in the Annual Increase column. An example is a kitchen-exhaust heat-recovery ECM that requires soap solution for a heat-recovery coil wash-down system.

c. Subtract the Annual Increase value from the Annual Savings and put that value in the Maint. box in this section. If this value is positive, put in the Maint. box of the Savings. If it's negative, put the value in the Maint. box of the Costs as a *positive value.*

d. The value obtained by subtracting the Annual Increase value from the Annual Savings should also be added to the Annual Energy Savings to put in the Total Annual Savings box in the Present Value Savings section.

e. If there are significant differences between the baseline system and ECM in life, periodic maintenance costs, or replacement costs, complete Page 2 as described under section "C ECM…." below and carry forward the Equivalent Annual Savings (RM1) and Equivalent Annual Increase (RM2) to the RM1 and RM2 boxes. If there are no significant differences, enter NA in these boxes.

4. **Present Value of Cost**

a. Enter the ECM costs and the Baseline deductions

b. Enter the Design cost increase, if any.

c. Add the ECM costs to the Design cost increase, subtract the Baseline deductions and enter in Cost box

d. The annual total maintenance cost from the operating and maintenance section, if negative, is put in the Maint. box in this section as a *positive* value.

e. Go to the Year row of the *Discount Factor* Table 2 that matches the ECM life (Life). Find the uniform present worth (UPW) factor and enter it in the UPW box.

f. Multiply the annual cost increase (Maint.) by the UPW. Enter the result in the PV1 box.

g. Add the present value of annual maintenance/operation cost increase to the Cost. Enter the result in the PVC box.

5. **Present Value of Savings**

a. Enter the fuel types for the building and find the following for each fuel:

(1) Enter in the MMBtu column the annual energy savings by fuel in million Btu (MMBtu) for the entire building for the ECM. Divide Btu by 1 million to determine MMBtu. Table 3 lists Btu per unit for the various fuel types.

      (2)   Find the annual energy cost savings for each fuel and enter the results in the Annual $ column. **Note:** Where fuel rates are ratcheted or incremental, use the incremental rate to calculate the annual energy cost savings. Some modeling programs include an economic analysis package that determines the energy cost based on complex rate schedules. Include the electric demand cost savings with the electricity cost savings.

      (3)   Go to the Year row of the *Discount Factor Table 2* that matches the ECM life listed in the Life box of the worksheet. Select Fuel Escalation Factors (FEF) for each fuel and enter them in the FEF column.

      (4)   Calculate the present value (PV) savings for each energy type by multiplying the current annual savings by the FEF. Enter the result in the PV Savings column.

b.   Total the savings in MMBtu, Annual $, and PV$ for all fuels and enter in the appropriate column of the Total Energy Savings line.

c.   If the annual maintenance savings in the operating and maintenance section is positive, put that value in the Maint. box in this section.

d.   Go to the Year row of the *Discount Factor* Table 2 that matches the ECM life (Life). Find the uniform present worth (UPW) factor and enter it in the UPW box.

e.   Multiply the total annual non-energy operating savings (Maint.) by the UPW. Enter the result in the PV2 box.

f.   Add the present value of energy savings (PV1) to the present value of maintenance/operation savings (PV2). Enter the result in the PVS box.

g.   Add the annual energy savings to the total annual operating and maintenance savings, which may be positive or negative, and enter the result in the Total Annual Savings box.

6. Cost Effectiveness Summary

Find the cost-effectiveness indicators for this ECM.

a.   The net present value of savings (NPV) indicates the total net benefit in today's dollars that will result from ECM implementation. Take the present value of savings (PVS) and subtract the present value of the costs (PVC). Enter the result in the NPV box.

b.   The benefit-to-cost ratio (BCR) indicates the relative cost effectiveness of the ECM. Take the present value of savings (PVS) and divide by the present value

of costs (PVC). Enter the result in the BCR box.

7. Result of Preliminary ECM Analysis

Determine the status of the ECM for the next phase of analysis.

a. **Cost Effective - Include in initial ECM package.** An ECM is considered interactively cost effective if the BCR is greater than about 1.5 for an ECM with small interaction or if the BCR is greater than about 2.0 for an ECM with large interaction. ECMs that fall into this range should be included in the initial interactive package.

b. **Potential - Add to ECM package.** The measure is individually cost effective if the BCR is greater than 1.0 or the NPV is positive. This measure does not have a BCR high enough to be included in the initial ECM Package. It should be added to the initial ECM package during the package analysis to see if the NPV is increased.

c. **Not cost-effective – Do not add to ECM package.** The measure is not cost effective if the BCR is less than 1.0 or the NPV is negative. There may be other reasons besides cost effectiveness for the measure to be discarded. These reasons should be documented. **A non-cost effective measure may be added to an ECM package in order to have the package result in a building that uses a minimum of 20% less energy than the code baseline building. This should only be done if the resultant package has a BCR greater than 1.**

Figure I1-- ECM Sample – Page 1

PRELIMINARY ECM COST EFFECTIVENESS ANALYSIS				State Energy Efficient Design
Building:	Sample Building	By:	Agency:	
ECM Name:	C133 Water-cooled versus air cooled		ECM Life:	25 YRS

ECM DESCRIPTION (Compare Baseline Conditions with ECM Changes):

BASELINE CONDITIONS	ECM CHANGES
300 ton air-cooled screw chiller	300 ton water-cooled screw chiller
F.L. kw/ton= 1.2	F.L. kw/ton = 0.60

ECM MAINTENANCE AND OPERATING COST IMPACT

ITEMS	ANNUAL SAVINGS	ANNUAL INCREASE
Cooling Tower Chemicals		1,000
Cooling Tower water use		650
Chiller Maintenance	1,000	
If page 2 is used, enter Replacement and Periodic Maintenance from page 2: RM1	2,641	1,087 RM2
TOTAL = (SAVINGS) - (INCREASE) = $904 MAINT TOTALS: TOTALS	$3,641	$2,737

PRESENT VALUE COST

CAPITAL COST OF ITEMS:	BASELINE DEDUCTS	ECM COSTS
Chiller	$ 185,000	$ 175,000
Cooling tower		$ 28,000
Condenser pumps and piping		$ 10,000
Chemical feed system		$ 2,000
TOTAL ECM COSTS AND BASELINE DEDUCTS	$ 185,000	$ 215,000

DESIGN COST INCREASE (if any) $ -   (ECM COST) - (DEDUCTS) + (DESIGN) = $ 30,000 COST

	MAINT.	UPW*	PV O&M COST
NON ENERGY O&M COST INCREASE	$ -	X 15.6	= $ -
*USE UPW FOR YEAR EQUAL TO ECM LIFE		Total PV cost	$ 30,000 PVC

PRESENT VALUE SAVINGS

ANNUAL ENERGY SAVINGS

Fuel Type		Units	MMBtu	Cost $/unit	Annual $	FEF*	PV Savings
Electricity	kWh	109,874	375	$0.060	$ 6,592	19.6	$ 129,302
Natural Gas	therms	0	0	$0.800	$ -	19.6	$ -
#2 Oil or Diese	gal	0	0	$1.000	$ -	19.6	$ -
Propane Gas	gal	0	0	$0.900	$ -	19.6	$ -
Total Energy Savings			375		$ 6,592		$ 129,302

*THESE ARE VALUES FOR FEF OR UPW FOR YEAR EQUAL TO ECM LIFE

	MAINT.	UPW*	PV ANNUAL SAVINGS
Total O&M Savings:	$ 904	X 15.6	= $ 14,125
Total Annual Savings (Energy + Maint.)	$ 7,497		
		Total PV Savings	$ 143,427 PVS

COST EFFECTIVENESS SUMMARY

Net Present Value Savings	PVS	$ 143,427	-PVC	$ 30,000	=	$ 113,427	NPV
Benefit to Cost Ratio	PVS	$ 143,427	/ PVC	$ 30,000	=	4.8	BCR

RESULT OF PRELIMINARY ECM ANALYSIS

[X] Cost Effective - Include in initial ECM Package	[ ] Potential - Add to ECM Package	[ ] Non Cost-Effective BCR < 1.0, or other reason

Figure I-2-- ECM Sample – Page 2

| PRELIMINARY ECM COST EFFECTIVENESS ANALYSIS (Page 2) | | State Energy Efficient Design | | |

Building:	Sample building	By:		Agency:	

| ECM Name: | C133 Water-cooled versus air cooled | | ECM Life: | 25 | yrs |

Use this form only when ECM life is significantly different
from baseline system life and there are significant
differences between the ECM and Baseline in either
periodic maintenance or replacement costs.

Baseline Life: 20 ys

AVOIDED BASELINE REPLACEMENTS
Include only major replacements at end of baseline system life

ITEM COST

Air cooled chiller replacement	$129,500

	YRS DIFF	/	BASE LIFE	X	COST	X	SPW BASE	=	REP-PV1
Present Value of Replacements (net of salvage value)	5	/	20	X	$129,500	X	0.46	=	$14,776

AVOIDED BASELINE PERIODIC MAINTENANCE

BASELINE PERIODIC MAINTENANCE ITEMS	OCCURS IN YEAR	CURRENT $ COST		SPW AT YEAR		PV COST CURRENT $	
Chiller overhaul	7	$	15,000	X	0.76	=	$	11,399
Condenser refurbishment	10	$	10,000	X	0.68	=	$	6,756
Chiller overhaul	15	$	15,000	X	0.56	=	$	8,329

SPW is the Single Present Worth factor from Discount Factor Tables for year periodic maintenance occurs in.

Present value of Baseline periodic maintenance: PM-PV1 $26,483

ADDED ECM PERIODIC MAINTENANCE

ECM PERIODIC MAINTENANCE ITEMS	OCCURS IN YEAR	CURRENT $ COST		SPW AT YEAR		PV COST CURRENT $	
Chiller and Tower overhaul	10	$	15,000	X	0.68	=	$	10,133
Chiller and Tower overhaul	20	$	15,000	X	0.46	=	$	6,846
				X	0.39	=	$	-

SPW is the Single Present Worth factor from Discount Factor Tables for year periodic maintenance occurs in.

Present value of ECM periodic maintenance: PM-PV2 $ 16,979

REPLACEMENT AND PERIODIC MAINTENANCE IMPACT (Enter on page 1 under O&M Cost Impact)

	REP-PV1	+	PM-PV1	=	SAVED PV$	/	ECM UPW	=	Equivalent Annual Savings	
Annual Savings	$14,776	+	$26,483	=	$41,259	/	15.6	=	$ 2,641	RM1

	REP-PV2	+	PM-PV2	=	ADDED PV$	/	ECM UPW	=	Equivalent Annual Increase	
Annual Increase	$0	+	$16,979	=	$16,979	/	15.6	=	$ 1,087	RM2

ECM UPW is the Uniform Present Worth factor from Discount Factor Tables for ECM life.

III.   ECM COST-EFFECTIVENESS ANALYSIS WORKSHEET INSTRUCTIONS — FIGURE I-2

For most ECMs, Figure I-2 - ***Page 2*** of the *Preliminary ECM Cost-Effectiveness Analysis* will not be required. The purpose of determining replacement and periodic maintenance costs is to allow a uniform comparison between different types of systems. In this way, a rooftop system that requires replacement every 15 years can be compared to a central plant system that will last 30 years. *Only major equipment and items that are different for different systems need to be included.* Minor differences in cost or equipment life that will not affect the analysis should not be included. Use this sheet on page 2 only when there are *significant differences* between a baseline system and an ECM in the following areas:

- The ECM life is significantly different than the baseline system life.
- There are significant differences between the ECM and baseline system in equipment replacements required.
- There are significant differences between the ECM and baseline system in periodic maintenance requirements.

1. **Heading**

    Identify the building, the person completing the analysis, the agency, the ECM number from the *ECM Checklist*, and the ECM name.

    ECM Life in Years – Enter the ECM life. This will be the same as the life entered on Page 1.

    Baseline System Life in Years – Enter the baseline system life from Table 1 below.

2. **Avoided Baseline Replacements**

    This section is used when the ECM life is longer than the baseline system life and there are **major** pieces of equipment that require replacement at the end of the baseline system life. If partial replacements or refurbishments are required before the end of the baseline life, analyze them under the Avoided Baseline Periodic Maintenance section.

    a. Determine the difference in life by subtracting the baseline system life from the ECM life. Enter the results in the Difference boxes.

    b. Find the cost of **major** items of baseline system equipment that must be replaced during the ECM life. The analysis assumes these replacements occur at the end of the baseline system life. For each major replacement item, describe the replacement and list the replacement cost in current dollars. Do **not** inflate

the cost to the time the replacement will be installed.

c. Total the item costs and enter in the Total Cost box.

d. Go to the Year row of the *Discount Factor Table 2* that matches the baseline system life. Copy the single present worth (SPW) factor for the baseline life and enter in the SPW Base box.

e. Calculate the present value (PV) cost for baseline replacements with the formula:

$$\text{(Difference / Base Life)} \times \text{Total Cost} \times \text{SPW Base} = \text{REP-PV1}$$

This formula accounts for the remaining salvage value of replacement equipment. In this way, a replaced item that still has value at the end of the ECM life can be compared with a system that is fully depreciated at the end of the ECM life.

f. Enter the result in the REP-PV1 box in this section and in the Replacement and Periodic Maintenance Impact section.

3. Added ECM Replacements

This section of the sheet is used when the ECM life is shorter than the baseline system life and there are **major** pieces of ECM equipment that require replacement at the end of the ECM life. If partial replacements or refurbishments are required before the end of the ECM life, analyze them under the Added ECM Periodic Maintenance section.

a. Determine the difference in life by subtracting the ECM life from the baseline system life. Enter the result in the Difference box.

b. Find the cost of **major** items of ECM system equipment that must be replaced during the baseline life. The analysis assumes these replacements occur at the end of the ECM life. For each major replacement item, describe the replacement and list the replacement cost in current dollars. Do **not** inflate the cost to the time the replacement will be installed.

c. Total the item costs and enter in the Total Cost box.

d. Go to the Year row of the *Discount Factor Table* that matches the ECM life. Copy the single present worth (SPW) factor for the ECM life and enter in SPW ECM box.

e. Calculate the present value (PV) cost for baseline replacements with the formula
$$\text{(Difference / ECM Life)} \times \text{Total Cost} \times \text{SPW ECM} = \text{REP-PV2}$$

This formula accounts for the remaining salvage value of replacement ECM equipment. In this way, a replaced item that still has value at the end of the baseline life can be compared with a system that is fully depreciated at the end of the baseline life.

f. Enter the result in the REP-PV2 box in this section and in the Replacement and Periodic Maintenance Impact section.

4. Avoided Baseline Periodic Maintenance

This section of the sheet is used for baseline system periodic maintenance, refurbishment, or minor replacements that are **significantly different** from the ECM system. The purpose of determining periodic maintenance costs is to allow a uniform comparison between different types of systems. For example, a large central chiller may require a major overhaul after 10 years; small compressors in rooftop units may require refurbishment at seven years.

a. Determine the cost of **significant** items of baseline system equipment that require refurbishment, periodic maintenance, or minor replacement during the ECM system life. Describe each item and enter the year after installation and periodic maintenance cost in current dollars. Do **not** inflate the cost to the year periodic maintenance occurs.

b. Go to the Year row of the *Discount Factor Table* that matches the "occurs in year" value. Copy the single present worth (SPW) factor for the year and enter in SPW at Year column.

c. Calculate the individual present value PV Cost, Current $ for each item.

$$\text{Current \$ Cost } \times \text{ SPW at Year } = \text{ PV Cost Current \$}$$

d. Find the total present value of avoided baseline periodic maintenance by adding each individual PV Cost and Current $. Enter the results in the PM-PV1 box in this section and in the Replacement and Periodic Maintenance Impact section.

5. Added ECM Periodic Maintenance

This section of the sheet is used for ECM periodic maintenance, refurbishment, or minor replacements that are **significantly different** from the baseline system. The purpose of determining periodic maintenance costs is to allow a uniform comparison between different types of systems. For example, a heat-recovery chiller may require an overhaul more often than a standard chiller. An overhaul for the heat-recovery chiller (ECM) might occur in year seven; the standard chiller (baseline) overhaul would be listed at year 10 in the avoided baseline periodic maintenance section.

     a. Determine the cost of **significant** items of ECM equipment that require refurbishment, periodic maintenance, or minor replacement during the ECM life. Describe each item and enter the year after installation and periodic maintenance cost in current dollars. Do **not** inflate the cost to the year periodic maintenance occurs.

     b. Go to the Year row of the *Discount Factor Table* that matches the "occurs in year" value. Copy the single present worth (SPW) factor for the year and enter in SPW at Year column.

     c. Calculate the individual present value PV Cost, Current $ for each item.

$$\text{Current \$ Cost} \; \times \; \text{SPW at Year} \; = \; \text{PV Cost Current \$}$$

     d. Calculate the total present value of added ECM periodic maintenance by adding each individual PV Cost and Current $. Enter the total in the PM-PV2 box in this section and in the Replacement and Periodic Maintenance section.

6. Replacement and Periodic Maintenance Impact

Determine the equivalent annual cost savings and increases due to replacements and periodic maintenance.

     a. Calculate the Saved PV$ by adding REP-PV1 and PM-PV1.

     b. Calculate the Added PV$ by adding REP-PV2 and PM-PV2.

     c. Go to the Year row of the *Discount Factor Table 2* that matches the ECM life. Copy the uniform present worth (UPW) factor for the ECM life year and enter in the ECM UPW column for both savings and increases. The UPW will be used to convert a total present value of savings or costs to an equivalent uniform annual savings or costs.

     d. Calculate the equivalent annual savings (RM1) by dividing the present value of operating savings (Saved PV$) by the uniform present worth factor (ECM UPW). Enter the result in the RM1 box on Page 2 and in the ECM Maintenance/Operating Cost Impact section on Page 1.

     e. Calculate the equivalent annual increase (RM2) by dividing the present value of operating increase (Added PV$) by the uniform present worth factor (ECM UPW). Enter the result in the RM2 box on Page 2 and in the ECM Maintenance/Operating Cost Impact section on Page 1.

Figure I-3-- Package ECM Analysis

PRELIMINARY ECM COST EFFECTIVENESS ANALYSIS					State Energy Efficient Design
Building: Sample Building		By:	Package		

SELECT ECM PACKAGE COMBINATION (forward data from individual ECM analyses)

ECM Number and Name	O&M SAVINGS	ECM LIFE		ECM COST		LIFE FACTOR
E112 Above grade wall insulation	$ –	30	X	$ 57,000	=	1,710,000
C133 Water-cooled versus air cooled	$ 904	25	X	$ 30,000	=	750,000
E118e High-performance low-e coating	$ –	25	X	$ 20,000	=	500,000
L150 Optimize Daylighting	$ (200)	10	X	$ 6,300	=	63,000
			X		=	0
			X		=	0
			X		=	0
			X		=	0
			X		=	0
			X		=	0
			X		=	0
			X		=	0
			X		=	0
PACKAGE TOTAL:	$ 704			$ 113,300		3,023,000

PACKAGE AVERAGE ECM LIFE (Cost Weighted)

	LIFE FACTOR	/	ECM COST	=	PACKAGE LIFE
COST-WEIGHTED PACKAGE LIFE:	3,023,000	/	$ 113,300	=	27

PRESENT VALUE OF COST

	ANNUAL	UPW*			TOTAL ECM COST	$ 113,300
NON-ENERGY O&M COST INCREASE	$ –	X	16.3	=	PRESENT VALUE	$ –
* UPW AT COST-WEIGHTED PACKAGE LIFE					TOTAL PV COST	$ 113,300 PVC

PRESENT VALUE OF SAVINGS (interactive energy savings)
ANNUAL ENERGY SAVINGS

Fuel Type		Units	MMBtu	Cost $/unit	Annual $	FEF*	PV Savings
Electricity	kWh	205,098	700	$0.0600	$ 12,306 X	20.8	$ 256,075
Natural Gas	therms	24,190	2,419	$0.8000	$ 19,352 X	20.8	$ 402,700
#2 Oil (Diese	gal		0		$ – X	20.8	$ –
Propane Ga	gal		0		$ – X	20.8	$ –
TOTAL ENERGY SAVINGS			3,119		$ 31,658		$ 658,775
					MAINT.	UPW*	
NON-ENERGY OPERATING AND MAINTENANCE SAVINGS					$ 704 X	16.3 =	$ 11,499
Total Annual Savings (Energy + Maint.)					$ 32,362		$ 670,274 PVS

* FEF AND UPW AT COST-WEIGHTED PACKAGE LIFE

COST EFFECTIVENESS SUMMARY

Net Present Value Savings	PVS	$ 670,274	- PVC	$ 113,300	=	$ 556,974 NPV
Benefit to Cost Ratio	PVS	$ 670,274	/ PVC	$ 113,300	=	5.9 BCR

RESULT OF PRELIMINARY ECM ANALYSIS

☐ Recommended Package Highest NPV with BCR > 1.0	☐ Initial Package	☐ Non Cost-Effective Package NPV reduced vs. previous pack

IV.   PACKAGE COST-EFFECTIVENESS ANALYSIS WORKSHEET INSTRUCTIONS

Each ECM package under consideration shall be analyzed for cost effectiveness using the *Package Cost-Effectiveness Analysis* worksheet provided in Appendix G. A worksheet is prepared for each ECM package investigated according to analysis requirements.

1. Heading

Include the building name, person completing analysis, and package letter (A, B, etc.).

2. ECM Package Combination

List the ECMs included in the package. Include the ECM number and name from the *ECM Checklist*. Use the maintenance savings (Maint.), ECM life (Life), and incremental investment cost (Cost) from the preliminary ECM cost-effectiveness analysis. The agency may include the cost of the analysis and participation in the SEED Program.

a. For each ECM, multiply the cost by the life and enter the product in the Life Factor column.

b. Total the maintenance savings, cost, and life factor for all ECMs.

3. Package Average ECM Life

An average life must be determined for the package as a whole so that proper discounting factors can be obtained.

a. Divide the Life Factor value by the ECM Total Cost to find the cost-weighted package life.

b. Round the package life to the nearest whole number and enter in the Package Life box.

4. Present Value of Costs

a. Enter the total package cost in the Cost box

b. If the annual operating and maintenance savings for all ECMs is negative, carry forward to the Maint. box in this section as a *positive value*.

c. Go to the Year row of the *Discount Factor Table 2* that matches the Package

Life. Find the uniform present worth (UPW) factor and enter in the UPW box.

d. Multiply the total annual non-energy operating increase (Maint.) by the UPW and enter the result in the PV1 box.

e. Add the present value of maintenance and operation savings (PV2) to the Cost. Enter the result in the PVC box.

5. **Present Value of Savings**

Find the annual energy-use savings and present value of energy costs savings for the package being analyzed.

a. List the fuel types for the building and enter the following for each fuel.

(1) Enter in the MMBtu column the annual energy savings by fuel in million Btus (MMBtu) for the entire building for the interactive ECM package by fuel. Divide Btu by 1 million to determine MMBtu. Table 3 lists Btu per unit for the various fuel types.

(2) Calculate the annual energy cost savings for each fuel and enter the results in the Annual $ column. **Note**: Where fuel rates are ratcheted or incremental, use the incremental rate to calculate the annual energy cost savings. Some modeling programs include an economic analysis package that determines the energy cost based on complex rate schedules. Include the electric demand cost savings with the electricity cost savings.

(3) Go to the Year row of the *Discount Factor Table 2* that matches the cost-weighted package life in the Package Life box in the title section of the worksheet. Select the Fuel Escalation Factor (FEF) for each fuel and place in the FEF column.

(4) Calculate the present value (PV) savings for each energy type by multiplying the current annual savings by the FEF. Enter the result in the PV Savings column.

b. Total the savings in MMBtu, Annual $, and PV$ for all fuels and enter in the appropriate column of the Total Energy Savings row.

c. If the annual operating and maintenance savings for all ECMs are positive, carry forward and enter to the Maint. box in this section.

d. Go to the Year row of the Discount Factor Table 2 that matches the Package Life. Find the uniform present worth (UPW) factor and enter in the UPW box.

e. Multiply the total annual non-energy operating and maintenance savings

(Maint.) by the UPW and enter the result in the PV2 box.

f. Add the present value of energy savings (PV1) to the present value of maintenance and operation savings (PV2). Enter the result in the PVS box.

g. Add the annual operating and maintenance for the package to the annual fuel savings and put the sum in the total annual savings box.

6. **Cost-Effectiveness Summary**

Find the cost-effectiveness indicators for the package of ECMs.

a. The net present value of savings (NPV) indicates the total net benefit in today's dollars that will result from ECM package implementation. Subtract the package incremental cost (PVC) from the present value of savings (PVS). Enter the result in the NPV box.

b. The benefit-to-cost ratio (BCR) indicates the relative cost effectiveness of the package. Divide the present value of savings (PVS) by the present value cost (PVC). Enter the result in the BCR box.

7. **Comments**

Enter any comments regarding ECM interaction or package analysis.

8. **Result of Final Package Analysis**

Once the analysis for all packages is complete, determine the status of the packages.

a. **Recommended Package**. This package has a BCR greater than 1.0 and the highest NPV.

b. **Initial Package.** Check this box if the package is selected for initial analysis.

c. **Not cost-effective** –The package is not the most cost-effective package of those analyzed. The BCR is less than 1.0 or the NPV is lower than other packages. **A non cost-effective package may need to be implemented if no cost-effective package results in a building that uses a minimum of 20% less energy than the code baseline building.**

V. COMPUTER SPREADSHEETS

The cost-effectiveness analysis worksheets are available as Microsoft Excel computer spreadsheets for the convenience of the Energy Analyst. A copy of the spreadsheets can be

downloaded from the Oregon Department of Energy web page on the Internet:
http://www.energy.state.or.us/gov/SEEDhome.htm or
http://www.energy.state.or.us/SEED/index.html. Instructions are included. Report any
difficulties to the Department of Energy.

Table 1
Equipment Life

Equipment life varies, depending on quality of equipment specified, sizing relative to load, and maintenance. However, use the following list that indicates the maximum equipment life.

Equipment	Maximum		Equipment	Maximum
Building Envelope			**HVAC Plants & Distribution**	
Double Glazing	25		Cooling towers	20
Heat mirror	20		Cooling towers, ceramic	30
Low-emissivity coating	25		Chillers, reciprocating	20
Solar shade film (retrofit)	12		Chillers, centrifugal & absorption	25
Tinted & reflective coating	25		Boiler	30
Insulation, cavity	30		Boiler burners	20
Insulation, batt exposed/roof	25		Pumps, base mounted	25
			Pumps, inline	20
			Piping	30
HVAC			Insulation	25
Fans, utility/central	25			
Air conditioner, rooftop/split	15			
Air-to-air packaged heat pump	15		**Lighting**	
Water-to-air packaged heat pump	15		Energy-efficient ballast	15
			Electronic ballast	20
Coils, DX, water, steam	25		Lighting fixture (all types)	30
Coils, electric	15		Dimming systems	15
Radiant/unit heaters, electric	15		On-off switch	30
Radiant unit heaters, gas	20		Motion sensor	10
Radiant/unit heaters, hot water/steam	25			
Furnaces, gas/oil	20		**Motors, Drives, and Transformers**	
			Standard electric motor	20
Ice thermal energy storage	20		High-efficiency electric motor	25
Water thermal energy storage	20		Variable-speed drive, solid state	20
Plate type/heat pipe recovery system	20		Efficient AC electronic transformer	30
Rotary type heat recovery system	17			
Heat recovery from refrigeration condensers	15		**Domestic Hot Water**	
			Heat pump water heater	15
			Gas water heater	20
Low leak dampers	15		Solar water heater	15
Economizer dampers	20			
Ductwork	30		**Refrigeration**	
Make-up air unit for exhaust hood	15		Unequal parallel refrigeration	15
Air destratification fan	15		Condenser float head pressure control	15
Air curtain	15		Automatic cleaning system for conditioning tubes	15
			Hot-gas bypass defrost	12
Controls, pneumatic	20		Polyethylene strip curtain	5
Controls, electric	16		Refrigeration case cover	12
Controls, EMCS	15			
Controls, electronic	15			

Table 2
Discount Factors for Commercial-Sized Buildings
Real Discount Rate: 4%
Real electricity and fuel price increases: all 2%

YEAR	ELEC FEF	Nat Gas FEF	DIESEL FEF	Propane FEF	O&M UPW	Maintenance & Replacement SPW
1	0.98	0.98	0.98	0.98	0.96	0.96
2	1.94	1.94	1.94	1.94	1.89	0.92
3	2.89	2.89	2.89	2.89	2.78	0.89
4	3.81	3.81	3.81	3.81	3.63	0.85
5	4.72	4.72	4.72	4.72	4.45	0.82
6	5.61	5.61	5.61	5.61	5.24	0.79
7	6.48	6.48	6.48	6.48	6.00	0.76
8	7.34	7.34	7.34	7.34	6.73	0.73
9	8.18	8.18	8.18	8.18	7.44	0.70
10	9.00	9.00	9.00	9.00	8.11	0.68
11	9.81	9.81	9.81	9.81	8.76	0.65
12	10.6	10.6	10.6	10.6	9.39	0.62
13	11.4	11.4	11.4	11.4	9.99	0.60
14	12.1	12.1	12.1	12.1	10.6	0.58
15	12.9	12.9	12.9	12.9	11.1	0.56
16	13.6	13.6	13.6	13.6	11.7	0.53
17	14.3	14.3	14.3	14.3	12.2	0.51
18	15.0	15.0	15.0	15.0	12.7	0.49
19	15.7	15.7	15.7	15.7	13.1	0.47
20	16.4	16.4	16.4	16.4	13.6	0.46
21	17.1	17.1	17.1	17.1	14.0	0.44
22	17.7	17.7	17.7	17.7	14.5	0.42
23	18.4	18.4	18.4	18.4	14.9	0.41
24	19.0	19.0	19.0	19.0	15.2	0.39
25	19.6	19.6	19.6	19.6	15.6	0.38
26	20.2	20.2	20.2	20.2	16.0	0.36
27	20.8	20.8	20.8	20.8	16.3	0.35
28	21.4	21.4	21.4	21.4	16.7	0.33
29	22.0	22.0	22.0	22.0	17.0	0.32
30	22.5	22.5	22.5	22.5	17.3	0.31

FEF	=	Fuel escalation factor: Present worth factor including escalation of fuel greater than inflation and discounted with the real discount rate.
UPW	=	Uniform present worth factor: Discounts uniform annual amounts to a present value.
SPW	=	Single present worth factor: Discounts a single future amount to a present value.
Distillate Oil	=	Diesel fuel oil grade Nos. 1, 2, or 4 (PS 100, 200), no preheating for combustion.
Residual Oil	=	Residual fuel oil grade Nos. 5 or 6 (PS 300, 400), requires preheating for combustion.

Table 3
Btu per Unit of Fuel

Fuel	Units	x	Btu/unit	=	Btu
Electricity	kWh	x	3,413	=	Electricity Btu
Natural Gas	therm	x	100,000	=	Natural Gas Btu
Diesel/ Residual Oil	gallon	x	139,000	=	Diesel or Residual Oil Btu
Propane	gallon	x	91,500	=	Propane Btu
Steam	lbs.	x	1,000 or site-specific value	=	Other Btu
Chilled water	tons	x	12,000	=	Other Btu