Energy Conservation Measures for Buildings: A Replacement Analysis

Mitra Amini, Larry Ball, Fredy Gomez, Bahar Saatchi, Mike Uffelman

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Abstract

This paper conducts a Financial Replacement Analysis for the Heating Ventilating and Air Conditioning (HVAC) Building Systems for the Oregon Trail Building. Data was based on an Engineering Consultants Energy Study Report, which examined five HVAC replacement Energy Conservation Measures (ECMs) created to reduce building HVAC operating costs.

Utilizing a Financial Replacement Analysis Methodology, two of the ECMs were disqualified for selection and three ECMs were selected. The three selected ECMs were ranked in order of preference based on the results of the Replacement Analysis. The Replacement Analysis Methodology utilized Total Marginal Cost, Benefit Cost Ratio and Incremental Benefit Cost Ratio.

I. Introduction

Purpose of the Replacement Analysis

This purpose of this study is to determine the financial feasibility of upgrading the Heating Ventilating and Air Conditioning (HVAC) Systems for the Oregon Trail Building, a Chester Company property. The Oregon Trail property is a seven story, 100 year old building located in downtown Portland. Its primary revenue stream is from the leasing of 60,000 square foot (sqft) commercial office space. The building existing HVAC Systems are past their service lives and have been depreciated to zero, with no salvage value.

Desirability of Upgrading the Existing HVAC Systems

Upgrading the existing HVAC systems will improve the marketability of the commercial office spaces, by improving client comfort. As a whole, the existing HVAC systems are functional and well maintained. Building energy use as expressed as energy cost to the Owner could be reduced by upgrading various HVAC system components. Seeking to improve client conform and reduce energy costs, the Chester Company commissioned an Energy Study [1] from PAE Consulting Engineers, Portland Oregon., which was delivered in February of 2000 with an addendum for Opinions of Probable Costs [2] revisions received in June of 2000.

PAE Energy Study

The primary purpose of the Energy Study was to identify and document specific HVAC System Energy Conservation Measures (ECMs), which could be implemented to reduce energy costs. The ECMs upgraded or replaced existing HVAC systems at the property.

The secondary purpose of the Energy Study was to determine the simple payback of each ECM, based on Energy Savings and Opinions of Probable Construction Costs for the upgrades. And finally, the Energy Study provided documentation for the Oregon Department of Energy Business Energy Tax Credit (BETC) program and for other Energy Efficiency Programs that provide financial incentives for Energy Conservation. See Appendix 1 for the PAE Energy Study Report.

PAE Proposed Energy Conservation Measures (ECMs)

Table 1: Summary of Proposed ECMs [1]

ECM	Description
1	Replace existing steam boiler with a high efficiency condensing hot water boiler
2	Replace 4th, 5th and 6th Floor Heat Pumps with a new Air Handling Unit, Variable Air Volume (VAV) distribution system, and a new air cooled
3	Replace 7th Floor Multizone Unit with a new Air Handling Unit and a Variable Air Volume (VAV) distribution system.
4	Upgrade 3rd Floor Multizone Unit wth Variable Frequency Drives and VAV thermafuser air diffusers.
5	Upgrade Basement Dual Duct Constant Volume System with Variable Frequency Drives and a Variable Air Volume (VAV) distribution system.

ECM 1 – High Efficiency Natural Gas Fired Condensing Boiler [1]

ECM 1 proposes is to replace the existing steam boiler with a high efficiency condensing hot water boiler. The existing cast iron boiler is powered by natural gas and has a heat exchanger. The replacement will be a more efficient gas fired hot water condensing boiler. Condensing boilers utilize the heated water vapor produced as a byproduct of natural gas combustion while non-condensing boilers lose the heated water vapor through exhaust. The older cast iron boiler is by nature of a less energy efficient design.

This ECM is projected to yield annual savings of -5425 kWh in electricity and 12,242 therms in Natural Gas savings with annual energy cost savings of $7366. The capital cost is $84,730 with a 12 year simple payback estimate. With a 35% BETC rebate, the capital cost would be reduced to $55,075 and the simple payback would be 7.5 years.

ECM 2 – Replace the Heat Pumps with VAV System and Air Cooled Chiller [1]

This ECM proposes to replace the 4th 5th and 6th floor water source heat pumps with a new air handling unit. It would also include new variable air volume (VAV) terminal units and install an additional air cooled chiller in the 7th floor mechanical well. This ECM would replace the existing cooling tower and chillers. This ECM will feed the new air handling unit (AHU) and serve the existing air handlings units. This system serves not only the 4th 5th and 6th floor, but also serves the basement, 1st, 2nd, and 3rd floors. The air cooled chiller would also be easier to maintain and control than the current cooling tower and existing two chillers.

This ECM is projected to yield annual savings of 220,765 kWh in electricity and -5611 therms in Natural Gas savings with annual energy cost savings of $9,953. The capital cost is $443,475 with no payback.

ECM-3 Replace Penthouse Multizone Unit with a New Air Handling Unit and VAV System [1]

This ECM will replace the 7th floor constant volume multi-zone air handling unit (AHU-3) with a new air handling unit and new VAV terminal units. The constant volume multi-zone unit mix hot and cold air to attain the desired air temperatures to the 7th floor. This is an inefficient process and efficiency will be increased with a new air handling unit and new VAV units. The new VAV air handling unit and new

VAV terminal units will draw low pressure steam from the boiler to heat the 7th floor. This ECM will also retain the existing condensing unit serving AHU-3 to provide cooling.

This ECM is projected to yield annual savings of 28,106 kWh in electricity and 4220 therms in Natural Gas savings with annual energy cost savings of $4,165. The capital cost is $116,696 but has a payback of 28 years making the payback calculation negligible.

ECM 4 – Upgrade 3rd Floor Multizone Unit with Variable Speed Drives & VAV Thermafusers [1]

This ECM will upgrade the 3rd floor constant volume Multizone unit with variable speed drives (not constant volume) and VAV Thermafusers. Thermafusers allow for variable volume air discharge to a space (again, not constant). They are not as expensive as VAV terminal units but also do not offer as much controllability. The constant volume multi-zone units are not as efficient as variable HVAC techniques. This is because they use energy to heat and cool to two extremes then mix the air to the desired temperature. The VAV Thermafusers will heat or cool then vary the volume of air to meet the heating or cooling requirements of the space.

PAE noted that even though this ECM replaces the existing constant volume multi-zone air handler with a VAV handler with VAV terminal units, the air economizer capacity will be unchanged. PAE also notes that additional improvements could be made by installing a day lighting system with dimming ballasts and occupancy sensors.

This ECM is projected to yield annual savings of 71,152 kWh in electricity and 9,826 therms in Natural Gas savings with annual energy cost savings of $9,517. The capital cost is $44,330 with a simple payback of 5 years. With a 35% BETC rebate, the capital cost is %28,815 with a simple payback of 3 years.

ECM-5 Upgrade Basement Dual Duct Constant Volume System with Variable Speed Drives and VAV Air Distribution System [1]

This ECM applies to the basement and 1st floor. It would install variable speed drives in the air handling unit and incorporate dual duct variable air volume terminal units in the existing framework of the setup. The current AHU is a constant volume dual duct unit, which is energy inefficient and no longer allowed by current Energy Codes for new construction. The dual duct system mixes previously heated and cooled air streams to produce a desired discharge temperature, making this type of system inherently inefficient. On the contrary, VAV systems with variable speed drives are inherently more efficient. VAV systems also allow the use of an air economizer, which would vastly improve system efficiency. PAE also recommends installing a day lighting system which includes dimming ballasts and occupancy sensors.

This ECM is projected to yield annual savings of 115,611 kWh in electricity and 9,323 therms in Natural Gas savings with annual energy cost savings of $10,972. The capital cost is $91,965 with a simple payback of 8 years. With a 35% BETC rebate, the capital cost is 59,780 with a simple payback of 5 years.

PAE Energy Study Results:

Table 2: Energy Study Annual Saving & Simple Payback [1]

ECM	Energy Savings (kWh)	Energy Savings (Therms)	Total Energy Savings (kWh)	Total Energy Saving ($)	Incremental Cost ($)	Simple Payback (Years)
1	-5,425	12,242	287,159	7,366	84,729	12
2	220,765	-5,611	86,662	9,953	445,322	45
3	28,106	4,220	128,964	4,165	116,073	28
4	71,152	9,826	305,993	9,507	44,941	5
5	115,611	9,323	338,431	10,972	93,812	9

The study concluded that ECMs 1, 4, 5 and R, a combination of ECM 1, 4 & 5, were feasible based on a simple payback period of less than 25 years. See Appendix 1, PAE Energy Study, for a detailed discussion of Study results.

Comments Regarding the PAE Energy Study

While the study was executed ten years ago, it provides useful data for decision making and in obtaining Green Financing. The need to upgrade HVAC performance still exists at the Oregon Trail Property. The study indicated that ECM 1, 4 and 5 are most likely to be feasible economically. However, the simple payback method does not allow for the time value of money, depreciation, inflation, taxes and other important variables. It simply calculates payback based on construction (project) costs versus annual energy savings. Therefore, a Replacement Analysis was conducted by the Chester Company Staff to determine the benefits & costs to the Chester Company.

II. Replacement Analysis

Replacement Analysis Objectives

Chester Company Management directed the Chester Financial Team to conduct a Replacement Analysis for the Energy Conservation Measures proposed by the PAE Consulting Energy Study to replace existing HVAC systems at the Oregon Trail Property. The stated objective of the Analysis was to evaluate each ECM for Financial Feasibility and to rank the feasible ECMs. The Recommended combined ECM was excluded from the Analysis. Existing data from the Energy Study was to be utilized.

Methodology

Replacement Analysis Procedure

Since the study focused on technology replacement, a Replacement Analysis methodology was used. The following process was used:

1. Determine Total Marginal Cost (TC) for each Alternate (ECM).
2. Select candidate ECMs for further analysis based on a comparison of the Baseline (existing) HVAC Total Cost versus the ECM HVAC Total Cost. Those ECMs with Marginal TC less than 1 are disqualified. ECM Marginal TC values less than 1 have higher Total Costs than the Baseline (existing) system Total Costs.

3. Calculate the Benefit-Cost ration for the selected ECMs and disqualify those ECMs whose B-C ratio is less than one.
4. Rank the finalist selected ECMs by the Incremental Benefit Cost Analysis method. Selected ECMs are ranked from lowest cost to highest cost. A do nothing option with cost of zero (the defender) is compared against the lowest cost ECM (the challenger). If the incremental B-C ratio is greater than one, then the challenger becomes the defender in the next comparison against the next least costly ECM. The process is repeated until all ECMs are ranked.

Total Marginal Cost (TC) [3]

Total Marginal Cost (TC) is calculated for each HVAC Alternate. The governing equations for determining TC are as follows:

$$TC_k(i\%) = MV_{k-1} - MV_k + iMV_{k-1} + E_k$$

$Where$:

$$Depreciation = MV_{k-1} - MV_k$$

$$Interest\ on\ Capital = iMV_{k-1}$$

$$Expenses = E_k$$

All TC values are brought back to Present Worth (PW).

Depreciation

For all the alternates under consideration, a GDS Depreciation for a twenty year service life is used. The 150% Declining Balance (DB) method was proscribed, which switches to the Straight Line (SL) method, when the SL method provides greater depreciation.

Interest on Capital

For all the alternates under consideration, Interest on Capital is calculated using a MARR of 10%.

Expenses

Two expenses were considered for the Analysis: BETC Rebate and O&M. Both are calculated as negative expenses, as both are savings to each alternate. O&M Expenses included operating and maintenance cost expenses.

ECM Candidate Selection [3]

TC values for each baseline and ECM are compared for each alternate. Because the baselines are already depreciated to zero and the maintenance costs are assumed to be equivalent for the baseline and the ECM, the baseline TC values are assumed to be zero.

Benefit-Cost (B-C) Ratio [4]

Benefits and Costs from the Total Marginal Cost (TC) calculations are brought back to Present Worth. Benefits included the negative expenses of BETC Rebate and O&M savings. Costs included Depreciation and Interest on Capital. The Benefit to Cost ratio is calculated for candidate alternates by:

$$Benefit\ Cost\ Ratio\ = \frac{B}{C} = \frac{PW_B}{PW_C}$$

Incremental Benefit-Cost (B-C) Ratio [4]

Selected Present Worth Benefits and Costs are compared using the following equation:

$$Incremental\ Benefit\ Cost\ Ratio\ = \frac{\Delta B_{A-B}}{\Delta C_{A-B}}$$

Using the procedure previously discussed in the Replacement Analysis Procedure, the ECMs are ranked.

Input Data

The following Input Data was utilized:

1. Project Cost (Capital Investment) for each Alternate (ECM) from the PAE Energy Study Opinions of Probable Costs [2].
2. Annual Energy Consumption (kWh) for each Alternate (ECM) from the PAE Energy Study [1].
3. Annual Energy Savings ($) for each Alternate (ECM) from the PAE Energy Study [1].
4. Life in years for each Technology [5].

Assumptions:

Minimum Acceptable Rate of Return or Cost of Capital (MARR)

Most experts recommend a discount rate equal to the opportunity cost of capital [6]. The opportunity cost of capital is the rate of return on the best alternative investment available. The cost of capital varies from one investor and investment to another, which limits its usefulness as a proxy for a general discount rate. However, for this study we adopt the recommendation made by Short et al [6]. They recommend a real after-tax discount rate of 10% (add in expected inflation to estimate a nominal discount rate) be used within the Energy Efficiency and Renewable Energy sectors. Of course, if the analysis concerns a specific investor, the discount rate should be based on the investor's opportunity cost of capital for investments of similar riskiness.

Life of the projects

Per the engineering literature [5] and expert engineering input [7], all the projects of this study have the same life which was calculated for 20 years. This allows us to evaluate and apply the methodologies PW, FW or AW using the same number periods for all alternates.

Business Energy Tax Credit (BETC)

The project qualifies for the Oregon Department of Energy Business Energy Tax Credit (BETC) [1]. BETC allows for a Rebate of 35% of the project costs, eligible over a five year period. After project completion, 10% of the total project cost is rebated at the end of years one and two, and 5% of the total project cost is rebated at the end of years three, four and five.

Salvage Value

Per the engineering literature [5] and expert engineering input [7] none of the alternatives (technologies) has a value after the 20 years of use. Therefore, a Salvage Value of zero will be assumed at the end of the life of the technologies.

Maintenance Costs

Maintenance costs for the Baseline (existing) and ECM conditions were assumed to be equivalent for each Alternate. In the case of Alternate (ECM) Two, this was not strictly true. The maintenance cost difference for a water cooled chiller (Baseline) versus an air cooled chiller system (ECM) are estimated to be in the in the order of magnitude of several thousand dollars per year. However, to make ECM 2 selectable, the maintenance savings would have to be approximately $28,000 per year. Therefore the assumption of assumption of equivalent costs for ECM 2 has no impact on the Analysis outcome.

Financial Evaluation

All dollar calculations are based on FY 2000 dollars. All costs and benefits are calculated as Earnings Before Income Tax (EBIT) per Chester Company Accounting Department direction.

Independence of Alternates (Energy Conservation Measure)

All alternates (ECMs) are independent projects. The combined recommended ECM R was not evaluated.

Analysis

Total Marginal Cost Procedure [3]

GDS Depreciation: Declining Balance (DB) at 150% Switchover SL

- Notations:
  B: initial cost;
  D: Total Depreciation
  d_k: annual depreciation deduction in year *k*;
  BV_k: book value at the end of year *k;*
  N: number of service years = 20 years;
  SV: Salvage Value at the end of year 20 = 0;

- Declining Balance (DB) 150%
  $R = 1.5 / N = 1.5/ 20 = 0.075$
  $d_1 = B * R$
  $d_k = B * (1-R)^{k-1} * R \qquad 1< k \leq N$

$BV_k = BV_{k-1} - d_k$

- SL
  $dk = B / (N-k+1)$
  $BV_k = BV_{k-1} - d_k$

  If d_k (DB) > d_k (SL) *then* use d_k (DB) as the depreciator.
  If d_k (DB) < d_k (SL) *then* use d_k (SL) as the depreciator.
  Switchover for this analysis occurs at year eight, therefore:

$$\boldsymbol{D = \sum_{k=1}^{7} B * (1-R)k-1 * R * (P/F, 10\%, k) + \sum_{k=8}^{20} B / (N-k+1) * (P/F, 10\%, k)}$$

See Appendix 3 for all ECM Depreciations calculations.

Interest on Capital

- Notations:
  i: MARR = 10%
  MV_k: Market Value at period k
  $IC = i * MV_k$

$$\boldsymbol{IC = \sum_{k=1}^{20} i * MV_k * (P/F, 10\%, k)}$$

See Appendix 4 for all ECM Total Marginal Cost calculations

Rebate

- Notations:
  B: initial cost;
  r_k: annual rebate percentage of initial cost in year *k;* $1 \le k \le 5$
  E_R*:* total amount of rebate after 5 years;

$$\boldsymbol{E_R = \sum_{k=1}^{5} B * r_k * (P/F, 10\%, k)}$$

Table 3: Rebate Calculation

Year	r_k	(P/F, 10%, k)	ECM1		ECM2		ECM3		ECM4		ECM5	
			B	R_k	B	R_k	B	R_k	B	R_k	B	R_k
			84729		443475		116696		44330		91965	
1	10%	0.9091	8,472.9	7,702.7	44,347.5	40,316.3	11,669.6	10,608.8	4,433.0	4,030.0	9,196.5	8,360.5
2	10%	0.8264	8,472.9	7,002.0	44,347.5	36,648.8	11,669.6	9,643.8	4,433.0	3,663.4	9,196.5	7,600.0
3	5%	0.7513	4,236.5	3,182.8	22,173.8	16,659.1	5,834.8	4,383.7	2,216.5	1,665.3	4,598.3	3,454.7
4	5%	0.6830	4,236.5	2,893.5	22,173.8	15,144.7	5,834.8	3,985.2	2,216.5	1,513.9	4,598.3	3,140.6
5	5%	0.6209	4,236.5	2,630.4	22,173.8	13,767.7	5,834.8	3,622.8	2,216.5	1,376.2	4,598.3	2,855.1
R				23,411.5		122,536.6		32,244.3		12,248.8		25,410.8

See Appendix 4 for all ECM Total Marginal Cost calculations.

O&M Savings

- Notations:
  E_k: annual operating & maintenance costs in year *k;* $1 \leq k \leq 20$
  E_k: values are equal for all year k for each ECM.
  $E_{O\&M}$: total amount of rebate after 20 years;

$$E_{O\&M} = \sum_{k=1}^{20} E_k * (P/F, 10\%, k)$$

See Appendix 4 for all ECM Total Marginal Cost calculations.

Total Marginal Cost Analysis:

This study applied replacement to omit non-profitable alternatives through 20 years. It assumed benefit as a negative cost. So all alternatives with negative total cost are attractive to keep since they are beneficial alternatives and the all alternatives with positive total cost are ignored (table 4). See Appendix 4 for all ECM Total Marginal Cost calculations.

- Notations:
  TC: total marginal cost
  TC_k: total marginal cost at the end of year *k;* $1 \leq k \leq N$
  i: MARR = 10%
  N: number of service years = 20 years;
  MV_k: market value at the end of year *k;* $1 \leq k \leq N$
  E_k: present worth of annual expenses;

$$TC_k\,(i) = MV_{k-1} - MV_k + (i * MV_{k-1}) + E_k$$
$$+$$
$$TC\,(i) = \sum_{k=1}^{20} E_k \times (P/F, i, k)$$

Table 4: ECM Selection

Alternate	Baseline TC	ECM TC	ECM TC < Baseline TC	Don't Select ECM	Select ECM
1	0	-$1,394	Yes		X
2	0	$237,537	No	X	
3	0	$48,541	No	X	
4	0	-$48,415	Yes		X
5	0	-$25,521	Yes		X

See Appendix 4 for all ECM Total Marginal Cost calculations.

Benefit Cost Methods [4]

Benefit- Cost Ratio

- Notations:
  PW(.): present worth of (.);

B: benefits of the proposed project (alternative);
I: initial investment;
MV: market value at the end of useful life*;*
O&M: operating and maintenance costs;

$$B - C = \frac{PW\ (benefits\ of\ the\ proposed\ alternative)}{PW\ (total\ cost\ of\ the\ proposed\ alternative)} = \frac{PW\ (B) - PW\ (O\&M)}{I - PW\ (MV)}$$

Table 5: Benefit Cost Analysis Results for ECM 1, 4 & 5

ECM	PW (Benefit)	PW (Cost)	B/C Ratio	Test (B/C ≥ 1)
1	$86,123	$84,728	1.02	Passes
4	$93,188	$44,940	2.07	Passes
5	$118,822	$93,811	1.27	Passes

ECM1, ECM4, and ECM5 B-C ratios are greater than 1; therefore they are selected for ranking. See Appendix 5 for all ECM Benefit Cost Ratio calculations.

Incremental Benefit- Cost Ratio

The incremental B-C ratio procedure [2], is used to rank the selected ECMs. The procedure first ranks the selected ECMs from the lowest *PW (cost)* to the highest *PW (cost)* (Table 6) and then evaluates the rank order of the ECMs through pair-wise comparison method (Table 7).

Table 6: Rank Alternatives by *PW (Cost)*

ECM	PW (Benefit)	PW (Cost)	B/C Ratio
4	$93,188	$44,940	2.07
1	$86,123	$84,728	1.02
5	$118,822	$93,811	1.27

Table 7: Incremental B-C Analysis

ECM	PW (Benefit)	PW (Cost)	Compare	ΔB/ΔC	Decision
0	$0.00	$0.00	4-0	2.07	4 better than 0
4	$93,188	$44,940			
4	$93,188	$44,940	1-4	-0.18	4 better than 1
1	$86,123	$84,728			
4	$93,188	$44,940	5-4	0.52	4 better than 5
5	$118,822	$93,811			
1	$86,123	$84,728	5-1	3.60	5 better than 1
5	$118,822	$93,811			

The results of the Incremental B-C Analysis is to rank the ECMs in the order ECM 4, then ECM 5, then ECM 1, then do nothing. ECM 4 would thus be the most beneficial ECM for HVAC replacement.

III. Analysis of Results and Recommendations

Analysis of Results

There are some factors that should be discussed:

1. Since the salvage value (Zero), maintenance costs and service lives were equal, calculating the Total Marginal Cost was simplified. If these assumptions were not true, the methodology would have remained the same, but the calculations would have been more complex. Different salvage, maintenance costs and service lives might have resulted in a different outcome.
2. Since all the R values for Depreciation were the same for all evaluated ECMs, the switchover from Declining Balance (150%) Depreciation to Straight Line Deprecation occurred in the same years for all ECMs.
3. The Simple Payback Method supports the results of the Replacement analysis. If time for simple payback is used as a ranking criterion, then the Simple Payback methods also supports the ranking provided by using the Incremental Benefit Cost Analysis Method.

Recommendations

Based on our financial analysis, ECM1, ECM4, and ECM5 are all financially possible. Besides, performing incremental cost-ratio analysis and simple payback method as a support, our analysis suggests the below ranking:

1. ECM4
2. ECM5
3. ECM1

IV. Further Study

Future Replacement Studies might refine maintenance costs for each Baseline and Energy Conservation Measure. Since the execution of the HVAC replacement would occur in the present, Opinions of Probable Cost (Cost Estimates) could be revised to reflect inflation specific to the local HVAC Market.

V. References

[1] PAE Consulting Engineers, “Energy Study for the Oregon Trail Building” Report, February 2000.

[2] PAE Consulting Engineers, “Energy Study for the Oregon Trail Building: Opinions of Probable Cost Addendum”, June 2000.

[3] W.G. Sullivan, E.M. Wicks, and C.P. Koelling, "Replacement Analysis", in *Engineering Economy*, 15th ed. Upper Saddle River: Person Hall., 2009, Ch. 9. Sec.9.4, 9.5 & 9.6 pp. 384.

[4] W.G. Sullivan, E.M. Wicks, and C.P. Koelling, "Evaluating projects with the benefit-cost ratio method", in *Engineering Economy*, 15th ed. Upper Saddle River: Person Hall., 2009, Ch. 10. Sec.10.9, pp. 436.

[5] American Society of Heating, Refrigeration and Air-Conditioning Engineers, *1991 ASHRAE Handbook: HVAC Applications*, ASHRAE, 1991, pp. 33.3.

[6] Walter Short, Daniel J. Packey, and Thomas Holt (1995) A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies. National Renewable Energy Laboratory

[7] Larry Ball PE, PAE Oregon Trail Building Energy Study Contributor, Consultation, November 2011.

VI. Appendix

Appendix 1: PAE Energy Study (See Attached PDF)

Appendix 2: Opinions of Probable Construction Costs

PAE OPINION OF PROBABLE COSTS — Oregon Trail Building
Job No. 3222.10
27 June, 2000

ECM	Measure	Item	DESCRIPTION	Material $	Labor $	Total $
1	High Eff Boiler	1	1000 MBH Ray Pack hot water boilers (3)	$34,500	$9,180	$43,680
		2	Ray Pack Y5B Boiler Management System	$1,200	$500	$1,700
		3	AL294FC Stainless Boiler Flue System	$4,100	$2,650	$6,750
		4	Water to Water heat exchanger	$3,000	$500	$3,500
		5	Hot Water Coil for AHU-1	$920	$500	$1,420
		6	Hot Water Coil for AHU-2	$1,275	$600	$1,875
		7	Hot Water Coil for AHU-3	$465	$200	$665
		8	Boiler circulation pumps (3)	$3,474	$345	$3,819
		9	Heating water circulation pumps (2)	$4,500	$720	$5,220
		10	Piping and Accessories	$5,000	$700	$5,700
		11	Demo Boiler	$450	$450	$900
		12	Demo Steam Piping	$700	$700	$1,400
		13	Demo Steam AHU Coils (3)	$1,300	$1,300	$2,600
		14	Electrical	$500	$5,000	$5,500
			Totals	$61,384	$23,345	$84,729
2	Replace HPs w/VAVs & & Air Cooled Chiller	1	VAV AHU (30,000 Cfm)	$44,800	$16,370	$61,170
		2	Electric Motor (50 HP General Electric)	$3,289	$192	$3,481
		3	Electric Motor (10 HP General Electric)	$914	$77	$991
		4	Variable Frequency Drive (50 HP Square D)	$7,925	$1,000	$8,925
		5	Variable Frequency Drive (10 HP Square D)	$2,940	$475	$3,415
		6	DDC Controls for AHU	$8,625	$8,625	$17,250
		7	Air Cooled Chiller (180 Tons)	$86,400	$9,600	$96,000
		8	DDC Controls for Chiller	$3,750	$3,750	$7,500
		9	VVR Terminal Units w/Controls (15)	$54,000	$120,600	$174,600
		10	Piping and Accessories	$3,000	$6,000	$9,000
		11	Medium & Low Pressure Ductwork	$4,680	$16,380	$21,060
		12	Demo Water Source Heat Pumps (15)	$0	$4,350	$4,350
		13	Demo 40 Ton Chillers (2)	$0	$21,120	$21,120
		14	Demo Cooling Tower	$0	$3,960	$3,960
		15	Demo Condensor & Chilled Water Piping	$0	$7,000	$7,000
		16	Electrical	$500	$5,000	$5,500
			Totals	$220,823	$224,499	$445,322

NOTES:
1. This project also includes items that are not being claimed for the energy credit program. Only eligible items are shown above.
2. Cost Data per Means Mechanical Cost Data 2000.
3. All Item Costs contain 20% O & P Contractor Fees.

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Appendix 2: Opinions of Probable Construction Costs

PAE OPINION OF PROBABLE COSTS Oregon Trail Building
Job No. 3222.10
27 June, 2000

ECM	Measure	Item	DESCRIPTION	Material $	Labor $	Total $
3	Replace Penthouse Multizone w/VAV AHU	1	VAV AHU (5,000 Cfm)	$14,280	$6,600	$20,880
		2	Electric Motor (5 HP General Electric)	$264	$68	$332
		3	Electric Motor (1 HP General Electric)	$177	$68	$245
		4	Variable Frequency Drive (5 HP Square D)	$2,070	$400	$2,470
		5	DDC Controls for AHU	$8,625	$8,625	$17,250
		6	VVR Terminal Units w/Controls (5)	$18,000	$40,200	$58,200
		7	Piping and Accessories	$1,000	$2,000	$3,000
		8	Medium & Low Pressure Ductwork	$1,560	$5,460	$7,020
		9	Demo AHU-3	$0	$1,056	$1,056
		10	Demo Medium & Low Pressure Ductwork	$0	$120	$120
		11	Electrical	$500	$5,000	$5,500
			Totals	$46,476	$69,597	$116,073
4	Refurbish 3rd Flr Multizone AHU / Conver to VAV	1	Electric Motor (15 HP General Electric)	$1,378	$96	$1,474
		2	Electric Motor (7.5 HP General Electric)	$394	$73	$467
		3	Variable Frequency Drive (15 HP Square D)	$2,650	$600	$3,250
		4	Variable Frequency Drive (7.5 HP Square D)	$1,500	$600	$2,100
		5	DDC Controls for AHU-3	$8,625	$8,625	$17,250
		6	VAV Therma-fusers (34)	$3,400	$8,500	$11,900
		7	Refurbish AHU-2	$1,000	$2,000	$3,000
		8	Electrical	$500	$5,000	$5,500
			Totals	$19,447	$25,494	$44,941
5	Upgrade Basement Multizone w/VSDs & VAV	1	Electric Motor (50 HP General Electric)	$3,289	$192	$3,481
		2	Electric Motor (10 HP General Electric)	$914	$77	$991
		3	Variable Frequency Drive (50 HP Square D)	$7,925	$1,000	$8,925
		4	Variable Frequency Drive (10 HP Square D)	$2,940	$475	$3,415
		5	Dual Duct VAV Terminal Units w/controls(25)	$25,000	$25,000	$50,000
		6	DDC Controls for AHU-1	$8,250	$8,250	$16,500
		7	Demo Dual Duct CV Mixing Boxes (25)	$0	$5,000	$5,000
		8	Electrical	$500	$5,000	$5,500
			Totals	$48,818	$44,994	$93,812

NOTES:
1. This project also includes items that are not being claimed for the energy credit program. Only eligible items are shown above.
2. Cost Data per Means Mechanical Cost Data 2000.
3. All Item Costs contain 20% O & P Contractor Fees.

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Appendix 3: ECM Depreciation Calculations

ECM1

Year	BV (150% DB)	DB dk	BV (SL)	SL dk	DB < SL	Depreciation	PW (Depreciation)	BV (Total)	
0	84,729		84,729						
1	78,374	6355	80,493	4236	No	6355	5777	78,374	
2	72,496	5878	76,368	4125	No	5878	4858	72,496	
3	67,059	5437	72,340	4028	No	5437	4085	67,059	
4	62,030	5029	68,395	3945	No	5029	3435	62,030	
5	57,377	4652	64,519	3877	No	4652	2889	57,377	
6	53,074	4303	60,693	3825	No	4303	2429	53,074	
7	49,094	3981	56,902	3791	No	3981	2043	49,094	
8	**45,412**	**3,682**	**53,126**	**3,776**	**Yes**	**3776**	**1762**	**45,317**	Switchover
9	42,006	3406	49,350	3,776	Yes	3776	1602	41,541	
10	38,855	3150	45,573	3,776	Yes	3776	1456	37,764	
11	35,941	2914	41,797	3,776	Yes	3776	1324	33,988	
12	33,246	2696	38,020	3,776	Yes	3776	1203	30,211	
13	30,752	2493	34,244	3,776	Yes	3776	1094	26,435	
14	28,446	2306	30,467	3,776	Yes	3776	994	22,659	
15	26,312	2133	26,691	3,776	Yes	3776	904	18,882	
16	24,339	1973	22,915	3,776	Yes	3776	822	15,106	
17	22,513	1825	19,138	3,776	Yes	3776	747	11,329	
18	20,825	1689	15,362	3,776	Yes	3776	679	7,553	
19	19,263	1562	11,585	3,776	Yes	3776	617	3,776	
20	17,818	1445	7,809	3,776	Yes	3776	561	0	
Totals		66,911		76,920		84,729	39,280		

ECM2

Year	BV (150% DB)	DB dk	BV (SL)	SL dk	DB < SL	Depreciation	PW (Depreciation)	BV (Total)	
0	445,322		445,322						
1	411,923	33399	423,056	22266	No	33399	30363	411,923	
2	381,029	30894	401,376	21680	No	30894	25531	381,029	
3	352,451	28577	380,207	21168	No	28577	21470	352,451	
4	326,018	26434	359,475	20732	No	26434	18054	326,018	
5	301,566	24451	339,099	20376	No	24451	15182	301,566	
6	278,949	22617	318,995	20104	No	22617	12768	278,949	
7	258,028	20921	299,070	19925	No	20921	10737	258,028	
8	**238,676**	**19,352**	**279,221**	**19,848**	**Yes**	**19848**	**9259**	**238,179**	Switchover
9	220,775	17901	259,373	19,848	Yes	19848	8418	218,331	
10	204,217	16558	239,525	19,848	Yes	19848	7652	198,483	
11	188,901	15316	219,676	19,848	Yes	19848	6957	178,635	
12	174,733	14168	199,828	19,848	Yes	19848	6324	158,786	
13	161,628	13105	179,980	19,848	Yes	19848	5750	138,938	
14	149,506	12122	160,132	19,848	Yes	19848	5226	119,090	
15	138,293	11213	140,283	19,848	Yes	19848	4752	99,241	
16	127,921	10372	120,435	19,848	Yes	19848	4319	79,393	
17	118,327	9594	100,587	19,848	Yes	19848	3926	59,545	
18	109,452	8875	80,739	19,848	Yes	19848	3571	39,697	
19	101,243	8209	60,890	19,848	Yes	19848	3245	19,848	
20	93,650	7593	41,042	19,848	Yes	19848	2947	0	
Totals		351,672		404,280		445,322	206,450		

ECM3

Year	BV (150% DB)	DB dk	BV (SL)	SL dk	DB < SL	Depreciation	PW (Depreciation)	BV (Total)	
0	116,073		116,073						
1	107,368	8705	110,269	5804	No	8705	7914	107,368	
2	99,315	8053	104,618	5651	No	8053	6655	99,315	
3	91,866	7449	99,101	5517	No	7449	5596	91,866	
4	84,976	6890	93,697	5404	No	6890	4706	84,976	
5	78,603	6373	88,386	5311	No	6373	3957	78,603	
6	72,708	5895	83,146	5240	No	5895	3328	72,708	
7	67,255	5453	77,952	5193	No	5453	2799	67,255	
8	**62,211**	**5,044**	**72,779**	**5,173**	**Yes**	**5173**	**2413**	**62,081**	**Switchover**
9	57,545	4666	67,605	5,173	Yes	5173	2194	56,908	
10	53,229	4316	62,432	5,173	Yes	5173	1994	51,734	
11	49,237	3992	57,259	5,173	Yes	5173	1813	46,561	
12	45,544	3693	52,085	5,173	Yes	5173	1648	41,388	
13	42,128	3416	46,912	5,173	Yes	5173	1499	36,214	
14	38,969	3160	41,738	5,173	Yes	5173	1362	31,041	
15	36,046	2923	36,565	5,173	Yes	5173	1239	25,867	
16	33,343	2703	31,391	5,173	Yes	5173	1126	20,694	
17	30,842	2501	26,218	5,173	Yes	5173	1023	15,520	
18	28,529	2313	21,044	5,173	Yes	5173	931	10,347	
19	26,389	2140	15,871	5,173	Yes	5173	846	5,173	
20	24,410	1979	10,698	5,173	Yes	5173	768	0	
Totals		91,663		105,375		116,073	53,811		

ECM4

Year	BV (150% DB)	DB dk	BV (SL)	SL dk	DB < SL	Depreciation	PW (Depreciation)	BV (Total)	
0	44,941		44,941						
1	41,570	3371	42,694	2247	No	3371	3064	41,570	
2	38,453	3118	40,506	2188	No	3118	2577	38,453	
3	35,569	2884	38,370	2136	No	2884	2167	35,569	
4	32,901	2668	36,277	2092	No	2668	1822	32,901	
5	30,433	2468	34,221	2056	No	2468	1532	30,433	
6	28,151	2283	32,192	2029	No	2283	1288	28,151	
7	26,040	2111	30,182	2011	No	2111	1084	26,040	
8	**24,087**	**1,953**	**28,178**	**2,003**	**Yes**	**2003**	**934**	**24,037**	**Switchover**
9	22,280	1806	26,175	2,003	Yes	2003	849	22,034	
10	20,609	1671	24,172	2,003	Yes	2003	772	20,030	
11	19,063	1546	22,169	2,003	Yes	2003	702	18,027	
12	17,634	1430	20,166	2,003	Yes	2003	638	16,024	
13	16,311	1323	18,163	2,003	Yes	2003	580	14,021	
14	15,088	1223	16,160	2,003	Yes	2003	527	12,018	
15	13,956	1132	14,157	2,003	Yes	2003	480	10,015	
16	12,910	1047	12,154	2,003	Yes	2003	436	8,012	
17	11,941	968	10,151	2,003	Yes	2003	396	6,009	
18	11,046	896	8,148	2,003	Yes	2003	360	4,006	
19	10,217	828	6,145	2,003	Yes	2003	327	2,003	
20	9,451	766	4,142	2,003	Yes	2003	297	0	
Totals		35,490		40,799		44,941	20,834		

ECM5

Year	BV (150% DB)	DB dk	BV (SL)	SL dk	DB < SL	Depreciation	PW (Depreciation)	BV (Total)	
0	93,812		93,812						
1	86,776	7036	89,121	4691	No	7036	6396	86,776	
2	80,268	6508	84,554	4567	No	6508	5378	80,268	
3	74,248	6020	80,095	4459	No	6020	4523	74,248	
4	68,679	5569	75,727	4368	No	5569	3803	68,679	
5	63,528	5151	71,435	4292	No	5151	3198	63,528	
6	58,764	4765	67,200	4235	No	4765	2690	58,764	
7	54,356	4407	63,002	4197	No	4407	2262	54,356	
8	**50,280**	**4,077**	**58,821**	**4,181**	**Yes**	**4181**	**1951**	**50,175**	**Switchover**
9	46,509	3771	54,640	4,181	Yes	4181	1773	45,994	
10	43,021	3488	50,459	4,181	Yes	4181	1612	41,813	
11	39,794	3227	46,277	4,181	Yes	4181	1466	37,631	
12	36,809	2985	42,096	4,181	Yes	4181	1332	33,450	
13	34,049	2761	37,915	4,181	Yes	4181	1211	29,269	
14	31,495	2554	33,733	4,181	Yes	4181	1101	25,088	
15	29,133	2362	29,552	4,181	Yes	4181	1001	20,906	
16	26,948	2185	25,371	4,181	Yes	4181	910	16,725	
17	24,927	2021	21,190	4,181	Yes	4181	827	12,544	
18	23,057	1870	17,008	4,181	Yes	4181	752	8,363	
19	21,328	1729	12,827	4,181	Yes	4181	684	4,181	
20	19,728	1600	8,646	4,181	Yes	4181	621	0	
Totals		**74,084**		**85,166**		**93,812**	**43,491**		

Appendix 4: ECM Total Marginal Cost Calculations

ECM1

Year	Cost	Rebate	O&M	Depr	MV	Interest on capital ($i*MV_{k-1}$)	Interest on capital ($i*MV_{k-1}$) in present	TC	PW (TC) (P/F,10%,K)
0	84,729				84,729				
1		-8,473	-7,366	6,355	78,374	8,473	7,703	-1,011	-919
2		-8,473	-7,366	5,878	72,496	7,837	6,477	-2,123	-1,755
3		-4,236	-7,366	5,437	67,059	7,250	5,447	1,084	815
4		-4,236	-7,366	5,029	62,030	6,706	4,580	133	91
5		-4,236	-7,366	4,652	57,377	6,203	3,852	-747	-464
6			-7,366	4,303	53,074	5,738	3,239	2,675	1,510
7			-7,366	3,981	49,094	5,307	2,724	1,922	986
8			-7,366	3,776	45,317	4,909	2,290	1,320	616
9			-7,366	3,776	41,541	4,532	1,922	942	400
10			-7,366	3,776	37,764	4,154	1,602	564	218
11			-7,366	3,776	33,988	3,776	1,324	187	65
12			-7,366	3,776	30,211	3,399	1,083	-191	-61
13			-7,366	3,776	26,435	3,021	875	-568	-165
14			-7,366	3,776	22,659	2,643	696	-946	-249
15			-7,366	3,776	18,882	2,266	542	-1,324	-317
16			-7,366	3,776	15,106	1,888	411	-1,701	-370
17			-7,366	3,776	11,329	1,511	299	-2,079	-411
18			-7,366	3,776	7,553	1,133	204	-2,457	-442
19			-7,366	3,776	3,776	755	123	-2,834	-463
20			-7,366	3,776	0	378	56	-3,212	-477
Total		**-29,655**	**-147,320**	**84,729**		**81,879**	**45,448**	**-10,367**	**-1,394**

ECM2

Year	Cost	Rebate	O&M	Depr	MV	Interest on capital ($i*MV_{k-1}$)	Interest on capital ($i*MV_{k-1}$) in present	TC	PW (TC) (P/F,i%,K)
0	445,322				445,322				
1		-44,532	-9,953	33,399	411,923	44,532	40,484	23,446	21,315
2		-44,532	-9,953	30,894	381,029	41,192	34,043	17,601	14,547
3		-22,266	-9,953	28,577	352,451	38,103	28,627	34,461	25,891
4		-22,266	-9,953	26,434	326,018	35,245	24,073	29,460	20,122
5		-22,266	-9,953	24,451	301,566	32,602	20,243	24,834	15,420
6			-9,953	22,617	278,949	30,157	17,023	42,821	24,171
7			-9,953	20,921	258,028	27,895	14,314	38,863	19,943
8			-9,953	19,848	238,179	25,803	12,037	35,698	16,653
9			-9,953	19,848	218,331	23,818	10,101	33,713	14,298
10			-9,953	19,848	198,483	21,833	8,418	31,728	12,233
11			-9,953	19,848	178,635	19,848	6,957	29,744	10,425
12			-9,953	19,848	158,786	17,863	5,692	27,759	8,845
13			-9,953	19,848	138,938	15,879	4,599	25,774	7,466
14			-9,953	19,848	119,090	13,894	3,659	23,789	6,264
15			-9,953	19,848	99,241	11,909	2,851	21,804	5,220
16			-9,953	19,848	79,393	9,924	2,160	19,819	4,313
17			-9,953	19,848	59,545	7,939	1,571	17,835	3,528
18			-9,953	19,848	39,697	5,954	1,071	15,850	2,851
19			-9,953	19,848	19,848	3,970	649	13,865	2,267
20			-9,953	19,848	0	1,985	295	11,880	1,766
Total		**-155,863**	**-199,060**	**445,322**		**430,345**	**238,867**	**520,744**	**237,537**

ECM3

Year	Cost	Rebate	O&M	Depr	MV	Interest on capital ($i*MV_{k-1}$)	Interest on capital ($i*MV_{k-1}$) in present	TC	PW (TC) (P/F,i%,K)
0	116,073				116,073				
1		-11,607	-4,165	8,705	107,368	11,607	10,552	4,540	4,128
2		-11,607	-4,165	8,053	99,315	10,737	8,873	3,017	2,493
3		-5,804	-4,165	7,449	91,866	9,931	7,462	7,411	5,568
4		-5,804	-4,165	6,890	84,976	9,187	6,275	6,108	4,172
5		-5,804	-4,165	6,373	78,603	8,498	5,276	4,902	3,044
6			-4,165	5,895	72,708	7,860	4,437	9,591	5,414
7			-4,165	5,453	67,255	7,271	3,731	8,559	4,392
8			-4,165	5,173	62,081	6,725	3,137	7,734	3,608
9			-4,165	5,173	56,908	6,208	2,633	7,217	3,061
10			-4,165	5,173	51,734	5,691	2,194	6,699	2,583
11			-4,165	5,173	46,561	5,173	1,813	6,182	2,167
12			-4,165	5,173	41,388	4,656	1,484	5,665	1,805
13			-4,165	5,173	36,214	4,139	1,199	5,147	1,491
14			-4,165	5,173	31,041	3,621	954	4,630	1,219
15			-4,165	5,173	25,867	3,104	743	4,113	985
16			-4,165	5,173	20,694	2,587	563	3,595	782
17			-4,165	5,173	15,520	2,069	409	3,078	609
18			-4,165	5,173	10,347	1,552	279	2,560	461
19			-4,165	5,173	5,173	1,035	169	2,043	334
20			-4,165	5,173	0	517	77	1,526	227
Total		-40,626	-83,300	116,073		112,169	62,260	104,317	48,541

ECM4

Year	Cost	Rebate	O&M	Depr	MV	Interest on capital ($i*MV_{k-1}$)	Interest on capital ($i*MV_{k-1}$) in present	TC	PW (TC) (P/F,i%,K)
0	44,941				44,941				
1		-4,494	-9,507	3,371	41,570	4,494	4,086	-6,136	-5,579
2		-4,494	-9,507	3,118	38,453	4,157	3,436	-6,726	-5,559
3		-2,247	-9,507	2,884	35,569	3,845	2,889	-5,025	-3,775
4		-2,247	-9,507	2,668	32,901	3,557	2,429	-5,530	-3,777
5		-2,247	-9,507	2,468	30,433	3,290	2,043	-5,996	-3,723
6			-9,507	2,283	28,151	3,043	1,718	-4,181	-2,360
7			-9,507	2,111	26,040	2,815	1,445	-4,581	-2,351
8			-9,507	2,003	24,037	2,604	1,215	-4,900	-2,286
9			-9,507	2,003	22,034	2,404	1,019	-5,100	-2,163
10			-9,507	2,003	20,030	2,203	849	-5,301	-2,044
11			-9,507	2,003	18,027	2,003	702	-5,501	-1,928
12			-9,507	2,003	16,024	1,803	574	-5,701	-1,817
13			-9,507	2,003	14,021	1,602	464	-5,902	-1,709
14			-9,507	2,003	12,018	1,402	369	-6,102	-1,607
15			-9,507	2,003	10,015	1,202	288	-6,302	-1,509
16			-9,507	2,003	8,012	1,002	218	-6,502	-1,415
17			-9,507	2,003	6,009	801	159	-6,703	-1,326
18			-9,507	2,003	4,006	601	108	-6,903	-1,242
19			-9,507	2,003	2,003	401	66	-7,103	-1,161
20			-9,507	2,003	-0	200	30	-7,304	-1,086
Total		-15,729	-190,140	44,941		43,430	24,106	-117,499	-48,415

ECM5

Year	Cost	Rebate	O&M	Depr	MV	Interest on capital ($i*MV_{k-1}$)	Interest on capital ($i*MV_{k-1}$) in present	TC	PW (TC) (P/F,i%,K)
0	93,812				93,812				
1		-9,381	-10,972	7,036	86,776	9,381	8,528	-3,936	-3,578
2		-9,381	-10,972	6,508	80,268	8,678	7,172	-5,167	-4,271
3		-4,691	-10,972	6,020	74,248	8,027	6,031	-1,616	-1,214
4		-4,691	-10,972	5,569	68,679	7,425	5,071	-2,669	-1,823
5		-4,691	-10,972	5,151	63,528	6,868	4,264	-3,644	-2,262
6			-10,972	4,765	58,764	6,353	3,586	145	82
7			-10,972	4,407	54,356	5,876	3,016	-688	-353
8			-10,972	4,181	50,175	5,436	2,536	-1,355	-632
9			-10,972	4,181	45,994	5,018	2,128	-1,773	-752
10			-10,972	4,181	41,813	4,599	1,773	-2,191	-845
11			-10,972	4,181	37,631	4,181	1,466	-2,609	-915
12			-10,972	4,181	33,450	3,763	1,199	-3,028	-965
13			-10,972	4,181	29,269	3,345	969	-3,446	-998
14			-10,972	4,181	25,088	2,927	771	-3,864	-1,017
15			-10,972	4,181	20,906	2,509	601	-4,282	-1,025
16			-10,972	4,181	16,725	2,091	455	-4,700	-1,023
17			-10,972	4,181	12,544	1,673	331	-5,118	-1,013
18			-10,972	4,181	8,363	1,254	226	-5,536	-996
19			-10,972	4,181	4,181	836	137	-5,954	-974
20			-10,972	4,181	0	418	62	-6,373	-947
Total		**-32,834**	**-219,440**	**93,812**		**90,657**	**50,320**	**-67,805**	**-25,521**

Appendix 5: ECM Benefit- Cost Ratio Calculations

ECM 1

Annual Energy Saving	7,366
Intial Cost	84,729
Simple Payback (Yrs)	12
Rebate Benefit	23,411
O&M Benefit	62,711
Dpr Cost	39,280
Interest on MV Cost	45,448
PW(Benefit)	86,123
PW(Cost)	84,728
B-C ratio	1.02

Passes

ECM 2

Annual Energy Saving	9,953
Intial Cost	445,322
Simple Payback (Yrs)	45
Rebate Benefit	122,537
O&M Benefit	84,736
Dpr Cost	206,450
Interest on MV Cost	238,867
PW(Benefit)	207,272
PW(Cost)	445,316
B-C ratio	0.47

Fails

ECM 3

Annual Energy Saving	4,165
Intial Cost	116,073
Simple Payback (Yrs)	28
Rebate Benefit	32,244
O&M Benefit	35,459
Dpr Cost	53,811
Interest on MV Cost	62,260
PW(Benefit)	67,703
PW(Cost)	116,071
B-C ratio	0.58

Fails

ECM 4

Annual Energy Saving	9,507
Intial Cost	44,941
Simple Payback (Yrs)	5
Rebate Benefit	12,249
O&M Benefit	80,939
Dpr Cost	20,834
Interest on MV Cost	24,106
PW(Benefit)	93,188
PW(Cost)	44,940
B-C ratio	2.07

Passes

ECM 5

Annual Energy Saving	10,972
Intial Cost	93,812
Simple Payback (Yrs)	9
Rebate Benefit	25,411
O&M Benefit	93,411
Dpr Cost	43,491
Interest on MV Cost	50,320
PW(Benefit)	118,822
PW(Cost)	93,811
B-C ratio	1.27

Passes