CE Systems – HW Engineering Economic Evaluation – 2014 - Solution

1. Compare three projects: Write out your solution, **by hand**, in terms of **Interest Factors**, then with **equations**, then substituting **values** in the equations. Finally, substitute the final value of the interest factor. Of course, once this is done for a given interest factor--e.g., (P/F,0.04,5)--you can go directly from the interest factor to the final value. Use an effective annual interest rate of **4%**. You may check your answers with Excel.

1. Create cash flow tables from the information given below, 4, 6, and 12 years, respectively. Also do 12 year cash flow tables for A and B.

Cash Type	Project A	Project B	Project C[a]
Capital Cost, $	40,000	20,000	65,000
Revenue, $/yr	13,000	11,000	A + G (A =7,000 & G=2,000)
O&M, $/yr	6,000	3,000	4,000
Salvage Value, $	9,000	5,000	4,000
Lifetime, yr	4	6	12

[a]Project C Revenue = 7,000 first year & increases 2,000/year thereafter (i.e., 7,000, 9,000, 11,000,…)

2. Determine the Present Worth of the three alternatives. Use 12 yr cash flow tables.
3. Determine the Annual Cash Flow of each Project. Use 6 AND 12 yr cash flow tables for Project B (just to prove that both give the same answer).
4. Determine the Rate of Return (i*) of each project, using a trial by error method. Stop when you get an i* value that gives a PW of $0 \pm \leq \$50$
5. Determine the **discounted** payback period for each project. Use the project lifetime cash flow table.
6. Determine the **undiscounted** payback period for each project. Use the project lifetime cash flow table.
7. Which project has the maximum net benefit (Present or annual)? Which has the best Return Rate? The best Payback Period? Why can the methods give different answers?

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1	**End of Year**	A	A*	B	B*	C				
	0	-40	-40	-20	-20	-65				
	1	7	7	8	8	3				
	2	7	7	8	8	5				
	3	7	7	8	8	7				
	4	16	-24	8	8	9				
	5		7	8	8	11				
	6		7	13	-7	13				
	7		7		8	15				
	8		-24		8	17				
	9		7		8	19				
	10		7		8	21				
	11		7		8	23				
	12		16		13	29				
2	**PW of CFT**	NA	($17.83)	NA	$46.35	$60.15				
3	**ACF of PS**	($1.90)	NA	$4.94	NA	$3.37				
	ACF of PV	NA	($1.90)	NA	$4.94	$6.41				
4	**i* of CFT**	-2.7%	-2.7%	34.8%	34.8%	13.5%				
	PW at IRR	$0.00	NA	$0.00	$0.00	$0.00				
5	**PB Discounted**	A	A PW	A Cum	B	B PW	B Cum	C	C PW	C Cum
	0	-40	-40	-40	-20	-20	-20	-65	-65	-65
	1	7	6.7	-33.3	8	7.7	-12.3	3	2.9	-62.1
	2	7	6.5	-26.8	8	7.4	-4.9	5	4.6	-57.5
	3	7	6.2	-20.6	8	7.1	2.2	7	6.2	-51.3
	4	16	13.7	-6.9	8	6.8	9.0	9	7.7	-43.6
	5				8	6.6	15.6	11	9.0	-34.5
	6				13	10.3	25.9	13	10.3	-24.3
	7							15	11.4	-12.9
	8							17	12.4	-0.4
	9							19	13.3	12.9
	10							21	14.2	27.1
	11							23	14.9	42.0
	12							29	18.1	60.1
				No PB			3			9
	Year									
6	**PB Undiscounted**	A	A Cum	B	B Cum	C	C Cum			
	0	-40	-40	-20	-20	-65	-65			
	1	7	-33	8	-12	3	-62			
	2	7	-26	8	-4	5	-57			
	3	7	-19	8	4	7	-50			
	4	16	-3	8	12	9	-41			
	5			8	20	11	-30			
	6			13	33	13	-17			
	7					15	-2			
	8					17	15			
	9					19	34			
	10					21	55			
	11					23	78			
	12					29	107			
						0	107			

2. Compare alternative indoor lighting scenarios for your family home (NOT your dorm room). Compare incandescents (Halcos) and compact fluorescents (Energy Misers). Investigate using ALL incandescents or ALL fluorescents where ever a 40, 60, or 100W incandescent is (or could be) in use, e.g., lamps and ceiling fixtures. Do not evaluate linear florescent tubes, flood lights, etc. MARR = 0.06. Determine answers with calculator (to prepare for the test) and Excel (to prepare for the real world). Turn in your Excel solution, appropriately documented.

Table 1: Bulb Information*

Bulb	Wattage, W	Incandescent Equivalent, W	Lifetime (in operation), hr	Price, $	Picture
Halco # 6320	40	It is Incandescent!	5,000	0.50	
Halco # 6321	60	It is Incandescent!	5,000	0.55	
Halco # 6323	100	It is Incandescent!	5,000	0.60	
Energy Miser FE-IISB-9W	9	40	10,000	2.70	
Energy Miser FE-IISB-14W/41K	14	60	10,000	2.80	
Energy Miser FE-IISB-23W/27K	23	100	12,000 (we'll assume 10,000)	2.90	

*1000Bulbs.cpm (2010) "1000Bulbs.com". www.1000bulbs.com, accessed Sept. 11, 2013. Prices changed to provide new problem.

1. Import Table 1 into Excel and add the following columns: Daily Operation, hr; Lifetime (Elapsed), yr; Number of Bulbs; Total Purchase Cost, $; Annual Electric, kWhr; Annual Electric, $. Assume the Daily operation is **3.425 hours per day**, **365 days per year**. This will give an 8 and 4 year elapsed lifetime for the CFL & INC light bulbs, respectively. Base the number of each bulb type on your home. First determine the number of INCs of each type you need (if ALL bulbs were INCs), and then repeat using the SAME numbers for the equivalent CFLs (if ALL bulbs were CFLs). We are looking at the economic benefit of switching from ALL INCs to ALL CFLs. Assume electricity cost = **$0.13/kWhr**. Document how the table values were determined (some were "Given", others are calculated using equations). See Prof Everett's Course page and use the "Student Reference" link for guidance on "How to document tables".

2. **Make an 8 yr cash flow table for the INC and CFL Alternatives.** There will be one column for the CFLs and one for the INCs. The INC Alternative will be repeated twice, <u>as you will need to replace the INC light bulbs after 4 years.</u> While only the PW analysis requires you to double the INC Alternative, using it for the other analyses is OK as you'll get the same answer either way for them. These two cash flow tables will only have costs, i.e. the cost of purchasing bulbs and powering them. All of the values will be negative! And no Salvage Costs!

3. Add a third cash flow column to the 8 yr cash flow table that is the CFL cash flow column MINUS the INC cash flow column, i.e., subtract each year's values. This column should have a negative amount at the end of year 0 and positive amounts in all other years. The CFLs should cost more to purchase than the INCs, but should cost less to power. **Estimate the PWNB and ANB of this cash flow table.** These numbers give the net benefit of switching from ALL INC to ALL CFL. **Also determine the rate of return and discounted payback period** associated with switching from INC to CFL. You'll need two more columns to do the discounted payback period. **Interpret your answers.**

4. What assumptions used to complete steps 1 - 3 do you think are most inappropriate for your home?

If you haven't already switched to CFLs, I hope this convinces you! But make sure you dispose of CFLs properly, as they contain mercury. Do you disagree with any of the assumption I used?

You can use my solution to check your excel solution, but YOUR homework MUST have DIFFERENT numbers of bulbs. I assumed five 40W, ten 60W & twenty 100W INCs (and the same numbers of CFLs) and ended up with (third cash flow column) PW=$2111, ANB = $340, i* = 441%, Payback Period = 1 year. Outstanding i* and Payback Period! Why do people still buy incandescent bulbs? ☺

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Table 1: Light Bulb Information

Bulb	Wattage W	Equivalent to (Inc.) W	Lifetime (operation) hr	Daily Operation hr/d	Lifetime (elapsed) d	Lifetime (elapsed) yr	Price (each) $	Quantity	Total Purchase Cost $	Annual Electric kWhr	Annual Electric $
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Halco # 6320	40	It is Incandescent!	5,000	3.425	1460	4	0.5	5	2.5	250	$33
Halco # 6321	60	It is Incandescent!	5,000	3.425	1460	4	0.55	10	5.5	750	$98
Halco # 6323	100	It is Incandescent!	5,000	3.425	1460	4	0.6	20	12	2500	$325
Energy Miser FE-IIS-9W	9	40	10,000	3.425	2920	8	2.7	5	13.5	56	$7
Energy Miser FE-IISB-14W/41K	14	60	10,000	3.425	2920	8	2.8	10	28	175	$23
Energy Miser FE-IIS-26W-27	23	100	10,000	3.425	2920	8	2.9	20	58	575	$75
Columns 1 - 5 & 8 were given								5	6	6	6
Column 6 = Col 4 / Col 5						Elecrtricity Price		0.13	$/kWhr		
Column 7 = Col 6 / 365							MARR	0.06	MARR		
Column 9 is assumed (based on lights needed for home)											
Column 10 = Col 9 x Col 8						Orig # - 5, 10, 20					
Column 11 = Col 2 x Col 5 x Col 9 x 365/1000											
Column 12 = Col 11 x Electricity Price											
	5	5	5								

Table 2: Cash Flow Tables

End of yr	CFL $	INC $	CFL-INC $	PW $	Cum-PW $						
(1)	(2)	(3)	(4)	(5)	(6)	Answers	CFL	INC	CFL-INC		
0	-99.5	-20	-80	-80	-80	PWNB	-$750	-$2,862	$2,111		10
1	-$105	-$455	350	330	251	ANB	-$121	-$461	$340		
2	-$105	-$455	350	312	563						
3	-$105	-$455	350	294	857	RR			441%		10
4	-$105	-$475	370	293	1150	B-C Ratio			27.56		10
5	-$105	-$455	350	262	1412	PayBack Period			1	yr	10
6	-$105	-$455	350	247	1658						
7	-$105	-$455	350	233	1891				20	No Doc	
8	-$105	-$455	350	220	2111						

Column 1 is given

Column 2 is the cost to purchase CFLs (yr 0) and to power (yrs 1 - 8), From Table 1

Column 3 is the cost to purchase INCs (yr 0 & 4) and to power (yrs 1 - 8), From Table 1

Column 4 = Col 2 - Col 1

Column 5 = Present worth of Col 4 = Col 4 x (1 + MARR)^Col 1

Column 6 is the cumulative sum of Col 5

CFL = Compact Fluorescent Light

INC - Incandescent Light

PC = Purchase Price

AEC = Annual Electricity Cost

AES = Annual Electricity Savings switching Incs to CFLs

Selected Sample Calculations

PW_CFL = -PC_CFL - AEC_CFL x (P/A,i,8)

PW_INC = -PC_INC - AEC_INC x (P/A,i,8) - PC_INC x (P/F,i,4)

ANB_CFL = -PC_CFL x (A/P,i,8) - AEC_CFL

ANB_INC= -PC_INC x (A/P,i,8) - AEC_INC - PC_INC x (P/F,i,4)(A/P,i,8)

RR - Solve the following equation for i*: AES x (P/A,i8,8) - (PC_CFL - PC_INC) + PC_INC x (P/F,i8,4) = 0