Problem 9-1

Goal: Determine optimum number of Evaporator Effects — converted to English units — old 4th Edition 11-1

Given:

Multiple effect evaporator	200,000	kg of water per day from salt	440,529	lbs per day	400,000
First Effect investment	$18,000				
additional effects investments	$15,000				
Service life	10	years			
Fixed Charges	15.0%	of equipment costs			
Maintenance expenses	5.0%	of equipment costs			
Steam costs	$0.0033	per kg steam	$1.4982	per 1,000 lbs	$1.50
Operates	300	days per year			
Steam effectiveness	0.85	* number of effects	kg water evaporated/kg steam used		

Assume: no salvage value
straight-line deprerciation

Approach: Minimize Annual Cost = Fixed Costs + Steam Costs
Let N = number of effects

Derive Cost Equation:

Total Investment = $18,000 + $15,000 (N - 1)

Annual Depreciation = 1/10 [18,00 + 15,000(N-1)]
Annual Fixed Charges = 0.15 [18,00 + 15,000(N-1)]
Annual Maintenance = 0.05 [18,00 + 15,000(N-1)]

Annual Fixed Costs = (0.1+0.15+0.05) [18,00 + 15,000(N-1)]
= 0.3*[$18,000 + $15,000 (N-1)] = $5,400 + $4,500 (N-1)
$900 **$4,500** **N**
= $900 + $4,500 N

Annual Operating Cost for Steam:
= 200,000 kg H_2O/day * 300 day/year /0.85 N kg H2O/kg steam * $0.0033/kg steam
$232,941 **/ N** $211,765

Total Annual Cost, C_T = $900 + $4,500 N + $232,941/N

Calculations:

differentiate and set equal to ZERO

$$dC_T/dN = 0 = \$4,500 - \$232,941/N^2$$

$$N = (\$232,941 / \$4,500)^{1/2}$$

Answer a.) **7.1948** effects — prepared by: D. C. Drown — 6.860 effects

Discussion: 11/7/2003

Must use integer number of effects, hence round down **7** effects

Problem 9-1

Goal: Determine practical number of integer effects

Approach:

Tabluate calculations of integer effect cost & plot
Calculate incremental return on additional investment for each effect

Calculations:

No. Effects	Investment	Annual Fixed	Annual Steam	Annualized Total Cost	Incremental ROI
1	$18,000	$5,400	$232,941	$238,341	
2	$33,000	$9,900	$116,471	$126,371	746%
3	$48,000	$14,400	$77,647	$92,047	229%
4	$63,000	$18,900	$58,235	$77,135	99%
5	$78,000	$23,400	$46,588	$69,988	48%
6	$93,000	$27,900	$38,824	$66,724	**21.76%**
7	$108,000	$32,400	$33,277	**$65,677**	**6.97%**
8	$123,000	$36,900	$29,118	$66,018	-2.27%
9	$138,000	$41,400	$25,882	$67,282	-8.43%
10	$153,000	$45,900	$23,294	$69,194	-13%
11	$168,000	$50,400	$21,176	$71,576	-16%
12	$183,000	$54,900	$19,412	$74,312	-18%

Answer b.)

prepared by: D. C. Drown

Discussion:

11/7/2003

An incremental return of 21.8% justifies using at least **6** effects

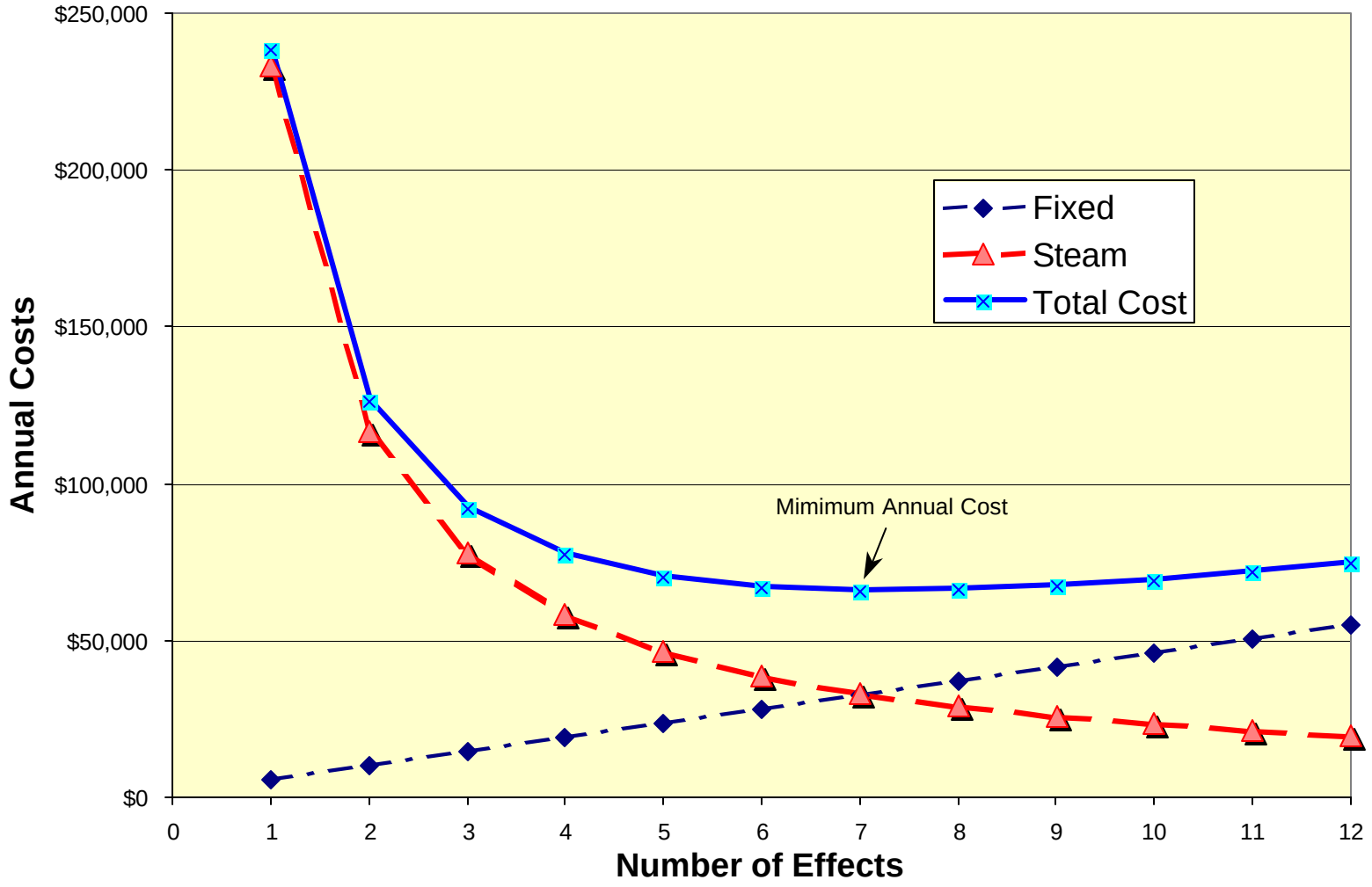
Depending upon the acceptable MARR (Minimum Acceptable Rate of Return), 7% might be attractive in which case **7** effects would be reccommended

Using 8 or more effects is not justified since annual costs increase after 7 effects.

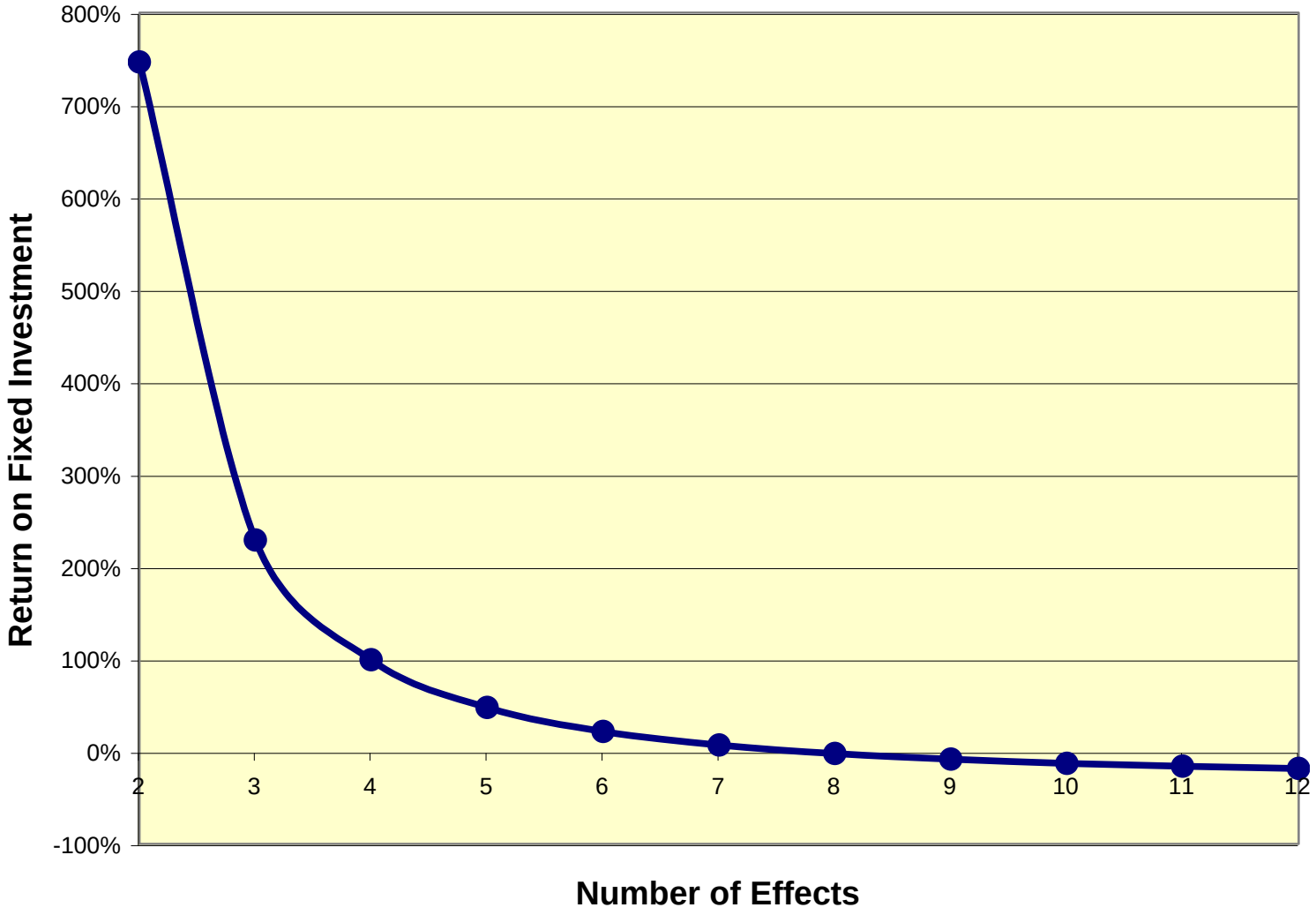
Speculating that energy cost will increase in the future, investing now to retain lower fixed costs and then see improved returns in the future; Recommend **7** effects

Problem 9-1

Optimum Number of Evaporator Effects



Problem 9-1 Incremental ROI



Problem 9-1

Optimum Number of Evaporator Effects based on ROI