Chapter 6 Annual Equivalence Method

6.1)

$$\begin{aligned} AE(9\%) &= \$20,000(A/P,9\%,5) \\ &= \$51,420 \end{aligned}$$

6.2)

$$\begin{aligned} AE(10\%) = A(P/A,10\%,3) &= \$100,000 \\ A &= \$40,210.70 \end{aligned}$$

6.3)

$$\begin{aligned} AE(12\%) &= -\$25,000(A/P,12\%,6) \\ &+ \begin{bmatrix} \$4,000(P/F,12\%,1)+\$13,000(P/F,12\%,2)+\$13,000(P/F,12\%,3) \\ +\$13,000(P/F,12\%,4)+\$8,000(P/F,12\%,5)+\$5,500(P/F,12\%,6) \end{bmatrix}(A/P,12\%,6) \\ &= \$3,351 \end{aligned}$$

6.4)

$$\begin{aligned} AE(8\%) &= -\$2,154(A/P,8\%,6) \\ &+ \begin{bmatrix} \$400(P/F,8\%,1)+X(P/A,8\%,2)(P/F,8\%,1) \\ +\$400(P/F,8\%,4)+X(P/A,8\%,2)(P/F,8\%,4) \end{bmatrix}(A/P,8\%,6) \\ &= \$200 \end{aligned}$$

$$\begin{aligned} 200 &= -465.94+(370.36+1.65X+294+1.31X)(0.2163) \\ 924.64 &= -1,489.78+2.96X \\ X &= \$815.68 \end{aligned}$$

6.5)

$$\begin{aligned}
\text{AE}(10\%)_A &= -\$3,000(A/P,10\%,5) \\
&\quad +\left[\$600(P/A,10\%,2)+\$1,000(P/A,10\%,3)(P/F,10\%,2)\right](A/P,10\%,5) \\
&= \$25.43 \text{ (Accept)} \\
\text{AE}(10\%)_B &= -\$5,000(A/P,10\%,5)+\$500 \\
&\quad +[\$2,500(P/F,10\%,1)+\$1,500(P/F,10\%,2) \\
&\quad +\$500(P/F,10\%,3)](A/P,10\%,5) \\
&= \$206.65 \text{ (Accept)} \\
\text{AE}(10\%)_C &= [-\$4,000-\$2,000(P/F,10\%,1) \\
&\quad \cdots+\$2,000(P/F,10\%,5)](A/P,10\%,5) \\
&= \$781.85 \text{ (Accept)} \\
\text{AE}(10\%)_D &= [-\$32,000+\$12,000(P/F,10\%,1) \\
&\quad +\cdots+\$14,000(P/F,10\%,5)](A/P,10\%,5) \\
&= \$6,592.33 \text{ (Accept)}
\end{aligned}$$

6.6)

$$\begin{aligned}
\text{AE}(12\%) &= \$1,000+[\frac{\$1,000}{0.15}(P/F,15\%,6)] \\
&= \$1,432.3
\end{aligned}$$

6.7)

$$\begin{aligned}
\text{AE}(9\%) &= -\$1,000(A/P,9\%,5)+\$800+\$300(P/F,9\%,2)(A/P,9\%,5) \\
&\quad +\$800(P/F,9\%,3)(A/P,9\%,5) \\
&= \$766.65
\end{aligned}$$

6.8)

$$\begin{aligned}
\text{AE}(13\%)_A &= -\$4,000(A/P,13\%,3)+\$5,500(A/F,13\%,3) \\
&= -\$79.75 \qquad \text{Not Accept} \\
\text{AE}(13\%)_B &= -\$3,500(A/P,13\%,3)+\$1,500 \\
&\quad +\$300(A/G,13\%,3) \\
&= \$293.36, \text{ Accept} \\
\text{AE}(13\%)_C &= -\$5,000(A/P,13\%,3)+\$3,000 \\
&\quad -\$1,000(A/G,13\%,3) \\
&= -\$36.2, \text{ Not Accept} \\
\text{AE}(13\%)_D &= -\$4,500(A/P,13\%,3)+\$1,800 \\
&= -\$105.75, \text{ Not Accept}
\end{aligned}$$

6.9)

$$\text{PW}(14\%) = \frac{\$100}{1.14} + \frac{\$100}{1.14^2} + \frac{\$60}{1.14^3} + \frac{\$60}{1.14^4} = \$240.69$$
$$\text{AE}(14\%) = \$240.69(A/P,14\%,4) = \$82.60$$

6.10) Given: $I = \$55,000, S = \$6,000, A_1 = \$5,000, G = \$2,500, N = 10$ years, $i = 12\%$

(a)

$$\begin{aligned}\text{AE}(12\%)_1 &= (\$55,000 - \$6,000)(A/P,12\%,10) \\ &\quad + \$6,000(0.12) \\ &= \$9,392\end{aligned}$$

(b)

$$\begin{aligned}\text{AE}(12\%)_2 &= \$5,000 + \$2,500(A/G,12\%,10) \\ &= \$13,962\end{aligned}$$

(c)

$$\begin{aligned}\text{AE}(12\%) &= \$13,962 - \$9,392 \\ &= \$4,570\end{aligned}$$

This is a good investment.

6.11)

$$\begin{aligned}\text{PW}(15\%) &= -\$15M - \$3.5M(P/F,15\%,1) + \$5M(P/F,15\%,2) \\ &\quad + \$9M(P/F,15\%,3) + \$12M(P/F,15\%,4) + \$10M(P/F,15\%,5) \\ &\quad + \$8M(P/F,15\%,6) \\ &= \$6.9464M\end{aligned}$$
$$\text{AE}(15\%) = \$6.9464M(A/P,15\%,6) = \$1.83524M$$

Yes, the project is justified.

6.12)

$$\begin{aligned}\text{CR}(20\%) &= (\$220,000 - \$20,000)(A/P,20\%,10) + \$20,000(0.2) \\ &= \$51,700\end{aligned}$$

6.13)

$$\begin{aligned}\text{CR}(15\%) &= (\$34,000 - \$3,000)(A/P,15\%,10) + \$3,000(0.15) \\ &= \$6,628.3\end{aligned}$$

6.14)

$$\text{CR}(6\%) = (\$18,500 - \$9,000)(A/P,6\%,4) + (0.06)(\$9,000)$$
$$= \$3,281.7$$

6.15) Given: $I = \$235{,}000, S = \$47{,}000, N = 5$ years, $i = 18\%$

$$\text{CR}(18\%) = (\$235,000 - \$47,000)(A/P,18\%,5)$$
$$+\$47,000(0.18)$$
$$= \$68,582.4$$

6.16)

- Capital cost:

$$\text{CR}(15\%) = (\$25,000 - \$2,000)(A/P,15\%,5) + \$2,000(0.15)$$
$$= \$7,160.9$$

- Annual operating costs: $\$15{,}000$

$$\text{AE}(15\%) = \$7,160.9 + \$15,000 = \$22,160.9$$

6.17)

$$\text{PW}(8\%) = \$10,000(P/A,8\%,10) + \frac{\$10,000}{0.06}(P/F,8\%,10)$$
$$= \$67,101 + \$77,200$$
$$= \$144,301$$

The amount of additional funds should be \$44,301.

6.18)

$$\text{AE}_1(10\%) = \$100,000(0.1) = \$10,000$$
$$\text{AE}_2(10\%) = \$10,000$$
$$\text{AE}_3(10\%) = \$20,000(A/F,10\%,4) = \$4,310$$

$$\text{AE}(10\%) = \text{AE}_1(10\%) + \text{AE}_2(10\%) + \text{AE}_3(10\%)$$
$$= \$24,310$$

6.19)

$$
\begin{aligned}
\text{CR}(10\%) &= (\$500,000-100,000)(A/P,10\%,15)+100,000(0.1) \\
&= \$62,600 \\
\text{AE}(10\%) &= \$40,000X - \$30,000X
\end{aligned}
$$

$$
\begin{aligned}
\text{CR}(10\%) &= \text{AE}(10\%) \\
\$62,600 &= \$10,000X
\end{aligned}
$$

$$X = 6.26 \text{ (or rounds up to 7)}$$

6.20)

(a)

$$
\begin{aligned}
\text{AE}(13\%) &= -\$5,000(A/P,13\%,4)+\$1,500 \\
&\quad +(X-\$1,500)(P/F,13\%,2)(A/P,13\%,4) \\
&= -\$181+(0.2633)(X-\$1,500) \\
&= 0 \\
X &= \$2,187
\end{aligned}
$$

(b)

$$
\begin{aligned}
\text{AE}(15\%) &= \$6,000(A/P,15\%,4)-\$1,200-300(A/G,15\%,4) \\
&= \$503.91 > 0
\end{aligned}
$$

Accept project B.

6.21)

- Option 1: Purchase-Borrow Option:

  Annual repayment of loan amount of $36,000:

$$
\begin{aligned}
A &= \$36,000(A/P,7\%,5) = \$8,780 \\
\text{AEC}(10\%)_1 &= \$4,000(A/P,10\%,5)+\$8,780 \\
&= \$9,835
\end{aligned}
$$

- Option 2: Cash Purchase Option:

$$\text{AEC}(10\%)_2 = \$36,000(A/P,10\%,5)$$
$$= \$9,497$$

Option 2 is a better choice.

6.22) The total investment consists of the sum of the initial equipment cost and the installation cost, which is $\$195,000$. Let R denote the break-even annual revenue.

$$\begin{aligned}\text{AE}(12\%) &= -\$195,000(A/P,12\%,10) - \$40,000 \\ &\quad -\$5,000 + \$15,000 + R \\ &= 0\end{aligned}$$

Solving for R yields

$$R = \$64,512$$

6.23)

- New lighting system cost:

$$\begin{aligned}\text{AE}(12\%) &= \$55,000(A/P,12\%,20) + \$8,000 + \$4,000 \\ &= \$19,364.5\end{aligned}$$

- Old lighting system cost:

$$\text{AE}(12\%) = \$30,000$$

Annual savings from installing the new lighting system $= \$10,635.5$

6.24)

$$\begin{aligned}\text{PW}(14\%) &= -\$100,000 + \$35,000(P/A_1,-3\%,14\%,5) \\ &= \$14,058.92 \\ \text{AE}(14\%) &= \$14,058.92(A/P,14\%,5) \\ &= \$4,095.13\end{aligned}$$

$$AE(14\%) = \$4,095.13/3,000 = \$1.37 \text{ per hour}$$

6.25)

Let T denote the total operating hours in full load.

- Motor I (Expensive): Annual power cost:

$$\frac{150}{0.83} \times (0.746) \times (0.05) \times T = \$6.741T$$

Equivalent annual cost of operating the motor:

$$\text{AEC}(6\%)_{\text{I}} = \$4,500(A/P,6\%,10) + \$675 + 6.741T$$
$$= \$1,286.41 + \$6.741T$$

- Motor II (Less expensive): Annual power cost:

$$\frac{150}{0.80} \times (0.746) \times (0.05) \times T = \$6.9938T$$

Equivalent annual cost of operating the motor:

$$\text{AEC}(6\%)_{\text{II}} = \$3,600(A/P,6\%,10) + \$540 + \$6.9938T$$
$$= \$1,029.11 + \$6.9938T$$

Let $\text{AEC}(6\%)_{\text{I}} = \text{AEC}(6\%)_{\text{II}}$ and solve for T.

$$-\$1,286.41 - \$6.741T = -\$1,029.11 - \$6.9938T$$

$$T = 1,017.8 \text{ hours per year}$$

6.26)

- Pump I:

$$(\frac{180}{0.86})(0.746)(0.06)T = \$9.368T$$
$$\text{AEC}(8\%)_{\text{I}} = \$6,000(A/P,8\%,12) + \$500 + \$9.368T$$
$$= \$1,296.2 + \$9.368T$$

- Pump II:

$$(\frac{180}{0.8})(0.746)(0.06)T = \$10.071T$$
$$\text{AEC}(8\%)_{\text{II}} = \$4,000(A/P,8\%,12) + \$440 + \$10.071T$$
$$= \$970.8 + \$10.071T$$

-

$$\$1,296.2 + 9.368T = \$970.8 + 10.071T$$
$$T = 463 \text{ hours}$$

6.27)

- Capital cost

$$\text{CR}(10\%) = (\$30,000 - \$10,000)(A/P,10\%,2) + (0.10)\$10,000$$
$$= \$12,524$$

-

$$\begin{aligned} \text{AE}_{\text{savings}}(10\%) &= [\frac{\$25,000}{1.1} + \frac{\$40,000}{1.1^2}](A/P,10\%,2) \\ &= \$32,143.39 \\ \text{Net annual savings } &= \$32,143.39 - \$12,524 \\ &= \$19,619.39 \end{aligned}$$

-

$$\begin{aligned} \text{AE}_{\text{hours}}(10\%) &= [\frac{C(5,000)}{1.1} + \frac{C(8,000)}{1.1^2}](A/P,10\%,2) \\ &= 6,428.68C \\ \$19,619.39 &= 6,428.68C \\ C &= \$3.05 \text{ per hour} \end{aligned}$$

6.28)

- Option 1: Pay employee $\$0.40$ per mile:
- Option 2: Provide a car to employee:

$$\begin{aligned} \text{AE}(10\%)_{\text{capital cost}} &= (\$22,000 - \$5,000)(A/P,10\%,3) \\ &\quad +(0.10)(\$5,000) \\ &= \$7,336 \\ \text{AE}(10\%)_{\text{operating cost}} &= \$1,000 + (\$0.22)(30,000) \\ &= \$7,600 \\ \text{AE}(10\%)_{\text{total cost}} &= \$7,336 + \$7,600 \\ &= \$14,936 \end{aligned}$$

Operating cost per mile $= \$14,936 / 30,000 = \$0.498$
Option 1 is a better choice.

6.29)

- Option 1: Purchase units from Tompkins

  Unit cost $= \$25 + (\$70,000 - \$35,000) / 20,000 - \$3.50 = \$23.25$

- Option 2: Make units in house

$$\begin{aligned}\text{PW}(15\%)_{dm} &= \$63,000(P/A_1,5\%,15\%,5)\\ &= \$230,241\\ \text{PW}(15\%)_{dl} &= \$190,800(P/A_1,6\%,15\%,5)\\ &= \$709,491\\ \text{PW}(15\%)_{vo} &= \$139,050(P/A_1,3\%,15\%,5)\\ &= \$490,888\\ \text{AEC}(15\%) &= (\$230,241+\$709,491\\ &\quad +\$490,888)(A/P,15\%,5)+\$70,000\\ &= \$496,776\end{aligned}$$

$$\begin{aligned}\text{Unit cost} &= \$496,776/20,000\\ &= \$24.84\end{aligned}$$

Option 1 is a better choice.

6.30)

- Capital costs:

$$\begin{aligned}\text{CR}(7\%)_1 &= (\$25,000-\$2,000)(A/P,7\%,12)\\ &\quad +(0.07)(\$2,000)\\ &= \$3,036\end{aligned}$$

- Annual battery replacement cost:

$$\begin{aligned}\text{AEC}(7\%)_2 &= \$3,000[(P/F,7\%,3)+(P/F,7\%,6)\\ &\quad +(P/F,7\%,9)](A/P,7\%,12)\\ &= \$763.14\end{aligned}$$

- Annual recharging cost:

$$\text{AEC}(7\%)_3 = (\$0.015)(20,000) = \$300$$

- Total annual equivalent costs:

$$\begin{aligned}\text{AEC}(7\%) &= \$3,036+\$763.14+\$300+\$700\\ &= \$4,798.84\end{aligned}$$

- Cost per mile:

$$\text{cost/mile} = \$4,798.84/20,000 = \$0.2399$$

6.31)

- Annual total operating hours:

$$(0.70)(8,760) = 6,132 \text{ hours per year}$$

- Annual electricity generated:

$$50,000 \times 6,132 = 306,600,000 \text{ kilowatt-hours}$$

- Equivalent annual cost:

$$\begin{aligned}\text{AEC}(14\%) &= \$85,000,000(A/P, 14\%, 25) + \$6,000,000 \\ &= \$18,367,364\end{aligned}$$

- Cost per kilowatt-hour:

$$\$18,367,364 / 306,600,000 = \$0.06 \text{ per kilowatt-hour}$$

6.32)

- Annual equivalent revenue:

$$\text{AE}_{\text{Revenue}} = \$32,000 + 40,000X$$

- Annual equivalent cost:

$$\begin{aligned}\text{AEC}(8\%)_{\text{Cost}} &= \$800,000(A/P, 8\%, \infty) + \$133,000 + \$50,000(A/F, 8\%, 5) \\ &= \$64,000 + \$133,000 + \$8,525 \\ &= \$205,525\end{aligned}$$

$$\begin{aligned}AE_{\text{Revenue}} &= AEC_{\text{Cost}} \\ \$32,000 + 40,000X &= \$205,525\end{aligned}$$

$$X = \$4.34$$

6.33)

$$\text{Salvage Value: } \$1,200,000(F/P, 5\%, 25) = \$4,063,680$$

$$\begin{aligned}\text{CR}(12\%) &= (\$6,000,000 - \$4,063,680)(A/P, 12\%, 25) + (0.12)\$4,063,680 \\ &= \$734,522.4 \\ \text{AEC}_{\text{O\&M}} &= \$100 \times 12 \times 40 + \$400,000 = \$448,000 \\ \text{AEC}(12\%) &= \text{CR}(12\%) + AE_{\text{ma}} = \$1,182,522.4 \text{ per year} \\ \text{AEC}(0.9489\%)_{\text{Monthly}} &= \$1,182,522.4(A/F, 0.9489\%, 12) \\ &= \$93,506 \text{ per month}\end{aligned}$$

6.34)

Discounted payback period at full load operation:

n	Investment	Revenue	Maintenance cost	Net Cash flow
0	-$30,000			-$30,000
1		$8,000	-$500	7,500
⋮	⋮	⋮	⋮	⋮
15	+$2,000	8,000	-500	9,500

$$\$30,000 = \$7,500(P/A, 9\%, N)$$

Solving for n yields

$$N = 5.179 \text{ years}$$

6.35)

- Capital cost:

$$\begin{aligned} \text{CR}(6\%) &= (\$150,000 - \$3,000)(A/P, 6\%, 12) \\ &\quad +(0.06)(\$3,000) \\ &= \$17,714 \end{aligned}$$

- Annual operating costs:

$$\begin{aligned} \text{O\&M}(6\%) &= \$40,000 + \$7,000 + \$2,000 \\ &= \$49,000 \end{aligned}$$

- Total annual system costs:

$$\text{AEC}(6\%) = \$17,714 + \$49,000 = \$66,714$$

- Number of rides required per year:

$$\text{Number of rides} = \$66,714/(\$0.10) = 667,140 \text{ rides}$$

6.36)

Given: Investment cost $=$ \$7 million, plant capacity $= 200,000$ 1bs/hour, plant operating hours $= 3,600$ hours per year, O&M cost $=$ \$4 million per year, useful life $= 15$ years, salvage value $=$ \$700,000, and MARR = 15%.

(a)

$$\text{PW}(15\%) = -\$7,000,000 + (R - \$4,000,000)(P/A,15\%,6)$$
$$= 3.7845R - \$22,137,900$$
$$= 0$$

Solving for R yields

$$R = \$5,849,700 \text{ per year}$$

(b) Minimum processing fee per 1b (after-tax):

$$\frac{\$5,849,700}{(200,000)(3,600)} = \$0.0081 \text{ per 1b}$$

Comments: The minimum processing fee per 1b should be higher on a before-tax basis.

6.37) Let C denote the green fee per round during the first year.

- Capital cost:

$$\text{CR}(15\%) = (\$20,000,000 - \$25,000,000(A/P,15\%,10)$$
$$+(0.15)(\$25,000,000)$$
$$= \$2,753,740$$

- Operating and maintenance cost:

$$\text{O\&M}(15\%) = \$650,000 + \$50,000(A/G,15\%,10)$$
$$= \$819,160$$

- Equivalent annual revenue:

$$\text{AE}(15\%)_{\text{Revenue}} = \$15 \times 40,000$$
$$+40,000(1.15)C(P/A_1,5\%,15\%,10)(A/P,15\%,10)$$
$$= \$600,000$$
$$+\$46,000C\left[\frac{1-(1+0.05)^{10}(1+0.15)^{-10}}{0.15-0.05}\right](A/P,15\%,10)$$
$$= \$600,000 + 54,752C$$

- Breakeven green fee:

$$\$600,000 + 54,752C = \$2,753,740 + \$819,160$$
$$54,752C = \$2,972,900$$
$$C = \$54.30$$

6.38)

Let X denote the average number of round-trip passengers per year.

- Capital costs:

$$\begin{aligned}\text{CR}(15\%) &= (\$12,000,000 - \$2,000,000)(A/P, 15\%, 15) \\ &\quad + (0.15)(\$2,000,000) \\ &= \$2,010,171\end{aligned}$$

- Annual crew costs: $225,000
- Annual fuel costs for round trips:

$$(\$1.10)(3,280)(2)(3)(52) = \$1,125,696$$

- Annual landing fees:

$$(\$250)(3)(52)(2) = \$78,000$$

- Annual maintenance, insurance, and catering costs:

$$\$237,500 + \$166,000 + \$75X = \$403,500 + \$75X$$

- Total equivalent annual costs:

$$\begin{aligned}\text{AEC}(15\%) &= \$2,010,171 + \$225,000 + \$1,125,696 \\ &\quad + \$78,000 + \$403,500 + \$75X \\ &= \$3,400X\end{aligned}$$

Solving for X yields

$$X = 1,156 \text{ passenger round-trips per year}$$

or

$$1,156/(52)(3) = 7.41 \approx 8 \text{ passengers per round trip}$$

6.39)

- Model A:

$$\begin{aligned}\text{AEC}(10\%) &= (\$95,000 - \$12,000)(A/P, 10\%, 3) + (0.1)(\$12,000) \\ &\quad + \$3,000 \\ &= \$37,574.3 \text{ per year}\end{aligned}$$

- Model B:

$$\begin{aligned}\text{AEC}(10\%) &= (\$120,000 - \$25,000)(A/P, 10\%, 6) + (0.1)(\$25,000) \\ &\quad + \$9,000 \\ &= \$33,312 \text{ per year}\end{aligned}$$

Therefore, select Model B (The ROT 8).

6.40)

$$\text{AEC}(12\%)_X = (\$4,500 - \$250)(A/P,12\%,10) + (0.12)(\$250)$$
$$+\$300 + [\frac{150(0.746)}{0.83}](2,000)(\$0.05)$$
$$= \$14,564$$
$$\text{unit cost} = \frac{\$14,564}{2,000}$$
$$= \$7.28 \text{ per hour}$$

$$\text{AEC}(12\%)_Y = (\$3,600 - \$100)(A/P,12\%,10) + (0.12)(\$100) + \$500$$
$$+[\frac{150(0.746)}{0.80}](2,000)(\$0.05)$$
$$= \$15,119$$
$$\text{unit cost} = \frac{\$15,119}{2,000}$$
$$= \$7.56 \text{ per hour}$$

- The difference is \$ 0.28 / hour. Therefore, select Brand X.

6.41)

(a)

$$\text{AE}(15\%)_A = -\$22,000(A/P,15\%,4)$$
$$+[\$9,120 - \$1,280(A/G,15\%,4)] - 2000(A/F,15\%,4)$$
$$= -\$684.86$$
$$\text{AE}(15\%)_B = -\$22,000(A/P,15\%,4) + \$7,350$$
$$= -\$356.6$$

(b) Process A: $-\$684.86 / 2,000 = -\$0.3424 / \text{hour}$
Process B: $-\$356.6 / 2,000 = -\$0.1783 / \text{hour}$

(c) Since neither option provides enough savings to recover the required investment, the do-nothing alternative (status quo) is a better choice.

6.42)

- Equivalent annual cost:

$$\begin{aligned}\text{AEC}(13\%)_A &= (\$1,200,000 - \$60,000)(A/P, 13\%, 20) \\ &\quad + (0.13)(\$60,000) + \$50,000 + \$40,000 \\ &= \$260,083 \\ \text{AEC}(13\%)_B &= (\$750,000 - \$30,000)(A/P, 13\%, 10) \\ &\quad + (0.13)(\$30,000) + \$80,000 + \$30,000 \\ &= \$246,596\end{aligned}$$

- Processing cost per ton:

$$\begin{aligned}C_A &= \$260,083/(20)(365) = \$35.63 \text{ per ton} \\ C_B &= \$246,596/(20)(365) = \$33.78 \text{ per ton}\end{aligned}$$

Incinerator B is a better choice.

6.43) Assumption: jet fuel cost $= \$1.80$ /gallon

- System A : Equivalent annual fuel cost: A_1 = (\$1.80/gal)(40,000gals/1,000 hours)(2,000 hours) $= \$144,000$ (assuming an end of-year convention)

$$\begin{aligned}\text{AEC}(10\%)_{fuel} &= [\$144,000(P/A_1, 6\%, 10\%, 3)](A/P, 10\%, 3) \\ &= \$152,248 \\ \text{AEC}(10\%)_{sys.A} &= (\$100,000 - \$10,000)(A/P, 10\%, 3) \\ &\quad + (0.10)(\$10,000) + \$152,248 \\ &= \$189,438\end{aligned}$$

- System B : Equivalent annual fuel cost: A_1 = (\$1.80/gal)(32,000gals/1,000 hours)(2,000 hours) $= \$115,200$

$$\begin{aligned}\text{AEC}(10\%)_{fuel} &= [\$115,200(P/A_1, 6\%, 10\%, 3)](A/P, 10\%, 3) \\ &= \$121,798 \\ \text{AEC}(10\%)_{sys.B} &= (\$200,000 - \$20,000)(A/P, 10\%, 3) \\ &\quad + (0.10)(\$20,000) + \$121,798 \\ &= \$196,179\end{aligned}$$

- Equivalent operating cost (including capital cost) per hour:

$$\text{System } A = \$189,438/2,000 = \$94.72 \text{ per hour}$$

$$\text{System } B = \$196{,}179/2{,}000 = \$98.09 \text{ per hour}$$

System A is a better choice.

6.44) Since the required service period is 12 years and the future replacement cost for each truck remains unchanged, we can easily find the equivalent annual cost over a 12-year period by simply finding the annual equivalent cost of the first replacement cycle for each truck.

- Truck A: Four replacement cycles are required

$$\begin{aligned}\text{AEC}(12\%)_A &= (\$15{,}000 - \$5{,}000)(A/P, 12\%, 3) \\ &\quad + (0.12)(\$5{,}000) + \$3{,}000 \\ &= \$7{,}763.50\end{aligned}$$

- Truck B: Three replacement cycles are required

$$\begin{aligned}\text{AEC}(12\%)_B &= (\$20{,}000 - \$8{,}000)(A/P, 12\%, 4) \\ &\quad + (0.12)(\$8{,}000) + \$2{,}000 \\ &= \$6{,}910.80\end{aligned}$$

Truck B is a more economical choice.

6.45)

(a) Number of decision alternatives (required service period = 5 years):

Alternative	Description
A1	Buy Machine A and use it for 4 years. Then lease a machine for one year.
A2	Buy Machine B and use it for 5 years.
A3	Lease a machine for 5 years.
A4	Buy Machine A and use it for 4 years. Then buy another Machine A and use it for one year.
A5	Buy Machine A and use it for 4 years. Then buy Machine B and use it for one year.

Both A4 and A5 are feasible but may be not practical alternatives. To consider these alternatives, we need to know the salvage values of the machines after one-year use.

(b) With lease, the O&M costs will be paid by the leasing company:

- For A1:

$$\begin{aligned}\text{PW}(10\%)_1 &= -\$6,500 + (\$600 - \$100)(P/F, 10\%, 4) \\ &\quad -\$800(P/A, 10\%, 4) - \$200(P/F, 10\%, 3) \\ &\quad -\$100(P/F, 10\%, 2) - \$3,000(P/F, 10\%, 4) \\ &= -\$10,976 \\ \text{AEC}(10\%)_1 &= \$10,976(A/P, 10\%, 5) \\ &= \$2,896\end{aligned}$$

Note: Why would one change the oil filter at the end of service life? In this example, we assume that the salvage value of the asset ($600) is only feasible when the asset is maintained properly.

- For A2:

$$\begin{aligned}\text{PW}(10\%)_2 &= -\$8,500 + \$1,000(P/F, 10\%, 5) \\ &\quad -\$520(P/A, 10\%, 5) - \$280(P/F, 10\%, 4) \\ &= -\$10,042 \\ \text{AEC}(10\%)_2 &= \$10,042(A/P, 10\%, 5) \\ &= \$2,649\end{aligned}$$

- For A3:

$$\begin{aligned}\text{AEC}(10\%)_3 &= [\$3,000 + \$3,000(P/A, 10\%, 4)](A/P, 10\%, 5) \\ &= \$3,300\end{aligned}$$

A2 is the best choice.

6.46)

- Option 1:

$$\begin{aligned}\text{AEC}(18\%)_1 &= \$200,000(180)(A/P, 18\%, 20) \\ &\quad -(0.08)(\$200,000)(180)(A/F, 18\%, 20) \\ &\quad +(\$0.005 + 0.215)(180,000,000) \\ &= \$46,305,878 \\ \text{cost/lb} &= \$46,305,878/180,000,000 \\ &= \$0.2573 \text{ per 1b}\end{aligned}$$

- Option 2:

$$\begin{aligned}\text{AEC}(18\%)_2 &= (\$0.05 + \$0.215)(180,000,000) \\ &= \$47,700,000 \\ \text{cost/lb} &= \$47,700,000/180,000,000 \\ &= \$0.2650 \text{ per 1b}\end{aligned}$$

Option 1 is a better choice.

6.47) Given: Required service period = indefinite, analysis period = indefinite

Plan A: Incremental investment strategy:

- Capital investment :

$$\begin{aligned}\text{CR}(10\%)_1 &= [\$1,500,000 \\ &\quad +\$1,500,000(P/F,10\%,15)](A/P,10\%,\infty) \\ &= \$185,910\end{aligned}$$

- Supporting equipment:

$$\begin{aligned}\text{CR}(10\%)_2 &= [(\$200,000 + \$200,000/3.1772)(P/F,10\%,30)] \\ &\quad \times(A/P,10\%,\infty) \\ &= \$1,507\end{aligned}$$

Note that the effective interest rate for 15-year period is

$$(1+0.1)^{15} - 1 = 3.1772$$

- Operating cost:

$$\begin{aligned}\text{OC}(10\%)_3 &= \begin{pmatrix}[\$91,000(P/A,10\%,15) \\ +\$182,000(P/A,10\%,5)(P/F,10\%,15)] \\ +[\dfrac{\$185,000}{0.10} + \$3,000(P/G,10\%,\infty)] \\ \times(P/F,10\%,20)]\end{pmatrix}(A/P,10\%,\infty) \\ &= \$117,681.33\end{aligned}$$

Note that $(P/G,i,\infty) = 1/i^2$ or $(P/G,10\%,\infty) = 100$

- Total equivalent annual worth:

$$\begin{aligned}\text{AEC}(10\%)_A &= \$185,910 + \$1,507 + \$117,681 \\ &= \$305,098\end{aligned}$$

Plan B: One time investment strategy:

- Capital investment:

$$\begin{aligned}\text{CR}(10\%)_1 &= \$1,950,000(A/P,10\%,\infty) \\ &= \$195,000\end{aligned}$$

- Supporting equipment:

$$\begin{aligned}\text{CR}(10\%)_2 &= \frac{\$350,000}{16.4494}(A/P,10\%,\infty) \\ &= \$2,128\end{aligned}$$

Note that the effective interest rate for 30-year period is

$$(1+0.1)^{30}-1=16.4494$$

- Operating cost:

$$\begin{aligned} OC(10\%) &= [\$105,000(P/A,10\%,15) \\ &\quad +\$155,000(P/A,10\%,\infty)(P/F,10\%,15)] \\ &\quad \times(A/P,10\%,\infty) \\ &= \$80,235 \end{aligned}$$

- Total equivalent annual worth:

$$\begin{aligned} AEC(10\%) &= \$195,000+\$2,128+\$80,235 \\ &= \$277,363 \end{aligned}$$

Plan B is a better choice.

6.48)

- Installed cost per kilowatt $=\dfrac{\$84,000}{60}=\$1,400$ per kW. But if you consider the time value of money, say 10% annual interest, the capital cost per kW without considering any salvage value at the end of its service life is as follows:

$$\frac{\$84,000(A/P,10\%,10)}{60}=\frac{\$13,671}{60}=\$227.84 \text{ per kW}$$

or

$$\frac{\$13,671}{60\times 24\times 365}=\$0.026 \text{ per kWh}$$

- Operating cost per kilowatt-hour:

$$\frac{\$19,000}{(60)(24)(365)}=\$0.036$$

6.49)

- Make option:

$$\text{AEC}(14\%)_{\text{Make}} = \$4,582,254$$
$$\text{or}$$
$$\$4,582,254/(48\times 79,815)$$
$$= \$1.196/\text{unit}$$

- Buy option:

$$\begin{aligned}
\text{AEC}(14\%)_{\text{Buy}} &= CR(14\%) + \$4,331,127 \\
&= (\$405,000 - \$45,000)(A/P, 14\%, 7) + (0.14)(\$45,000) + \$4,331,127 \\
&= \$90,249 + \$4,331,127 \\
&= \$4,421,376 \\
&\text{or} \\
&\$4,421,376/(48\times 79,815) \\
&= \$1.154/\text{unit}
\end{aligned}$$

6.50) Given: annual energy requirement $= 145,000,000,000$ BTUs, 1-metric ton $= 2,204.6$ lbs (an approximation figure of 2,000 lbs was mentioned in the case problem), net proceeds from demolishing the old boiler unit $= \$1,000$

(a) Annual fuel costs for each alternative:

- Alternative 1:

$$\begin{aligned}
\text{Weight of dry coal} &= \frac{145,000,000,000 \text{ BTUs}}{(0.75)(14,300)} \\
&= 13,519,814 \text{ lbs} \\
&= \frac{13,519,814}{2,204.6} \\
&= 6,132.45 \text{ tons}
\end{aligned}$$

$$\begin{aligned}
\text{Annual fuel cost} &= 6,132.45 \times \$55.5 \\
&= \$340,350.98
\end{aligned}$$

- Alternative 2:

$$\begin{aligned}
\text{Gas cost} &= \$9.5\frac{145,000,000,000(0.94)}{(0.78)(1,000,000)} \\
&= \$1,660,064.10
\end{aligned}$$

$$\begin{aligned}
\text{Oil cost} &= \$1.45\frac{145,000,000,000(0.06)}{(0.81)(139,400)} \\
&= \$111,722.20
\end{aligned}$$

$$\begin{aligned}
\text{Annual fuel cost } &= \$1,660,064.1 + \$111,722.2 \\
&= \$1,771,786.3
\end{aligned}$$

(b) Unit cost per steam pound:

- Alternative 1: Assuming a zero salvage value of the investment

$$\begin{aligned}\text{AEC}(10\%) &= (\$2,570,300 + \$145,000 - \$1,000)(A/P, 10\%, 20)\\ &\quad + \$340,350.98\\ &= \$659,281.25\end{aligned}$$

$$\begin{aligned}\text{Unit cost} &= \$659,281.25 / 145,000,000\\ &= \$0.004547 \text{ per steam lb}\end{aligned}$$

- Alternative 2:

$$\begin{aligned}\text{AEC}(10\%) &= (\$1,289,340 - \$1,000)(A/P, 10\%, 20)\\ &\quad + \$1,771,786.3\\ &= \$1,923,166.25\end{aligned}$$

$$\begin{aligned}\text{unit cost} &= \$1,923,166.25 / 145,000,000\\ &= \$0.01326 \text{ per steam lb}\end{aligned}$$

(c) Select alternative 1.