ECE 333 Green Electric Energy

Homework 5 - Solution

P497-7.12

Option a:

$$\mathbf{20,000\,\$\,/\,(year \cdot turbine) \cdot 30\,turbines\ =\ 600,000\,\$}$$

Option b:

The estimated power factor

$$\mathbf{CF = 0.087\bar{V} - \frac{P_R}{D^2} = 0.087 \cdot 7 - \frac{1.6 \cdot 1000}{80^2} = 0.359}$$

Including the 15% loss, those thirty 1.6-MW turbines will generate:

$$\mathbf{30 \cdot 1.6 \cdot 8760 \cdot 0.359 \cdot (1 - 0.15) = 128,309\ MWh}$$

And the cost is

$$\mathbf{128,309\ MWh \cdot 1000\ kWh\,/\,MWh \cdot 0.005\,\$\,/\,kWh = 641,547\,\$}$$

Option c:

The array area

$$\mathbf{(5 \cdot 10D) \cdot (4 \cdot 3D) = 600D^2 = 3,840,000\ m^2 \approx 948\ arces}$$

The buffer area

$$\mathbf{5D \cdot (10D + 5 \cdot 10D) \cdot 2 + 5D \cdot (4 \cdot 3D) \cdot 2 = 720D^2 = 4,608,000\ m^2 = 1138\ arces}$$

Thus the total cost is

$$\mathbf{948\ arces \cdot 500\$\,/\,(year \cdot arces) + 1138\ arces \cdot 100\$\,/\,(year \cdot arces) = 582,800\,\$}$$

Problem 1

a. the present value of this 30-year savings:

$$\mathbf{P_{saving}\ =\ \sum_{t=1}^{n} A_t\,\beta^t\ =\ 0.55\sum_{t=1}^{30}(\frac{1}{1+0.12})^t\ =\ A\beta\left[1 + \beta + \beta^2 + \ldots + \beta^{n-1}\right] = 4.43\$\,/\ ft^2}$$

thus the NPV is **4.43-3=1.43 $\$/ft^2$**

b. when NPV is zero, the present value of saving is equal to the additional cost of the windows

$$P_{saving} = \sum_{t=1}^{n} A_t \beta^t = 0.55\sum_{t=1}^{30}(\frac{1}{1+d})^t = A\beta\left[1+\beta+\beta^2+...+\beta^{n-1}\right] = 3\$/ft^2$$

Then we can solve the above equation and have ***IRR*=0.1821**

c. if the savings escalate at 7% per year due to fueling savings

$$d' = \frac{d-e}{1+e} = \frac{.12-.07}{1+.07} = \frac{.05}{1.07} = 0.046729$$

$$P_{saving} = \sum_{t=1}^{n} W_t \beta'^t = 0.55\sum_{t=1}^{30}(\frac{1}{1+0.046729})^t = 8.78\$/ft^2$$

thus the NPV is **8.78-3=5.78** $\$/ft^2$

d. we have the IRR'**=0.1821 ,** because

$$P_{saving} = 0.55\sum_{t=1}^{30}(\frac{1}{1+IRR'})^t = 3\$/ft^2$$

thus the actual ***IRR*** is $IRR'(1+e)+e$=0.2649**,** because

$$IRR' = \frac{IRR-e}{1+e}$$

Problem 2.

a. the annual saving is:

$$0.07\cdot 60{,}000+9\cdot 25\cdot 12 = 6900\ \$$$

b.

$$P_{saving} = \sum_{t=1}^{n} A_t \beta^t = 6900\sum_{t=1}^{30}(\frac{1}{1+IRR})^t = 135{,}000\ \$$$

$$IRR = 0.02993$$

c.

$$P_{saving} = \sum_{t=1}^{n} A_t \beta^t = 6900\sum_{t=1}^{30}(1+0.06)^t(\frac{1}{1+IRR})^t = 135{,}000\ \$$$

$$IRR = 0.0917$$

Problem 3.

Annual cost is

$$A \;=\; P\frac{1-\beta}{\beta(1-\beta^n)} = 15{,}000\frac{1-\dfrac{1}{1+0.06}}{\dfrac{1}{1+0.06}[1-(\dfrac{1}{1+0.06})^{20}]} = 1307.77\$/\,year$$

Annual energy production is:

$$10\cdot 8760\cdot 0.25 = 21900\;kWh$$

The electricity price is

$$\frac{1307.77}{21900} = 5.97 cents/kWh$$

Problem 4. **(skip this problem since we are not covering this problem yet)**

Problem 5. A *PV* systems that generates 8,000 *kWh/yr* cost *$*15,000. It is paid for with a 6*%*, 20-*year* loan. Ignoring any tax implications, what is the electricity cost from the *PV* systems

Annual cost is

$$A \;=\; P\frac{1-\beta}{\beta(1-\beta^n)} = 15{,}000\frac{1-\dfrac{1}{1+0.06}}{\dfrac{1}{1+0.06}[1-(\dfrac{1}{1+0.06})^{20}]} = 1307.77\$/\,year$$

The electricity price is

$$\frac{1307.77}{8000} = 16.33 cents/kWh$$