Problem 6.3 (p. 401)

(a)

\[ p_{DC,sc} = \frac{\text{annual energy}}{\chi' \times \left(\frac{\text{daily insolation}}{1 \text{ kW/m}^2}\right) \times 365} = \frac{4,000}{0.72 \times \left(\frac{5.5}{1}\right) \times 365} = 2.76kW_p \]

(b)

\[ \text{area} = \frac{p_{DC,sc}}{1 - \text{sun} \times \eta} = \frac{2.76}{1 \times 0.18} = 15.4m^2 \]

(c)

\[ \text{total installation costs} = 4 \times p_{DC,sc} = 4(\$ / W_{DC,STC}) \times 2760(W_{DC,STC}) = 11,040 \]

\[ \text{c.r.f. (5\%, 30 years)} = \frac{0.05 \times (1 + 0.05)^{30}}{(1 + 0.05)^{30} - 1} = 0.065 \text{ year}^{-1} \]

\[ \text{annual payment} = 0.065 \times 11040 = 718 \] $

\[ \text{first-year tax} = 0.05 \times 11040 \$ = 552 \] $

\[ \text{first-year tax saving} = 0.29 \times 552 \$ = 160 \] $

\[ \text{first-year electricity costs} = \frac{718 - 160}{4,000} = 0.14 \] \$/kWh
Problem 6.4 (p. 401)

From the given data in the spreadsheet we can evaluate:

\[ P = 8,000 \, \text{\$} \]

\[ \text{annual energy} = \frac{380}{0.19} = 2,000 \, \text{kWh} \]

\[ \text{Marginal Tax Bracket (MTB)} = \frac{120}{400} = 0.3 \]

\[ i = \frac{400}{8,000} = 0.05 \]

\[ \text{c.r.f.} = \frac{500}{8,000} = 0.0625 \]

For the second year:

Payment: \( 500 \, \text{\$} \)

Interest: \( 7,900 \times 0.05 = 395 \, \text{\$} \)

Delta balance: \( 105 \, \text{\$} \)

Loan balance: \( 7,900 - 105 = 7,795 \, \text{\$} \)

Tax saving: \( 0.3 \times 395 = 118.5 \, \text{\$} \)

Net cost: \( 500 - 118.5 = 381.5 \, \text{\$} \)

Electricity cost: \( \frac{381.5}{2,000} = 0.19075 \, \text{\$/kWh} \)

Problem a.

Solution:

Since the storage capability is defined by the ratio of physical capability and the maximum power block input; we can determine that the physical capability is:

\[ \text{storage capability} = \frac{\text{physical capability}}{\text{max power block input}} \Rightarrow 6h = \frac{\text{physical capability}}{280 \, \text{MW}} \]
physical capability = 6h * 280 MW = 1680 MWh

A 6-h TES for the 100-MW CSP implies: without the absorption of solar energy, the plant can generate electricity at the capacity of 100 MW for 6 hours if the storage is fully charged at the beginning.