27. Solar Panels

Finding total Area

$$5\,acres \times \frac{43560\,ft^2}{1\,acre} \times \frac{1\,m^2}{10.8\,ft^2} = 20166.667\,m^2$$

Calculating Energy Generated

$$20166.666\,m^2 \cdot \frac{1000\,W}{m^2} \cdot \frac{0.8\text{ usable land}}{1\text{ total land}} \cdot \frac{0.18\,W_{actual}}{1\,W_{theoretical}} \cdot 0.25 \cdot 1\,year \cdot \frac{8760}{year}$$

$$= 6359760000\,Wh \cdot \frac{1\,MW}{10^6\,W} = 6359.76\,MWh \approx \underline{6000\,MWh}$$

Wind Scenario

Calculating Energy for 1 Turbine

$$1\text{ Turbine} \rightarrow P = \frac{1}{2}\rho A v^3 = \frac{1}{2}(1.225\,\frac{kg}{m^3}) \cdot (\pi(3600\,m^2)) \cdot (7\,m/s)^3$$

$$= 2376033.648\,W \cdot \frac{10^6\,MW}{1\,W} = 2.376\,MW$$

Energy Generated

efficiency, capacity factor

$$\frac{2.376\,MW}{turbine} \cdot 5\,turbines \cdot \frac{8766\,hr}{year} \cdot 0.27 \cdot 0.3 = 8429.692176\,MWh$$

$$= \underline{8000\,MWh}$$

28. Delivered Power = 100 MW $P = I \cdot V$ $P_{loss} = I^2 R$

Voltage = 110 kV

There is a voltage drop & power dissipated over the line.

Voltage Drop = $I \cdot R = 20\Omega I$ Current through line → $I = P/V = \frac{100 \text{ MW}}{110 \text{ kV}}$

$= 909.\overline{09}$ A

$V_{original} - V_{delivered} = 20\Omega \cdot I$

$V_{original} = 20\Omega \cdot I + 110{,}000V$

$= 128181.\overline{81}$ V

$P_{loss} = I^2 \cdot R = 16528925.6198$ W

Power Output = $P_{delivered} + P_{loss} = 100 \times 10^6 \text{ W} + 16.528925 \times 10^6 \text{ W} \approx 20$ MW

Voltage Output = 130 kV

As a percent: $\frac{P_{loss}}{P_{delivered}} = \frac{16{,}528925.6198 \text{ W}}{100{,}000{,}000 \text{ W}} = 0.1652 \approx 0.2$

29. Capital Cost ~~$18~~ $18/bulb Assuming 1kwh = 30¢

$$CRF = \frac{0.04}{1-(1.04)^{-10}} = 0.1232909443$$

Capital Cost × CRF = \$2.21923/year

Fuel Costs (LED)

$$15W \times 1 year \cdot \frac{8760h}{year} \cdot 0.3 = 39420 kWh \cdot \frac{\$0.3}{kwh} = \$11826 \text{ annually}$$

Fuel Costs (Incandescent)

(From problem)

\$11826 × 4 = \$47304

$$CCE = \frac{\text{Annualized capital cost}}{\text{Annual energy savings}} = \frac{\$2.21923}{\$35471} = 6.255 \times 10^{-5}$$