

Homework 6 Solutions

6.50

Shunt Capacitor State	Shunt Capacitor Rating (Mvar)	Shunt Capacitor Output (Mvar)	V_2 (p.u.)	Line 2-4	Line 2-5	Line 4-5	Total Power Losses (MW)
Disconnected	0	0	0.834	27%	49%	19%	34.37
Connected	200	184.0	0.959	25%	44%	16%	25.37
Connected	261	261.0	1.000	25%	43%	15%	23.95

When the capacitor rating is set at 261 Mvar, the voltage at bus 2 becomes 1.0 per unit. As a result of this, the line loadings decrease on all lines, and thus the power loss decrease as well.

- 6.52** With the line connecting HOMER 69 and LAUF 69 removed, the voltage at HANNAH 69 drops to 0.966 p.u. To raise that voltage to 1.0 p.u., we require 32.0 Mvar from the capacitor bank of HANNAH 69.

- 6.59 (a) Since bus 7 is the slack bus, we neglect row 7 and column 7 in our B matrix and P vector.

$$B = \begin{bmatrix} -20.833 & 16.667 & 4.167 & 0 & 0 & 0 \\ 16.667 & -52.778 & 5.556 & 5.556 & 8.333 & 16.667 \\ 4.167 & 5.556 & -43.056 & 33.333 & 0 & 0 \\ 0 & 5.556 & 33.333 & -43.056 & 4.167 & 0 \\ 0 & 8.333 & 0 & 4.167 & -29.167 & 0 \\ 0 & 16.667 & 0 & 0 & 0 & -25 \end{bmatrix}$$

$$P = \begin{bmatrix} 160 \\ 110 \\ -110 \\ -30 \\ -130 \\ 0 \end{bmatrix} \quad MW = \begin{bmatrix} 1.6 \\ 1.1 \\ -1.1 \\ -0.3 \\ -1.3 \\ 0 \end{bmatrix} \text{ p.u.}$$

(b) $\delta = -B^{-1}P$

$$= \begin{bmatrix} 7.6758^\circ \\ 4.2020^\circ \\ -0.4315^\circ \\ -0.3265^\circ \\ -1.3999^\circ \\ 2.8014^\circ \end{bmatrix}$$

This agrees with the angles shown in PowerWorld.

12.19 $\frac{dC_1}{dP_1} = 15 + 0.1P_1 = \lambda$

$$\frac{dC_2}{dP_2} = 20 + 0.08P_2 = \lambda$$

$$P_1 + P_2 = 1000$$

$$\begin{bmatrix} 0.1 & 0 & -1 \\ 0 & 0.08 & -1 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ \lambda \end{bmatrix} = \begin{bmatrix} -15 \\ -20 \\ 1000 \end{bmatrix}$$

$$P_1 = 472.2 \text{ MW}, P_2 = 527.8 \text{ MW}, \lambda = 62.2 \text{ \$/MWh}$$

$$\text{Total cost} = \$41,230/\text{hr}$$

- 12.20 Since the unlimited solution violates the P_2 limit constraint, $P_2 = 500 \text{ MW}$, which means $P_1 = 500 \text{ MW}$. The system lambda is determined by the unlimited unit $= 15 + 0.1 * 500 = \$65/\text{MWh}$. Total cost is $\$41,300/\text{hr}$.