4.6

At minimum costs marginal costs of all units must be the same λ

$$Marginal\ Cost\ A = \frac{dCA}{dPA} = 1.4 + 0.08 * Pa$$

$$Marginal\ Cost\ B = \frac{dCB}{dPB} = 1.6 + 0.010 * Pb$$

$$Marginal\ Cost\ C = \frac{dCC}{dPC} = 1.8 + 0.04 * Pc$$

Find the simple marginal cost λ

$$Pa + Pb + Pc = 350$$

$$PA = \frac{\lambda - 1.4}{0.08}$$

$$PB = \frac{\lambda - 1.6}{0.10}$$

$$PC = \frac{\lambda - 1.8}{0.04}$$

Solving this

$$\lambda = 9.02$$

Plug λ to get each output for each unit

$$PA = 95.3 \quad MW$$
$$PB = 74.2 \quad MW$$
$$PC = 180.5\ MW$$

Add hourly total cost:

$$C(A) + C(B) + C(C) = \mathbf{1927.15}\ \$/\boldsymbol{hr}$$

4.7

Borduria can now buy from the spot market at 8.20 $/MWh

This price is less than the system's marginal cost calculated in 4.6. This means that it's cheaper to buy power rather that generate it at the margin price. New marginal price

$$\lambda = 8.20\ \$/MWh$$

$Plug\ in\ new\ \lambda$:

$$PA = 85\ MW$$
$$PB = 66\ MW$$
$$PC = 160\ MW$$

New total 311 MW.

$$350 - 311 = 39\ MW$$

39 MW bought from the market.

$$\boldsymbol{Total\ Cost}: \mathbf{1911.21}\ \$/\boldsymbol{hr}$$

4.8

$$New\ \lambda = 10.20$$

$$PA = 110\ MW$$
$$PB = 86\ \ MW$$
$$PC = 210\ MW$$

$$Total\ generation = 406MW$$

$$56MW\ sold$$

$$Marginal\ cost\ rises\ from\ 9.02 \to 10.2$$
$$\frac{9.02 + 10.2}{2} = \frac{9.61\$}{MWh}$$

$$Profit\ per\ MWh = 10.2 - 9.61 = \frac{0.59\$}{MWh}$$

$$Profit\ from\ sale = 0.59x56 = \frac{\$33}{hr}$$

$$\boldsymbol{Profit} = \$\mathbf{33.03}$$

4.9

PA = 100 MW (limit)
PB = 80 MW (limit)
PC = 210 MW

$$Total\ generation = 390\ MW$$

$$390 - 350 = 40\ MW$$

$$\boldsymbol{Profit\ of}\ \$\mathbf{27.23}$$