10.10

10.10, 10.21, 10.22, 10.23

a) $\dot{Q}_{IN} = \frac{1\ GW}{\eta} = \frac{1\ GW}{0.35}$ $\eta = 1 - .65 = 0.35$

$\dot{Q}_{IN} = 2.86\ GW$

$\dot{Q}_{OUT} = 1.86\ GW = \dot{Q}_{STACK} + \dot{Q}_{H_2O}$

$= A(0.12 + 0.53) = 2.86(0.12 + 0.53)$

$A = \frac{1.86}{.65} = 2.86$ $1.86 = \boxed{0.34\ GW\ \text{STACK}} + \boxed{1.52\ GW\ H_2O}$

Hot water: $1.52\ GW_t = \frac{dm}{dt} C (\Delta T\ 10°C)$ $C = 4.2 \frac{kJ}{kg\ °C}$

$1.52 \times 10^9 \frac{J}{s} = \frac{dm}{dt} \frac{4200\ J}{kg\ °C}(10°C)$

$\frac{dm}{dt} = \frac{1.52 \times 10^9}{10 \quad 4.2 \times 10^3} = 0.36 \times 10^5 \frac{kg}{sec} = 36 \frac{tonne}{sec}$

b) $\dot{Q}_{IN}^{nuke} = \frac{1\ GW}{0.32} = 3.13\ GW = \dot{m}\, C\ 10°C$

$\dot{m} = \frac{3.13 \times 10^9}{10°C \times 4.2 \times 10^3} = 0.75 \times 10^5 \frac{kg}{s} = 75 \frac{tonne}{s}$

a) lower η b) no stack loss

10.21

$\eta_{Bray} = \frac{W_B}{Q_{in}}$ $\eta_R = \frac{W_R}{Q_{in}}$ $\eta_{CCGT} = \eta_B + \eta_R(1 - \eta_B)$

$W_R = \eta_R (1 - \eta_B) Q_{in}$

$= 0.38 + 0.32(1 - 0.38)$

$= 0.38 + (0.32)(0.62)$

$= 0.38 + 0.20$

$\boxed{\eta_{CCGT} = 0.58!}$

$\Delta Q/_{kwh} = \frac{3.6 \times 10^6\ J}{0.58} = 6.21 \times 10^6\ J/_{kwh}$

TOPS 35500

10.21

$$\dot{Q}_{heat} = \frac{500\ MW_e}{\eta\ (0.58)} = 862\ MW_t = \dot{m}\left(\frac{1.03M\ Btu}{1000\ cu\ ft}\right)\left(\frac{10.}{Bt}\right)$$

$$\underset{(1000\ cu\ ft/sec)}{\dot{m}} = \frac{862 \times 10^6\ W}{(1.03 \times 10^6\ Btu)} \frac{Btu}{(1055\ J)} = 0.80\ \frac{(1000\ cu\ ft)}{sec}$$

over a year $0.80 \times 3.15 \times 10^7 \frac{s}{y} = 2.5 \times 10^7\ \frac{1000}{ft^3}$

at $\frac{\$5?}{1000\ ft^3}$ $\frac{\$5}{1000\ ft^3} \times 2.5 \times 10^7 = \$1.3 \times 10^8$

at 5¢/kwh at bus $(\$0.05)(500{,}000\ kw)(8766\ \frac{h}{y})$

$= \$2.2 \times 10^8$

1000 ft³ is called 1 MCF where M is 1000, Roman!!!

10.22

$$\dot{Q}^{Coal}_{heat} = \frac{200\ GW_e}{0.4} = 500\ GW_t$$

$$\dot{Q}^{NG}_{heat} = \frac{200\ GW_e}{0.6} = 333\ GW_t$$

saves 167 GW$_t$ heat

Annual Saves Carbon $(0.26 - 0.10\ \frac{kg\ C}{kwh})(2 \times 10^{11-3}\ kw)(8766\ \frac{h}{y})$

(0.16)

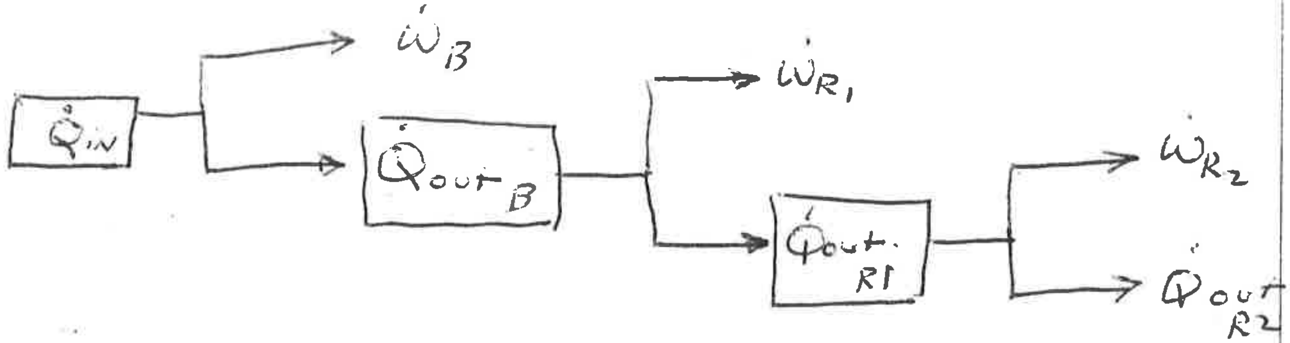
$= 2.8 \times 10^{8+3}\ kg\ C = 2.8 \times 10^{11}\ kg\ C = 2.8 \times 10^8$ tons C

if CO_2 then $\times$ $12 + 32 = \frac{44}{12} = 3.67$

$= 10.2 \times 10^8$

This is ~15% of US Total $= 1.02\ Gt\ CO_2$

10.23



$$\eta_B \quad \cdot \quad \eta_{R_1} = \eta_{R_2}$$

$$\eta_{3\,CCGT} = \frac{\dot{W}_B + \dot{W}_{R_1} + \dot{W}_{R_2}}{\dot{Q}_{IN}}$$

η_B

$\dot{W}_{R_1} = \eta_R (1-\eta$

$\dot{W}_{R_2} = \dot{Q}_{IN}(\eta_R)(1-\eta_R$

$$= \frac{\dot{W}_B}{\dot{Q}_{IN}} + \frac{\eta_R(1-\eta_B)\dot{Q}_{IN}}{\dot{Q}_{IN}} + \frac{\dot{Q}_{IN}}{\dot{Q}_{IN}}\eta_R(1-\eta_R)(1-\eta_B)$$

$$\boxed{\eta_{3\,CCGT} = \eta_B + \eta_{R_1}(1-\eta_B) + \eta_R(1-\eta_R)(1-\eta_B)}$$

$$= 0.38 + 0.32(1-0.38) + 0.32(1-0.32)(1-0.38)$$

$$= 0.38 + 0.20 + 0.135 = \boxed{71.3\%}$$

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