ME485 Chap 8 HW Sol. SS DiJulio

8.22 The actual $\Delta T_{realized}$ is estimated to be about 0.6°C, which is 75% of the equilibrium ΔT

$$\Delta T_{realized} = 0.6^{o}C = 0.75\ \Delta T_{equilibrium}$$

so, $\Delta T_{equilibrium} = 0.6/0.75 = 0.8^{o}C$

but, $\Delta T_{equilibrium} = \lambda\ \Delta F_{actual} = 0.57 \times \Delta F_{actual} = 0.8$

that is, $\Delta F_{actual} = = \dfrac{0.8}{0.57} = 1.40\,W/m^2$

The direct forcing is 2.45 W/m^2, so aerosols etc are 2.45 - 1.40 = 1.05 W/m^2

8.23 Energy sources and carbon intensity:

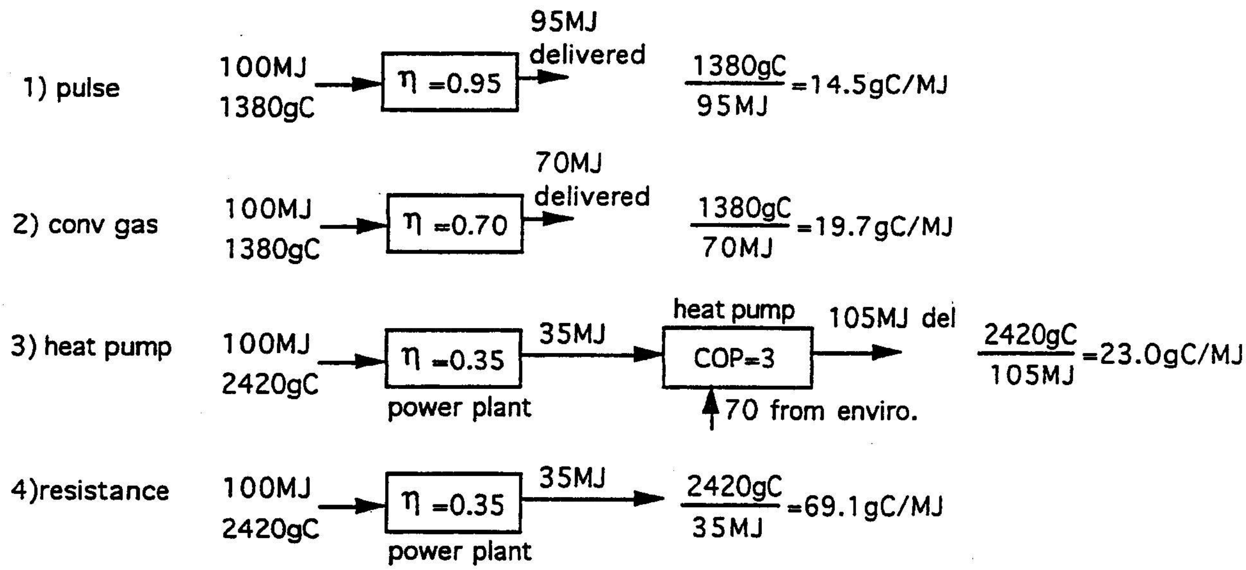
Coal	25%	@ 24.2 gC/MJ
Oil	45%	@ 19.7 gC/MJ
Gas	20%	@ 13.8 gC/MJ
Other	10%	@ 0

a. avg C intensity = 0.25x24.2 + 0.45x 19.7 + 0.20x13.8 + 0.10x0 = 17.68 gC/MJ

b. Coal replaced by non-carbon emitting sources:

avg C intensity = 0.25x0 + 0.45x 19.7 + 0.20x13.8 + 0.10x0 = 11.63 gC/MJ

8.27 Using LHV carbon intensities from Table 8.9, the four options are:



Notice the tremendous range: 14.5 to 69.1 gC/MJ, almost 5:1 !

8.34 Gasoline C_7H_{15}, 6.15 lbs/gal, fully combusted,

a. $\text{gasoline} = \dfrac{6.15 \text{ lb gas}}{\text{gal}} \times \dfrac{(7 \times 12 = 84) \text{ lbs C}}{(7 \times 12 + 15 \times 1 = 99) \text{ lb gas}} = 5.22 \text{ lbsC/gal}$

$$C = \frac{40{,}000 \text{miles}}{12 \text{miles / gal}} \times \frac{5.22 \text{ lbs C}}{\text{gal}} = 17{,}394 \text{ lbsC that will be released}$$

b. 4000 lb car, 10,000 mi/yr,

$$C = \frac{17{,}394 \text{ lbsC}}{40{,}000 \text{ mi}} \times \frac{10{,}000 \text{mi}}{\text{yr}} = 4348 \text{ lbs C/yr}$$

$$\frac{\text{carbon}}{\text{vehicle wt.}} = \frac{4348 \text{ lbs C/yr}}{4000 \text{ lb}} = 1.09$$

the car emits slightly more carbon per year than it weighs!

c. $\text{carbon tax} = \dfrac{5.22 \text{ lbs C}}{\text{gal}} \times \dfrac{\$15}{2000 \text{ lbs C}} = \$0.039/\text{gal} = 3.9¢/\text{gal}$

d. new car @40mpg. for 40,000 miles:

$$C_{\text{reduction}} = 17{,}394 \text{ lbsC} - \frac{40{,}000 \text{mi}}{40 \text{mi / gal}} \times \frac{5.22 \text{ lbsC}}{\text{gal}} = 12{,}174 \text{ lbs C saved}$$

e. trading in the clunker for the 40 mpg vehicle would save

$$\text{tax savings} = 12{,}174 \text{ lbsC} \times \frac{\$15}{2000 \text{ lbsC}} = \$91 \text{ per car}$$

that is, those C offsets would save the utility $91, which they could spend to get the clunker off the road.

8.33 Leaky landfill, 10 tonnes CH_4 per year:

a. 20-yr GWP for methane = 56,

$$10 \text{ tonnes } CH_4/\text{yr} \times 56 = 560 \text{ tonnes } CO_2 (\text{equivalent})$$

b. burning the methane,

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

$$CO_2 \text{emitted} = \frac{1 \text{ mol } CO_2}{\text{mol } CH_4} \times \frac{(12 + 2\text{x}16)\text{tonne}CO_2/\text{mol}}{(12 + 4\text{x}1)\text{tonne}CH_4/\text{mol}} \times \frac{10\text{tonne}CH_4}{\text{yr}}$$

$$= 27.5 \text{ tonne } CO_2/\text{yr}$$

c. equivalent CO_2 savings = 560 - 27.5 = 532.5 tonne CO_2

$$\text{as C: } 532.5 \text{ tonne}CO_2/\text{yr} \times \frac{12 \text{ tonneC}}{44 \text{ tonne } CO_2} = 145.2\text{tonneC}/\text{yr saved}$$

d. carbon tax saved = 145.2 tonneC/yr x \$20/tonneC = \$2900 / yr

e. same thing, 532.5 tonne CO_2 saved x \$5.45/tonneCO_2 = \$2900/yr

8.35 Electrics vs gasoline powered cars:

a. $$\text{gas car emissions} = \frac{5.22 \text{ lbs C/gal}}{40 \text{ miles/gal}} \times \frac{1000\text{g}}{2.2 \text{ lbs}} = 59.3\text{gC/mi}$$

b. with the very efficient natural-gas-fired power plant,

$$\text{electric emissions} = \frac{8000\text{kJ}}{\text{kWh}} \times \frac{13.8\text{gC}}{\text{MJ}} \times \frac{\text{MJ}}{10^3\text{kJ}} \times \frac{\text{kWh}}{5\text{mi}} = 22.1\text{gC/mi}$$

c. with the typical old coal plant,

$$\text{coal plant heat rate} = \frac{1\text{kW heat in}}{0.30 \text{ kW electric out}} \times \frac{1\text{kJ/s}}{\text{kW heat in}} \times \frac{3600\text{s}}{\text{hr}} = 12{,}000\text{kJ/kWhe}$$

$$\text{electric emissions} = \frac{12{,}000\text{kJ}}{\text{kWh}} \times \frac{24\text{gC}}{\text{MJ}} \times \frac{\text{MJ}}{10^3\text{kJ}} \times \frac{\text{kWh}}{5\text{mi}} = 57.6\text{gC/mi}$$

So, carbon can be saved with electric cars when efficient natural-gas power plants are assumed, but for the typical old coal plant, very little if any savings accrue.