UCC501 Homework 2 Solutions

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1 Energy Scales, CO2 Emissions and Renewables

1.1 Energy Scales

- Natural gas consumption year 2012: in Billion Cubic Feet: 2235.169.
- For natural gases btu we have

$$1cf \rightarrow 1027Btu \tag{1}$$

source: http://www.aga.org/KC/ABOUTNATURALGAS/ADDITIONAL/Pages/HowtoMeasureNaturalGas.aspx, use MATLAB to convert units, we have

$$2012\ Yearly\ btu\ =\ 2235.169 * 10^9 * 1027 \tag{2}$$

Evaluate the equation we get $2.2955 * 10^{15}\ Btu$, divided by millions we get $2.2955 * 10^9\ MBtu$.

- From this unit conversion site http://www.eia.gov/cfapps/ipdbproject/docs/units.cfm we have

$$MTOE\ =\ MBtu * 0.02520 * 10^{-6} \tag{3}$$

Evaluate the above equation we have $57.8471 MTOE$

- Similarly we have $1MBtu = 1.05506 * 10^9 Joules$ and $1KWh = 3.6 * 10^6 Joules$, thus

$$2012\, Yearly\, GKWh = 2.2955 * 10^9 * 1.05506 * 10^9 / (3.6 * 10^6 * 10^9) \quad (4)$$

Evaluate the above equation we have 672.7527 $GKWh$

1.2 CO2 Emissions

- Assume complete combustion, we have 2235.169 Bcf natural gas burned in UAE for year 2012. Assume under normal temperature and pressure the natural gas is measured, we google the bold texts **natural gas density** and get the following:

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Density
0.656 g/L at 25 C, 1 atm; 0.716 g/L at 0 C, 1 atm;
0.42262 g cm3; (at 111 K)
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Since we assume normal density, we use $\rho = 0.656 g/L = 656 kg/m^3$. Thus we have the total mass of CO2 burned in year 2012

$$Mass\ of\ CH_4 = 4.1525 * 10^{13} kg \quad (5)$$

Since the background is complete combustion, from chemistry we have

$$CH_4 + 2O_2 = CO_2 + 2H_2O \quad (6)$$

and introduce a concept from chemistry, **molecular weight** we have

$$Mass\ of\ CO_2 = m_{CH_4} * \frac{M_{CO_2}}{M_{CH_4}} \quad (7)$$

where m_{CH_4} is the mass, the M_{CH_4} is the molecular weight. This equation is deducted by **carbon equilibrium** under complete combustion. Evaluate equation (7) we have $m_{CO_2} = 1.1419 * 10^{14} kg$

1.3 Renewables

Since we mentioned **in total** in the question, my answer would follow the *total* CO2 generated by burning natural gas.

Thus $m1_{co_2} = 0.05 * m_{CO_2}$, evaluating it we have $m1_{co_2} = 5.7097 * 10^{12} kg$.

- Set the size of such solar plant is $x\ MW$, then from **Energy Conservation Law** we have

$$Energy_{solar} \ = \ Energy_{gas\ useful} * 0.05 \tag{8}$$

- For energy generated by a solar plant's lifetime, we have

$$E_{solar} \ = \ x * 3.6 * 10^9 * 1700 * 25 \tag{9}$$

- For energy generated by burning natural gas, we have the secondary energy as follows:

$$E_{gas_useful} \ = \ E_{gas} * 0.40 * 0.92 \tag{10}$$

  The E_{gas} can be calculated and/or converted from the above. Because we get 2012 yearly gas btu $2.2955 * 10^{15}$, convert that to Joule unit

$$E_{gas} \ = \ 2.2955 * 10^9 * 1.05506 * 10^9 \tag{11}$$

  Put all these values into (8) we have $x \ = \ 291.2624$. Thus the size of such a plant is $291.2624 \simeq 300\ MW$. (I put 300MW here for *industrial term*.)

2 Economic Analysis

Life is fucking awesome in the United Arab Emirates.