

# UCC501 Homework 2 Solutions

Yanan Xiao  
yxiao@masdar.ac.ae

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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

$$1cf \rightarrow 1027Btu \quad (1)$$

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

$$2012 \text{ Yearly } btu = 2235.169 * 10^9 * 1027 \quad (2)$$

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

$$MTOE = MBtu * 0.02520 * 10^{-6} \quad (3)$$

Evaluate the above equation we have  $57.8471MTOE$

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

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

Evaluate the above equation we have  $672.7527 \text{ GKWh}$

## 1.2 CO2 Emissions

- Assume complete combustion, we have  $2235.169 \text{ Bcf}$  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:

Density

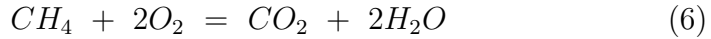
$0.656 \text{ g/L}$  at  $25 \text{ C}$ ,  $1 \text{ atm}$ ;  $0.716 \text{ g/L}$  at  $0 \text{ C}$ ,  $1 \text{ atm}$ ;

$0.42262 \text{ g cm}^3$ ; (at  $111 \text{ K}$ )

Since we assume normal density, we use  $\rho = 0.656 \text{ g/L} = 656 \text{ kg/m}^3$ . Thus we have the total mass of  $\text{CO}_2$  burned in year 2012

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

Since the background is complete combustion, from chemistry we have



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

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

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  $m_{CO_2} = 1.1419 * 10^{14} \text{ kg}$

## 1.3 Renewables

Since we mentioned **in total** in the question, my answer would follow the *total*  $\text{CO}_2$  generated by burning natural gas.

Thus  $m_{1_{CO_2}} = 0.05 * m_{CO_2}$ , evaluating it we have  $m_{1_{CO_2}} = 5.7097 * 10^{12} \text{ kg}$ .

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

$$Energy_{solar} = Energy_{gas\ useful} * 0.05 \quad (8)$$

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

$$E_{solar} = x * 3.6 * 10^9 * 1700 * 25 \quad (9)$$

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

$$E_{gas\ useful} = E_{gas} * 0.40 * 0.92 \quad (10)$$

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

$$E_{gas} = 2.2955 * 10^9 * 1.05506 * 10^9 \quad (11)$$

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.