

TTP-289
 The Hydrogen Economy - Technology, Pathways, Economics and Policy
 Homework #1
 Due Date: April 25, 2006 (in class)

Please show your calculations and units.

Energy

1. Estimate the power associated during refueling your car.
2. Assuming 30% steam cycle efficiency, calculate and compare the annual input (weight) of coal and uranium in a 1500MW coal and nuclear electric power plant.
3. Create a screening graph (Annual cost vs % operation) for the following generation technologies and determine the crossover points:

	Annual capital cost \$/MW/yr	Fixed O&M \$/MW	Variable O&M \$/MWh	Fuel Heatrate MMBtu/MWh	Fuel Cost \$/MMBtu
Scrubbed Coal New	187,350	25070	4.18	8.6	\$1.50
Natural Gas Comb Cycle	87,600	11370	1.88	6.8	\$5.00
Gas Combustion Turbine	61,050	11030	3.25	10.45	\$5.00

*MMBtu = 1×10^6 Btu

What happens to the crossover points when natural gas prices rise to \$7/MMBTU?

Fuel cells

4. Thermodynamics - A future breakthrough in materials has lead to a low-temperature (room temperature) methane fuel cell.
 - a. Write the balanced chemical equation for this reaction.
 - b. Calculate the theoretical efficiency for this methane – oxygen fuel cell.
 - c. What is the reversible voltage for this fuel cell?
5. Nernst equation – effects of reactant / product concentration
 - a. Write the equation for Q (the reaction coefficient) for the hydrogen/oxygen fuel cell reaction.
 - b. How (and by how much) would the reversible voltage of that reaction change for a Q of 100? Of 0.1?

6. Fuel Cell Systems - Graph the voltage (V) vs current (A) curve and efficiency (LHV basis) vs power (kW) curve for the following fuel cell.

$$E = E_0 - b \ln i - Ri - me^{(ni)}$$

where $E_0 = 1.031$ V , $b = 0.03$ V, $R = 2.45 \times 10^{-4}$ kOhm cm^2 , $m = 2.11 \times 10^{-5}$ V, $n = 8 \times 10^{-3}$ cm^2/mA i is in units of mA/cm^2 and the auxiliary load (cooling system, pumps and blowers) is equal to $P_{\text{aux}} [\text{W}/\text{cm}^2] = i * 0.0001 + 0.003$

Area of cells = 250 cm^2 , $N_{\text{cells}} = 75$

Assume constant utilization efficiency of 85%, and 100% faradaic efficiency.