Masdar Institute of Science & Technology

UCC501 – Sustainable Energy

Fall 2014

Homework # 2

Release Date: 29/09/2014 Submission Date: 13/10/2014

Topics: Type: Individual

- Exposure to Quantitative Energetic Assessment
- Unit Conversion
- CO_2 Emissions
- Financial Assessment
- Basic Economics

Learning Outcomes: Experience in energy economics and quantitative orders of magnitude relevant to large scale energetics. Experience in financial assessment of renewable energy related projects. CO_2 Emissions.

The problems below are fairly trivial mathematically. The main effort involves getting some reliable input data and structuring your answer. Work out each of the problems giving a reference from where you obtained the data or informed assumption – try to use as first priority our recommended sources and assumptions and ONLY if you need additional information refer to other material.

Answers should be submitted in pdf format. All information needed including the steps you have taken and your assumptions should be included in that document. Build an Excel spreadsheet to answer the questions. Include **all files** in your submission.

1. Energy Scales, CO_2 Emissions and Renewables (30 points)

a) **What was the total natural gas consumption in the UAE in 2012? Express in MTOE/year and GWh/year.**
Data source: Use Energy Information Administration (www.eia.gov) or BP data (www.bp.com/statisticalreview).

b) **What was the total annual CO_2 emissions (in kg) from natural gas consumption in 2012? Base your answer on 1.a findings. Hint:** Assume complete combustion.

c) **How much CO_2 do we save in total by installing a solar system that will generate (throughout its lifetime) energy equal to 5% of natural gas secondary (useful) consumption in 2012? What is the size (in MW) of such solar plant?**
Assumptions**:**
Solar power obtains 1700 Full Load Hours in UAE
The fossil fuel conversion efficiency is 40%
Grid transmission efficiency is 92%
Lifetime is 25 years
It is possible to convert any and all fossil fuel uses to electricity instantaneously

2. Economic Analysis (40 points)

The capital structure is as follows:

- Capital costs: 2700 $/kW of rated solar pv capacity.
- 3% return on debt.
- 15% return on equity.
- 70/30 debt-equity ratio.
- Construction time: 1 year.
- Life time: 25 years.
- Annual operations and maintenance costs: 5% of capital costs.
- Required land per MW of solar PV: 7.9 acres/MW direct
- Land compensation cost: 1800 $/ha/year

a) **Calculate the LCOE (in $/kWh) for the solar farm sized in 1.c**
b) **What is the IRR of the project in case of applying a feed-in tariff of 0.3$/kWh?**

3. Vehicle Kinetics, CO2 and Renewable Energy (35 points)

a) **Based on the principles of vehicle kinetics, estimate the propulsion power required (in Watts) for an average SEDAN (Toyota Camry XV50 type, gasoline). Use the following assumptions:**

- Average car speed: 72 km/h.
- 180km trip.
- Effective aerodynamic cross-sectional area = 2.45 m^2.
- Air density = 1.2 kg/m^3.
- Drag coefficient = 0.28
- Rolling resistance coefficient = 0.01
- Total vehicle mass: 1440 (vehicle) + 70 (passenger) + 40 (fuel) kg.

P_v= mechanical power + aerodynamic drag + rolling resistance

$$P_v = \frac{m_v * u^3}{2d} + \frac{1}{2}\rho_{air} * A * c_d * u^3 + m_v * g * c_{rr} * u$$

where: where m_v is the total vehicle mass, u the velocity, d the distance between stops, ρ_{air} the density of air, A the cross section area of the vehicle, c_d the drag coefficient, g the gravitational acceleration (9.79 m/s^2), and Crr the coefficient of rolling friction.

b) **For the CV in a), calculate the amount of energy (in MWh) required for traveling an average total distance of 40,000 km per year (hint:** consider all efficiencies**).**

c) **Calculate annual energy required (in MWh) for 600,000 vehicles registered in Abu Dhabi and estimate the corresponding CO_2 emissions (in kg) caused by the vehicle activity.**

d) **What is the rate of solar power installations that the UAE would need to install per year for the next 5 years so that the CO_2 emissions from the CVs are kept constant- at the level of 50% less than now? Use the assumptions in 1.c**