

Interim examination Energy Analysis

10 December 2009

9:00 – 11:00

- This examination has 3 questions with equal weights.
- You can use the book, the index to the book, a dictionary and Key World Energy Statistics.
- The answers of the exercises may **not** be used.
- You can use a calculator.
- The answers can be provided either in English or Dutch.
- Provide your name and student number on each separate sheet of paper.
- Success !!

Question 1 Energy Statistics

The (incomplete) energy balance of Nomansland in 2008 is given in the following table:

Energy Balance Nomansland (in PJ)				
	Coal	Gas	Electricity	Total
production	0		0	
Imports		0	0	
Exports	0	0	0	0
Stock changes	0	0	0	0
TPES				
Electricity Plants				
Other energy conversion	-100	-200	-70	-370
TFC				
Industry	115	250	220	585
Transport	0	22	10	32
Other sectors	15	400	500	915

Your task is to fill in all the empty cells in this energy balance.

All coal is imported and all gas is produced (mined) in Nomansland. No electricity is imported or exported.

- a. Calculate the 4 values for the TFC row
- b. How much electricity must Nomansland produce in 2008 (i.e., what is the value to fill in row 'Electricity Plants', column 'Electricity').

50% of the electricity is produced in coal fired power plants (efficiency 0.40) and the rest in gas fired power plants (efficiency 0.50).

- c. How much coal and natural gas is used for electricity production. Which values must be filled in in the remaining cells of the row 'Electricity Plants' (including the column 'Total').
- d. Determine the 4 values for the TPES row
- e. Determine the remaining values (for production and import) and present the complete energy balance for Nomansland.

Question 2 Making Coffee

A cup of coffee holds 150 ml at a temperature of 90 °C. The (environmental) reference temperature is 20 °C. The heat capacity of water is 4.18 kJ/(kg.K), the specific weight is 1.00 kg/liter. The (energy) efficiency of an electric coffee maker is 90% (not considering the energy needed to keep the coffee hot).

Questions:

- Determine the exergy (in kJ) of the cup of coffee
- Determine the electricity (in kJ) needed for making the cup of coffee

The coffee maker also has an electric hot plate to keep the coffee hot. Consider a cylindrical coffee pot with dimensions: diameter 10 cm and height 15 cm. Heat loss only occurs through the cylinder surface (so ignore the bottom and top part). The heat transfer coefficient is $k=12.5$ W/(m².K). The energy efficiency of the hot plate is 80%.

Further information:

Area of circle with radius r : πr^2

Surface of cylinder with radius r and height h : $2\pi r h$

Volume of cylinder with radius r and height h : $\pi r^2 h$

The completely filled pot of coffee is kept hot for 30 minutes.

Questions:

- How much electricity (in kJ) is needed to keep the pot of coffee hot (hint: use eq. 3.7)
- How much electricity (in kJ) is needed in total for one cup of coffee

Question 3 Electric vs Petrol car

The energy performance of a petrol car is 14 km/litre. The energy performance of an electric car is 7 km/k Wh. The batteries of the electric car are charged during the night using electricity from base load coal power plants with an efficiency of 40%.

- What is the primary energy requirement of driving each car (in MJ/km), use a second order approach.
- What is the cumulative CO₂ emission in gram CO₂/km, use a second order approach. (for simplification assume that indirect energy use is petrol for the petrol car and coal for the electric car).