
ENERGY ANALYSIS

INTERIM EXAMINATION
15 DECEMBER 2011, 9:00 -11:30

- This examination has 4 questions.
- You can use the book, the index to the book, a dictionary and Key World Energy Statistics.
- The answers of the exercises and assignments and your notes may not be used.
- You can use a (graphing) calculator.
- The answers can be provided either in English or Dutch.
- Provide your name and student number on each separate sheet of paper.

Good luck!

1) **Statistics**

- a) Calculate the average energy efficiency of CHP plants in the world in 2009.
- b) For China, which percentage of their total energy use (TPES) is covered by coal? Assume that all coal used by China has the heating value of Chinese steam coal.

2) **Heat pump**

In the manual of my heat pump I find the following measurement:

$$\text{COP}_{L7 W35} = 4,6$$

The heat pump extracts heat from the outside air. It uses electric energy to make hot water for room heating. The outside temperature is 7 °C (that is the "L7" in the measurement notation), the hot water temperature is 35 °C (that is the "W35" in the measurement notation). The water enters the heat pump with 30 °C (as specified in the measurement specifications).

What is the exergetic efficiency of this heat pump if you disregard the electricity production?

3) Shed

A man owns a shed. The walls of the shed are made of bricks, with a thickness of 10 cm. The roof is made of wood with tiles. The surface of the walls is 24 m², the roof has a surface of 10 m². The man works in the shed, so he produces heat (about 100 W). The shed has no heating. The outside temperature is 10 °C. The heat transmission coefficient of the roof (wood and tiles) is 3.5 Wm⁻²K⁻¹.

The heat transfer coefficient to the walls and the roof, inside, is 10 Wm⁻²K⁻¹, the heat transfer coefficient from the walls and the roof, outside, is 20 Wm⁻²K⁻¹.

The man buys and applies insulation. He uses extruded polystyrene foam with a thickness of 10 cm, and uses a 1 cm thick plaster finish. The insulation and plaster is applied on both walls and roof. The thermal conductivity of the plaster is 0.18 WK⁻¹m⁻¹.

Disregard the heat loss through the floor of the shed.

What will be the temperature in the shed, after the improvement with insulation?

4) Micro CHP

I found the following intriguing table in a Dutch report on micro CHP. In this table a comparison is made between a condensing boiler and a micro CHP for use in a normal Dutch household. The final energy use of the household does not change.

| | Energy use | | Primary energy use | |
|-------------------|----------------|-------------|--------------------------|---------|
| | natural gas | Electricity | Total primary energy use | savings |
| | m ³ | kWh | GJ | |
| condensing boiler | 1650 | 3500 | 80 | |
| micro CHP | 1900 | 1250 | 70 | 12,50% |

Table 1. translated from: "Micro-wkk: meer rendement uit aardgas" van de smart power foundation, 2010

The electricity use as given in the table is only the electricity taken from the grid. The condensing boiler, with a 107% efficiency, is taken as reference situation. In this reference situation, all the electricity is taken from the power grid. The lower heating value of Dutch natural gas is 31.65 MJ/m³.

- What is taken as the efficiency of the power production in the reference situation?
- What are the electric and thermal efficiencies of the micro CHP?
If you did not manage to produce an answer for question a, make a reasonable assumption for the efficiency of the power production.
- If you allocate based on exergy, what is the CO₂ emission associated with the electricity production of the micro CHP, in g CO₂ per kWh electricity production?
If you did not manage to produce an answer for question b, use a thermal efficiency of 90% and an electric efficiency of 11%.