Tfy-56-4311 Uudet energiatekniikat (5 op L) /New energy sources (5 p, G)
PHYS-C6370 Fundamentals of New Energy Sources (5 cr)

Choose 5 questions only/ Valitse vain 5 tehtävää !
Tentti 28.1.2014 / Exam 28.12014; You may write your answers in English, Finnish, German, Swedish
Indicate which course you choose! You are allowed to use a calculator in the exam (Peter Lund 0405150144)

1. Describe the physical principles, performance (energy output) and technology concepts of wind power. (6p)

2. Explain the main steps in biogas production. (6p)

3. Short answers only (each 1p):
   a) How large share of world energy do fossil fuels produce presently?
   b) Explain the term "peak oil"
   c) How much electricity does 1 kW_p of photovoltaics produce per year in Helsinki?
   d) IPAT
   e) Diffusion or penetration curve (you can also "draw" the answer)
   f) Why can a fuel cell in theory have a conversion efficiency >100%?

4. Short analysis (each 3 p)
   a) How does the output of a 5 MW wind power plant on the Danish coast change when the wind speed rises from 12 to 13 m/s?
   b) How does the thermal output of a 100 MW_{th} high concentrating solar power plant (CSP) in Spain change when the share of diffuse solar radiation (hajasäteily) of total radiation increase from 5 to 20%, while the total solar radiation on the collector remains constant at 1000 W/m^2?

5. Production of ethanol (EtOH) from barley starch takes place through the following reactions:
   Hydrolysis of starch into maltose: $(C_6H_{10}O_5)\ n + H_2O \rightarrow (C_6H_{10}O_5)\ n\text{-}2 + C_{12}H_{22}O_{11}$
   Fermentation of maltose into ethanol: $C_{12}H_{22}O_{11} + H2O \rightarrow 4\ C_2H_5OH + 4\ CO_2$

   a. If one third of the current 2,100,000 tons per year barley crops in Finland were dedicated for ethanol fuel production, which portion of our present 2200 million liter (1630 million kg) yearly gasoline consumption would the amount of ethanol thus available correspond to? Consider in your calculations that the average starch content of barley is about 62 wt.-%, and that lower heating values (LHV) for 95E gasoline and ethanol are 42.2 MJ/kg and 26.8 MJ/kg respectively. (3p)

   b. For every 1 kg of barley it is possible to collect 300 grams of barley straw with an LHV of 13.6 MJ/kg. Harvesting and transportation of straw takes up 0.4 MJ/kg of energy. How much energy/(kg EtOH) can be recovered by burning the straw of barley used for ethanol production in a combined heat and power plant with a total plant efficiency of 75 %? (3p)

6. Assume that only 170 units of a nonrenewable energy resource exist in the world. Extraction of the resource has *no cost*. The resource has a linear price-demand dependence such that $Qt=100-Pt$, where Qt and Pt are demand and price of the resource on year t, respectively. To the proprietor, \$1 earned immediately is 10% more valuable than \$1 earned a year later.

   a) How should the proprietor price the resource in order to maximize its present value? What is the present value of the resource stock? Use the Hotelling rule. In the beginning of the final year, both demand and remaining amount of resource are equal to 1. (3p)
   b) Compare the pricing strategy in (a) to the following pricing strategy: The price is initially \$68 and it increases 4% annually. (3p)