PHYS-C6370 Fundamentals of New Energy Sources (5 cr)
Exam December 15, 2014 (2 pages)

(you may use calculator of any type; inquires Peter Lund 0405150144)

1. Bioethanol and biomethanol as fuel.

   a) Explain the main differences between bioethanol and biomethanol (2p)
   b) In terms of avoided carbon dioxide emissions, which one is better and why? (2p)
   c) Explain shortly how to prepare bioethanol from wood? (2p)

2. To stabilize the atmospheric CO_2 concentration to a sustainable level, the annual global average carbon footprint should decrease to a level of 2 tons of CO_2 per capita by 2050. The carbon footprint of an average EU27 citizen was in 2012 about 9 tons of CO_2 per year.

   a) Calculate how fast energy technology should improve (annual % decrease in the ratio of CO_2(kg)/GDP(€)) if we want to achieve the above goal in Europe while preserving the 2% annual increase in real GDP (in 2012 euros). Average GDP in EU27 was 25,300 € per capita in 2012. (3p)

   b) If technology cannot be improved at all, how much would the GDP per capita need to decrease (annual % decrease) to reach the goal? (3p)

3. Photovoltaics (PV) is a disruptive energy technology. Please assess:

   a) qualitatively, draw a penetration curve for PV capacity from 1980 to 2050 and explain the different phases of penetration which you can identify? (2p)
   b) qualitatively, show how the unit cost of PV drops as a function of cumulative capacity till now and give an estimate of how much the costs could drop by 2050? (2p)
   c) what would be the typical cost of a PV module today ($/Wp), how does the LCOE ($/MWh) of PV look like against the price of electricity paid by the consumer ? (2p)

4. Assume that you are a consultant working on a wind turbine project for Turku City. A wind turbine by Vestas is considered for the site which has an annual average wind speed of 7 m/s. You are currently expecting a call from the project owner who wants to go through some key figures with you. The wind turbine brochure is already printed out and you locate it on your desk. Looking at the brochure you suddenly realize that it has been sabotaged by an unknown third party! Some important figures are obstructed and you need to find them out as soon as possible, or risk losing your contract. You know that the project owner is especially interested in the following information:

   a) Cut-in wind speed
   b) Cut-out wind speed
   c) Rated power (a.k.a. nominal power)
   d) Turbine blade length
   e) Capacity factor for the location
   f) Power coefficient of the turbine at 10 m/s
   (each sub-question gives 1 p)

   Calculate the above figures using the information from the attached brochure.

POWER REGULATION Pitch regulated with variable speed

OPERATING DATA

Rated power

Cut-in wind speed m/s

Cut-out wind speed m/s

Re cut-in wind speed m/s

Wind class

Standard operating temperature range: -20°C to +45°C with de-rating above 30°C*

*subject to different temperature options

SOUND POWER

(Noise modes dependent on site and country)

ROTOR

Rotor diameter

Swept area 8,659 m²

Air brake full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub height	site specific

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop*)	6.8 m
Length	12.8 m
Width	4.0 m

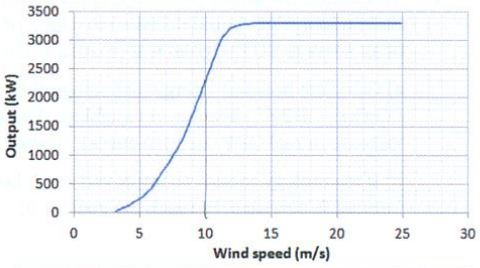
HUB DIMENSIONS

Max. transport height	3.74 m
Max. transport width	3.75 m
Max. transport length	5.43 m

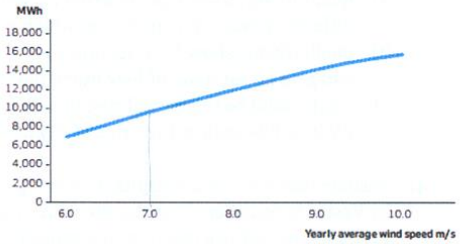
BLADE DIMENSIONS

Length	
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes



ANNUAL ENERGY PRODUCTION



Assumptions

One wind turbine, 100% availability, 0% losses, k factor = 2, Standard air density = 1.225, wind speed at hub height