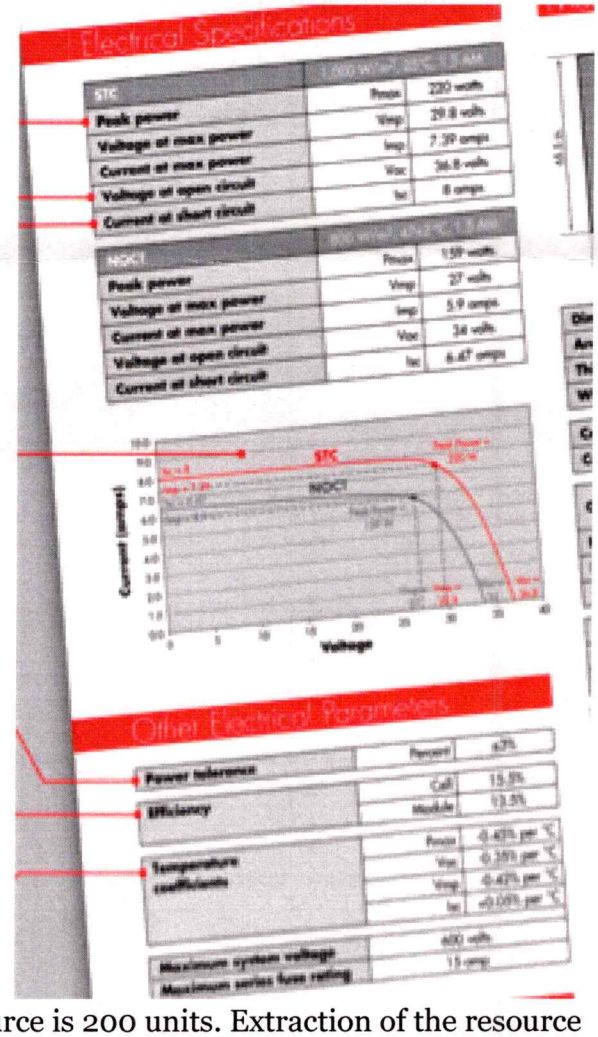
PHYS-C6370 Fundamentals of New Energy Sources (5 cr)
Exam December 13, 2017 (2 pages)
(you may use calculator of any type; inquires Peter Lund 0405150144)
You may respond in English, Finnish, Swedish or German languages. 5 questions

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 biomethanol from waste? (2p)

2. To stabilize the atmospheric CO_2 concentration to a sustainable level, the average EU carbon footprint should decrease to a level of 1 tons of CO_2 per capita by 2050, which is now 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(€)) while preserving a 2% annual increase in real GDP. Average GDP in EU is around 25,500 € per capita. (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. Using the data sheet for an old photovoltaics (PV) module, please assess:
   a) Assuming an outdoor temperature of -20 °C what would be the maximum power of this module in full sunshine? (2p)
   b) How much would this module produce electricity on average in a year if the yearly solar radiation were 1000 kWh/m²? (2p)
   c) Estimate the fill factor (FF), which describes the ratio of real to theoretical power maximum of the module (2p)



4. Assume that the nonrenewable energy resource is 200 units. 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 3% more valuable than \$1 earned a year later.

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. (6p)

5. Assume that you are a consultant working on a wind turbine project for Helsinki City. A wind turbine by Vestas is considered for the site, which has an annual average wind speed of 7.5 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 loosing 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. (6p)

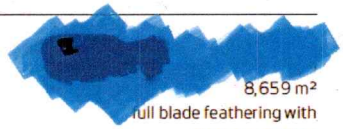
POWER REGULATION — Pitch regulated with variable speed

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

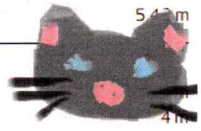
Hub height	site specific

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

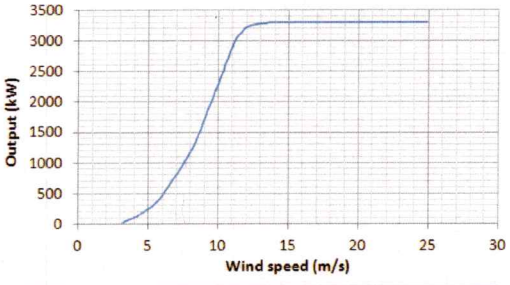
Max. transport height	3.74 m
Max. transport width	3.75 m
Max. transport length	5.4 m



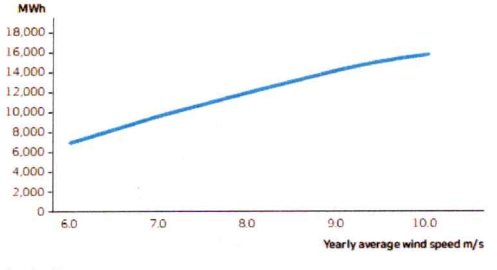
BLADE DIMENSIONS

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