ADANA ALPARSLAN TÜRKEŞ
SCIENCE AND TECHNOLOGY UNIVERSITY

EEE407 - Renewable Energy
Final Exam
Prepared by Dr Kasım Zor

4th Jan 2023, 13:15–14:45

Full Name : _____ Student ID: _____

Grade Table (for Lecturer use only)

Question	Points	Score
1	10	
2	60	
3	30	
Total:	100	

Instructions for Final Exam

Welcome to the final exam of EEE407 - Renewable Energy and good luck!

Please read the following rules and confirm by signing that you have read and understood the rules before you receive your exam:

- The midterm exam shall be conducted between 13:15 and 14:45. Exam duration is 90 minutes. Students must finalise the exam by delivering it before 14:45. Students are not allowed to leave the exam in the first 30 minutes.
- Student ID cards shall visibly be on the edge of desks till the end of the exam. Students without the student ID cards or Turkish identity cards shall not be participated into the exam.
- This is a closed-book exam which means that students are not allowed to take notes, books, or any other reference material into the exam. Throughout the exam, students shall not possess mobile phones and electronic devices that are capable of storing, receiving, or transmitting information or electronic signals, such as computerised watches.
- Students are not allowed to take a glance at the exam questions until told to do so. Students shall not communicate with any other student under any circumstances during the exam period. A student, who cheats, tries to cheat during the exam, or is identified to be cheating after investigating exam documents, is given 0 (zero) for that exam and a disciplinary investigation is opened against the student.
- All numerical values in the exam shall be calculated according to three decimal digits. Otherwise, there will be a penalty.
- An incorrect answer to a question is awarded no marks with no consideration of any partial credit. Therefore, no partial credit will be given.

In recognition of and in the spirit of the above rules which constitute Adana Alparslan Türkeş Science and Technology University Honour Code, I certify that I will neither give nor receive unpermitted aid on this examination.

Signature: _____

1. Answer the following questions.

   (a) **(5 points)** Why did you select EEE407-Renewable Energy course at the beginning of this term? Do you recommend this course for senior undergraduate students in our department and why?

   (b) **(5 points)** How can we improve this course? Please criticise the deficiencies and make suggestions to improve this course.

2. Answer the following questions.

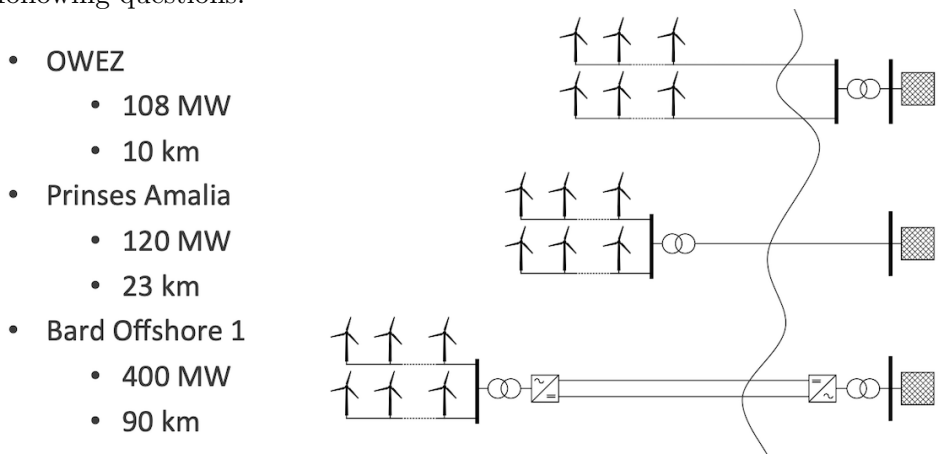


Figure 1: Offshore Wind Power Plants

   (a) **(15 points)** Three offshore wind power plants are demonstrated in Figure 1. Interpret the differences in the grid connection schemes in terms of installed power plant capacity, HV transmission current type, numbers and locations of transformers, power electronic components, and distance to shore.

(b) **(15 points)** The Humber Gateway Wind Farm is an offshore wind farm located in the North Sea in England. It consists of 73 wind turbines of 3 MW each. The capacity factor of the wind farm is estimated as 41%. What is the annual energy production of the wind farm in GWh.

Answer:

(c) **(15 points)** What is the the Betz limit and why does it equal to 59.3%? Draw a typical power curve for a wind turbine along with emphasising the following terms:

- Cut-in speed,
- Cut-out speed,
- Rated power.

(d) **(5 points)** Discuss conventional and future power systems in terms of the direction of power flow and the use of AC or DC.

(e) **(5 points)** Calculate the daily potential energy of a tidal power plant in kWh/m^2 according to the followings:

- The height difference between low tide and high tide is 8 m.
- The density of salt water is approximately 1,025 kg/m^3.
- The gravitational constant is equal to 9.81 m/s^2.

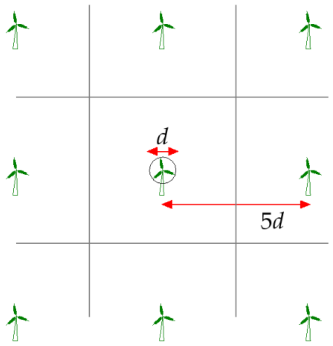
Answer:

Generator voltage	400	415	6300	10500	11000	V
Electrical output of generator (no overload capacity)	**2145**					kW_{el}
Thermal output (Engine cooling / lube oil / 1st stage HT mixture cooler)		**1155**		**1202**		kW_{th}
Thermal output (2nd stage LT mixture cooling)		**140**		**144**		kW_{th}
Total energy input		**5139**		**5299**		kW
Thermal output by 120°C (8% tolerance)		1204		1263		kW
		NOx < 500	|	**NOx < 250**		mg/m_n^3

(f) **(5 points)** Calculate electrical efficiency of an ideal combined heat and power (cogeneration) plant for generator voltage of 0.4 kV with respect to the data for $NO_x < 500$ mg/m_{n^3} in the above figure. (Assume whole produced energy is utilised and consumed on-site.)

Answer:

3. Please note that if you write down "*I would prefer to use my ASSIGNMENT score instead of solving this question.*", then your assignment score will be accepted, otherwise your answers to the question will be evaluated.
Declaration:



(a) **(5 points)** Consider a wind park with a layout as shown in the above figure in which d corresponds to the rotor diameter of each wind turbine. Prove that,

$$P = \frac{\pi}{100}\eta_c \frac{1}{2}\rho v^3$$

where P is the power per area, ρ is the mass density of the air ($\rho = 1.3$ kg/m^3), η_c is the conversion efficiency of the wind turbine, and v is the average wind speed.

Answer:

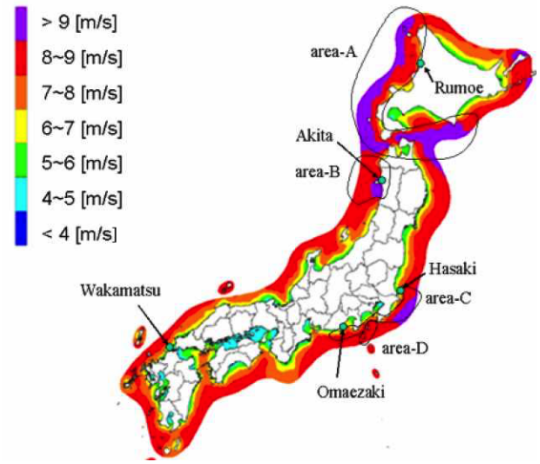
(b) Answer the following questions regarding virtual power plants (VPPs).

(a) **(2 points)** Define the concept of VPP.

(b) **(5 points)** Elaborate different types of VPPs with their advantages and disadvantages.

(c) **(3 points)** Name three projects for operational VPPs in the EU.

(d) **(5 points)** Discuss the current regulations for VPPs from the perspective of Turkish Electricity Market.



(e) **(10 points)** In this question, only shallow offshore wind will be considered (due to the high Japanese population density). The Japanese coastline is rather steep. For distances larger than 2 km out of the coastline, the average depth of the Pacific and Japanese Sea, is deeper than 25 m. The above figure shows the average wind map around Japan. The Japanese coastline as depicted in the figure has a total length of 5,700 km.

Consider that,

- 35% of the Japanese coastline is deployed with shallow offshore wind farms.
- The wind turbines have a conversion efficiency of 50%.
- The population of Japan is approximately 125.9 million.

According to the aforementioned data, calculate how much energy per day per person can be generated using the wind in the Japanese coastline?

Answer:_____