ADANA ALPARSLAN TÜRKEŞ
SCIENCE AND TECHNOLOGY UNIVERSITY

EEE7196 - Sustainable Energy
Midterm Exam

Announcement: 13 Apr 2023, 11:00
Deadline: 20 Apr 2023, 11:00

Full Name : _____ Student ID: _____

Grade Table (for Lecturer use only)

Question	Points	Score
1	35	
2	40	
3	25	
Total:	100	

Instructions for Midterm Exam

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

- You have exactly 7 days to solve the exam. It has to be received by me at 11:00 on 20 April 2022. ABSOLUTELY NO EXTENSIONS. Late submission will be severely penalised.
- The only option for submission is by e-mail with scanned and signed images by your own handwriting in one PDF file.
- E-mail problems will not be accepted as an excuse for late submissions. It is your responsibility to make sure that your e-mail works properly and that I receive the submission on time.
- This exam is "open book" which means you are permitted to use any materials handed out in class, your own notes from the course, the text book, and anything on the EEE7196 - Sustainable Energy course website.
- The exam must be taken completely alone. Showing it or discussing it with anybody is forbidden, including (but not limited to) the other students in the course in current or previous years.
- Make an effort to make your submission clear and readable. Severe readability issues may be penalised by grade.
- Please sign the below Honour Code statement.

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)** Describe the relationship between energy and power. Match the following units with either energy or power: hp, J, W, and Wh.

   (b) **(5 points)** What is the electrical efficiency of a coal-fired power plant that instantly generates 750 MW of electric power and typically consumes 9,000 tonnes coal per day? The coal has a calorific value of 20 GJ/t.

   Answer:_____

   (c) **(5 points)** What do TSO and DSO stand for? Describe these terms from the perspective of Turkish Electricity Market.

   (d) **(10 points)** Write down the four main types of grid-connected inverters according to the their implementation topologies and types of power converters used within those topologies.

      1.

      2.

      3.

      4.

   (e) **(10 points)** Draw an IV-curve for a PV cell under illumination and depict V_{OC}, I_{SC}, V_{MPP}, I_{MPP}, and P_{MPP} on the IV-curve.

2. Suppose that you have a small house in the countryside which is not connected to the grid. The place enjoys 4 equivalent sun hours. Therefore, you have decided to install a stand-alone PV system to supply the demand of your house.

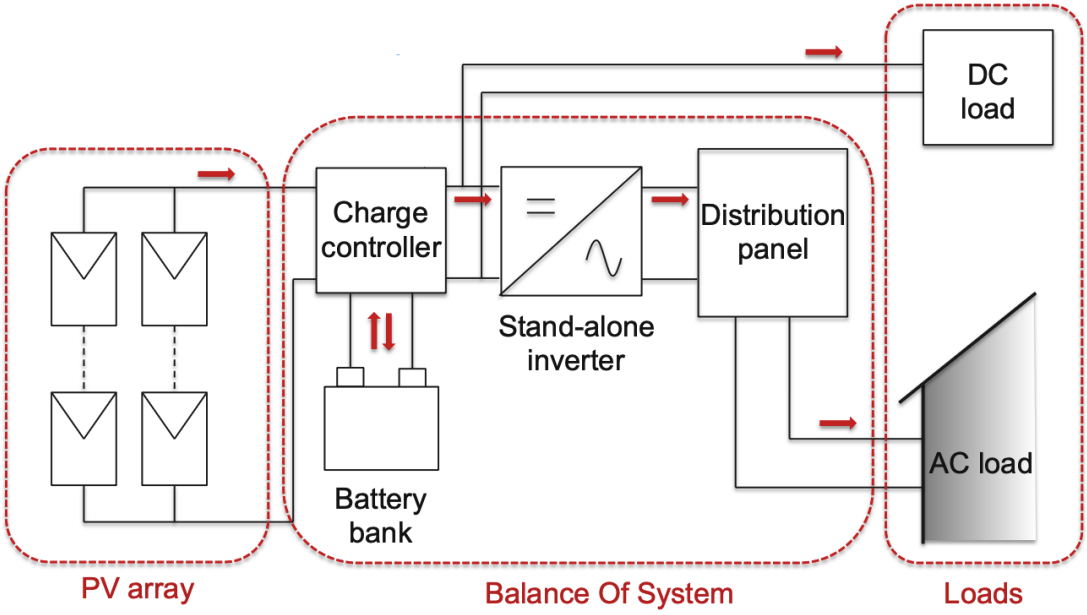

Figure 1: An illustration of a stand-alone PV system

Electrical needs of the house are summarised in the below table.

Load	Quantity	Power per Item (W)	Time of Use (h)	Type
Incandescent Lamp	4	25	3	DC
TV	1	100	2	AC
Laptop	1	100	1	AC
Refrigerator	1	75	24	AC
Wi-Fi Router	1	10	24	AC

Design the system in accordance with the followings:

- Assume that the days of autonomy is equal to 2, the combined efficiency for the cables, the charge controller, and the battery system is 90%, and the stand-alone inverter efficiency is 95%.
- PV Module Characteristics:

P (W_p)	V_{mpp} (V)	I_{mpp} (A)	V_{oc} (V)	I_{sc} (A)
250	30.78	8.13	37.44	8.90

- MPPT Charge Controller Specifications:

V_{max} (V)	I_{max} (A)	$V_{operational}$ (V)
150	35	12/24

- Battery Features:

Depth of Discharge (%)	$V_{battery}$ (V)	$C_{battery}$ (Ah)
70	12	135

Answer the following questions according to the aforementioned instructions.

(a) **(15 points)** Calculate how many panels are required to supply the demand and determine the connection configuration of panels.

Answer:

(b) **(15 points)** Calculate how many batteries are necessary for your design and determine the connection configuration of batteries.

Answer:

(c) **(10 points)** Calculate size of the stand-alone inverter for your design.

Answer:

3. **(25 points)** Calculate electrical energy generation unit cost of a 10 MW CSP plant with a unit equipment cost of \$3,000 per kW (including thermal energy storage), a power plant lifetime (ℓ) of 10 years, a capacity factor of 48%, a land price of \$10 per m^2, and a valuation ratio (ξ) of 20% per year by taking into account the followings:

   - In layout planning of the plant,
     - 10 m^2 area is needed for deploying 1 m^2 heliostat,
     - Heliostats will be placed by leaving a margin of 10%,
     - For other equipment, an additional area will be reserved which corresponds to the half of the area occupied by the heliostats.
   - Net power capacity of each heliostat is 0.285 kW/m^2.
   - Average solar insolation per year is 1,940 kWh/m^2.

Answer:_____