



FACULTY OF SCIENCE

DEPARTMENT OF GEOGRAPHY, ENVIRONMENTAL MANAGEMENT & ENERGY STUDIES

MODULE	ENS8X04 ENERGY TECHNOLOGY
CAMPUS	APK
EXAM	NOVEMBER 2021

DATE 11 NOVEMBER 2021

SESSION 08:30 – 11:30

ASSESSOR(S)

DR KRISTY LANGERMAN

EXTERNAL MODERATOR

JOANNE CALITZ (ENERTRAG SA)

DURATION 3 HOURS

MARKS 300

NUMBER OF PAGES: 4 PAGES

Dr K.E. Langerman

Ms J. Calitz

INSTRUCTIONS:

1. Please answer any THREE of the five questions below.
2. If a question is selected, all components of the question should be answered.
3. The format of the answer (essay, paragraph or bullets) and the mark allocation is indicated for each question.

4. Calculators are permitted.
5. **The use of cell phones, email and/or the internet** (except for Blackboard, for students writing remotely) during the examination period **is NOT allowed**.
6. References are not required.
7. **There is to be no communication between students whatsoever between 08:00 and 12:00.**
8. The only communication permitted between 08:00 and 12:00 is with the examiner.
9. No person may assist you in any way to answer the exam questions.
10. The following schedule must be adhered to for students writing remotely:

Time	Action
08:00	Log on to Blackboard and find the exam question paper under Energy Technology – Exam: 11 November 2021. Read the question paper.
08:00-08:30	Email/whatsapp any questions for clarification to the examiner at klangerman@uj.ac.za / 083 704 2543.
08:30-11:30	Write or type your answers to the questions. (If typing, save your file every few minutes as you go along.)
11:30	Stop writing. Exam question paper will be removed from Blackboard.
11:30-12:00	If typing , ensure all your answers are saved in one file. If answers are hand-written , scan your answers. The best way to do this is by downloading the (free) Adobe Scan app onto your cell phone. Scan your answers by taking a series of photographs of the pages with your phone (through the app) and saving as a pdf document. Upload your answers to Blackboard through the Submit exam link found under Exam: 11 November 2021. If any technical problems with Blackboard are experienced, please email exam answers to klangerman@uj.ac.za .
12:00	Deadline for uploading exam answers to Blackboard.

11. Exam answers will be subject to a plagiarism test. Answers that are plagiarised, even in part, will receive zero. The disciplinary process will be followed for those found guilty.

12. If any technical problems are experienced during the exam, please send a screen shot and email/whatsapp to Kristy Langerman (klangerman@uj.ac.za; 083 704 2543).
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QUESTION 1

Sustainable transport. Answer the following questions in paragraph or bullet format:

- a. Discuss three drivers for sustainable transport. [15]

Any three of the following or another suitable driver [5 marks each]

- Air pollution
- Greenhouse gas emissions
- Other environmental impacts
- Technology
- Congestion
- Regulation
- Urbanisation

[Question is vague so need to allow latitude]

- b. Identify five measures that may be implemented to promote sustainable transport. For each measure, explain how it works and how it improves transport sustainability. [75]

For each of the measures:

- Measure [5 marks]
- Explanation of how it works [5 marks]
- How improves transport sustainability [5 marks]

Measures may include:

- Alternative fuels
- Vehicle technologies
- Mass transit infrastructure
- Smart mobility
- Reducing demand e.g. through full-cost pricing, parking controls, trip avoidance, traffic bans

- c. Which initiative/technology do you think should be prioritized in the South African context and why? [10]

Initiative/technology – 3 marks

Reason – 7 marks

Total: [100]

QUESTION 2

Baseload power is traditionally supplied by either coal-fired power plants or nuclear power plants. Answer the following questions in paragraph format:

- a. Compare and contrast the environmental, economic and technical advantages and disadvantages of coal and nuclear generation technologies. [90]

Assign marks using essay scoring.

Environmental: 30 marks

Economic: 30 marks

Technical: 30 marks

- b. In your opinion, which technology is preferred in the South African environment and why? [10]

Assign marks using essay-type scoring. [10 marks]

Total: [100]

QUESTION 3

Discuss the challenges of integrating electricity generated from renewable sources in the grid, and assess the effectiveness and maturity of three potential solutions to the problem of grid integration. The answer should be in essay format.

Mark allocation:

Challenges of integrating renewable energy [40 marks]

(Include variable output from renewable sources; problems with increased output of renewable generation incl. short-term fluctuations: rapid ramp-up and ramp-down; medium-term fluctuations; network congestion)

For each of three solutions:

- identify solution [5 marks]
- effectiveness [10 marks]
- maturity [5 marks]

[100]**QUESTION 4**

Consider the case of a concentrating solar plant (CSP) with thermal energy storage. Answer the following questions in paragraph or bullet format. The workings of equations should be shown.

- a. Calculate the overall efficiency of a CSP, if 80% of the incident radiation is absorbed by the receiver (optical efficiency), the receiver has an efficiency of 50%, the turbine has an efficiency of 50% and the generator has an efficiency of 98%. [10]

Answer: Efficiency = $0.8 \times 0.5 \times 0.5 \times 0.98 = 0.196$ or 19.6%

[5 marks for correct equation and 5 marks for correct answer]

- b. State the first and second laws of thermodynamics and explain how both laws apply in a CSP. [40]

First law of thermodynamics: energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another [10 marks]

Second law of thermodynamics: the entropy of any isolated system always increases (or variation thereon) [10 marks]

Application in a CSP [10 marks for each law]

- c. Compare and contrast the operation and output of CSPs and solar photovoltaic (PV) installations. [40]

Operation of CSPs [15 marks]

Operation of PVs [10 marks]

Output of CSPs – AC [5 marks]

Output of PV – DC [5 marks]

Extended generation time of CSP relative to PV because of storage [5 marks]

- d. Comment on and account for the role of solar PV and CSP in South Africa's current and future energy mix. [10]

Solar PV 1 000 MW per year new capacity from 2026 – second most new capacity after wind. (Also embedded generation). No more CSP to be built [5 marks].

Reason for preference of PV (cost) [5 marks]

Total: [100]

QUESTION 5

Wind power. Answer the following questions in paragraph or bullet format. Equations and diagrams may also be used.

- a. Explain the operation of a modern horizontal wind turbine, including factors that determine the amount of power generated and the main components of a wind turbine. [30]

Factors that determine amount of power generated [5 marks]: length of turbine blade, wind speed. Can mention

$$\text{Power} = \frac{1}{2} \rho A v^3$$

Where

ρ is air density (kg/m³)

A is swept area (m²)

v is velocity

Components and operation [5 points, 5 marks per point]

- Blades with airfoil cross-sections. Lift force rotates blade.
- Blade is tilted in order to align with relative wind speed.
- Wind turbine rotates too slowly for generator. Speed increased in a gearbox before connected to generator.
- Brake to stop the wind blades from rotating when wind speeds are too high.
- Electricity transported via cable to base where voltage stepped up by step-up transformer.
- Velocity sensor measures wind speed and direction. Sent to electronic controller connecting to yawing mechanism to align with wind direction.
- Blade tilting mechanism to ensure proper alignment with relative velocity.
- Produces alternating current

- b. Explain the process in South Africa by which wind energy is procured on a grid level. [20]

Essay-type marking

- c. Discuss siting considerations for new wind farms [10]

[any 5 factors, 2 marks per factor]

- Distance to houses and roads
- Wind resource
- Environmental impact e.g. protected areas
- Grid connection
- Local acceptability

- d. Explain the four phases of a typical wind farm construction timeline

[For each phase, 5 marks for identification of the phase and 5 marks for the explanation]

- i) Project development
- ii) Construction
- iii) Operation (and maintenance)
- iv) Decommissioning

[40]

Total: [100]

TOTAL [300]
