UNIVERSITY OF JOHANNESBURG

# FACULTY OF SCIENCE

**DEPARTMENT OF GEOGRAPHY, ENVIRONMENTAL MANAGEMENT & ENERGY STUDIES**

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|---|---|
| **MODULE** | **ENS0037**<br>ENERGY ECONOMICS |
| **CAMPUS** | **APK** |
| **EXAM** | **NOVEMBER 2020** |

**DATE** **03 NOVEMBER 2020** **SESSION** **08:00 – 12:30**

**ASSESSOR(S)** **MS LUNGILE MASHELE**

**EXTERNAL MODERATOR** **MS JOANNE CALITZ**

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Lungile Mashele Joanne Calitz

**DURATION** **4 HOURS** **MARKS** **100**

**INSTRUCTIONS:**

1. Please answer **ALL Questions**
2. Answers are to be written as short essays or bullet points, with tables, graphs and diagrams where these may be appropriate to enhance your answer.
3. The mark allocation is shown next to each question.
4. Answers are to be written on A4 white paper.
5. Write your student number and the course code/course name clearly at the top of the first page of your answers.
6. You may type your answers or write by hand. Hand drawn diagrams may be used to supplement answers.
7. If you type your answers, please use Arial 12 font and portrait mode A4 and save all your answers in one file.
8. Clearly number the answers to the questions.
9. Since the examination is open book, you are allowed to refer to course material.
10. The use of cell phones, email and/or the internet (except for Blackboard) during the examination period is NOT allowed.
11. Calculators are permitted.
12. There is to be no communication between students whatsoever between 08:00 and 12:30.
13. The only communication permitted between 08:00 and 12:30 is with the examiner.
14. No person may assist you in any way to answer the exam questions.
15. References are not required.
16. The following schedule must be adhered to:

| Time | Action |
|---|---|
| 08:00 | Log on to Blackboard and find the exam question paper under Energy Economics – Exam. Read the question paper. |
| 08:00-08:30 | Email any questions for clarification to the examiner at lungile.mashele@gmail.com. The examiner will respond to the questions in the order received. |
| 08:30-12:00 | Write or type your answers to the questions. (If typing, save your file every few minutes as you go along.) |
| 12:00 | Stop writing.<br>Exam question paper will be removed from Blackboard. |

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|---|---|
| 12:00 – 12:30 | If **typing**, ensure all your answers are saved in one file.<br><br>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.<br><br>Upload your answers to Blackboard through the **Submit exam** link found under Exam.<br>If any technical problems with Blackboard are experienced, please email exam answers to lungile.mashele@gmail.com. |
| 12:30 | Deadline for uploading exam answers to Blackboard. |

17. 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.

If any technical problems are experienced during the exam, please send a screen shot and email/whatsapp to Lungile Mashele (lungile.mashele@gmail.com; 082 443 1136).

## QUESTION 1

Gourikwa is an Eskom owned plant in the Western Cape. The plant has an installed capacity of 750MW. In December 2019 however, the plant ran for only 30 days, 22 hours a day.

1. Calculate the December 2019 capacity factor for Gourikwa 88.71%
2. Why was the December 2019 capacity factor so high/low? High, supply constraints, stage 6, maintenance, nuclear
3. On the 9th of December, Eskom implemented stage 6 loadshedding – why did we not use Gourikwa to minimise loadshedding? Diesel
4. Calculate the annual capacity factor assuming the run time was 6 hours a day for 216 days in 2019. 14.79%

**[20%]**

## QUESTION 2

**Table 1b. Estimated levelized cost of electricity (unweighted average) for new generation resources entering service in 2023 (2018 $/MWh)**

| Plant type | Capacity factor (%) | Levelized capital cost | Levelized fixed O&M | Levelized variable O&M | Levelized transmis-sion cost | Total system LCOE | Levelized tax credit[1] | Total LCOE including tax credit |
|---|---|---|---|---|---|---|---|---|
| **Dispatchable technologies** | | | | | | | | |
| Coal with 30% CCS[2] | 85 | 61.3 | 9.7 | 32.2 | 1.1 | 104.3 | NA | 104.3 |
| Coal with 90% CCS[2] | 85 | 50.2 | 11.2 | 36.0 | 1.1 | 98.6 | NA | 98.6 |
| Conventional CC | 87 | 9.3 | 1.5 | 34.4 | 1.1 | 46.3 | NA | 46.3 |
| Advanced CC | 87 | 7.3 | 1.4 | 31.5 | 1.1 | 41.2 | NA | 41.2 |
| Advanced CC with CCS | 87 | 19.4 | 4.5 | 42.5 | 1.1 | 67.5 | NA | 67.5 |
| Conventional CT | 30 | 28.7 | 6.9 | 50.5 | 3.2 | 89.3 | NA | 89.3 |
| Advanced CT | 30 | 17.6 | 2.7 | 54.2 | 3.2 | 77.7 | NA | 77.7 |
| Advanced nuclear | 90 | 53.8 | 13.1 | 9.5 | 1.0 | 77.5 | NA | 77.5 |
| Geothermal | 90 | 26.7 | 12.9 | 0.0 | 1.4 | 41.0 | -2.7 | 38.3 |
| Biomass | 83 | 36.3 | 15.7 | 39.0 | 1.2 | 92.2 | NA | 92.2 |
| **Non-dispatchable technologies** | | | | | | | | |
| Wind, onshore | 41 | 39.8 | 13.7 | 0.0 | 2.5 | 55.9 | -6.1 | 49.8 |
| Wind, offshore | 45 | 107.7 | 20.3 | 0.0 | 2.3 | 130.4 | -12.9 | 117.5 |
| Solar PV[3] | 29 | 47.8 | 8.9 | 0.0 | 3.4 | 60.0 | -14.3 | 45.7 |
| Solar thermal | 25 | 119.6 | 33.3 | 0.0 | 4.2 | 157.1 | -35.9 | 121.2 |
| Hydroelectric[4] | 75 | 29.9 | 6.2 | 1.4 | 1.6 | 39.1 | NA | 39.1 |

1. What is the impact of tax credits in technology selection? Cheaper, more viable
2. As an energy analyst you are asked to select five technologies for possible investment – which technologies would you select based on the parameters in the table above and why? Capacity factor, LCOE, tax credits
3. For large hydropower projects the weighted average LCOE of new projects added over the past decade in China and Brazil was USD 0.040/kWh, around USD 0.080/kWh in North America and USD 0.120/kWh in Europe. For small hydropower projects (1-10 MW) the weighted average LCOE for new projects ranged between USD 0.040/kWh in China, 0.060/kWh in India and Brazil and USD 0.130/kWh in Europe. Explain why these LCOEs are different for the same technology. Geography, technology learning curve, subsidy

**[20%]**

**QUESTION 3**

A renewable analyst at a utility company is assessing the operating economics of four different wind farms that could potentially supply the utility's service area. The operating characteristics for each installation are summarised in the table below:

| Wind farm | Nameplate capacity (MW) | Capacity factor |
|---|---|---|
| A | 275 | 0.25 |
| B | 210 | 0.32 |
| C | 180 | 0.40 |
| D | 145 | 0.46 |

1. What is the approximate total annual output (in MWh) for wind farm B, assuming there are 8,760 hours in a year? 588672
2. Which wind farm should the analyst prioritise for additional evaluation, if the most important decision criterion is highest expected output? C
3. Why is capacity factor not the best measure for technology selection? Uncertainty not reflected, excl. Tx and D, neglects effect on energy security and environment, cost stability unknown

**[20]**

**QUESTION 4**

Consider the following operational information for a power generating plant over the course of a week:

- Nameplate capacity: 350 MW
- Average actual power produced: 305 MW
- Average power price: USD 51.50/MWh
- Average heat rate: 9.4 MMBtu/MWh

1. What is the difference between capacity factor and equivalent availability factor? actual output vs rated energy output and time operational
2. Given the information above, what was the approximate capacity factor for this plant during this week? 87%
3. What factors impact on EAF? Fuel, design, operations
4. Using the techno spread phenomenon, which technology could be paired with this generator? Why? intermittent technologies

**[20]**

**QUESTION 5**

1. Discuss, using a formula, how annual electricity revenue for a gas IPP is calculated by the Regulator. Give an example or a brief explanation for each cost item. AR=PE+O&M+Dep+ROC
2. According to S&P what is the probability of default if a company has a BB rating? 15.4%
3. What consideration do ratings agencies make when issuing a rating? Capacity, collateral, character, covenants

**[20]**

**TOTAL [100%]**

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