FACULTY OF SCIENCE

DEPARTMENT OF GEOGRAPHY, ENVIRONMENTAL MANAGEMENT & ENERGY STUDIES

MODULE	**ENS0037** ENERGY ECONOMICS
CAMPUS	**APK**
EXAM	**NOVEMBER 2021**

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

ASSESSOR(S) **MS LUNGILE MASHELE**

EXTERNAL MODERATOR **MS JOANNE CALITZ**

Lungile M Mashele

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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. The use of cell phones, email and/or the internet (except for Blackboard) during the examination period is NOT allowed.
10. Calculators are permitted.
11. There is to be no communication between students whatsoever between 08:00 and 12:30.
12. No person may assist you in any way to answer the exam questions.
13. 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. Exam question paper will be removed from Blackboard.
12:00 – 12:30	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. 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.

14. 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

Koeberg has a nameplate capacity of 1940MW. The average availability over last 3 years is 79.7%. In the first half of 2021 however the Koeberg capacity factor has been 39%. It is estimated that in 2025 Koeberg will have a run time of 7 650 987MWh.

1.1. Calculate the Koeberg generating capacity for the first half of 2021
756.6MW
1.2. Why was the Koeberg capacity factor so low for 2021?
Long outage
1.3. Forecast the 2025 capacity factor
45%
1.4. Calculate the December 2025 capacity factor assuming Koeberg runs for 25 days and 19 hours a day
64%

[20%]

QUESTION 2

Table 1a. Estimated capacity-weighted[1] levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2026 (2020 dollars per megawatthour)

Plant type	Capacity factor (percent)	Levelized capital cost	Levelized fixed O&M[2]	Levelized variable cost	Levelized transmis-sion cost	Total system LCOE or LCOS	Levelized tax credit[3]	Total LCOE or LCOS including tax credit
Dispatchable technologies								
Ultra-supercritical coal	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*
Combined cycle	87%	$7.00	$1.61	$24.97	$0.93	$34.51	*NA*	$34.51
Combustion turbine	10%	$45.65	$8.03	$45.59	$8.57	$107.83	*NA*	$107.83
Advanced nuclear	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*
Geothermal	90%	$18.60	$14.97	$1.17	$1.28	$36.02	-$1.86	$34.16
Biomass	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*
Battery storage	10%	$57.51	$28.48	$23.93	$11.92	$121.84	*NA*	$121.84
Non-dispatchable technologies								
Wind, onshore	41%	$21.42	$7.43	$0.00	$2.61	$31.45	$0.00	$31.45
Wind, offshore	45%	$84.00	$27.89	$0.00	$3.15	$115.04	*NA*	$115.04
Solar, standalone[4]	30%	$22.60	$5.92	$0.00	$2.78	$31.30	-$2.26	$29.04
Solar, hybrid[4, 5]	30%	$29.55	$12.35	$0.00	$3.23	$45.13	-$2.96	$42.18
Hydroelectric[5]	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*	*NB*

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2021*

[1]The capacity-weighted average is the average levelized cost per technology, weighted by the new capacity coming online in each region. The capacity additions for each region are based on additions from 2024 to 2026. Technologies for which capacity additions are not expected do not have a capacity-weighted average and are marked as *NB*, or *not built*.

[2]O&M = operations and maintenance

[3]The tax credit component is based on targeted federal tax credits such as the production tax credit (PTC) or investment tax credit (ITC) available for some technologies. It reflects tax credits available only for plants entering service in 2026 and the

2.1. What are some of the limitations of evaluating investment decisions using levelized cost of energy (LCOE)?
- Market realities and risks such as uncertainties and pricing are not reflected;
- The generation cost provided refers to plant level and excludes transmission and distribution costs;
- No indication is provided of a technology's effect on energy security or environmental sustainability;
- No indication is given of the stability of a technology's production cost and, therefore, its potential contribution to overall cost stability is unknown.

2.2. In addition to evaluating LCOE, what additional factors do you think should be considered in making technology investment decisions?
Operational costs, policy, regulation etc
2.3. What are the LCOE components of hybrid solar in the US?

Capital cost, fixed O&M, tax credit, transmission

2.4. What impact do tax credits have on technology investment decisions?
Reduce LCOE, technology cheaper

2.5. Based on the LCOE above, which three technologies should the US invest in?
Geothermal, solar and wind

[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

3.1. What is the approximate total annual output (in MWh) for wind farm B, assuming there are 8,760 hours in a year?
588 672MWh

3.2. Which wind farm should the analyst prioritise for additional evaluation, if the most important decision criterion is highest expected output?
Wind Farm C

3.3. Why is capacity factor not the best measure for technology selection?
Technology differentials
Performance differentials

[20]

QUESTION 4

	Week														Annual (Jan - Dec)	
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	YTD	2020
Energy Availability Factor (Eskom EAF)	66.62	67.87	68.50	67.15	68.24	66.90	68.11	69.79	64.72	65.39	65.22	64.76	62.43	64.35	**63.11**	**65.04**
Planned Outage Factor	6.66	7.54	8.76	8.93	7.53	5.92	7.60	9.59	11.85	9.69	12.79	11.59	10.49	11.33	**10.38**	**11.24**
Unplanned Outage Factor	24.77	22.81	20.42	21.32	21.75	24.88	21.90	18.51	21.08	22.57	19.45	21.17	24.52	21.05	**23.51**	**20.88**
Other Outage Factor	1.95	1.78	2.32	2.60	2.48	2.30	2.39	2.11	2.35	2.35	2.54	2.48	2.56	3.27	**3.00**	**2.84**

The following table gives the Eskom EAF for weeks 24 to 37 of 2021.

4.1. Define energy availability factor (EAF)
EAF (energy availability factor) is the percentage of maximum energy generation that a plant is capable of supplying to the electrical grid, limited only by planned and unplanned outages.

4.2. Why is the EAF important for a utility?
Fleet performance
Investment decisions
UCLF/PCLF

4.3. Why is the unplanned outage factor critical to monitor?
Lack of maintenance

Loadshedding
RCA – skills, performance, incentives

4.4. Do you think Eskom's unplanned outage factor is acceptable? Explain your rationale.
No

[20]

QUESTION 5

5.1. Explain some of the funding challenges utilities experience and how they can be resolved.

- IHC/DRC or LCOE revenue methods can cause liquidity problems related to debt interest
- Long construction lead-times require capital much earlier than revenues are produced
- Equity capital for new replacement asset: inflation (even 2%) plus long asset lives makes 'depreciation cash' insufficient
- Equity capital for expansion?

- Moderate capital structure gearing ratio
- Combining old/new assets (of different life cycle stages)
- Matching the profile of cash outflow for debt obligations (principal redemption and interest payments) to the revenue profile
- Capital investment tax incentives that reduce initial tax cash flow
- For self-constructed assets in a regulated environment: recovering (annually, through revenue) the interest incurred, already during the construction period
- Annual transfer of a portion of the equity returns to a non-distributable 'replacement reserve' and 'expansion reserve'
- Responding to the factors/criteria upon which credit risk ratings are assessed (refer rating agencies' credit ratings methodologies)

5.2. Should energy markets be regulated? Explain in context of the recent gas price turmoil in the UK.

[20]

TOTAL [100%]