NATIONAL UNIVERSITY OF LESOTHO

BA EXAMINATIONS

EC4321 – Energy Economics & Policy

January 2024	**100 Marks**	**3 Hours**

INSTRUCTIONS:

1) Answer any two questions from Section A and any two questions from Section B.

2) Explain your answers and show relevant workings *(other useful information is provided in the Appendix)*.

SECTION A

Question 1

a) Given that Lesotho will have to renew its energy policy after 2025, prescribe the process that it has to follow as well as the inputs that need to be considered. **[15]**

b) Discuss five emerging innovative private sector financing mechanisms that Lesotho can exploit to promote green growth. **[10]**

Question 2

a) Every year, the Lesotho Electricity Company (LEC) submits its request for electricity tariff hikes to the Lesotho Electricity and Water Authority (LEWA). Explain the process that LEWA follows when setting electricity tariffs and justify why in most cases the approved tariffs are lower than the ones requested by LEC. **[10]**

b) LEWA introduced the electricity subsidy in the 2019/20 financial year for households in the form of a low lifeline tariff for the first 30 kWh/month and a higher standard tariff for all household consumption above 30 kWh.

i. Briefly discuss other existing methods of implementing lifeline tariffs that LEWA could have chosen. **[5]**

ii. Who are the winners and losers of the current lifeline electricity tariff? Justify. **[5]**

iii. How should the regulator strike the balance between affordability and cost recovery when implementing the lifeline electricity tariff? **[5]**

Question 3

a) Why do regions, including Africa, need to have power pools? **[5]**

b) Discuss five main design factors impacting the performance and outcome of African power pools. **[10]**

c) Recommend what needs to be done to improve the development of African power pools. **[10]**

SECTION B

Question 4

Suppose the total primary energy consumption (E) can be specified in terms of total GDP (Y) as well as country i's GDP shares (S) and energy intensities (I) as follows:

$$E_t = \sum_i Y_t \frac{Y_{i,t}}{Y_t} \frac{E_{i.t}}{Y_{i,t}} = \sum_i Y_t S_{i,t} I_{i,t} \tag{1}$$

and the change in total primary energy consumption between the base year 0 and the year t can be decomposed in the following format:

$$\Delta E_{\text{tot}} = E_t \text{-} E_0 = \Delta E_{\text{out}} + \Delta E_{\text{str}} + \Delta E_{\text{int}} \tag{2}$$

where the activity (or output) effect, structural effect, intensity (or efficiency) effect and the estimated change in total primary energy consumption are given by

$$\Delta E_{\text{out}} = \sum_i w_{i,t} \ln(Y_t / Y_0) \tag{3}$$

$$\Delta E_{\text{str}} = \sum_i w_{i,t} \ln(S_{i,t} / S_{i,0}) \tag{4}$$

$$\Delta E_{\text{int}} = \sum_i w_{i,t} \ln(I_{i,t} / I_{i,0}) \tag{5}$$

$$\Delta E_{\text{tot}} = E_t \text{-} E_0 = \sum_i w_{i,t} \ln\left(\frac{Y_t S_{i,t} I_{i,t}}{Y_0 S_{i,0} I_{i,0}}\right) \tag{6}$$

respectively, with the logarithmic weighting scheme captured by

$$w_{i,t} = L(E_{i,t}, E_{i,0}) = \frac{(E_{i,t} \text{-} E_{i,0})}{\ln(E_{i,t} / E_{i,0})} \tag{7}$$

a) Using the provided information and the dataset in Table 1, determine,

i. Activity (or output) effect; **[5]**

ii. Structural effect; **[5]**

iii. Intensity (or efficiency) effect; **[5]**

Table 1: GDP and total primary energy supply for different regions across the world				
	2015		2020	
Regions	GDP (Trillion Maloti)	Total Primary Energy Supply (Mtoe)	GDP (Trillion Maloti)	Total Primary Energy Supply (Mtoe)
OECD	47,161	6,667	62,597	8,564
Middle East	994	488	1,852	860
Former Soviet Union	891	1,169	1,289	1,588
Europe-Non-OECD	235	124	362	165
China	2,169	1,445	5,453	3,069
Other Asia	2,987	1,440	4,798	2,145
Latin America	2,716	563	4,029	857
Africa	1,034	643	1,726	980
World	***58,187***	***12,539***	***82,105***	***18,228***

b) To what extent do the results in part **a)** confirm or contradict the claim that '*technologies and processes became more energy efficient, while structural factors curbed the power of these technological gains to improve energy intensity*'? Justify. **[10]**

Question 5

Given that you obtained the following estimated models for electricity consumption (ELEC) (measured in kWh) as a function of real GDP (RGDP) (measured in Million Maloti) and real electricity price (PRICE) (cents/kWh) using the two approaches, namely, the autoregressive distributed lag (ARDL) technique (Model 1) and the Kalman filter method (Model 2: average coefficients are reported) over the period 1960-2005:

Model 1 (ARDL):

$$\ln(\widehat{\mathrm{ELEC}}) = -0.014 + 0.46\ln(\widehat{\mathrm{ELEC}_{t-1}}) + 0.98\ln(\widehat{\mathrm{RGDP}}) - 0.10\ln(\widehat{\mathrm{PRICE}})$$

Model 2 (Kalman filter):

$$\ln(\widehat{\mathrm{ELEC}}) = -0.008 + 1.8\ln(\widehat{\mathrm{RGDP}}) - 0.15\ln(\widehat{\mathrm{PRICE}})$$

a) Forecast the electricity demand (in GWh) for 2010, 2015, 2020, 2025 and 2030 using the estimated models and the information provided in Table 2. **[10]**

b) Use the root mean square error and Theil's inequality coefficient to assess which model is more accurate in forecasting electricity demand. Explain your findings. **[10]**

c) Plot the actual and forecasted values of electricity demand from 2010 to 2030 and comment on the observed trends [*Use a single graph*]. **[5]**

Table 2: Real GDP, real electricity prices and electricity consumption						
	Actuals				Forecasts	
Variable	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Real GDP (Million Maloti)	80000	95000	115582	106609	102387	119779
Real electricity prices (cents/kWh)	22	15	28	29	16	25
Electricity consumption (GWh)	350	600	690	750		

Question 6

Consider two technologies – solar and coal. The relevant data for the levelised cost evaluation is given in Table 3. Determine which technology is preferable. Justify. **[25]**

Table 3: Data for investment decision of power technologies		
Details	**Solar**	**Coal**
Capacity (MW)	11	11
Plant cost (M/kW)	484	88
Fixed O&M cost (M/kW/year)	176	15
Variable O&M cost (M/MWh)	35	40
Heat rate (kcal/kWh)	0	1950
Fuel cost (M/Gcal)	0	10
Capacity factor (%)	38	68
Fuel price escalation (%/year)	0	1
Discount rate (%/year)	10	10
Levelised fixed charge rate (%/year)	15	15
Project life (years)	25	25

Appendix [Other Useful Information]

$$\text{RMS Error} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}$$

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^s\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^a\right)^2}}$$

Levelisation Factor:

$$U = \frac{\left[1 - \left(\frac{(1+a)^n}{(1+i)^n}\right)\right]}{(i-a)}\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] = \text{PVF} \times \text{CRF}$$