NATIONAL UNIVERSITY OF LESOTHO

BA SUPPLEMENTARY EXAMINATIONS

EC4321 – Energy Economics & Policy

August 2023	**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) The energy mix gives a group of different primary energy sources from which secondary energy for direct use is produced. On the basis of the trends in global energy mix from *Our World in Data* (from 1800 to 2021), address the following questions:

- ***i.*** How has the global energy mix changed over centuries? **[5]**

- ***ii.*** What sources do we get our energy from and how much of global energy comes from low carbon sources? **[5]**

- ***iii.*** Which countries get the most energy from low carbon sources and why? **[5]**

b) Picture yourself as finance minister of a developing economy. Other countries try to convince you of the moral imperative of cutting your country's greenhouse gas emissions, yet your country is full of problems, from economic instability and inflation to challenges funding public services. Should you capitalise on the green transition? Justify. **[10]**

Question 2

a) Various tariff setting structures can be implemented to ensure long term financial sustainability of the regulated entity. Discuss how the following tariff setting methodologies attempt to achieve this:

- ***i.*** Cost of service regulation. **[5]**

- ***ii.*** Performance-based regulation. **[5]**

- ***iii.*** Revenue-cap regulation. **[5]**

b) Explain the process that the Lesotho Electricity and Water Authority (LEWA) follows when setting electricity tariffs and indicate why in most cases the approved tariffs are lower than the ones requested by the Lesotho Electricity Company (LEC). **[10]**

Question 3

a) On the basis of the theory of policymaking, prescribe the process that one has to follow when designing the national energy policy as well as the inputs to energy policymaking that need to be considered. **[15]**

b) Discuss different types of policy briefs and the factors that one has to bear in mind when developing them. **[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:

$$E_t = \sum_i Y_t \frac{Y_{i,t}}{Y_t} \frac{E_{i,t}}{Y_{i,t}} = \sum_i Y_t S_{i,t} I_{i,t} \quad (1)$$

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

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

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

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

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

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

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

respectively, with the logarithmic weighting scheme captured by

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

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]**

iv. Residual. **[5]**

Table 1: GDP and total primary energy supply for different regions across the world				
	2010		2015	
Regions	GDP (Trillion Maloti)	Total Primary Energy Supply (Mtoe)	GDP (Trillion Maloti)	Total Primary Energy Supply (Mtoe)
OECD	43,841	7,178	46,910	6,873
Middle East	924	525	1,388	690
Former Soviet Union	828	1,258	966	1,274
Europe-Non-OECD	219	133	271	133
China	2,016	1,556	4,087	2,463
Other Asia	2,776	1,550	3,596	1,722
Latin America	2,524	606	3,019	688
Africa	962	692	1,293	786
World	***54,091***	***13,498***	***61,530***	***14,628***

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. **[5]**

Question 5

Suppose 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):

$$\ln(\widehat{\text{ELEC}}) = -0.014 + 0.46\ln(\widehat{\text{ELEC}_{t-1}}) + 0.999\ln(\widehat{\text{RGDP}}) - 0.153\ln(\widehat{\text{PRICE}})$$

Model 2 (Kalman filter):

$$\ln(\widehat{\text{ELEC}}) = -0.008 + 1.792\ln(\widehat{\text{RGDP}}) - 0.165\ln(\widehat{\text{PRICE}})$$

a) Using the estimated models and the information provided in Table 2, forecast the electricity demand (in GWh) for 2010, 2015, 2020, 2025 and 2030. **[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 option is preferable. Justify. **[25]**

Table 3: Data for investment decision of power technologies		
Details	**Solar**	**Coal**
Capacity (MW)	10	10
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 (%)	40	70
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:

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