S-18.3154 Electricity Distribution and Markets Exam
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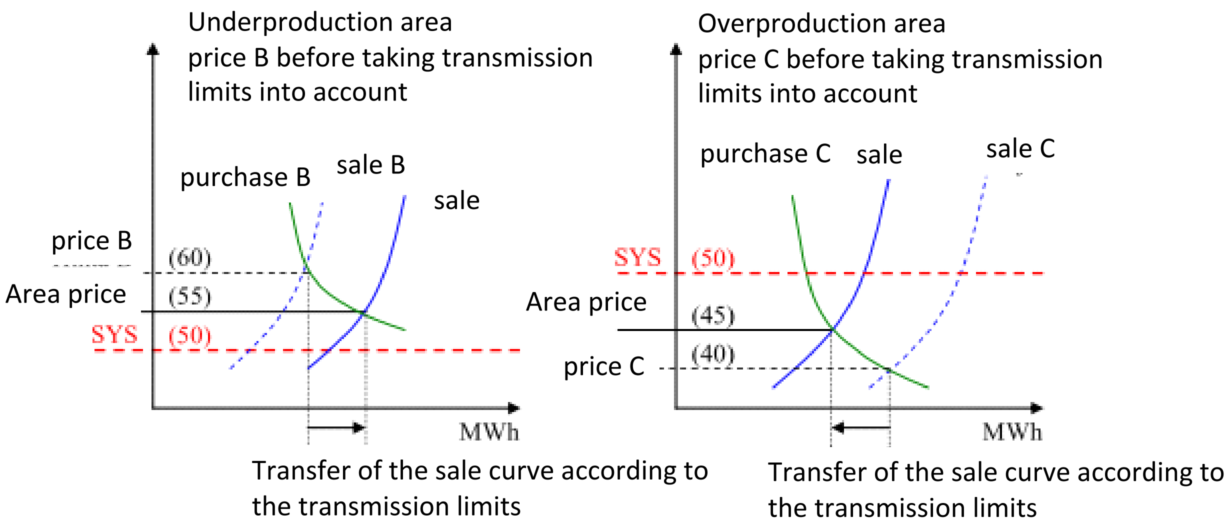
Q1. General

Briefly discuss the following topics

a) List 2 main differences between a disconnector and a circuit breaker?
b) What is a tap changer used for?
c) List 2 benefits of AMR (Automatic Meter Reading).
d) What is the most commonly restricting technical constraint in urban cable networks?
e) What is one major advantage of a resonant earthed MV system in comparison to an isolated neutral MV system?
f) List two main differences between urban and rural distribution networks.

Q2. Markets

Explain the behaviour of the area Elspot prices in the example below where one area is originally an underproduction area and its neighbouring area has overproduction.



Q3. Power Quality

a) ***Some power quality characteristics are given in the table below. What would be typical causes of these disturbances? Who is technically responsible for these power quality issues? Answer on the separate sheet.***

Power quality parameter	Typical cause	Technically responsible			
		G	T	D	C
Interruptions					
Voltage sags	ANSWER TO THE				
Voltage level (magnitude)	SEPARATE SHEET				
Unbalance	ATTACHED TO THE				
Harmonics, interharmonics	EXAM MATERIAL				
Flicker					
Frequency					
Transient overvoltages					

G Generation
T Transmission
D Distribution
C Customer

b) Describe shortly a long interruption, a voltage sag and a voltage swell.

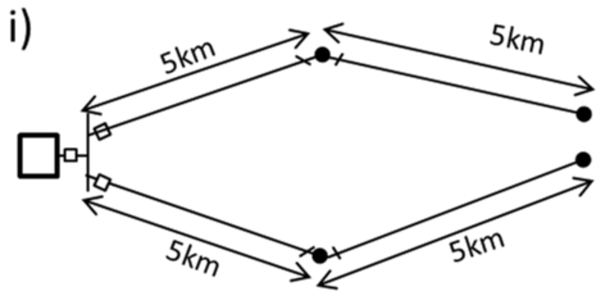
c) Briefly give two examples of power quality phenomena where the characteristic of short circuit power of the power system represents an important role.

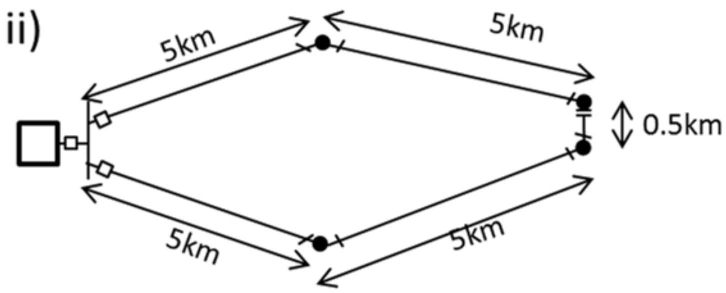
Q4. Economics – investment, losses and interruption

a) ***The following two overhead line networks (i and ii) are technically OK, but which is most economic?***

- The load growth is 3 %/year, the interest rate is 5 %/year and the review period is 40 years.
- The line investment costs are 30 000 €/km.
- The cost of each manual disconnector is 3 000 €.
- The ac line resistance (of one phase) is 0.5 Ω/km.
- The cost of losses is 6 c/kWh.
- The utilisation time for losses (based on maximum demand) is 3000 h/year.
- The fault frequency of the bare conductor overhead lines is 4 faults/100km/year.
- Switch time is 1 hour.
- Repair time is 4 hours.
- All 4 load nodes have 100 kVA maximum demand ($\cos\varphi = 1$) and customer interruption costs of 1€/kW/fault and 10 €/kWh, based on maximum demand.

You may sum the loads to approximate the load flows in each line section.





b) ***What is the cost of the line losses over the 40 year review period?***

This formula may be of use: $\kappa = \gamma \dfrac{\gamma^t - 1}{\gamma - 1}$

where, for load related annual costs: $\gamma = \dfrac{(1 + r/100)}{(1 + p/100)}$

and for loss related annual costs: $\gamma = \dfrac{(1 + r/100)^2}{(1 + p/100)}$

Q5. Technical constraints

A heavily loaded 20 kV urban cable must be built to supply a load node through which the normal initial load is 3.0 MW with a power factor of 0.9_{ind}. The load is projected to increase at an average annual rate of 3 % over the review period of 20 years. In addition, being a main trunk feeder, it is required to cope with double the loading during faults on the adjacent feeder to which it is connected via an open disconnector. Faults on underground cables take a long time to repair, so it can be assumed that the temperature of the cables reaches steady-state conditions when being used for back-up purposes.

The total time from the occurrence of a short circuit fault to the circuit breaker opening is 0.4 s.

The distribution company prefers to use either the AHXAMK-W 3x120 or AHXAMK-W 3x240 XLPE cables in their MV network.

Is one of these cables technically suitable? Justify your answer.

Cable type	r (Ω/km)	x (Ω/km)	Max steady-state load current (A)	$I_{sc,1s}$ (kA)
AHXAMK-W3x120	0.3	0.123	265	11.4
AHXAMK-W3x240	0.15	0.11	375	22.6