1) ***General***

Briefly describe 6 things (these could, for example, be technical, cost or even town planning considerations) **that influence the topology** (the layout) **and/or protection of a distribution network?**

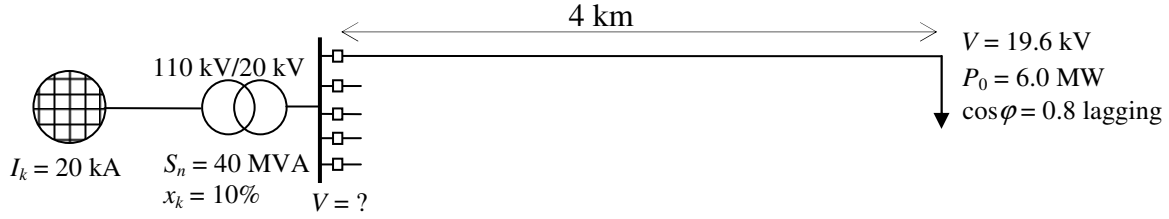
2) ***Regulation***

c) What part of the electricity business requires regulation and why?
d) What are the main principles of this regulation? (You can answer this by specific reference to a particular country's regulation model or in general terms)

3) ***Technical constraints***
Let's say the voltage at the end of a medium voltage distribution feeder is 19.6 kV and that it is feeding a load of 6.0 MW with a power factor of 0.8 lagging.

a) What is the voltage at the busbar of the primary substation?
b) What is the maximum 3 phase short circuit current? Is this OK if the protection operates in 0.4s?
c) What is the minimum 2 phase short circuit current?
d) Do you have any (short!) **comments to make about the accuracy of the calculation method you have used?**

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	9.4



4) ***Economics***

A distribution network company has decided to invest in a substantial amount of new cabling. They forecast installing 100 km of 3-phase 20 kV cable a year for the next 5 years. The cable manufacturer is offering substantial discounts on large purchases.

You must decide whether to:

i) buy 500 km of 240 mm^2 cable at 22.00 €/m

or

ii) 250 km of 185 mm^2 cable at 21.90 €/m and 250 km of 240 mm^2 cable at 26.00 €/m.

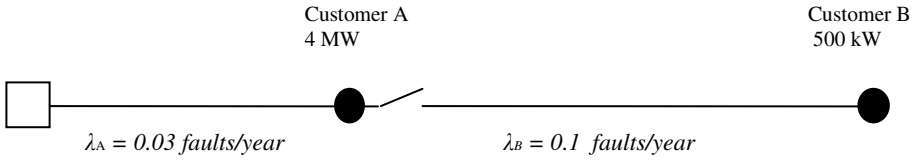
The cable will be bought in the present, but the costs of installing the cables differ, at 65.50 €/m for the smaller section and 70.00 €/m for the larger. Assume that the same amount of each cable type (50 km of each) will be installed each year in option **ii)**.

The interest rate projected for the 5 year period is 5%/year. You do not have to take loss costs into account, but you must calculate the present value of the annual costs of installation over the 5 year period.

a) Which is the cheaper investment?

b) Based on this result, which cable section would you advise should be purchased?

5) ***Reliability***



Should a manually operated disconnector, a remote operated disconnector, a circuit breaker, or no switch be installed in the switch position shown in the diagram (just downstream from customer A)**?**

Repair time for faults in line section B is 4 hours including switching. The disconnectors cannot break fault currents. Load growth is 3% per year and the interest rate is 5% per year. The review period is 20 years.

Customer interruption values	***a*** (€/kW/fault)	***b*** (€/kWh)
Customer A	3.50	30.00
Customer B	0.50	5.00

Switch type	***Operating time***	***Investment cost***
Manual disconnector	1 hour	€3000.00
Remote-operated disconnector	0.1 hour	€12000.00
Circuit breaker	0 hours	€20000.00

Some formulae that may or may not be of help...

$$\kappa = \gamma \frac{\gamma^t - 1}{\gamma - 1}$$

where, for load related annual costs:

$$\gamma = \frac{(1 + r/100)}{(1 + p/100)}$$

and for loss related annual costs:

$$\gamma = \frac{(1 + r/100)^2}{(1 + p/100)}$$