2.3 Network Configuration of 115 kV and 22/11 kV Networks

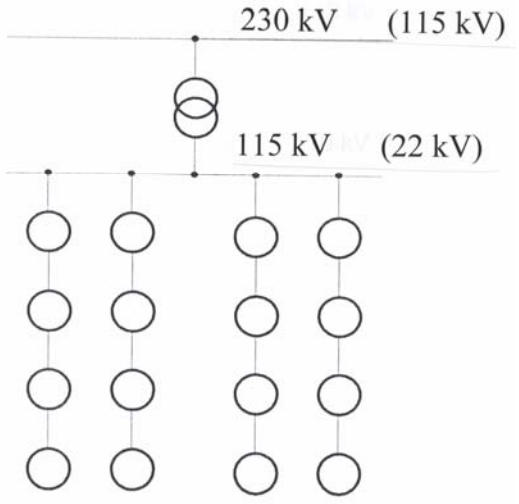
The network configuration influences the

- *availability*
- *loadability of the network components*
- *network protection*
- *investments and costs for operation and maintenance*
- *operation and extension measures*
- *redundancy under consideration of the underlayed network*

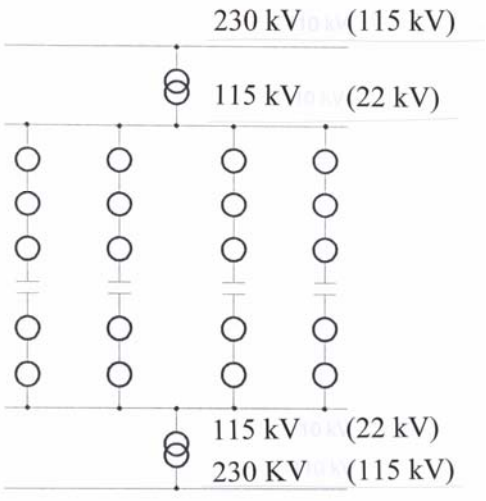
Radial network	
115 kV	**22 kV**
° low availability	° dito
° max 100% of nominal load	° dito
° relative simple protection, staggered over-current or distance protection	° dito - overcurrent at the 22 kV busbar (excitation current < min I_K) - distance protection - fault indicators
° low investments	° dito
° easy to supervise	° dito
° limited redundancy by the underlayed network	° normally no redundancy only in areas with a low load density

Network between corresponding substations	
115 kV	**22/11 kV**
° - acceptable availability - switching over with interruption	° dito
° - max. load of lines > rated load - good utilisation of transformers	° dito
° - over-current, distance and differential protection including bus bars	° over-current and distance protection (fault localisation) by digital relays)
° - average investments - telecontroled supervisory and switching	° dito - automation (partly)
° - operation with care; risk of mis-switching	° dito
° - redundancy (n-1)	° dito
° - only sensful with a small number of looped substations	° one of the usual MV networks 10...20 transformer stations included in one line between two substations

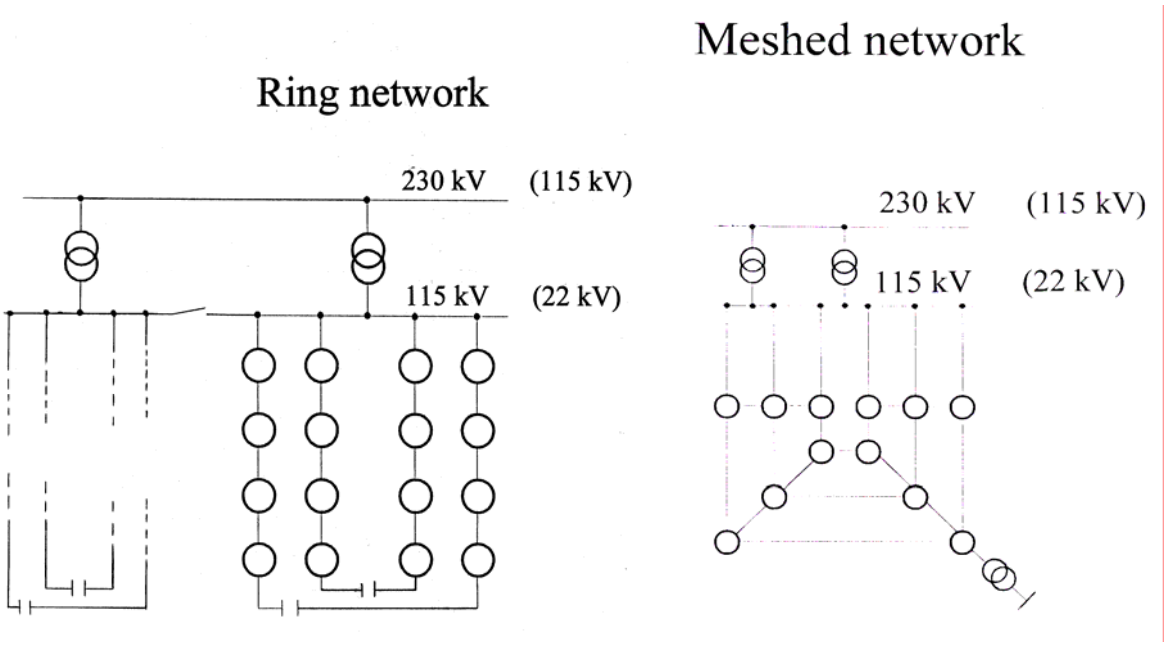
Radial network



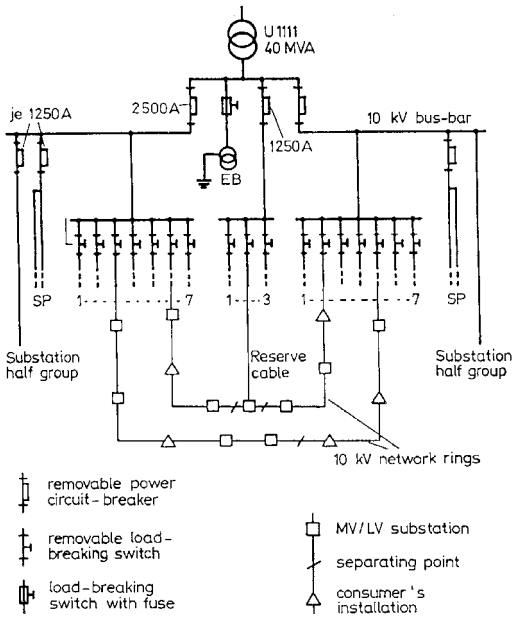
Network between corresponding substations



Ring network	
115 kV	**22/11 kV**
° high availability - switching over without interruption - normally double bus bar at the injection point	° dito ./.
° max. load > 100% of rated load	° 120%...140%
° without disconnection in the middle of the ring: - differential protection - distance protection	° with disconnection radial operated: - over current - distance protection
° suitable investments - telecontroled supervisory and switching - circuit breaker or some load breaking switches	° dito - short circuit indicators - automation measures
° easy to operate	° dito
° redundancy (n-1)	° dito

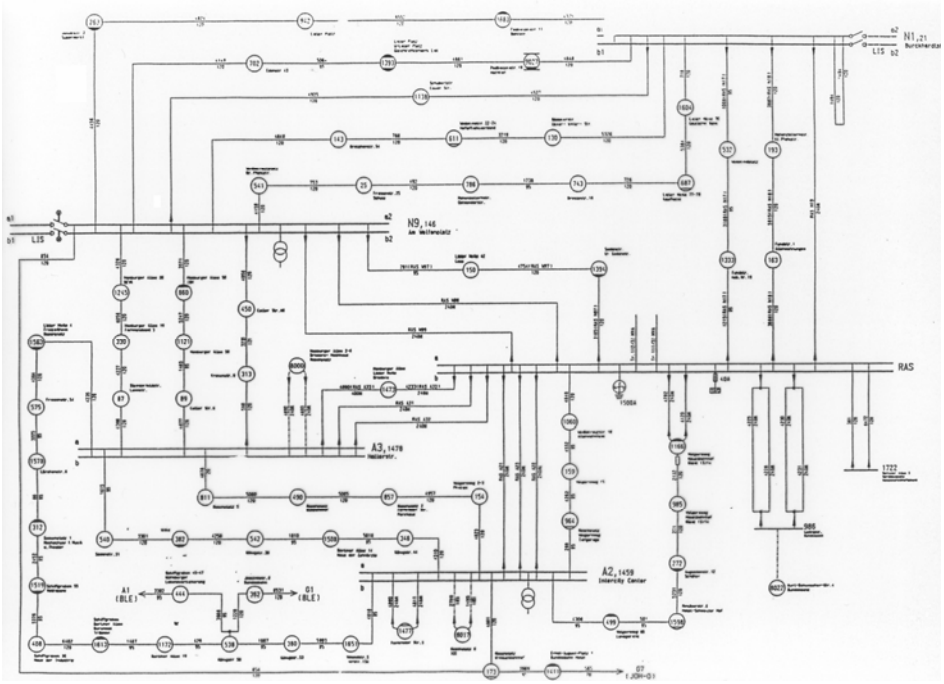


Meshed network	
115 kV	**22/11 kV**
° highest availability	° dito
° load flow must be supervised - load flow control - outage simulation (n-1) - I > 100% acceptable (limited time for n = 0) - minimum losses	° dito
° differential and distance protection	° dito
° investments high - circuit breakers and double busbars - telecontroled system	° dito - circuit breakers, load breaking switch
° extension easy - operation difficult (easy if rate of meshing is systematically reduced	° dito
° high redundancy (meshed rate) - substation HV/MV too with high reliability	° high redundancy



10 kV switchgear installation of compact construction

Most usual networks	
115 kV	**22 kV**
° **transmission network** - simplified meshed - rings included (rare) - lines between corresponding substations - radial lines with redundancy from MV-network as first step of extension	° normally no transmission function
° **distribution** - radial with redundancy by parallel lines - supplying load centres	° **distribution** - ring network (high load density; urban networks) - network between corresponding substations (medium load density, rural areas) - mixture of different kinds



Usual MV network with several types of configuration

Usual LV networks: radial, partly meshed or partly meshed with up to four MV/LV transformer stations