

## 4. Operation - Supervisory & Control Centres

### 4.1 Operation & Control of HV, MV and LV Networks

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#### *Task of the utility:*

*Quality of service and of the product electricity have to be made available (for all) at tariffs as low as possible.*

*This is influenced by the cycles during the lifetime of the network equipment*

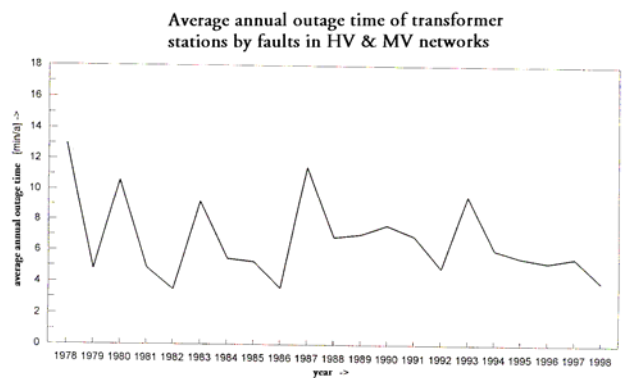
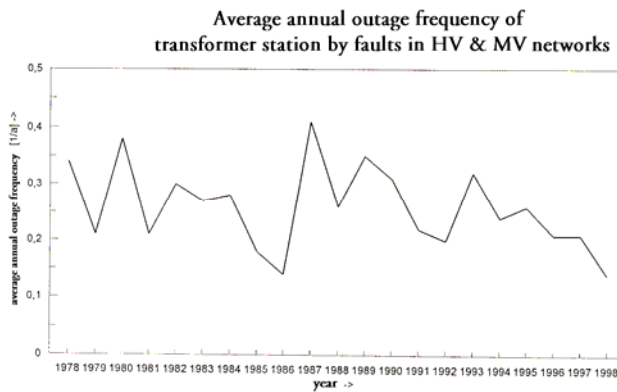
- Basic-planning principles (long term)
- extension planning (middle term)
- project planning (short term)
  
- procurement
- construction of stations and lines
  
- taking into operation
  
- supervising the networks and control measures (current, voltage,  $\cos \varphi$ , temperature, gas pressure, oil quality,... automation devices,
- maintenance
  - > **Control**
  - > **Inspection**
  - > **Repair**
- checking and taking into operation again
- total or partial renewal of network components

#### *Improvement of the network system*

- > considering statistics and details about grave failures and damages with their reasons (feed back from the operation to the planning !)
- > improvement measures in network operation; current, voltage, temperature, ...
- > new methods of measuring and calculation for network supervision; ex.: LV
- > introduction of telecontrol
  
- > *harmonising the measures with the planning principles and including them as influencing factors in the system extension planning reflections.*

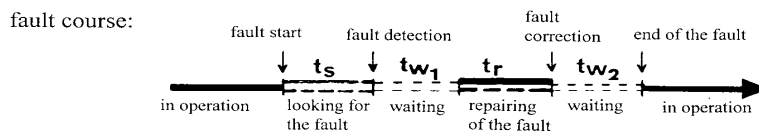
	<i>normal supply</i> $x > 1; NDE = 0$	<i>internal failure</i> $x = 0; NDE = 0$	<i>supply interruption</i> $x < 0; NDE > 0$
economical supply	status 1 $P_{(1)} = 0,990$	↓	
system reliability $T_I = \min$	→	status 2 $P_{(2)} = 0,009$	↓
system reliability $NDE = \min$		→	status 3 $P_{(3)} = 0,001$

**NDE:** Non delivered energy      **T<sub>I</sub>** = Time of interruption      (n - x) components available



Reliability of the service equipment

**Failure duration**



total time of failure       $t_A = t_s + t_{w_1} + t_r + t_{w_2}$

free decision

total delay time       $t_W = t_{w_1} + t_{w_2}$

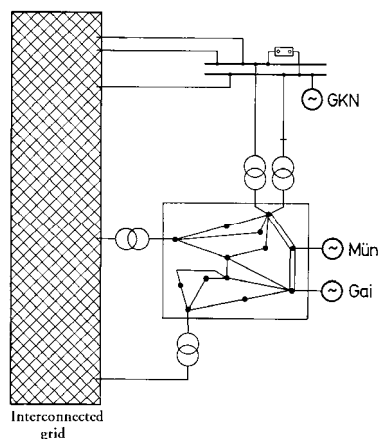
proposal:      statistical registration:  $t_A, t_W$   
 -----      analysis:  $t_A - t_W = t_O$

for reliability calculation: (mean annually) failure duration

$$d_o = \bar{h}_o \cdot \bar{t}_o = \bar{h}_o \cdot \frac{1}{n} \sum_{i=0}^n (t_{A_i} - t_{W_i}) \quad \text{:non-reliability}$$

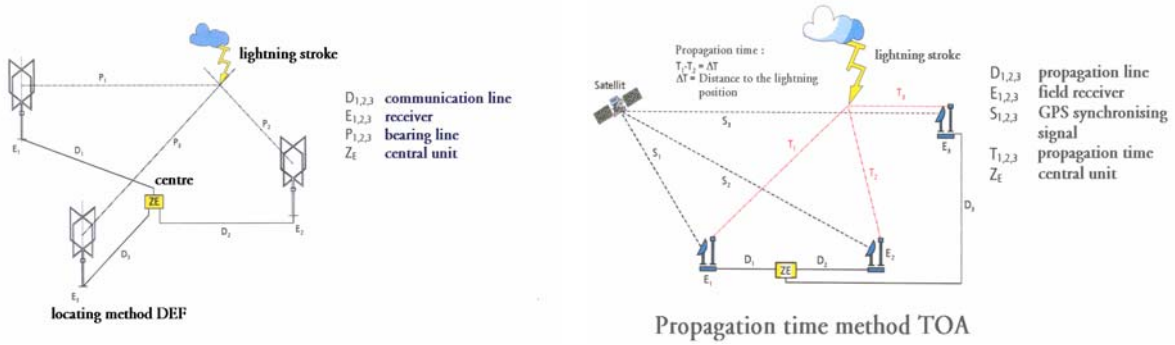
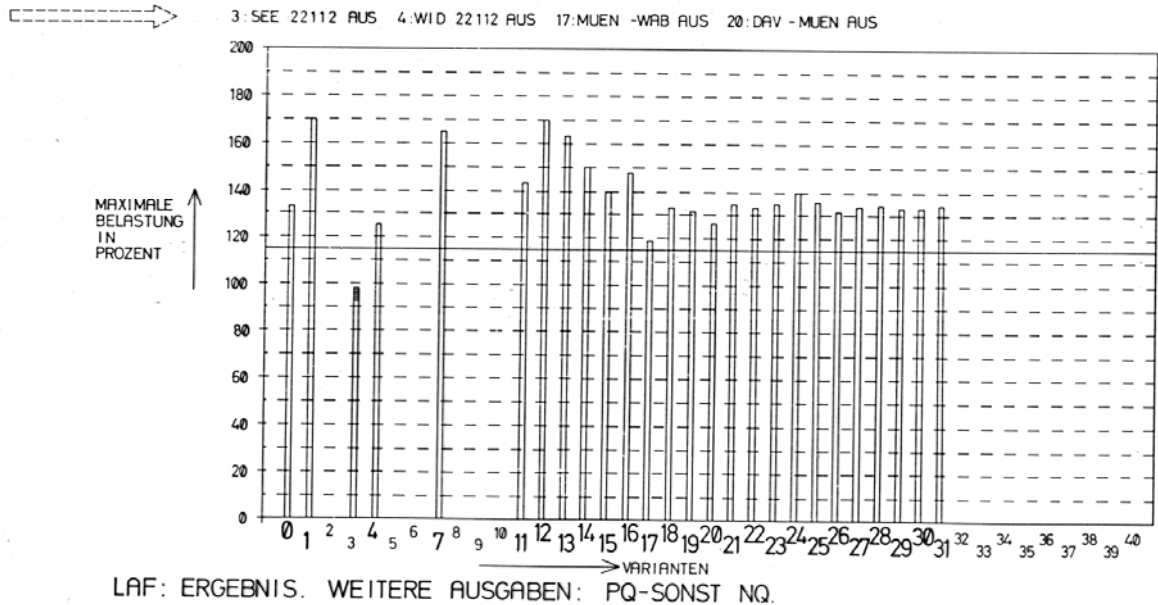
**Information is the base for operational reactions/decisions:**

- all important information
  - with short time delay
  - reliable & precise
  - \* clear rules how to react; responsibility in case of mis-switching etc.
  - \* short reaction time
  - \* acceptable repair time; rules to ensure the supply during the (n-x) time
  - \* technical auxiliary equipment available
- *Exceeding limited currents, voltage, temperature, pressure, ... leads from **undisturbed operation** -> **endangered operation***
- Measures to be done now:
- \* restoring the status 1 as quick as possible
  - \* information about the situation before and during status 2  
(load flow calculations and outage simulation, reactive power flow, tap changer of transformers, load shedding, ..., shifting load, ...)
- ***endangered operation** -> **disturbed operation** with some or many interrupted customers*
- HV -> re-supplying as quick as possible (planned system);  
many customers affected, very short time for re-supply foreseen;  
realisation only by protection and automatic devices;  
interruption time ~ **seconds**
- MV -> re-supplying as quick as possible (less redundancy)  
non delivered energy (NDE) less than in HV networks;  
automatic devices, telecontrol, switching over by hand;  
acceptable interruption time ~ **minutes**
- LV -> re-supplying can too include the repair of lines;  
information concerning outages are coming from customers;  
acceptable interruption time ~ **hours**

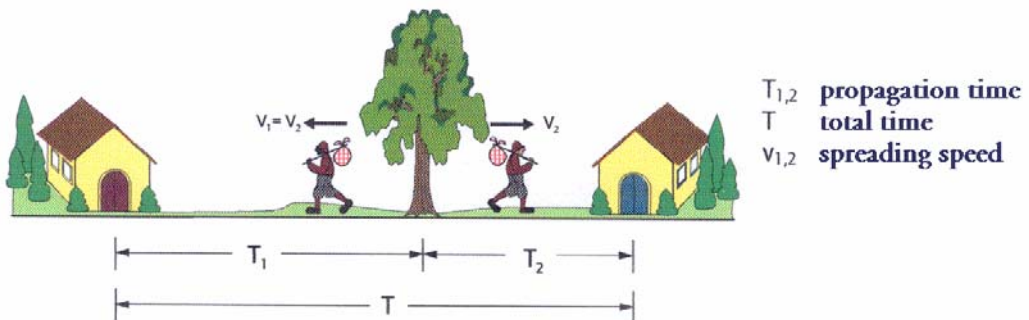


LASTFLUSS AM 05.12.78 09.56.45 UHR

LTGN: MUEN-SEE 1 AUS  
 KPLN:  
 LAST:  
 STUF:  
 GRNZ: L= 115 % , T= 115 % , U= 102-118 KV



### Pinciple of distance measuring



### To cope with operational requirements

- information in case of a fault has to be offered clearly and should give links to the reason of the interruption
- operational staff must be prepared to react correctly in all situations
  - knowing the system very precisely
  - being confidential with the secondary system (protection, telecontrol, transmission of information, logical correlation, .... ("off-line reactions", bounded information in SCC, closed loop, ...)
  - being able to valuate unusual information ( consequences of partial discharges, chemical behaviour of oil, Thermal consequences of over loaded components, ...)

### Main tasks of the network operation

- organisation of the network operation
  - staff has to be available on duty 24 h/day in the SCC
  - call readiness of additional staff for re-supply measures 365 days/year
- transmission networks (420 .. 240 .. 110 kV) have to cope with higher requirements than MV & LV networks
  - different aerial extensions
  - hierarchical organisation of UHV/HV–SCC, MV-SCC, LV-SCC
  - small power utilities: HV + MV networks together in one SCC  
bigger utilities: e.g. 1 x UHV/HV SCC + 3...7 MV SCC
- Operational Planning
  - permissibility of switching situations
  - coordination of maintenance measures
  - annual program for more important interventions
  - coordination of isolated projects (maintenance measures, new lines, ..
  - analysis of short term required taking components out of service
  - planning re-supplying strategies in case of a black out
  - control the compensation grade for compensated networks
  - .....
- Supervisory & control
- Fault analysis and documentation
- Statistics and reporting
- .....

Tools being available to support the operational tasks

- mimic board / projection board
- acoustical & optical signals
- telecommunication systems
- SCADA system, EMS
- interactive AF/FM graphic system
- historical load documentation, load forecast
- online load flow & short circuit calculation programs (security calculation)
- simulation programs (outages, reliability, protection, load shedding, ...)

Tools for MV SCC are simpler

- operational work and indicating the network situation have priority
  - network switching situation (screens, active boards)
  - communication systems (radio, telephone, direct lines, ...)
- distance protection used for fault localisation in extended networks
- switching over without interruption after having calculated the difference current
- control of bus bar voltage and the current in feeders
- organisation oriented at fault clearing and fast repair of damaged devices

LV SCC

- Documentation graphique computer system, maps
- telephone, radio,

Computer:

- workstation : SCADA, EMS, graphic systems, part of the utility wide data management system
- PC : in the offices

Telecommunication systems

- separate utility used systems as
  - telephone
  - radio transmission
  - direct lines
  - data exchange by optical fibres
- public telecommunication systems, including handy and satellite