Remedial actions

- Measures in the customers' installations
- Measures in the grid

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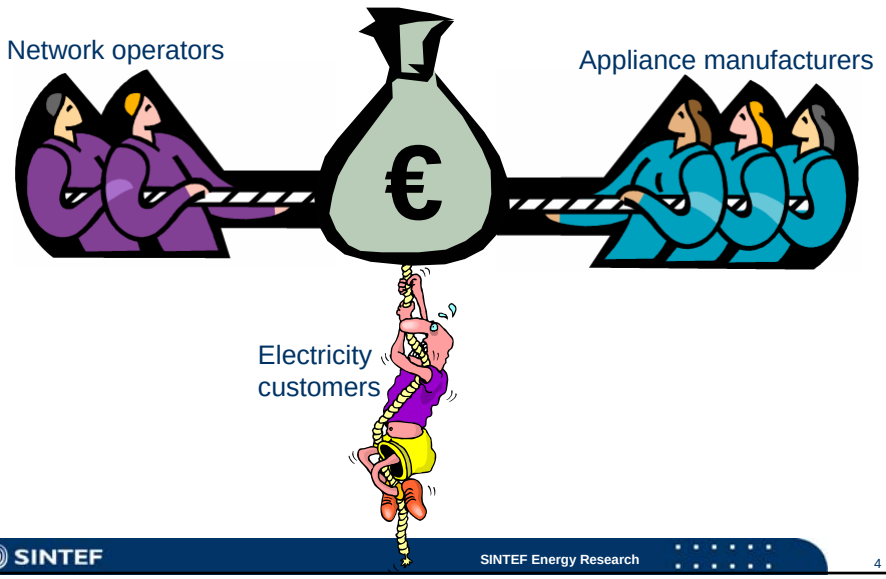
WHERE to perform remedial actions

Considerations and reasons for selecting location:

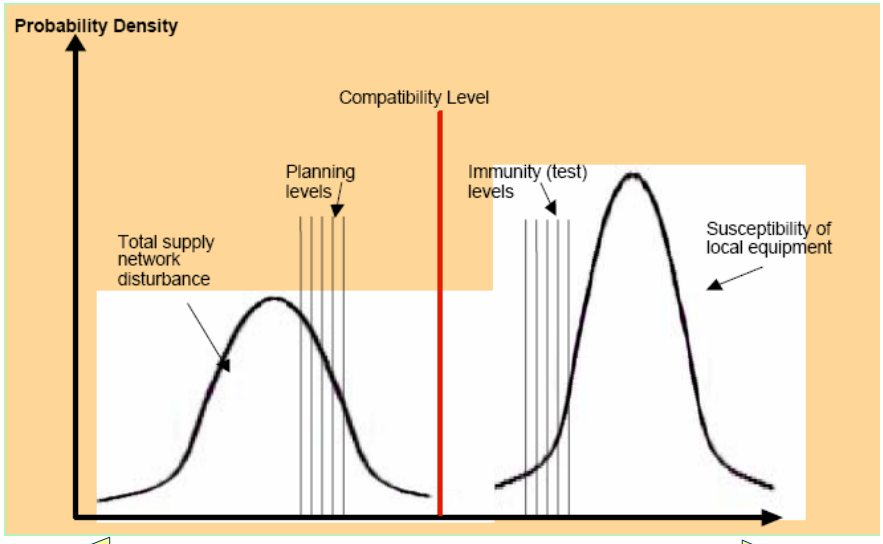
- Technical reasons
- Economic reasons
- Environmental / Esthetic reasons

WHERE to perform remedial actions

WHERE to perform remedial actions



EMC - Emission - immunity



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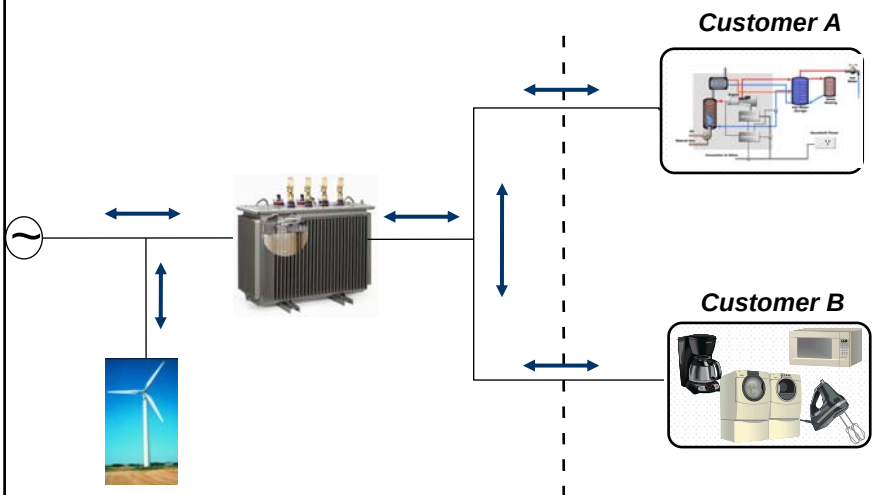
Voltage quality
Interaction and harmonization



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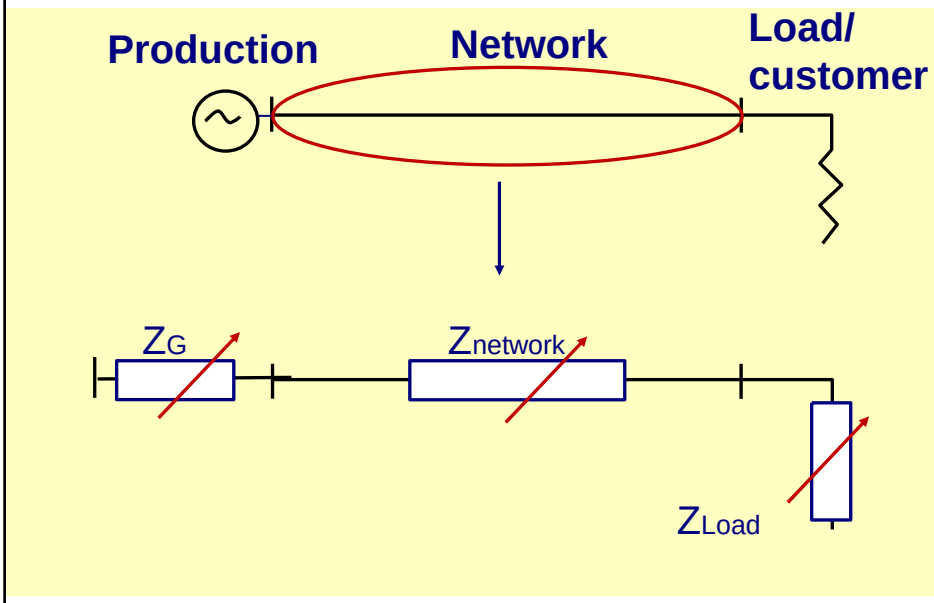
Voltage quality - Interaction



Location and costs of remedial actions

Depend on:

- Voltage quality parameter
- System voltage
- Available technical solutions
- Number of affected customers

Voltage quality parameters – and their “sources”

- Power frequency
- Supply voltage variations
- Supply voltage unbalance
- Single rapid voltage change
- Flicker
- Voltage dips (& Voltage swell)
- Short interruptions
- Long interruptions
- Temporary overvoltages phase-ground
- Transients/Impulses
- Harmonic voltages
- Interharmonic voltages
- Mains signaling voltage

Most parameters are influenced both from end-users loads and the network

Load characteristics
Network impedance

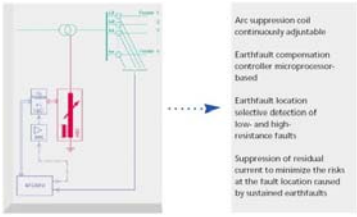
Available technology and system voltage

- Network reinforcements
  - Thicker lines/cables
  - Larger transformer
  - Increasing system voltage
  - etc
- Voltage booster
- STATCOM
- Synchronized switches
- Petersen coils/Arc suppression coils
- Local production (may be both at problem and a solution)
- Grounding
- Protection circuits
- Adjusting protection circuits
- Passive filters
- Active filters
- Maintenance
- Surge arrestors
- Uninterruptible power supplies - UPS
- Soft starters
- Emergency generators
- Load limitations
- ETC…

	Skogn (name of the place)			Frosta (name of the place)		
Year	(1)	(2)	(3)	(1)	(2)	(3)
1990	91	40	5	94	35	4
1991	145	39	8	100	60	1
1992	106	8[4]	4	101	27	5
1993	49	0	1	61	22	3
1994	75	0	5	61	15	2
1995	110	0	4	59	20	3
1996	203	0	7	100	24[5]	1
1997	113	0	8	124	0	1
1998	156	1	0	110	0	0
1999	114	0	5	33	1	2

[1] Temporary earth faults – self extinguishing faults.
[2] Temporary earth faults causing short interruption – auto reclosure.
[3] Sustained earth faults.
[4] **Peterson coil** in operation in Skogn from medium August **1992**.
[5] **Peterson coil** in operation in Frosta from ultimo August **1996**.

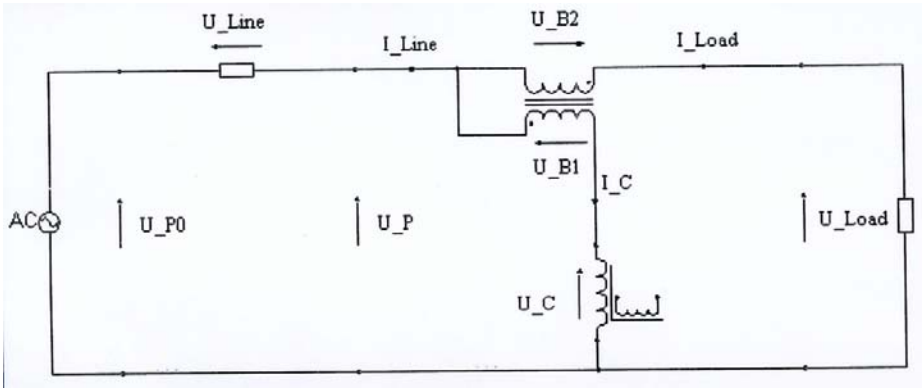
Petersen coil



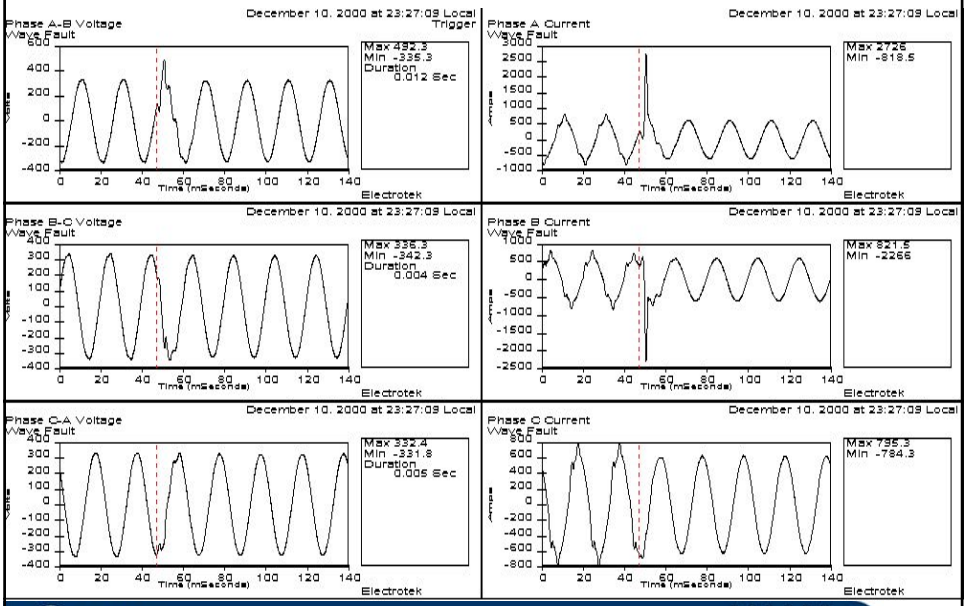
Voltage booster

- Increase the voltage at the far end of distribution lines
- An alternative to for example low voltage network reinforcements

http://www.magtech.no/



Capacitor bank switching at 132 kV



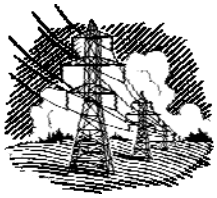
Synchronized switches

- Without synchronized switches increased voltage peak values occur.
- Frequency converters (motor drives) have been verified to handle only 17 % increased voltage before tripping.
- Capacitor bank switching without synchronized switches in network with resonance problems have caused damage to a very large number of equipment and end-user appliances. Peak voltages much higher than the theoretical 2 pu

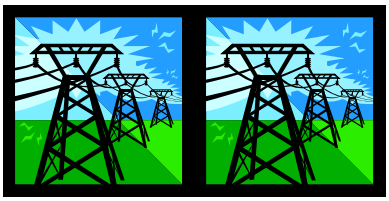
Reliability vs Voltage quality (?)

CASE: GAS treatment and export plant

- 2-side supply (ring)
- Interruptions do not often occur
- The plant trips several times per year due to network related events (mainly voltage dips)
- The events causing trip are mainly supplied through one of the supplying lines -> Single sided supply (from the south) would have reduced the number of plant trip to less than half
- The reason for the events are to a significant extent the network configuration



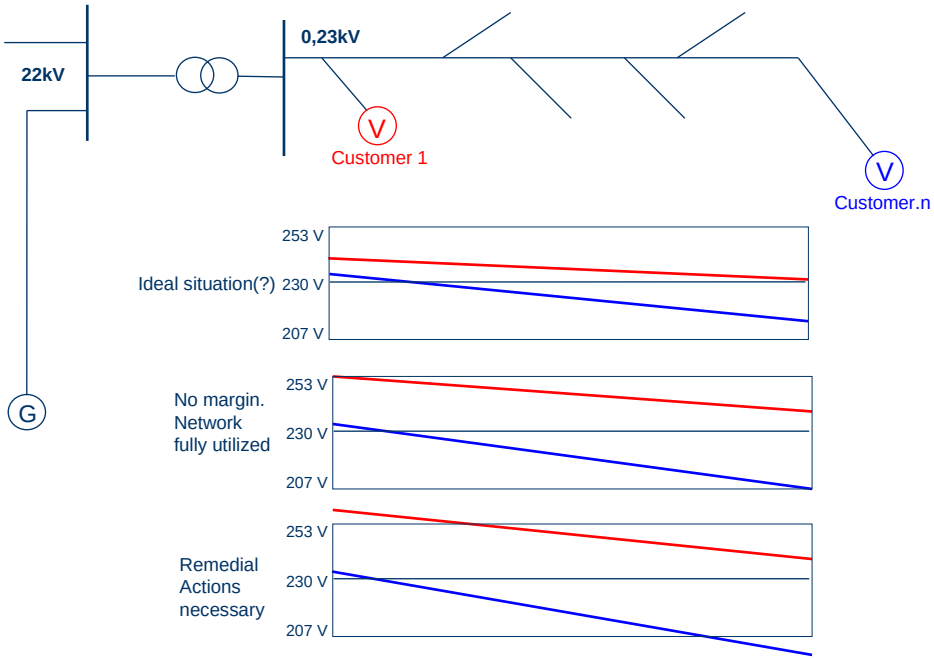
VS

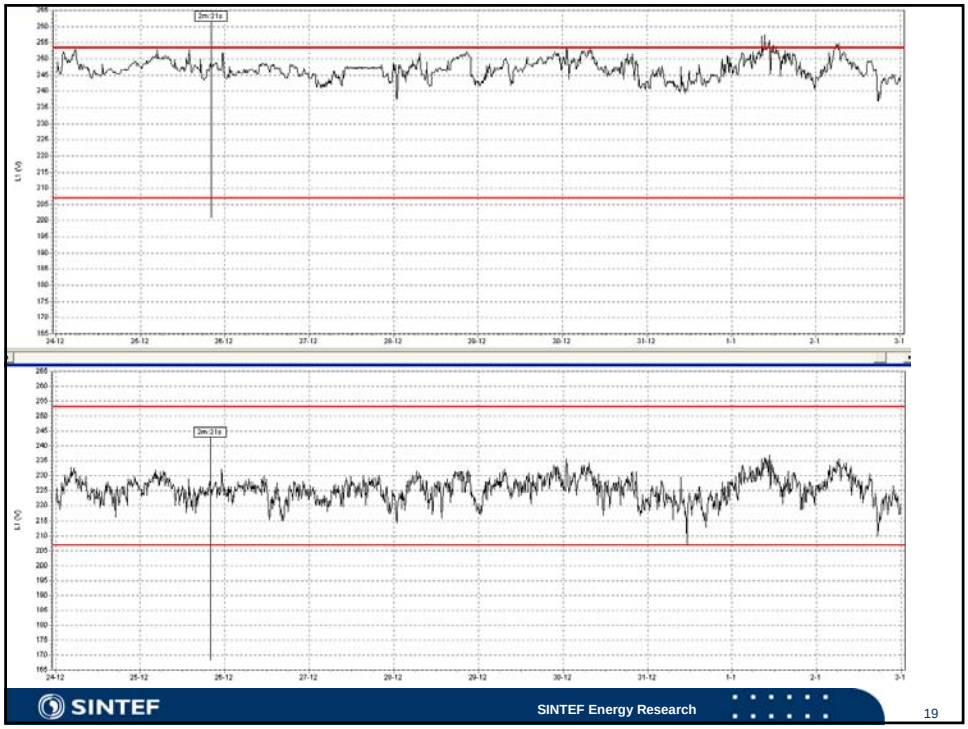


Single tower/power corridor configuration

VS

dual tower/power corridor

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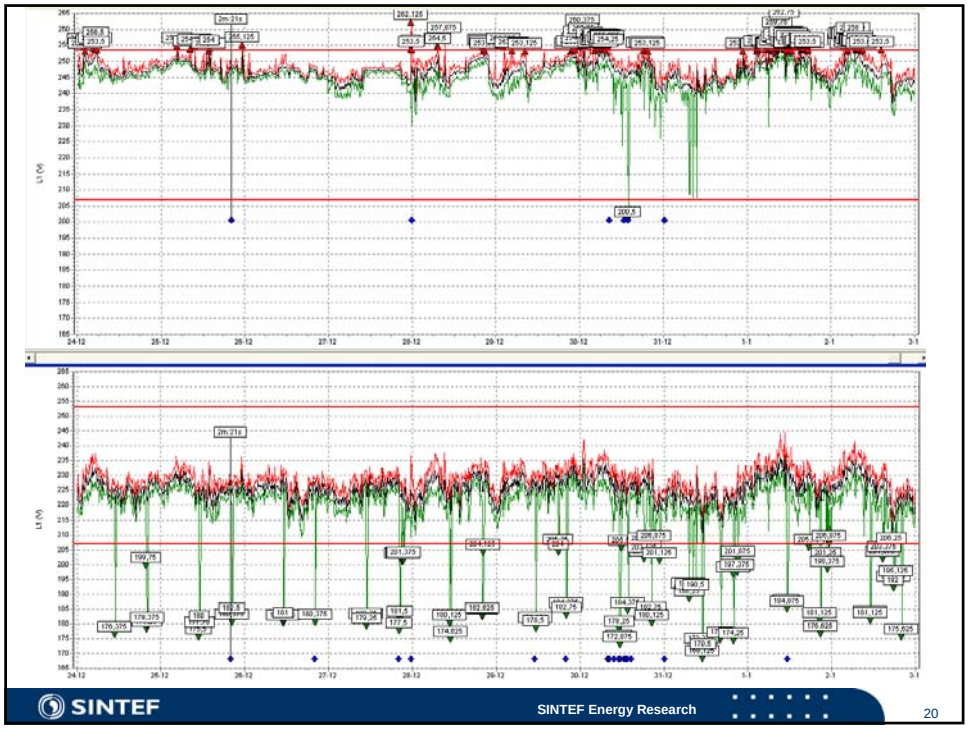
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THANK YOU FOR YOUR ATTENTION!