NETWORK PLANNING AND OPERATION IN THE ENVIRONMENT OF COMPETITION

G. BRAUNER
Technische Universität Wien
Gusshausstrasse 25/373
A-1040 Wien
Tel.: 0043 1 58801 37310
e-mail: g.brauner@tuwien.ac.at

W. Tenschert, E. Vierlinger
Energie*AG* Oberösterreich
Böhmerwaldstrasse 3
A-4021 Linz
Tel.: 0043 732 6593 3361

TODAY UTILITY SITUATION

From monopolistic to liberalized market

Today in Europe many utilities are in the state of transition to the liberalized electricity market. In Austria in February 1999 all consumers with a total consumption of more than 40 GWh will be liberalized in the first step.
The liberalization of the electricity market results in separation into generation, transmission, distribution and energy trade/energy sale. From the view of network planning and operation the network tariffs are vital important preconditions to evaluate cost efficiency. Tariffs for power transits are to be defined and agreed by the regulatory commission.
Under monopolistic market conditions the electricity prize was defined as

Prize = costs plus profit margin

In a competitive market, there is

Costs (aim) = tarif minus profit margin

This means, that the costs have to be reduced to assure a minimum profit margin, which is necessary to operate and maintain the networks.

The utilities in the monopolistic market were characterized by the following:

- High power quality and reliability of supply,
- New equipment or exchange within lifetime of about 30 years,
- High quality equipment,
- Sufficient staff for operation, maintenance and repair,
- Strategic network development not always under rigorous cost planning.

Potential in cost reduction

In fig. 1 the cost situation of a typical utility is shown.

To be competitive in the liberalized market, the following measures have to be undertaken:

- Reduction of staff. As the utility costs are to about a quarter be caused by wages, there is a tendency for increased early retirement of qualified utility people to reduce costs. This can be a risk, as a lot of know how is lost and inexperienced personal will have some problems in design and operation. Also outsourcing can only to some extend be suggested, as it will increase the costs for subcontracts.
- Reduced investments. Today investments are cut down to about 50% compared to the state of five years ago. Only investments which are vital necessary will be performed. Mainly the return on investment is considered but only to a smaller extend power quality and reliability.
- Reduction of maintenance cost. Ten years ago the mean life time of equipment, e.g. of switchgears was about 30 years. Today there is a tendency to enlarge the life time to about 50 years and to perform rehabilitation instead of complete exchange against new equipment.
- Simplified equipment. Today simplified equipment is preferred, e.g. switchgear with only one busbar instead of double busbar and simplified breaker and insulator configuration. Earlier switchgears were equipped with all bays for future use, without asking if all bays are really needed at the time of installation.
- Pooling of utilities to reduce numerous types of equipment, to increase the volume of investment and to reduce prices.
- Improved planning methods, to avoid unnecessary equipment by better prognosis of future demand and peak load situations.
- Demand side management by new methods, e.g. variable tarifs to reduce peak load situations and to avoid investments.
- Increased automation to save operational costs.

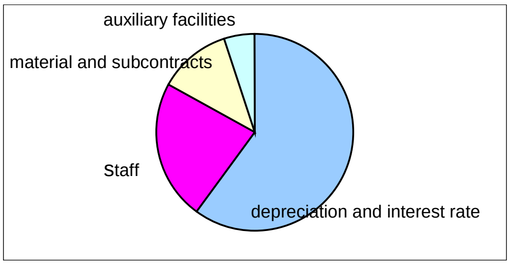

Fig.1 Cost situation of distribution utilities

POWER QUALITY IN LIBERALIZED MARKET

Power quality indices

Power quality is defined for low voltage networks, as in MV-networks only a few consumers are present, which can have special agreements with the utility.
Power quality is today on a high standard. The question is, what influence will have the need for more efficiency and profitability. Generally a significant reduction of power quality and reliability will not be accepted by the consumers and the regulatory government, because the costs of non delivered energy for industrial and public consumers are much higher than energy prices.

The future strategy is to reduce costs of equipment without significant reduction of reliability.
The indices of power quality according to EN 50160 are:

Voltage variations	230V $\pm$ 10% (+6/-10%)	
Long term flicker	$P_{lt} \leq 1$	
Voltage dips	$\leq$ 1min	10 to 1000 p.a.
Short interruptions	$\leq$ 3 min	10 to 100 p.a.
Long interruptions	> 3 min	10 to 50 p.a.

Voltage dips and interruptions, as defined here are recommendations for consumer complaints. From the view of network planning and reasonable power quality the upper limit of permissible interruptions seems to high. Seen from utility point of view the reduction of profit due to the non delivered energy caused by interruptions is of low influence.
If in future quality is paid by special tariffs and if in case of interruptions a fine has to be paid to the consumer, the reliability will have quite different cost aspects.

Measures for power quality in LV-networks

In urban low voltage networks power quality in relation to voltage variations and interruptions is normally no problem. In rural areas it is costly to maintain a reasonable supply quality.

For planning of power quality in rural LV-networks the target of voltage drop and the available short circuit power are used as follows:

Voltage drop	$\leq$ 6 %	
Short circuit power	$\geq$ 600 kVA	(minimum 450 kVA)

The planning is performed under the condition of 3 kW per household and 5 kW per farm. Only if in some regions the indices fall below these limits measures for improving the network conditions are undertaken.

To improve voltage quality the following solutions are possible:

- Cable instead of overhead line
- Ring structure by double cable
- New transformer station
- Changing from 400V to 980V operation
- 980V with double cable

For a LV-network in fig. 2 with over head lines the short circuit power in one km distance from the infeeding station is only 200 kVA. By replacing the overhead line by a cable of 150 mm^2 Al, the available short circuit power increases two to three times and reaches 600 kVA in one km distance.

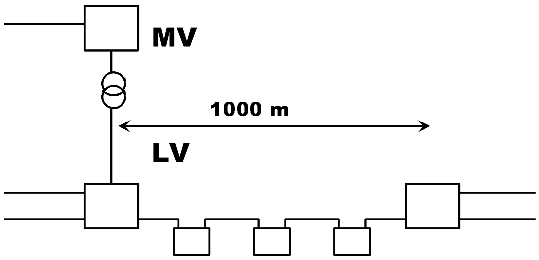

Fig. 2 LV-network structure

A second cable in parallel to the existing increases also the short circuit power and also the reliability (fig. 3). The cable can be without intersections and brought in by direct laying.

By building a new transformer station and a new MV-line the technical requirements can be fulfilled in nearly any case (fig. 4). This is the most costly solution and can in some cases not be realized because of environmental considerations in the context of new MV-lines.

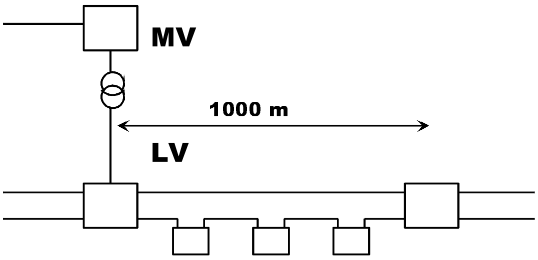

Fig. 3 Ring cable structure

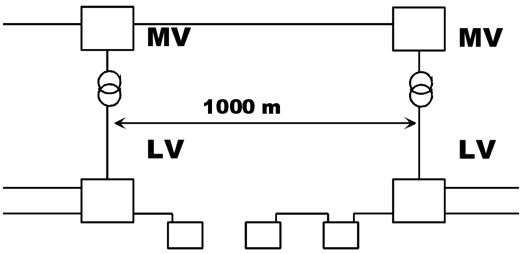

Fig. 4 New transformer station

In some cases in areas with low density population an increasing of the LV-line voltage to 980V (fig. 5) can be a cost efficient solution. In this case the voltage drop is significant influenced by the short circuit voltage of the transformers, which should be very low (1,2 to 1,4%).

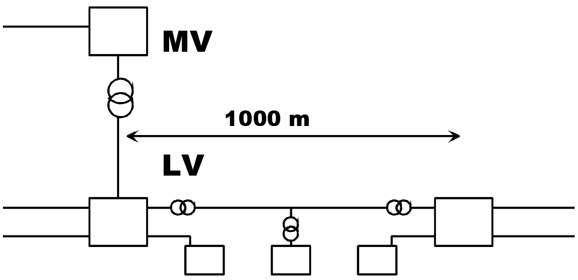

Fig. 5 LV with 980V instead of 400V

The ring cable structure according to fig. 3 has limitations in load. If the load demand increases, the cable without intersections can be operated with 980V by simply connecting 400/980V transformers at the beginning and the end of this cable (fig. 6).

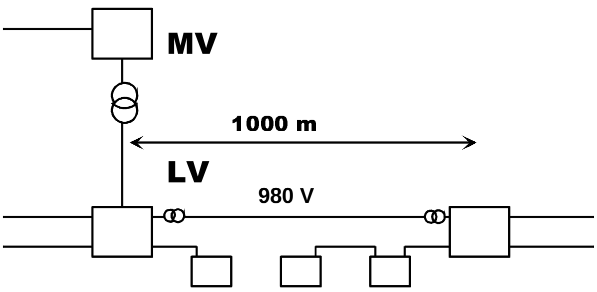

Fig. 6 Ring cable with 980V

The loading capability increases by a factor 2 to 3. If the load does not increase above these limits, this additional investment can be saved. The investment can be adapted according to the real demand.
The limits for supply of the different solutions is shown in fig. 7.

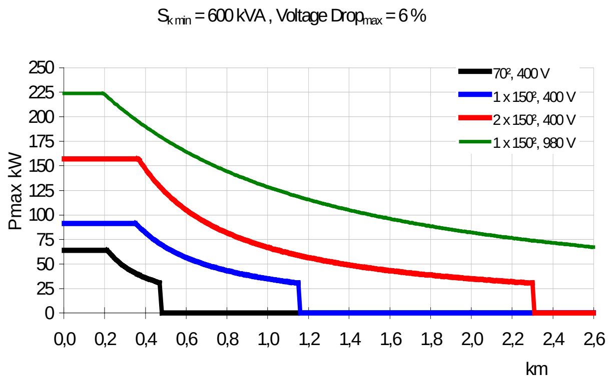

Fig. 7 Limits of supply in LV-network for different solutions

Cost reduction potential by network planning

In the above example the following costs in relation to a new transformer station are shown in fig. 8.

Solution variant	Short circuit power [kVA]	[% of target]	Investment costs % of transformer station	Max. voltage drop In LV [%]
Today	180	30%	-	17%
Cable instead of overhead line	530	90%	40%	10%
Double cable	850	140%	60%	5,4%
Transformer station	1240*	210%	100%	2,7%
980V at OH-line	730	120%	15%	5,5%
980V at double cable	1280	210%	70%**	6%***

* depending on transformer-kVA
** present value, 980V after 10 years
*** at double load

Fig. 8 Costs of different solutions in relation to new transformer station (100%-reference)

COST EFFICIENT EQUIPMENT

In the distribution networks 80 to 90% of all investments in networks are present. Measures for cost reduction have to be investigated for all elements of the distribution networks.

As can be seen from the examples above in many cases LV- and MV-cable networks are more economic than overhead lines. In MV-networks polyethylene cables are now used for network extension and rehabilitation.

Overhead lines are only exceptionally newly built. For existing overhead lines the following cost saving potentials can be used:

- Partial renewal instead of replacement
- Use of LV-insulated wires instead of LV-OH-lines
- Replacement of overhead-lines by cables instead of renewal
- Prolongation of maintenance intervals
- Cost efficient MV-overhead lines

Switch gears for 110/20kV and 20/0,4kV represent 30 to 50% of the total network costs. Cost savings are in reduction of the number of fields which is equivalent to a reduction of the number of MV-cable rings and in simplified MV-switchgears with single busbar and reduction of the number of breakers and replacement of some by load interruptor switches.

Transformers can be used according to newer investigations for about up to 50 years instead of 30 years. Elder transformers can be further used for reserve function if they are mostly switched off in cold stand by.
For LV-transformers it is recommended to use standardized unit sizes to reduce stock-holding costs.

Cost efficiency and technical validity is very much depending on the local situation. Especially the influence of on the availability of supply must be considered.

AUTOMATION IN DISTRIBUTION NETWORKS

Automation in liberalized electricity market

In the liberalized electricity market automation comprises two separate fields of application:

- Automation of network operation
  Here the classical SCADA systems are present. New functions for transit and emergency management are necessary in future.
- Automation for energy trade
  Due to the unbundling the energy trade has to use separate automation systems. Here all function for marketing, contracting, resource management, optimization and risk management are incorporated.

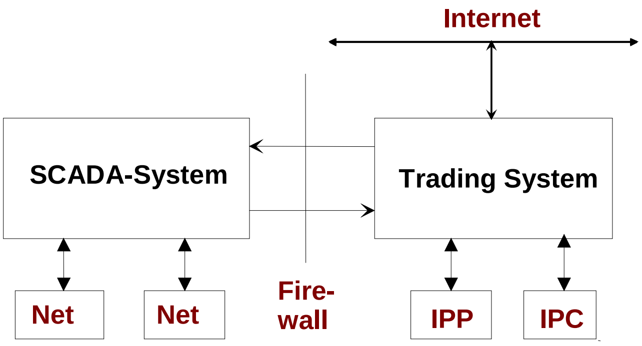

Fig. 9 Architecture of a automation system

In fig. 9 the architecture of an utility automation system is shown. The data exchange between technical and commercial system has to be limited by a fire wall to guarantee competitive conditions.

Automation system for network operation

The future automation systems for network operation will be designed under the following aspects:

- Reduction of the number of control centers and integration of different network operation systems in one SCADA system
- Additional functions for technical risk management as the networks will be operated at higher load
- Functions for fault locating and automated fault clearing
- Lightning information system for prognosis of risk of interruption and for planning of reliable operation
- Geographical information system
- Data base for system control, maintenance and planning
- Call center function with graphical visualization
- DSM by variable tariffs
- Remote metering and tariff management
- New functions for prognosis of load, available transit capacity, distance to stability limit
- Functions for transit management, e.g. supervision of transit limits of independent power producers (IPP) and independent power consumers (IPC)
- Management and accounting of network services
- Monitoring functions for network and network components and maintenance management functions
- Data exchange with energy trade system for information of available transit capacity under normal transit situations and of measures necessary in emergency situations.

All the above functions have to be considered under cost efficiency. One aspect is in the balance of reduction of personal costs in relation to additional costs for investment, operation and maintenance of automation systems.

A further aspect is in improvements in operation performance especially shortening of time for fault locating and fault clearing.

Automation system for energy trade

According to fig. 9 the energy trade uses its own information system. In future communication to market partners such as IPP, ICC, brokers and traders will be performed via a world wide net such as Internet. Today the contracts are for a longer time period e.g. month or year. In future there will be developing a electricity spot market, which necessitates shorter response time in the range of minutes or hours to conclude a contract.
The trading system has some of the following basic functions

- Data acquisition of all relevant market partners including competitors
- Strategy for optimization of trading processes
- Commercial risk management for new contracts
- Automated billing system
- Interaction with SCADA systems for clearing of available transit capacity, supervision of contracts (only account number is given) and technical risk management

In Europe there is no international unified computerized trading system available. In the starting phase there degree of liberalization and the tariff models are very different in the countries of the European Union.
In future there may be a better harmonization in these countries, helping to simplify international energy trade.

FUTURE DEVELOPMENTS

At the beginning of liberalization in many European countries measures to increase cost efficiency in utilities are now under way.
The tendency in distribution networks is to reduce costs by simplifying of equipment and network structures, reducing investments to minimum necessary value according to equipment loading, prolongation of maintenance intervals and reduction of personal costs.
Automation in network operation and use of information systems for graphical and operational databases as well as for call centers can be an additional measure to improve cost efficiency.
The broader application of these measures will take about 5 to 10 years. In this time range, it can be assumed, that the legal preconditions will be adopted and new rules for competition will be activated.