MEĐUNARODNO REGIONALNO SAVETOVANJE O ELEKTRODISTRIBUTIVNIM MREŽAMA

REGIONAL CONFERENCE AND EXHIBITION ON ELECTRICITY DISTRIBUTION

Crna Gora, Herceg Novi, 5 - 8. oktobar 2004. / ***Montenegro, Herceg Novi, October 5 - 8, 2004***

REMOTE MONITORING AND CONTROL IN THE MV DISTRIBUTION NETWORK – NEW TECHNICAL SOLUTIONS

D.Runjic*, KONCAR-Power Plant and Electric Traction Engineering Inc; Zagreb, Croatia
D.Majeric,KONCAR - Power Plant and Electric Traction Engineering Inc; Zagreb, Croatia

INTRODUCTION

Distribution Automation (DA) systems are increasingly being introduced by electric utilities to improve system efficiency, ensure a reliable supply of electric power and reduce maintenance and operating costs. First, we tried to define globally accepted term “Distribution Automation” which is too often related only to MV network (remote) monitoring and control. DA comprises a number of functions that should help distribution utility to improve its performances and to survive in the deregulated environment.

Most distribution utilities, starting DA project, are facing the problem of finding an optimal automation concept. Is the control scheme where system responsible for decisions and operations is centralised at the control room, best choice? Is the distribution of authority to lower level devices in the MV network better solution? In this part of the paper, we are tried to present few potential automation architectures.

On the last conference, we have presented some technical solutions regarding MV network remote monitoring and control, applied in Croatia. Now, we are able to share some now experiences presenting new generation of remote controlled pole switch disconnectors that made system more efficient and reliable in terms of installation and maintenance. Also, new solutions for measuring current and voltage are presented – sensor technology, which in practice rules out conventional instrument transformers because of their large size and higher costs. Due to their characteristics, current and voltage sensors become the standard equipment in MV switchgear automation process.

The communication system, selected for data transmission, has a direct bearing on the success of a distribution automation project. Therefore, last part reviews the types of communication systems available as well as their strengths and weaknesses.

Darijo Runjic, Koncar-KET, Zagreb, Croatia, darijo.runjic@koncar-ket.hr

DISTRIBUTION AUTOMATION DEFINITION

Unfortunately, many distribution utilities tend to view both Supervisory Control and Data Acquisition (SCADA) and DA systems only as remote control and status, indication tools. DA does more than that. On Figure 1, we can see five main Distribution Automation function groups and related functions.

Electric utilities must shift their focus from conservative «reliability at all costs» emphasis to a more efficient and economic emphasis. That means that future decisions or calculations regarding investments should be based on both technical and economic studies. Therefore, additional “filter” in assessing DA function process is cost-benefit analysis that should be done resulting with DA functions which should be adopted by distribution utility. Therefore, Distribution Automation is not only technical issue, rather commercial approach – valuing what to do, where and in what scope.

This paper deals just with the MV network monitoring and control.

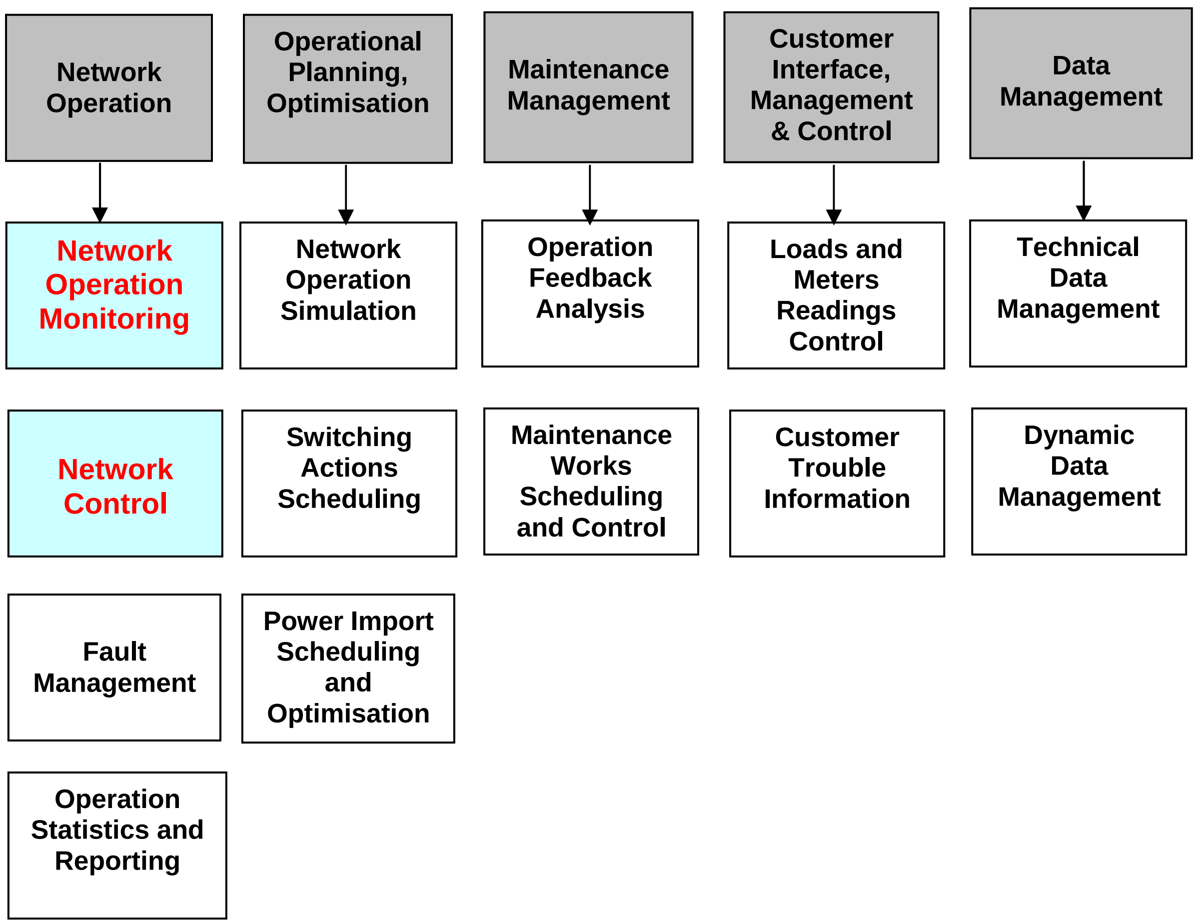

Figure 1 - Distribution Automation – main functions

MV NETWORK MONITORING AND CONTROL - AUTOMATION ARCHITECTURES

Distribution utilities starting DA projects are facing number of questions: what is optimal automation concept, what equipment to chose, how to start? Summarising experiences from different country lead as to a conclusion that there is no unique receipt. As we said, DA is not only technical issue, rather commercial approach – valuing what to do, where and in what scope. Now, is the control scheme where system responsible for decisions and operations is centralised at the control room, best choice? Is the distribution of authority to lower level devices (RTU's) in the MV network better solution?

Darijo Runjic, Koncar-KET, Zagreb, Croatia, darijo.runjic@koncar-ket.hr

We will consider few potential architectures:

1. Centralised
The SCADA (Supervisory Control And Data Acquisition) system (control centre) communicate as a master to a number of slave RTU's (Remote Terminal Units) installed through MV network. The master station will make all control decisions and the RTU's will act as a source of information and execute commands. This scheme is adopted in every distribution utility in Croatia.

2. Decentralised master/slave topology
A number of devices will act like masters and have access to a number of slaves RTU's. Decision-making is resident in the master device(s) and based on real-time data sharing.

3. Decentralised peer-to-peer topology
There are no master devices and all devices hold the same status within the DA scheme. All decision making takes place at the traditional slave RTU level, and real time data sharing is possible between these RTU's.

4. Decentralised with no communication requirements
This type of control scheme relies on the capability of the intelligent devices-RTU's to autonomously detect abnormal conditions in the system, make a decision and perform the operation without need for operator intervention. When normal conditions are restored, the RTU's should be capable of detecting it without, or with very limited, operator intervention, and return the network to its original configuration. This scheme requires very accurate co-ordination for correct operation of the automation scheme. SCADA system (control centre(s)) can be present but is not necessary for the successful operation of the algorithms. It plays a supporting role and is used only for reporting events to higher levels in the control scheme. It also provides the tools for operator intervention if required.

5. Hybrid architecture
It is typically applied within a network equipped with a combination of electromechanical, electronic and numeric devices.

On the Figure 2, different functions, supporting different control schemes mentioned above, related to the equipment price and performances are shown.

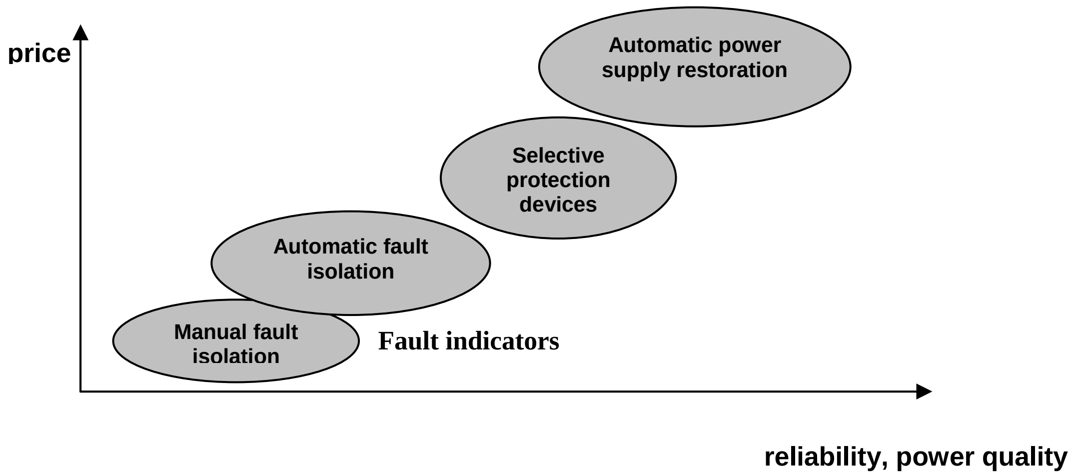

Figure 2 - New equipment - functions related to the price and performance

Now, question is what to choose? Cost-benefit analysis is definitively required in order to set at least framework for the distribution utility engineers and managers. Experts can calculate the actual figures and conclusions, after they review the utility's operating environment and future goals. Due to the lack of actual data, this paper is neither aimed at providing formulas, specific recommendations and estimated figures, nor giving detailed calculations and savings. Cost-benefit analysis results may be summarised in the diagram like one on the Figure 3. In fact, Figure 3. and Figure 2. are relating to same think, but on different ways.

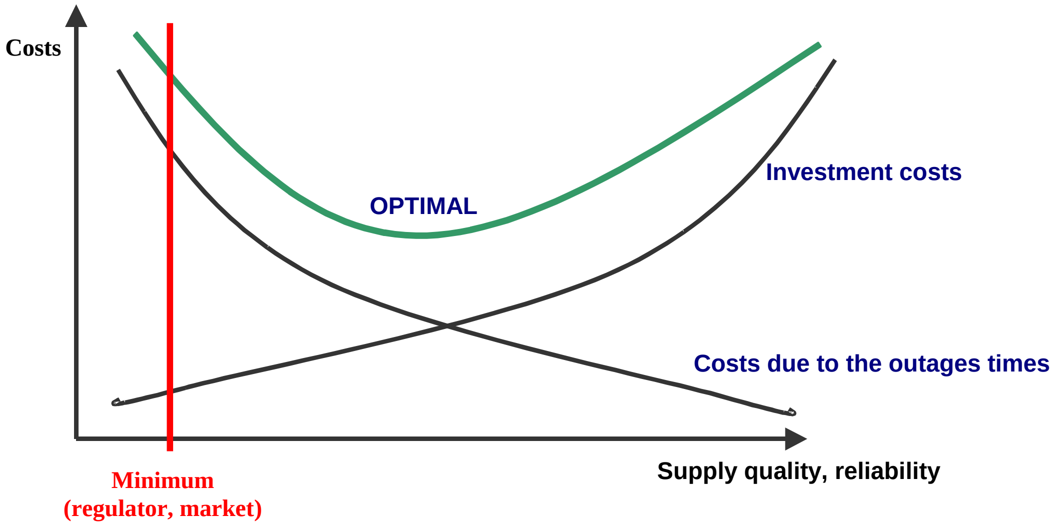

Figure 3 - Finding optimal solution

MV NETWORK REMOTE MONITORING AND CONTROL - WHAT ARE THE TRENDS?

MV overhead network

Here, we are presenting new generation of pole mounted switch disconectors (Figure 4. - more than 40 installations in Croatia) that made overhead network remote control systems more efficient and reliable in terms of installation and maintenance.

Figure 4 - New generation of pole mounted switch disconnector for remote control

Price and characteristics listed below; practically roles out “old” systems with the conventional disconector, which is mechanically connected to the down pole control cubicle:

- the sealed enclosure eliminates risks from environmental hazards and increases the reliability of electrical distribution systems,

- The enclosure of stainless steal is hermetically sealed and corrosion resistant. The hydrophobic silicone rubber insulators are well suited even to the most extreme conditions,

- The switch inside the sealed tank in an inert SF_6 gas atmosphere is insensitive to outside pressure changes. This kind of switch is practically maintenance free,

- Reliability and safety of electricity supply is increase even in densely populated areas,

- Motor drive, for switch remote control, is mounted directly on switch axle, eliminating need for mechanical connections between switch and control cubicle mounted down pole (classic remote controlled pole disconnector).

MV underground network

Most electric utilities starting their underground network automation adopt a “puzzle” principle. That means that first MV switchgear should be replaced with modern ones, which is prepared for remote monitoring and control. Than, RTU with the communication equipment comes with the supply (usually 48VDC). That is all needed for MV/LV transformer station remote monitoring and control. But problem occurs later on when, as a system extension, fault indicators have to be installed, or measuring equipment. Than we have a situation shown on Figure 5, with the problems regarding available space, installation problem, etc. Mufactures have been reacting very quickly, and nowadays, trend is integration of all equipment required, that will be installed now or later on, in one compact switchgear (Figure 5.).

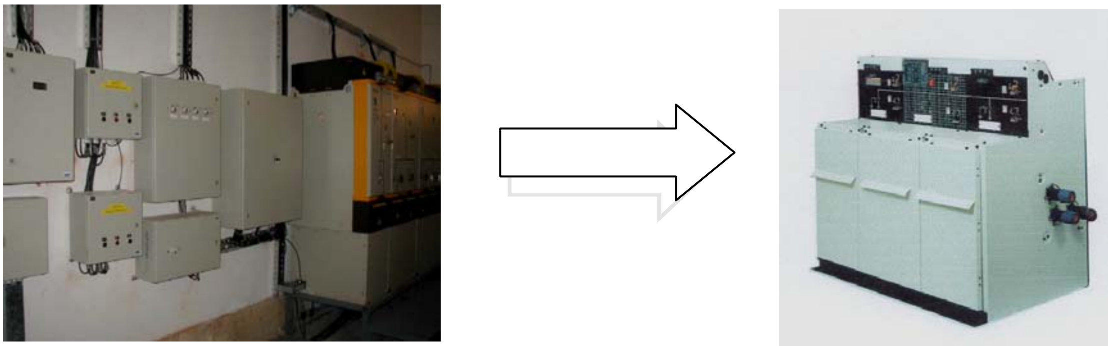

Figure 5 - MV/LV switchgear – integrated solution

Sensor technology – new measurement technology

Real time analogue voltages and currents are required to achieve most effective DA schemes and this should be considered when selecting the RTU's. Conventional current and voltage transformers are not the best solution for application in MV switchgears. The main force in the development of new measurement technology based on **current and voltage sensors** (Figure 6.), has been need to standardise and optimise the MV switchgear design and manufacturing.

The current sensors are based on the Rogowski coil in which the iron coil has been replaced by non-magnetic material. The measuring principle for voltage measurement is based on a resistive or capacitive voltage divider, which results in a wide dynamic range and high linearity. Of course, mentioned principles are well known, but sensors as new measuring equipment have become technically feasible due to the introduction of microprocessors in the secondary equipment. Equipment that can use the required accurate low signals received from a sensor has been available on the market for some years.

Technology summary:

- One of the long-term trends in MV switchgear design has been towards smaller size. In conventional switchgear, current transformer (CT) and voltage transformer (VT) takes a significant part of the total volume of the cubicle. The volume of the sensors is less than 1/3 of the volume of the conventional transformer. In addition, due to the small size of the sensing elements, combi-type sensors are possible. In this type of sensors, current and voltage measurement functions are integrated in the same compact cast resin part.

- Another trend in the switchgear industry is aim for shorter delivery times. Here the complicated logistics of conventional CT's and VT's is a major problem. To specify transformer, lot of information must be known (load current, secondary burdens, accuracy classes). Result is a transformer manufactured individually, according to order. The new sensors, on the other hand, have a very wide linearity range. The result is, that for rated currents 40…1250A, and for rated voltages 7,2….24Kv only one model is needed. The improvement in the logistic chain is obvious.

- The nonlinearity of magnetic cores in the CT's and VT's sets inevitable physical limitations on the measurement range and accuracy. Therefore, these novel sensors give benefits that are not achievable with conventional technologies like:
  - large measuring range and high accuracy
  - integration of protection and measurement functions using the same sensors for both.

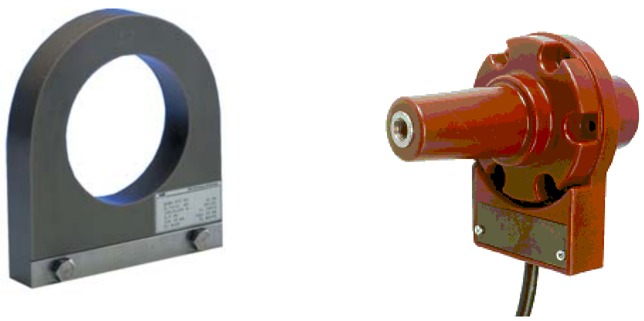

Figure 6 - Current and voltage sensors

- The sensors have a positive impact on the reliability of switchgear. Risk of damage by human error is reduced by the use of the sensors due to the:
  - easy installation
  - no direct damage caused by incorrect wiring
  - small output voltages
  - safe opening and short-circuiting of the sensor secondary circuits possible without overvoltages and overheating

As a conclusion it can be said that, sensors together with modern protection and control RTU's provide a safe and cost-effective solution, when you invest in new substation or refurnish old ones.

COMMUNICATION SYSTEMS FOR MV NETWORK REMOTE CONTROL

The communication system, selected for data transmission, has a direct bearing on the success of a distribution automation project. Electric utilities often use several types of communication media for different functions. This part of the paper reviews the types of communication systems suitable for MV network remote monitoring and control. But before that, we should take a look on some basic facts:

1. Number of transformer stations or pole disconnectors to be remotely controlled is relatively very high,

2. Transformer stations or pole disconnectors are very dispersive, geographically speaking,

3. Data transfer should be safe and reliable

Here are the most common communication options available today:

- Telephone lines - owned

Very reliable media. Exploitation costs for this type are the least, but it could be applied only if cable, used for other utility needs, passes near switchgear to be remotely controlled. Obviously, it is suitable only for automation of the network in the town.

Darijo Runjic, Koncar-KET, Zagreb, Croatia, darijo.runjic@koncar-ket.hr

- Telephone lines - leased

Same as above, but in the cases of line fault or damage, utility doesn't has impact on repair time. In addition, leasing price isn't really acceptable, especially in the town area. This type of media (owned or leased) is definitely not suitable for urban network automation.

- Fibre-Optics

Fibre-optics system provides the highest quality transmission, and transport extremely large amounts of information. Being made of glass, the fibre cable is non-conduction, and is not susceptible to noise or ground potential problems. However, the question is whether are these characteristics really needed for MV switchgeras automation. In addition, the price of terminal equipment (installation cost) is still very high and it may take some time before utilities will start using fibre optic links installed along the MV distribution network.

- Wireless - GSM, GPRS

Implementation is very simple: you buy terminal devices and make a contract with the provider. These solutions did no meet expectations (Croatia case) due to the limited coverage (mostly in urban areas), unavailability during disturbances, still high monthly fees and service unavailability. Maybe, situation would be different with more competition on the field.

- Satellite systems

Satellite systems are somewhat exotic and expensive. Exploitation expenses are highest. It is necessary to provide absolute satellite visibility, that point out very high demands regarding antenna installation. In addition, during very bad weather conditions (situation with the highest number of disturbances in the MV network) is it very unreliable. However, it is potentially interesting for locations way out of radio and GSM system areas.

- DLC (Distribution Line Carrier)

DLC system injects a low frequency radio signal over the distribution lines. Field devices are coupled to the conductors to receive communications from the SCADA master station. Communication cannot be maintained while a disturbance, such a damaged poles or broken power lines, is in progress in the distribution network. Technical and reliability problems limit these systems.

- Conventional radio systems

Dedicated conventional radio systems, based on licensed channels, are very suitable for DA. If the system is properly designed, these channels are available when needed. However, many countries suffer from the shortage of available frequencies in the VHF/UHF bands, forcing utilities to use the same frequencies for both voice and data transmission. In this case possibility of constant interference between voice and data transmission is very high. Still, this solution is acceptable but only if number of stations to be controlled is not high and if it's a just temporary solution till utility builds up a radio system just for a data transmission. This is probably the best choice, not because of it's technical characteristics (although they are acceptable), but tech-economic ones. It has high flexibility, simple expansion and acceptable price. Practical experiences with this system are very good. In order to achieve optimal coverage, telemetric equipment, installed in MV network, should be able to perform”store and forward” function witch rules out additional costs due to the repeaters installation costs.

Communication systems summary

As we can see from the previous chapter, most communication system has at least one very "bad" characteristic that other positive one can't compensate. Those systems can be practically applied only if there are some special demands on technical characteristics possessed by one, and as a temporary solution. So, it is obviously that authors suggest radio system (built just for data transmission) as an optimal solution. It is must especially on the locations in the areas where wireless and fibre links are unavailable or not viable. Someone think that a communication response achieved using radio system is poor. Although fast response (update on the operator's screen) is always desirable, it is important to remember that performing functions, such as isolating a demaged portion of the network and restoring the power, can be done even after a delay of several seconds or even minutes. Using radio for these applications is therefore acceptable.

Darijo Runjic, Koncar-KET, Zagreb, Croatia, darijo.runjic@koncar-ket.hr

CONCLUSION

Distribution Automation (DA) must be considered as one of the business strategies sanctioned by distribution utilities. As we said, DA is not only technical issue, rather commercial approach – valuing what to do, where and in what scope. Distribution utility launching DA project often starts with the pole mounted switches and MV/LV transformer station remote monitoring and control. In this paper we've considered potential automation architectures, regarding remote control, as well as relations between price of the equipment supporting mentioned architectures and achieved performances.

We have also tried to point out trends in MV network remote monitoring and control by presenting new equipment and technologies that make automation systems more efficient and reliable in terms of installation and maintenance. At the end, authors suggest radio system, built just for data transmission, as an optimal solution for data transmission between intelligent devices installed in MV network.

REFERENCES:

1. Oleg Samarski, Stephen Pell, 2001, "Distribution System Automation As A Tool For Reliability Centred Performance", DistribuTech Europe.
2. Dan Ehrenreich, 1995, "Cost Benefits Resulting From Use of Integrated Communication for Distribution Automation", DA/DMS Asia
3. Darijo Runjic, 2003, "Primjenjena i nova tehnička rješenje na podrucju daljinskog vodjenja u SN mrezi distribucijskog EES-a"; HK CIGRE, VI savjetovanje
4. CIRED, 2003, Tutorial, "Basics of Distribution Automation", Barcelona
5. Pentti Mahonen, Vesa Virtanen, 2001, "The Rogowski coil and voltage divider in power systems protection and monitoring", ABB Transmit Oy, Vaasa, Finland
6. Vinko Fabris i suradnici, Darijo Runjić, 2002, "Daljinsko upravljanje u SN mreži DP "Elektra" Zagreb, HK CIGRE, IV Savjetovanje o distribucijskoj djelatnosti.