IMPLEMENTATION OF DISTRIBUTION AUTOMATION SYSTEMS (DAS) IN THE “ELECTRICA” COMPANY – ROMANIA

Gheorghe Ion MAZILU - ELECTRICA SA
Romania

Mihaela CONU - ELECTRICA SA
Romania

Serban COCULESCU - ANRE
Romania
scoculescu@anre.ro

Adrian Ion MAZILU – ELECTRICA Muntenia Sud SA
Romania

SUMMARY

The paper presents the concept of Distribution Automation (DA) imposed by the necessity of fast service restoration and avoiding the fault spreading in the Distribution Network.

The program implementation is legitimated by the quality indicators, which permits to reduce the present 4 to 5 hours fault interruption duration at less than a third of it.

The redeem of capital cost is estimated to be achieved in maximum 7 years.

The program implementation will be achieved by steps for both MV overhead rural networks and MV urban voltage networks.

GENERAL CONSIDERATIONS

As it is known, the operation of electric energy systems demands for the use of protection, automation and measurement systems, as well as the existence of control of these systems, all in the purpose of fast elimination of local failures, particularly in order to avoid the extension of a failure over a large area.

The electric energy distribution outfit includes equipment (protective relays, switching equipment) properly installed, but obsolete and asking too large costs for operation and maintenance.

The existence of energy market imposes new rules for the distribution operation as well, aiming to a high quality of the service offered to the consumer. Also, the competition that appears in distribution of electric energy, makes the lower tariffs put into practise by the distribution companies as well as the quality of the service offered to the customers essential to win the leading place in this competition.

The systems for automation of distribution (DAS) are very important for the quality of distributed electric energy by eliminating quickly the faults and re-establishing the service as fast as possible.

The implementation of DA will allow to redistribute the staff working in the 110 kV /MV sub – stations to other activities and augment the value added of their work.

The chosen solutions are based upon the following concepts:

- the design for modular equipment will observe the international SCADA standards, acknowledged as “open” type;
- the IT system architecture allows completion with products from different suppliers;
- the “open” type system allows IT completion at different moments.

Another advantage of DAS is the lowering of costs for operating and maintenance, which is reflected in the lowering of electric energy tariff.

Also, an advantage of DAS implementation is the redistribution of the operating staff from sub-stations to other activities of the company, where to produce the predicted augmented value.

Most of the existing equipment for protection, control, automation and measurement is electromechanical and it is no more adequate for today requirements of he distribution companies, although these have been operated and maintained by highly qualified stuff.

DAS can nowadays hardly be conceived without digital equipment and lead by computers. DAS have a major part in the commercial management of an electric company, with financial advantages, such as the short term (5 to 7 years) redemption of the investments for these systems.

Nowadays there is unlimited access to modern technologies for DAS, some components being successfully produced in our country a well. But there are two major disadvantages that slew down the DAS implementation after 1990, which are:

- limited financial resources;
- the infrastructure for data communication.

The first disadvantage has diminished beginning with the
year 1999, when the distribution activity was separated from other activities, but the financial resources of the new distribution companies are still limited.

The communication substructure has developed quickly and lead to many alternatives, one being the building of the distribution companies own communication lines. The solution chosen for the lines of communication was one of conjuncture, either by hiring from different operators, or by building own communication lines (optical fibre, radio trunking). The costs were large, which fact slowed the DAS implementation.

**DAS IMPLEMENTATION**

Taking into account the physical dimension of the distribution network (which includes 110 kV /MV substations, MV networks, MV/LV substations) the DAS implementation must be realised by stages. It is possible to maintain the same territorial structure of the company:
- subsidiary for electric energy distribution and supply
- branch – subsidiary (subordinates of the subsidiary)
- operating section
- 110 kV/MV substation and the network connected to it.

Data which will be collected and real time processed will result from the former presented structure and will be also processed by technical, commercial and economic management, suitable for the company. The regulations imposed by the safety of the national energy system, which are the duty of the System Operator, part of the National Energy Transportation Company, will be observed, such as other regulations issued by the National Authority for Electricity Regulation – ANRE.

It is not our purpose to issue an infallible solution as concerns the stages of development for the DAS implementation, but, taking into account the existence of the electric energy market and the regulations that rule it technically, commercially and financially, we suggest that the next hierarchy is suitable for it:
- the MV part of an 110 kV/MV substation, also with the MV network connected to it;
- MV/MV substation and the network connected to it;
- 110 kV/MV group of substations, each with the afferent MV network, as an integrated subsystem;
- all 110 kV/MV substations, each with the afferent MV network as an integrated system for the branch-subsidiary or for the subsidiary for distribution an supply.

Besides, we consider more convenient to start with the implementation of DAS at the 110 kV/MV substations whereby the exchange of energy is made, either between branch-subsidiaries of the same distribution and supply subsidiary, or between different subsidiaries (future companies), such as at the substations which will remove the operating staff (beginning with those with home-located operating staff).

The DAS implementation may be done either with the retrofit of the protective, control and automation equipment and of the primary equipment as well, or by keeping the existing primary equipment and replacing only the protective, control and automation equipment. The second solution is more accessible from the financial point of view, the primary equipment may be kept, by using an appropriate maintenance, for a longer period of time under operation.

The new 110 kV/MV substations will be from the beginning achieved with SCADA which will be integrated into the planned system of the subsidiary or branch-subsidiary. It is recommended that the MV network, connected at the new substations, to be equipped (concomitantly with the new substations) with equipment integrated into the general DAS.

The solutions for achieving the DAS shall obey the following concepts:
- modular design, based upon international SCADA standards, acknowledged as “open” type;
- the design shall cover the solutions for the whole IT system architecture of the DAS, anyone would be the soft and hard supplier;
- the “open” type system allows to the user IT completions at any next moment of time.

The DAS architecture adaptability is given by the use of programmable microprocessors, modifying their parameters being made locally or remote.

Another important concept is the communication facility using as much as possible the equipment of the communication operators, especially of these who offer a larger communication band in order to achieve fast communication.

The DAS architecture shall include equipment easy to operate, in order to reduce the costs for professional training and for maintenance.

In any network area (overhead or underground electric MV line) is better to install fault locators which help to faster discover the fault occurred at any part of the network. These kind of equipment are used often by the distribution companies to locate the damage and eliminate it, restoring the supply with energy. These locators are installed along the MV electric lines in pre-established places. The occurrence of a fault activates the locators, so the location of the fault, to the place where they are activated, id easy to be done. The fault area can be isolated through manoeuvres by the intervention squads or by the operator from the central point of DAS if these indicators use a line of communication (radio-trunking,, SMS through GSM operators).

It is also very important to have a many security level structure of the DAS architecture, in order to prevent any unauthorised intervention in the system. In Figure 1 it is presented the proposal for the area for DAS implementation.
In the principle, the DAS architecture consists of:

1. **The element – Overhead electric MV line, connected at the bars of a 110 kV/MV substation.**
   
   As a rule the equipment installed for DAS consists of:
   - remote control load sectionalizers;
   - reclosers.

   The remote control load sectionalizers allow remote separation of the faulted area from the rest of the network and to re-establish the supply service or the rest of the customers. Sectionalizers are remote operated by use, more often, of radio waves (using either their own radio-trunking network, or using the GSM operator network existing in the overhead line area). This way is reduced the duration of interruption of the whole line and re-establishing the service after separating the damaged element, and the intervention an maintenance squads will be able to fix the damage in a short period of time.

   As a rule, the remote-control sectionalizers are installed choosing an optimal number of branches from the main axle of the line.

   Reclosers are equipment which are able to take their own decisions at the moment of a fault occurrence. Their performance is based upon the idea: “instead of loosing everything, I better loose a half of it”.

   The recloser is a breaker – type equipment, usually vacuum – insulated (or hexafluoride SF₆) installed along a MV overhead electric line. It must separate the part of the line which is placed downstream from it from the rest of the line and re-establish the supply service. This equipment performs anytime when necessary, independent from the dispatcher’s decision.

   The reclosers also comprise RTU type equipment (which allows data collecting, concerning the analogical states of the line, and stocking of the data). It’s parameters may be set from a remote location or locally).

   For the existing distribution system, consisting of an electric 110 kV/MV substation plus overhead line, the recloser also protects the MV cell breaker from the substation, which would have performed if a passing fault occurred.

   The recloser also acts as a remote control sectionalizer. The remote command has to be done from a central point, usually by the dispatcher, which is common for both remote control sectionalizers and reclosers.

   The criteria or choosing the place for installing the reclosers in a MV overhead line will be:
   - protection of the main energy consumption area;
   - fast isolation of these long branches of the line, where occur a greater number of faults;
   - protection of some important energy consumers, in conformity with the stipulations of the supply contracts;
   - the frequent repetition of MV overhead line faults (for instance more than 5/100 km);
   - ageing of the MV overhead lines insulation.

   The investment for the acquisition and installation of a recloser may be recovered in 3 to 4 years. Not all the reclosers have to comprise the RTU functions, which makes them more expensive. The reclosers which will not comprise the RTU function will achieve their functions properly.

2. **The element – underground MV electric line connected at the bars of a 110 kV/MV substation.**

   There are two situations to be met more often concerning the DAS architecture to be approached, which are:

   a) Underground MV electric lines which supply MV/LV substations, connected at a supply MV station, which is connected at the MV bars of 110 kV/MV substation. The situation can often be met in the urban agglomerations and consists of:
- MV/LV substations (about 5 to 8) supplied through a MV cable line (distributors) connected at the supply station, radial operated. The reservation is ensured through the LV network, in mesh or complex mesh configuration;
- the supply stations are connected by MV cables (feeders) at the MV bars of the 110 kV/MV substation; there are groups of 2 or 3 supply stations connected at the same MV bar, one of them being the main supply, that ensures the reserve for the other 2 supply stations.

The solutions of supply described before are characteristic to the year 1970, and it would also now be convenient that the LV network is operated in a mashed or complex mashed diagram. In actual fact this operation diagram was not to be used, because of the great number of LV distribution cable faults, so this philosophy has been abandoned. Also, because of the small available room, the 110 kV/MV substations could afford only a small number of MV cells, which imposed diagrams where a number of 2 to 4 supply stations were supplied through the same path, with a single breaker. This caused diminished reliability and the possibility of extension of a fault in case of refuse of disconnecting of a supply station breaker, afferent to a feeder.

Another major inconvenient is due to the fault of a part of the distribution cable, which directs to the disconnection of the MV breaker installed in the supply station. To re-establish supply and find the fault location, manoeuvres are one successively to reconnect each MV/LV substation supplied from the same distributor, operating the afferent breaker from the supply station. The duration of these operations is long, about 3 to 4 hours, while the consumers are not supplied.

Using DAS the quality of distribution and supply service can be much improved, using a solution like:
- replacement of the electromechanical protections by digital protections into the feeder and distributor cells from the supply station;
- setting on each branch of distribution, into a MV/LV substation, of a breaker fit with the necessary protective equipment; this will perform like a recloser;
- all the protections will include the RTU element, able to set parameters from remoteness, using the area existing communication lines;
- there will be achieved a selectivity of the protections, allowed by the digital protections.

The new breaker to be installed will be smaller sized (with vacuum or hexafluoride insulation), and will be fixed into the distributor cell from the MV/LV substation. It is advantageous to fix fault locators outside the MV/LV substation.

b) Underground MV electric lines which supply MV/LV substations, connected directly at the MV bars of the 110 kV/MV substation. This solution eliminates the supply stations, described previously, but the major disadvantage, due to the

fault occurred with a MV cable area, persists; this is amplified by the fact that the MV/LV substations connected to a feeder is greater, about 12 to 14.

The DAS solution in such cases is identical to the one previously described; to choose the protection selectivity one shall mind that the first MV/LV substation on the distributor branch towards the 110 kV/MV station is equipped with a breaker, but without the automation, control and measurement system. It is also recommended to install fault locators at the MV/LV substations.

The investment may be recovered in 6 to 8 years, but it is important the increase of the service of distribution and supply quality, observing the regulations of the ANRE.

3. The element - 110 kV/MV electric station (only the MV bars).

It is presented a principle DAS architecture, based upon the previous described criteria. The fact hat the DAS architecture is “open” and modular type allows that each equipment, soft and hard producer be fit with the demands of the system; this way, the system may be achieved by stages, according to the available budget.

4. The system (the subsystem) is an integration of all elements, according to SCADA standards with the “open” and modular type and may be achieved by stages, irrespective of the chosen equipment, soft and hard producer.

The soft programming will allow the access towards:
- data concerning the equipment way of operation, including graphic schedules;
- data concerning the electric parameters;
- sequential recordings of the events;
- report issuing;
- monitoring the equipment switching;
- adjustments;
- remote or local re-configuration of the network diagram;
- electric energy quality (distortions, harmonics, voltage variations, power factor);
- alarming;
- accessing the data base with the complete history of events;
- security of access and information.

CONCLUSIONS

To the implementation of the DAS program it must be decided without any doubt the following:
- the data communication substructure (basis and redundant system);
- the priorities concerning the 110 kV/MV substations;
- the priorities concerning the MV electric lines, in connection to the previously named substations;
- establishing the central point (that may first be the 110 kV/MV substation, afferent to the MV network where the DAS is implemented, except for the 110 kV/MV substations where the staff will be removed and redistributed;
- how much of the primary MV equipment which is installed in a substation may be still used, to sustain a greater financial effort to replace the protective, automation, control and signalling equipment; by use of an appropriate and permanent maintenance an important part of the primary equipment may be able to operate, postponing an important investment effort;
- if all the reclosers will include the RTU function, or a part of them only;
- including in DAS of the MV/LV transformers as well, using, for instance, reset able fuses;
- the DAS implementation approach only related to the prognosis for at least 3 to 5 years of the capital budget as a part of the society budget to ensure the financial resources for the work to be done.

Implementation of DAS systems based on SCADA international standards is an investment that entails the capital budget as a whole at a company. The advantages are certain and the investment redemption is sure up to 7 years, however it is necessary to establish stages of the works, yearly resources being limited. The stages establishing has to rely on the next criteria:
- image
- service quality
- commercial
- clients satisfaction
- employees satisfaction.

The company has to be sensitive at the clients requests, taking into account that interruption of the distribution and supply service causes important financial prejudices. The implementation of DAS has to be done with great promptness, even if by stages, and it is the single solution for:
- diminishing the affected fault area
- diminishing the duration of interruption and fasten the service re-establishing.