FEEDER AUTOMATION IMPROVES MEDIUM VOLTAGE NETWORK OPERATING EFFICIENCY

Yves CHOLLOT
Schneider Electric – France
yves.chollot@schneider-electric.com

Jean-marc BIASSE
Schneider Electric – France
jean-marc.biasse@schneider-electric.com

Alain MALOT
Schneider Electric – France
alain.malot@schneider-electric.com

ABSTRACT

This paper shows how improving the network management by increasing the level of network automation and control improves the operating efficiency of medium voltage distribution networks. Specifically, the presentation shows the steps to equip gradually the network according to progressive investment capability, from Fault Passage Indicators (FPIs) and remote control, to automatic circuit reclosers (ACRs) and sectionalisers used in a feeder automation scheme to both minimize the number of disturbances and minimize the outage times experienced during these disturbances.

INTRODUCTION

An increasing demand for energy

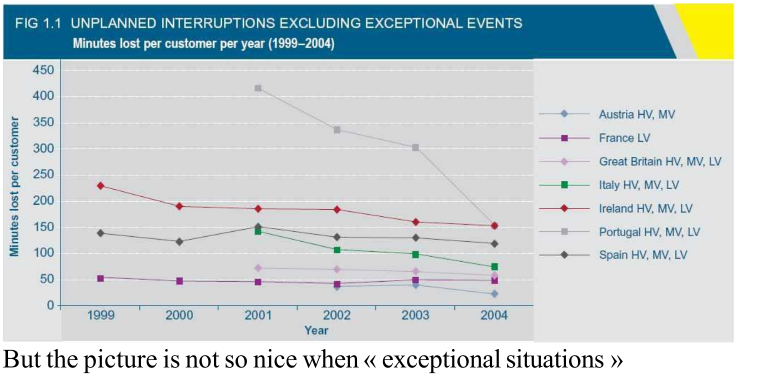
A direct consequence from population growth and related economic development at industrial, commercial and tertiary levels is an increasing demand for energy.
To fit that requirement, utilities need to produce more power but also to improve their transmission & distribution networks, for customers demand more energy reliability.
In countries with fast growing economy, MV distribution networks spread at such a speed that utilities and their employees need very efficient global solutions to decrease outages occurrences and duration, hence improving the quality of service.
Depending on the technical solutions chosen, it is possible to help chasing the revenue losses (non-distributed energy or non-technical losses).
The present paper describes the benefits of fault tracking and network reconfiguration that help to achieve these goals.

Measuring the quality of supply

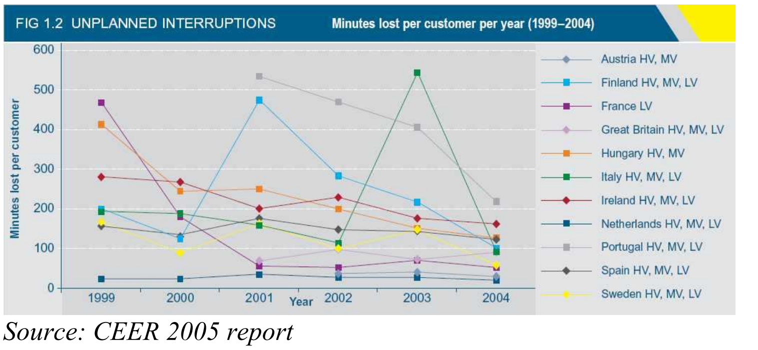
To reach the required level of quality of service, it is first necessary to accurately quantify it in a factual manner. To do so, utilities commonly use measurement indexes (source: CEER EU-25 3rd benchmarking report on quality of electricity supply):

- the "SAIDI" (system Average Interruption Duration Index) measures the average cumulated power outage time during one year and per customer
- the "SAIFI" (system Average Interruption Frequency Index) measures the average number of outages.

When comparing the SAIDI measured in the '90s on the LV standpoint, we can see that this index varied from 16 min down to 11h30.
In France, the quality of service in the 10 largest cities continually improved from 1990 to 1997 thanks to EDF investment efforts: in 7 years the SAIDI went from 2h00 down to 19 min.



But the picture is not so nice when « exceptional situations » are taken into account :



Source: CEER 2005 report

Last but not least, if we look at the cause of faults, 25% come from the HV network, 25% from the LV network and 50% from the MV network. The MV network is therefore the part of the whole network to which the greatest care should be taken to improve the quality of service.

Another variable to be taken into account in the quality of service is the cost estimation for non-distributed energy per year. It increases with the number of faults per year, the peak power demand, the length of distribution lines or cables that are connected to each feeder, the length of the outage, the billed price per kWh and above all the cost of consequences. That is why this cost can vary from 5 to 30 dollars per kWh.

A global approach

Each of the significant problems listed here (safety, voltage losses and drops, long outages, numerous short outages) can be solved taking appropriate actions on the MV network, such as protection, reactive compensation, adapted neutral system with ASC, multiple sectionalising and use of appropriate fault detection tools.

Among these different problems, two of them, long outages and numerous short outages, can be solved using different types of solutions :

- Standalone Fault Passage Indicators (FPIs).
- Remote monitored FPIs
- remote control switchgears
- Recloser and sectionalizer automation

These solutions of feeder automation can be used separately but also associated. Historically, the remote control with SCADA comes from European networks and the recloser & sectionnalizer automation without remote control is inspired from American networks.

The choice between these kinds of solutions is indeed a technico-economical choice, FPIs being a very economical solution to improve significantly quality of service, while remote control systems, with bigger investment, allowing even bigger impact.

Pole mounted reclosers used in Distribution lines are a very efficient solution to clear transient faults and isolate faulty sections, however no utility is rich enough to install them on every branch.

The global approach concept aims to increase the efficiency of the network management, in term of investment optimisation, reduction of minutes loss, reduction of customers concerned by loss of voltage and reduction of time to localise and reconfigure.

It involves a segmentation of the network into 3 levels. 3 types of substations will split the distribution network into 3 types of section

3 types of substations

Fault location and network reconfiguration scheme is defined from the use of 3 main types of substation:

Type 1: S/S or pole mounted switch with standalone FPI

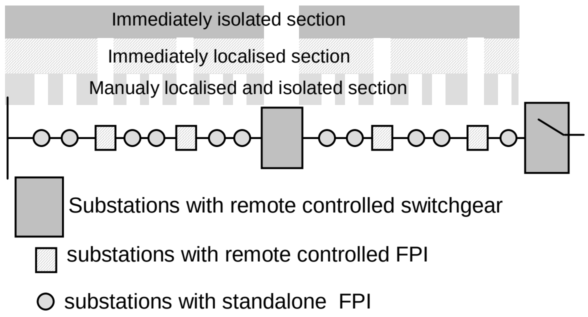
Type 2: S/S or pole mounted switch fitted with remote controlled FPI

Type 3: S/S or pole mounted switch fitted with a remote control cabinet including FPI function

A trade-off is to mix the 3 types according to various criteria such as number of customers, Accessibility of the S/S, importance of customers in each section (hospital, ministry , plant, ...)

According to all these above considerations, a typical network feeder could be organised as follows:

- ❑ 1 to 3 S/S with full remote control
- ❑ 5 to 10 S/S with remote controlled FPI
- ❑ all other S/S with 1 FPI for all other S/S



A graduate solution

The concept of the definition of 3 main types of section gives the advantage to simplify the investment analysis regarding the reality of the network.

A network could be equipped gradually according to progressive investment capability.

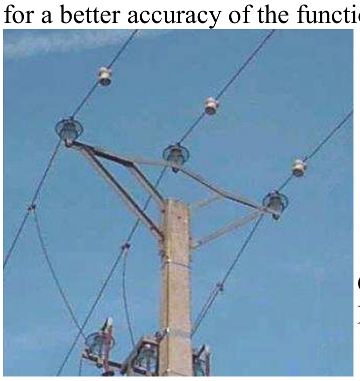
A first step is to place a FPI in all ground mounted S/S. The benefit is immediately visible in term of time to locate faults, but also in term of saving assets because FPI are easy to install on an existing network and the localisation of the faulty section is done by a patrol relatively fast.

A second step is either to install fully remote controlled S/S, this operation gives the benefit to quickly isolate the faulty section from the control centre, either FPI connected to the control centre in order to decrease the duration of outage.

FAULT PASSAGE INDICATORS

Standalone FPIs

The Fault detection function must be seen as a part of the network protection plan. So, depending on local specificity of line and cable distribution, the setting should be adapted for a better accuracy of the function.



UG: FPI embedded in the RMU

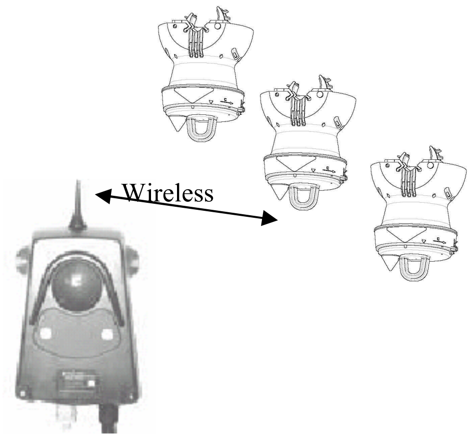
OH: Clip on Fault Passage Indicators

Remote controlled FPIs

Clip-on FPIs

First solutions was simply to add a radio chip inside their existing clip-on FPI, that was sending a short range radio signal to a radio received located on a direct line of sight at 10 meters from it. The contact of the receiver was connected to a digital input of a small RTU that was forwarding the signal to the SCADA.
Since then, users have discovered that this technical solution lacked three main features:
First, it was impossible to remotely test the short range radio link: if a branch was growing in the path of the direct line of sight between the FPI and its receiver, then the whole system was not working any more.
Second, when the battery was empty, the receiver could not be informed and so the SCADA operator could not get an alarm
Third, given the fact that there is a remote communicating indicator installed, it should be possible to get a current measurement as well, in order to optimise the data communication costs (GPRS, etc.)

Some manufacturers have covered the gap, by designing a system where the FPI and the receiver use a bi-directional radio communication system, and where the receiver is based on a true RTU with advanced feature like remote FPI configuration (fault thresholds, etc.), more than 3 FPIs connected to a receiver and metering functions.



Pole mounted FPIs

Obviously such FPIs do not suffer the drawbacks of a wireless link: it is very easy to connect the dry contact output relay of a standalone FPI to a small RTU and reports the alarm to the SCADA.
However, it is not able to manage more than one MV line, except when located near a branch. In addition, it cannot measure the accurate load on the phase conductors.

Underground cables

In the underground cables, the solution is even easier because there is no wireless link requested, the FPI is connected to three phase CTs.

From a function point of view, it is a downsized version of a true remote control cabinet, with the difference that he does not have the power supply to actuate a switch motor (it offers current and power measurement, time-stamped events recording, remote parameter settings, etc.).

REMOTE CONTROL

In a remote controlled S/S, electronic components have to perform the following functions:

First one is RTU function to control the switchgear from the SCADA when a fault occurs. The RTU supports the range of protocols (IEC, DNP3, etc.) and MODEMs (GPRS, GSM, PSTN, Radio,..). It concentrates existing IEDs (FPI, protection relay, power measurement devices, etc.).

The remote control includes a function of backed-up Power Supply for switchgear motorisation, because most remote controls are operated during outage.

The FPI functions include direct acquisition from Current Transformers, phase over current and Earth fault thresholds, Load and/ or power measurement facility.

The devices have functions of interfaces: dedicated interface with the switchgear, ready to connect, with a graduated capacity from 1 to numerous feeders and operating local interface and maintenance facilities.

Such a control cabinet may be build from standard components: however, a specially designed control cabinet (IRTU or Integrated Remote Terminal Unit), is cost effective. Fully tested units from complete control cabinet manufacturers are more attractive, for they guarantee a safety installation, a simplified commissioning, a full EMC compatibility and the minimum wiring and cabling, which dramatically increase the reliability and the availability of the control system.

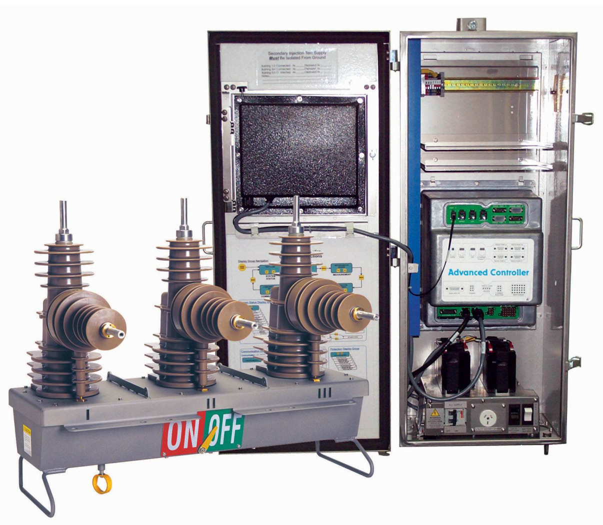
IRTU : **I**ntegrated **R**emote **T**erminal **U**nit for 4 feeders.

MV OVERHEAD FEEDER AUTOMATION

In an effort to improve reliability of supply, providers are rethinking the levels of sophistication deployed in their Medium Voltage (MV) Overhead Feeders.
An auto-reclose cycle should clear a transient fault without interrupting supply to the customer. In most cases no further operator assistance would be required to clear the fault.

Some faults are however more permanent. Examples include distribution equipment, such as transformer, failures and fallen power lines due to motor accidents or storms. Protection equipment is designed to minimise damage by interrupting supply to a segment containing a fault. The supply will remain off until the fault is removed and the protection equipment is turned back on.

Today's reclosers are capable of sophisticated protection, communication, automation and analytical functionality.
It is possible to operate in either a "manual" mode where the operator has to perform the reconfiguration of the network, or in a "Loop Automation" mode where the reclosers perform all the task automatically.



Solid dielectric recloser

Loop Automation
Loop Automation uses time, voltage, power flow and these simple rules to isolate the fault and reconfigure the network without any communications or operator assistance.
In a loop automation network the following actions will take place when a fault occurs:
The recloser immediately upstream of the fault automatically trips, recloses to lockout and remains open;
Reclosers downstream of the fault automatically change the protection settings in anticipation of power flowing in the opposite direction; and
The normally-open tie recloser closes automatically.
Due to the fault still being present, the recloser immediately downstream of the fault trips and locks out without reclosing. This will automatically restore power to the healthy parts of the network. An operator can now despatch line crews to the faulted segment.

Recloser&Sectionaliser Automation
A feeder automation network combines reclosers and sectionalisers in a feeder to provide grading on both current/time and number of operations. This is accomplished by introducing up to two sectionalisers in each zone protected by a recloser.

In a feeder automation network the reclosers protect the downstream portion of the feeder up to the next recloser. Similarly to the recloser network described earlier, the recloser will trip and reclose in the presence of a fault and the sectionalisers count the through-faults similarly to the sectionalising switchgear network described earlier. The difference is that if the fault occurs downstream of a sectionaliser, the sectionaliser closest to the fault will open before the recloser reaches lockout. Therefore, for this system to work correctly, it is essential that the recloser is configured with four trips to lockout and the sectionalisers are configured with supply interrupt counters of three and two respectively.

CONCLUSION

It is now clear that in most countries, delivering electricity with high level of quality and availability becomes a priority challenge.
From years and years the utilities have experimented various solution. It is now time to take advantage from all these experience.
It appears clearly that the remote control and the Fault Detection are two of the key solutions. The customers are mainly affected by faults on the distribution MV Network, to which, consequently, we have to pay a particular attention.
The introduction of Fault Detection, network monitoring and control and automation needs to be driven with pragmatic and optimised actions.
The cherry on the cake when using Remote controlled FPIs and IRTU fitted with load measurement and feeder automation, is that utilities can easily optimise their power generation and chase non-technical losses.
The global concept described here synthesise the experience cumulated from various utilities world wide. (France, Spain, UK, Australia, Canada…).
The components which must be associated to such a concept, such as IRTU, remote controlled FPIs, reclosers and sectionalisers… are available on the market.
Cost effective solutions are proposed also by main manufacturers with embedded concept. It allows proposing FPI, IRTU and other electronic devices built into the RMU or into the MV cubicle.