# IMPACT OF TELESUPERVISION IN SUBSTATIONS M.V. / L.V.

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## ABSTRACT

*In order to improve the quality of service EDENOR S.A. (Empresa Distribuidora y Comercializadora Norte S.A.) has undertaken a campaign of installation of low cost telesupervision equipment for their substations. This allowed them to:*

*a) Minimize the shutdown and repair time letting them to restore power more quickly.*
*b) Have alarms and load profiles of the substations.*
*c) Reduce SAIDI (System Average Interruption Duration Index) and NSE (Non supplied energy) penalties.*
*d) Minimize costs and prepare the network for the telecontrol.*
*e) Detect enters to the installations.*

*This solution allowed to improve the quality of service and has also developed a better image of the company while reducing "non sold energy" costs.*

*Briefly the main idea of the system is to measure the most important physical variables from the telesupervised substations, and send them to the Mid Voltage Control Center (CCR) and also to the local operation bases in order to identify and take real-time decisions to solve a potential problem.*

## TELESUPERVISION SYSTEM

We can divide it in three blocks:

Remote units, sensors and transducers.
Communication system.
Central Unit.

## <u>Remote Units (UTR), Sensors and Transducers</u>

### Remote Units

Remote units, also called UTR, were installed in each telesupervised substation.
Their duty is to collect all the information that comes from the sensors and the transducers, and send it to the Central Units through the Communication system.
How do they work?
Voltage, current and other parameters are sent to the CCR twice a day or whenever the operator requires the measurement.
Regarding to the voltage and current, the system calculates their averages within 15 minutes intervals and stores them until the next package to be sent to the UTRs.
In case any of the state variables goes above or below normal levels, an alarm is released. These alarms are immediately sent to the UTR without waiting for a request from the operator so he can take some corrective action.

### Sensors

Sensors and transducers are the lowest level of the system. They send the following variables information to the UTR:

a) Water level on buried chambers.
b) Short circuit current (Foult indicators).
c) Open door (Magnetic indicators).

In the case of aerial cables the foult indicators have a wireless link with the UTR.

### Transducers

Transducers are present on the low voltage network where they directly measure the following parameters:

1) Phase voltage
2) Phase current
3) Neutral current

Having these measurements and considering a constant Φ on the three phases, Active Power and Reactive Power are calculated by software.

### Communication System

Communication between UTR and CCR was initially made through GSM network. Nowadays is made through GPRS network which is faster and specially designed for digital traffic. That's why we'll find in every remote unit and also in the CCR a GPRS modem and its respective antenna.

### Central Units

Central Unit manages the communications and the data sent by the remote units of each substation or chamber.
Every physical value measured is stored in a server being able to be consulted later by the operator to check it value

and determine if it was in normal operation or alarmed.

## STATE VARIABLES – ALARMS

State variables and their alarms can be resumed in:

**State of the Substation access:**
It represents how the substation access door is.

**State of foult indicator:**
Foult indicator generates a pulsed signal that is holded until the operator recognizes it. Once the operator recognizes it, it returns to normal state.

**Water level in the buried chamber:**
Only applicable in buried chambers. It indicates the presence of water in the chamber using a switch and a floating device that activates the switch when the water pushes it up.

**Sub-voltage, over-voltage and over-current alarms:**
Alarms are released when the voltage or current values are above or below 20% of the normal values.

## RESULTS

The implementation of this simple system has allowed for the detection of the following events in real-time:

a) Flow of short circuit current
b) Presence of water in buried chambers.
c) Opened doors in substations.
d) Phase current out of normal values.
e) Neutral current out of normal value.
f) Phase voltage out of normal values.

Getting to know that gave the possibility to:

- Early detection of failure.
- Lower the repair time since we know short circuit currents in real time.
- Prevent accidents and unsafe conditions because we know the state of the access doors.
- We could avoid buried chambers to shutdown because of high water levels.
- We could prevent of substations going out of service because of over-current while transferring loads to other substations.

So, the Cost/Benefit relation that this implementation represents is really good, since it is a low cost system that provides with such vital information.

## PLANIFICATION AND EXECUTION

The following issues were considered on this phase of the project:

- Quality service indexes (SAIDI) giving priority to those mid-voltage sources that has the most interrupted annual service time.
- Sensitive customers such as Hospitals, Trains, Airports and all those who are electrical dependant.

For the aerial networks, the following issues were additionally considered:

a) Existence of low-voltage network.
b) Spare space available for the cabinet installation.
c) Ensure no interference is present so the wireless link can be established.
d) Accessibility for future maintenance.

**Installation and start up:**

- As a first stage, EDENOR workers installed foult indicators and transducers, on one of the phases and neutral, in those substations which were defined as ‘first intervention’.
- Later, the sensors were connected to the UTR and the GPRS modem and antenna were installed, and the connection to with the Central Unit checked.
- A few interference problems were detected while performing the connection tests. As a result, for the system to work properly, the antenna had to be moved somewhere outside the substation where the lower interference levels made the connection possible.

## SAIDI reduced (System Average Interruption Duration Index):

The following parameters had to be considered when installing and placing of the sensors in order to optimize the system:

a) Failure rates measured in the mid-voltage underground substations in between 2008-2009 and identifying the affected section.

| FAILURE RATES | |
|---|---|
| SECTION 1 | 34,01% |
| SECTION 2 | 13,40% |
| SECTION 3 | 11,96% |
| SECTION 4 | 8,50% |
| SECTION 5 | 8,07% |
| SECTION 6 | 7,64% |
| SECTION 7 | 6,34% |
| SECTION 8 | 10,09% |

Table #1. Failure rates in between substations

b) Global SAIDI contribution of each mid-voltage source.

Also a table for the standard operation time was developed. This table includes travel time and maintenance procedures time:

*Standard Times:*

| Description | Code | Time |
|---|---|---|
| First Shift | S1 | 00:40 |
| Shift | S | 00:10 |
| Handling | H | 00:10 |
| Measurement | M | 00:20 |

Table #2. Standard operation times

It was also evaluated the different installation possibilities regarding to the foult indicators. Different systems and topologies, such as telesupervised against a classic 3 indicators system without telesupervision were compared.

## EXAMPLE: FAILURE TO MV STRETCH

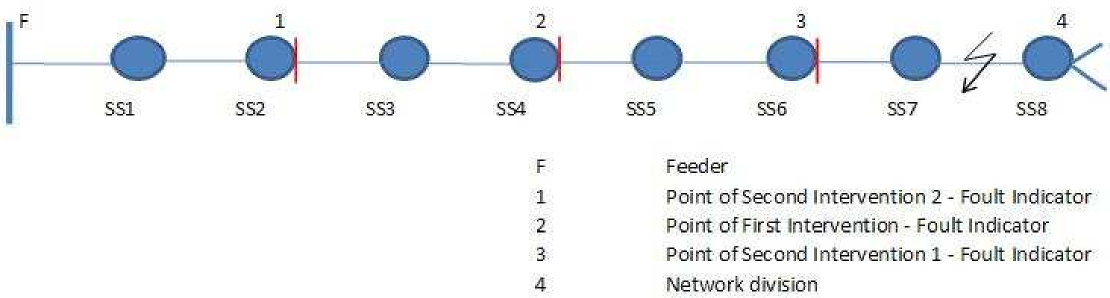


Fig #1: Typical mid-voltage architecture in between SS7 y SS8

Table #3 Operation Sequence without telesupervsion

| 1. WITHOUT TELESUPERVISION | | |
|---|---|---|
| Affected Substations = 8 | | |
| WG 1 attends to the point 2 (SS4) | S1 | 00:40 |
| WG 2 attends to the point 4 (ND) | | |
| 1.1. SCC flow through point 2 (SS4) | | |
| WG 1 opens LBS SS4 S/SS5 | H | 00:10 |
| WG 2 opens LBS SS8 S/SS7 | H | 00:10 |
| Feeder energizes | | |
| WG 2 closes LBS SS8 S/ND | H | 00:10 |
| 1° Energization: 5 SS | | 01:10 |
| WG 1 attends to the point 3 (SS6) | S | 00:10 |
| 1.1.A SCC flow through point 3 (SS6) | | |
| WG 1 opens LBS SS6 S/SS 7 | H | 00:10 |
| WG 2 attends to the SS7 | S | 00:10 |
| WG 1 attends to the SS4 | | |
| WG 1 closes LBS SS4 S/SS5 | H | 00:10 |
| 2° Energization: 7 SS | | 01:50 |
| WG 2 measures sections 6-7 and 7-8 | M x 2 | 00:40 |
| WG 2 opens LBS SS7 S/unsafe cable | H | 00:10 |
| WG 1 from SS6 or SS8 whichever is applicable normalizes SS7 | S - H | 00:20 |
| Total Energization: 8 SS | | 03:00 |

Table #4 Operation secuence with telesupervision

| 2. WITH TELESUPERVISION - 1 FOULT INDICATOR PPI | | |
|---|---|---|
| Affected Substations = 8 | | |
| 2.1. SCC flow through point 2 (remote indication) | | |
| WG 1 attends to the point 2 (SS4) | S1 | 00:40 |
| WG 2 attends to the point 3 (SS6) | | |
| 2.1.A SCC flow through point 3 (SS6) | | |
| WG 2 opens LBS SS6 S/SS7 | H | 00:10 |
| Feeder energizes | | |
| 1° Energization: 6 SS | | 00:50 |
| WG 1 attends to the SS8 | S | 00:10 |
| WG 2 attends to the SS7 | | |
| WG 1 opens LBS SS8 S/SS7 | H | 00:10 |
| WG 1 closes LBS ND S/SS8 | H | 00:10 |
| 2° Energization: 7 SS | | 01:20 |
| WG 2 measures sections 6-7 and 7-8 | M x 2 | 00:40 |
| WG 2 opens LBS SS7 S/unsafe cable | H | 00:10 |
| WG 1 from SS6 or SS8 whichever is applicable normalizes SS7 | S - H | 00:20 |
| Total Energization: 8 SS | | 02:30 |

*References:*

| Description | Code |
|---|---|
| Working Group | WG |
| Load break switch | LBS |
| Substation | SS |
| Network division | ND |
| Short circuit current | SCC |

Table #5 References codes

**SAIDI Reduction Calculation**

**SAIDI = ∑(customers out of service*downtime) / ∑(total customers)** [hours]
**Note:** Calculations were considered for the same amount of customers per substation**.**

$$\textit{SAIDI without Telesupervision}: \frac{8}{8}\cdot\frac{70'}{60'}+\frac{3}{8}\cdot\frac{40'}{60'}+\frac{1}{8}\cdot\frac{70'}{60'}=1.562$$

$$\textit{SAIDI with Telesupervision}: \frac{8}{8}\cdot\frac{50'}{60'}+\frac{2}{8}\cdot\frac{30'}{60'}+\frac{1}{8}\cdot\frac{70'}{60'}=1.104$$

$$\textit{SAIDI Reduction}\ \%: \frac{\textit{Without Telesup.} - \textit{With Telesup.}}{\textit{Without Telesup.}}\cdot 100\% = \frac{1.562-1.104}{1.562}\cdot 100\% = 29\%$$

**CONCLUSIONS**

We arrived to the conclusion that, to place the foult indicators in equivalent 4 sections of the mid-voltage feeder is the best and optimal configuration.
In cases where old not supervised ICC (indicador de corto circuito – spanish for foult indicator) were present, the solution, based on an exhaustive analysis, was to place one telesupervised ICC in the first substation. Doing that allowed us to obtain a 10,5% SAIDI reduction.
Also, in order to optimize the operation times according to this new facilities and based on the location of the ICCs, the failures location and the availability of maintenance teams for the repair, a new procedure manual had to be developed and introduced to the operators.

**REFERENCES**

[1] Internal EDENOR Magazine “A toda luz”, March and May 2009 edition.