INNOVATIVE MONITORING SYSTEM FOR LV GRID

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ABSTRACT

In addition to consumers' smart metering and intelligent transmission energy management, the real potential of smart grid management can only be unlocked through real time, accurate monitoring of all LV energy flows.
With a very high integration of PV production on its LV grid, RESA has to find new solution to manage it.
On the 16th March 2016, the first prototype of smart LV board is going to be installed in MV/LV public substation of the RESA distribution network.

INTRODUCTION

After working on HV and MV solutions, RESA DSO started a project to make the LV equipments in substations change to a safer and smarter solution. Key points were a full IP2X protection and a complete LV monitoring.
For this study, RESA chose to work with SOCOMEC, expert in this both areas, developing a new monitoring technology.

A SMART ENVIRONMENT

The increase in decentralized Renewables production, energy storage, the use of electric vehicles and load shedding will disrupt the traditional grid and will create new challenges for those responsible for operating grids. As everything becomes connected to the network, there is a need to be more flexible and adaptable and utilities will need to develop a comprehensive understanding of what is happening on the grid.

1- OBJECTIVES & TECHNICAL FEATURES

Objectives

The most important for the DSO RESA is to know the energy flow of LV grid to respect the Belgium delivery energy conditions with an important concentration of photovoltaic productions in the distribution LV grid.
Another objective is to optimize OPEX by the reduction of non-technical losses (frauds) and CAPEX by a better anticipation of the grid evolution.
The RESA mid-term objective is to develop a LV SCADA integrating all decentralized productions, existing and in the future.

Grid issues

With the massive development of renewables energies in Belgium in previous years, RESA has today an unknown number of decentralized PV producers on its grid.

In some district, the rate of PV measured can reach up to 66%. On the drawing below, yellow points show the concentration of PV productions.

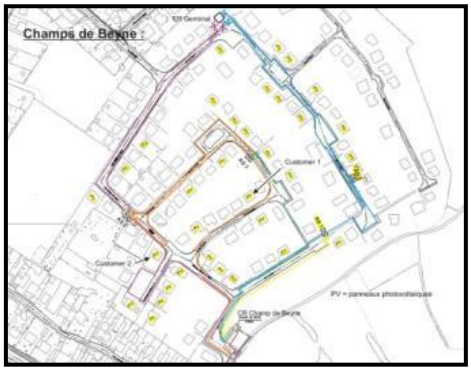

Figure1 - High rate of PV productions in a district

Technical constraints	Consequences / Impact on
Overvoltage	Energy quality Non-respect of regulation
Bidirectional current	Feeding back to MV grid and to others LV feeders
Load balance	Transformer capacity - Grid architecture evolution CAPEX
Losses detection	Revenues, OPEX

Solutions portfolio

To solve these problems, main solutions are:

- **New distribution substations or HV-LV cables**
  Creating new substations or changing the size of the cables increase the CAPEX, when it may be unnecessary.

- **Smart distribution transformer**
  Using this type of transformer solves the problem of overvoltage, but not of phase balance.

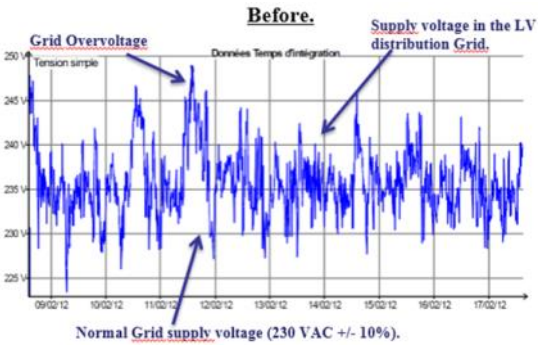

Figure 2- LV overvoltage due to PV

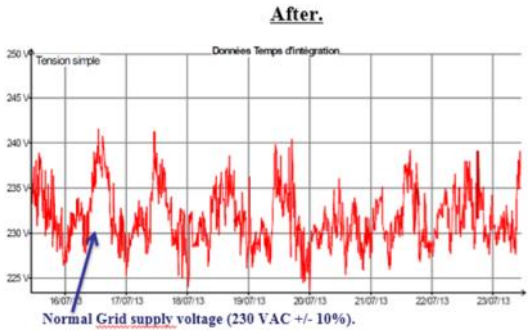

Figure3 - Voltage correction with a smart transformer

Before deciding the best solutions to manage all these problems, a complete analysis of LV grid is required.

2- THE NEW LV MONITORING SYSTEM

Needs & Benefits to implement LV monitoring

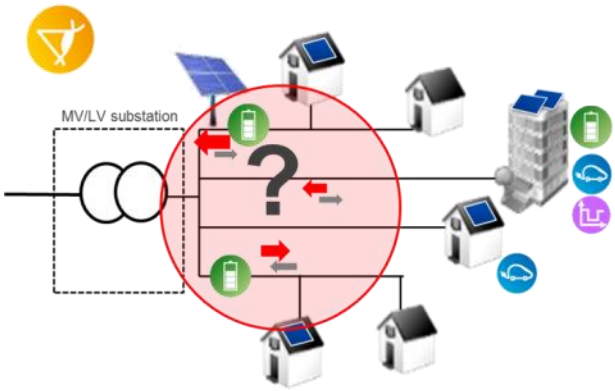

Figure 4 – New constraints on a smart LV grid

The main topic is to really understand the LV grid with a precise analysis of all electric flows on each active conductor.

Main concerns :

- Renewable (mainly PV)
- Frauds
- Energy quality
- Consumption profiles
- Anticipation of architecture evolution

In a near future:

- Electric vehicles
- Energy storage
- Peak shaving

Innovation of the LV monitoring system

This new plug & play measurement and monitoring system is designed especially for multi-circuit electrical installations.

This system is a hub of technological innovations that revolutionises the world of measurement, bringing a high degree of flexibility to installations and making connection and configuration easy.
These innovations, together with unrivaled performance in terms of accuracy and functionality, make it the most effective solution for metering consumption and monitoring the quality of electrical energy.

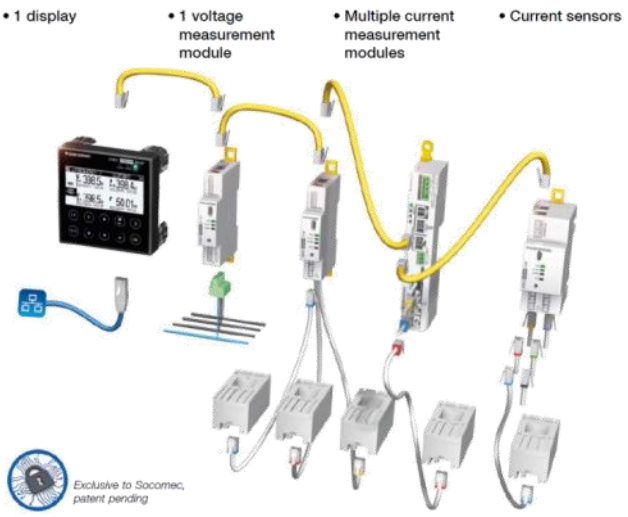

Figure 5 – Innovative monitoring concept

This concept is based on a modular solution separating and pooling the functions as possible. Only one voltage measurement is necessary while adding the number of current modules required. All modules and sensors are connected through a bus, with plug & play connections (RJ12). The current transformers are not any more in current (5A) but in voltage (mV), which avoids an additional protection for the opening of the secondary.
Particularly adapted for substation board, the Rogowski sensors can be installed on live cables.
The accuracy class of the global measurement chain is 0.5% from 2 to 120% of rated current.
This system is completed with communication devices in order to centralize data coming from all meters and to make them available on an Ethernet network. These communication devices, composed by gateways and dataloggers, includes an embedded web server to allow real time monitoring of electrical values and analysis of consumption data.

LV monitoring deployment

In addition, an economical goal was to design a cost-effective solution, which can be deployed by RESA.
Instead to do a full deployment in all substations on all feeders, RESA choose first to deploy this monitoring in key substations, already categorise as sensible points, with PV producers or high loaded transformer.
This system is for **new** substations but also for **existing** installations.

The concept of the smart LV distribution board

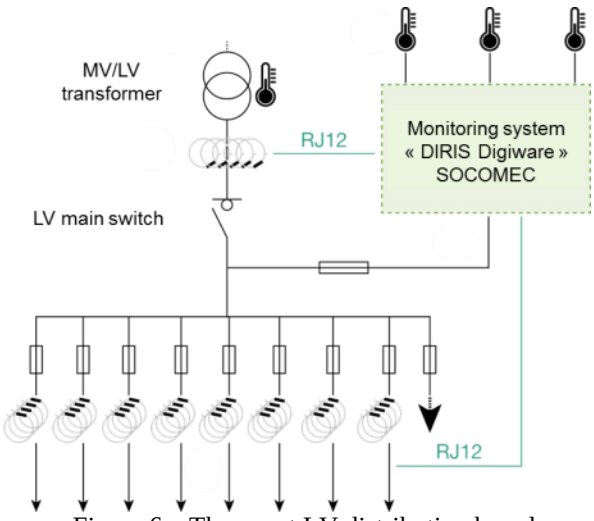

Figure 6 – The smart LV distribution board

An integrated and flexible system to monitor:

- The secondary of the transformer
- One or all LV feeders on the board

Measurements of

- Voltage (U)
- Currents (I1, I2, I3, I NEUTRAL), with their directionnal component, Rated current (In)
- Powers (S, P, Q)
- Harmonics THD (I and U)
- Temperatures of the substation (In – out) and also of the transformer oil (PT 100 probe)
- Energy metering (Ea+ and Ea-)

Communication

- Data centralization thanks to a gateway
- Communication with the Ethernet connection of the gateway and a 3G modem.
- Storage of LV grid values in RESA data servers or directly on the LV Board for one year duration, with devices memory.
- MV information to the SCADA by the communication protocol IEC 60870-5-104.

All the LV boards equipped of this new technology of LV monitoring will be connected on the RESA VPN in IP technology by CATV communication network (cable modem). This IP connection will allow RESA to know and to analyse the low voltage grid values in real time or over a given duration (production and load grid diagrams). The consultation of this information is realized by the use of the Web server embedded on the new LV Board.

On the LV board, an IEC 60870-5-104 gateway will repatriate the MV information from the RMU, which is already in the substation, to the SCADA system; particularly information about relay contacts from VDS LRM, short-circuit fault indicator systems and also the mechanical position of circuit breakers and switchgears.

Prototypes of new smart LV distribution board

Two prototypes of this smart LV board are going to be installed on the 16th of March in substations for field experimentation.

Figure 7 – The smart LV board

Figure 8 – Rogowski current sensors

The smart LV board:

- French design TIPI board for 8 to 12 feeders, full IP2X
- Adaptation to the Belgian DSO technical rules and RESA request, especially for the Neutral and Earth connections.
- Surge protection on the board for the measurement devices protection
- Monitoring modules directly on the board for new board or in a small box
- Pre-wiring of current modules for a very quick connections of current sensors
- User friendly application with all safety conditions and without cut customers
- Electrical overview for each LV Feeder.

3- MAIN BENEFITS

Main advantages of this innovative monitoring are:

- Local view of all data directly in the substation on the display
- Ethernet communication to a SCADA (IP connexion)
- Measurement of the Neutral current
- High accuracy guarantee with new-type Rogowski current sensors, for a very easy-of-use
- Scalable system facilitated by an integrated pre-wiring for future additional monitoring or removal
- Possibility to add or remove the LV Feeder system monitoring on the TIPI RESA very easily
- Allowing a progressive implementation of the features for power monitoring and data management
- Completely transparency for the DSO customers
- In safety conditions for the DSO operational department peoples
- Centralization in a unique application data coming from all MV/LV substations
- Perfect technical interface to the MV SCADA system, also for the future LV SCADA system.

CONCLUSION

It will be one of the first times to have full monitored LV board in MV/LV substations, as grid management tools. This will lead to a complete change of working methods for DSO (CAPEX and OPEX).

The monitoring investments are optimised with this solution, really modular and flexible.
The good knowledge of the balance of loads and productions on the LV Grid will make it possible to carry out the right investments.

A real analysis of the impact of a massive PV integration will be very instructive and helpful to know what are the best solutions in reality to manage it.
Monitoring solutions are a real tool for the future, with the increase of renewables, electric vehicles and other smart developments.

To conclude, this is a technical solution which takes account of the best practices and also of the economic reality of the DSO Grid

In June 2016, first results issued of a 3-month experimentation will be showed.