Integration of Monitoring system for the assessment of Low voltage

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Abstract: This paper outlines the strategic advantages of installing an integrated monitoring system on the low-voltage (LV) side of secondary substations for Electronic Data Processing (EDP) Distribution. This technology represents a significant advancement in the digitization of the LV grid. It works in tandem with active smart grid appliances to foster synergies and improve visibility in this area of the grid. Every LV circuit is measured as part of the monitoring system, and the data is integrated and processed live. Four use cases are suggested for these metrics in conjunction with smart grid data: (i) monitoring LV asset status; (ii) network power quality; (iii) identifying grid topology; and (iv) energy balance.

1 Introduction

Nowadays, new tendencies are arising for low-voltage (LV) grids such as the increase of distributed energy resources (DERs), the changing role of consumers ('prosumers') and their habits, electric vehicles (EVs) penetration etc. are setting a new paradigm for the way electricity is used and are adding a more complex energy transit topology. This usage of electricity in a more dynamic way has a higher effect on the LV grid due to the higher volume of assets and the lower level of control presently.

During the last decades, the DSOs across Europe have been concentrating their efforts in the high-voltage (HV) and medium-voltage (MV) of the grids, promoting sensorisation and automation, and in this way achieving higher quality of service indicators.

For the LV, smart grid infrastructure has been tested recently, transitioning to an in-deployment state. Consequently, these assets are in an early stage of maturity.

In addition, electricity networks were not initially designed for these new tendencies, which make it increasingly difficult for the DSOs activities in this level of the grid. Operation, planning and maintenance of LV networks need to be conducted in this scenario with flexibility one of the future key tools for grid management.

New strategies, new methodologies and new technologies in the LV grid are becoming increasingly important as electrification continues to rise.

2 InteGrid project

Within the scope of the H2020 program, InteGrid aims to demonstrate intelligent grid technologies for renewables integration and interactive consumer participation, enabling interoperable market solutions and interconnected stakeholders, while addressing the challenges derived from this goal from a technological, market and regulatory and societal perspective.

The Portuguese demonstrator, which intends to innovatively boost the management of the distribution network using new DERs (including, here, consumers' flexibility) with already-implemented assets, in a predictive and integrated way, fostering the implementation of cost-effective, replicable and scalable solutions, will be the place where the herein described function will be demonstrated.

The LV monitoring system, hereinafter described, is one of the tools developed and demonstrated with this purpose.

3 LV monitoring system

Eneida DeepGrid® is an Operational Analytics (OA) Applications platform for monitoring and optimizing, remotely and in real time, the condition and operation of LV networks. It combines data from secondary substations and smart meters for faster and more efficient integration of EVs, PV panels, heat pumps and other DER, and for a significant improvement in network planning, quality of service and energy efficiency.

In this pilot, the OA Apps were deployed with the Eneida Deep grid Software and were fed with data from Eneida smart sensors – the EWS DTVI-m, installed in substations, and data from different generations of smart meters presented in the grid.

The EWS DTVI-m is measuring currents per feeder and per phase with Rogowski coils, and the voltages directly from the busbar. This smart sensor calculates all relevant energy and power quality parameters, according to IEC 61557-12, and makes available the NPQ analysis according to IEC 50160.

The processed data is then sent to a web server for storage allowing it to be accessed at any time through the web application for visualisation. The data can also be used as input to other applications, such as feeder mapping.

4 Results for LV supervision from the DSO side

EDP Distribution, using Eneida's DeepGrid® solution, launched a Proof of Concept pilot starting in early 2019 to explore a digital LV grid management system. The goal of such a system is to allow better visibility and granularity of the LV network by Digitalizing secondary substations.

The methodology for selecting the location of the demonstrators was mainly associated with the Inter-grid project, plus two extra secondary substations with a special interest such as very high loads and low quality of service indicators.

The location of the map of each 12 secondary substations tested in the POC is shown in Fig. 1).

Aligned with EDPD LV interests, four use cases are assessed for this POC.

UC 1. LV asset condition monitoring

Digitalizing LV grids allows management from reactive approaches to a more proactive operation. Real-time measurements of LV circuits allow grid management teams to configure different types of alarms relating to voltage, current or frequency. More precisely, Eneida's platform permits to set alarms related to loads associated with fuse ratings, voltage violations, voltage imbalance, voltage–frequency or MV dead section.

More precisely, the solution permits to include specific values according to Portuguese standards. Specific values can be defined for each secondary substation allowing to mislead false alarms in more extensive grids, which demand higher voltages at feeder level guarantying regulated voltage at the end of the grid.

Regarding overloading issues, it is possible to personalise fuse rating by the circuit as well as by phase, which allows clear visibility of the phase balance. It was verified such an unbalanced grid with >100 A in neutral. In these cases, where such an unbalance is extreme, and a neutral outage occurs, voltage rises can be monitored and make specific actions to mitigate the damages on customer installations.

With this measurement solution, it is possible to instantly react in case of failure. During the demonstration time, it was possible to detect some situations. One of the most significant was the early detection of a change-over in the pattern where two phases had an overload overcoming 370 A. This overload was followed by a short-circuit affecting roughly 100 clients, as can be seen in Fig. 2.

This was one of the examples that alarms can be used for identifying failures at an early stage allowing to send field teams.

With the large scale of this solution, it is expected quality indicators to be improved and therefore, a better customer experience.

UC 2. Network power quality

One of the responsibilities of DSOs is to measure the quality of energy in the network. This task can be related to several situations such as contractual applications for reporting effects or for evidence information to present in the courts in case of complaints. In these cases, equipment need to be certified according to IEC 61000-4-30 and Portuguese norm NP 50160.

Fig. 1 *Location of the secondary substations tested*

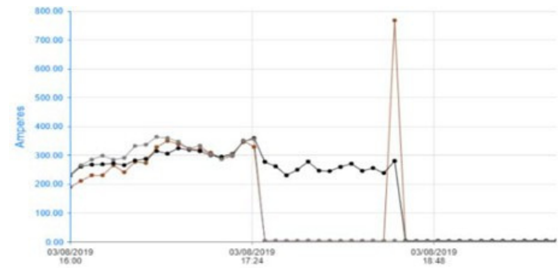

Fig. 2 *Outage real-time detection*

Without this equipment being certified for such norms, there is still interest from a DSO point of view in making preliminary quality analyses for grids with possible voltage, harmonics or flicker constraints such as high penetration of distributed resources or EV charging points among others.

In future next steps, the platform is expected to develop algorithms to automatically detect the presence of production or EV chargers connected to the monitored grid.

UC 3. Grid topology identification

One of the main challenges for managing the LV grid is the uncertainty of network topology. DSOs often have knowledge about the circuit's location but very little or none about the client's association to feeder and phase.

It has been tested in this project an algorithm for the automatic identification of feeder and phase of each client associating the data coming from the feeders in the secondary substation with the consumption data. More precisely, the necessary data for feeding the algorithm is voltage and active power injected and consumed from both clients and at the secondary substation feeder level.

The algorithm was tested in several secondary substations considered in the present project. The objective has been to test the results in different conditions of smart meter communication technology, urban and rural areas and in the presence of distributed production. In this project, 432 clients were analysed from four secondary substations.

The results for the analysis are close to 100% of success rate for the identification of both feeder and phase (Fig. 3). These results are consistent for different communications technologies and in the presence of distributed production.

This algorithm is very valuable for grid mapping, improving the time-consuming process of going to each house and identifying each client individually. Despite the good results, the algorithm output depends on data availability from metering infrastructure.

UC 4. Energy balance

Based on results obtained in 'Use case 3', it was possible to calculate the energy losses by a feeder. EDP Distribution already had the results for the energy balance by a secondary substation in the country, through the already implemented telemetering infrastructure, which provided sensibility to the energy losses at a general level. The equipment and methodologies tested allowed EDP Distribution to take one step forward in this subject.

Fig. 3 *Phase and feeder identification success rate*

A higher level of granularity for this type of data is very helpful to create insights for detecting and mitigating commercial losses in the grid, generally due to fraudulent behaviour such as unmetered interceptions. With this granularity of information, it is possible to make some adjustments to the grid topology (changing phases, for instance) which will optimise equipment management (by reducing stress) and reduce technical losses.

After performing an energy balance for all secondary substations, we got for ‘PT 214 EVR’ high values of losses in one of the four LV circuits (Fig. 4).

After analysing this feeder, it was possible to make some corrections regarding the mapping of the grid (one installation of auxiliary services was not being considered in the balance calculations and it was possible to transfer some charges from feeder C2 to feeder C3 to balance the loads).

Also, the platform shows high unbalance values for those circuits as shown in (Fig. 5).

Using the correct configuration of grid topology, it was possible to calculate the theoretical technical losses supported on the *software DPLAN BT*. The results showcase a possibility to reduce technical losses by >50% with this configuration of the grid (Fig. 6).

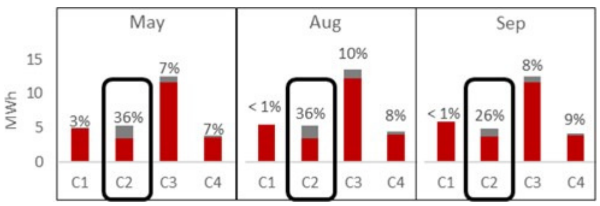

Fig. 4 *Losses per month per feeder (PT 214 EVR)*

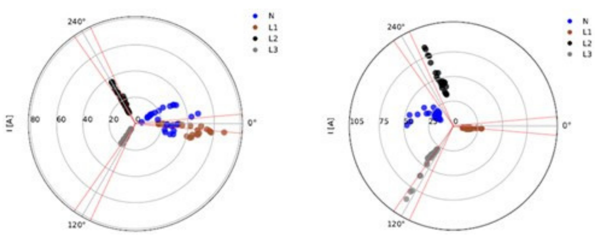

Fig. 5 *Load distribution per phase for feeders 2 and 3 of PT 214 EVR*

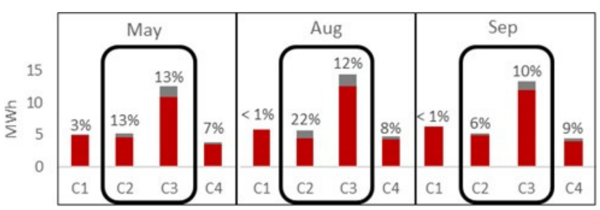

Fig. 6 *Losses per month per feeder (PT 214 EVR) after mapping grid*

5 Future applications and benefits

As described below, this paper highlights the results of a pilot project gathering data for almost a year of usage. Over this time, it is concluded that LV supervision technology is mature enough and has great potential, especially if synergies with smart grid infrastructure data are considered.

Once this technology showed maturity, real applications could be included to increase its potential. More specifically, EDPD is studying the deployment of this solution in three main vectors considering the results and conclusions of the present project.

The first vector will be focused on the early detection of LV failures considering the expertise gained from UC 1 specially the alarms configuration. The final output of this project will be the selection of secondary substations with lower levels of quality of service and a high level of client penetration. The option of integrating this data directly in the SCADA system of EDPD will also be evaluated in this project.

The second vector will be focused on LV technical and non-technical loss reduction. This vector is a mix from UC 3 and 4 considering that the initiative will be done to map the grid and subsequently the energy balance calculation. The final output of this project will be the selection of secondary substations with a high level of smart grid infrastructure deployment and a high level of LV losses measured from current internal systems.

The third vector will be focused on studying the quality of energy of grids with high penetration of distributed production and EV chargers. The objective is for EDPD to be well prepared for possible upcoming constraints with solid methodologies to manage the grid under these situations.

6 Conclusions

The digitalisation of LV networks has been growing in the last years with the deployment of smart grid infrastructure. In the same way, new initiatives such as feeder monitoring systems mean a step forward in creating synergies that benefit DSOs in the way they manage the grid.

This paper has shown the principal benefits of installing such a monitoring system in the circuits at the secondary substation level and how to take advantage of the data collected. More precisely, four use cases have been tested: (i) real-time monitoring system; (ii) power quality measurement; (iii) grid topology identification; and (iv) energy balance.

This technology has proven good benefits from a DSO’s perspective increasing the visibility of LV networks which, according to the upcoming technology trends, will be crucial for the best grid management methodologies in the next years.