EVOLUTION OF THE QUALITY OF SUPPLY IN THE PORTUGUESE DISTRIBUTION SYSTEM

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ABSTRACT

This paper addresses the Evolution of the Quality of Supply (QoS) in the Portuguese Distribution System over the last years. This Quality of Supply can be noticed both in what regards continuity of supply and power quality (PQ). An overview of a case study is presented by EDP Distribuição (EDP D).

This evolution is quantified through the analysis of standardized indexes for system reliability such as SAIDI and SAIFI, in their different voltage level, for what concerns the continuity of supply.

Regarding to power quality, this paper focus on significant results in improvement of NP EN 50160 standard compliance in MV and LV busbars, and on the evolution of EDP D PQ monitoring programme.

Throughout several approaches from investments in infrastructures and tools, to the revision of procedures as well as innovation, EDP D manages to present nowadays indexes similar to the average of the European electric utilities. Moreover, EDP D is aligned with the best European practices. This improvement was achieved in an environment of an increasing regulatory effort.

INTRODUCTION

In the 90's, the electric sector started to undertake major structural changes in Portugal which led to separated activities in the electric system, creating four main activities: generation, transmission, distribution and commercialization. Both transmission and distribution are organized by a natural monopoly.

EDP D holds the concession of the high and medium voltage networks which was granted by the Portuguese State. The low voltage network is granted by several municipal concessions. These two network concessions consist of the national electricity distribution activity that EDP D operates on a daily basis.

This role as a distribution system operator (DSO), is regulated by the Portuguese National Regulatory Agency for Natural Gas and Electricity, ERSE. This agency is entitled to publish the regulation for QoS, which has been reviewed through the years producing a regulatory effort for DSO by always being more demanding.

The quality of service of an electric system can be divided in two major areas: one regarding its technical nature which is related with the continuity of service and with power quality provided to the customer and the other which is focused on a commercial nature and that is related to aspects of communication and services provided to the client.

As continuity of service can be summed up as what measures the number and duration of supply interruption, the power quality is assessed through the measurement of voltage continuous phenomena data, including voltage r.m.s., harmonics, flicker, unbalance and frequency and voltage events, including voltage dips and swells and others.

CONTINUITY OF SERVICE

Electric network users expect a high continuity of supply. At the customer level, fewer the interruptions and the quicker the return of electricity supply, the better. Therefore the DSO has to optimise the continuity of supply of its networks and the processes related to its management so that the QoS improve.

Under the Portuguese regulatory framework, interruptions on the electric network can be defined as:

- Short interruption – interruption with a duration equal or longer than 1 second and less than or equal to 3 minutes;
- Long interruption – interruption with a duration longer than 3 minutes.

When any type of interruption or a network disturbance

occurs in the EHV, HV and MV networks, EDP D can identify the users affected by using SCADA system and its Outage Management System (OMS). If a long interruption has its origin at the LV network, the customers affected are mainly identified on the OMS based on phone calls.

In what concerns two common standardized indexes for system reliability and CoS, considering long interruptions, such as the System Average Interruption Duration Index and the System Average Interruption Frequency Index, commonly known as SAIDI and SAIFI respectively, EDP D compute its values weighted by delivery point (for HV and MV) and by the number of customers for LV.

Over the years the Regulation of Quality of Service has also evolved making the regulatory effort always present as an EDP D orientation vector, also reflecting nowadays more demanding and active clients as well as the new stakeholders of the distribution network. The NRA establishes QoS standards for SAIDI and SAIFI accordingly to the voltage level and zone: zone A, that concerns a district capital or an area with more than 25000 costumers, zone B which is linked to areas with a number of costumers between 2500 and 25000 and a zone C for the areas which do not achieved the criteria of the mentioned zones. In the revisions of the regulation carried out in 2005 and 2013, these standards were shortened and as a consequence an even more challenging commitment was and is required of EDP D.

EDP D has made a large investment to improve its reliability indexes of the electric distribution grid. The same evolution of quality of service has been registered across several operating structures, including planning, operation and maintenance. An impressive improvement in the Portuguese distribution system has been noticed since 2000, as presented on Figure *1* and Figure *2*.

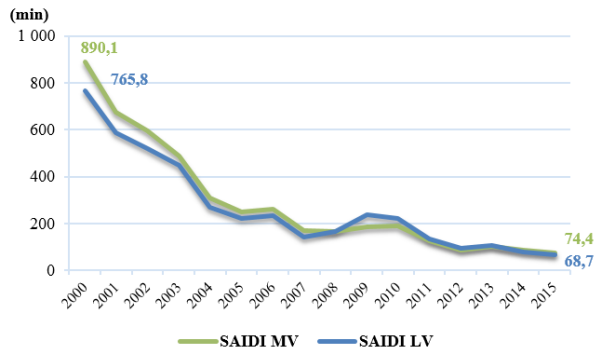

Figure 1 - Evolution of SAIDI in EDP D.

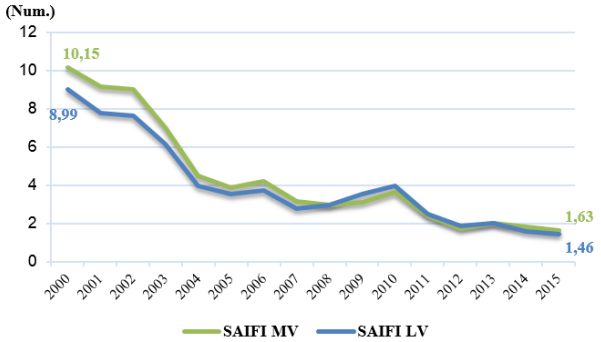

Figure 2 - Evolution of SAIFI in EDP D.

As can be seen, both indicators had a huge improvement whether in MV or LV distribution network. A reduction of more than 90% and more than 83% was achieved for SAIDI and SAIFI respectively, despite the voltage level. On the other hand, for short interruptions at HV and MV, the Momentary Average Interruption Frequency Index (MAIFI) also registered strong improvements.

Since 2000 an amount of approximately 4,000 M€ has been invested with the focus on improving the distribution network, throughout automation, construction of new infrastructures, maintenance and new operation approaches. Furthermore, the investment in control automation and supervision of the network also contributed to better indexes. Since the Portuguese distribution network is nearly 80% composed of overhead lines both for MV and LV networks, it also required a lot of planning so that the relation between cost and benefits was not unbearable. Between 2008 and 2015, the remote controlled reclosers installed in the distribution network were more than doubled reaching more than 6000 units. This allowed the operators in the dispatches to perform remotely more operations that can reestablish electricity supply in case of outage in a faster way. Also new connections have been built, created possibilities of operating in closed loops that combined with these equipments led to a decrease of the interruption duration making the electric network more agile and with increased flexibility.

Besides a strong commitment in what concerns the investment on the network itself, innovation tools were also developed and tuned for a goal of having a more robust and resilient network. Projects such as the MV defect location allowed gains in case of fault detection. Through the gathered experience over the years EDP D also revised many procedures in order to optimize all its operations and created new ones to face adversities that may come. For instance, the business continuity plan for electricity distribution, named POAC, which was conceded to improve operational effectiveness and recovery time in the electric network in case of extreme scenarios was approved in 2009. After this date, several extreme scenarios occurred, which allowed EDP D to

conclude the benefits of its implementation including during the storm Gong. Its performance was later awarded the Most Effective European Recovery in 2013.

The current regulation, issued in November 2013, imposed adjustments in the characterization of occurrences in the network classified as force majeure. EDP D had to adjust its methodology and processes. For an event to be classified as Exceptional Event (EE) and therefore its contribution to be excluded from the system reliability indexes, regarding system level standards, it has to fulfill several characteristics and criteria such as: low probability of event occurrence, that cause a significant impact on the quality of supply provided and that the event itself and its consequences are not attributed to network operators. EDP D submits these occurrences in form of a report to ERSE describing the incident and its impact as well as many evidences that can be gathered (photos, reports of other entities such as civil protection, police, firefighters and meteorological institute). Only the ones that ERSE evaluates as EE are classified as such. To face this regulatory requirement EDP D developed a tool in its DMS that allowed the integration of these annexes and that has its own process flow to make post mortem reports more agile.

Moreover, the regulation framework has an incentive mechanism for the improvement of continuity of service. This mechanism aims to promote an adequate improvement of the overall network performance in terms CoS and ensure a consistent improvement in CoS for the worst served customers in order to reduce asymmetries. It is divided in two components both presenting a system of incentive trough rewards or penalties as illustrated in Figure *3*. As ERSE states, dead band are used to avoid the activation of incentives when small performance or possible deterioration is expected.

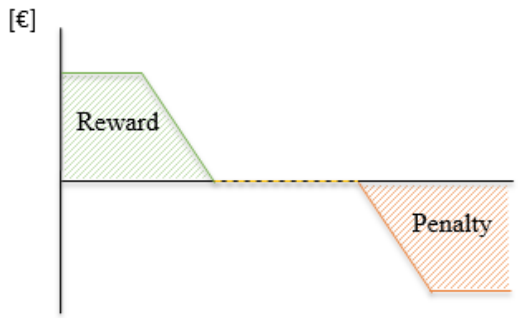

Figure 3 – Generic scheme for reward or penalty.

The first component is associated to the Energy not Distributed (END), whereas the second component was only introduced in the last regulation revision and it is related to the SAIDI MV of the worst served 5% MV delivery points (MV/LV secondary substations and MV customers). The parameters for these 2 incentives schemes are defined for each regulatory period. This last component aims for an asymmetry reduction in the distribution network. Since this concern is also present in EDP D framework, EDP D has achieved satisfactory results.

Other incentive mechanism are the automatic compensations based on customer level standards. The regulation defines standards for the costumers taking into account its voltage level and its QoS zone, as previously described. There are standards both for number of interruptions and for the duration of the interruptions. When this standards are not achieved, the customer is informed and an automatic compensation is payed to the customer, without needing to perform any complaint.

POWER QUALITY

EDP D has been complying, for many years, a Power Quality (PQ) monitoring programme to ensure a better QoS, in global terms, and a better PQ, in particular, of the distribution network operated and managed by EDP D. According with QoS Regulation Code in application in Portugal, EDP D develops and applies, every two years, a monitoring plan including HV/MV substations and also MV/LV substations.

As can be seen in Figure *4*, in the last years the number of weeks analyzed regarding compliance to NP EN 50160 standard, in MV busbars of HV/MV substations and in LV busbars of MV/LV substations, has considerably increased. Between 2009 and 2015 this number has increased almost 138%.

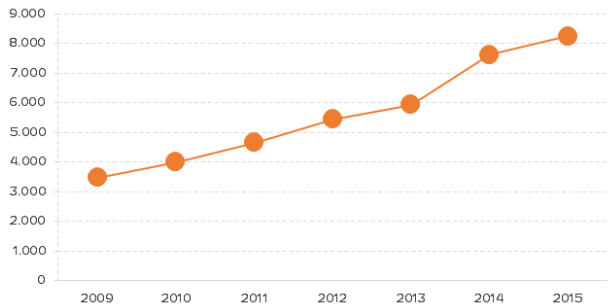

Figure 4 – Evolution of weeks analyzed according to NP EN 50160 standard from 2009 to 2015.

The EDP D ambitious PQ monitoring programme in MV and LV networks has presented significant results of NP EN 50160 standard compliance in MV, as can be seen in Figure *5*, but also in LV, as can be seen in Figure *6*.

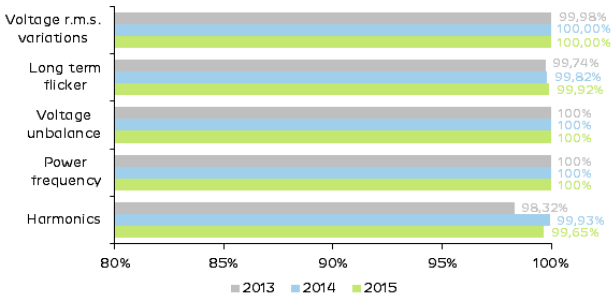

Figure 5 – Evolution of NP EN 50160 standard compliance in MV busbars from 2013 to 2015.

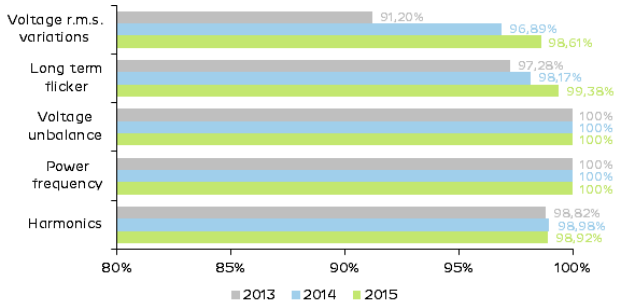

Figure 6 – Evolution of NP 50160 standard compliance in LV busbars from 2013 to 2015.

Although most of the continuous phenomena compliance with NP EN 50160 standard has improved consistently since 2013 for MV busbars, it is important to highlight that the number of weeks in noncompliance with NP EN 50160 standard in 5th harmonic voltage on MV busbars has been significantly reducing since 2009, as can be seen in Figure *7*.

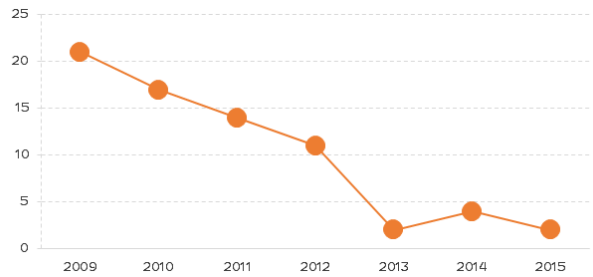

Figure 7 – No. of weeks with nonconformities on 5th voltage harmonic according to NP EN 50160 standard in MV busbars, from 2009 to 2015.

Also in LV busbars, where most of the continuous phenomena compliance with NP EN 50160 standard has improved consistently since 2013, it is important to highlight that the relation between the number of weeks in non-compliance with NP EN 50160 standard in voltage variations and the number of weeks analyzed in MV/LV substations is consistently decreasing since 2014, as can be seen in Figure *8*.

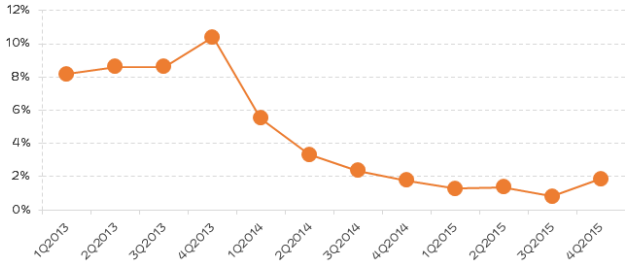

Figure 8 – No. of weeks with nonconformities vs weeks analyzed, according to NP EN 50160 standard in LV busbars, from 2013 to 2015.

In the specific PQ area of EDP D website it is possible to access to the EDP D' PQ monitoring plans established according the QoS Regulation Code and also to PQ results with the information about continuous phenomena data and voltage events recorded for all monitored points since 2014.

CONCLUSIONS

Throughout a set of policies and investments in the network, EDP D defined an aggressive plan in several areas, including planning, maintenance, operation, innovation and others in order to improve its QoS.

As a result of the recovery of degraded assets and asset management, the investment on the network redundancy as well as an intensive plan of medium voltage remote operation equipments and network automation, EDP D manages to present a more robust and flexible distribution network. The contingency plans such as the crisis operation plan in addition to network operation center concentration and optimization outcome on an operational efficiency. Despite the overall indexes are usually the ones used for benchmarking EDP D always had the concern of performing a reduction of asymmetries. As a consequence of all these actions EDP D reached in 2015 its best record regarding the continuity of service.

Though that much has been achieved a challenging future is expected as the sector faces even more changes. To improve its reliability indexes EDP D is already conducting several studies in different areas such as integration of distribute generation and storage on possible impacts that new stakeholders could have on the electric grid. Regarding PQ, the need for its improvement as well as an awareness of its importance to all stakeholders.

ACKNOWLEDGMENTS

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REFERENCES

[1] ERSE, "Regulamento da Qualidade de serviço do Setor Elétrico", 2013.

[2] ERSE, "Regulamento de Relações Comerciais do Setor Elétrico", 2014.

[3] "6th CEER Benchmarking Report on the Quality of electricity and gas Supply", 2016.

[4] P. Terras Marques, A. Vaz, R. Soares, A. Santos, R. Messias, 2015, "Organizational Flexibility for Extreme Scenarios Effectiveness", *23rd International Conference on Electricity Distribution*, Lyon 2015, paper 0346.

[5] EDP Distribuição, "Relatório da Qualidade de Serviço 2015", 2016.