PERFORMANCE STANDARDS APPLIED TO ROMANIAN TSO AND DSO

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ABSTRACT

The paper presents the challenges caused by the new regulations, issued two years ago, experienced both by Transmission System Operator (TSO) and Distribution System operators (DSO's) in Romania. The first part of the paper describes the new (2016) Romanian Power Transmission Grid-Standard of Performance and the Power Distribution Grid-Standard of Performance. The second part of the paper presents the new (2015) Romanian Metering Code, which outlines the new requirements for smart meters and for the energy services markets. The third part of the paper analyses the traceability of the energy transfer features in the power transmission infrastructure as revealed by the Power Quality Monitoring System (PQMS) deployed by Transelectrica. The fourth part of the paper presents the steps taken by DSO in the effort to meet the Performance Standard requirements. The final part consists of conclusions, recommendations and further work in view of implementing the new Romanian Technical Regulations while keeping them compatible with Smart Grids requirements.

INTRODUCTION

'Transelectrica' is the Romanian Transmission System Operator (TSO) and also the metering operator of the wholesale electricity market in the country. Following the rapid evolution of Smart Grids paradigm, Transelectrica adopted a 10 years plan for the power grid development, adopting a rapid pace in refurbishing the installations, and setting new requirements for metering and power quality monitoring systems.

"Electrica", the main Distribution System Operator (DSO) is for the first time confronted with regulation that specifies penalties in case of overpassing several performance indices, including some Power Quality (PQ) specific parameters.

Power quality includes, as an important component of monitoring, control and performance reporting, a service provided by TSO and the DSOs for the other participants in the market. Power quality indicators are addressing both the technical component and the commercial one.

The performance indicators obtained from power quality monitoring systems and metering systems are used for:

- creating databases necessary for the Romanian Energy Regulation Authority (ANRE) studies which further develop strategies for such services (update standards);
- solving customer complaints regarding the distribution of various electrical energy services;
- studies and researches regarding power quality;

revision of technical codes.

Results are annually to be monitored and reported by TSO and each DSO to the ANRE. TSO and DSOs have torespect the methodology required by ANRE and, as a consequence, dedicated equipment has been installed in each relevant measurement node of the power transmission system and power distribution system, respectively.

NEW PERFORMANCE STANDARDS

The new version (2016) of the Performance Standards [1, 2] for power distribution and transmission system services is actually a revision of the corresponding 2007 versions.

The scope of the performance standard for power distribution is to ensure the quality of service for distribution grids and to establish the performance indicators in the provision of distribution services as well as the way those performance indicators are monitored and recorded.

Through this standard, the customers will benefit from a higher quality of distribution service as a consequence, for example, of the reduction of the number and duration of the interruptions. In the same time, the standard specifies that the end-users of the power network (in most cases the customers) will receive financial compensations in case that the energy provider (DSO) does not reach performance indicators related to power quality.

In order to fulfil the requirements all over the country for the performance indicators as provided in the Standard, concessionaries of distribution operators will have to promote investment in both urban and rural areas. Moreover, targeting the investment in those areas of electrical distribution network where PQ problems have been found will also lead to an increase of energy efficiency and, as a first consequence, to lower distribution tariffs, further giving an impulse to the economic development of those areas.

According to the law, the TSO provides a public service of national interest for all the users of the transmission grid, ensuring their access without discrimination to the network, in compliance with technical and commercial

regulations in effect.

The performance indicators established by the standard guarantee public service obligations the fulfilment by the network operator, ensuring the quality of service for electricity transmission. Meeting the guaranteed level of performance indicators is a warranty that the TSO ensures safe operation of the national power system, within the constraints of high efficiency and reliability.

The performance indicators monitoring gives information on their yearly evolution and by such provides valuable input for the TSO in the attempt of deriving the right measures required for improvement of the quality of services. At the same time, the inclusion of the obligation to grant compensation in case the specific performance indicators are not met paves the way to a more responsible operator, constantly aiming at meeting customer satisfaction by increasing the quality of services.

All devices deployed for monitoring the power quality indicators should at least include functionalities for the measurement, data storage (recording) and analysis of the following quality of voltage indicators: temporary outages interruptions, short and long outages, frequency, the actual parameters of voltage, voltage dips, temporary overvoltage at commercial frequency (50 Hz) between phase and earth or between phases, flicker phenomenon, fast and slow voltage variations (rapid voltage changes), harmonics, interharmonics, total harmonic distortion, unbalance. Devices should also be able to perform current measurement (with data storage), for both the fundamental component and harmonics.

The standard for transmission and distribution grid requires each TSO/DSO to have enough portable monitoring devices with same performance, in order to be able to address in a timely manner complaints regarding the power quality. If complaints are confirmed, TSO/DSO are required to take necessary remedial measures. Monitoring costs are supported by DSO even in case the quality parameters are within acceptable limits (not confirmed complaints) or in case the low power quality is to be inferred directly by the user equipment.

NEW METERING CODE

The new 2015 revision of the Metering Code [5] keeps all technical conditions outlined in the previous version, brings them at the level of technological evolution and aims to enable communication and access to the relevant data for all interested parts, using the new ICT capabilities developed in the past 12 years, since previous edition has been issued. Considering this, the new Metering Code: a) addresses the whole sale and detail energy market; b) focuses on the electrical energy measurement; c) enables third parties to perform and evaluate the energy services, according to European legislation; d) gives the possibility to all interested parts for data access in real-time, using technically feasible solutions.

The new Metering Code [5] introduces, as a novelty, the term of *metrological part of the meter*, which is that "part of the meter covered by legal metrology", i.e. the "part of the meter comprising specific internal programmes and electronic modules, having following functionalities: a) measurement is performed according to a given Accuracy Class and b) it ensures a secure storage of active and reactive and electricity indexes. In order to ensure fairness and transparency in commercial transactions, the new Metering Code was completed with clearly defined and detailed aspects regarding metrological verification and meter installation.

Another novelty is that new Metering Code specifies in chapter 4 (for class A metering points), in section1, that the local measurement subsystems should provide, in case requested, following instrumentation values: three-phase value of active and reactive power (P and Q), the rms values of voltages and currents (U and I) for each phase,and the frequency f, to be available for readout with a reporting rate of at least 1 value/minute.

Transelectrica already implemented during its refurbishment program the local metering systems in 40% of the transformer substations. In the past 14 years those systems evolved in pace with technology, so now most of the functionalities required by the new Metering Code are already fulfilled by integrated energy meters.

Energy meter became the basic element that provides in quasi real time multiple metering information, enabling service flexibility, network observability trough instrumentation values, and status data. In this respect, the meters performance increased over time while offering Smart Metering functionality at lower price, including e.g. higher reporting rates for billing purposes and multiple options for secure communication.

Metering Code revision is positioning intelligent metering systems as fundament for the SMART GRIDS concept and it states the technical conditions to be fulfilled by the metering systems:

- The operators of the energy measurement systems must enable data to be exchanged with the measurement systems of the contractually involved parties;
- The measurement and SCADA systems of a given network operator, or of two different network operators operating the same installation, must be technically separated (independent) systems;
- Communication errors must be detected and recorded when measurement data is reported (and read);
- data will be transmitted under conditions of high security, which involves both the use of password login technology and data encryption;
- The measurement systems must automatically acquire and store the measurement data read by the local measurement subsystems with a frequency (reporting rate) of at least once per day;
- The infrastructure of smart metering systems must allow additional meters to be fitted and additional measurement points to be integrated, without the need of replacement existing components;

- The infrastructure of smart metering systems must enable unauthorised access prevention and warnings of any unauthorised access to be detected and transmitted to the central measurement data management system.

TSO OVERVIEW

Considering the specificity of high RES penetration in the Romanian system, the TSO has developed a set of complex connection rules regarding PVPS (PhotoVoltaic Power Systens) integration [6, 7]. The aim of the process was to ensure observability, control of main generation nodes, and the improvement of synthetically provided inertia. The technical requirements were developed in accordance with the drafts of new Network codes [1,2], product standard evolution and the necessity to offer maximum flexibility to photovoltaic sources a. A high level of importance was given to ensuring the power quality minimal level in the PCC (point of common connection).

In case of photovoltaic (PV_based) generation nodes, power quality analysis is based on the corresponding inverter PQ indices as provided by certificates, on the PCC perturbation analysis, and on real PVPS measurements during conformity tests or PQ indices monitored during operation [8, 9].

A major objective of Romanian SMART Grid project is the improvement of Power Quality for energy transferred from producer to the end customer having as support the concept of "network of the future". The new Metering Code states that the energy meter use for monitoring power quality parameters is a strategic objective of "Europa 2020".

In this respect Transelectrica implemented the Power Quality Monitoring System in transmission network in a significant number of stations. This monitoring system allows measurement for all PQ parameters related to voltage.

According with "Report regarding achievement of the performance indices for electricity transmission, system and distribution services and state of art of electricity transmission and distribution networks in 2015" [10]:

- In terms of compliance with the normal variation, approved by standard, frequency is within the permitted limits; From the data analyzed [10], for the 400 kV voltage level and 220 kV bars substations emerges that the voltage is within the limits, in over 99,7% of time for 51 locations from a total of 57. For the other six locations the values were inside the limit for 98% of time.

At the 110 kV voltage level in these stations, the Total Harmonic Distortion (THD) was within limits on all weekly intervals for 95% of monitored intervals. At TSO level voltage's unbalance negative factor, had deviations from the values allowed in 5 transformer stations, for a cumulated period of 48 weeks leading to a separate case analysis. Related to the monitoring of quality indicators concerning the commercial quality of the service, it shows a significant improvement of service, due to increased ANRE' exigency and following the penalties in case of operator's failure to comply with the limits from the standard of performance. The duration for approval of the Technical Connection Agreement to the Transmission Grid has been reduced with 40% [10].

DSO'S OVERVIEW

In order to meet the new Performance Standard requirements several steps were taken by DSO:

SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index), calculated for the whole DSO (planned and unplanned outages), provides both ANRE and the DSO information regarding the infrastructure in their area and the organization/management of the distribution service, with the aim of having a global view on the electricity distribution service of each DSO and also to compare the average values with the ones from other European countries. Information must be correlated with the networks peculiarities in each different area.

Taking into account the results obtained from existing PQ Monitoring Systems, a strategy for further development has been defined. This strategy includes:

- Implementation of new operational procedures aimed to reduce the number and duration of planned interruptions.
- Defining the procedures for monitoring all parameters included in the new standard that will include the methodologies for financial compensations.
- Extension of the current PQ monitoring system in full correlation with Distribution Automation System development.
- Use of new technologies for MV and LV network monitoring including installation of several micro PMU's.
- Introduction of Automat Voltage Regulation in HV substations where RES are connected.
- Considering extended functionality of the Smart Metering System that can provide valuable information about voltage events and interruptions in the LV network.

In terms of power quality parameters, ANRE standard requires DSO's to carry out monitoring campaigns in the relevant sections of the network (specifying the number and location) with dedicated power network analysers.

PQ Management has to integrate the technical, legal issues / regulatory and managerial aspects of PQ for entire National Power System for all operators in the energy market. The main objective is the ensure that PQMS operates by respecting all conditions for providing secured and efficient power supply for the energy end-users.

Reports obtained with existing PQMS show that for HV and MV networks PQ parameters are well within the limits imposed by Performance Standard for the large majority of monitored locations.

Still there were filled several complains concerning the

number of dips and short interruptions. In most cases the causes were traced to equipment' malfunction and had only local effects.

PQ MONITORING RESULTS FOR DSO'S

According to Distribution Performance Standard issued by ANRE, the monitoring of PQ indices have to be done by each DSO and submit annualy to regulator. In Romania 9.2 mil. end users are connected to the distribution network.
Every year, ANRE collects the DSO's Report and publish an integrated Report at the Romania level [10].
The main perturbations were monitored and the result is included in the report. The technical standards give the admissible limits for Cumulative Probability (CP) 95%, for perturbations having an stochastic evolution.
Voltage frequency – CP 95% of this indicator was inside the addmisible limits all the time.
SAIFI and SAIDI indices, related to interruptions – Table 1 and 2 show the evolution of these indices for last four years, which reflect an improvement of the distribution services performed by DSOs.
Results recorded in ANRE's Report [10], according to the Distribution Performance Standard show services continue improvement through reduction of planned/unplanned SAIFI indices in last 4 years.
In last four years, an improvement of SAIDI indices could be observed. The reduction of unplanned SAIDI in 2015 was of 15% less than the value of indices in 2014.
Of course, SAIFI and SAIDI indices are better in the urban area in comparison with rural areas.

TABLE 1. The evolution of SAIFI for last four years

SAIDI	Unit	2012	2013	2014	2015
Planned	Min/year/ client	246	270	230	211
Unplanned	Min/year/ client	630	427	361	308

TABLE 2. The evolution of SAIDI for last four years

SAIFI	Unit	2012	2013	2014	2015
Planned	Interruption /year/client	0.9	1.0	0.8	0.77
Unplanned	Interruption /year/client	5.5	4.75	4.35	4.19

Harmonic regime – THD monitoring in the substations where PQ analysers are operational show that NO overpassing of the admissible limits were recorded.
Unbalance – NO exceeding of the admissible limits were recorded in monitored nodes.
Voltage Fluctuations (Flicker) – some exceeding of the admissible limits were recorded. For each case, DSO has to study and identify the cause and to establish the appropriate actions.
Additional analysis performed during year 2014-2016 revealed that in case of PVPP's:

- High ''flicker'' values are accompanied by other PQ events such as voltage dips or interruptions.
- Simultaneous measurements in low voltage network show little propagation effect.
- The ''flicker'' recorded at MV may be a ''ghost effect'' of voltage dips and short interruptions.
- The probability of severe events is greater in case of PVPP put in operation when there is no daylight available to ensure a steady power flow.

CONCLUSIONS

The end scope of the network connection is to assure that all connected users, especially potential voltage disruptors are checked and accepted in the grid only if they are providing "clean" operation in terms of PQ perturbation.
The aim of those concentrate efforts applied to existing systems is to reduce the power losses in the electrical power system, to limit the perturbations and to guarantee the quality level of services for all the customers.
An important debate that emerges is that Romanian National Energy Authority has an important role in the promotion of PQ solutions. To ensure the transparency and the harmonization of stakeholders interests, the Regulator should consult all stakeholders, including experts from academia, the economic field and the interested operators [11].
The regulator must play the role of a "watch dog" in the energy market, not only in the relationship between DSO and the final user, but also in the relationship between TSO/DSO/energy producers from renewable sources.
The harmonization of secondary regulations in the PQ field is a success factor in the implementation of PQ strategy; there will be correlated provisions from the technical codes of electrical networks, from performance standards for DSOs and TSO services.
Non-discrimination principle needs to be applied in the regulations of energy and especially in the PQ. It should be emphasized that no difference should be made between so-called *New entrants* (new customers, which have to be connected to the grid) and existing customers. The allocation of perturbations rates both for new and disruptive customers and for each of the existing ones should be based on transparent and non-discriminatory rules [11].
New technical regulations will ensure adequate voltage quality on the supply bars, for all end users connected to the same network node, in order to operate undisturbed, according with the standard power quality parameters, as applied to both power transmission and distribution grids.
The new Metering Code considers the energy meters as basic elements in the Smart Grid framework and includes requirements for the smart metering systems. The technological advancement allows the energy meter to provide complex functionalities, to support Smart Grids deployment, in addition to those for billing. This revision ensure technical conditions for energy market operation

and for development of energy services and future more dynamic energy markets that will use smaller billing intervals, i.e. high reporting rates, adequate to a more efficient operation of the energy infrastructures.

The connection requirements have stimulated power quality system development at the DSO and TSO levels. The TSO and DSO's power quality monitoring systems ensure professional services according to specific regulations: Technical Code, Performance standard, Maintenance Internal Code and ENTSO-E Codes and Regulations.

TSO and DSO's are implementing the next steps in order to support and improve network monitoring, surveillance and maintenance, to guarantee the quality of service for all customers, implementation and harmonization of the new Romanian Technical Regulations with the Smart Grids requirements.

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