POWER QUALITY MONITORING SYSTEM SMART GRIDS COMPONENT

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ABSTRACT

Transelectrica is the Romanian TSO and the Metering Operator of the Wholesale Electricity Market (WEM). The first part of the paper contains the Power Quality (PQ) regulations issued by the Romanian Regulatory Authority (ANRE). According with these, TSO has to monitor permanent and temporary the PQ technical parameters with dedicated instruments. The second part presents the PQ permanent monitoring systems, in the Supply Terminals (ST), at the interface between TSO and the Distribution Systems Operators (DSO), also at the interface between TSO and the Eligible Customers (EC). Information gathered from the integrated system will help to identify measures to be taken for network optimization; technical loses reduction, increase reliability, transparency and customer satisfaction. The third part presents the Romanian training classes Leonardo Power Quality Initiative Vocational Education System (LPQIVES) and Smart Grids. The PQMS is a very powerful source of data, but only if the persons who are using it are aware of its possibilities. The final part presents the conclusions and recommendations for future development. PQ has an important effect in the network economic efficiency and represents a Smart Grids component in the evaluation of the network performances. The goal of these systems is to assist the National Dispatcher in taking the necessary action to provide transmission services in conditions of power quality at international standards.

INTRODUCTION

The concept of “smart grid” was started from a number of the technology innovations in the power industry. It is a result of the new technologies applied in power systems, including renewable energy sources generation, distributed generation, and the latest information and communication technology.

In the ongoing discussions about smart grids, power quality has to become an important aspect and should not be neglected. An adequate power quality guarantees the necessary compatibility between all equipment connected to the grid. It is therefore an important issue for the successful and efficient operation of existing as well as future grids. However power quality issues should not form an unnecessary barrier against the development of smart grids or the introduction of renewable sources of energy [1].

In 2004 Electricity Regulatory Authority (ANRE) issued “The Electricity Transmission power grid- Technical code” [2] including some PQ aspects and since then, TSO has performed the following necessary steps:

In 2004 the Romanian transmission power grid has been integrated in the UCTE and the special equipments for secondary control, with high accuracy acquisition rate were installed, assuring the monitoring of frequency to National Dispatch Centre;

In 2005, during commissioning of metering and SCADA projects, in each metering points on WEM, the best accuracy current transformers and capacitive voltage transformers and dedicated traducers for monitoring the supply voltage magnitude to National Dispatch Centre were installed;

In 2006, after metering system was operational, the first temporary and then first permanent PQ monitoring systems were dedicated to the PQ monitoring of the interface between TSO - DSO and TSO - EC;

Since 2006 TSO’s specialists attended annual PQ “working meeting” and were involved in the LPQIVES training programs. At present they are certified “International Power Quality 1st and 2nd Degree Experts”;

In 2007 the WEM has been total liberalized and the third PQ monitoring systems has been dedicated to the permanent monitoring at the interface between TSO and EC to OMEPA.

In 2007 Electricity Regulatory Authority (ANRE) issued “The Electricity Transmission Power grid–Standard of performance” [3] including more PQ aspects from international standards EN 50160, CEI 61000-4-30 and, since then, TSO has performed the following necessary steps:

In 2008 TSO has approved its own PQ Policy, taking under consideration the Voltage Quality, Continuity of Supply and Commercial Quality, involving OMEPA Subsidiary, National Dispatch Centre, Commercial Management Direction and Power Grid Operating Direction;

Since 2008, TSO’s PQ certified specialists have carried on LPQIVES training programs for certification “International Power Quality 2nd Degree Experts”;

In 2010, according to TSO’s PQ strategy, the new PQ project has been implemented for integration of existing PQ monitoring systems, upgrading the instruments with new standard IEC 61000-4-30 ed.2, comunication lines and developing a new enterprise software platform.

On Romanian WEM the PQ parameters are regulated by “The Electricity Transmission Grid Technical Code” [2], “The Electricity Transmission Grid – Standard of performance” [3], and at the same time, by “The Electricity Distribution Grid Technical Code” [4] and “The Electricity Distribution Grid – Standard of performance” [5], issued by ANRE. The PQ conditions at the interface between transmission power grid and eligible customers are regulated by the Connection Notice issued by TSO, which establishes the admissible limits for PQ parameters.

According with the regulations [2] and [3] TSO has to monitor, permanent or temporary, with dedicated

instruments and has to report periodically to Economy Ministry and ANRE, the following PQ parameters:
1. Power frequency: fulfill UCTE requirements
2. Supply voltage magnitude:

nominal value	admissible limits interval
400kV	[380kV … 420kV]
220kV	[198kV … 242kV]
110kV	[99kV … 121kV]

3. Supply voltage harmonics
   THDu ≤ 3%
4. Supply voltage unbalance (symmetrical components)
   Ku ≤ 1%

POWER QUALITY MONITORING SYSTEMS

The first PQ permanent monitoring system analysis the measurements recorded by the seven instruments, at the interface between TSO and DSO, at voltage level of 110kV. Panel montage solution without current probes was adopted for the installation of PQ instruments inside seven TSO's substations.
The second PQ permanent monitoring system analysis the measurements recorded by the sixteen instruments, at the interface between TSO and EC, at voltage level of 220kV, inside eight TSO's substations. These eligible customers are: ALRO Slatina, the largest aluminium smelter in Central and Eastern Europe, MECHEL Targoviste, the biggest plant in Romanian metallurgy industry, MECHEL Campia Turzii, TMK Resita and ArcelorMittal Hunedoara, the Iron and Steel Plants.
The temporary PQ monitoring system consisting of eight portable PQ instruments is installed at the interface between TSO and DO. The scope of this monitoring system is to analyse the electromagnetic chain of propagation the disturbances, from distribution to transmission power grids. For the customers like the metallurgy processing plants, the railway power stations, supplied at voltage level of 110kV the perturbations generated by their technological processes are conducted in the transmission power grid.
According to the annual program of PQ monitoring, during each year the portable PQ instruments are installed for a minimum interval of two weeks in over 25 metering points, located inside the more than four TSO's substations. With this dedicated PQ instrument the data acquired can be used for special PQ analyses.
Since 2010 TSO completed the software platform for integration of all these PQMS, upgraded or replaced the PQ instruments according to class A and upgraded the communication system to optical fibber.
The automated readout software at the central level uses dedicated PQ software, to determine PQ parameters of the transmission power grid. This software is open to integrate up to 300 PQ instruments and provides access for different end users, like National Dispatch Centre, DO / Customers, via internet browsers, see figure 1, [8].

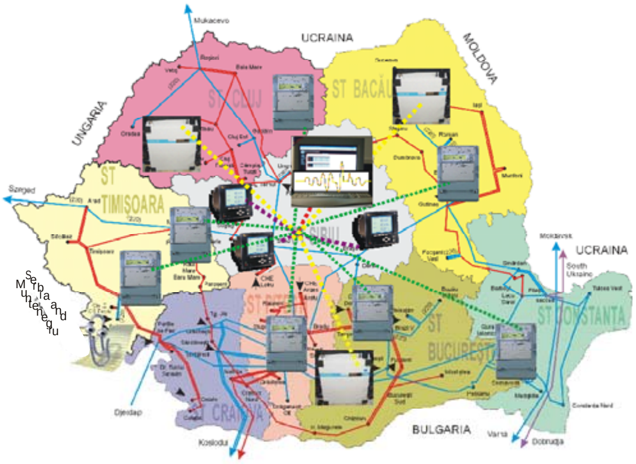

Figure 1.The integrated PQMS

Analysing the measurements from the PQMS at the interface between TSO and DSO, the harmonics of the supply voltage are outside the limits, but these were not reflected at voltage level of 220kV. The railway power stations, connected at a voltage level of 110kV, adjacent the substation, produced these perturbations, because their supplied by transformers connected on HV between only two phases.

EN 50160 Summary Report

Meter Name: test.Resita
Start Date: 2010/Sep/25 00:00
End Date: 2010/Oct/30 00:00

Complete Compliance in this Summary? No

Measurement and Observation Period Compliance Table

		Power Frequency	Supply Voltage Magnitude	Flicker	Supply Voltage Dips	Short and Long Interruptions	Temporary Overvoltages	Supply Voltage Unbalance	Harmonic Voltage	Interharmonic Voltage
Observation_1	2010/Oct/02	Y	Y	N	N	N	N	N	Y	Y
Observation_2	2010/Oct/09	Y	Y	N	N	Y	N	Y	Y	Y
Observation_3	2010/Oct/16	Y	Y	N	Y	Y	N	Y	Y	Y
Observation_4	2010/Oct/23	Y	Y	N	N	Y	N	Y	Y	Y
Observation_5	2010/Oct/30	Y	Y	N	N	Y	N	Y	Y	Y

Figure 2.The PQ monthly reports

Analysing the results of the permanent monitoring for each EC supplied at HV the PQ flicker parameters are outside the limits, as presented in figure 2, for TMK Resita. Also for some EC the voltage total harmonic distortion is outside the admissible limits, so the duty of EC is to install a specific equipments/installations for reduce the voltage harmonics and flicker distortions.
These reports are sent monthly to the National Dispatch Centre and included in the reports for the Economy Ministry and ANRE. 'Statistical analysis of network quality' reports according to [2] are issued automatically for weekly analyse of cumulative probabilities 95%, maximum, minimum and average values. The reports generated present the numerical and graphical analyses of the PQ parameters: power frequency, supply voltage magnitude, supply voltage unbalanced, total harmonic, voltage

harmonics, current harmonics, flicker Plt, slow voltage changes.

When the PQ parameters do not fit into the admissible limits is necessary to extend the measurements on areas of influence, using portable PQ instruments. Sometimes this needs to be followed up by dedicated studies which will identify the causes and find solutions that will limit the recurrence of perturbation and keep them in the allowed limits. According to the study [9] the consumer responsible for the perturbations needs to install reactive power compensation systems (SVC or STATCOM type) in order to reduce the effects of flicker.

Analyzing the processes that take place at the interface between different operators on the power grid, establishing each operator's responsibility in limiting the propagation of perturbations and their recurrence will help increasing the PQ level in the entire power grid.

Integration of existing PQMS for monitoring on WEM was planned according to the new revisions of the standards EN 50160 [6] and CEI 61000-4-30 [7]. This leads to the following strategy implemented by TSO for 2011, trough the new "ongoing" projects:

•the new PQ instruments fulfill class A requirements [7];

•in 2 metering points the "pilot project" consists in replacing the existing inductive current measuring transformers with new optical ones and installing PQ instruments class A;

•the "green energy project" requests that each metering point were renewable energy generators are coupled in the transmission power grid, will have PQ instruments integrated in new PQMS.

•analyses of monitored data acquired with permanent PQMS from the interface between TSO, DO and EC highlights the following facts, according to the study [8]:

•the temporary over voltages and the voltage dips at 110kV voltage level in TSO substations are usually transferred from distribution power grid;

•the nonsinusoidal operating mode is generated in small extend by transmission power grid (including the transformers), being mostly generated by distribution power grid, for ex. railway power stations supplied at a voltage level of 110kV;

•the unbalanced voltage, resulting from unbalanced current is sometimes generated by transmission power grid (non-transposed overhead lines, unbalanced consumers) but generally by distribution power grid;

•the flickers generated by sudden variations of the load or supply voltage are causing problems to the nearest costumers, connected to the same grid;

•the transmission of reactive power at the interface between TSO and DO, requests a special attention because increases the energy losses and creates difficulties in keeping the voltage magnitude inside the admissible limits.

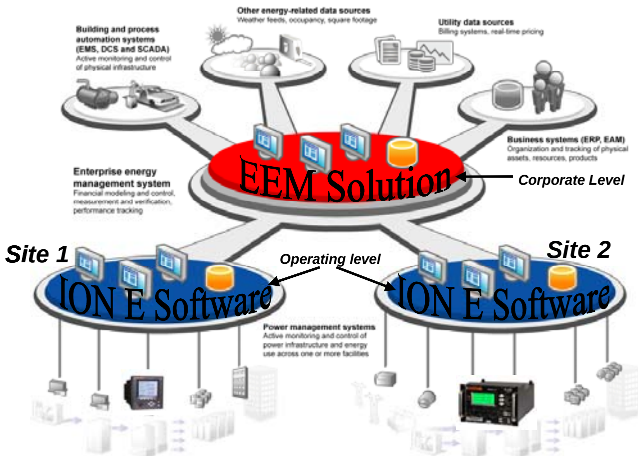

Figure 3.The PQMS Smart Grids component

The Smart Grid, as seen in figure 3, will mitigate PQ events that originate in the transmission and distribution levels of the electrical power system. Its advanced control and monitoring systems will enable rapid diagnosis and correction of PQ events. Advanced components will apply the latest in superconductivity, energy storage, and power electronics to improve power quality.

At the transmission level, voltage sags are frequently the result of faults (short circuits), which can exist for many milliseconds. High voltage static VAR compensators (a FACTS device) are fast enough to mitigate many of these events. As semiconductor component costs drop, these devices will be a common element of the Smart Grid. Also looking toward the future, affordable current-limiting devices will reduce the severity of voltage sags associated with faults. And eventually, lossless superconducting transmission lines will further reduce voltage sag concerns. More conventional techniques such as broader application of surge arresters, improved line shielding and grounding, and controlled switching angles will also be employed more aggressively to limit PQ disturbances.

THE EDUCATIONAL PROGRAMS LPQIVES

The PQMS is a very powerful source of data, but only if the persons who are using it acknowledge its possibilities, for this reason being very important to educate people who are in charge of such a system. Over 170 specialists from different Romanian companies attended Leonardo Power Quality Initiative Vocational Education System (LPQIVES) training and educational programs for formation and professional certification in power quality domain.

Mod	Subjects for Power Quality Expert 1st and 2nd levels
M00	Introduction into power Quality
M01	Voltage dips and short interruptions
M03	Harmonics and Interhrmonics
M04	Voltage fluctuations (flicker)
M05	Reliability of electricity supply
M06	Earthing systems

M07 The influence of static conventers on the supply power grid
M08 Compensation of reactive power. Voltage and current unbalance
M09 Distributed Energz Sources and Power Quality Energy storage systems
M10 Utility package (Frequency variations, Quality of supply in the electricity market. DSM. Tariffs and power quality, Rational use of energy)

The current stage of LPQIVES program in Romania consisting in three studying cycles completed until the end of year 2009:
•First cycle took place between October 2005 and November 2006 and completed in December 2006, with final Certification Test for the first 50 International Power Quality 1st Degree Experts;
•Second cycle took place between October 2006 and November 2007 and completed in December 2007 with final Certification Test. Another 22 International Power Quality 1st Degree Experts were certified;
•Third cycle took place between October 2008 and November 2009 and completed in December 2009 with final Certification Test. Another 50 International Power Quality 1st Degree Experts were certified.
•The fourth cycle took place between March 2008 and November 2009 and completed in February 2010 with final Certification Test and were certified the 40 International Power Quality 2nd Degree Experts. [10]

CONCLUSIONS

Correlation of Romanian standards of performance for transmission and distribution power grids and updating of all PQ regulations is necessary according to the international standards, including also the voltage fluctuations (flicker). PQMS create a necessary statistical database for development of PQ regulation and the ascertainment of contractual conditions.
In order to respect the limits of perturbations in ST, TSO needs to assign in the Connection Notice the admissible levels of perturbations for each DO/Customer connected to the grid and needs to permanent monitor their compliance. If PQ parameters do not fit into the admissible limits is necessary to extend the measurements on areas of influence, using portable PQ instruments. Sometimes these measurements need to evolve in dedicated studies which will identify the causes and the solutions that will reduce the recurrence of perturbation. The consumer responsible for the flicker perturbations needs to install reactive power compensation systems SVC/STATCOM type, in order to reduce its effects. [8]
Continue training programs LPQIVES is necessary for accurate and complete operating of the database generated by PQ monitoring systems and finding solutions to maintain PQ parameters within admissible limits. We recommend to follow up OTS's strategy regarding PQ by extending on monitoring the WEM, in order to review the regulations, to control the perturbations, to ensure optimal operation mode and reduce active power losses in the power grid, finally providing quality services for all consumers.
The Smart Grid will help buffer the electrical system from irregularities caused by consumer electronic loads. Part of this will be achieved by monitoring and enforcing standards that limit the level of harmonics a consumer load is allowed to produce. Beyond this, the Smart Grid will employ appropriate measures to prevent harmonic pollution from feeding back into the grid.
Smart Grid technologies can be applied to the problem of power quality, but to do so will require the coordinated efforts of government, utilities, regulators, and standards bodies

REFERENCES

[1] Math H.J. Bollen, Jin Zhong, 2010, " Power Quality aspects of Smart Grids" *Procedings of International Conference on Renewable Energies and Power Quality*

[2] ANRE, Romania, 2004, "The Electricity Transmission Grid - Technical code"", www.anre.ro
[3] ANRE, Romania 2007, "The Electricity Transmission Grid – Standard of performance"
[4] ANRE, Romania, 2000, "The Electricity Distribution Grid - Technical code"
[5] ANRE, Romania, 2007, "The Electricity Distribution Grid – Standard of performance"
[6] EN 50160, 2009, "Voltage characteristics of electricity supplied by public distribution system"
[7] IEC 61000-4-30, 2008, "Testing and measurement techniques – Power quality measurement methods"
[8] Institute Study Design Engineering, Romania, 2008, "Fezability Study and Tender Specification for development a system for integrating the existing PQMS"
[9] Institute Study Design Engineering, Romania, 2009, the study "Study for identifying the causes and solutions for transmission power grid perturbations"
[10] F. Vatră, A. Poida, P. Postolache, 2009, "Leonardo Energy/LPQI/LPQIVES educational programs for formation and professional certification in power quality domain. Actual stage in Romania" *Procedings of National Conference and Exposition on Electric Power*