Power Quality Requirements for the Smart Grid Design

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***Abstract*—**Power quality issues are one of the most important aspects of future smart grid design and operation. The first reason is the more active consumer participation in the power sector, and the other one is the introduction of renewables, having a great impact on voltage variation because its intermittency. This paper discusses power and especially voltage quality issues in the smart grid environment. New demands that are placed in front of the distribution network by introducing the concept of Smart (Intelligent) network are presented. Through several practical examples from the distribution utilities in Serbia, a few typical problems regarding power quality, which have to be solved in a new environment are presented, together with proposed smart grid architecture and description of distribution management system functions. The need of strategic planning of smart grids is illustrated on some examples of non-compliance of laws and practices in Serbia.

***Keywords*—** distribution network, distribution management system, harmonics, power quality, power quality monitoring, smart grids, volt var control

I. Introduction

THE fundamental expectation of the electric power industry in this age is to meet growing demand: cleanly, reliably, sustainably, and at low cost. That's the main reason for the definition of Smart Grid policies on the national level. European Smart grid concept - EU Smart Grids Technology Platform vision and strategy for Europe's Electricity Networks of the Future was launched in 2006 [1]. The Smart Grid vision is aiming for "new products, processes and services, improving industrial efficiency and use of cleaner energy resources while providing a competitive edge for Europe in the global market place". The Smart Grid vision is highly important as a means to support the EU environmental as well as economical ambitions, and there are already a number of new technologies involved, such as renewable, electric cars and power flow control equipment, while an increased use of digital communication and control including smart metering and advanced grid wide area real-time monitoring can also be expected. Main expected benefits of smart grids are:

- Improved Power quality and Reliability through Advance Distribution Automation
- Increased deployment of distributed generation and other assets
- Support for integrating microgrids and residential PV
- Increased monitoring and data resources

To fulfill these anticipated requirements, principal functionality characteristics of Smart Grids are defined through [2, 3]:

- Active consumers participation
- Seamless accommodation of all generation and storage options
- Enablement of new products, services, and markets
- Power quality (PQ) for the digital economy
- Optimization of asset utilization
- Anticipation and response to system disturbances (self-heal)
- Resilience against attack and natural disaster (cyber security)

The evolution of existing grids is therefore necessary, and it will include:

- high use of renewables 20% – 35% by 2020,
- bidirectional metering,
- distributed storage,
- smart meters that provide near-real time usage data, time of use and dynamic pricing,
- smart appliances communicating with the grid, energy management systems in homes and industrial facilities linked to the grid,
- growing use of plug-in electric vehicles
- networked sensors and automated controls throughout grid.

However, this evolution of existing grids will face them with new challenges regarding power quality issues. Regarding distributed generation for instance, depending on applied

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technology (synchronous, single or doubly fed induction asynchronous machines or inverter technology) influence on power quality will be manifested through [4]:

- magnitude of supply voltage
- increased unbalance
- transient overvoltages
- voltage sags, and
- flickers.

Based on this facts, one can conclude that voltage quality is becoming increasingly important to customers for two reasons:

a) Voltage quality levels are affected by the increased use of distributed generation and different electronic devices (inverters, battery chargers, energy saving lamps).
b) Sensitive electronic devices are strongly affected by voltage quality.

Not only for consumers, but for all stakeholders involved in new, smart grid environment, power quality deserves particular attention. Thus, potential disturbance source may be found on both, generation and consumer side. From regulator point of view, it is important to asses what he should consider when establishing a voltage quality regulatory framework for distribution networks.

The aim of this paper is to emphasize the need of improved and enhanced power quality monitoring, taking into account new requirements and new Smart grid technologies. Another goal of the paper is to outline that actions regarding power quality cannot be treated independently, without broad strategic planning frame.

In the first chapter, the need for change of actual power quality policies and the need for integrated planning of all power aspects is presented through some examples of Serbian power industry.

In the next chapter, new smart grid functions addressing power quality aspects are presented. Through several study cases from Serbian distribution network, the need for integrated platform including power quality is elaborated. Finally, conclusions are brought regarding the change in power quality treatment in the new environment.

II. Strategic planning regarding Power Quality in the New Environment

A. Power quality standardization

While the reliability indices are not yet standardized, voltage characteristics of European public distribution system, concerning the supplier's side, are regulated by the EN 50160 standard. This standard is supplemented in some regions or countries by other supplemental standards. However, not all voltage quality parameters are defined in a totally satisfactory manner in EN 50160. Some types of voltage events appear to require improvements in definitions:

a) Limits for voltage variations - "95%-of-time" clause should be avoided together with long time intervals for averaging measured values.
b) There are still ambiguous indicative values for voltage events. Limits for voltage events according to network characteristics should be introduced as well.

To many problems are still open for VQ measurements. Solving these measurement problems with sound definitions and measurement methods is a necessary preliminary step towards setting VQ standards.

Some national energy regulatory authorities have already gone beyond EN 50160. Several options are still open; some countries will probably always refer to EN 50160 no matter how loose limits or definitions may be, and some countries will instead choose a "two-level" option, adopting definitions and measurement rules given in international standards (like EN 50160, adequately revised) but introducing national VQ limits and requirements by the national regulators, as has already happened in Norway and some other countries.

Until now, the main focus of quality regulation has been on the reliability and commercial dimensions of quality. In contrast, there is far less experience with the issue of voltage quality regulation, especially in integrated, multy function and multy communication platform like smart grid.

The proper approach to the intelligent network and all matters related to this concept, and the issue of power quality, can be of crucial importance for the countries that will be found in the way of its application.

If serious attention is not given to strategic planning and appropriate actions to prepare the system to move to a new concept, one can easily get into a situation that much greater financial resources are expended to remedy the consequences of damage, loss coverage, or payment of fees and penalties. The only alternative is the timely planning and implementation of actions to predict and mitigate the occurrence of such losses and to optimize the adaptation to market conditions.

B. Power quality strategic planning

The illustration of disharmony between regulatory requirements and actual network level will be explained on the case of Serbian electric power industry, in the last decade. First example was the question of increasing the nominal voltage in low voltage distribution systems from 380 V to 400 V.

Being aware of this change, many countries have made adequate preparations so that the transition did not cause adverse effects. On the other hand, Serbia has not had an adequate attitude towards this issue, so the transition to a higher voltage level was carried out almost right away. Because for example, motors in electric drives are replaced with new adapted nominal voltage of 400 V or 416 V as the regulations allowed a much higher voltage ranges (in Serbia, the maximum voltage at the consumer's place is 440 V), there was a large increase in reactive power in the system and a much larger number of failures in electric drives.

Another example of bad strategic planning is the lack of high level incentives for reactive power reduction for customers, by appropriate tariff system. Without these incentives, electricity consumers didn't have an interest to invest in actions for reducing reactive power consumption. So, after an increase of reactive power consumption in the system, Electric Power Industry of Serbia has invested in installation of reactive power compensation facilities in electricity distribution, the total installed capacity of 600 MVAr. In this way the huge financial resources are spent on unnecessary delays in manufacturing processes, repair of damaged equipment, insurance premiums, coverage of unnecessary energy losses and the investments that were not necessary. All these actions have been treating only the consequences, not the real causes of the problem.

By the introduction of the smart grid concept, the focus is changed, and new information and telecommunication infrastructure is required, as presented in figure 1. Power quality monitoring has to be included in this new infrastructure as well.

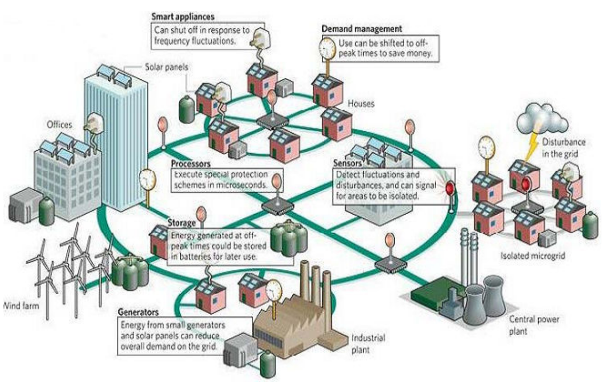

Fig. 1 Smart grid overview

The focus of achieving cost savings and improved customer service lies in distribution management systems (DMS) that provide real-time response to adverse or unstable conditions. In a smart grid, software programs must provide self-healing functionality in order to instantly detect and react to power disturbances with minimal customer impact. In the next chapter, some of the most important DMS functions regarding power quality are explained, through practical examples.

III. Smart Grid Functions Regarding Power Quality

The effective realization of smart grid concept is not possible without advanced distribution network automation. This automation is introducing advanced distribution network operation as well, through the set of advanced distribution functions. Important parts of such implementation are:

- Substation automation
- Advanced Metering Infrastructure
- Distribution Automation
- Outage Management System
- Virtual Power Plants
- Distribution Management System including functions like:
    - Volt Var control
    - Fault location, isolation and restoration
    - Optimal network reconfiguration
    - Demande response
    - Harmonics Analyzer

While the layout of proposed smart grid architecture and some smart grid applications are described in [5] regarding high voltage networks, problems of distribution network power quality are not related. In [6], applications like streetlight telemanagement, advanced metering infrastructure and LV network automation are introduced, togheter with modern hardware and control methods of smart grids. However, there is a need to define all requirements regarding power quality issues, and ways to integrate them in one complete smart grid solution.

A key aspect of electricity supply quality in a power system is the optimum application of voltage levels to all transmission and distribution networks. With significant penetration of distributed generation, the distribution network has become an active system with power flows and voltages determined by the generation as well as the loads. Growing customer expectation and use of sophisticated electrical equipment puts an added responsibility upon the network operator to ensure that the delivered level and quality of supply is maintained within the parameters set down by the regulatory bodies, while at the same time permitting the maximum amount of distributed generation to be installed and operated. Some of innovative solution in that field are elaborated in [7, 8, 9, 10].

A. *Smart Grid Architecture*

Unlike distribution network in North America, the low voltage lines represent high portion of European networks. That is the reason why the main smart grid unit and data concentrating point in European MV network shoulde be the MV/LV transformer station. This data concentrator in Serbia has been recognized in the form of Measurement Information System (MIS) with more detailed functionality explained in [11, 12]. The need for constant monitoring of the TS MV/LV where problems can occur, in order to rapidly respond to the possible occurrence of losses, the comfort in working with large amounts of data that provided the accompanying software and financial savings that utilities have accomplished by reducing energy losses, promoted MIS as the standard equipment in many TS MV/LV in Serbia. Security aspects of using the public communication grid are fullfiled as well [13].

Further development of Smart Grid platform was a logical upgrade of this platform, because following requirements emerged in many electrical utilities:

- centralized data collection with MIS,
- management of switching elements in the TS,
- integration with the systems of remote control switching equipment in medium voltage distribution networks,
- detection of unauthorized entry into a facility TS,
- video surveillance in TS facility,
- remote access systems with prior authorization in order to be able to remotely configure systems and to monitor their work,
- forecast of electricity consumption,
- ability to exchange information with a number of parent centers, and authorized users.

As the information section of MIS was based on the latest embedded computers, with many communication ports, the extension of this system is easy and configurable. The above requirements are implemented step by step. With this approach, electrical utilities are allowed to have one unified system that will integrate many functions and will be interoperable with existing intelligent electronic devices and systems. In terms of hardware that can meet the previous requirements, the configuration in Fig. 2. is used.

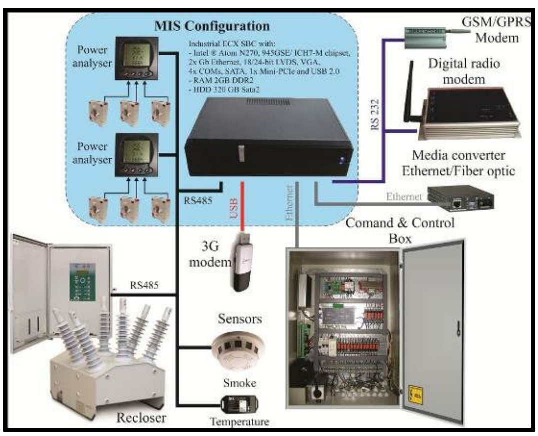

Fig. 2. Hardware configuration for TS MV/LV as part of a smart grid platform

With the similar requirements as they arise from other users in Serbia (measurement, remote monitoring and control, protection of buildings and equipment), developed smart grid platform was used in different applications: water supply, industrial consumers, small power plants, buildings and residential facilities. In terms of communication technologies that were used, almost all available communication services have been tested (digital radio modems, GSM/GPRS, 3G, dial-up ISDN, ADSL modems, fiber-optic cables, etc.) and their combinations. Protocols were devoloped to enable systems to use different communication channels with automatic choice of optimal one (without interruption in the communication, maximal redundency of channels is enabled). Interoperability of systems integration is demonstrated with the equipment of a large number of domestic and foreign manufacturers, whether it took place at the remote terminal units, or at the level of control centers (SCADA).

All these systems are independent autonomous entities, accessed only by authorized system users. Since these systems basically use the same platform, the exchange of useful information between them becomes a matter of time and the adoption of appropriate regulation. The overview of the multi user platform is represented in Figure 3.

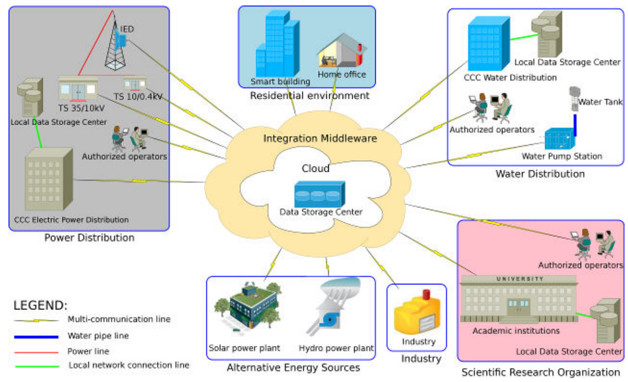

Fig 3. Smart grid platform as a service for different users

The latest researches conducted within the framework of the project [11, 12], realized by the 34 scientific and research organizations from Serbia, aimed at developing of a decentralized distributed computing system (DDS), which represents a significant improvement of the smart grid platform. The new grid computing DDS technology should provide intelligent linking of all individual computers belonging to the smart grid into a unique system, allowing optimal use of all available computer resources. Special attention in its developing is paid to the transparent system and user services.

DDS is designed to be fault-tolerant, self-balancing, self-maintaining, self-supervising, modular and easily scalable system, independent of computing platforms and the type of communication services. It enables maximum utilization of network resources, secure communication over insecure channels, and can be used in different services: grid, utility, and cloud computing, web hosting, data storing and data processing, etc.

Appropriate pilot projects are in testing phase, but some examples of the use of this platform for advanced smart grid funcionality (volt var control, fault location, and harmonic analysis) are presented in the sequel.

IV. VOLT VAR CONTROL

Integrated VoltVar control is an important and one of the most desirable functions of a modern Distribution Automation (DA) system, as an integral part of Smart Grids. This function deals with the complexity of voltage and reactive power control in distribution systems. This complexity usually limits the capabilities of local automatic controllers which conventionally control Load Changing Transformers (LTCS) or Voltage Regulators (VRS) on the bases of local voltage measurements, and, Capacitor (CAP) banks on the bases of temperature or voltage changes.

Performing the Volt/Var control in an integrated manner provides a flat voltage profile over the feeder while minimizing the power loss on the system. In addition, a coordinated operation of VRS and CAP banks permits avoiding of an excessive and unnecessary tripping of these devices.

Centralized voltage and reactive power control is typically considered the most cost effective function of real-time DA. Rule based Centralized Capacitor Control with an objective of unity power factor has a relatively long history of real-time implementation. With development of a more reliable real-time Power Flow, the power flow based Optimal Volt/VAr control attracts more and more attention.

Optimal Volt/VAr control allows a wider choice of objectives which can be achieved with higher mathematical accuracy. The objective of operating the distribution network within voltage and loading constraints serves as the primary objective, where other objectives – power losses, demand, etc. – serve as secondary. In addition, more and more distribution utilities are investing in remotely controlled capacitors and step voltage regulators as part of their distribution automation strategy. This offers the opportunity for periodic closed loop Volt/VAR control, which determines the optimal set of control actions and executes them immediately.

The trend for these applications goes towards more intelligent solutions that react to fault events and assist the operator in clearing and restoring the fault or take action without any operator interaction at all. Fault location programs evaluate the SCADA information of breaker trip events and fault

However, the proper introduction of these function is not possible without advanced monitoring of all important values in the power network, including the monitoring of voltage quality. In other words, power quality monitoring, together with the proper information and telecommunication techniques, is becoming the back bone of fully implemented smart grid.

Few case study taken from authors experiences in Serbian power network will demonstrate the need of advanced and integrated measurement and data analysis for the full achievenebt of desired functionality.

A. *Voltage reduction*

The first case study represents the common problem of voltage reduction in the transmission system. Due to some problem of unbalance between production and consumption, transmission network operators are commonly performing the short term (1 – 2h) voltage reduction (of the order of 5 – 10%). This reduction is leading to the short term demand reduction, but after few hours, the demand is continuing to grow, because of the „pay back effect". Consequently, the problem is the drastic decrease of voltage quality for many customers, affected by this wide area voltage reduction.

Figure 4 is representing voltages measured in one TS 10/0,4 kV, at the low voltage bus bars. The voltage magnitude decrease is of order of 10%, registered after 10h, in total duration of 1h and 30minutes.

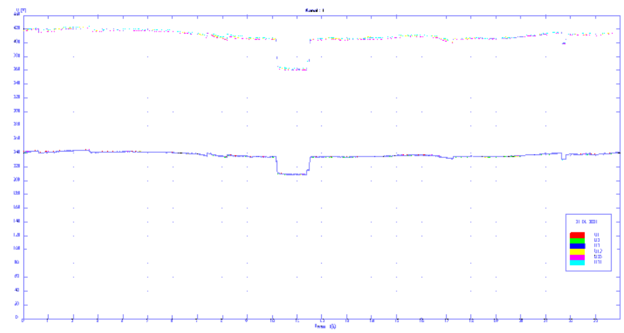

Figure 4. Voltages measured at the low voltage bus bars in TS 10/0.4 kV „Kadinjača" 31.01.2011.

The distribution company has not been warned, so the situation represented in figure 4 had as the result, many customers complaints for the low voltage in their households.

Figure 5 is representing diagrams of active and reactive power from the TS 400/110 kV „Petrovac" at one 110 kV bay, which supplies, through one intermediate TS 110/35 kV „Ilićevo" and one TS 35/10 kV „21. oktobar", the TS 10/0.4 kV „Kadinjača", represented in figure 4.

The measurement information system (MIS) in the TS "Kadinjača", recorded data with 12 s time resolution. The architecture of measurement information system installed in TS 10/0,4kV to record the parameters of voltage quality in power distribution networks is presented in figure 6.

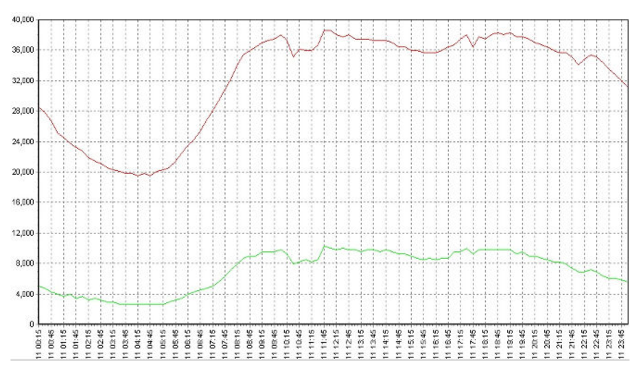

Figure 5. Active and reactive power in the supply TS station 400/110 kV „Petrovac" 31.01.2011.

The measurement system which measured the active and reactive power at 400/110 kV "Petrovac" recorded the data at 900 s (15 min), and forms of change shown in the diagram would not faithfully convey.

The presented example is aimed to demonstrate the need of measuring information system with adequatly alocated measuring units, and analysis software that allows the analysis of recorded data.

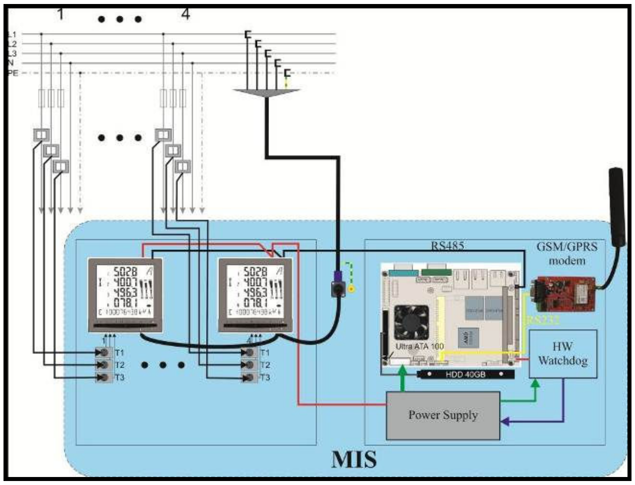

Figure 6. MIS architecture

For instance, data recorded from other distribution utilities which are equipped with similar devices. Figures 7 and 8 show the diagrams of voltage changes in two other TS 10/0,4 kV in other areas supplied by the same TS 400/110 kV.

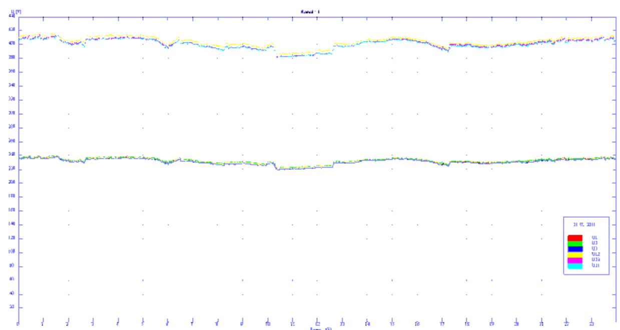

Figure 7. Voltages measured at the low voltage bus bars in TS 10/0.4 kV „Vranje " 31.01.2011

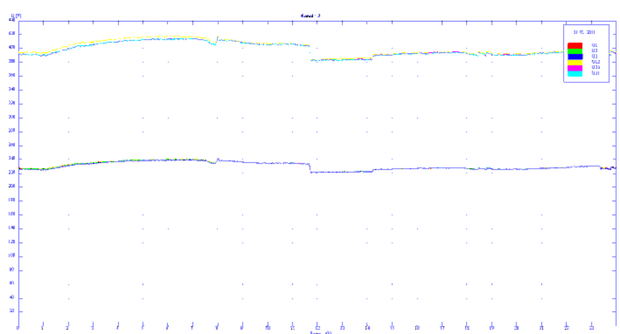

Figure 8. Voltages measured at the low voltage bus bars in TS 10/0.4 kV „Pirot" 31.01.2011

It is shown that without data recorded by measuring information systems and proper analysis software, many phenomena that affect the quality of voltage in electricity distribution network, and when the causes of these phenomena are beyond the site of measurement (and even outside the territory covered by the entire company for distribution) often can not be explain.

B. *Excessive operation of voltage regulator*

We already stated above, that performing the Volt/Var control in an integrated manner provides a flat voltage profile over the feeder while minimizing the power loss on the system. In addition, a coordinated operation of Voltage regulators and CAP banks permits avoiding of an excessive and unnecessary tripping of these devices. The simplified layout of one distribution feeder is represented in figure 9.

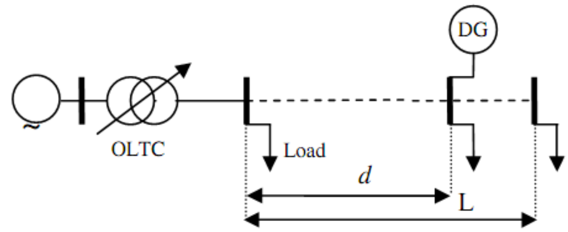

Figure 9. Simplified model of distribution feeder

The Load connected to the main bus bars, presented in figure 9, represents one forest industry facility. At the distance *d* from this facility, a small distributed generator (DG) is connected. Distributed generation connected to the public grid affects both static and dynamic aspects of voltage quality. Firstly, steady state voltage limits are endangered in the case of long, lightly loaded feeders, according to the following approximation:

$$P_{DG}^{max} = \frac{(V_{DG}^{max} - V_i^{min})}{R} + \frac{Q_{import}X}{R} \qquad (1)$$

P_{DG}^{max} – Maximal permissible active power of DG
V_{DG}^{max} – Maximal voltage at DG side
V_i^{min} – Minimal allowed voltage at the feeder begining
Q_{import} – Reactive power at the DG side
R – Line resistence
X – Line reactance

Secondly, intermitency of solar and wind represents the source of flickers and sags in the distribution network. That is the reason of introducing the voltage monitoring with high time resolution in the distribution network.

Voltage variation at Load busbars is represented in figure 10. The problem in this particular case was the excessive operation of On Line Tap Changer (OLTC) in distribution transformer station. The reason for irregular voltage conditions at transformer substation were electric deveices in the facility, with very intermitent work. Only after installation of power quality measurement device and, what is more important, introduction of these measurement in the central data warehouse, the problem is solved by proper settings of OLTC in supply transformer station.

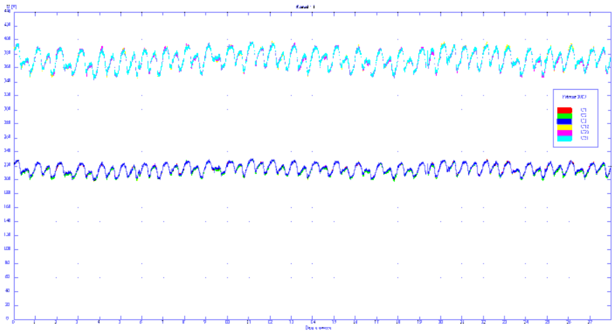

Figure 10. Voltages measured at the low voltage bus bars in TS 10/0.4 kV at consumer side

The same problem was registered in another TS 110/10 kV station, which supplied one TS 10/0,4 kV with voltage variations represented on figure 11.

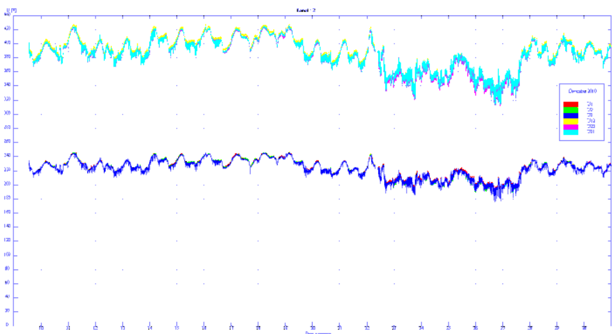

Figure 11. Voltages measured at the low voltage bus bars in TS 10/0.4 kVin ED Nis at consumer side

Only after detection of sources of voltage variations at the lower level, the proper setting of OLTC in supplying station were made possible, adjusting the voltage deadband and the time dealy of voltage regulator.

V. Fault Location, isolation and restoration

Fault Location, Isolation, and Restoration applications in a DA environment have also recently increased in importance. The following caswe study explain the use of MIS in the fault location. A case of extreme voltage drops appeared on one of the LV feeders of TS 10/0.4 kV "V. Jovanovic", located in Niska Banja, is shown in Fig. 12, and the LV feeder topology is given in Fig. 13.

The time period shown in Figure 4 refers to the 3-hours period (between 14:00 and 17:00). Image shows that the voltage drops at the moment of fault occurrence even exceeded 40% of nominal voltage. Even though the fault currents were high, due to relatively short duration of the phenomenon, there was no reaction of any protection system or any fuse failure, and the voltage drops repeated many times per day. This caused a very negative impact on all electrical equipment connected to the electrical network by this feeder. Obviously, the faults appeared completely aperiodically and Electrical Utility teams could not discover the cause with common control methods and common measurement techniques.

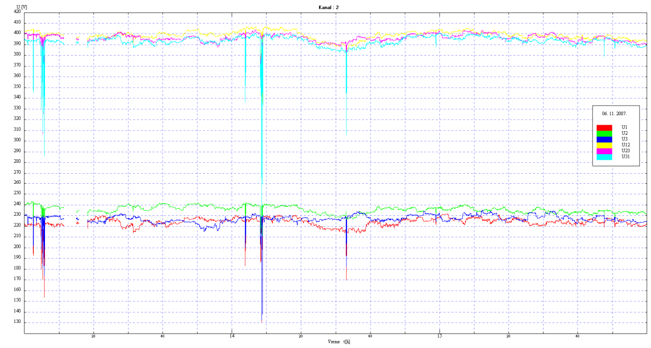

Figure 12. Phase and line voltages recorded on a pole of LV feeder of TS 10/0.4 kV "V. Jovanovic" - 06.11.2007.

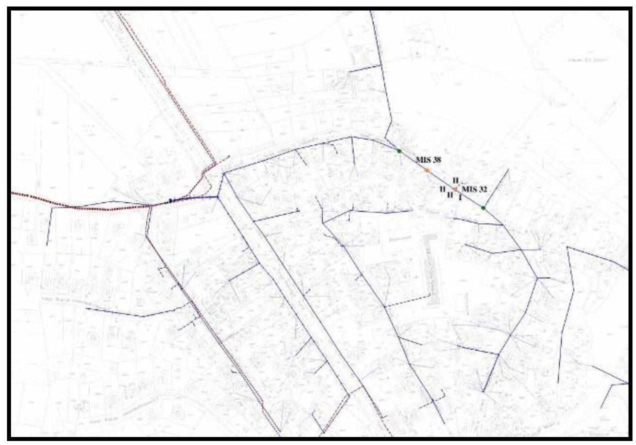

Figure 13. Topology of LV feeder with the described fault

For this reason, several MIS are used for a closer localization of the fault source in the feeder. Three hours were enough to found the source. It was a cable used for temporary site connection.

VI. Harmonic analyzer

The final case study is dedicated to the problem of harmonics. Harmonic Analyzer function in distribution managament systems is used for analysis of harmonics influence in MV and LV networks. Power quality of energy in LV networks can be severely affected because of presence of electronic devices; various commutations are very intensive sources of harmonics in the LV network, also the intensity of harmonics is not damped by means of transformation or isolated transformer neutrals.

The following is the example of electricity customer who injected into the network a large content of higher harmonics and cause unauthorized voltage drops of other electricity customers in the region. Figure 14 represents the active, reactive, and apparent powers of the consumer.

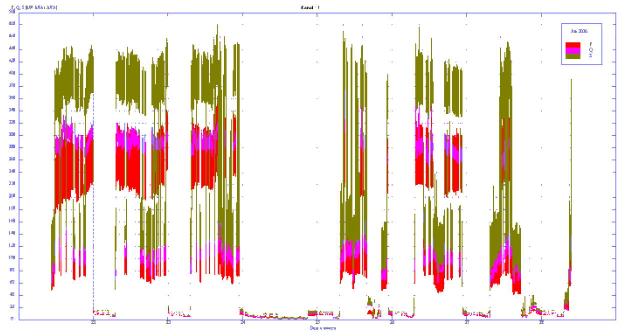

Figure 14. Active, reactive, and apparent powers of the consumer

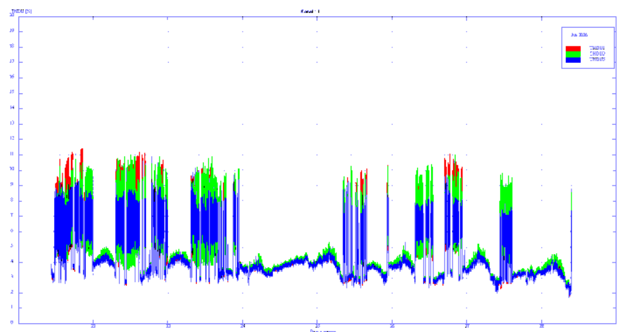

Figure 15. THD factors of the consumer's phase voltages

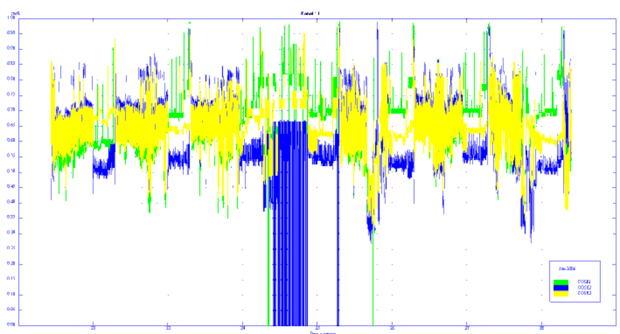

Figure 16. Corresponding phase power factors

Fig. 15 presents the high level of THDu (greater than 12%), while Figure 16 presents the corresponding power factor. Checking the technical requirements for the connection, the conclusion was that are connected to the network without their fulfilment.

VII. Conclusion

The paper points out that the problem of monitoring power quality parameters should be given far more serious attention in order to adopt laws and standards in the EU, and to fulfil requirements regarding EU SmartGrid technology platform.

It is shown that solutions to the problems described above should not be sought independently but as part of the development concept of intelligent networks (smart grids).

Moreover, power quality problems can be one of additional "driving factor" for the implementation of Intelligent network. Finally, it is shown that the elaboration of an integrated measurement and information platform is required, in order to achieve full functionality of smart grids.

References

[1] *Toward Smart Power Networks, Lessons learned from European research FP5 projects*, European Commission, 2005.

[2] *Strategic Research Agenda for Europe Electricity Networks of the Future European Technology Platform,* European Commission, April 2007.

[3] *Strategic Deployment Document for Europe Electricity Networks of the Future European Technology Platform*, European Commission, April 2010.

[4] T. Degner, J. Schmidt, P. Strauss, "Dispower, Distributed Generation with High Penetration of Renewable Energz Sources", Final Public Report, iSET, Kassel, 2005.

[5] S. Javadi, S. Javadi, "Steps to Smart Grid Realization", Recent Advances in Computer Engineering and Applications, 4th WSEAS International Conference on COMPUTER ENGINEERING and APPLICATIONS (CEA'10) Cambridge. *January 27-29, 2010*

[6] M. Yang, B.N.Ha, S.W.Lee, "The Study on the Design of the Smart Grid Test-Bed in KEPCO", Selected topics in power systems and remote sensing 10th WSEAS/IASME International Conference on ELECTRIC POWER SYSTEMS, HIGH VOLTAGES, ELECTRIC MACHINES (POWER '10) ,6th WSEAS International Conference on REMOTE SENSING (REMOTE '10) Iwate Prefectural University, Japan October 4-6, 2010

[7] M.H.J. Bollen, J.Zhong et all. "Power Quality aspects of Smart Grids" International Conference on Renewable Energies and Power Quality (ICREPQ'10) Granada (Spain), 23th to 25th March, 2010.

[8] H. Spaack et all. "Intelligent Transformer Substations in Modern Medium Voltage Networks as Part of "Smart Grid" 7th Mediterranean Conference and Exhibition on Power Generation, Transmission, Distribution and Energy Conversion7-10 November 2010, Agia Napa, Cyprus (Paper No. MED10/240).

[9] J. Kester et all. "A smart MV/LV station that imrpoves power quality, reliablity and substation load profile", 20th International Conference on Electricity Distribution Prague, 8-11 June 2009.

[10] J. Heckel, "Smart substation and feeder automation for a smart distribution grid", 20th International Conference on Electricity Distribution, Prague, 8-11 June 2009.

[11] A. Janjić, Z. Stajić, I. Radović, "Power Quality Issues in Smart Grid Environment - Serbian Case Studies, WSEAS CSCC 2011 Conference, Special Session: Power Quality Impacts on Energy Efficiency and Renewables, (Corfu Island, Greece, July 14-17, 2011)

[12] Z. Stajić, A. Janjić, Power Quality and Electrical Energy Losses as a Key Drivers for Smart Grid Platform Development, WSEAS CSCC 2011 Conference, Special Session: Power Quality Impacts on Energy Efficiency and Renewables, (Corfu Island, Greece, July 14-17, 2011)

[13] R. J. Robles, T. Kim, Communication Security for SCADA in Smart Grid Environment, DNCOCO'10 Proceedings of the 9th WSEAS international conference on Data networks, communications, computers, Faro, Portugal, November 3-5, 2010

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