MANAGEMENT ISSUES POWER QUALITY IN DISTRIBUTION SYSTEM

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ABSTRACT

In recent years, the number of power quality problems has increased dramatically. This increase in electricity demand of recent years, consecutively with increasing the number of power plants and power, along with changing the structure of energy agents and increase power receivers, led to deterioration of power quality parameters, with implications serious about working arrangements and consumer networks. Most disputed aspect in terms of power quality standards is the regime's control sizes. A clear understanding of issues related to power quality management in all its complexity, correctly identifying the causes, phenomena and present solutions in the area of power quality can help to avoid damage / failure, that the increased benefit.

1.INTRODUCTION

In the modern sense, electricity (EE) is considered a commodity to be delivered by the supplier to the consumer in terms of quality and economic efficiency of energy facilities and limit the impact on the environment.

If we take into account that Romania's energy resources are about to be exhausted in a relatively short time: in 14 years is over oil reserves in 15 years the natural gas and coal in existing mines will end about 32 years, even if the Romanian state has obtained over 80% of the "gold mine" of the Black Sea (9700 km2), that by some estimates about 70 billion m3 of gas and 12 million tons of oil, enough to Romania to support consumption for several years to come [1], every effort will be made to develop a sound national strategies, with efficient management of power quality. In perspective 2007-2025, the strategic objectives of the energy sector are: ensuring the quality of energy services by covering the energy demand affordable prices, promoting efficient use of energy policies for protection of the environment and improve public perception of the impact industry medium and long term energy and optimizing the use of internal resources in terms of integration into the national power system market and European Regional [2]. With regard to the wishes of the national power system interconnection with the European energy system, there is more and more obvious concerns of modernization, efficiency and improving the quality of electricity supply.

2.POWER QUALITY

What is meant by quality of electricity? A perfect food, which is always available, with frequency and voltage parameters in a band permissible and perfectly sinusiodală voltage curve. In order to identify deviations from a perfect food, equipment must be famous B & B that the user will use its perception on the conditions.

Quality of electricity supply is influenced by two groups of phenomena: random phenomena (transient overvoltage, short and long term interruptions, dips) and semi-permanent and permanent phenomena (rapid or slow changes in voltage, current and voltage unbalance, harmonic generated).

Among them among the most frequent and most important effects are: the presence of current harmonics and voltage harmonics and unbalance of supply voltages and currents.

Unlike other commodities, which we ask them to purchase quality problem, and we have a choice in terms of power quality depends on how it is negotiated between supplier and consumer. However, if any other products as we can say that it raises the price for electricity can be said, that certain quality standards reflected in the price of the consumer's budget may even fall. Bidirectional power quality must be addressed both from a consumer perspective and in terms of provider. No matter how it is collected: electricity product quality, service quality of electricity supply, the quality of the hierarchical system that automatically produces electricity, it is assessed on the basis of quality indicators, quality indicators that can be specific or global. Modern technologies in a constantly evolving, based on power electronics and computing, today present in all consumer sectors, involve complex processes, some of which are sensitive to electromagnetic interference, both from their environment and from the suplly network. Providing power quality has become an increasingly complex task because of the increased number of users with nonlinear receivers. Currently, in Romania, over 65% of consumers causes harmful emissions in the supply network. Summarizes some of the power quality system nonlinearities, whose effects are difficult to quantify and amounts allocated under the economic. To define appropriate mechanisms capable of accurately reflect the technical aspects of power quality is difficult. To achieve acceptable levels of power quality have been raised incentives and penalties, which were based on profit impact on the 'players' market. The problems that arise relate to inability to achieve clear distinction between causes and effects of most disturbances, a distinction without which the assignment of responsibilities, with the creation of mechanisms for incentive / penalty is very difficult and sometimes impractical [3]. Issues related to power quality management are related and five categories of damages, which may cause deviations from perfection in food supply: the harmonic distortion, disruption, tension over or under acceptable values, goals (variations) and transients.All these problems have other causes, which may be the result of partitioning infrastructure [4] . One of the issues users face is the decision to be taken on the type and quantity of additional equipment to purchase to obtain the required quality of supply. Currently, there are few published statistics could then determine the cost to consumers to justify the cost of incidents and preventive measures.

3.CAUSES TO INFLUENCE POWER QUALITY

Power quality management is faced with the following categories of cases:

3.1.Dips and short interruptions

They highlight the difference between the views of consumers and suppliers. Electric power industry tends to evaluate disruptions to the cost of electrical energy delivered, while a consumer evaluated in relation to losses in production due to interruption. Electricity is relatively cheap and relatively short interruptions, while the losses in production time can be very important and unavailable for preparing to resume production facilities is very high. So there are different views on the importance of voltage sags and justified level of investment in equipment to limit them.

3.2. Long interruptions

Entitled - Disconnect - are commonly regarded as being due to the supplier, but may be due to equipment failure. Careful design using solutions with high reliability can minimize these effects. The objective is to identify points where breaks occur and they can be removed. It can provide backup equipment (redundant) or alternative supply routes for the activity may continue for a single incident. Systems designed in this way are easier to maintain and as a result are better maintained. It is important that maintenance procedures be developed during the first stage, as part of the concept of safety design. UPS backup sources and systems needed to cover short and long breaks are essential for a system able to cope with variations in power supply.

3.3. Harmonics

They are primarily the responsibility of the consumer. Harmonic currents cause problems in plant and when these currents circulate back through the supply path impedance at the point of common coupling is a voltage harmonic. This distortion of the voltage, or at least some of its components, are transmitted throughout the system and summed to the total harmonic (background) power present in any system of transportation (eg, due to the nonlinearity of the transformer).harmonic (background) power present in any system of transportation (eg, due to the nonlinearity of the transformer).

3.4. Transient Disturbances

There are events with a high frequency. Amplitudes can be several thousand volts and can cause serious damage to both plant and equipment connected to it. Electricity suppliers and telecommunications companies are striving to ensure that their facilities do not allow propagation of transient disturbances dangerous (which can cause damage) in consumer installations. However, transient disturbances considered hazardous may cause serious damage by affecting the data. It can be stated that power quality problems result in a business venture, even industries with a low-tech may be exposed to serious financial losses. On the other hand, if proper design techniques are applied, the installation of appropriate personal protective equipment, the costs may be lower.

4. POWER QUALITY MANAGEMENT RESEARCH

Implementation of modern technologies in energy applications in the current circumstances require increasingly stringent supply voltage is maintained within acceptable limits. Inconvenience caused by these problems requires the measurement and analysis of power quality and this increases the importance of monitoring tools for locating problems and finding solutions. Power quality problem is not only simple monitoring equipment must be taken into account the technological aspects and nontehnologice. The non-technological and project management of power quality and economic impact of power quality problems are still poorly addressed. Monitoring plays a role in finding solutions for solving power quality monitoring, but an appropriate coordination helps minimize costs for troubleshooting. Monitoring is required by both the customer and the supplier / distributor, but is made bearable cost.

Costs of non-power quality can be identified:

- defective product costs due to interruption or continuous process produtos stages,
- losses due to production time / reduction in productivity
- losses due to resume,
- increased production costs by the failure of timely data.

Monitoring project leads us to find answers to the following questions:

Why measure ?

This question is clear: monitoring objectives,
selection of monitoring equipment
thresholds measurementanalysis of
necessity of monitoring the plan is
implemented,effort required to achieve the
monitoring plan.

What measure?

Measurements should be made to obtain information about:

- supply voltage frequency,
- voltages Ua, Ub, Uc, A, Uo,
- currents Ia, Ib, Ic, Io.

Where measure?

To analyze problems to determine the technical flaws should be closer monitoring of sensitive loads, minimizing the costs involved

How measure?

Organization definition of physical problems involving measurements:

- number of devices required
- type and number of clamps,
- Accessibility to the point of measurement (with or without adjustment signals).

What we measure?

Power quality measurements are made using specialized machines are called "power quality analyzers".

How we measure?

Standard periods of analysis are: Tvsh = 3 sec, Tsh = 10 min, Td = Tw = one day a week, but for critical processes and apply continuous measurement. After clarifying the problems related to the six questions, go to training following the steps of monitoring: [5].

- **Research plan**. All persons involved must participate in the development and approval of a program to install monitoring equipment, transfer of information and remove equipment.
- **Preparation for measurement**. Meeting all the right equipment and tools necessary for the monitoring process. Preparing and training staff to use equipment that is not human errors occur.
- **Site inspection**. Since the optimal location for placement of equipment may be difficult to access, may be necessary changes in the distribution box may be necessary or disruption of energy is required prior to site inspection. Now they gather and the most important characteristics of the installation to be monitored.
- made in compliance with all safety rules, protective equipment is essential to prevent incidents during the installation of equipment.
- **Monitoring itself**. In this phase the equipment is installed for the monitoring period established. It is recommended to check the memory, possibly periodically downloading data, the thresholds for measuring memory is not filled with irrelevant events.
- **Possible extension of the period of monitoring or removal equipment**. Now to remove the equipment, also to security compliance. If the event is not expected to occur has occurred, a decision will be taken for the purposes of monitoring or prolong its abandonment.
- **Analysis of monitoring and verification of data recorded**. This is the most difficult part - analyzing and interpreting data collected during monitoring. Some analyzers have special software to help users capable of generating automatic reports. However, the correct interpretation of the results of these units can only be done by an experienced engineer, familiar with the process of the electricity but also the power quality field **Define and implement corrective solutions**. Now there remains only the development and implementation of an immunization program, based on analysis of monitoring results. It must be based on monitoring results and the analysis of the production process and the economic impact of disturbances. It is also recommended at a theoretical estimate of immunization and also accessible to a simulation and / or testing of the proposed actions. After estimating the costs and other benefits of reducing lost production data, it decided the application (performance) immunization project. The final decision and implementation strategy for implementing immunization is always taken in accordance with the economic parameters for depreciation. There are a number of engineering solutions able to eliminate or mitigate problems as being a very active area of innovation and development. Thus,

consumers must be informed of the range of solutions available, and benefit costs [6].

- **Monitoring to confirm the viability of corrective solutions**. They often want a reduction in the level of disturbance for the recruitment rules and the solutions applied estimated effect. Confirmation is expected to obtain results with a new monitor for a shorter period. The success of the program planning and execution of power quality is dependent on technological knowledge and also deep nontehnologice such as project management and monitoring organization, the degree of interest, as the regional operating electrical equipment and other factors. The most important element in achieving desired results is dealt with correctly defining the objectives and proper management of the shares underlying the program to improve power quality.

5. FINANCIAL RISK REDUCTION DUE TO INCIDENTS AND FREQUENCIES

In a competitive market in Romania is the quality factor of the electricity distribution services, and influencing consumer costs. Safety in power supply, part of the electricity supply quality management involves financial efforts Distribution Operators (DO) dedicated to investments, maintenance and repair network. Optimization of these costs can be achieved mainly using data from the indicators of reliability - and Said Saifi - designated by the competent authority - by ANRE, Technical Code Red and performance standard. Collecting information in time will make it possible to determine the frequency of interruptions for each network element and the cause that prompted the interruption, something that may assess the financial risk of Distribution Operator who will avoid paying a penalty for exceeding a predetermined limit service disruption to customers and competent authority, and why not, it is possible future development of Distribution Operator rewards if he will have good reliability indicators .Measurable criteria: Indicators of reliability - and Said Saifi - can be determined for a group of power plants serving a particular area of service as well as for individual wiring. In general the causes that produce disruption to customers are:

- weather (winter / summer)
- contact with vegetation
- influences of Foreigners
- errors of the personnel of OD electricity bill-paying (at solocitarea licensed provider)
- failures in its own facilities OD
- Unknown
- interruptions in the transmission network of electricity.

OD staff can provide information on the field because of interruptions that are stored in the database so you can achieve distribution and Said Saif indicators monthly, yearly and multi-annual basis which can be applied to rule on the rewards and penalties.

Another important rule is to evaluate the fault rate for electrical facilities serving a given service area, the rate can be determined on the sets of electrical circuits on a single circuit. Defect rate can be obtained for each component of a circuit (eg cable, transformer, overhead conductors, insulators, poles, etc..). A third important rule is to determine the residual life of a facility or component thereof that is calculated by equation (1):

$$a=\frac{b-c}{b} \quad (1)$$

where,
a-to represent residual life;
b-is the period of estimated useful life;
c-is age.

Also important is the database of the assets. Use measurable criteria in maintenance, will also allow better planning of repair work, especially for investments to improve distribution service. Maintenance and repairs are mutually binding programmed investments OD respectively. Repairs and maintenance investments can reduce costs. Investment must pursue work leading to lower maintenance costs by implementing automation software distribution, integrated in the program as part of SCADA (Supervisory Control and Data Acquisition), made mandatory for any OD.

A well-planned maintenance can be a "source" for postponing cost while repairs and investment. For this reason distribution operator must reorganize the intelligence centers, in fact operate with the concept of 'reengineering', concentrating on what "should"be an OD on the free market and competitive power. Given that the main source of income is the charge distribution of OD, which is regulated by the competent authority, it can calculate the financial risk being put on by non-standard employee performance.

6. POWER QUALITY MANAGEMENT SOLUTIONS

6.1. INVESTMENTS

It is one of the ways to improve power quality management. In the computer industry, work supervision, control and data acquisition in distribution of electricity, SCADA / DMS, requires investment, which are accounted for:

- improving the performance indicators established by ANRE for electricity distribution service;
- Increase customer satisfaction by reducing the number and duration of incidents;
- reducing costs and improving the organization's financial performance

through increased efficiency in operating activities of plants;

- increasing involvement in plant safety by obtaining real-time information from field.

Operative management by dispatcher will have to provide practical, on-line by exploiting real-time management of networks, optimal conditions for supply to consumers in the technically and economically for both provider and customer. It follows two types of functions that are interdependent:

- predominantly technical functions;
- economic functions.

With the introduction of power exchange, the purchase price differential of different points of purchase, there is need to assess and continuously improving the cost (both the cost of electricity purchased and delivered electricity). It is estimated that in the immediate future as the economic role of the Board approached the dispatcher will be particularly complex. Implementation and results obtained in a case study can be found in [7].

6.2. FUTURE NETWORKS

In future, the operation of the system will be divided between central and distributed generation (Distributed Generation-DG). Control of distributed generators will be done by aggregating them into a virtual micro or central, in order to facilitate their integration in both physical systems and in the energy market in figure1

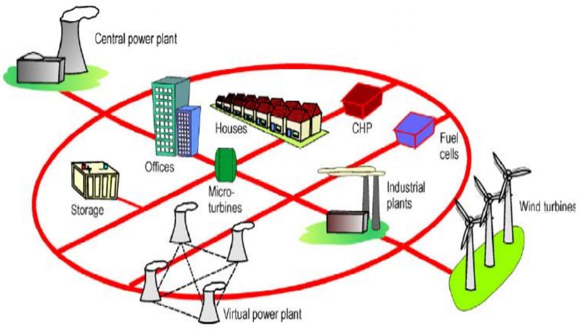

Figure 1. Smart Grids (source KEMA)

What is the Smart Grid? An advanced, telecommunication / electric grid with sensors and smart devices linking all aspects of the grid, from generator to consumer, and delivering enhanced operational capabilities that :

1. Provide consumers with the information and tools necessary to be responsive to electricity grid conditions (including price and reliability) through the use of electric devices and new services;

2. Ensure efficent use of the electric grid (optimizing current assets while integrating emerging technologies such as renewables and storage devices);

3. Enhance reliability (protecting the grid from cyber and natural attacks, increasing power quality and promoting early
detection and self correcting grid "self-healing") [8].

Smart Grids can enable integration of distributed resources (DG) in figure 2

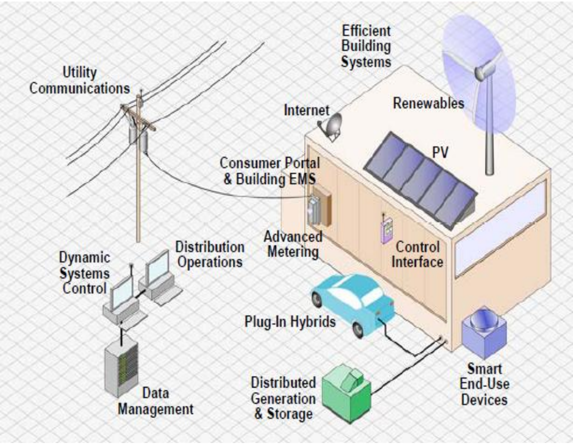

Figura 2. Smart Grid Network (adapted from[13]).

Vision for distribution management system integration with Smart Grid in figure 3.

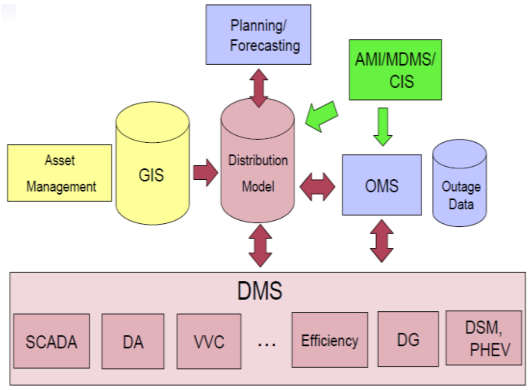

Figure 3. Distribution Management System

Distributed generation (DG) is expected to become more important in the future generation system. In general, DG can be defined as electric power generation within distribution networks or on the customer side of the network.

Benefits and impact of DG:the idea behind the connection of DG is to increase the reliability of power supplied to the customers, make use of a locally available resource and, if possible, reduce losses in transmission and distribution systems.

The connection of DG to the power system might improve the voltage profile, power quality and support the voltage stability. This allows the system to withstand higher loading conditions and defers the construction or upgrading of new transmission and distribution infrastructures.

Some DG technologies have high overall efficiencies and low pollution such as combined heat and power (CHP) and some micro-turbines. See in figure 4

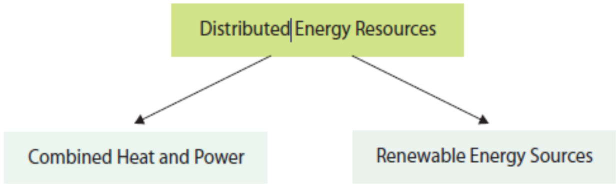

Figure 4. **Split up of Distributed Energy Sources** [14].

In addition, many DG units are using renewable energy resources. Renewable energy is from an energy resource that is replaced by a natural process at a rate that is equal to or faster than the rate at which that resource is being consumed. This, in one way or another, contributes to the reduction of greenhouse gases.

In another order of ideas, the connection of DG to the network might cause a significant impact on the power flow, voltage stability, voltage profile, protection selectivity and the power quality for both customers and electricity suppliers.

On one hand, the power injected by DG might support the voltage profile and stability of the system. On the other hand, many DG units are connected to the grid via power electronic converters. This might inject harmonics. The connection of DG might cause overvoltage, power factor, dip, fluctuation, harmonics, and unbalance of the system voltage. The variation in power output, along with the virtually inertia-less nature of the power electronic frontends, of some DG technologies such as wind turbines and photovoltaics might cause voltage fluctuations.The relation between distributed generation and power quality is an ambiguous one.

On the one hand, many authors stress the healing effects of distributed generation for power quality problems.

For example, in areas where voltage support is difficult, distributed generation can contribute because connecting distributed generation generally leads to a rise in voltage in the network (IEA (2002)).

Typical examples of DG would be a system with three micro-turbines that provides both heat and electricity for a hospital, or an array of photovoltaic (PV) panels assembled on to the roof of a single house. In figure 5 below demonstrates some basic types of DG and their connection to grid.

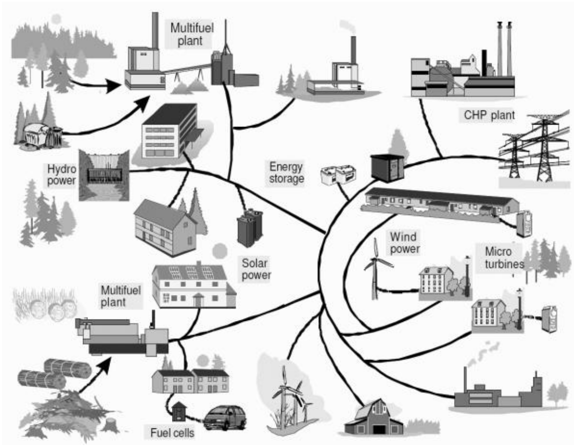

Figure 5. **Implementation of distributed resources in the distribution system (adapted from** [11]).

DG systems could be characterized by small unit size, modularity, and local energy resource utilization. Where as centralized power generation units can take advantage of economics of scale effects, DG profits from cost reduction in the transmission or distribution network and from incremental unit sizes and related investments. Typically DG is connected to the distribution grid. As the amount of DG increases, several issues arise relating to system safety and quality of the delivered power. The DG type also plays a role, as synchronous and asynchronous generators as well as DG connected through power electronic converter all have slightly different impacts on the grid [12].

A DG unit can influence the grid safety in at least four different ways. First, the DG unit changes the fault current direction and magnitude in the grid. Second, a grid that has DG equivalent to its load is in danger of islanding if a fault occurs. If controlled and wanted, this can be an advantage, but accidental islanding is a severe safety risk. Third, excess power generation can alter the direction of power flow in the distribution grid. If the grid is not properly equipped for this, equipment failure may result. Fourth, the connection of DG alters the transient stability of the distribution grid.

Power quality, moreover, is influenced by DG in at least four different ways.

First, DG can influence power quality by introducing harmonics to the grid. This is typically an issue connected to the power converter technology.

Second, DG may cause voltage flicker. Such event can result from starting an engine or from rapid step change in DG power output. Third, DG integration may increase or decrease system reliability. On the one hand it can provide the grid support to ride through a problem, on the other hand failures in the DG unit or because of the DG unit can reduce the system reliability. Fourth, if the local power generation exceeds the local consumption it can potentially damage the local power quality by causing over-voltage.Overall quality of electricity and its measurement are important within the client's site distributed generation than public distribution network. Thus, the client either locally generated or consumer needs results on power quality measurements. If there were an illegal attempt at connecting consumers or recipients of disturbing the system operator can remotely disconnect the power supply, will act quickly in case of failure, they were spotted and reported in real time.

7. CONCLUSIONS

Lately we are experiencing exponential growth in the amount of data from monitoring systems power quality. To provide information to produce value-added distribution companies' activities, these data should be consolidated with other contextual data from various sources (SCADA systems, financial data, etc..) in a database dedicated to subject power quality management. The system used should allow storage of both structured data (eg events), as well as the unstructured (eg samples of the shape signal or the actual values calculated half period). By analogy with intelligent data analysis systems implemented at the business level, the system aimed at collecting data on power quality and processes for intelligent analysis of these data have been grouped under the name Power Quality Intelligence (PQI). Architecture of an intelligent system for power quality analysis and the principles underlying the organization of data in a database on the subject of specific power quality could be a challenge for experts in the field.

A condition for the success of such a system in terms of integration of the company's business processes is the distribution of community consultation to potential domestic and external dimensions on where you want to be described events and the ways their analysis and visualization. Ensure appropriate quality of electricity requires a good initial design, which takes into account the conditions of power quality equipment and provide effective corrective distribution cooperation with the operator and the supplier, frequent monitoring of quality parameters and proper maintenance electrical installations. It should be noted that over 70% of total energy consumption in buildings can be found, be they residential or commercial. Issues related to power quality devices require the implementation and realization of measurement and monitoring systems for electricity. Distributed generation units providing power supply locally gives the utility and the customers more choices on demand management, which helps to increase the reliability of power supply and relieve the transmission congestion. It is expected that new development in distributed generation technology with higher volume will lower the investment cost of installing distributed generation units resulting in greater usage.

A future power system with central and distributed resources (DR) is presented in figure 6.

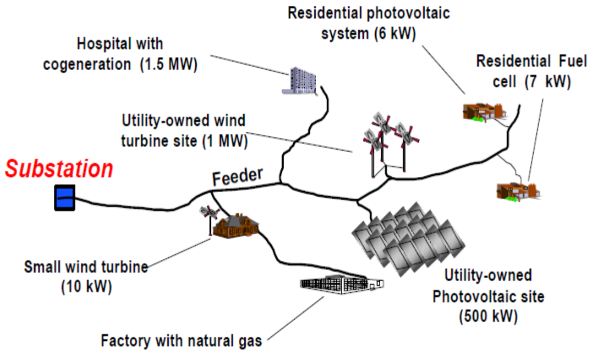

Figure 6. Power Quality opportunities with DR

Distributed Resources (DR) is coming …. But how fast? Some products are available now, we expect wider utilization of wind, micro-turbines, fuel cells, and other DG technologies within a few years

DR can be integrated with the right equipment to provide UPS grade power with parallel generation and even heat recovery as an "all-in-one" package

DR must be installed properly or PQ/reliability could be made worse and utility distribution systems could face problems.

8. REFERENCES

1. Băhnăreanu, Cristian., *Romania's energy security in the European context, University of National Defence „Carol I"* (2010) ,ISBN 978-973-663-847-3.
2. Zamfir, Andreea „ *Romania's energy sector development - the main objective of the strategy of sustainable development horizon 2025*", Economy Management Series, Anul VIII, Nr. 2, (2005).
3. A.E.Emanuel., „*Harmonic cost analysis: a difficult task*", Proc. IEEE Power Engineering Society Summer Meeting, Vol.1, pp.333-338 (1999) .
4. David, Chapman.„ *Introduction to Power Quality, Power Quality Application!",* Guide-Electric,Leonardo da Vinci, (2001).
5. Sumper, A., Andreu A.S., Duran J.R., „*Successful Power Quality Monitoring*", Electrical Power Quality and Utilisation, Magazine, vol.1,no.1,(2005).
6. www.lpqi.org;
7. Bălan, Daniel., Ion,.Dobre., Gavril, .Lungoci., ,,*Contributions to the commissioning and operating experience of HV switching equipment associated with MT, PA, PC*", SIE 2010, Section 1, pp 117-121, ISSN:1842 – 4392.
8. Mark, McGranaghan.„*Projects focused on large scale distributed resource integration*", Electric Power Research Institute, March 11 (2009).
9. Ackermann, Thomas., et al, „*Distributed generation: a definition,*" Department of Electric Power Research, Royal Institute of Technology, Electric Power Systems Research, Vol. 57, p.p. 195–204,(2001).

10. Dondi, P., Bayoumi, D., Haederli., C., Julian, D., Suter, M., ,,*Network integration of distributed power generation*”, Journal of Power Sources, vol. 106, p. 1-9, (2002).
11. M. Kara, R. Hirvonen, L. Mattila, et al., ,,*Energy visions 2030 for Finland*”., Helsinki, Finland: VTT Energy, pp. 237, (2001).
12. T. Ackermann., V. Knyazkin, ,,*Interaction between distributed generation and the distribution network: operation aspects*", in IEEE/PES Transmission and Distribution Conference and Exhibition 2002: Asia Pacific, vol. 2, pp.1357-1362, (2002).
13. www. smartgrid.epri.com
14. Peter, Vaessen and Davy, Thielens., ,,*Policy and Incentives on Distributed Generation*” KEMA Consulting May,pp.2 (2007)