The Perceived Power Quality Way as New Frontier of Relationships between Customers and Producers

F. Leccese
Electronic Engineering Department, University of "Roma Tre"
Via della Vasca Navale n.84 00146, Roma, Italy, tel. 06 57337085, fax. 06 57337101, leccese@uniroma3.it

***Abstract* -The description of perceived power quality state of art is presented. The necessity to satisfy a constant demand of quality in the electric energy field is faced presenting the procedure that should be followed to safeguard the economic interests of the electric energy customers is pointed out with the remarkable by-product to increase the diffusing of the Knowledge of the electric energy by customers.**

***Keywords* - Power Quality (PQ), Perceived Power Quality (PPQ).**

I. INTRODUCTION

The Knowledge progress through two steps: the scientific experimentation and the speculation. The first has the role to show the tangible realty allowing us to avoid rough errors, the second allows us to imagine new possible scenarios and help us to establish technical and practical choices. Both steps are necessary to progress and they must be understood by people to obtain the more widespread and more correct interpretation of phenomena.

The fundamental method of the scientific experimentation is the Measure, without it, it is not possible to quantify in no way the entity under control that we want to know, but the finality of the analysis of the Knowledge confine this first step in a world of experts.

On the contrary, the speculation has many facets not necessarily joined to a world of specialists, but open to contributes of the Thought coming from all fields of the human knowledge and from the human sciences, not last the economic one.

To allow the fantasy to open new scenarios and new perspectives it is necessary that people that have very different cultural backgrounds get dialogue among them.

This process is difficult because the majority of mankind haven't a scientific or technical bases which could allow to understand the deep sense of the entities under examination. Therefore, for them, it is hard to understand or analyzing phenomena difficultly understandable as electric ones for which the human body hasn't efficacious biological sensors. This lack of sensibility is then translated in indifference attitude for this entity.

To interpret the electric energy is necessary to provide parameters that synthesize it and that are share and understood by the most of people.

In this direction the power quality (PQ) quantitative parameters[1,2], typical of the normative, which describe the quality of the energy, can be supported by qualitative parameters, obtained by researches on the perceived power quality (PPQ) of electrical energy [3,4,5,6,7,8] with the declared objective to integrate the real exigencies of the production with the more aseptic normative parameters.

II. THE WAY

It is necessary to outline a course of action that allows to overcome the historical incommunicability [3,4,5,8] between the producers and the customers trying to balance a situation at present strongly favorable to the firsts.

The procedure, that at "Roma Tre University" they are following since five years ago, is based on three points:

a) the research of the real expectations of the customers joined with the electrical energy, determining the PPQ parameters;
b) realization both of new instrumentation with high metrological value and new instrumentation with high performances/costs ratio able to measure in real time the normed PQ parameters;
c) the same instrumentation should match PQ and PPQ parameters in real time to provide a new instrument to build new producer-customers electrical energy agreement typologies based on the quality of the energy.

A. The Expectations Researches

The researches try to understand what the customers want from the electrical energy and they born from practical experiences and from the observation of the real world.

We used two different approaches for different targets: little and medium enterprises (LME)[4,5,6,7] and low voltage customers (LVC)[8].

In both cases the first problem is to find a common language that realize a "linguistic bridge" between the customers and academic lexicon. To obtain it, the collaboration of electric operators (EO), that constantly work on the electric plants of the customers and so know their real electrical problems and needs and far from the Academy, has been fundamental.

In both cases we proposed a questionnaire to the customers but conceived starting from different assumptions. In the first case, the bad quality of electrical energy can often produced significant damages to the electric and electronic equipments as well as in terms of lost of productivity, so the endurance level is very low. In this case we thought that, to provide a good questionnaire, was necessary to try to understand which were the most significant problems signaled by the customers asking

to well educated EO, able to understand the Academy language and contemporaneously knower of the LME electrical problems and needs, to prepare a list of questions on perceived power quality. The lists is been furnished to a restricted numbers of EO asking them to suggest their personal experiences in terms of "job lexicon".

By means of Academy supervision the combination between the two previous steps permitted to determine a "Pertaining to the Technology of Commerce Filter" able to establishes the correct languages to use in the questionnaire to arrive directly to the customers electric knowledge.

The questionnaire supplying in a restricted area (the Rome area), permitted us to determine the worst and the best electrical energy geographic points so allowing to define the perceived power quality fluxes the global signatures for the PPQ[4,5].

A different strategy has been adopted for LVCs. The consideration that everybody is a LVC, guided us in this research: everybody can have a own idea about electrical energy and its implications so everyone can freely express own impressions on it. So through few simple questions, we verified to qualified engineering students, to express their knowledge

about the electrical energy. Their answers clearly show how, also for them, that should be well prepared, the concept of electrical energy is faint! Basing on this assumption we divided the questionnaire in two parts the first part wants verify the electric energy knowledge level of a common LVC, the second part wants to verify which kinds of electrical problems they encountered and their endurance level for each problem.

Only for this second part the contribute of well prepared and not EO has been used. For this second part, as for the previous LME test, the questions are expressed in terms of failures.

Both researches anyway demonstrates the poor knowledge of the electric energy, the remarkable number of electric problems that the customers record during they workday or home life, the sense of impotence when a problem happens and, above all, the no ability to quantify the problems to express their owns needs.

B. The Instrumentation

The only way to try to solve this last problem is to effect measurements of the PQ normed parameters. To obtain these parameters are necessary instruments able to measure them possibly in real time.

A new instrument it has been developed for this aim (Fig 1) [3,4,5,6,7].

The hardware is based on a personal computer that have inside an acquisition card with eight channels, four connected to voltage sensors and four connected to current sensors. The firsts are voltage dividers able to partition the input voltage to preserve the analog input stage of the acquisition card channel. The maximum input voltage will be 6000 V as required by the normative. The current sensors are Rogowski coils that give an output signals proportional to the derivative of the measured current. This implies that it is necessary to integrate their output before to pass them to the acquisition card. The choice of this type of sensor, compared with others as amperometric clamp or current transformer, assures that the harmonic content would be unaltered. This aspect is fundamental to satisfy the harmonic analysis as required by normative. The accuracy of these sensors is ± 1%. By these eight sensors, the probe is able to pick up voltage and currents of the four phases (R,S,T,N) of an electric net.

One of the most important problem in case of civil suit, it is to determine more accurately possible the time of the fault. So it will be desirable that the synchronisms of the instrument, and particularly, of the sampling, were linked to the National Time Standard. At the present, the four active probes gets the synchronism directly by I.N.RI.M the Italian Metrological National Institute. The instruments are inserted in particular structures, the Medium/Low voltage transformer room of Telecom, the most important Italian telecommunication company, that receives the time directly from the I.N.RI.M.

To make independent the probes by the Telecom synchronism, we are studying the possibility to connect them with the GPS system. We are investigating the possibility to realize a new time reference constantly locked to the Caesium-derived GPS satellites carriers by means of a new GPS receiver architecture able to lock the two GPS carriers and mix them to obtain a reference frequency with an accuracy close to the GPS one.

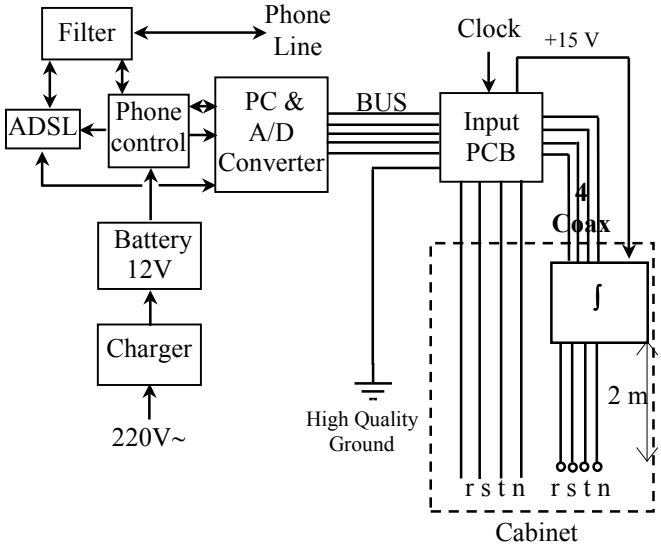

Figure 1. Block diagram of a PQ probe.

The software must be thought to satisfy the exigency to have the system under control in real time; this both for legal reasons and to reduce as soon as possible the intervention time in case of malfunctions. To respect as much as possible this constraint the FFT algorithm is not suitable [3,4,5,6,7,9], while the Curve-Fitting Algorithm, if appropriately modified, offers high accuracy performances producing results in real time[3,9,10]. At the present the program, that run in the probes, is able to determine the frequency of the fundamental with only three periods with an accuracy of 2‰. The program is then able to give al the PQ parameters required by the norms, quantifying, e.g., amplitude and frequency of the fundamental

and its harmonics up to the 24th, short and long interruptions, voltage dips, supply voltage unbalance etc..

Another software problem is the accumulation of the enormous data quantity. Also this is an opened problem because the probe transforms the acquired samples in synthesized PQ parameters every 5 seconds and store them in the hard-disk: every day is represented by about 5Mbytes of data.

It is clear that to accumulate, to transfer and to analyze this data quantity multiplied for *n*-possible sites during a large time could be extremely hard. A possibility to solve this problem could be to send the data to a central server with a very large memory capacity and able to further synthesize the PQ parameters, e.g., recording only the normative limits overcoming.

Another problem for this kind of instrument is the cost that could be unsustainable for LVC. To overcome this problem the previous research on the electrical energy real expectations for this kind of consumer is fundamental to understand which aspects of the power quality can be neglected. This approach is useful to plan a cheaper instrument, which can equally provide the measurements really interesting for the customers.

A series of these devices will be designed in the next future.

C. *The Matching*

Fixing PPQ parameters, measuring the PQ ones, their matching could seem a mechanic operation, but also for this, it is possible to work on different planes joined with the kind of customers.

The LMEs can be completely different to each other: they need energy for very different applications and with their energy use they can be protagonist in the production of energy "pollution" on the net. Instead LVC, and in particular the domestic customers, are very similar. Their low power energy request will be unlikely able to create significant problems to the electric net.

A first analysis could effect an electric energy quality local balance evaluating by quality fluxes for each quality parameters under study. Whereas on the one hand this analysis safeguards the users verifying that the energy bought has really the wished characteristics, on the other hand the measurements help the costumers to understand that their specific uses of the energy could be cause of undesirable "pollution" that could be transmitted to other users connected on the same electric network.

Conventionally we consider the instrument as the analysis point of view; if it record an harmonic distortion generated by the producer, it is taken with positive sign otherwise if the probe record that the harmonic distortion is generated by the customer, the pollution sign is taken negative.

A balance of the recorded parameters signs under control could be the base of an electric energy producer-customer agreement that could consider the energy quality an its essential component.

A most general analysis could allow to study also the quality parameter's fluxes and gradients to establish which zone of the geographic area under control produces more "pollution".

Following this approach it should be thinkable a kind of supply contract that could be extended to whole geographic zone. This analysis could take in consideration both the power consumption of the single user and the electric influence exerted by the zone on the others and vice versa.

III. Conclusions and Perspectives

The Perceived Power Quality suggest a different point of view in the analysis of electric energy problems; it asks to integrate the power quality research with a new element: the human electrical energy needs and expectations.

First of all, it suggests to study these needs and propose to find a common language between worlds completely different as producer and customers so trying to create a cultural bridge that could help these last to understand better this entity.

Only with the constant growth of costumer's Knowledge in this field it is possible allow them to quantify more and more precisely this entity and it will be possible to warrant their electric energy necessities.

In this approach a fundamental role could be expressed by independent research institute, as University, that could collaborate with the control Authority for the Electrical Energy to sustain before cultural policies to diffuse the Knowledge and then, to establish new type of relationships between customers and producers which lead to supply contracts that consider the quality an essential constituent element.

Surely the most important aspects, described in the article, point out the "road map" to diffuse the electric energy culture among customers, but large efforts have to be still done.

First of all, more researches must be done to define more and more accurately the real customers needs and necessities and, by the analysis of the customers feedback, trying to define the PPQ parameter and their relations with PQ ones with high accuracy.

It needs to develop instruments suitable for these necessities and able to satisfy different commercial targets.

References

[1] *IEC 61000-x-y (with x:1-6 and y:1-7) Electromagnetic Compatibility "Guide"*,1984-1995.

[2] *IEEE 1159: Recommended Practice on Monitoring Electric Power Quality*, 1995.

[3] M. Caciotta, F. Leccese, A. Trifirò, "From Power Quality to Perceived Power Quality", *Proc. of the IASTED International Conf. on Energy and Power Systems EPS 2006*, Chiang Mai, Thailand, 28-31 March 2006, 526-119.

[4] M. Caciotta, F. Leccese, A. Trifirò, "The Perceived Power Quality of Electrical Energy: an Assessment in Italy", *Proceedings of the XVII IMEKO WORLD CONGRESS, Metrology for a Sustainable Progress*, Rio de Janeiro, Brazil, 17-22 September 2006.

[5] F.Leccese, "Rome: A First Example Of Perceived Power Quality Of Electrical Energy", *Proc. of The Seventh IASTED International Conference on Power and Energy Systems ~EuroPES 2007~*, Palma de Mallorca, Spain, 29-31, August, 2007, CD-proceedings 582-084.

[6] F. Leccese, "Rome, a first example of Perceived Power Quality of electrical energy: the telecommunication point of view, *Proc. of International Telecommunications Energy Conference INTELEC 2007,* September 30 – October 4 2007, Rome, Italy, CD-proceedings.

[7] F. Leccese, "Analysis Of Power Quality Data On Some Telecommunication Sites In Rome", will be presented on *The Eighth IASTED International Conference on Power and Energy Systems*

~*EuroPES 2008*~, Corfù, Greece, 23-25, June, 2008 CD-proceedings 608-086.

[8] F. Leccese, "A First Analysis Of Perceived Power Quality For Domestic Customers" unpublished.

[9] M. Caciotta, F. Leccese, T. Trifirò: "Curve-Fitting-Algorithm (CFA) as Power Quality Basic Algorithm" , *Proceedings Of The XVII IMEKO WORLD CONGRESS, Metrology For A Sustainable Progress*, Rio De Janeiro, Brazil, 17-22 September 2006.

[10] M. Caciotta, F. Leccese, T. Trifirò: "Frequency Valuation In Curve Fitting Algorithm", *Proceedings of XVIII IMEKO WORLD CONGRESS, Metrology for a Sustainable Development*, , Rio de Janeiro, Brazil, September, 17 – 22, 2006, CD-proceedings.