PROBLEMS REGARDING POWER QUALITY AND SERVICES IN ROMANIAN DISTRIBUTION SYSTEM INTELLIGENT HYBRID SYSTEMS IMPLEMENTED FOR POWER QUALITY APPLICATIONS

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SUMMARY

This paper presents an evolution of Power Quality Level in Romanian Distribution System, based on the monitoring done last years in different points of the Power Network (industrial customers and domestic customers supplied at low voltage) Based on the questionnaires, the degree of the satisfaction of customers is analyzed regarding to the Power Quality (perturbations, interruptions) and the quality of complementary services. Some information about an intelligent system in order to control the Power Quality supply service are presented in the end of the paper.

INTRODUCTION

The Romanian Electricity Company-CONEL is national company of electricity in which the generation, transmission and distributions activities are separated, The ELECTRICA Company is a distribution company.
ELECTRICA had relations based upon electric power supply contracts with 8 263 305 customers. In compliance with the legal framework these customers are classified upon two criteria as follows:
Depending on the nature of consumption these customers are:

7 743 586 householding customers
114 226 industrial and similar customers
395 493 social customers

The total electric power demand was 40 680 GWh in 1998 dispatched by the following voltage levels:
-high voltage (U >110 kV) 13 850 GWh (34 %)
-medium voltage (110 kV>U>1kV)13 423 GWh (33 %)
-low voltage (U< 1 kV) 13 427 GWh (33 %)
From the structure`s point of view this demand was shared as follows:

- Industry Extractive 3 940 GWh
  Processing 21 178 GWh
- Agriculture 2 340 GWh

- Transport and Storage 1 967 GWh where:
- Inhabitants 7 833 GWh
- Other 3 422 GWh

After 1989 Romania recorded a dramatic decrease in the electric power demand until 1994 when the demand represented 62% from that recorded in 1989, but with an increase of the householding demand that reached 18% in 1996 against 5.2% in 1989. In 1997 and 1998 the demand decreased with approx. 7% / year rate.
The increase in number and power demand of the disturbing customers (electric arc owns, control equipment using the power electronics, electric traction, lamps with discharge in metallic vapors etc.) as well as the increase of the householding demand in the power balance of the country need a new relationship between supplier and customer, where the checking and keeping the harmonic distortions below the limits allowed by the norms becomes one unneglectable component.

RESULTS OF THE MONITORING

Some of the most important power quality problems of the Romanian Electric Power Utilities find in:

- Electric Traction,
- Low Voltage urban networks,
- Industrial customers.

1. Electric Traction (National Railway Company)

An important particular in supplying the electric traction in Romania is that the substations of the National Power System that supply this important customer are big nodes of the 110 kV system performing very high short-circuit powers. For this kind of customers, when choosing the solution of supply one takes into account the high security level required by them.
The harmonic operation monitoring implemented by the National Railway Company in the point of connection to the system has been performed gradually, in stages of measurements in the some substations. Last five years, these stages of measurements have been performed and some results of these measurements are available.
The measurements have been performed by means of a large scale of analyzers. The measurement results have been statistically analyzed according to [1],[2] and [3].

The most important characteristics of this kind of customers are [4]:

- **the harmonic operating evolution <u>has been the same</u> (with small deviations) in one substation supplying the National Railway Company (for a five year period),**
- **the values of Cumulative Probability CP 95% of the Total Harmonic Distortion (THD) of the voltage are <u>within admissible limits [1],[2] (Table 1)</u>**
- **the harmonic state in this area of the power system has little deviations into a long interval monitoring (years)**
- **only the order 15, 21 or 27 harmonic voltages are without of the admissible limits**

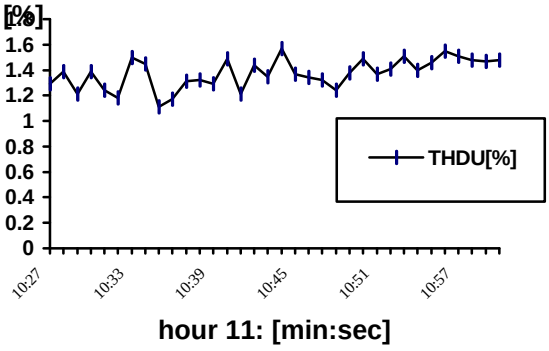

Fig. 1. Evolution of the Total Harmonic Distortion of the voltage waves (THDU) in the case of the Electric Traction supplied from the Ploiesti-Nord Substation.

The evolution of the total distortion factor of the voltage curve (upon 110 kV) demonstrates that the interference of distortions induced by the railway does not give values out of the limits for distorting the voltage curves. Note that the short-circuit power of the substations supplying the railways is quite high (1500 to 4500 MVA) because these nodes of the system are closely meshed and electrically close to heavy sources [5].
The values of Cumulative Probability CP 95% of the Total Harmonic Distortion (THD) of the voltage are:

- 1.1% - 1.73% in the case in which the short-circuit power is about 4500 MVA and
- 2.29% - 2.65% in the case in which the short-circuit power is about 1500 MVA.

2. Harmonic evolution in one Low Voltage urban network

The 0.4 kV urban distribution network radically operated supplies customers of relatively small powers:

* householding customers
* small customers -small shops
  -small workshops
  -small hospitals
  -offices
* public lighting.

In this case, the transformer substation 0.4 kV busbars there are equipped with capacitor banks for a whole compensation of the power factor.
The results of 0.4 kV voltage curve monitoring in the urban transformer substations (householing and social customers) of the Ploiesti town are shown here below. The current and voltage curve samples have been recorded at equal time spans of 1, 3, 10, 20 and 60 seconds.
Generally speaking, from a transformer point various circuits are going out: mixed demand circuits (householding customers below 10 kW installed power), one public lighting circuit and one circuit for the capacitor bank [6].
The most important characteristics of this kind of customers are:

- **the existence of three different periods of harmonic level in one day (from 8 AM to 5 PM, from 5 PM to 11 PM and from 11 PM to 8 AM**
- **the values of the Cumulative Probability CP 95 % of the voltage harmonic <u>are within the admissible limits [1]</u>.**

The 5^{th} rank harmonic holds the highest level in these networks, with no spectacular jumps, but showing a smooth evolution in time (Fig. 2).
Further to the data analysis there resulted an important interference of the public lighting in generating harmonics, as well as the use of electrical appliances (Fig. 3).

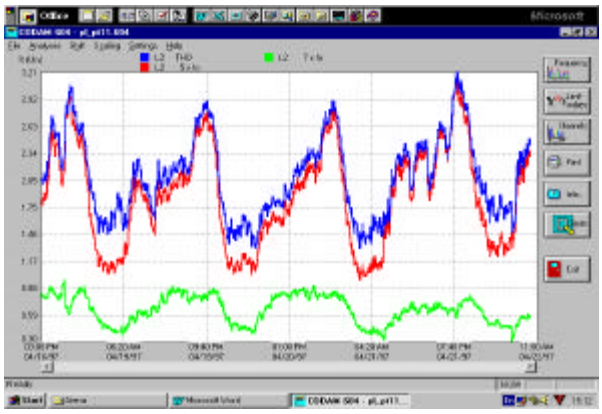

Fig. 2. Evolution of the 5^{th} and 7^{th} order voltage harmonics and THDU for a transformer point at Low Voltage 0.4 kV from PLOIESTI for a long time.

The small values of the THDU in comparison with [1], [2] can be explained by the fact that the transformer points are electrically close to heavy sources and the number of household electric appliances equipped with power electronics is still small.

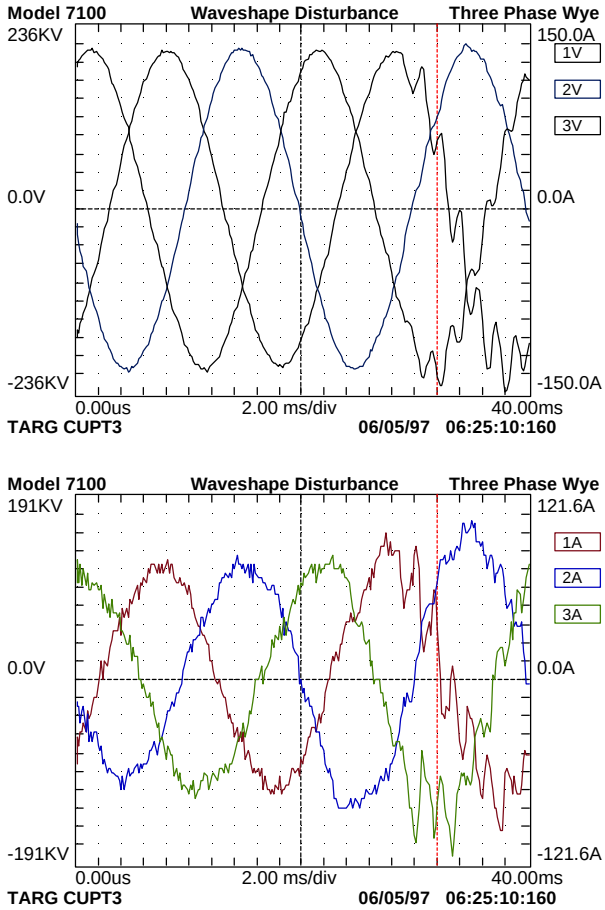

Fig. 3. Waveshape disturbances of the voltage and current curves for an industrial metallurgic customer (COS Targoviste)

3. Industrial consumers

The monitoring has been done for a big industrial metallurgic customers. The customer has arc furnaces and is supplied from a power substation at 220kV. The monitoring has been done in common coupling point (fig. 3). The values of the THDI are between 10% and 28% and the values of the THDU are between 1.2% and 1.99%. The short-circuit power of this node is about 6000 MVA.

Deviations from voltage standard level in low voltage systems .

The load and voltage measurements recorded upon more than 1000000 urban and rural householding customers demonstrates a series of deviations out of the voltage standard values , as they are shown in Figures 4 and 5 .
In Figure 4 we can see that the number of the consumers where the voltage is out of admissible limits of the standards is **13%** of all studied consumers (approx. 1000000 consumers supplied at LV).

In Figure 5 we can see the structure of these voltage deviations:
*63% of deviations have U = (-10% .... -15%) Un
*17% of deviations have U = (-15% .....-20%) Un
*7% of deviations have U < -20% Un
*12% of deviations have U = (+10% .... +20%) Un
*1% of deviations have U > +20% Un.
The voltage deviations are distributed thus:

* *rural area* - more deviations under admissible limits
* *urban* area - more deviations over admissible limits.

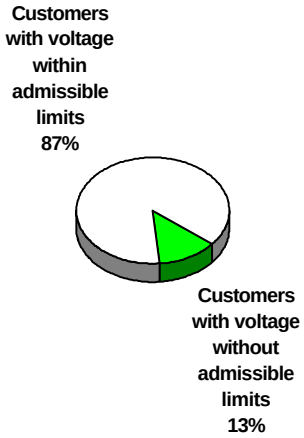

Fig. 4 A structure of the customers

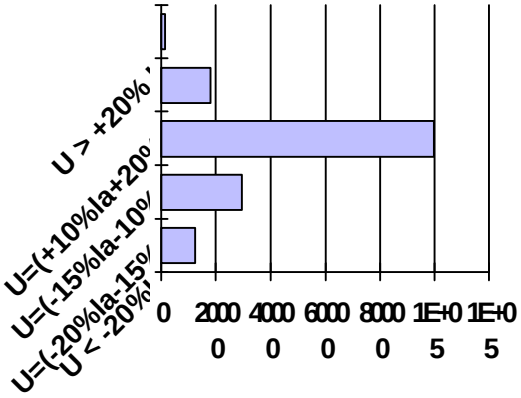

Fig. 5 Structure of voltage deviations

QUALITY OF SERVICES

Liberalisation of the electric power market and the customer exigences ever higher need deep changes in the supplier - customer relationship.

The last years, a number of structural changes occurred in the legislative field: the Power Law has been approved and a new type of contracts have been elaborated, that settle the supplier - to - customer relationship on a commercial principle and abolish the power monopoly owned by the former RENEL.

At the same time, trying to win the customer trust and respect, S.C. ELECTRICA S.A. keeps alive the dialogue with its customers aiming to know their needs and give them immediate satisfaction.

With this aim in view, two types of investigation have been developed:

A. Local meetings with the large customers, and

B. Householding and small trade customer opinion sounding, based upon questionnaires.

A number of 30 among 42 regional distribution subsidiaries participated in this investigation. A number of 30000 questionnaires have been spread to the customers, but an important part were not filled and sent back to the supplier, showing in this way a poor level of receptiveness.

The result estimate allowed to draw the following conclusions:

1. Conduct of the stuff that comes in direct touch with the customers at the subsidiary's head office:
   - right 76%
   - satisfactory 17%
   - unproper 7%

2. Conduct of the reading-billing agents:
   - right 72%
   - satisfactory 22%
   - unproper 5%

3. Quality of electric power supplied and service to the customer:
   - right 40%
   - satisfactory 54%
   - unproper 6%

4. Operativeness in solving the customer problems:
   - prompt, right 44%
   - satisfactory 48%
   - unproper 8%

5. Does customer monitor its consumption?
   - yes 55%
   - no 45%

This inquiry made possible to identify a few shortcomings in the relationship with the customer and the measures to be taken in order to improve the supplier's conduct versus the customer.

Another inquiry, this time among the staff of one distribution subsidiary has been developed for finding out the "ideal customer" features.

The answers allow to stand the following pyramid of values:

IDEAL CUSTOMERS

Confident in recommendations	37%
Informed on decisions, legislative changes, concerning the relationship	22%
Armed with technical knowledges	19%
Polite	7%
Honest	5%

IDEAL EMPLOYEE

Responsible	46%
Emotionally balanced	17%
Polite	12%
Competent	11%
Clever	7%

Both inquiries demonstrate the relationship with the customer is perceived as a partnership and the necessity of this partnership to give satisfaction generate

now and in the future, mutations in the corporate culture. And, admitting that the change becomes continuous, then the strategy of a long lasting development must be assumed by all the employees by corporate learning where the client concern is a priority.

INTELLIGENT HIBRID SYSTEM

A intelligent hibrid system based on the fuzzy logic is implemented this year in Romania. This hibrid system will analyze the wave shapes, the numeric values of the voltage and current date, will diagnose the problem and will recommend a solution.
Techniques and methods have been used in an integrated way in the building of the global system for the identification of the Power Quality waveshapes [7]. In this respect it is used a combination made by Expert System (which implements the wavelets waves methods), a Neuronal Artificial Networks, a Fuzzy System and genetic algorithms.

CONCLUSIONS

Main conclusions resulting from the surveys:

- The National Railway Company's conduct related to the distortions operating duty must be esteemed depending on the current curves, according to [2].
- In case of the National Railway Co., the upper rank harmonics exceeding the limit values (15, 21 and 27) demonstrate the need of performing surveys able to answer to the following questions:
  - the admissible limits of [1],[2], are they correct ?
  - how much costs the transit of a 1A current in the electric network upon these harmonics [8]?

- In the urban LV network, the difference between $U_{hvsh\ max}$ (the highest voltage harmonic level on the whole monitoring time with one reading to each 3 seconds) and the CP 95 % is relatively small . One can use the $U_{hvsh\ max}$, but an adjustment factor shall be settled.
  After each other 3 sec. reading, for the studied cases it is possible to enlarge the time spans between readings (10, 20 or 60 sec.) with no influence upon the results.

- At a countrywide scale, one ascertains deviations from the voltage level to a relatively large number of customers Supplied with low voltage. Nowadays in Romania there are under way programs of LV network rehabilitation aiming to keep the voltage deviation within the prescribed limits.

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