THE POWER QUALITY PANORAMA IN PORTUGAL

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ABSTRACT

The problems that affect the electrical sector in Portugal are likely to be similar to other countries, since the types of equipment (and loads) used in the industry and service sectors are nowadays almost universal. Liberalization is now making its first steps in Portugal, leading to discussions and additional pressure for providers to increase the quality levels provided to consumers. But do the consumers have sufficient known-how about the new problems that affect the sector today? Are they adopting the correct measures for dealing with the emerging problems related with non-linear loads proliferation, more sensitive equipments, etc.?
Based on these realities, facts and the perception that power quality related problems in Portugal are still at an early perception stage, when compared with other countries, we conducted a detailed survey, focusing on the more demanding activities (premium power consumers), in order to identify the present levels of knowledge, needs and opinions about power quality.

1. INTRODUCTION AND SAMPLE

The target of this study comprises a subset of Portuguese companies, criteriously selected and distributed, covering the following industrial and service sectors: Automotive, Electronics, Plastics, Glass, Ceramics, Cement, Pulp and Paper, Textile, Metalomechanic, Wood and Furniture, Pharmaceutical, Ornamental Stone, Railway Transports, Suppliers of Electrical Equipments and Services (Banks, Hospitals, Hotels, Schools). Overall, a total of 48 companies was thus included in our sample and a written survey was sent to all of them, with a response ratio of 83,3 %.
Within this sample of companies, 60.0 % are certified according to ISO 9000 or QS 9000 standards; 77,5% work 24 hours/day, 15 % with 2 shifts and 7,5 % with a single shift, 5 days/week.
These companies are fed by tensions in the following range of values: 15 kV, 30 kV, 60 kV and 150 kV. Those with continuos processes are mainly supplied at 30 kV and 60 kV; due to the highest level needs of power quality and reliability, some companies in the Electronics Sector are fed at 150 kV; in the service sector companies are mainly fed at 15 kV. Furthermore 12,5 % of the companies in the sample are auto-producers.
Reactive power compensation (with capacitive banks) is made in 97,5 % of the cases (only some small companies in the service sector don't do it).
About 35 % of the companies follow and have implemented one program, for rational use of electricity and 60 % state that they will do so in a near future; 50 % do have an External Technician who provides advice for the exploration of the electrical installation, visiting the installation between 2 times per year and 2 times per month, or when solicited.

2. LOAD TYPES USED IN THE INDUSTRY AND SERVICE SECTORS

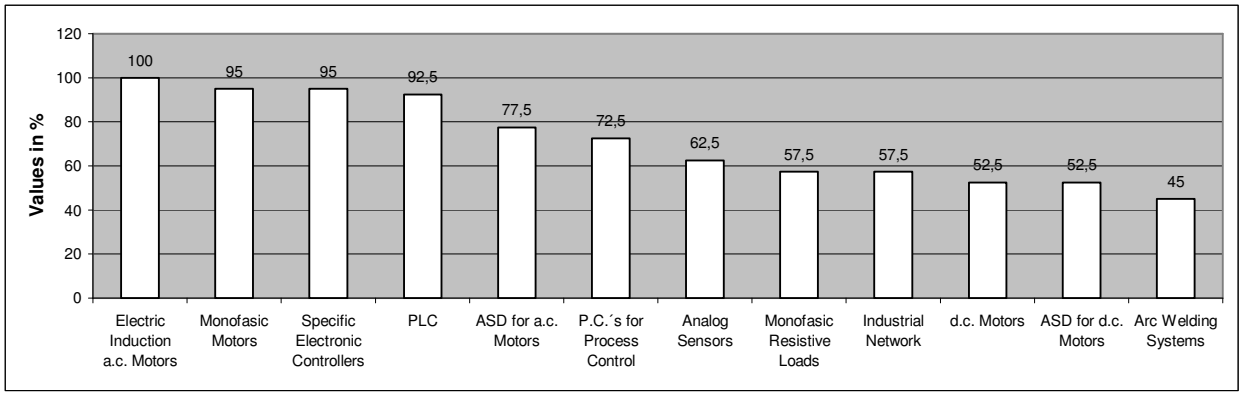

Fig. 1 - Load Types.

Figure 1 shows a large use of Adjustable Speed Drives for a.c. motors (77,5 %) and d.c. Motors (52,5 %) at the plant level, as well as large levels of automation.

The service area is characterized by the existence of non-linear loads in 100 % of the companies (PC´s, Printers, Fax, Copiers, etc). There are UPS units in 90 % of the companies and this fact is due mainly to the need for assuring continuous power feeding to Information Processing Equipment. We can refer also the existence of LAN for services, Internet and E-mail connections for 72,5 % of the companies and the use of High Efficiency Illumination in 47,5 % of the cases.

3. COMPLAINTS RELATED WITH POWER QUALITY

3.1: Do you have complaints related with the power quality that you receive?

About 57 % of the replies were affirmative, although with quite significant differences between sectors (see Table 1).

Table 1 - Power Quality complaints.

	Answer	
Sector	***Yes***	***No***
1. Automotive	86	14
2. Electronics and Pharmaceutical	50	50
3. Pulp and Paper	75	25
4. Ceramics, Glass and Cement	67	33
5. Plastics and Textiles	60	40
6. Metalomechanic and Railway Transports	33	67
7. Stone, Wood and Furniture	75	25
8. Services	11	89

The sectors with more complaints, according with this survey are as follows: Automotive, Pulp and Paper, Stone, Wood and Furniture, Ceramics, Glass and Cement Industries and Plastics and Textiles.

3.2: What are the most common power quality problems that you observe at your installation?

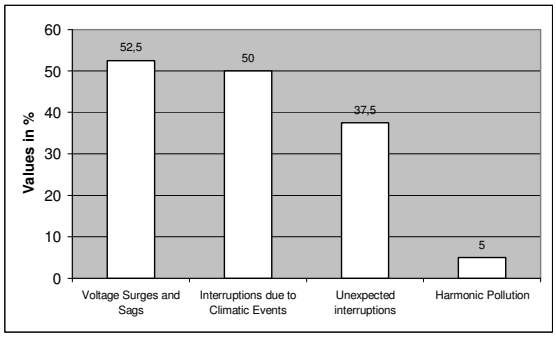

Fig. 2 - Power quality problems observed.

The most common power quality problems were found to be (Figure 2) as following: • Voltage Surges and Sags; • Interruptions due to climatic events; and • Unplanned and Unexpected Interruptions from the power provider.

One should also notice the low values obtaining regarding Harmonic Pollution, in spite of the real impact of disturbances caused by non linear loads and harmonics, if we take into account the loads mentioned earlier.

3.3: What were the main problems at your installation during the last 12 months?

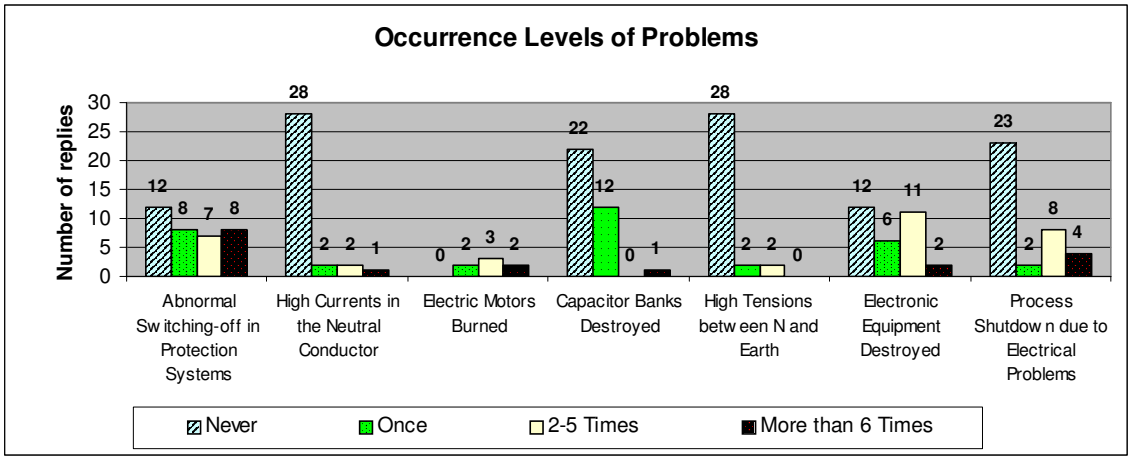

Fig. 3 - Main problems in the installation during the last 12 months.

We can see that the most relevant problems found are (Figure 3):

- Abnormal switching-off of protection systems.
- Shutdown of the processes due to electrical problems.
- Electronic equipment destroyed.
- Capacitors Banks burned.

However, one should caution that • high currents in the neutral conductor and • high tensions between Neutral and Earth may not be declared and/or observed because no relevant measurements are conducted regarding these issues.

3.4: How do you classify the criticity level associated with each of the following troubles?

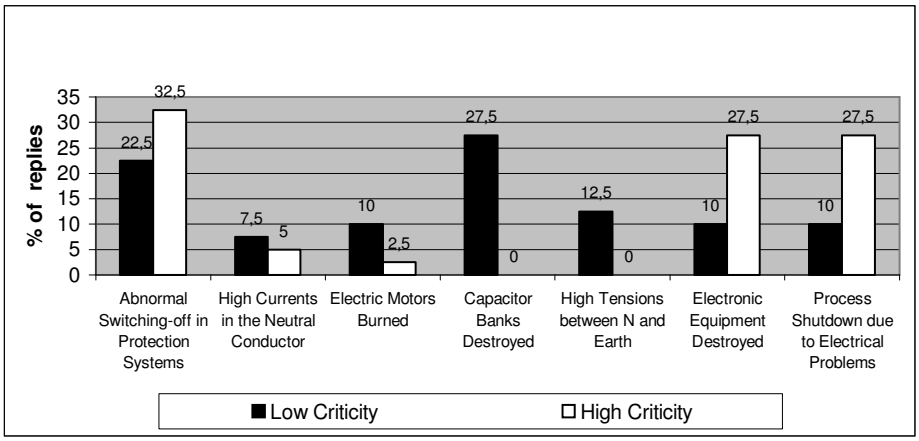

Fig. 4 - Levels of criticity for each of the anomalies.

The results obtained here (Figure 4) are consistent with the previous question, and nobody considered of High Criticity the existence of High Tensions between Neutral and Earth, or the Destruction of Capacitors.

Costs associated with failures deriving from the electrical problems

Only about 40 % of the companies surveyed do have estimates for the costs associated with failures deriving from electrical problems and poor power quality. Such costs are mostly related with • Product/Service (47,5%) and • Maintenance (35 %), ranging between 1.000 and the 6.500 Euro per year. In the Glass, Plastics, Automotive and Cement Industries some companies declared that a single supply interruption of 1 second can cost a minimum 5.000 Euro, due to the total production shutdown, material and/or equipment losses, restart the plant etc.

4. PREVENTIVE ACTIONS TO MITIGATE NEGATIVE IMPACTS

Table 2 - Preventive actions.

	Answer	
Question	***Yes***	***No***
4.1 When you buy new equipment do you consider their electrical efficiency?	**87%**	13%
4.2 Are you interested in knowing the impact and harmonic distortion introduced by new equipments?	**87%**	13%
4.3 Do you take special precautions with the supply of energy for non-linear loads?	**97%**	3%
4.4 When you decide to repair some damaged equipment, do you consider the impact of that operation in the original efficiency?	**95%**	5%
4.5 When you must decide between repairing or buying new equipment, do you evaluate all the aspects related with the costs of exploring of more efficient technologies?	**87%**	13%
4.6 Do you have in your installation any system for performing harmonic filtering or compensation?	**5 %**	**95%**

It is curious to notice that the few companies that considered Harmonic Pollution as one of the most common power quality problems are doing something to mitigate its effects.

In spite of the answers obtained here (Table 2) one must take into account also the fact that there are some equipment suppliers and market segments that don't sell in Portugal some technologies (with big advantages in electrical efficiency and harmonic distortion) because *the majority of the consumers does not have sensibility regarding these issues* and thus are not willing to pay higher prices in order to have additional functionalities.

5. IMPACT OF POOR POWER QUALITY

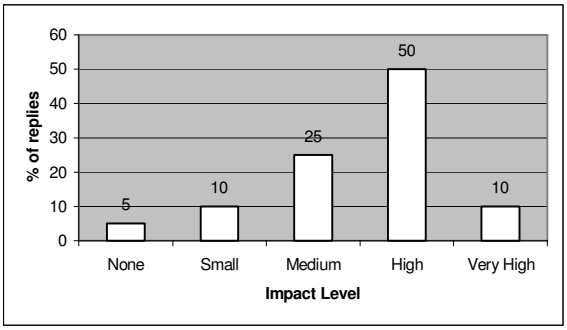

Fig. 5 - Unbalanced and asymmetric tension system.

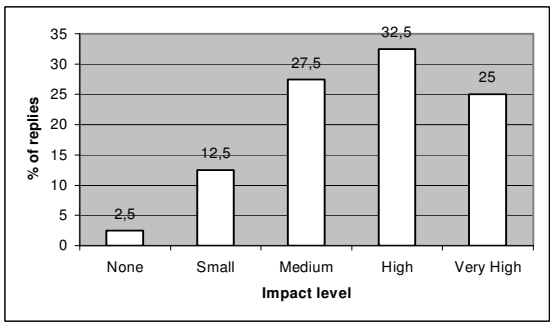

Fig. 6 -Supply micro-interruptions (few millisec to 1 sec).

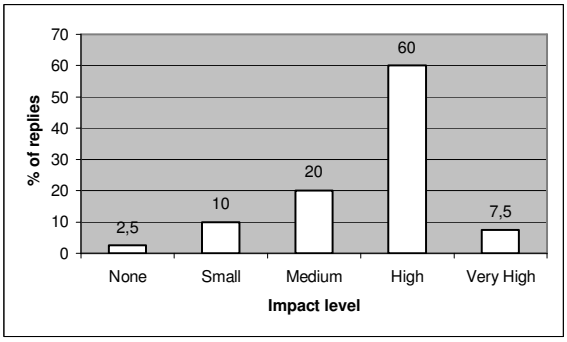

Fig. 7 -Temporary outages (1 sec to 1 min).

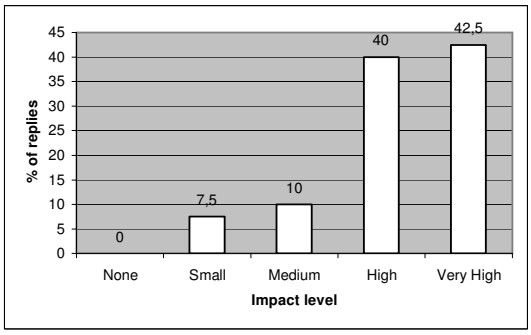

Fig. 8 -Long outages (superior to 1 min).

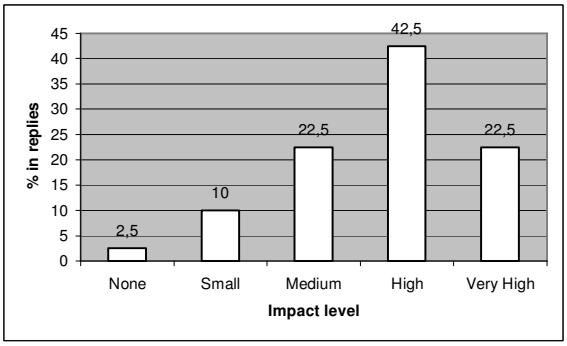

Fig. 9 - Transitory and spikes with short duration.

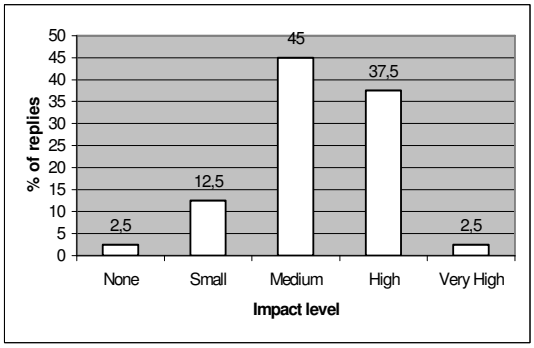

Fig. 10 - Harmonic distortion.

One can thus see (Figures 5 to 10) that the most serious occurrences have to do with:
1) All kinds of interruptions (very short, temporary and long)
2) Tension level oscillations (overvoltages, sags, spikes and flickering)
3) Unbalanced and asymmetric system of tensions.

Once again we must emphasize that the majority of the companies do not seem to give to Harmonic Pollution and Distortion the gravity that we consider it may have in this universe of activities, given the levels and loads already mentioned.

6. CUSTOMER SATISFACTION SERVICE AND COMMERCIAL ASPECTS

6.1: General communication sympathy
62,5 % of the replies consider that it is Good, 2.5 % Very Good, and 5% Bad or Very Bad.

6.2: Fast replacement of energy
The level of satisfaction in this domain is mostly Medium (45 %), with Good for 37.5 % and Bad for 17,5%.

6.3: Commercial issues
Evaluation of this item resulted in Medium (good performance), with only a small group 2.5 % answering Very Good.

6.4: Establishment of clear liability clauses
The establishment of clear liability clauses from the power supplier was rated mostly as being Poor, with only 20 % of answers considering as Good the supplier's behavior regarding this issue.

6.5: The supplier assumes the responsibility associated with costs that results from power quality failures
In this domain the actual supplier was considered to provide Bad service (55 %) and 15 % even as Very Bad; only 25 % of the replies consider the service as Medium and 5 % as Good.

6.6: How do you consider the electricity price for your activity?
The electricity price is classified as being Bad (57.5 %), while 35 % rate it as being normal, and 7.5 % as Very Bad.

6.7: How do you consider the pricing (tariffary) system available?
The pricing system (price changes during the day, etc) received 67.5 % replies as Normal, 25 % as Good and 7.5 % as Bad.

In the end, the overall satisfaction level regarding service and commercial quality aspects is summarized in Figure 11.

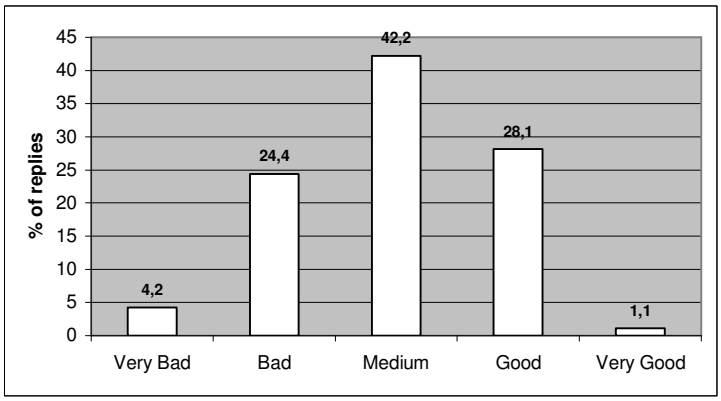

Fig. 11 - Overall satisfaction level regarding service and commercial quality aspects.

Replies for this group are thus centered around the Medium level (42,2 %), with significant answers also for the Bad and Good levels of performance.

7. INTEGRATED PACKAGES OF SERVICES

Another group of questions in our survey covered the acceptance and interest of consumers in a number of supplementary services that may be supplied directly (or not) by electricity providers.

- Remote measurement of electricity consumption.
- Joint venture with companies for maintenance of electrical equipments.
- Offer of Auditing and Consulting services to the consumer.
- Package of insurance services for electrical equipments.
- Installation of equipments for protection against atmospheric discharges
- Support of telecommunication services.
- Integration of multiple payment services in the same invoice packet.
- Existence of structures to provide information and help about programs, incentives and other related information that benefits the consumer.

Among such additional services, the ones that receive higher acceptance levels are:

1) Existence of structures to provide information and help about programs, incentives and other related information that benefits the consumer 100 %
2) Installation of equipments for protection in case of atmospheric discharges 90 %
3) Offer of Consulting services for better use of the electricity 77 %
4) Offer of Auditing services to the consumer 67 %
5) Package of insurance services for electrical equipments 65 %
6) Joint of electrical maintenance programs 62 %

8. ELECTRICITY SELF-PRODUCTION

About 18 % of the companies in our sample do have internal capacity for electricity generation, including emergency systems for long outages. Auto-producers with large capacity installed and operating on a continuous basis corresponds to 12,5%, while installed capacities range from 3 MVA to 75 MVA.

8.1: What are the main reasons why you have production capacity installed?

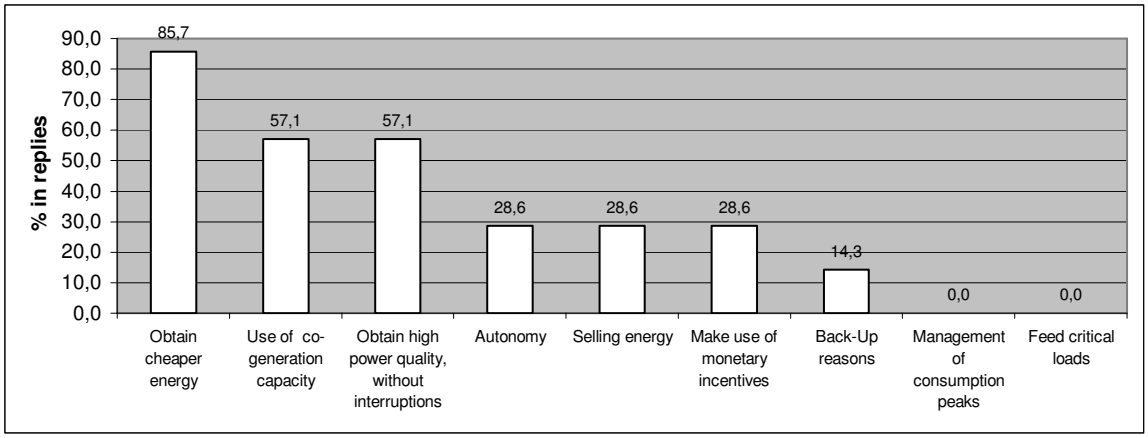

Fig. 12 - Reasons for the production capacity installed.

Therefore the 3 main reasons for adopting self-production are:

1) To obtain cheaper energy
2) Production of electricity and use of co-generation capacity for the process.
3) To obtain electricity with high power quality and reliability.

9. ORIGINS OF POWER QUALITY PROBLEMS

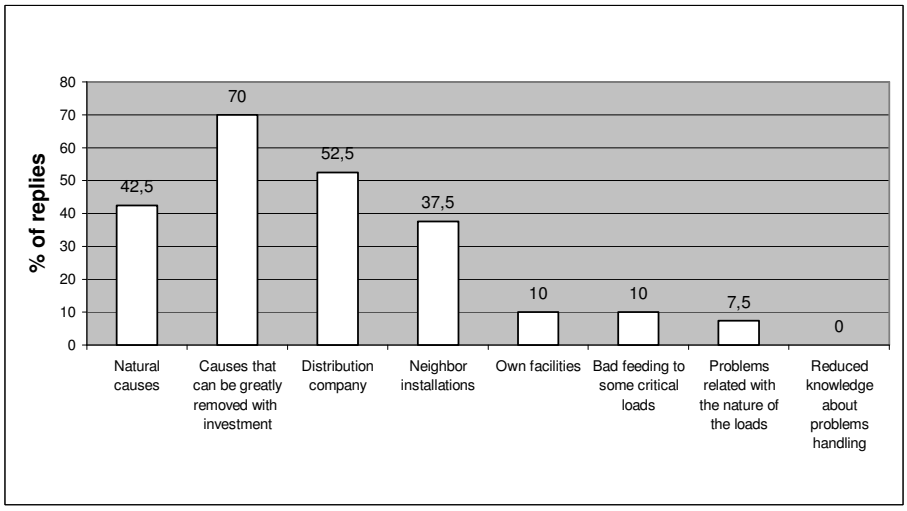

Fig. 13 - Main motives for the power quality problems at the installations.

About 70 % of the replies (Figure13) believe that the causes of the power quality problems that they have can be greatly removed with more investment in technology, transportation and distribution systems.
The causes considered inevitable, related with atmospheric phenomena, are referred by 42,5 % of the answers.
Although only 10 % consider their own installation and loads as being at the origin of problems, this score may be underestimated, due to the significant lack of information in this domain.
One interesting fact, is that nobody considers that the level of knowledge in the power quality related problems is one of the roots for their problems, eventhough the present knowledge levels are in general quite low (many technicians do not know for instance about the existence of the *True RMS* equipments and their relevance in the context of nonlinear loads).

10. EXISTING KNOWLEDGE

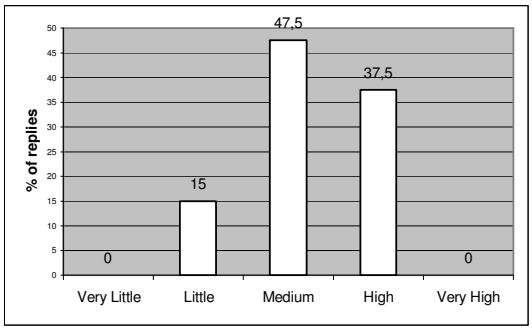

Fig. 14 - Multiple aspects related with power quality.

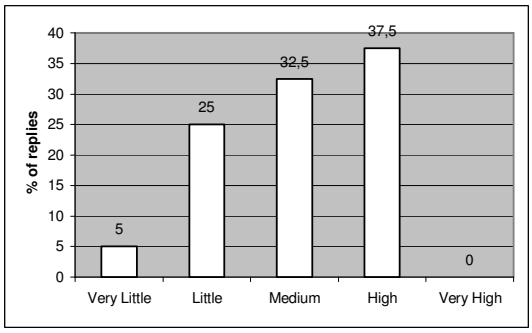

Fig. 15 - Origins of Harmonic Pollution.

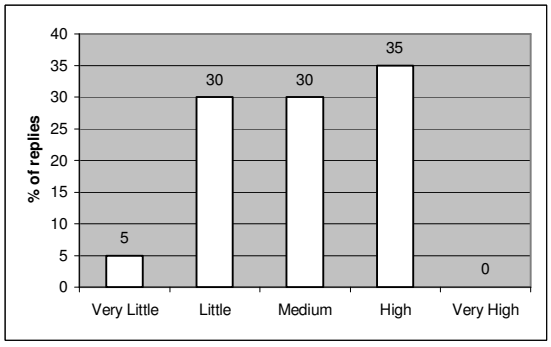

Fig. 16 - Consequences of Harmonic Pollution.

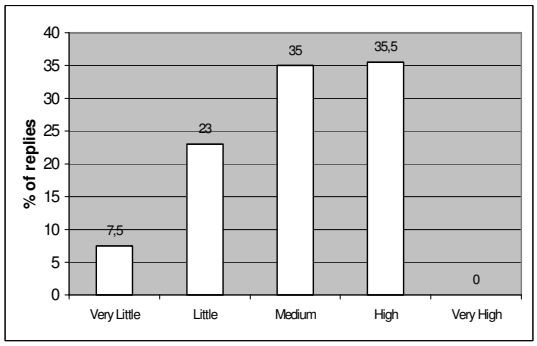

Fig. 17 - Global knowledge.

Once again (Figures 14 to 17), the above answers may be somewhat overoptimistic, given the specific knowledge levels that are indeed available and were detected while visiting some specific companies within our sample.

11. ENERGY ATTRIBUTES IMPORTANCE

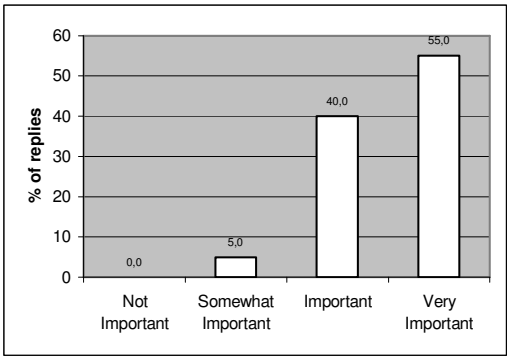

Fig. 18 - Supply reliability.

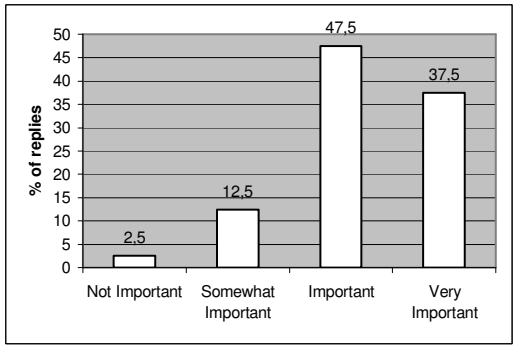

Fig. 19 - Price.

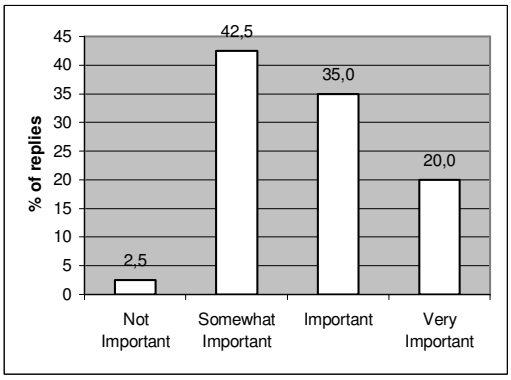

Fig. 20 - Wave quality.

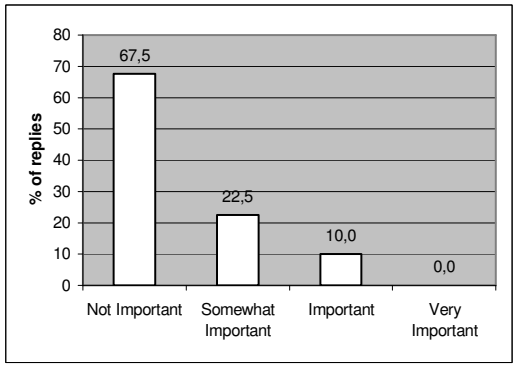

Fig. 21 - Services associated with power delivery**.**

From this final set of questions (Figures 18 to 21), we concluded that the most relevant energy attributes are:

1) Supply reliability
2) Price
3) Wave quality
4) Services associated with the power delivery

12. CONCLUSIONS

Some partial conclusions, remarks and comments were already made, but there are some general considerations that deserve being mentioned:

❶ The levels of automation and technology available in the industry and service sectors in Portugal are mainly modern technologies, recently imported or updated, and comparable with the levels reached in other countries like the U.S.A., Germany or U.K. .

❷ In that countries the dimension and relevance of the power quality related problems is enough much higher than the results captured by this study in the Portuguese context. Also in that countries these problems are best known and simultaneously better quantified with systematic use of methodologies and specific technologies for that purpose.

If we concentrate our attention in the more critical domains related with power quality, we can't obtain one single picture that can reflect the real dimension of these problems in the actual context of electricity use in the industrial and services sectors.

Some of the survey results are felt to be somewhat overoptimistic. Two possibilities may however be raised:
1) Results represent faithfully the present reality of the Portuguese Industry, and thus there aren't serious problems in this domain, as opposed to the real situation of companies, observed in the field namely the levels of automation and types of loads.
2) There is a significant lack of information and scientific knowledge about this subject in Portuguese companies, that are thus unable to get the real perception of the problems and how to overcome them. Only with more information and know-how about new developments in the electrical sector will they be able to identify the origins and consequences for many of the problems that they have at present.

For the Portuguese companies power quality related problems are mainly centered (almost exclusively) around interruptions. From an immediate economical perspective, the continuity of supply is effectively the first priority, but all the other dimensions of power quality receive very few attention, although they are also very important factors for industrial competitiveness.
The adoption of rules and regulation for the electrical sector that take into account power quality features and their mitigation is also imperative and urgent, since at present it is very incipient (e.g. the section of the neutral conductor in a triphasic systems can have 1/3 of the phase conductors section).
Furthermore, Suppliers of Electrical Equipment and Consultants can act as strong disseminators of new technologies with less impact, higher robustness and more efficiency. Although with slightly higher investments such alternatives provide big economical and profitability advantages over equipments lifetimes.
The adoption of correct and modern methodologies in these domains in order constitutes one important factor to improve the competitiveness of Portuguese Industry.

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