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An Assessment of Power Quality and Electricity Consumer's Rights in Restructured Electricity Market in Turkey

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Summary: **Recently, electricity consumers have shown increasing concern for power quality. Indeed, power quality standards have become higher than before for certain customers due to sensitivity of automation devices. In addition, power quality is affected by the deregulation of power markets in Turkey.**
In this study, the consumers are provided with the basic knowledge of power quality and the cost of the poor power quality while on the other hand, the existent regulations are evaluated in terms of consumers' rights so that poor power quality costs and loss are identified and amended. There are so many regulations in relation to the rights of electrical power consumers in legislation that regulates the relations between distribution companies and the consumers, whereas, in this study, only the issue of power quality is dealt with.

Key words:
Consumer's rights, power interruption, power quality, Turkey

1. INTRODUCTION

Feeding, clothing, protection and receiving basic health services are the basic requirements and an individual becomes happy to the extent that these are satisfied. Heating, lighting, transportation, communication are the substantial rights of the consumers today, which are obtained by using electrical power. The consumers who fall sick because they can not use natural gas or their heating devices due to power outage and whose devices breakdown due to frequent interruptions have to put up with the costs of poor power quality (e.g. medical, repair and replacement costs)

With an increasing usage of sensitive electronic equipment power quality has become a major concern now. Short power outages, small voltage fluctuations or other disturbances, which almost were not noticed in previous years, have made important damages to so many electronic devices [1]. Since the information technology and computer-oriented industrial transactions become more common in Turkey every single day, the need for reliable and high-quality electrical power continues increasingly. Even though these devices that are sensible to power quality are not damaged, it is known that they cause significant economical losses due to the malfunctions in the industrial systems in which they are used. The power consumers using various power quality improvement methods in order to reduce the economical losses that emerge as a result that they can not receive high quality electrical power, have to put up with the improvement investments and the operating costs of these investments. [2].

In this study, the consumers are provided with the rudimentary knowledge of cost of the poor power quality while on the other hand, the existent regulations are evaluated in terms of consumers' rights so that poor power quality costs and loss are identified and amended. There are so many regulations in relation to the rights of electrical power consumers in legislation that regulates the relations between distribution companies and the consumers, whereas, in this study, only the issue of poor power quality is dealt with.

2. ELECTRICAL POWER QUALITY IN TURKISH REGULATIONS

In recent years, Turkish economy is the world's 16th largest economy because of Turkey has improved its economic situation. The electricity industry, which is essential for economic and social development, has an important role to play in the development of the Turkey economy. Also, the electricity market in Turkey was the most rapidly growing market in the OECD over the last two decades. The investment opportunities in Turkey are particularly attractive in the framework of country's ongoing ambitious privatization agenda.

In countries around the world, the electricity industry used to operate in a vertically integrated; the electric utilities controlled the generation, transmission, and distribution. Until 1993, generation, transmission and distribution of electricity were public services that needed to be delivered by Turkish Electric Authority (TEK) in Turkey. In September 1993, TEK was divided into two public companies: TEAŞ (generation and transmission) and TEDAŞ (distribution). The two companies were created in order to speed up the privatization of electricity assets in Turkey. The activities of both TEAŞ and TEDAŞ were excluded from the scope of public services. TEAŞ was further divided into generation (EÜAŞ) and transmission (TETTAŞ) companies in 2001. Transmission remained state-owned while private sector continued to enter the generation business. The share of EÜAŞ generation in total was down to about 71% in 2001. TEDAŞ's monopoly on distribution was diminished by the privatization of several distribution systems around the country [3].

Deregulation of the electric power market present the possibility of improving the power quality. This power quality requires the development of an infrastructure that can address the information needs of the sector in a less centralized and more organized sense. The generation, transmission, distribution, wholesale, retail sale and retailing services, import, export of electricity and the establishment of the Energy Market Regulatory Authority (EMRA) and

rules and principles related to its operations, is the subject of law in Turkey [4].

Power quality has become a major concern in today's electric utility industry. This concern has resulted from independent events within the electric power industry. Utilities because of deregulation and competition find it necessary to operate their systems closer to its limits than ever before. At the same time modern loads are often more sensitive to power quality fluctuations than the traditional electromechanical loads of several decades ago. Hence, system disturbances, which were tolerated earlier, may now cause interruption and misopreation to industrial power system with a resulting loss of production [5].

Especially for a developing country like Turkey, power quality (PQ) is of prime importance considering the need for energy conservation. It is a paradox that some of the energy conserving devices themselves is the reason for some of the power quality problems. Though the need and importance for improving power quality is well known and solutions also have been available for a long time. The rules the power distribution companies need to follow in respect of the quality of electrical power consumers use have been identified under the work prepared by Energy Market Regulatory Authority (EMRA) called " Regulations about the continuity of power supply, its commercial and technical quality offered in distribution system on electricity market" [6]. According to this regulation, **the distribution company is responsible for the power quality offered to the consumers in the specific area that is determined on distribution license.** In the regulation, the following definitions have been made in respect of the services offered to be delivered to the consumers and electrical power quality.

— **Commercial quality**; is the realization of relations that are possible to emerge in all phases of the said activities between the users who want to get connected to the distribution system or the connected users and the parties furnishing services within the context of the retail sale or bilateral agreement or in respect of the service-offering in accordance with the standards to be determined by EMRA
— **Quality of supply continuity** is the capacity of the distribution system to meet the power demands of the consumers within economically agreeable cost and minimum interruption time and frequency.
— **Technical quality** is the capacity of the distribution system to meet the power demand of the users without interruptions and in high-quality in terms of agreeable voltage, frequency, amplitude, and waveform and three-phase symmetry.

It is observed that supply continuity and technical quality definitions are the definitions in relation to the product quality of the purchased power. Whereas the commercial quality define the quality of the services offered to the users by the distribution companies.

A general definition of power quality that covers the technical quality and supply continuity definitions is possible as follows: "**Electrical power quality that is frequency, number and period of interruption, disturbance in voltage, sine waveform and voltage unbalance should be within the limits specified in the standards and regulations**" [7]. The power quality problem in literature, is defined in to be the occurrences that cause the electrical devices to breakdown or malfunction [1].

The most common power quality problems the users come across are the interruptions, long or short term voltage fluctuations and disturbance of the sine waveform. Traditionally, the price of power in the electrical utility was based solely on the quantity used. The customer pays more for using more power and less if the usage is less. A customer who is prepared to pay for higher quality and one who wants a discount even if it meant lower quality power-both get the same quality and pay the same rate [8]. Numerous surveys indicate that customers differ widely in their need for quality power and willingness to pay for the same. Once they are made to understand that high-quality power can be custom-made, but that it will come at a price, a more realistic assessment will be made by the customers taking into account the nature and characteristic of the equipment and also the capacity and willingness to pay for the improved quality [9].

In vertically integrated utilities (monopolistic in nature) the power had only quantity and cost. With deregulation and opening up of the markets and competition a third dimension, namely quality has been added to the product in restructured electricity market in Turkey.

In Turkey the problems are due to weak regulations, lack of enforcing agencies, no uniformity among various utilities, inconsistency in policies/tariff etc. Also in most cases the tariff does not reflect the actual cost of poor power quality or the actual cost of power conditioning. It is time utilities introduced more advanced tariff structure considering the power quality issues

3. ELECTRICITY CONSUMER'S RIGHTS ISSUE IN TURKEY

Consumer protection-oriented studies have emerged from the need to protect the unaware consumers against the organized suppliers. The power distribution system is presently in privatization process in Turkey and consumers should be informed about the distribution companies and the available regulations constituting the relations of the consumers, and encouraged to seek their rights.

Consumers need to obtain adequate information so that they should make a suitable choice in the light of their own demand and requirements. This has been uttered in the United Nations Universal Consumer Rights Declaration as follows: "It must be ensured that the consumers are provided with required access to information so that they make a conscious and suitable selection for their individual demands and needs [7]. The consumers should be provided with information about the nature of qualified power and the consumers who lack of information should be protected. Initially, the existent regulations and standards need considering so that the consumers are provided with necessary information as to which qualities the electrical power is to bear.

In the United Nations Universal Consumer Rights Declaration, it is uttered that "goods that have any **material, legal or economic deficiencies which affect its quality or**

quantity, is contrary to its quantity or either reduces or eliminates its value or the expected benefit of the customer in terms of its installation or its intended use that are stated in its package, label, introduction and users manual or its advertisement or announcement specified by the seller or determined in its standard and technical specification" are deemed to be defective" [7].

Supply continuity and technical quality definitions are the definitions in relation to the product quality of the purchased power. Therefore, it would be suitable that the power, once it is delivered to the end user, should be measured on the meter by the user and the power for which a payment is made, should be evaluated as goods. **The definitions of supply continuity and technical quality are the definitions in relation to the product quality (quality of the goods) of the purchased power and the power that does not comply with the values specified in the regulations and the standards can be treated as defective goods.**

Under the rubric of the statue about the indemnification of Customer rights and damages of Power Market Customer Services Regulations (Article 33) it is articulated as follows: "In accordance with the provisions of the hereby regulations, for the indemnification of the rights and the damages of Customers who purchase power supply service, 11th article of the said Act and **about provisions of the law in relation to Consumer Protection** [10] and other regulation provisions are applied" [11]

4/A Article in relation to of Turkish Customers' Rights Protection has been arranged as follows: "**Services that have any material, legal or economic deficiencies which affect its quality or quantity that either reduces or eliminates its value or the expected benefit of the customer in terms of its installation or its intended use or is contrary to its quantity or quality or simply affects it according to its or its standard and technical specification** are deemed to be defective services " [10]. In the continuation of the Act, it is mentioned that "**The Consumer, in this case, is entitled to a discount in the amount of the deficiency itself** [10].

In commercial and technical quality regulations it is mentioned about the continuity of supply as follows: [6] "**On condition that it does not derive from the user's own fault, the indemnification paid to the user do not waive the restitutory right of the user for the damage of the equipment pertaining to the user. The damages shall be indemnified by the Distribution Company If the invoice showing the repairing charges of the equipment is submitted, that it is supported by documents that damages derive from interruption or voltage disturbance and that it corresponds to the records of the Distribution Company about the interruption time and place**."

The legal person who has a distribution license is liable to preserve the distribution system to be qualified and to ensure that constant power supply is provided to the consumers except the force majeure described in the 51st Article of License Regulations of Power Market [12] or private force majeure defined in its license or the scheduled interruption.

Whereas in the regulations of Power Market Customer Services [11], there are provisions in relation to the followings:; "service quality standards in relation to efficient and qualified service supply, determination and assessment of power consumption, principles and methods to be followed to ensure power and/or its capacity in a competitive atmosphere for consumption purposes, principles and methods in relation to receiving and assessment of customer complaints and providing information to the customers, indemnification of the customers for rights and liabilities so that the consumers are provided with a constant, qualified and adequate powers supply".

Electrical power whose quality does not comply with the standards and the regulations is deemed to be defective good. In accordance with the provisions that the consumers should be protected, 'a discount' should be made in the amount of the utility bill. Besides, making a reduction on one's utility bill because the power supply is deemed to have been defective does not waive the restitutory right of damages and losses incurred by the consumer on his/her equipment due to the poor power quality. It is required that not only the defective equipment but also all other economical losses be indemnified. Determining by the expert witnesses that the economical losses derive from the poor quality power supply should be a good enough reason for the payment.

The establishment (EMRA) ensures that all processes and data and all other information and documents in relation to the supply continuity of power, measurement and registration of its commercial and technical quality by the distribution company in accordance with the relevant standards and determination of the performance of the distribution company according to these indicators are investigated.

It would be appropriate to clarify the supply continuity, the names of the standards in relation to commercial and technical qualities, measuring methods and specifications of the devices to be used, the measuring place of measurement on the network.

It is emphasized in quality description of supply continuity that *the distribution system should provide power supply to its users within reasonable and agreeable costs*.

According to the United Nations Universal Declaration of Consumer Rights "*the states should encourage a fair and effective competition to supply the consumers with the utmost production and service in minimum price*." [7]

It should be clarified as to what are the agreeable costs. Making the honest users pay for those who theft electricity by means of increasing the power unit prices means that the right of the consumers to receive power in minimum price is forfeited.

"The distribution company registers the long, short or momentary interruptions that occur in all or partial distribution system. The distribution company releases the quality indicators according to the records on its website on monthly basis. On request, the distribution company provides its users with the information that takes place in interruption records" [6].

Not only the interruptions but also other power quality problems such as harmonics need registering so that the damages and losses emerging as a result of poor power quality are indemnified. Besides, it will be disadvantageous If judicial authorities only recognize the unilateral records of the distribution company in case of any disagreement arising from the records between the consumers and the distribution companies. It should be encouraged that for the future, meters

used by the subscribers record the interruptions and other power quality components in memory. Besides, teams that can perform studies in technical issues should be prioritized within EMRA.

"In case the target values in relation to the annual maximum power outages are exceeded, the distribution company is to pay 20 (twenty) YTL (Turkish Lira) to dwelling subscribers and 80 (eighty) YTL to other subscribers for each power outage that exceeds the granted limit in terms of duration" [6].

It will be proper for the distribution company to make payments to its subscribers not only for the power outages but also for the matters such as unbalance and the harmonics.

4. COST OF POOR POWER QUALITY TO ELECTRICITY CONSUMERS

Poor power quality cause economical losses for the users from many aspects. The most common poor power quality problems are interruptions, voltage dips and harmonics, every single problem causes different economical losses on the same facility. Even the problems that last shorter than one second may result in considerable losses at large loads.

There have been several efforts to assess the cost of power interruptions and power quality. In the last ten years, a number of large-scale customer interruption cost surveys have been performed by utilities in the U.S [13]. These include comprehensive statistical surveys of customer outage costs carried out by utilities As the results of these surveys have become available to planners, they have been applied in a number of areas of utility planning, including transmission and distribution system design [14,15].

The critical loads that are sensitive to power quality problems are the industrial establishments such as computer centers, paper factories, semi-conductor factories, arc furnace facilities and the plastic factories, these loads generally cause economical losses due to the fact that high production loss per hour and losses during the time that elapses while systems are reset and brought back. Power industry has been aware for a very long time that poor power quality causes economical losses. However, researches about the economical losses caused by poor power quality is surprisingly very few in Turkey [8,9]. It is expected that the utilization of customer poor power quality costs will increase in the future, as the restructuring and privatization of the electricity supply industry in Turkey have increased commercial pressures on utilities, regulators and other market participants.

The prime study assumes that outage costs experienced on summer weekday afternoons can be used to assess outage costs experienced at other times during the year. Most surveys of customer outage costs have found very large differences in costs depending on the time of day, week, and season during which an outage occurs [9]. Costs associated with outages on summer weekday afternoon are typically the highest because of high electricity usage during this time, largely because virtually all businesses are in full operation and electricity use for space conditioning is at a maximum in Turkey. Unreliability is not confined to summer afternoons and the use of summer weekday outage cost estimates likely results in overestimation of total power interruption and power quality costs.

Besides, the users who can not receive power in adequate quality from the distribution companies are subject to economical losses as a result of the costs of solution methods they implement themselves in order to improve the power quality. Furthermore, Turkey economy faces considerable losses due to the fact that power distribution networks do not make low-cost investments to improve the power quality problem for various reasons and the separate investments of the users in order to solve the problems. Power quality problems may drive from users or utilities. The most economic solution to this would be to solve problem at utility side if it derives from utility, at user side If it derives from the user.

Initially cost analysis must be done so that power quality problems are deriving either from the user or the utility be diminished and the power quality costs are considerably reduced although they are not completely eliminated. To get rid of all power quality problems might not be convenient economically. What is the most convenient solution is the method that can supply the demanded power quality level and reduce the improvement cost of total power quality to minimum; the basic steps to execute an economic analysis of power quality are given below:

— Identification of the demanded electrical power quality level.
— Identification of the basic costs of the power quality problem.
— Identification of alternative solutions to improve the power quality.
— Identification of the reduced cost of power quality for each improvement method.
— Identification the most convenient economical solution.

The power quality level needed for the electrical devices change according to their operation characteristics. Therefore, the power quality level for the demanded network should be identified considering the devices to be connected.

The respondents were instructed to include equipment damage, raw material and finished product spoilage or damage, and the cost of special procedures to restart production. Other costs such as the cost of operating standby equipment or of special procedures to prevent damage were included. The survey asked users to identify the worst time in a day, a week and a year for outage to occur as the "base case", for which the respondent provided detailed value cost estimates. Users were also asked to indicate the possibility and amount of cost saving that could be expected if advance warning or interruption duration was provided. An attempt was also performed to obtain introductory information

The improvement cost of total power quality is calculated by the formula given below [2]:

$$TPQC = BPQI - CPQI \quad (1)$$

TPQC — Total power quality cost.
BPQI — Benefit from the power quality improvement.
CPQI — Cost of power quality improvement

Benefit from the power quality improvement means that the cost of the problem arising from it is reduced and it is calculated by the formula given:

$$BPQI = BPQP - RPQP \quad (2)$$

BPQP — Basic cost of power quality problem
RPQP — Reduced cost of power quality problem

The cost of power quality improvement equal to the annual cost of required equipment purchase, its installation and regular maintenance, alternative solutions and the amendments to be performed either on the network or the user side. The best solution is the one having least TPQC value

Electrical devices have different sensitivities against voltage dip, which is one of the power quality problems. To start with the identification of the power quality cost, initially the systems that are influenced by the power quality problem are identified. Later on, power energy systems need monitoring and the obtained data need evaluating so as to identify the reasons leading to power quality problem.

Even very short-term problems with large loads may result in considerable cost increases. For problem free operation with critical loads, all power quality problems must be eliminated. General problems for these loads are production loss per hour and losses during the time that elapses while systems are reset and brought back.

The calculation of interruption cost has been given in books and articles [2,5]:

$$BPQP = A + B + C \quad (3)$$

BPQP — Total cost of interruption
A — Cost of the affected employees
B — Material loss due to the interruption
C — Initial cost
A, B and C values can be calculated as follows:

$$A = D.E.F \quad (4)$$

Where:
D — Number of affected producing employees
F — Per hour cost per affected employee
E — Duration of interruption

$$B = IG \quad (5)$$

Where:
I — Unit of defected product due to the interruption
G — Cost Per defected unit due to the interruption,

$$C = HJF + KL \quad (6)$$

Where:
L — Cost Per unit of the defected product due to the interruption
H — Starting time (in hours)
J — Number of the employees required for starting
K — Unit of the defected product deriving from the starting

Cost of the interruption for utility as follows: cost of non-consumed power, legal obligations in networks due to power outage, consumer who are not satisfied with the power quality or generating their own electricity and consumers who change their supplier.

Calculating the cost of voltage dips is not so easy as that of outages. The effect of voltage dip to the sensitive equipment depends on the equipment itself as well as the size of the voltage dip and its duration. Small voltage dips effects the equipment in a less sense, therefore they produce relatively less financial effects in comparison to large voltage dips.

Another problem that causes a cost increase for industrial and commercial consumers is the harmonics. The cost of harmonics to the consumer emerges as the harmonic current is added to the normal current and increases the load with the losses. With the increasing loading, the capacity of the conductors, transformers and motors in the system drops. Whereas, an increase in loading ratio cause the system units such as transformers and motors to have lower operation life time. Other harmonic based problems such as noise and vibration cause decreases in motor torque, in power factor, in the performance of televisions and the relays, faulty readings of induction meters

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5. COST OF INTERRUPTION IN INDUSTRIAL AND COMMERCIAL CONSUMERS STUDY RESULTS

Electricity, which is an essential requirement for economic and social development, plays an important role in the development of the Turkish economy. The study examined the economic impact on interruptions of electricity delivered to commercial and industrial consumers in Turkey. The assessment consists of reviewing existing guidelines on power quality, analyzing poor power quality and its economic impact on a sample of commercial and industrial consumers and providing recommendations for power quality improvements.

The investigation was carried out using a detailed survey 98 sample of commercial and industries consumers. Industrial sector losses attributable to unplanned electric power interruptions average 0.92 US$/kWh, while they are only 0.41 US$/kWh for planned outages. Thus the unplanned interruptions result in economic losses that are nearly two and one-half times those of planned interruptions.

The study found that the frequency of unplanned interruptions during the year averages nearly one interruption per day lasting about 40 minutes. In contrast, the number of planned interruptions is about one in six months but with each lasting about 3 hours. Therefore, 96% of the total unserved energy resulting from interruptions is due to unplanned outages, but only 4% is attributable to planned outages. Overall, nearly 11% of the industrial sector electricity

demand cannot be met by the utilities due to planned and unplanned interruptions.

On average, 77% of the industrial consumer and 31% of the commercial consumers in 98 samples have standby generation facilities. The relatively high cost of unplanned outages in comparison to planned outages requires special attention to reduce the frequency and duration of unplanned outages and to convert such outages to planned outages whenever possible. The standby generation level in the industrial sector is significant and is likely to increase in the future unless necessary measures are taken to reduce grid supply outages. Further, these future standby generation facilities are likely to be based on natural gas instated of fuel oil.

To address these issues; convert unplanned interruptions to planned outages where possible, introduce an interruptible electricity tariff to industries that can absorb planned interruptions without serious disturbance to their production processes, introduce a well-planned load management scheme, particularly to reduce the system peak demand, recommendation can be made.

6. CONCLUSION AND OPINIONS.

While underlining the basic information the consumers need to know about power quality and the cost of poor power quality, an assessment of the existent regulations has been made in terms of consumer rights so that damages and lost arising from the poor power quality are determined and they are indemnified.

Without needing that the consumers seek remedy, high-quality power should be provided to the consumer within the limits specified in the standards and regulations on the base of customer satisfaction.

It should be emphasized more strongly that the right of using high-quality power is deemed to be one of the fundamental rights, the rights specified in United Nations Universal Declaration of Consumer Rights, Consumer Protection Act and EMRA regulations should be applied more commonly. The consumer who purchases power should asses it as a product and in case of poor quality, he/she consider it as any defective good.

Considering the already known speed of the juridical courts, the remedy-seeking process of the consumers for their damage indemnification as a result of poor power quality is a difficult process. This process of remedy-seeking as a result of poor power quality should be made much more simple, easily attainable and fast for the consumers.

Sparing the record procedures of power outage numbers and periods for the discretion of the distribution company, which should make a payment for power outage, will make this remedy-seeking process of consumers much longer.

It is required that the consumers be informed, enlightened and educated about power quality as well that they be encouraged to seek redress so that they are protected against the cost of poor power quality.

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