Electricity Distribution.

Is Quality really regulated or just given? *

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Abstract

In the last two decades, unbundling, liberalization and privatization has considerably modified the structure of the electricity supply industry. The need to set up adequate frameworks for regulating the unbundled network sectors in the restructured electricity market and the discontent with traditional regulation systems like rate of return has led regulators to implement schemes such as price-caps and yardstick. To supply Quality Service is the main goal of the electricity distribution sector, but the diversity and characteristic of the distribution networks pose a huge problem of regulation to be studied. The quality of electricity is not considered, at least not correctly, by the economic regulation models (traditional, incentive or competition) of the electricity distribution sector. The incentive and competition schemes provide strong incentives for efficiency, unlike the traditional regulation. However, these systems mostly focus on costs reduction; thus, the quality of the offered services is at risk. Economically speaking, an eventual lead to quality degradations is equivalent to higher prices. Both price and quality are highly appreciated by customers; therefore regulators are increasingly interested to assure an inclusion of both aspects within the regulation system. In other hand, the absence of a global definition of electric quality in distribution raises the issue of how to establish the quality costs production, and also, which are the logical, economic and technical bases of definition of the standards and the penalties used.

This paper surveys the literature and models of Quality Regulation. We first present the function and role of the electrical distribution activity, and why the electricity distribution quality is relevant. Second, we define Quality in the context of electricity distribution services. Third, we look how the quality is considered in some of the classics and newest regulatory models used in electricity distribution (rate-of-return regulation, price-cap regulation and yardstick competition). Also, we discuss the main problems of these regulatory models and the need to include quality regulation under the new economic regulation schemes.

Finally we draw some conclusions. Depending on the regulation model, the Quality of Electricity is simply left to the will of the distributor (rate or return), or is administratively imposed by a command & control regulation (price-cap), or if not it is hardly comparable due to the heterogeneity of the Distribution Networks (yardstick competition). Therefore, the absence of robust incentive quality regulation and the lack of a global definition of electric quality in distribution highlight the interest to establish mechanisms of economic incentive regulation of Electric Quality in Distribution.

Keywords - Electricity, distribution, regulation, quality.

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Introduction

The main intends of distribution activity is the electrical energy transport from the transmission or sub-transmission networks to the points of consumption, in the suitable conditions of quality, as well as the sale of electrical energy to the consumers. The distribution activity is carried out by it distributors who are mercantile societies that intend to distribute electrical energy, to construct, to operate and to maintain his facilities and to sell energy in terms anticipated by the Law. Also the cooperative societies of consumers and users can be considered as distributors according their own regulatory norms.

Although the definition is clear, there are characteristics of the distribution activity that are necessary to consider within the present analysis. The activity not only is a natural monopoly, and thus regulation targets, but also an intense capital business that includes diverse activities, in very different geographic areas. Due to the business characteristics, a single company can have diverse scenarios for delivery his service (rural/urban, valley/mountain, medium or low voltage, to cross or not a river…) E.g. the borders of urban sectors, in many cases a company serves urban and rural areas at the same time, and, of course, the infrastructure involved in these zones can be very different, as the requirements of investment for development, and costs associated with the system operation and maintenance.

Unlike the generation and retail activities, the electricity distribution sector is a regulated activity. This means that the regulator dictates the basic norms on which the business is developed. The regulation of the distribution activity looks to allow the distributors to receive a return adapted of its facilities, and to the clients to suitably pay its energy under parameters, also regulated, of quality. On the other hand, sometimes the laying of the distribution networks responds to historical variables related to the growth of cities and towns. Usually it happens that the historical conditions with which the decision was taken to construct a network change in the time. Thus the decision to develop a network that in its time was done professionally and according to the needs of that one moment, in the present has technical, social, environmental problems, etc. It will also happen to the works that are at the moment in execution.

Even though the central subject of this working paper is the quality, this one and also other subjects that affect the distribution activity have been invested with a dark mantle, The previous thing makes the propose task more difficult. This last one, in attention that the distribution sector underwent historical appreciations, that delayed their technical and economic attention. Consequently, today, it exists a manifest lack of tools of analyses and design that take into account a set of singularities of the distribution networks (in particular on LV), such as: random consumptions, networks with unbalanced structures with and without neutral conductor, grounding return, asymmetric structures (1 phase, 2 phases, 3 phases), reconfiguration, etc. On the other hand, it is well known that the study of the electrical quality, when this one is measured through reliability indicators, must be centered in the sector of the distribution. This conclusion is based on global statistical failure measures. The 80\% of the failures, measures in terms of the unavailability, i.e. $U=\lambda *r$, perceived by the client come from the distribution network (Weedy 1972), 16% are assignable to causes of "greater force" (maintenances, expansion tasks, reinstatement of the supply, etc.), and 4% due to the generation and transmission systems.

After to have presented the function and role of the electrical distribution activity, and why it's relevant the electricity distribution quality, we define Quality in the context of electricity distribution services. Later we survey the literature and models of Quality Regulation, looking to how the quality is considered in some of the classics and newest regulatory models used in electricity distribution (rate-of-return regulation, price-cap regulation and yardstick competition). As well, we discuss the mains problems of these regulatory models and the need to include quality regulation under the new economic regulation schemes. Finally we draw some conclusions.

Quality of Electricity

Often, Energy Economists does not define what it is "Electrical quality", as Paul Joskow (2006) it gives by understood that certain kind of electrical quality is present, or they ignore all technical characteristics, and focus only on the Reliability dimension of Electricity Distribution Quality (Joskow 2004). However, for electricity distribution, it is common to make a distinction between three different quality dimensions: Commercial Quality, Power Quality, and Reliability (Ajodhia, 2006).

Firstly, Commercial Quality is related to individual agreements between the Electricity Distribution Company and their consumers. Examples of such agreements are the conditions for (re)connection of new consumers, installation of measuring equipment, regular transactions such as billing and meter readings and sporadic transactions such as responding to problems and complaints.

Secondly, Power Quality, sometimes called voltage quality, covers a variety of disturbances the voltage waveform. The relevant technical phenomena are variations in frequency, fluctuations in voltage magnitude (flickers), short-duration voltage variations (dips, swells, and short interruptions), long-duration voltage variations (voltage regulation), transients (temporarily transient over-voltages), and waveform distortion (harmonics). Voltage Regulation is by far the most important quality feature in Power Quality.

The third quality dimension is Reliability, which is a measure for the ability of the network to continuously meet the demand from consumers. Network reliability can be divided into two main elements namely adequacy and security. Adequacy relates to the availability of sufficient network capacity to guarantee supply of electricity to consumers in the longer run. That is, no interruptions occur under normal operating and demand conditions. Security relates to the ability of the network to - given that it is adequately designed - withstand disturbances i.e. consumers do not experience an interruption in the electricity service.

However, commonly the Commercial Quality does not depend of the planning or maintenance departments' of the Distribution Firm. In addition, many of the disturbances measured in Power Quality are caused by the clients or come from the Transmission Network. Reason why between electric power engineers at the end, quality it is, mainly understood, as a "hybrid feature" given by the "Voltage Regulation" and the "Continuity of the Supply".

Quality Regulation

The level of quality depends on the requirements of each client. E.g. a Networks research group - GRJM Ph.D. student always hopes that each night does not happen an ENS‡ outcome of the supply, because he prepares all nigh long important contributions at home. Level of quality also depends on technical reasons. E.g. the quality tail-effect: In electrical distribution systems, the quality of the tail client is always the worst. Other example is the perceptive fractionation of the quality: The network quality is not all the time seen by a client, the faults in a sector of the network are not seen by a client of another sector; the previous one happens for two reasons: by sensorial perception or by omission. The level of quality depends also on the location of the client. E.g. by moments, the high power factor demanded to certain clients branched to very long lines producing excess of reactive power. Consequently, the electrical quality does not have to be uniform, as currently it is established in standards. Then, if the quality is locally distributed so, it is possible to establish local norms of electrical quality.

In order to establish a policy of incentive to the quality, it must be had presents that for different networks, even of a same electrical company of distribution (e.g. the urban case versus the rural one), differentiation of the quality to satisfy exists. That it is very important when the Regulator uses a fragile model in the incorporation of the quality. Then, necessarily, the problem of bad quality it must be solved through a strategy of strong penalties, that imperatively force the electrical company of distribution to invest in quality.

‡ Energy Not Supplied

In this section, we look at how the quality is considered in some of the classics and newest regulatory models used in electricity distribution (rate-of-return regulation, price-cap regulation and yardstick competition). And, we discuss the main problems of these regulatory models and the need to include quality regulation under the new economic regulation schemes.

Traditional regulation (rate of return) and quality

Much of today's increased attention for quality regulation is driven by the anticipation of quality problems resulting from the change towards price-cap regulation (Ajodhia 2006). The question then arises whether these concerns have not been there under rate-of-return regulation and if not, why this has been the case. A passage from the influential book by Kahn (1970) helps to explore this question: "*But it is far more true of quality of service than of price that the primary responsibility remains with the supplying company instead of with the regulatory agency, and that the agencies, in turn, have devoted much more attention to the latter than to the former. The reasons for this are fairly clear. Service standards are often much more difficult to specify by the promulgation of rules*". Kahn's observation suggests that the perceived difficulties of regulating quality have been the reason for regulators to "leave quality to the firms". Regulators seem to have recognized the importance of quality, but at the same time did not see an explicit need for quality regulation.

But why were regulators so comfortable in ignoring quality issues? The answer perhaps lies in the natural tendency to oversupply quality under rate-of-return regulation. There is a tendency towards overcapitalization if the fair rate-of-return is set higher than the firm's costs of capital. If quality is capital intensive, then quality levels will automatically tend to be high and there will be less need for explicit quality regulation. Then, rate-of-return regulation can be considered as a substitute for quality regulation (Spence 1975).

However, overcapitalization does not necessarily mean that quality is at an optimal level. From a theoretical point of view, quality would only be optimal if the costs to produce it and consumer demands for it would be equal at the margin. In the rate-of-return regulation case, one may expect an oversupply of quality (so-called gold plating) i.e. a quality level higher than the optimum. This would come at additional costs and thus a higher price - consumers will be paying a too high price for a too high quality level.

Another observation by Kahn (2002) is very relevant in this respect: "*But there is reason to believe that it [high reliability] has come at too high a price. There is substantial evidence that the [high quality] standards were selected by engineers to make their lives easy rather than to save customers money*". The concern about gold plating is supported by different empirical studies that use US data to compare the costs of supplying higher system reliability against the benefits of doing so and find that - at given existing reliability levels - the former is substantially higher than the latter (Adojhia 2006). The main reason for this is the choice of too high reliability standards. For example, reliability in New York State should be reduced by a factor five to arrive at optimal levels. More recently, a study by the Dutch energy regulator showed that the total costs of interruptions caused annually to consumers in the Netherlands are only a small fraction (2.5%) of the total system costs. Although this cannot be considered conclusive evidence, it does point out into the direction of too high rather than too low reliability levels. Studies like these seem to confirm the view that rate-of-return regulation not only resulted in low productivity but also led to inefficiently high quality levels in the electricity industry.

Finally, as Kahn (1970) and Spence (1975) insinuate, we can conclude that in the traditional regulation (rate of return) the quality it is not directly regulated but established by the distributor.

Incentive regulation (price–cap) and quality

Rate-of-return regulation provides incentives to overuse capital inputs and this, given that quality is capital using, results in high quality. In contrast, price-cap regulation gives firms an incentive to cut costs and this raises the concern that (part of the) cost reductions may be achieved through adverse quality reductions. Theory confirms this concern. Spence (1975) and Sheshinski (1976) already showed that where price is fixed or taken as given, the monopoly firm will always set quality too low. Subsequent publications have studied the quality problem under price-cap regulation in more detail. Fraser (1994) examines the relationship between price-cap regulation and the reliability of supply of a monopolist. In his analysis, the X-factor in the price-cap represents the extent to which the firm is permitted to pass onto consumers any specific cost increases in the form of higher prices. He finds that when the firm has increasing costs and is allowed to pass onto consumers a proportion of the costs increase that is sufficient to maintain expected profits, then the associated level of reliability will be increased. This, effectively, would resemble a situation of rate-of-return regulation. However, if the firm is forced to absorb the cost increase to the detriment of its level of expected profits, then the firm's response will be to minimize the loss of expected profits by lowering reliability. Thus, if consumers are protected against the cost increase, this protection will be at the expense of lower reliability. Fraser's conclusions are important to consider in a regulatory setting. Often, regulators impose a price-cap with a gradual price decrease (through the X-factor) reflecting the regulator's expected improvement in efficiency. Fraser's results imply that if the X-factor is set too high and the firm cannot achieve the regulatory cost targets, its strategic response to maintain sufficient profits will be to lower reliability. To solve this problem, Fraser proposes to include a reliability element into the price-cap. This benefits consumers in a situation where the firm is required to absorb a cost increase because it can no longer protect profits by reducing its existing reliability level. The effects of a regulatory shift from rate-of-return regulation to price-cap regulation are studied. This study finds that if quality is capital driven, the regulatory shift reduces both price and quality. In the reverse case, when quality is effort-related, the shift to price-cap regulation will reduce price and raise quality. Price-cap regulation is not suitable to regulated industries in which the amount of investment is crucial for the resulting level of quality. In this case, some rate-of-return regulation amendments may increase the total social surplus. In other words, a hybrid form of price-cap regulation and rate-of-return regulation may enhance social surplus. When applied to the electricity network industry, results suggest that a shift to price-cap regulation will cause quality degradation as quality (reliability) is predominantly capital-related. For effort-related quality, a reverse tendency may be expected. This suggests that it is preferable to price-cap regulate only those activities that are primarily effort-related while maintain a rate-of-return regulation system for capital-related activities.

In line with the previous authors, Weisman (2002 and 2005) finds that under price-cap regulation, the regulated firm's incentive to invest in service quality increases with the level of the price-cap. Secondly, Weisman shows that the incentive to reduce investment in quality under price-cap regulation may be tempered by the regulated firm's participation in complementary, competitive markets. A reputation of poor quality in the provision of monopoly services can spill over to adversely affect sales in the competitive markets Weisman also analyses the effect of increased information dissemination actions, i.e. exposing the firm's performance to the public. He finds that exposing performance provides the regulated firm with incentives to increase investment in quality without distorting the efficient investment in cost reducing effort. Anecdotal evidence points out the problems of quality under stricter price regulation. Weisman (2002) provides the examples of Idaho and Oregon where an incentive system for the telecommunications industry was abandoned due to problems with service quality. According to Ter-Martirosyan (2003), the State Public Utility Commission of Oregon terminated performance based regulation plans for Pacific Power in 1995 because of the resulting low quality of service, and reintroduced it in 1998 only after incorporating strict quality standards for reliability. In Hungary, a large increase in the number of interruptions was noticed after the introduction of price-cap regulation of electricity distribution firms and this accelerated the introduction of explicit quality regulation schemes. These examples tend to confirm the concern with quality decline under price-cap regulation. Unfortunately, there are only a few studies available that collected empirical evidence of quality effects under price-cap regulation. For the telecom industry, Sappington (2003) compares four empirical studies on the effects of incentive regulation on quality to retail telephony consumers in the US. He finds that these studies produce diverging results; the hypothesis that quality declines with stricter regulation cannot be unambiguously proved for the case of US telecom. This, as he argues, reflects in part the limited success of the existing studies in capturing all relevant aspects of regulatory policy.

For the electricity industry, as far as known, there is only one empirical study by Ter-Martirosyan (2003) that looks at the effects of price-cap regulation on reliability.24 She found that price-cap regulation indeed led to worse quality performance in terms of an increase in the SAIFI and CAIDI indicators. In her study, she analyses a pooled sample of 78 electricity firms from 23 states of the US during the period 1993 to 1999. The econometric model takes into account the type of regulatory regime, the presence of quality standards, the per capita income in the state, average length of line per consumer, the share of underground lines, the share of self-generation by the firm, and the damage caused by severe weather conditions in the territory served by the firm. Her analysis supports the hypothesis that price-cap regulation has a negative impact on quality if no precautions are taken to safeguard quality. This is particularly true for the duration of interruptions. However, incorporation of quality standards appears to reduce this effect. Then, interruption duration remains the same or even improves in some instances. In contrast, price caps do not seem to have significant impact on the frequency of interruptions. Possible explanations given for this are the absence of data and the different causes that contribute to frequency of interruptions. She refers to a study conducted by the Oregon Public Utility Commission showing that the main cause of interruption occurrence is equipment failure, whereas interruption duration is mostly affected by storms and the time it takes to repair the damage. Thus, she argues, if price-cap regulation affects the cost structure of the firm, the impact on equipment is a long-term effect and related changes in reliability may not be noticed in the short run. The appropriate model to be used for interruption frequency would be one with lagged values of regulatory regimes. The short history of incentive regulation, however, does not allow the testing of such models yet. Ter-Martirosyan also considers the potential problem that price-cap regulation and quality standards may be endogenous: They are more likely to be applied when the firm has a poor performance. After adjusting her model to capture this effect, she finds that price-cap regulation still negatively affects reliability performance and that quality standards help to mitigate this problem. Another issue studied by Ter-Martirosyan is how incentive regulation affects the firm's spending on operational and maintenance. In principle, incentive regulation is designed to promote efficiency and therewith reduce spending levels. But, as discussed at length in previous sections, it also comes with the risk of adverse cost reductions at the expense of quality. Ter-Martirosyan analyses reductions in spending for firms with and without quality standards. In line with expectations, she finds that in both cases, spending levels have fallen which suggests that the firms have operated more efficiently. However, she finds that firms with quality standards have reduced costs less than those without. In the former case, spending levels were reduced by 17 percent since 1993 while for firms without quality standards this decrease has been about 37%. This is a substantial difference, which seems to support the hypothesis that price-cap regulation without quality measures generates perverse incentives to under-spend on quality. In conclusion, Ter-Martirosyan's empirical study proofs that the problem of quality degradation

Regulation by competition (yardstick competition) and quality

As yardstick competition for price regulation has already proven to be difficult, including reliability elements into yardstick competition is an even more challenging issue. Mikkers and Shestalova (2001) present a model that includes reliability in the yardstick competition framework. In their model, an optimal cost and reliability outcome is achieved by internalizing the costs of undersupply of reliability equal to the customer value of the associated losses. To satisfy the individual rationality constraint - that is, a company will not participate if the expected pay-off is too low - the total amount of penalties are redistributed between companies based on relative performance to the mean. The net effect is that companies choose socially optimal reliability levels i.e. balance costs and reliability optimally while simultaneously operating as efficient as possible. Such a scheme is compelling because the regulator does not need to bother with information - this is simply solved through the virtual competition that is introduced. At the same time however two problems arise which are perhaps just as difficult - if not more difficult - to solve. The first problem is to calculate the mean reliability against which companies are evaluated against i.e., how to properly benchmark quality between companies. The second problem is to determine the value that customers attach to reliability. This is needed to be able to internalize the appropriate amount of costs to companies.

While all network companies use broadly the same inputs (labor and capital), some providers may use proportionately more of some inputs and less of others. Similarly, the nature of services provided by networks varies according the nature of customer demands. For example, some companies may need to maintain significant network capacity to transport power to a small number of customers while others may serve a large number of customers with limited and highly variable demand. When reliability is included in the comparison, the issue gets even more complicated as the factors beyond the companies' control can influence the level of reliability. A yardstick calculation should be able to accommodate these different supply and demand conditions. Further, it should recognize that it is possible to operate at equal efficiency while substituting between using different inputs and supplying different outputs. To demonstrate the difficulty of benchmarking reliability, consider the following example. It is well-known that networks in rural areas more vulnerable for outages because these are usually longer and above ground in contrast with networks in urban areas. This means that even if rural and urban companies were operating equally efficient, reliability levels would significantly differ. This effect would need to be taken into account in calculating the yardstick. Furthermore, if we relax the assumption of equal efficiency, the benchmarking analysis would need to be able to differentiate between differences arising from efficiency and from operating differences. In summary, properly distinguishing between efficiency and costs while taking account of company specific factors is a perplexing difficult issue.

Another problem is the substantial lag that exists between cost decisions and reliability outcome. For example, the results of freezing all preventive maintenance activities today only results in a reliability decrease after some time. When this period is long, the incentives may not be noted in time i.e. there is a problem of lagged feedback. Management who focuses on short term profit maximization may thus not pick up the signals from the regulation system. This becomes a substantial problem when the management's sitting term is shorter than the time by which the feedback arrives. If all companies engage in this behavior, than mean reliability levels drop significantly and the yardstick does not pick up this socially undesirable effect. Regulatory commitment would then require the regulator not to interfere - this is not likely to be sustainable in practice.

Conclusion

The main characteristic of the electricity distribution activity it is the heterogeneity of the firms: geographic dispersion, size of the concession, technology used, diverse peak powers, etc. For that reason, each company has different costs that reflect their current costs (OPEX, CAPEX) and historical costs (Stock of the capital), associated of their own programs of investments, with operational entrances of the new facilities and that respond to differentiated strategies of management.

The regulation of the Quality in the electricity distribution sector it is a truth big problem of regulation. One of the deficiencies of the regulatory process of the electricity distribution sector says relation with the Regulator policies; this one pays attention mainly on the control of the tariff as indicator of the success of the adopted model, and like instrument to influence the financial balance of the companies. On the contrary, the Regulator brings less attention to the correct regulation of the individual activity and to the main goal of the distribution that is the supply of Quality Service. The second deficiency talks about the lack of a global definition of electric quality in the electricity distribution.

The "classics" regulatory methods do not offer a real incentive for increase Quality to the distribution firm since they do not respond as basic to regulatory principles as: a) Individualized treatment, b) Association of the remuneration to electrical quality, and c) Relation with the real and necessary investments. Depending on the regulation model, the Quality of Electricity is simply left to the will of the distributor (case of the rate or return regulation), or is administratively imposed by a command & control regulation (case of the price-cap regulation), or if not it is hardly comparable due to the heterogeneity of the Distribution Networks (case of the yardstick competition). In the other hand, the incentive policy through "carrots and sticks" of the command & control regulation seeds a doubt cloud of which are the logical, economical and techniques bases of definition of the standards and penalties.

The models of economic regulation of the electricity distribution do not consider, or not correctly, the quality of electricity. It exist agreement and conviction that the system of distribution economic regulation can frankly be improved. For the previous thing it is precise to remember that "the regulation solutions always arise from processes in which appear greater doses of subjectivity to the permissible ones to identify, by means of analytical techniques, the optimal solutions". Therefore, the absence of robust incentive quality regulation of electric quality in distribution highlights the interest to establish mechanisms of economic incentive regulation of Electric Quality in Distribution.

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