Optimal Quality Levels of Electricity Distribution. How they are set up?*

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February 12, 2008

WORKING PAPER

Very Preliminary Version

Abstract

In this working paper we analyze and compare regulatory approaches and policies regarding electricity distribution quality; we discuss the inter-relationship between cost and quality in incentive regulation scheme; also we highlight difficulties to establish the value of quality for both customers and distributors; also we explore how the standards of quality service are set by the regulators. Finally, we look for the targets, rewards and penalties for quality, and the response of the companies.

Index Terms— Electricity, distribution, regulation, quality, rewards, penalties.

I. Introduction

The main task of distribution activity is transporting electrical energy from the transmission or sub-transmission networks to the points of consumption, in the suitable conditions of quality, i.e. supply quality service to the consumers. Waveform characteristics of the electrical energy are very important, as is the capacity of the distribution network whether or not to supply the electricity, as well as the treatment of the consumer himself. Since equipment at the customers will get more sensitive for lack of voltage quality, it can be expected that regulators will extend regulation on quality service. It is important to consider all quality parameters individually (Fig.1). Lack of uniform measures of quality of service for electric utilities presents a considerable challenge for analyses of quality effects of regulation.

Often, Energy Economics authors do not define what "Electrical quality" is (R. López 2007a and 2007b). They only assume that a certain kind of electrical quality is present (Joskow 2004). In certain cases, they ignore all technical characteristics (in particular, Power Quality) and focuses only on the reliability dimension of Electricity Distribution Quality (Joskow 2006). Between

* Financial support from the scholarship "Beca Presidente de la República", of the Planning Ministry of the Government of Chile, is gratefully acknowledged.

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Electrical Power Engineers, at the end, quality is mainly understood as a "hybrid feature" given by the "Voltage Regulation" and the "Continuity of the Supply" (Raineri 1996 and Rudnick 2000). Outage of supply of the electrical service, i.e. the unavailability of the provision, is probably the most well-known or visible element for the consumers of electrical quality. It is absolutely comprehensible then that the continuity of supply is the driving force in most of the technical-economic discussions related to quality. Nevertheless, usually, economists have in mind the transport system behavior when they speak of quality. But it is an error to confuse reliability in transport with that in distribution. The strongest argument for this is the security of supply, because most current failures are related to infrastructure failures and not to the lack of the balance between production and consumption (R. López 2007a and 2007b). However, for electricity distribution, it is also a mistake to think that quality is limited to reliability because it is common to make a distinction between three different quality dimensions: commercial quality that is related with the costumer's treatment, power quality that takes into account about disturbances to the voltage waveform, and reliability that consider the security and availability of distribution network to supply the electricity service (Ajodhia 2006). It is noted that electricity distribution companies have different services and cost structures to fulfill the aforementioned services.

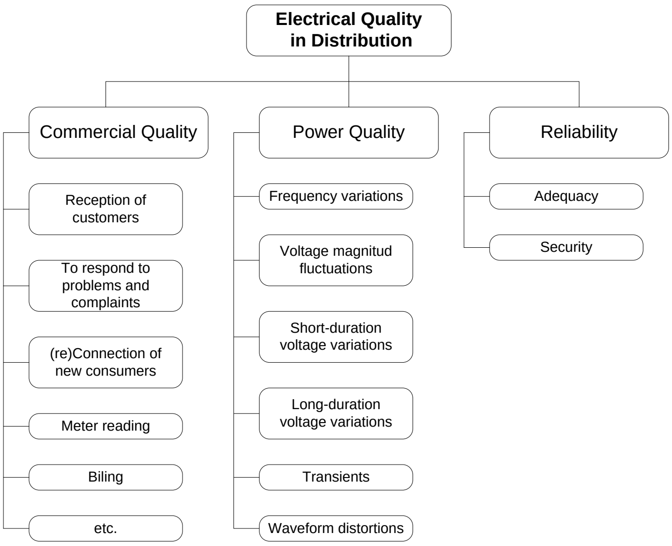

Fig. 1. Electricity distribution quality dimensions.

Efficiency analysis of electricity distribution networks is often limited to cost efficiency measure. However, an important aspect of their service such as quality of service is generally not part of the analysis. However, valuation of service quality for inclusion in regulatory models is particularly difficult. Tariff and price regulation without quality regulation may result into unintended and misleading signals to quality levels. Efficiency incentives may potentially be interpreted in terms of reducing costs at the expense of quality. Thus, customers may end up paying lower prices but at the same times, also suffering from inadequate quality levels. Quality regulation is designed to ensure that cost cuts are not introduced by electric utilities at the expense of quality. To prevent undesired reduction of quality, setting in place incentives for high quality is essential. This comes in the form of quality regulation – requiring network operators not only to become more efficient but also to maintain high quality levels or where applicable, improve the level of quality offered to customers. When setting up a quality regulation framework, there are a number of basic issues that need to be considered first. This understanding is crucial in order to make the right choices in order to arrive at an effective quality regulatory system: 1) first developing a good understanding of what quality is and how it can be measured; 2) clearly defining the objective of quality to pursue; and 3) choosing the appropriate quality control in order to achieve the defined objectives.

Therefore, regulators will need to accompany the price regulation with quality regulation to protect customers against a decrease in quality and performance standards below certain limits. Standards put a floor to the performance level of the company. Violation of the standard can lead to a fine or tariff rebate. However, literature shows us that regulators are motivated by political as well as economic factors, and that companies may not respond primarily to the regulator's financial rewards or penalties for their quality targets. Literature also shows us that very few studies have included quality of service measures in electricity distribution benchmarking analyses.

II. Incentive Regulation and Quality of Service

A. Inter-relationship between cost and quality

In many of the recently established electricity markets, regulators are required to monitor both the tariffs charged and the service quality levels of operators. For that purpose, they normally rely on separate tariff and quality incentive schemes. The tariff incentive scheme, generally involving revenue-cap or price-cap regulation, often makes use of a benchmarking model that seeks to identify the efficient level of costs for each operator. The quality regulatory scheme on the other hand generally involves a reward/penalty mechanism that is based on pre-specified quality standards. Electricity distribution units face a clear trade-off between network investments and operational expenditures driven by quality performances.

All types of incentive regulation (price caps, rate case moratorium, rate freeze and revenue caps) cause a significant increase in the duration of electric outages if they are not accompanied by strict quality standards. It appears that price cap regulation has the strongest impact on the duration of outages. It became clear that cap regulation provides strong incentives to reduce cost more than obliged by the regulator in order to realize efficiency gains. Both theory and practice suggest that, without additional quality regulation measures, these incentives eventually lead to perverse quality degradation especially for smaller customers with less bargaining power. I.e. this may imply less maintenance and postponing of investments that could lead to an overall decrease in quality of supply at short-term and long-term effects, and/or quality restrictions for certain customer groups. Therefore quality regulation is a necessary component of an incentive regulation system in order to avoid reductions of quality under the level customers are prepared to pay for or in order to push quality to a higher level. Both are necessary to protect customers from monopoly power and unwanted effects of incentive regulation.

While the regulation of quality was not an issue during the first years of price regulation, in the meantime more or less all European regulators have introduced a regulatory scheme controlling reliability. The introduction of quality of supply regulation is in line with the main task of a regulator, the protection of customers (especially smaller customers) from monopoly power of the network operators. In doing so, quality regulation helps to overcome incentives to reduce quality that are provided within the system of cap regulation. Thus quality regulation is a necessary component of price regulation to balance the incentives to cut cost in order to provide the amount of quality the customers expect and are willing to pay for.

If one compares between utilities with incentive regulation plans, the utilities with quality standards have on average higher expenses per customer than the utilities without quality standards for all years. In addition, for the utilities with quality standards their total distribution-related expenses go up through time, while for utilities without quality standards total expenses go down. This is especially transparent for operations expenses. It appears that presence of incentive regulation is associated with decrease in the overall level of expenses. This may be due to two causes: 1) overspending in case of rate of return regulation, and; 2) underspending in case of incentive regulation schemes. Estimation of the impact of operations expenses and maintenance expenses on quality of service reveals that there is a strong impact of operations and maintenance spending per customer on the duration of electric outages.

B. How to establish the value of quality?

Difficulties of determining both the optimal level of quality and whether it is being delivered, are recognized. Ideally, consumers can be given a choice of quality, and charged according to the costs of providing it. But the possibility of choosing different service qualities has been highly politicized. One characteristic of network industries is the common level of quality provision across at least some groups of consumers, so that one consumer's quality of supply must be shared with that of his neighbor. In such cases regulators have to determine which services they should set standards for, and identify, appropriate target levels and penalties. A difficult question is what quality level should be the one that the regulator should aim at. From an economic point of view, this should be the quality level that provides highest net economic benefits.

It is generally accepted that in order to achieve a higher quality level, one will need to invest more in the network. Furthermore, the cost to increase quality increases at the margin; to increase quality further, each additional unit of quality increase will require more and more costs. At the same time, higher quality implies additional benefits to customers. The additional benefits generated by the additional unit of quality reduces at higher quality levels. Conversely, higher quality produces additional benefits but these decrease at the margin. Clearly, increasing quality only makes sense if the additional benefits are higher than the higher costs involved in doing so. At some point, benefits and costs will be equal at the margin. This point can be defined as the optimal quality level and is the theoretical objective that one should pursue to achieve.

In economic terms, the appropriate incentives to the firm would involve a penalty for breaching the standards which is equal to the total monetary valuation of the consumer losses incurred for each quality standard. In each case the optimal quality is that at which the willingness to pay for additional quality by all the consumers affected is exactly equal to the cost of providing that extra quality. But this would clearly be very difficult operationally, both in establishing what consumers wanted and in fine tuning of the system. Ascertaining consumers' willingness to pay is itself problematic. Consumers often give inconsistent responses to surveys about willingness to pay, because of both conceptual difficulties and well known free rider problems; moreover there is usually an asymmetry between willingness to pay and compensation demanded if standards fall (willingness to accept), which is typically about twice as high. There are obvious explanations of this (for example consumer expectations) but it does not ease the task of the regulator in determining what targets should be set.

Another issue to address is the costs of lack of quality. Finding costs for lack of quality is already a complicated issue, on which different customers have different ideas and different studies lead to (very) different results. Additionally, the cost of lack of quality differs for both customers and for the different dimensions of quality. Moreover, below a certain threshold, customers will not face any costs because the immunity level of their equipment withstands this value. For certain dimensions of quality, lack of quality does not lead to high direct costs but are simply annoying.

One crucial factor determining consumer valuation of quality is their previous experience. Whether standards were above or below the optimum level in the regulated industries' nationalized predecessors is a moot point. Standards were generally driven by the engineers who operated and in most cases managed the industries, and were likely to be determined by technical capacity rather than consumer choice. Moreover consumer expectations have increased across the economy, but particularly for these industries since they became private. Furthermore, public consciousness and valuation is affected by media coverage and is unlikely to be stable, making optimum quality very difficult to identify.

C. Quality standards

The idea of optimal quality is well known in economic theory and forms the conceptual framework around which a quality regulatory system should be designed. From the regulatory point of view, the network company should be provided with incentives to provide customers with an optimal level of quality. If this is the case, then society is best off, as net economic benefits have been maximized. The concept of optimal quality is however only a theoretical concept. In practice, in order to identify the optimal quality level, one would need to have information about both the costs as well as the benefits of quality (as a function of the quality level). This information is very difficult to acquire. Furthermore, as a result of changing circumstances and customer preferences, costs and benefits may well change over time. Consequently, the optimal quality level will also change, making the optimum a moving rather than fixed target. Another complication is that customer quality costs may well be different from one customer to the other. This implies that different optimal quality levels exist.

To calculate the optimum quality, it is necessary to know the interruption costs of several customer groups. In practice, it is not easy to make a meaningful difference between different customer groups when valuating the outages. I.e. even within a category of e.g. industrial customers, the sensitivity to outages differs enormously, which means that also the valuation of outages differs enormously. This issue could be overcome by using more categories. However, this has the disadvantage of having more categories, which makes it more difficult for network operators to collect data. In practice this leads to unreliable quality data.

The costs of an interruption are driven by a number of factors (duration, perceived reliability level, interruption timing, if an interruption is planned or not, consumer dependence on reliable electricity supply…). These factors have been extensively studied in the interruption costs literature.

An approach to fix the reference quality is to apply the historic quality level. Thus, the network operator has to attain a similar performance level as it has previously been able to reach. There is, however, some consensus that in general the high quality levels resulting from traditional schemes may in fact have been too high. Different studies suggest that historic quality levels are too high when customers' willingness to pay for quality is taken into account.

An approach to fix the reference quality tries to measure the cost of improving the network quality (reliability cost of the network operator) and the cost of interruptions (outage cost of the customers). The minimum of the aggregated social cost curve gives the optimal quality level. This is an economically sound approach that entails the question on how to measure these costs. For the measurement of interruption cost different methods (proxies, surveys) are applied, each of it with its pros and cons.

Standards can be defined per region or zone. In this case, the standard is called a zonal standard. Usually, zones with higher customer density (e.g. urban zones) have a higher standard, reflecting the higher costs involved in supplying customers living in rural and less densely populated zones. Consequently, the minimum standard for urban zones would be set higher than for rural ones.

The main problem of a standard is that it imposes a discrete (rather than continuous) relationship between quality and price. The company either pays a fine or it does not, depending on whether it violates the set standard: there is nothing in between. The question then is at what level the standard should be set, and what the level of the fine should be. These two need to be low enough to be defensible, and high enough to be effective. If they are set too high, the standard may severely punish the company for not meeting unrealistic targets. If the standard is set too low, it does not "bite" and quality degradation may occur.

For standards and especially for incentive schemes the regulator has to determine a reference quality to guide the regulated utility to a certain quality level. This quality level should be in line with the demand and their willingness to pay.

For monopoly sectors, regulators have typically developed two sets of standards. One relates to performance for individual consumers and attracts compensation (fixed by the regulator) for the consumer if it is not met (in gas and electricity known as guaranteed standards). Such compensation may be automatic or in response to consumer requests. The second set of standards, overall standards, relates to areas where it is inappropriate to provide individual guarantees, but where customers have a right to “expect” a minimum level of service. These may cover similar areas, and are often focused on the system as a whole and achievement of a particular percentage of a target standard. The electricity regulator applied guaranteed standards for individual consumers, which should be met in every case, or a penalty, whose minimum level was set by the regulator, was payable. Overall standards for the system were also set, either as supplementary to guaranteed standards or in different areas. No predetermined penalty attached to failing to meet these overall standards.

The minimum standard can be derived directly from standards which are already adopted and used within the power sector industry. Minimum standards dictate a minimum level to be achieved for a certain performance aspect. In case of not meeting this standard, the utility can be penalized financially or otherwise. Sometimes the minimum standard is only indicative and violating the standard does not lead to any penalties i.e. financial consequences. However, the regulator could bring the fact that the utility did not meet a certain standard to the attention of the media and public. This has an indirect effect which can be substantial as it affects the utility’s public image.

A minimum standard provides a clear boundary about what is “good” performance and what is “bad” performance. The minimum standard may even go further and penalize the company for substandard performance. Even if this penalty may not be high in absolute terms, it can have high symbolic value to customers.

In the case that the regulator aims at increasing performance, minimum standards provide clear guidelines about what quality network operators should aim at. They set quantitative targets for the companies to achieve. If combined with financial incentives for not meeting the standards, minimum standards can be very effective quality controls.

Overall, especially the design of a quality incentive scheme is not an easy task. Therefore a stepwise approach could be considered: In the short term the regulator will need to make sure that no uneconomic degradation of quality occurs, and in the longer term, after having gathered enough data, he will need to provide incentives apt to converge the level of quality towards a socially desired level.

In practice, the minimum standards are usually based on an internationally accepted standard.

Within the regulatory practice standards tend more and more to be set as guaranteed standards since they are easier to measure and to document. Guaranteed standards intend to protect the single customer and do not incentive the average performance of the regulated network operator.

The technical value of the quality is given generally by minimum standards or awaited ranks. The economic value of the quality is given by the minimum cost of the investments to guarantee a quality goal. Against this background, the existence of technical standards of quality without economic endorsement is current practice. Consequently, the existence of penalties for non respect of these standards without economic endorsement is current practice too. Political agreements, between the actors, emulating economic optimums and technical optimums seem to be the norm.

D. Targets, penalties and rewards for quality

Regulators set both price caps and some quality standards in the industries which they regulate. Since privatization, price levels which industries were allowed to charge under their cap generally decreased while the quality standards were being raised. Alternatively, the regulator could impose a particular level of quality, and make breach a matter for legal action. In this case the penalties are likely to depend on legal arguments, but should conform to the same principles as if penalties are applied by the regulator. Ideally any degradation away from the optimum level should confront the company with costs which are equal to the value of the total consumer losses. There may also be direct or indirect loss of revenue from degraded quality. However, most consumers do not have an alternative if a network fails, so revenue losses are small and costs need to be reflected in a financial penalty for the firm. In terms of incentives it makes no difference whether this is in the form of lower allowed revenue, fines or compensation, i.e. whether the money is paid to a central regulator or government fund or to consumers through lower prices or compensation. But there is clearly an attractive political and distributive argument that consumers who have suffered poor service should receive some compensation.

Researches shows that while the economic model is clearly useful in guiding decisions of regulators and responses of companies, the regulatory arena incorporates much broader considerations for both parties. The regulators operate within a much broader political context, while the companies are concerned not only with the politics of regulation, but the spin-off in terms of profitability in other (unregulated) markets. Regulators need to carry both public and political opinion with them in determining service quality levels, even when they suspect that this would not fit the strict economic model of balancing willingness to pay against improvements in service.

III. Conclusion

It is generally know that quality is an important aspect of the electricity service. Not only low prices are important, high quality also matters to customers. Price and quality are complementary; together they define the value that customers derive from consuming electricity. However, in spite of the obvious relevance of the quality of service for the consumers, the distribution activity is regulated but the quality is not in the heart of the regulatory models.

Up till now, literature on quality of service in regulated industries is relatively sparse. And most widely used benchmarking analyses in electricity distribution have involved models that incorporate standard output characteristics does not have included quality of service measures. Quality is a complex issue as it is composed to several parameters, each of them with its own characteristics. Determination of costs of lack of quality is extremely complicated.

Economic theory suggests that regulators should choose standards according to consumers' valuation and the marginal cost of quality improvements, and that firms respond by equalizing the marginal costs from not making improvements with the marginal costs of improvement. Incentive regulation causes a significant decrease in quality service if they are not accompanied by strict quality standards. Electricity distribution units face a clear trade-off between network investments and operational expenditures driven by quality performances.

The regulators operate within a much broader political context, while the companies are concerned not only with the politics of regulation, but the spin-off in terms of profitability in other (unregulated) markets. Regulators need to carry both public and political opinion with them in determining service quality levels, even when they suspect that this would not fit the strict economic model of balancing willingness to pay against improvements in service. Against this background, the existence of technical standards of quality without economic endorsement is current practice. Consequently, the existence of penalties for non respect of these standards without economic endorsement is current practice too. Political agreements, between the actors, emulating economic optimums and technical optimums seem to be the norm.

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