Regulating and improving the quality of electricity supply: the case of Italy

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Abstract

In the past nine years a number of European regulatory authorities have designed and implemented specific sets of rules with the objective of improving the level of quality in electricity networks. This paper focuses mainly on the experience of the Italian Regulatory Authority for electricity and gas in finding appropriate solutions for regulating continuity of supply in electricity distribution, during the years 2000 to 2008. We observe that the applied incentive mechanism has resulted in significant improvements of the continuity levels at an extremely low cost for consumers. The mechanism has also considerably evolved over time and 'learning along the way' has distinctively characterized the process. Several lessons are derived from the analysis of this experience: the centrality of data collection, the importance of a regulator's independence and commitment, the advantages of a gradual approach to quality, and the fundamental role of the consultation process.

1. Introduction

The quality of the electricity supply is a crucial issue for final consumers of all types and sizes. Consumers value the timeliness with which their requests are dealt with (commercial quality), the reliability of electricity supply (continuity of supply), and also the characteristics of the supply voltage (voltage quality). The literature, as well as some recent empirical work, indicate clearly that strong incentives in cost reduction – such as those implied in price-cap regulation and privatization of utilities – might decrease a firm incentives to invest in service quality. Nonetheless, the introduction of quality regulation in the electricity sector in Europe is still not as extensive as one would expect.

There are a number of reasons why regulating the quality of a transmission or distribution utility is not simple. First of all, there is the multi-dimensional nature of quality. Secondly, the ideal level of quality depends on consumer preferences, and these preferences can vary widely among customers. In addition, measuring quality can be difficult and consumers themselves can affect quality with their behaviour. In practice, there is no simple policy indication for service quality regulation: different means are normally used to induce regulated firms to deliver the desired levels of service quality on different quality dimensions [1].

In the past nine years a number of European regulatory authorities have designed and implemented specific sets of rules addressing the level of quality in electricity networks. These mechanisms, although inspired by the same theoretical framework, have adapted to the specific industrial and institutional factors of each country, as well as to national priorities and objectives, resulting in a variety of different regulatory designs. Indeed, theoretical references provide "relatively little direct guidance for empirical application in specific circumstances. Regulators need to find answers to a number of practical questions to apply the theory in practice in the design of actual incentive regulation mechanisms" (Joskow [2], p. 25).

Altogether, such diversity of approaches appears to have contributed significantly to the effectiveness of the regulation in practice. Moreover, this multiform experience can provide useful insights regarding the comparative incentive properties of the applied regulatory schemes, in terms of both short-term and long-term performance of network utilities.

This paper focuses mainly on the experience of the Italian Regulatory Authority for electricity and gas (AEEG) in finding appropriate solutions for regulating service quality in electricity distribution, during the years 2000 to 2008. We observe that the incentive mechanism has considerably evolved over time and 'learning along the way' has distinctively characterized the process - and it will do so in the future. Several lessons are derived from the analysis of this experience and indications are drawn on the expected development of quality regulation in the coming years.

The rest of this paper is organized as follows. Theoretical and empirical analyses of service quality regulation in the electricity industry are to be searched for in the technical as well as in the economic literature: Section 2 briefly summarizes the main contributions. Section 3 introduces a general framework for quality regulation in practice. The evolution of the Italian regulation is discussed in Section 4. Lessons learnt are presented in Section 5.

2. Literature review

In his survey of the theoretical literature on quality regulation Sappington shows that price regulation can reduce the level of quality delivered by a monopoly supplier when regulated prices are not allowed to "increase as the firm incurs greater costs to improve the quality of the services it provides" (Sappington [1], p. 130).[1] Moreover, the liberalization and privatization of utilities in the electricity sectors have created legitimate concerns on the effect that a generalized prevalence of the profit motivation could have on the quality of the services provided (P. Ranci, in [3]). In other words, the introduction of specific incentives for quality appears as a necessary measure to contrast the cost-reducing incentives implied in price-cap mechanisms and privatization.

In theory, an optimal incentive scheme specifies *(i)* performance standards and *(ii)* rewards and penalties - for exceeding and failing to meet the standards - that reflect customer valuations of quality. Hence, it implies that the regulator has sufficient information on consumer preferences. ``If the bonuses and penalties presented to the firm closely approximate the marginal benefits and costs to consumers of increases and decreases in quality, a profit-maximizing regulated firm will expand quality to the point

[1] In contrast, price ceilings that reflect realized costs can enhance incentives to increase service quality when service quality is costly to produce [1].

where the marginal benefit of additional quality to consumers (and thus the firms marginal reward) equals the firms marginal cost of increasing quality" (Sappington [1], p. 134). This is the desirable, welfare-maximizing level of service quality.

In practice, service quality is multi-dimensional and incentive mechanisms target several dimensions of quality at the same time (and are added to other incentive mechanisms pertaining to operational and capital expenditures).[2] Designing an incentive mechanism that will induce the regulated firm to deliver the welfare-maximizing levels of service quality on all relevant dimensions is, in practice, quite challenging [1][2].

Even if the theoretical literature on quality regulation is fully developed, only a few contributions provide a rigorous analysis of the relationship between theory and practice. In a recent work, Joskow offers an insightful, comprehensive valuation of incentive regulation as applied in the electricity transmission and distribution sector (with examples from Britain and the US) [2]. In his final observations, the author recalls the centrality of data collection, the problems posed by the uncertainties on the value of the energy-not-served, the growing complexity of the 'portfolio of incentive mechanisms' utilized by regulators, the evolutionary nature of the regulatory process, the dependence of the incentive regulation from the attributes of the restructuring and liberalization process of which it is part, and the lack of empirical research on the performance of the regulation in electricity networks. Another interesting contribution in this area is the paper by De Fraja and Iozzi [5]. The authors demonstrate that a regulator, who is well informed about consumers' marginal valuations of quality, can modify Vogelsang and Finsinger's [6] regulatory mechanism to induce a regulated monopoly to set welfare-maximizing prices and quality levels. In doing so, they provide a robust theoretical foundation for the practice, adopted by some regulators, to include a quality adjustment factor in the price cap formula.[3] A third work, by Weisman, provides a formal analysis of the properties of commonly used reward and penalty schemes and investigates

[2] Ideally, incentive regulation would integrate all costs and quality dimensions of a regulated firm in a unique framework that would provide balanced and efficient incentives on all relevant dimensions of the firm performance. In practice, operating expenditures, capital costs and quality of service are addressed by different incentive structures. This has been the main variation between incentive regulation in theory and in practice [2][4]. Although this 'fragmented' approach to incentive regulation does not conform to the integrated theoretical reference, it "has performed well and has given the regulator the flexibility to address and incentivise specific aspects of network regulation" (Jamasb and Pollit [4], p. 6183).

[3] At the same time, they find that, in the absence of further constraints on the firm's choices, the outcome is not necessarily socially optimal [5].

specifically the incentives they provide for investments in service quality [7]. The author finds that a regulated firm incentives to invest in service quality increase with the level of the price cap, the application of profit-share penalties, the regulated firm's participation in complementary competitive markets, and with information dissemination concerning compliance with service benchmarks. Finally, Ajodhia and Hakvoort offer a well-organized description of the objectives, methods, and difficulties of regulating the quality of electricity distribution networks [8]. They signal that information problems hinder the development of effective quality regulation schemes and suggest that, at some point, the benefits of stricter price regulation will not outweigh the additional regulatory costs of setting in place adequate quality regulation.

As far as empirical research is considered, the interest for quality of service in the electricity industry has considerably increased in the last few years. A first concern is that cost efficiency in electricity distribution can be achieved at the expense of important non-tradable aspects of the service, such as quality (and/or network energy losses). A strictly related question regards the effectiveness of the specific quality regulation.

The issue of effectiveness was addressed by Ajodhia *et al.* in an evaluation study of the Italian quality regulation in the distribution sector, at the end of the first regulatory period (2000-2003) [9]. The authors observe a considerable reduction in the average duration of interruptions and investigate the determinants of these results. Several factors appear to have contributed to the achievement of the regulatory objectives: among these, the fairness of the quality measurement system played a fundamental role. Finally, the authors indicate that longer term effects of quality regulation is a crucial issue that has not yet received adequate attention by regulators.

The work by Ter-Martirosyan, addresses both the questions above [10]**.** Using a panel data set that includes 78 major electric utilities from 23 states of the U.S., the author shows that price-cap regulation reduces the utility's operational and maintenance expenses at the distribution level, which engenders an increase in the duration of electric outages. Nonetheless, she finds also that the implementation of explicit quality benchmarks reduces the average duration of outages per customer.

Two papers investigate the relationship between efficiency and quality for the UK distribution sector. Giannakis *et al.* employ a Data Envelopment

Analysis (DEA) technique on a panel of electricity distribution utilities, between 1991/92 and 1998/99 [11]. They find that cost-efficient firms do not necessarily exhibit high service quality and that efficiency scores of cost-only models do not show high correlation with those of quality-based models. Their results demonstrate that *(i)* improvements in service quality have made a significant contribution to the sector's total productivity change and *(ii)* integrating quality of service in regulatory benchmarking is preferable to cost-only approaches. Similarly, Yu *et al.* calculate technical and allocative efficiency of the 14 distribution networks in the UK between 1990/91 and 2003/04 using the DEA technique [12]. They incorporate in the analysis both service quality and energy losses. Their results show a relatively low allocative efficiency - *i.e.* a mismatch in allocating resources among expenditures, service quality, and energy losses - and suggest that UK utilities may not be sufficiently incentivised to achieve socially optimal input bundles, under the existing regulatory scheme. The evolution of the British incentive regulation (over the period 1990-2007) is analysed in great details in the work of Jamasb and Pollitt [4]. Their work shows that the regulation provided adequate incentives for utilities to reduce costs, prices, and energy losses while maintaining quality of service. They also derive a number of lessons of experience, that are mostly in line with our own conclusions (Section 5).

An efficiency analysis of electricity distribution networks was conducted also by Growitsch *et al.*, using a sample of about 500 electricity distribution utilities from seven European countries [13]. The authors apply the stochastic frontier analysis (SFA) method to estimate cost and scale efficiency with and without incorporating quality of service. They show that introducing the quality dimension into the analysis affects estimated efficiency significantly. On the contrary, scale economy measures are not altered when quality of service is considered. Overall, their work emphasizes that quality of service should be an integrated part of efficiency analysis and incentive regulation regimes. Similar conclusions are found by Korhonen and Syrjänene (analysing a sample of 102 Finnish electricity distribution companies) [14].

Finally, Reichl *et al.* explore the relationship between tariff regime and service quality for the Austrian distribution sector [15]. In contrast with previous work, firms in their sample operate in a framework where service quality is not regulated. They find that *(i)* the correlation between tariffs and quality is significant and *(ii)* a decrease on tariffs leads, even in a short time frame, to a lower supply reliability. The econometric estimates show that a 1 €/MWh decrease in the distribution tariff results in a 1.36 minutes increase in the annual average interruption duration per installed capacity in the following year.

A more technical area of the literature provides interesting assessments of national experience with quality regulation in electricity networks. This includes Tersztyanszky [16] on Hungary, Lo Schiavo *et al.* [17] on Italy, Langset *et al.* [18] and Seljeseth *et al.* [19] on Norway, Rivier and Gòmez [20] on Spain, and Nilsson [21] on Sweden. This work confirms the effectiveness of incentive mechanisms in improving regulated (and sometimes also non-regulated) quality dimensions. In addition, the Council of European Energy Regulators (CEER) periodically issues a benchmarking report on quality regulation (the third was published in 2005, and the fourth in 2008) [22][23].

3. Quality regulation in practice: an overview

The quality of the electricity supply is described by a large number of attributes, both technical and non-technical, and it is affected by the choices of different operators in all segments of the electric system, from generators to consumers. We focus here on the distribution and retail sectors. In this domain, regulators employ in practice different *instruments* to achieve different regulatory *objectives*, in different *areas* of service quality. This model is illustrated in Table 1, where objectives are linked to instruments and areas of quality [3].[4]

A first area of concern for consumers includes the numerous non-technical aspects that arise in the relationship between the customer and the service providers (the distributor and the supplier/retailer). *Commercial quality* is concerned with the timing and/or accuracy of services such as the provision of a new connection, meter reading, billing, handling of customer requests and complaints.

Technical aspects of service quality are generally referred to as 'power quality' issues and include any variations of the voltage or current characteristics around their ideal values. So far, regulation has addressed two main areas of technical quality within the larger field of power quality:

[4] An empty space signals that a regulatory instrument corresponding to the relevant objective and area has not yet been employed in Europe.

continuity of supply, which focuses on interruption events, and *voltage quality* which covers a subset of the possible variations of the voltage characteristics from the desired values (for instance, voltage dips).

Table 1: <u>*A general framework for service quality regulation*</u>

	Collecting information and making it available	*Protecting the worst-served customers*	*Promoting quality improvements*	*Favouring market-like mechanisms and competition*
Commercial quality	Regulatory instructions for recording customer requests	GS on making and keeping appointments	RPS on the quality of call centres	Competition in providing connections
Continuity of supply	Regulatory instructions for recording interruptions	GS on the duration of an interruption	RPS on the average interruption duration	Premium quality contracts on the number of interruptions
Voltage quality	Measuring campaigns	Voltage quality standards		Premium quality contracts on supply voltage variations

Experience shows that regulators pursue four main objectives. The first objective, *making information available* to consumers, is best achieved by means of *publication* and *cross-company comparative publication* of performance (publication is any method used by the regulator to inform consumers and includes, for instance, bill inserts, media announcements, and website posting).

Note that, to ensure fairness and credibility of any regulatory instrument, performance data on the relevant quality dimension(s) must be collected in a 'regulated' manner. A fundamental part of the regulation in practice, *instructions and guidance on performance measurements* defines how a certain quality dimension should be measured, registered and reported to the regulatory authority. These rules apply equally to all regulated firms and are consistent with the scope of the regulatory framework. In addition, they enable the regulator to control the process of data collection. Service quality raw data are, in fact, in the hands of regulated companies. For this reason, quality regulation is normally supported by periodic *audits,* conducted on the field to verify the accuracy and robustness of the data (*i.e.* the compliance with the measurement protocol).

A second objective of quality regulation is to *protect worst served customers*. The instrument employed, Guaranteed Standard (GS), has a relatively simple structure: the regulator specifies performance standards[5] in the form of a minimum level of service quality that a firm is expected deliver to its customers. Non-compliance with these levels of quality normally entails the payment of penalties directly to the affected customer. This instrument can be valuable especially when the company tends to deliver particularly low levels of service quality to a group of customers.

For several years protecting worst served consumers was the sole objective of service quality regulation and GS the only regulatory instrument employed. Only from the year 2000, a number of EU countries began introducing *Reward and Penalty Schemes* (RPS), a regulatory instrument aimed at *promoting quality improvements*.[6] As illustrated in Figure 1, under this incentive structure, the regulated tariff (the allowed revenues) of a regulated firm is (are) increased or decreased in proportion to *(i)* the distance from the performance standard, set by the regulator, and *(ii)* an incentive rate, defined as a monetary value per unit change in quality. As discussed in Section 2, incentive rates should closely reflect customer valuations of quality. RPSs are complex to design and to implement; nonetheless, where already in use, they have delivered extremely positive results. As of today, RPSs and GSs are used both alternatively or complementarily in a large number of European countries.[7]

[5] Performance standards specify the level of quality that the company is expected to supply.
[6] RPSs were introduced in Italy in 2000, in Norway in 2001, in Great Britain and Ireland in 2002, in Hungary and Sweden in 2003, in Portugal in 2004, and more recently in The Netherlands and Estonia. A strong interest exists for RPSs in several EU countries, including Finland, Lithuania, France, Poland, Spain, and Slovenia [22].
[7] Note that GSs require the regulated quality dimension to be measurable for the single customer and/or for the single transaction. On the contrary, RPSs refer to the average level of quality, rather than to the quality level received by the individual consumer. Measures used for RPSs are calculated on a statistical basis, within given limits of space (for instance, a distribution territory) and time (for instance a year).

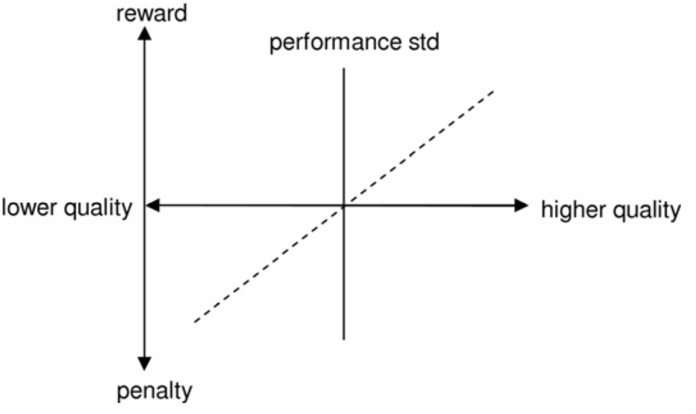

Figure 1: Rewards and penalties scheme: basic structure [3]

A fourth and last objective of quality regulation in practice is to *favour market mechanisms*, where quality and price are negotiated between customers and regulated firms. To this end, regulators may allow firms and customers to enter *premium quality contracts*. They specify individual performance standards and prices for the service, as well as individual compensation payments. These are paid by the firm if it fails to deliver the quality specified in the contract.[8] These contracts are especially useful for customers with a high valuation of service quality.[9]

4. Quality regulation in practice: the case of Italy

The current regulatory framework for quality regulation in Italy is the result of a process that started in the year 2000 and has evolved gradually over 3 review periods (2000-2003, 2004-2007, 2008-2011). Although the overall framework covers all three areas of service, for reasons of brevity we focus here on the evolution of the regulation in the area of continuity of supply. This experience illustrates the many practical challenges involved and the

[8] Premium quality contracts are implemented in France, in Norway, and are available, on a voluntary base, in Italy.

[9] In theory, premium quality contracts have the considerable advantage of revealing consumer preferences and to provide incentives for the firm to deliver differentiated levels of service quality accordingly [23]. In other words, premium quality contracts enable the firm to improve quality locally without affecting the general tariff (as it is in the case of RPSs); however, they are vulnerable to free riding: a consumer could benefit from the quality improvements requested by another, without entering a contract. Moreover, they imply well-informed consumers, capable of assessing the potential benefits of choosing a customized level of quality (normally on many dimensions) and of evaluating their quality-related costs. In practice, such contracts have not been widely employed.

'learning along the way' aspect of this process.

In the year 2000 the Italian regulatory authority introduced a RPS that linked the electricity distribution tariff to an output measure of continuity of supply: the average duration of interruptions per consumer - SAIDI indicator - for long (longer than 3 minutes), unplanned interruptions.[10] This indicator is measured separately in more than 300 territorial districts, covering the entire national territory (each district includes municipalities that are homogeneous in population density, that are located in the same province and whose network is managed by the same distribution company). Financial incentives are calculated per district on an annual basis, as a function of the difference between a target-SAIDI and the actual-SAIDI. The national distribution tariff, p_t in year t changes according to a modified price cap formula:

$$p_t = p_{t-1} \cdot (1+RPI-X+Q)$$

where *RPI* is the retail price index, *X* is the efficiency gain and *Q* is the quality adjustment. Yearly values of the parameter *Q* are calculated, *ex post*, on the basis of companies' performances and can assume a negative or a positive sign. When *Q* is positive (negative), it means that, at a national level, quality has improved more (less) than required and consumers are called to contribute (consumers pay a reduced tariff).

4.1. Main regulatory objectives

In terms of regulatory objectives, the incentive scheme was designed *(i)* to improve the overall continuity of supply and *(ii)* to reduce the gaps in service quality levels existing among different regions, especially between the South and the North of the country. The second objective, totally peculiar in the European context, has been maintained during the three regulatory periods and it is strictly related to the existence of a unique, national distribution tariff.

Accordingly, performance standards are defined separately for each territorial district. This 'decentralized' approach allows regulated firms to choose their level of quality and, at the same time, it enables the regulator to expect greater

[10] Continuity of supply is described by the number and duration of supply interruptions. For a given distribution area and time period, the average duration of interruptions per consumer is measured by SAIDI (System Average Interruption Duration Index) and the average number of interruptions per customer by SAIFI (System Average Interruption Frequency Index) [25].

improvements from companies that are underperforming with respect to the national average level and vice-versa. Since the second regulatory period, baselines are calculated using a formula that assumes a convergence in performance of all districts with equal population density to the same quality level, in the medium term (12 years) [26]. In particular, for a district *j*, the performance standard (*PS*) changes over time *t*, according to:

$$PS_{j,t} = PS_{j,\,t-1}\,(1-\alpha_j)$$

$$\alpha_j = max\left[1-\left(\frac{obj^k}{init_j}\right)^{1/12};\ 2\%\right]$$

where

obj^k is the quality level that was set as the medium term objective for districts of density *k*;

$init_j$ is the actual level of quality for district *j*, at the beginning of the regulatory period.

An important issue in setting the baseline is the periodicity of the quality reviews (coincident with the price review and conducted every four years). As indicated by the formula above, recalculation of the baseline accounts for the actual level of quality, measured at the end of the previous regulatory period. In other words, any benefits of quality improvements cannot be retained beyond the duration of the review period. This mechanism is similar to the periodic adjustment of the price-cap and it allows the transfer to consumers of the quality improvements attained by the company.

4.2. Scope of the regulation

In contrast to regulatory objectives, the number of regulated quality dimensions has significantly evolved over time. In the first regulatory period only one indicator entered the incentive scheme (both for the sake of simplicity and because the information available to the regulator was quite modest). Moreover, the measurement protocol required companies to classify interruptions according to three categories: *(i)* Force Majeure, *(ii)* external causes, *(iii)* utility responsibility. The actual-SAIDI used to calculate rewards and penalties did not include contributions from interruptions belonging to the first two categories, nor interruptions due to transmission or high-voltage, meshed networks.

Important changes were introduced in the second regulatory period, to fine tune the boundaries of the utility responsibility. First came the idea that regulated companies could take precautions to limit the faults caused by third parties (for instance, digging activities). Following an extensive consultation, regulated companies were given the choice to include these events in the incentive scheme (performance standards were thus revised accordingly) [26].

Secondly, AEEG addressed the issue of exceptional events. In the first period, distributors were allowed to attribute an interruption to Force Majeure only if the exceptional nature of the event could be proven by technical or administrative evidence. For instance, a formal declaration of calamity made by the government or measures of wind speed made by an independent weather centre. In practical terms, this procedure turned out to be rather burdensome both for the companies, that were collecting the data, and for the regulatory authority, that was controlling the documentation provided. In addition, a few controversial cases, where the exceptional nature of the event was claimed by the companies, but could not be formally proven, generated a large amount of disputes. In 2003 AEEG studied a different procedure, that would identify exceptional events on the basis of a statistical methodology.[11] A statistical method has several advantages: it simplifies the administrative procedures; it reduces the costs incurred by companies and by the regulator in order to, respectively, provide and control the correct attribution of responsibility; and it is easy to understand (only widely known, simple statistical concept such averages and standard deviations are normally used). Given the choice between the two approaches and beginning from the second regulatory period (2004-2007), most of the distribution utilities opted for the statistical method – which performed well in the large majority of cases.

Finally, to balance the attention given to interruption duration, a GS was introduced on the number of long unplanned interruptions for users connected at the medium voltage (MV) level (business customers, in manufacturing and tertiary sectors), as a form of protection for worst-served consumers. Note that distribution companies that do not fulfil the individual standards are always obliged to pay the penalties; on the contrary, customers are entitled to receive a compensation only if their protection system is deemed technically adequate (so that internal disturbances do not

[11] The methodology identified an extreme region in the daily SAIFI-SAIDI plane, where exceptional events belong to. For the sake of simplicity, the region boundaries were defined using thresholds defined by functions of the mean and of the standard deviation of daily SAIDIs and SAIFIs [27].

propagate to the distribution network). When consumers are not entitled to receive the penalties, these are used to decrease the (national, unique) distribution tariff.

By the end of the second period, the SAIDI indicator had improved by 70% with respect to the 1999 level (Figure 2). Regulated companies had responded to the incentive scheme by increasing capital expenditures, by upgrading the level of network automation and by modifying their network management techniques [9][28]. Thus, for the third period, the regulator confirmed the application of incentives to the SAIDI dimension, but enlarged also the scope of the incentive scheme to additional quality dimensions. In particular, a few innovations are noteworthy:

- the inclusion, in the RPS, of a further quality dimension: the frequency of interruption (in addition to the duration) – a choice that indicates a stronger attention to network reliability;
- the inclusion, in the RPS, of short interruptions (shorter than 3 minutes): the standard for the frequency of interruptions includes the number of both short and long interruptions - an extremely innovative decision in the European scenery, given that short interruptions are much more damaging for business customers than they are for household customers;
- the introduction of GSs on maximum restoration times, with the objectives *(i)* to protect customers in case of very long and widespread interruptions, including those caused by exceptional events, *(ii)* to introduce incentives for utilities to ensure prompt supply restoration under all circumstances (within the boundaries of ensuring safe working conditions for their personnel);
- the inclusion in the incentive scheme of small utilities (previously exempted).

In addition, an important refinement in the analysis of exceptional events became possible because of the availability of data on the number of faults on medium voltage (MV) and low voltage (LV) networks.[12] These data had been included, since 2004, in the interruption registers kept by regulated utilities and are now used to separate exceptional events from normal events (with a new, refined statistical methodology) in the application of both the RPS and the GS [29].

[12] The number of faults is a good, technical indicator of network performance and one closely linked to the physical operation of the grid.

4.3. Economic rewards and penalties

In the first regulatory period, specific information regarding customer valuations of higher and lower levels of quality was very limited. Nonetheless, AEEG managed to define a workable incentive scheme relying on the idea that, as long as quality was below the efficient level, penalties and rewards should have been large enough to provide meaningful incentives for the companies to improve quality. In other words, incentives were calibrated to be at least greater than the estimated costs incurred by companies to provide a unitary improvement in quality.

Before the second regulatory period, a customer survey was conducted to investigate consumer willingness-to-pay (WTP) for quality and the results of the survey were used to redefine penalties and rewards [30].[13] From a methodological perspective this procedure is more correct. In addition, two different valuations of quality were considered in the incentive scheme to reflect, in the calculation of rewards and penalties, the different WTP of domestic and industrial customers. This approach was confirmed for the third review period.

The issues with customer surveys are numerous. Although surveys provide useful information, results are difficult to transpose in 'monetary amounts per energy-not-served' to be used in the incentive schemes. Differences in WTP between consumer groups (and within groups), regions, as well as type and duration of interruptions, can be remarkable. The approximations that are necessarily introduced raise concerns regarding the ability of incentive schemes to reach socially efficient levels of quality. Beginning from the second period, lower and upper boundaries were defined to limit the financial exposure of, respectively, customers and firms with respect to quality-related performance.

4.4. Measuring requirements and audits

AEEG has devoted considerable attention to the collection of data since the introduction of quality regulation. Measuring, registration, and reporting rules are the foundation of the incentive scheme. The level of standardization, completeness and the quality of the data collected have

[13] Surveys have been conducted in other European countries, including Great Britain [31], Norway [32] and Sweden [33].

significantly increased since the year 2000. Audits on data and recording procedures have been conducted regularly by AEEG (by internal personnel) and the auditing procedure has been refined over time. In addition, information on quality-related performance of Italian distribution utilities was made available to the larger public by means of an on-line data set, accessible through the AEEG website.

Italy is the "frontrunner in terms of smart meter installation with the 86% of the LV customers already equipped with smart meters" (Vasconcelos [34], p. 25). The Italian experience shows that numerous benefits can derive from the smart meters in terms of service quality regulation. Smart meters enable, for instance, the exact identification of the LV customers that are affected by an interruption. This increases the accuracy in measuring continuity indicators and, more importantly, it introduces the possibility to pay automatic compensation to individual LV customers (vs. compensations upon request). Distribution companies that are able to automatically detect which customers are affected by an interruption by means of smart meters are entitled to receive, from AEEG, a one-off economic incentive. An additional important benefit of smart meters is, among others, the possibility to manage customer requests remotely.[14]

Looking forward at some of the future development of quality regulation, we note that, after years of work devoted primarily to commercial quality and continuity of supply, AEEG (as well as other European energy regulators) is becoming increasingly involved with the regulation of voltage quality. According to the principle that technical and economic indicators are the fundamental elements of and the precondition for the design of incentive regulation, AEEG initiated, in 2006, a measuring campaign to acquire data regarding the current level of voltage quality supplied to MV end-users.[15] Moreover, in 2007 AEEG conducted a study to estimate the costs sustained by end-users for very short interruptions (shorter than 1

[14] In Italy all LV customers (up to a rated-power of 30 kW) are equipped with a breaker that limits the power withdrawn from the grid at the rated value. In case of non payment, smart meters enable companies to reduce the rated-power, avoiding a complete disconnection of the customer and, similarly, to restore the full rated-power in a very short time after due payment (both operations are performed remotely, without crew intervention).

[15] The data are collected by two sets of power quality recorders: 400 recorders were installed on MV-bus bars of High-Voltage/Medium-Voltage transformers (chosen to represent a statistically significant sample) and 200 were installed, on a voluntary base, either on MV customer connection points (73) or on distribution networks (127), by users and distribution network operators. The peculiar feature of this monitoring system is the fact that all the measures are collected in a database that is publicly accessible through the Internet [35].

second) and voltage dips.[16] Finally, AEEG has been actively collaborating with other European energy regulators and the European Committee for Electrotechnical Standardization (CENELEC) to review the European Standard "Voltage characteristics of electricity supplied by public distribution networks" (EN 50160) [37][38]. The revised version of the EN 50160 (currently under CENELEC voting procedure) contains a number of important innovations that should facilitate customer protection against voltage disturbances [39].

4.5. Consultation and RIA (Regulatory Impact Assessment)

Consultation has always been at the basis of the decision making process of AEEG. An open and thorough consultation improves the quality of the decisions and, by increasing transparency and understanding of the regulator's work, it creates consent with respect to the policy solutions that are proposed and implemented [40].

The complexity of quality regulation is revealed also by the above-average complexity of the consultation process that has generally characterized the AEEG decisions in this area. For the second review period, consultation started eight months in advance (April 2003) with a document that contained a large share of quantitative information and data regarding the effects of the regulation. For the first time in the AEEG experience the process included multiple consultation rounds and also the number of public auditions was unusually large. The final deliberation contained also an assessment of the expected impact on tariffs, in different scenarios of improvement for the regulated dimensions.

The transition from the second to the third period saw an important innovation: the application, in the decision process, of the Regulatory Impact Assessment (RIA) methodology. In principle, a RIA is intended to provide a structure for evidence-based policy-making by *(i)* opening the spectrum of the policy alternatives, *(ii)* including stakeholder opinions in the decision-making, and *(iii)* by assessing the impact of the proposal in terms of cost, benefit and risk. Quality regulation was selected as an area for testing the application of the RIA methodology - together with other

[16] The research project concerned Italian industrial consumers connected to MV distribution networks and it had two practical objectives: *(i)* to estimate cost indicators for the single users and industrial sectors; and *(ii)* to estimate the significance of these costs for the Italian economy [36].

regulations including tariff setting - within a three-year trial period commenced by AEEG in 2005.

Accordingly, the second revision of service quality regulation started earlier than the first (15 months in advance, in September 2006) and contained different options regarding both the regulation of distribution quality as well as the quality of the transmission network.[17] The experience with complex consultation procedures was extremely useful in the analysis of the options and availability of high quality data was crucial in the assessment of costs and benefits. Along the way, some initially preferred options were confirmed, while others were radically modified thanks to both comments received during consultation process and to qualitative and, when possible, even quantitative analysis of different options. This supported the idea that, indeed, the RIA methodology represents an instrument for 'better regulation'.

4.6. Results of incentive regulation: improvement in continuity of supply

The Italian incentive scheme was successful in obtaining remarkable improvements of the regulated indicator (and partly also of the unregulated ones) at an extremely limited costs for consumers.

As illustrated in Figure 2, the average duration of interruptions per customer improved from 192 minutes lost in 1999 to 58 minutes lost in 2007 (- 70% in 7 years) and gaps in continuity of supply between the Northern and Southern regions of the country have been visibly reduced (Figure 3). Benefits were observed also in terms of a reduction in the number of long interruptions per customer (-43% in 7 years) even though SAIFI was not considered within the RPS until 2008 (Figure 4). In contrast, the increase in tariffs that derived from the incentive scheme was very small: it amounted - net of penalties paid by distribution companies that did not fulfil the standards - on average, to 3 €/customer/year and to 4 €/customer/year (including all customers), respectively in the first and second regulatory period. The impact on tariffs for household customers was lower than the average value.

[17] As for transmission networks, measurement rules and publication of quality data had been the only regulatory instruments employed in previous regulatory periods. Since the third period, a RPS applies, based on two quality dimensions: the energy not supplied and the number of interruptions per customer [41].

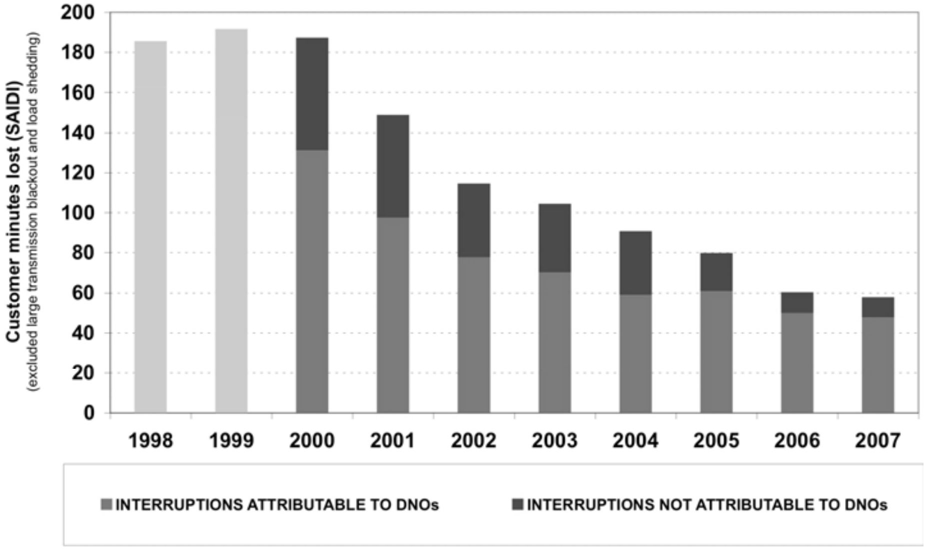

Figure 2: <u>Customer minutes lost (1998-2007)</u>

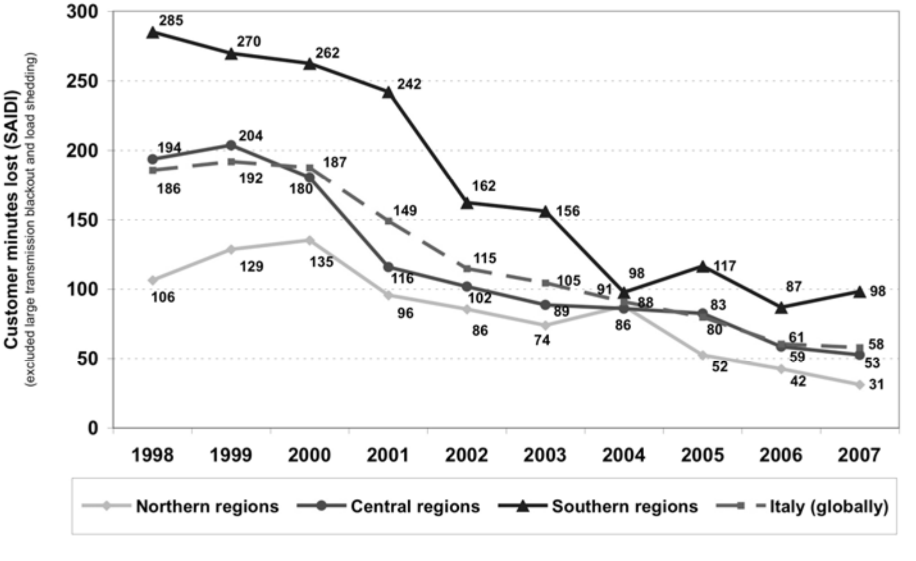

Figure 3: <u>Customer minutes lost per regions (1998-2007)</u>

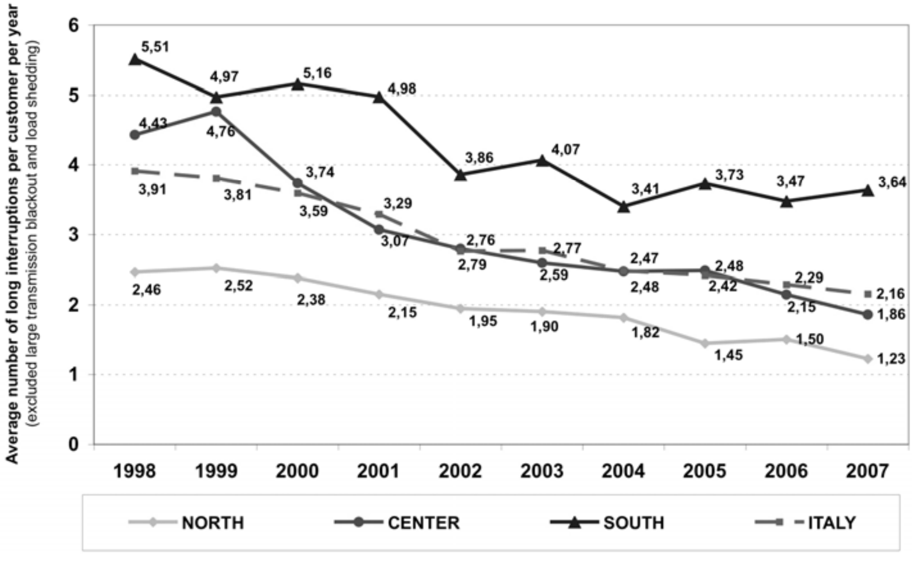

Figure 4: *Number of long interruptions per customer per year (1998-2007)*

5. Lessons of experience

There are a few interesting lessons that can be derived from the experience with quality regulation in Italy and in other countries in Europe. Indeed, sharing of information and good practices between regulators, firms and other stakeholders is important for quality regulation to evolve and improve.

First, measurement rules play a fundamental role in ensuring fairness in service quality regulation. Too little attention has been paid so far to this fundamental element of the regulatory process, often dismissed as merely technical. On the contrary, measurement rules are as important for quality management as accountancy rules are for cost management. Regulatory authorities that are active in this field have invested a considerable amount of time and resources in defining simple and viable rules for measuring quality indicators, in standardizing reporting formats, and in defining the boundaries of utility responsibility. These rules are the results of an open dialogue with the regulated companies, they are accompanied by a fieldwork of training and renewal of information systems, and they are regularly verified and "fine-tuned". Viable and fair measuring rules enable the regulator to avoid disputes in subsequent phases of the work, when company performances are evaluated and rewards and penalties are assigned.

Second, "incentive regulation in practice is clearly an evolutionary process. One set of mechanisms is tried, their performance assessed, additional data and reporting needs identified, and refined mechanisms developed and applied" (Jokow [2], p. 81). Quality regulation normally begins with a few quality dimensions and it evolves over time (when visible results have been captured and before possible side-effects appear)[18] to continue to meet customer needs. Indeed, an equilibrium is to be maintained between practical feasibility and the complexity of the real world. It is important to note that an evolutionary approach enables regulators to deal with the inherent multi-dimensional nature of quality in an efficient manner: learning along the way and maintaining a good level of flexibility in addressing new aspects of quality. Likewise, it is important to remember that periodical reviews should give to the regulated companies the necessary amount of time for making investment and operation decisions under stable regulatory conditions.

Third, regulatory objectives and resolutions should account for the specific industrial and institutional factors of each country. Although this creates differences across Europe, it also appears to contribute to the effectiveness of each regulatory framework. Similarly, independence of the regulator (but also his accountability), the power of his mandate and the commitment to address quality-related issues are important factors in the success of the regulatory process. Note that the existence of an independent regulatory authority with strong, direct powers over the industry, is necessary for the introduction of a quality regulation, but is not at all sufficient. Indeed, it is very important that the agency in charge of setting the tariff develops a deep-rooted commitment to quality improvement, and a determination in pursuing this objective - in particular, through continuous attention to the implementation work (for instance, auditing, on site, the data provided by companies).

Fourth, a regulatory policy for service quality leads to efficient outcomes when regulator, regulated companies and consumers are able to dialogue in an open manner, with reciprocal trust, and acknowledgment of the efforts

[18] Side effects could appear when companies focus their attention on the regulated quality indicators and disregard other aspects of service quality.

that each of them is making towards the common objectives. In this situation the inevitable mistakes are not only sanctioned and corrected, as indicated by the rules, but they are also an opportunity to learn and to introduce improvements. Effective consultation and transparency in the decision process have been at the basis of the success of quality regulation in practice.

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