CONTINUITY OF ELECTRICITY SUPPLY REGULATION DRIVEN BY ECONOMIC INCENTIVES: DOES IT WORK? THE ITALIAN EXPERIENCE

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INSTITUTIONAL BACKGROUND

In Italy the Regulatory Authority for Electricity and Gas (Autorità per l’energia elettrica e il gas, AEEG) is responsible for the regulation and control of quality in both sectors. The Law n. 481/95, that instituted AEEG, pays close attention to quality regulation. Customers protection and quality improvement are among the main goals pursued by the Authority, which has the legal powers for setting compulsory quality standards, associated either with individual compensations or with general tariff adjustments related to quality actual achievements.

To ensure the maximum level of accountability in its decisions, no decision is taken without a consultation round. AEEG issues consultation papers containing guidelines and proposals before it takes any decision on quality standards. Consultation papers are published on AEEG web site and all involved stakeholders are invited for views before the final decision. During the consultation process, all concerned parties may formulate questions, offer comments, and submit written proposals. On the occasion of important decision-making, formal hearings are organised with the main stakeholders (utilities, consumer associations, trade unions, environmental associations, technical bodies and associations, etc.).


Continuity data measurement

The regulatory order n. 128/99 introduced homogeneous rules for Distribution Network Companies (DNOs) in order to record interruptions of supply.

Firstly, interruptions have been classified as follows:
- unplanned interruptions vs. planned interruptions (to be considered as “planned”, customers must receive notice at least one day in advance);
- kind of interruption: long interruptions (duration > 3 minutes) vs. short interruptions (1 second < duration ≤ 3 minutes) vs. transient interruptions (duration ≤ 1 second).

Secondly, the Italian territory has been classified into three density levels:
- high density (urban) areas: municipalities with more than 50,000 inhabitants;
- medium density (suburban) areas: municipalities with more than 5,000 and less than 50,000 inhabitants;
- low density (rural) areas: municipalities with less than 5,000 inhabitants.

Thirdly, for each interruption, a list of items that must be recorded has been set, among which:
- the cause of interruption;
- the voltage level of the fault that originated the interruption;
- number of LV customers affected;
- the duration of the interruption.

Fourthly, all the information recorded for each interruption must be documented and kept by DNOs. Each year DNOs shall submit main continuity indicators to AEEG, that is the average yearly number of interruptions per LV user (Customer Interruptions, CIs, or SAIFI) and the average yearly cumulative interruption duration per LV user (Customer Minutes Lost, CML, or SAIDI), separately for each kind of interruption, for each grade of density, for each cause and for each voltage level. The continuity indicators are obtained as weighted sum of the single recorded interruptions events, using the number of users affected as weights.

Yearly continuity indicators provided by DNOs are used to assess the improve ment and to distribute incentives and penalties. AEEG makes regularly audits to check that interruptions are recorded in accordance with compelling requirements and that provided data are consistent with single records. Some indices are used to determine whether data provided by DNOs have to be considered valid or not.

CML regulation scheme

The continuity regulation was enforced for the first price-control regulatory period (2000-2003) devising a link between the continuity of supply and the tariff, through a quality-adjusted price-cap formula (regulatory order n. 202/99). The continuity regulation in the first regulatory period focused on CML due to long unplanned interruptions ascribed to DNOs responsibilities due to faults originated on MV and LV networks (reference indicator). The main objectives of CML regulation scheme were the following:
1. enhance the overall level of continuity in Italy and bring the country’s average level closer to European benchmarks [2];
2. bridge the gaps between North and South, reducing the differences among regional continuity levels;
3. avoid continuity deterioration in those areas where actual levels were already good.

A detailed description of regulatory mechanisms for continuity of supply enforced in Italy in the first regulatory period can be found in [1]. The most important mechanisms for CML regulation scheme are:
- mechanisms devised to mitigate volatility in distributors’ performances, due to weather effects (the two-years rolling
average of the reference indicator is used);
-application of the CML regulation separately for small territory cells called “districts” (continuity indicators are separately measured in more than 300 districts);
-nation-wide reference standards that indicate the optimal level of continuity for each grade of density;
- compulsory improvement baseline: for each district, a minimum improvement is required from the starting actual level, it being higher where the starting situation is worse;
-economic incentives and penalties, symmetrically associated to over- or under-performance with respect to the compulsory improvement baseline (companies performing in line with the compulsory improvement baseline neither receive incentives nor are subject to penalties);
-definition of an incentive system funded both by DNOs, through the penalties paid for underperforming districts, and by customers, in case incentives exceed penalties.

The tariff has been adjusted using a parameter \( Q \), in the price-cap formula:

\[
\Delta P [\%] = RPI - X \pm Q.
\]

The Q-factor is calculated ex-post in order to collect from customers (or to give back to customers) the net difference between incentives and penalties. The Q-factor may assume a negative or positive sign (it’s null if in each district the actual improvement is equal to the compulsory improvement: in this case the tariff is not impacted, meaning that the compulsory improvement is embedded in the base tariff).

In the case \( Q>0 \) incentives are higher than penalties, so as a whole the system improved more than required, and all LV and MV customers are called to contribute to the costs of the improvement. On the contrary, when \( Q<0 \), the whole system improved less than required, and all LV and MV customers benefit from a reduction in tariffs.

**Main effects of the CML regulation (2000-2003)**

The effects of CML regulation can be assessed in three ways: in light of the objectives set at the beginning of the 2000-2003 regulatory period, of the cost incurred by customers for the effective implementation of the regulation mechanisms and of customer satisfaction.

At nation-wide level, CML due to all long unplanned interruptions, for all causes, declined from 192 minutes lost in 1999 to 104 minutes lost in 2003. The overall improvement is largely the result of the improvement of the reference indicator which decreased from 147 minutes lost in 1999 to 70 minutes lost in 2003 (Figure 1; note that 2000-2003 continuity data have been recomputed using the actual number, instead of the estimation, of the interrupted customers).

At regional level, southern regions (where starting levels were worse) recorded better improvement rates, thus confirming the “convergence” structure of the incentive scheme. The improvement in CML (46% over 4 years) also led to a benefit in terms of reduction in CIs (28% in the same period). Regarding the impact on tariffs due to the incentives paid out net of penalties collected, it was equal to around 3.00€ per customer per year (around the half for domestic customers).

As far as customer satisfaction is concerned, the figures gathered by ISTAT (Central Statistics Institute) on behalf of AEEG and processed at regional level, provided confirmation of the strict correlation between “quality supplied” (actual standards of continuity of supply) and “quality perceived” (percentage of customers who are satisfied or dissatisfied with continuity of supply).

Lastly, while assessing the effects of continuity of supply regulation it is appropriate to remember that during the 2000-2003 period the number of DNOs subject to continuity of supply regulation progressively rose from 7 DNOs in 2000 to 24 in 2004, for a total of 33.4 million customers, equal to over 99% of the overall number of customers.


**Consultation and evaluation of the regulatory scheme**

During 2003 several activities were carried out in order to develop proposals for continuity regulation in the second price-control regulatory period (2004-2007). A wide consultation process was run through three consultation papers published and two formal hearings of all stakeholders. Furthermore, around twenty interviews were made with different key-players from DNOs, consumer associations, electricity industry associations, government agencies and research institutes, in order to evaluate the effects of the continuity regulatory scheme in the first regulatory period. It emerged from the interviews, as well as from the consultation process, that the regulatory policy towards higher and more uniform quality levels is well acknowledged and backed by DNOs which are well receptive of quality regulation as it is in line with their own internal policies.

CML regulation is generally perceived as fair as it recognises the differences in historical and operating conditions through differentiation of improvement targets, by customer density and historical performance levels. Furthermore, applying a symmetric incentive scheme – i.e. not only penalties for under-performance but also rewards for over-performance - strengthens the acceptance of the system [3].

The availability of uniform data measurement systems was found to be extremely important to assure the credibility of
the regulatory penalties and rewards calculation. Many findings of the evaluation study about the first regulatory period constituted a basis for proposals of the new continuity regulation for the second period (see table 1).

### Table 1 - Comparison among first and second regulatory period incentive scheme characteristics and evaluation study findings

<table>
<thead>
<tr>
<th>Issue</th>
<th>First regulatory period (2000-03) incentive scheme</th>
<th>Evaluation study main findings</th>
<th>Second regulatory period (2004-07) incentive scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of continuity regulation</td>
<td>Continuity regulation based only on CML</td>
<td>Promote better-balanced incentives for duration and frequency</td>
<td>Continuity regulation based both on CML and on CIs (the latter only for MV customers)</td>
</tr>
<tr>
<td>Kind of interruptions under consideration</td>
<td>All outages recorded, but for transient and short interruptions the estimation of involved customers is allowed</td>
<td>include also transient an short interruptions in the incentive scheme.</td>
<td>For both short and long interruptions estimations of affected customers are no longer allowed</td>
</tr>
<tr>
<td>Individual effects of continuity regulation</td>
<td>No direct compensation payments to customers affected</td>
<td>Consider the introduction of direct compensation payments to customers</td>
<td>Not fulfilling of CIs standards for worst-served customers implies compensation to the affected customers (only for MV users)</td>
</tr>
<tr>
<td>Audit system</td>
<td>Audit with sample of interruptions; at each audit three indexes are evaluated</td>
<td>Simplify the audit process while maintaining the accuracy and validity of the end-data.</td>
<td>Eliminated one index and simplified the two others; introduced a new system-oriented index</td>
</tr>
<tr>
<td>Recording requirements</td>
<td>DNOs can claim force majeure in given circumstances but must collect documental evidence</td>
<td>Develop a less debatable system for the classification of Force Majeure events.</td>
<td>Distribution companies can choose a statistical method for identifying major event days (MEDs); in this case no documental evidence is requested</td>
</tr>
<tr>
<td>Regulation for already excellent areas</td>
<td>Different incentive regime for distribution companies that already supply better than national reference standards</td>
<td>Consider ideas for future quality regulation after achievement of the national reference standards.</td>
<td>Eliminated separate regime and modified incentives for companies that already supply better than national reference standards</td>
</tr>
<tr>
<td>Market mechanisms aside continuity regulation</td>
<td>No market tool</td>
<td>None</td>
<td>Power quality contracts envisaged as a market tool able to respond to customers with special quality needs</td>
</tr>
</tbody>
</table>

Concerning CML regulation, the regulatory scheme was mainly confirmed for the second regulatory period 2004-2007, with the following most important changes being introduced (quality code: regulatory decision 4/04):

- introduction of a statistical method for identification of "major events days", which radically simplifies the previous method of document-based attribution to force majeure of interruptions due to extreme conditions [4];
- introduction of the obligation to perform individual recording of short interruptions for medium voltage customers (from 2006), as a basis providing the opportunity to introduce new quality standards on short interruptions from 2008 (third price-control regulatory period);
- updating of reference standards, taking into account the actual achievement in best-served areas, and definition of yearly targets for years 2004-2007 according to a new rule and starting from the actual level achieved in 2002-2003;
- modification of unitary incentive and penalty parameters, following the results of a large-scale survey on customer outage costs and their WTP/WTA (willingness to pay/accept) sentiments [5];
- modification of incentive mechanisms for territorial areas with standards of quality which are higher than reference standards;
- simplification of the indices used to evaluate outcomes of technical control on data measurement and reduction of penalties established in the event of continuity figures which are not valid.
- option for DNOs to include in the reference indicator, from 2005, interruptions due to external causes;

However, the most important regulatory innovation for the second regulatory period is the introduction of a completely new regulation scheme, the CIs regulation, based on individual continuity standards for the maximum allowed number of interruption per customer per year, associated with penalties for DNOs and compensations for worst-served customers as described in the following section.

### New CIs regulation for worst-served customers

For the second regulatory period guaranteed continuity standards have been determined for MV customers and for HV customers. Guaranteed continuity standards refer to the maximum number of long unplanned interruptions over the year (see table 2).

<table>
<thead>
<tr>
<th>Customers</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV customers, meshed connection</td>
<td>1 long inter./year</td>
</tr>
<tr>
<td>HV customers, new radial connection</td>
<td>2 long inter./year</td>
</tr>
<tr>
<td>MV customers, high density districts</td>
<td>3 long inter./year</td>
</tr>
<tr>
<td>MV customers, medium density districts</td>
<td>4 long inter./year</td>
</tr>
<tr>
<td>MV customers, low density districts</td>
<td>5 long inter./year</td>
</tr>
</tbody>
</table>

Table 2 – Guaranteed continuity standards for maximum number of long interruption per year

A period of intensive preliminary investigations preceded the definition of the guaranteed continuity standard which, at the end of the consultation, were determined by AEEG so as to identify nationwide about 10% of customers served with an annual number of interruptions higher than the guaranteed standard. On the basis of comments received during the consultation, AEEG limited the number of indicators for CIs...
Penalties for DNOs failing to comply guaranteed continuity standards

Starting from 2006, DNOs which fail to comply with guaranteed continuity standards must pay a financial penalty. Particular attention has been given to ensure the gradual application of the new CIs regulation. Therefore, it was decided to gradually modulate the financial penalties, progressively decreasing the threshold of maximum contractual power for MV customers ("major customers", including generators) upon which DNOs are penalised, should the guaranteed standards not be met. For 2006 the penalties will be calculated only with respect to HV customers and MV customers with contractual power exceeding 500 kW. This power threshold shall be lowered to 100 kW from 2007 and it is expected to be removed from 2008.

The penalty shall be calculated, for each major customer for which the guaranteed continuity standards are not met, only on interruptions exceeding the standard, and up to a maximum equal to twice the standard. The penalty shall be proportional to the average power of interrupted supply, which is conventionally assumed to be equal to 70% of the contractual power. AEEG proposed during the consultation process to refer penalties to the actual interrupted power, but implementation matters suggested that it would be too complicating for each customer and for each interruption the power which was actually consumed (or emitted into the network) at the time of the interruption, thus it has been conventionally assumed to be equal to 70% of the contractual power which may be consumed (or emitted).

The penalty formula takes AEEG’s aim of encouraging the reduction of the number of interruptions into account. The penalty is equal to:

\[ P = \sum_{j=1}^{m} \min(2v_j \times PMI_i) \]

where:
- \( m \) is the number of major customers for which guaranteed standards of continuity of supply are not met;
- \( n \) is the number of interruptions suffered by each major customer for which guaranteed standards of continuity of supply are not met;
- \( s \) is the guaranteed standard of continuity;
- \( PMI_i \) is the average power of interrupted supply relating to interruption \( i \) for major customer \( j \), expressed in kW and conventionally determined as equal to 70% of contractual power;
- \( v_j \) is a parameter expressed in €/kW which assumes the values indicated in table 3.

<table>
<thead>
<tr>
<th>Customers</th>
<th>( V_p [\text{€/kW}] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV customers</td>
<td>1</td>
</tr>
<tr>
<td>MV customers, interrupted power up to 500 kW</td>
<td>2.5</td>
</tr>
<tr>
<td>MV customers, interrupted power beyond 500 kW</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3 – Unitary penalty in case of mismatching guaranteed continuity standards for max. number of long interruption per year

Compensation for customers and incentives to modernise their electric plants

In Italy a large part of long interruptions is still not localised. Some of the non-localised interruptions may be originated within customers’ installations; therefore, it is of fundamental importance the selective coordination of protection relays in order to avoid that interruptions originated within customer’s installation may interrupt all the customers connected to the same MV line.

Owing to the complexity of this technical issue, AEEG decided to defer to subsequent order, following further specific consultation, the determination of the final aspects of the regulation of the number of interruptions:
- automatic compensation for worst-served customers;
- technical specifications of customers installations to be met in order for said customers to qualify for automatic compensation;
- deadline beyond which customers failing to comply with the aforesaid technical specifications shall be obliged to pay a extra-component of tariff and its amount and destination.

After a new consultation phase that took place over 2004, eventually AEEN published the regulatory order n. 247/04, that defines in detail the above listed final aspects in order to complete the CIs regulation scheme.
A worst served-customer \( w \) of any contractual power is qualified for an automatic compensation equal to:

\[
I_w = \min(w, 2) \sum_{i=1}^{n} (P \times PMI_i)
\]

(letters have the same meaning of those in the \( P \) formula) only if its installation fulfils technical specifications set by AEEG:
- for HV and MV customers it is envisaged a circuit breaker controlled by protection relays able to detect short circuit and earth fault currents (basic specifications);
- for MV customers with contractual power smaller than 400 kW, equipped with switcher and fuses, owning one MV/LV transformer and a MV underground cable shorter than 20m, a maintenance contract to their own substation and to the switcher (with a ISO 9000 qualified firm) and a register of the maintenance inspections are envisaged (simplifed specifications for MV customers with very low probability to cause earth faults);
- the probability to cause an interruption to the distribution network is presumptively as higher as the use of the network -the probability to cause an interruption to the distribution network is presumptively as higher as the use of the network -the probability to cause an interruption to the distribution network is presumptively as higher as the use of the network.

As from 2007, customers with contractual power larger than 500 kW and not fulfilling technical specifications must pay an extra-component of tariff, called \( CTS \), that is intended to compensate DNOs of costs due to interruptions originated in customer installations. \( CTS \) structure takes into account that:
- costs borne from customers and due to interruptions with origin in customer installations don’t depend on the size of the customer installation where the interruption has origin (fixed amount, equal to 1 €/day for each day of active connection);
- the probability to cause an interruption to the distribution network is presumptively as higher as the use of the network increases (variable amount equal to 0.15 €/h, related to the number of hours of use of the network, estimated by the ratio \( AE/CP \) between the annual energy \( AE \) consumed in the previous year and the contractual power \( CP \) in the same year). Customers with contractual power smaller than 500 kW must pay the \( CTS \) from 2008. It will be determined by the end of 2007, following the next price-control consultation.

**Power quality contracts**

Final customers have indeed widely differentiating needs as regards continuity of supply and voltage quality, and attach different weight to possible measures to avoid interruptions and supply disturbances. AEEG believes that there is room for power quality contract [6], through which DNOs and final customers can agree upon specific quality conditions which are better or further than those represented by the guaranteed standard of continuity of supply determined by AEEG. Final customers own all the necessary information to assess the benefits of a power quality contract. They are aware of the costs which they incur for interruptions and are capable of drawing their own conclusions on the matter. Furthermore, HV and MV customers receive an annual report on interruptions from DNOs.

The stipulation of power quality contracts must be offered on equitable terms, in compliance with the principle by which the DNO may not implement measures which discriminate between customers of the free market and those of the captive market supplied with the same voltage level and with the same localization. AEEG deemed it preferable not to impose the submission of power quality contracts to its preliminary approval and to limit regulatory activity to establishing a few general rules to be observed by the DNO:
- in power quality contracts the parties must define the agreed standard of quality to be observed by the DNO, the premium price to be paid by the customer and the penalty clause in the event of non-compliance on the part of the DNO, specifying cases of exclusion;
- the standard of quality shall be expressed as a threshold applied to one or more indicators of continuity of supply or of voltage quality. With reference to those indicators for which there is no obligation for individual measurement, the parties shall arrange for measurement during a period of at least a year prior to the stipulation of the power quality contract. The costs of measurement shall be borne by the party which intends to benefit from the higher standards of continuity of supply or voltage quality, and which is entitled to install its own measuring instrument.

Power quality contracts may not be stipulated for standards of quality which are lower than those defined by the AEEG. AEEG deemed that power quality contracts may be extended to include short, transient interruptions, voltage dips and the parameters of voltage quality identified by the CEI EN 50160 standard, provided that they are recorded in compliance with CEI EN 61000-4-30 standard procedures.

**REFERENCES**


