SAFETY IN GAS DISTRIBUTION ACTIVITIES: TECHNICAL STANDARDS, PERFORMANCE STANDARDS, AND ECONOMIC REGULATION

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ABSTRACT

Safety in gas distribution is the capability to prevent accidents and to manage emergencies; according to final customers, safety is the primary quality factor in gas distribution service.

Safety cannot be individually negotiated or individualized; in addition to this, an optimal safety policy is typically beyond the scope of private decision making. As a consequence, utility regulation should explicitly include safety rules.

Five reasons are frequently mentioned to ask for additional regulation to promote safety in gas distribution activities. These reasons are: privatisation of utilities, vertical separation of gas industry (unbundling), tendering contracting for gas distribution, price-cap regulation of monopolies, and competition in supply. All these changes in gas industry should generate lower prices for final customers, more competition and increasing opportunities for newcomers, but could also produce decreasing care toward public interest and safety. In such a situation, increasing roles for regulators are emerging: energy regulators are explicitly shifting their focus from economic to techno-economic regulation, where non-price issues are as important as price levels.

The paper discusses the relationship between gas market changes and safety levels, and analyses some national experiences where public safety rules for (at least partially) private management appears to be the new prevailing regulatory approach. The paper shows that regulation is partially replacing existing self-regulation in some European countries.

Three phases of regulation for safety in gas distribution can be found in European experiences: technical standards, performance standards, and economic incentives. New instruments do not substitute existing ones, but instead supplement them.

The Italian experience of safety regulation is analysed to show the evolution of safety regulation.

Some conclusions of the paper are the following: market opening is fully compatible with safety, but price-cap regimes, unbundling of activities and privatization require an increasing role of energy regulators. Regulation should be able to guarantee a welfare increase by achieving in a more cost-effective way the required level of safety; some economic incentives can be used to this purpose, in addition to existing technical and performance standards.
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1. THE IMPORTANCE OF SAFETY REGULATION

Gas industry is facing rapid changes worldwide. Privatisation of utilities, competition in supply, vertical separation of activities ( unbundling), new regulation strategies and instruments may generate lower prices for final customers, more economic competition and opportunities for newcomers, but also risk of decreasing care toward public interest and safety [1].

Economic regulation of utilities usually focuses on price regulation, with relatively less attention to performance standards and social obligations. On the other hand, technical rules are not generally concerned with economic aspects and cost-efficiency. The linkage of economic and technical regulation after liberalisation is a challenge for regulators.

Price regulation involves different incentives for quality of supply, including safety issues. In rate-of-return regulation, companies usually define their own investment and quality/safety levels. According to economic theory, this should create an implicit incentive to over-invest in quality and no incentive towards cost-efficiency, usually mentioned as Averch-Johnson “over capitalisation” effect [2]. In practice, excess quality (and safety) does not seem to be the main effect of rate-of-return regulation; an imbalance between different aspects of quality may sometimes arise, not necessarily reflecting customer preferences, but rather the preferences of system operators.

Simple price-cap regimes could stimulate a regulated company to reduce its quality of supply or safety by cutting investments, maintenance, or personnel with the aim of increasing its profits. Both rate-of-return and price-cap regulation have therefore to be accompanied by some kind of regulation of quality of supply and safety, with the aim of avoiding distorted or excessive investment in the former case, and to prevent a decrease of quality/safety in the latter. Price regulation without safety regulation may give unintended and misleading incentives to safety levels. Some authors claim to have found evidence to suggest a fall in quality following the introduction of price-cap controls where no specific provision was made for quality regulation (see section 4 in [3]). Such an evidence still doesn’t exist for safety, but regulators in many countries are taking care of this problems in addition to company autonomous decisions and technical bodies rules.

Adequate incentives can ensure that cost cuts are not achieved at the expense of lower quality and safety. This is particularly important as some aspects of quality have a long recovery time after deterioration, and some investments produce negative or positive safety effects with medium or long time delays. For these reasons, safety regulation should be introduced at restructuring or during price control reviews to avoid unexpected safety reductions and higher risk for population.

Even if there is not evidence that privatisation, different measures for separation of activities, deregulation and price-cap regulation necessarily generate safety reduction in distribution network, the simple existence of such a risk requires growing attention from regulators. For the reasons given above, Performance-Based Regulation, i.e. any rate-setting mechanism which attempts to link rewards (generally profits) to desired results or targets, should in principle include quality and safety incentives. Performance-Based Regulation under privatisation is widely discussed in the literature in relation to electricity distribution [4], while scarce literature exist on non-price issue in gas market liberalization.

Public ownership of distribution utilities and rate-of-return tariff regulation not necessarily create the right degree of safety: usually different companies adopt different investment and maintenance strategies for their pipelines. If safety could be properly measured, different safety targets and results would emerge from benchmarking.

Safety regulation is then necessary both before and after privatisation and liberalization; but after more than before.

2. SAFETY REGULATION IN THE NEW ENVIRONMENT

Self regulation of safety-related matters was the leading situation in many industrial countries during the expansion stages of gas networks. Where a “national champion” exists, the leading
company usually sets standards, rules and procedures for small companies as well. This was the case of Gaz de France for instance: “...no regulatory “safety” environment was developed for the distribution network since the operator’s internal rules established for its own use and for its sub-contractors’ use were de facto safety regulations. In fact, all the operators applied, with only several variations, the rules imposed in the gas distribution guide developed and maintained by Gaz de France” [6]. Similarly happened in Italy, but procedures and safety levels were not so homogeneous like in France, as a consequence of the very high number of local distributors (more than 700 till the end of the Nineties).

Co-operative self regulation prevailed in some other countries through technical organizations’ activities, and the creation of systems of self-control. This happened for instance in Switzerland and The Netherlands. According to some participants to these activities [7] “Self regulation in gas distribution is so complete and successful that till now there was neither a national supervision body nor a specific low-pressure gas law. Instead of a law and underlying ordinances, all necessary requirements for gas distribution in Switzerland are written down in a set of codes of practice, established by the national branch-association in co-operation with the gas inspectorate. Experts of the gas inspectorate effect control and supervision in charge of the regional authorities. By means of this legalisation, inspection results of the gas inspectorate become mandatory. But this official pressure is seldom necessary, because nearly all gas distribution companies are voluntary members of the gas inspectorate and impose themselves to obey the codes of practice and their interpretation by the gas inspectorate”. The success of this self-regulation is considered remarkable and even measurable: accident and incident rates in Switzerland, compared with neighbouring countries, are partly similar and partly even better.

In many countries a shift from self-regulated safety to regulated safety is ongoing. This transition is not usually related to the opening up of supply markets (from local monopolies to competition), but is rather connected to changes in the structure, ownership, and regulation for monopolistic activities like gas distribution.

These major changes are: increasing demand for high levels of safety in gas-related activities, transition from State owned gas distribution activities to private or semi-public ownership of distribution companies; pressure for cost reduction arising both from private ownership and price-cap or revenue-cap methods for distribution tariffs setting. These major changes in gas distribution activities organization and regulation may be followed or accompanied by the introduction of additional and innovative rules for safety preservation and enhancement. Public safety rules for (at least partially) private management appears to be the new prevailing regulatory approach.

In France the Government highlighted in 1999 the need for a regulatory text specific to the field of network gas distribution to standardize the practices of different operators and to ensure a high level of safety throughout the entire gas distribution chain. That was done with publication of the Government Order of July 13, 2000 on safety regulations for distribution of combustible gas through piping. The Order contains:

- a core that provides a framework for the organization of public gas distribution;
- administrative texts, essentially the licensing scheme and government supervision;
- technical rules applicable to what is inside and outside buildings;
- general texts, particularly on occupational safety.

In Switzerland the national Government started projects for establishing risk-based laws and a national safety institute dealing with all kinds of technical risks, including gas distribution. Politicians as well as gas industry insiders know that safety could become a second-class priority due to liberalisation, while the gas industry promotes its well-known self-regulation scheme.
3. GAS DISTRIBUTION: SAFETY REGULATION PHASES IN A LIBERALIZED MARKET

To make sure gas is distributed safety and continuously from the moment a system is operational, distributors have a series of requirements to meet that can basically be summarized as follows:

- distribution systems—when first built, when expanded or upgraded, when lines and equipment are replaced, and when installations are hooked up—have to be created with suitable materials and parts and in compliance with applicable laws;
- distribution systems have to be operated to ensure a safe, continuous supply of gas at all active delivery points where possible and envisaged by contract, by means of system inspection and maintenance (inspection of input points, pressure regulators, odourization, cathodic protection of steel pipes, gas line pressure; detection and elimination of leaks, etc.).

When required in the interests of safety, distributors must also deny or suspend service to customers hooked up to their network.

In a nutshell, once a distribution system is operational, safety consists of preventing gas-related accidents and providing a fast and effective emergency response.

In light of the responsibilities placed on distributors, regulating safety in a market that is opening up to competition typically evolves in three phases:

- **Phase 1:** Regulation of the main aspects of network construction (through product and installation standards), network operation (through guidelines or company procedures), and service provision (through utilities' own charters of service).
- **Phase 2:** Introduction of performance standards, comparative publication of distributors' service ratings, and definition of guaranteed standards of service entailing fines or other penalties for distributors that fail to comply.
- **Phase 3:** Provision of incentives to reward improved performance on matters critical to safety.

Phase 1, in which the energy regulator is usually uninvolved, could be defined as the "technical standards" phase. Next comes the "performance standards" phase, when the regulator begins to step in by monitoring service output. In Phase 3, the "economic regulation" phase, the regulator introduces financial incentives that tend to be focused on techno-economic variables that are affected, to some degree, by technical/managerial decisions.

The phases tend to overlap, since, for example, performance standards and service obligations require a basis of voluntary regulation allowing distributors to measure and monitor their performance and their compliance with standards of service.

Progress from Phase 1 to Phase 3 usually parallels the emergence of competition for distribution licences and the resulting pressure on service costs. The original voluntary regulation gradually becomes inadequate, on its own, to ensure that previous safety levels are upheld, once tariff systems involve cost recognition and price caps and once the market for service concessions takes root (see Figure 1).

In other words, the efficiency gains required of distributors must not translate into safety cutting.
Figure 1  Regulation of safety in gas distribution vs. stage of liberalization

Each phase of safety regulation has its own typical effects:

Phase 1: system construction and operation techniques grow more uniform, as do the means of service provision; this can occur faster or more slowly depending on the utility's technical capabilities and finances;

Phase 2: performance gradually improves and becomes more homogeneous, although the trend differs from one distributor to another; as utilities grow aware of their safety levels in comparison with others', overall performance tends to level out at the required minimum;

Phase 3: standards attained in Phase 2 gradually improve beyond the minimum, reaching individual cases of excellence that boost average safety for the country as a whole.

4. THE EVOLUTION OF SAFETY IN ITALIAN NATURAL GAS DISTRIBUTION

Below is a brief description of how safety regulation in Italy has travelled through these three phases, from the first safety legislation passed to the recent introduction of bonuses for safety improvements by Italy's energy regulator (the Authority for Electricity and Gas).

Phase 1: Voluntary regulation (technical standards, through 2000)

Since 1971, when Law 1083 was enacted, Italy has published technical standards of good practice for the construction of distribution systems and equipment, and standards for the operation and maintenance of specific components (pressure regulators and meters, odourization systems, cathodic protection systems, etc.).

By the late 1990s, these standards provided exhaustive coverage of all safety-related aspects of the gas distribution service, except for a few significant activities such as finding and eliminating leaks and setting up an emergency response protocol.
As from 1995, the year in which the Authority was set up pursuant to Law no. 481/95, those engaged in the integrated activities of gas distribution and sales, were provided with a Citizen’s Charter in which the company, on the basis of a reference chart, identified its own standards of performance. The indicators listed in the reference chart related to the most frequently requested services, such as the preparation of cost estimates, performing complete or aerial installations, connecting or disconnecting supply, reconnecting defaulting consumers, effecting adjustments to invoices and emergency calls. Other indicators refer to general service issues, such as the interruption of gas supply with prior notice and the percentage of the network which is subject to inspection.

As the annual reports on the quality of gas supply published by the Authority in the years 1997-2000 show, the implementation of the Citizen's Charter regulations brought to light some important critical points, such as:

1. lack of uniformity in standards declared by utilities and in effective levels of quality supplied to customers (Table 1);
2. lack of uniformity in measuring time (solar days, business days, different calculation methods, etc.) and the differing definitions adopted for the services reviewed;
3. failure to verify quality effectively dispensed to customers (figures which have been estimated rather than measured) and omissions in figures recorded and submitted to the Authority;
4. incorrect assignment of responsibility in the event of failure to observe standards and inefficiency of the refund mechanism to customer request in the event of failure to observe standards through utility’s fault.

Table 1 Lack of uniformity in effective levels of safety (Annual percentage of high and medium pressure network subjected to inspection) - 1999

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Phase 2: Performance standards, service obligations and fines (2000-2005)

On the basis of the lack of uniformity highlighted in Table 1, the Authority attempted to identify a set of indicators which could be correlated to service safety levels. To this end a study was made of the activities which are relevant not only from the point of view of safety in itself but also for the continuity of the service, in so far as the reconnecting of a suspended gas supply always represents a potential source of risk for the customer.

On 28 December 2000, after thorough consultation with all the interested parties, the Authority issued deliberation no. 236/00 containing the directive regulating the safety and continuity of gas distribution service. The directive identifies the following activities as being relevant to safety:

- detecting and eliminating escapes of gas along the network;
• odourization of gas supplied to customers;
• cathode protection of steel pipelines;
• emergency intervention upon customer request.

The new distribution safety regulation operates through the coordinated use of guaranteed national and general standards; these indicators replace the general standards which had previously been determined by individual companies solely on the matter of searching for gas escapes. In particular, the directive identifies four guaranteed safety standards, as illustrated in Table 2

**Table 2 Distribution service safety standards**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Indicator</th>
<th>General standard</th>
<th>Reference standard</th>
</tr>
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<tbody>
<tr>
<td>Gas escapes</td>
<td>Annual percentage of high and medium pressure network subjected to inspection</td>
<td>30%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Annual percentage of low pressure network subjected to inspection</td>
<td>20%</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>Annual number of escapes localized per kilometre of network inspected</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Annual number of escapes localized upon third party report per kilometre of network</td>
<td>0.8</td>
<td>0.1</td>
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<tr>
<td>Odourization</td>
<td>Formal number of measures of the degree of gas odorization per thousand end customers</td>
<td>calculated as per directive</td>
<td>0.5</td>
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<tr>
<td>Cathodic protection</td>
<td>To be defined</td>
<td>Monitoring</td>
<td>Monitoring</td>
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<tr>
<td>Emergency intervention</td>
<td>Time required to reach the scene</td>
<td>At least 90% within 60 minutes</td>
<td>Monitoring</td>
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</table>

*Note: Guaranteed standards are shaded*

Given the significance for safety purposes of the emergency response service, in 2005 the Authority introduced a €500 fine for every emergency call not resulting (through fault of the distributor) in arrival on the scene within 60 minutes, beyond the 5% leeway provided by that particular standard (at least 95% of calls must be addressed on-site within 60 minutes).

**Effects of Phase 2 safety regulation in Italy**

In Italy, Phase 2 of safety regulation for the distribution service by means of performance standards, service obligations and fines (Resolution 236/00) has produced appreciable results. For example:

• distributors now have to provide an emergency response to calls about gas leaks downstream from the delivery point, and emergency response time in general has improved (Table 3);
• distributors are required to register on a uniform basis their main safety variables (leaks, odourization checks, cathodic protection checks and emergency calls) and continuity indicators (momentary and sustained interruptions, with and without notice);
• distributors must notify the Italian Gas Committee of any emergencies on their distribution
systems and of gas-related accidents on their systems or downstream;

- voluntary standards have been completed by guidelines for activities relevant to safety and continuity of service (odourization, emergency response, scheduled network inspections, classification of leaks, cathodic protection, management of emergencies and gas accidents);
- the percentage of gas networks subject to scheduled inspections has risen substantially (Table 4), and become more uniform among different distributors.

Table 3 – Emergency calls regarding gas distribution systems – 2001-2004

<table>
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<tr>
<th>Year</th>
<th>Thous. of Calls: Distribution Network</th>
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<tr>
<td>2001</td>
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<td>2003</td>
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Table 4 – Percentage of network inspected, 1997-2004

Phase 3: Incentives for safety improvement (Economic regulation, since 2006)

Unlike the electricity sector, where economic regulation in Italy is anchored to the number and duration of power outages, for the gas distribution service it is not easy to determine safety-relevant outputs to which incentive systems can be linked; bonuses for safety improvements could be tied in with one or more aspects of service (odourization, emergency response, finding and elimination of leaks, cathodic protection, etc.).

After an in-depth consultation process with interested parties, the Authority issued Resolution 243 of 22 November 2005, which introduced (as from 2006) a system of incentives for safety
improvements confirming the goal of fewer gas leaks and thus fewer accidents on distribution networks. Through a system of bonuses and fines associated with the annual number of leaks found on each distribution system after being reported by third parties, the aim is to encourage natural gas distributors to use the best technical and managerial techniques they can to reduce such leaks to a minimum. The Authority has also set up incentives for gas odourization checks, a significant factor in pursuit of that goal. Proper odourization, in fact, is necessary for customers and the public in general to be able to detect gas leaks.

Safety data reported by distributors to the Authority for the period 2002-2004 shows a strong correlation between change in odourization level and change in the number of leaks found through the initiative of third parties. As a result, the Authority has decided that while it is always good policy to encourage odourization checks, bonuses will not be awarded for a reduction in leaks found after being reported by third parties on systems for which the quantity of odorizer has been significantly decreased. Reducing odourization makes the public less likely to perceive leaks and may significantly reduce the number of calls to the company's emergency line, hence the number of leaks found as a result of such calls.

For the same reason, the Authority has separated bonuses for odourization improvements from those associated with leaks. Each distributor can therefore earn the sum of two different kinds of incentive: one for systems eligible for odourization benefits, and one for the smaller number of systems eligible for leakage benefits.

For the leakage component, the bonus/penalty system is a long-term process (11 years, covering three regulatory periods: 2006-2008, 2009-2012 and 2013-2016) and will ultimately be extended on a mandatory basis to all natural gas distributors. The bonuses and penalties are tied to conventional leak targets to be reached by the end of that period, and to intermediate levels of annual improvement compared with the baseline situation for the individual distribution system.

To introduce the mechanism gradually, allow time for the new system to be tested, and give distributors the chance to comply with prerequisites, the Authority has ruled that participation will be voluntary for the first three years (2006-2008) and can produce benefits but no penalties. During the subsequent regulatory periods (2009-2012 and 2012-2016), penalties will also apply and participation will become mandatory, although on a duly gradual basis.

The incentive system entails calculation of variable alpha_j for each distribution system j eligible for leakage bonuses, whose network length and number of customers served at 31 December 2003 give it a certain clientele concentration ratio k (high, medium or low).

Variable alpha_j expresses the annual rate of improvement required to bring the distribution system j, over the course of three regulatory periods (11 years), from the baseline LivPart_j to the target level LivOb^k. It is calculated as follows:

\[
\alpha_j = \max \left[ 1 - \left( \frac{LivOb^k}{LivPart_j} \right)^{\frac{1}{11}} ; 2\% \right] \quad \text{where } \alpha_j \leq 20%;
\]

where LivOb^k is the target level for the distribution system's concentration ratio k and LivPart_j is its starting point.

For the period 2006-2008, variable alpha_j can range from 2% to 20%.

The intermediate levels for each year of the period 2006-2008 are calculated, for each distribution system j, by multiplying the baseline LivPart_j by improvement rate alpha_j obtained as described above.

As a result, for each distribution system j, the intermediate levels for the period 2006-2008 are determined according to the following formula (results rounded to the nearest thousandth):

\[
T_{2006,j} = \max \left[ LivPart_j \cdot (1-\alpha_j) ; LivOb^k \right]
\]

\[
T_{2007,j} = \max \left[ T_{2006,j} \cdot (1-\alpha_j) ; LivOb^k \right]
\]

\[
T_{2008,j} = \max \left[ T_{2007,j} \cdot (1-\alpha_j) ; LivOb^k \right]
\]
The incentive system suggests an improvement curve for 2006-2008 that is consistent with the concept of decreasing marginal returns and the principle of convergence toward the target levels expected to be reached in 2016, although those levels could be redefined at the start of the 2009-2012 or the 2013-2016 period if distributors achieve gains beyond their year-on-year targets.

By way of example, Figure 2 shows the intermediate-level curves for two distribution systems: System 1 has a $LivPart_1$ of 30.274 conventional leaks found at third parties’ initiative per thousand end customers, while for System 2 the corresponding figure is a $LivPart_2$ of 38.659.

**Figure 2 – Example of intermediate (annual) levels for high-concentration distribution systems**

In Figure 2, the intermediate levels are reported through 2016 for the sake of thoroughness, although the incentive system only defines them up to 2008 since parameters such as target and benchmark levels are expected to be revised by the end of that year.

### 5. CONCLUSIONS

Market opening is fully compatible with safety, but price-cap regimes, unbundling of activities, competition for distribution licences, and privatization of utilities require an increasing role of energy regulators. Regulation should be able to guarantee a welfare increase by achieving in a more cost-effective way the required level of safety.

This requires increasingly active intervention by the regulator, which initially limits itself to overseeing safety performance standards, but eventually offers incentives (including economic incentives) based on techno-economic factors. In that way it encourages distributors to exceed the mandatory minimum and strive for excellence.

In Italy, such a system was recently introduced with the goal of reducing the number of gas leaks and thus the number of accidents on distribution systems. Incentives will apply from 2006 and involve annual improvement targets over a horizon of 11 years.

Economic regulation of safety in gas distribution must be harmonized with existing kinds of regulation based on performance and technical standards, and is the natural evolution of that approach.
REFERENCES


