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Towards a Regulatory Methodology for Energy Efficiency in Gas Networks

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Contents

Abstract

The report gives an outline of a possible regulatory methodology for the enhancement of energy efficiency of gas networks at the European Union Level. The report addresses several related measures and the interaction with related energy systems and the development of new technologies.

Article 15 of the Energy Efficiency Directive requests for the definition of a methodology that Member States could implement towards a more efficient network. This report aims to reply to this demand by consulting relevant stakeholders, evaluating Member States network strategies and proposing regulatory and policy measures to be implemented by the countries.

Executive Summary

The outline of a regulatory methodology for the enhancement of energy efficiency of gas networks must consider several related measures, addressing closely related issues: demand side management; interaction with related energy systems (cross-vector integration); the development of smart grids, and policies aimed at curbing methane emissions. On the other hand, the requirement that grid flexibility be enhanced to allow the deployment of energy saving facilities of users seems to be limited to the electricity sector.

Whereas energy efficiency enhancement of gas networks has its own role, as foreseen by Article 15 of the EED, any related regulatory methodology should also consider and support, in particular, solutions involving cross-vector integration. On the other hand, demand side management (even if funded through the involvement of network operators) and smart grid policies should be left out of scope of the methodology, as they have been the subject of other studies. In any case, the regulatory methodology should consider any costs and benefits that operators may incur (or gain) through their involvement in measures addressing related issues, notably those addressing methane emissions reduction and smart grids.

There are several technologies that can be adopted to increase the energy efficiency of gas networks, with those addressing distribution losses and those reducing consumption of transmission and storage compressor units being the most widely recommended. However, local differences of starting conditions of facilities and input costs point against the adoption of general solutions. Any solution should be tailored to specific conditions and assessed on a case by case basis.

Furthermore, assessment methodologies and regulatory requirements for distribution losses in Europe are not harmonised, and quantitative benchmarking is currently hardly meaningful, even though (from currently available information) higher losses seem to occur in some Eastern Member States. In fact, official databases like Eurostat's lack information about several Member States. This points to inadequate information about network losses in the EU.

The first step for a better knowledge of the situation would be the definition of common methodologies, leading to harmonised data. No general standards can be discussed or introduced before harmonised and consistent data are collected and analysed.

Regulatory methodologies addressing losses are also quite different in the EU. Several Member States have maximum standards. Most tariff regulation schemes do not consider the cost of losses as a separate item. Therefore, network operators already have an incentive to reduce losses and other energy consumptions as far as economically efficient. Nevertheless, some countries have introduced procedures and incentive / penalty schemes to foster their reduction, also as part of measures aimed at improving the safety of gas usage.

A common regulatory methodology for the enhancement of energy efficiency of gas networks should:

1. consider that available technologies, operating conditions and costs are different so that their adoption should be decided on a case by case basis;
2. reckon that most energy efficiency improvements require investment. Therefore, the methodology should be based on (and possibly integrated in) the decision making process for new investment currently enforced in the EU, involving:
    a. the preparation and discussion of Network Development Plans;
    b. the assessment of proposals pursuant to Chapter V of the Capacity Allocation Mechanism Network Code;
    c. testing by Cost Benefit Analysis developed in line with the approved harmonised methodology;
    d. The above steps may be extended and adapted to investment undertaken by Distribution System Operators, notably within the framework of periodical tariff setting.

3. Network operators may (or should) be required to present and assess energy-efficiency investment proposals, to be considered as suggested above, for regulatory approval. These proposals may include those aimed at exploiting synergies of cross vector integration.

4. The common methodology should include steps towards harmonisation of data collection and reporting of network losses including obligations leading to the collection of comparable data. This task should start from work presented at the 2019 Madrid Forum by GIE and Marcogaz and may require the involvement of the Agency for Coordination of European Energy Regulators.

5. National Regulatory Authorities should ensure, at least in their reviews of networks tariffs, that network operators are incentivised to undertake economically efficient investments. DSOs should be required to present investment proposals, with cost benefit analysis drafted according to agreed EU methodologies.

6. NRAs should be allowed to introduce measures for energy efficiency investments that pass cost-benefit analysis tests. Measures may include accelerated depreciation, higher rates of return, early recognition into asset bases, incentive/penalty mechanisms. On the other hand, NRAs should consider (including for tariff setting purposes) costs and benefits that network operators may incur (or achieve) from their participation in other policies and mechanisms aimed at related issues, like broader energy efficiency obligation schemes, the Emission Trading System, and policies for smart grid deployment.

1 Introduction

In the frame of the Energy Efficiency Directive, Article 15 is intended to promote energy efficiency in the electricity and gas grids. In particular:

- Article 15(2) requires Member States to ensure that "national energy regulatory authorities, through the development of network tariffs and regulations, provide incentives for grid operators to make available system services to network users permitting them to implement energy efficiency improvement measures";
- Article 15(2a) states that "By 31 December 2020, the Commission shall, after consulting relevant stakeholders, prepare a common methodology in order to encourage network operators to reduce losses, implement a cost- efficient and energy-efficient infrastructure investment programme and properly account for the energy efficiency and flexibility of the grid".

The purpose, objectives and scope of this Report is the identification and preparation of a common methodology in order to encourage gas network operators to reduce energy losses, implement a cost-efficient and energy-efficient infrastructure investment programme and properly account for the energy efficiency and flexibility of the gas grid.

The present draft is based on desktop research and preliminary interviews with selected experts. Results of further consultation of experts and stakeholders will be presented in the next version.

The structure of the Report is as follows:

Section 2 defines the focus of the Report and describes its relationships with several related issues, which share the same purposes and involve an active role of National Regulatory Authorities (NRAs) in charge of the gas sector;

Section 3 reviews the main technological options that are available to achieve the objectives of loss reduction and may be adopted to enhance energy efficiency in gas networks;

Section 4 presents an overview of the current situation and policies aimed at controlling and reducing network losses and own consumption of gas networks;

Section 5 presents and discusses some relevant regulatory methodologies adopted in the past and present, which could be identified and selected as interesting examples;

Section 6 concludes by outlining the key elements of a regulatory methodology for the enhancement of energy efficiency in gas networks.

2 Focus of the Report and related issues

The focus of this Report is on energy efficiency of gas grids and the regulatory methodologies that may be deployed for its improvement. However, several related issues are closely related and are often mentioned as part of measures aimed at achieving related objectives, and involving gas grids and their operators. It is worth compiling a (non-exhaustive) list of such issues and measures, with a view to considering whether it is appropriate to extend the scope of regulatory policies, or recommend methodologies that are not limited (in a narrow sense) to improvements of the energy efficiency of gas grids.

This approach is also justified by the analysis of Article 15(2a) of the EED, which actually outlines three different obligations. It can indeed be read as requiring the preparation of a common methodology in order to encourage network operators:

(1) to reduce losses,

(2) implement a cost- efficient and energy-efficient infrastructure investment programme, and

(3) properly account for the energy efficiency and flexibility of the grid.

Whereas the interpretation of the first obligation (loss reduction) is straightforward, the second one is more open to different interpretations.

A narrower interpretation would restrict its meaning to the implementation of cost-efficient and energy-efficient investment in gas grids. For example, this would require that the construction of new (and replacement of discarded) compressor station equipment should be energy-efficient as well as cost efficient. In this perspective, a key role for the proposed regulatory methodology would be to reconcile cost efficiency and energy efficiency, to the extent that a conflict (*trade-off*) may emerge between them.

However, a broader interpretation may consider that an energy-efficient infrastructure investment programme may address the choice between a larger infrastructure capacity, able to accommodate a higher demand, and the adoption of measures aimed at curbing demand. This is the essence of the well known *Integrated Resource Planning* approach, and in particular of its key pillar that are most often known as *Demand Side Management* and *Demand Response*.

Thus, we can define Related Issue 1: What is the right definition of the scope of the proposed regulatory methodology, as regards the interpretation of an "energy efficient investment programme"?

As for the third obligation envisaged by Article 15(2a), its scope is even less clear and may involve several related issues. In fact, accounting for the energy efficiency and flexibility of the grid may be interpreted in several ways:

a) simply as (redundantly) confirming the obligations of the previous two points, i.e. reducing losses and pursuing cost- and energy-efficient investments;

b) as suggested by the second paragraph of Article 15(1), regulation should "provide incentives for grid operators to make available system services to network users permitting them to implement energy efficiency improvement measures". Pursuing such objectives may indeed represent a way of accounting for – and indeed exploiting – the flexibility of the grid (Related issue 2);

c) other ways of considering and using the flexibility of the grid are related to interactions that it may have with the *energy efficiency of related systems and* the facilitation of actions that pursue strictly related goals, notably in the field of *renewable energy* (Related issue 3).

Besides, whereas the objective of this Report only addresses the implementation of Article 15 (2a), it is suggested to consider it along the provisions of Article 15(1), whereas it requires NRAs to take advantage of grid flexibility to foster energy efficiency improvements, notably with reference to smart grid deployment, and by means of "tariffs and regulations". It may be worth considering how the proposed regulatory methodology may be related to *smart grid deployment and their utilisation for energy efficiency purposes*, to the extent that such provision applies to gas networks (Related issue 4).

Finally, it is worth recalling that energy efficiency measures of gas grids largely overlap with those aimed at *monitoring and curbing methane emissions*. Yet energy efficiency also pursues objectives other than emission reductions, and methane emissions in turn encompass other sectors, some of which are currently or potentially interconnected with gas grids, e.g. for the production of biomethane (*Related issue 5*).

Let us consider these related issues in some more detail, with a view to better define the scope of the proposed regulatory methodology.

Related issue 1: Demand side management

DSM was developed in the U.S. mainly as an alternative that regulators proposed to utilities in case new capacity was needed to match growing demand. It was originally designed for integrated utilities, acting as distributors and suppliers. Whereas it started in the electricity sector, gas became just as important and often represented the majority of achieved demand response. With a history of more than 30 years, DSM (or its broader version, *Integrated Resource Planning*) boasts a remarkable experience and has been extensively practiced and studied (See e.g. CPUC, 2001; Tegen & Geller, 2006); ICER (2010); Bergaentzlé et al., 2014).

DSM shares two key features with the scope of the present Report:

- the responsibility for the interventions is allocated to distributors, who typically "buy" energy saving actions on the market, e.g. from energy saving companies (ESCO), end customers, and other utilities. Therefore, only a limited part of the actions affects the utility's own assets;
- actions are pursued by a well-defined regulatory methodology, approved and administered by regulators (State Public Utility Commissions), and is mostly based on cost benefit analysis.

In Europe, similar schemes have been adopted. For example, the Italian "white certificates" mechanism is essentially a DSM scheme, entailing the responsibility of electricity and gas distributors, a certifying authority, and a market mechanism for energy saving (*white*) certificates. This scheme has been successful in triggering significant energy efficiency actions, at a limited cost, mostly (but not only) related to electricity and gas consumption by end customers (Termini, 2011). However, as part of the implementation of the 2012 EED, the scheme has been generalised and its administration moved to a different authority, while the regulator only approves the levies that are charged on top of network tariffs to finance the costs of the scheme.

Similar schemes exist in several countries and have been developed as key ways of implementing Article 7 and 7a of the EED (National EED Implementation Reports, 2016). The appeal of involving network operators in this process is twofold:

(i) involving in the administration a body that is familiar with the energy market and (given the unbundled nature of most European network operators) is also neutral towards consumption levels, and

(ii) the possibility of covering the costs of interventions by network-based levies, which are hardly escaped and appear fairer than general taxation, as they fall on energy consumption.

On the other hand, given the role that such schemes have in the implementation of Article 7a, it seems logical that it should not be duplicated when implementing Article 15(2a). In fact, the methodology should clarify whether network operators' actions pursuing the objective of article 15(2a) should be accounted for as part of the actions that pursue Article 7 objectives, and whether they are eligible for related support.

Related issue 2: Grid flexibility

The provision that NRAs should encourage the enhancement of grid flexibility in order to allow the deployment of energy efficiency measures seems to be addressed mostly (if not exclusively) to electricity grids. In fact, Article 15(1) of the EED mentions (para. 2) only the Electricity Market Directive (2009/72/EC), whereas the obligation of para. 1 (mentioning both the Electricity and Gas market directives (2009/73/EC) is more general and only considers the need to "pay due regard to energy efficiency".

The need to enhance the flexibility of the gas grid to allow energy efficiency actions by connected customers does not look significant. On the other hand, a significant improvement of grid flexibility seems to be necessary to accommodate growing shares of renewable gas and hydrogen, but these actions, albeit pursuing partly overlapping policy objectives, are definitely out of scope of this Report.

Related issue 3 – Interactions with related energy systems

In some cases, energy efficiency is achieved by joint action of different energy system rather than a single one. In particular, several technological options (see Section 3) span across electricity and gas and fall under the heading of "cross vector integration"[1]. These options include (among others):

- the exploitation of the easier storability and reduced transmission cost of energy in gaseous form as a way of storing and/or transporting electricity, notably of renewable origin (power-to-gas). Several such solutions involve the production and mixing of hydrogen or other synthetic gas into natural gas grids;
- the recovery of energy, often as power generation, from pipeline pressure drops;
- the use of electricity of renewable origin to power gas compressors of long distance pipelines and storage facilities.

Some cross-vector solutions may also involve the oil sector, e.g. the use of LPG as support of isolated gas grids and biogas injections, which could enable more efficient (or cleaner) energy supply, or a as a tool for conditioning renewable gas and allow its injection into distribution grids.It is not always easy to classify such solutions as energy efficiency actions, rather than as new or renewable energy. Moreover, these solutions are subject to continuous innovation and their range should not be restricted ex-ante.

Looking more into the future and on a broader scale, integration of renewable electricity with a significant role for hydrogen represents an important source of both economic and energy efficiency.

Hydrogen can help in sectors where the potential of electricity-based technologies remains limited, like very high temperature processes, heavy-duty transportation, heat generation in the winter, and the back-up of renewable power generation. It can allow a significant reduction of energy imports as well as of GHG emissions, irrespectively of the main technical solutions adopted for its production (renewable hydrogen from electrolysis, steam methane reforming, or pyrolysis with carbon sequestration). All hydrogen solutions definitely represent a huge challenge – as well as an opportunity – for gas networks, as they could involve reconversion of some networks and their adaptation, with the firsts steps generally agreed as the admixing of limited hydrogen shares into gas natural networks.

However, given the current state of development and the wide range of these solutions, they are in general better addressed under decarbonisation and innovation policy initiatives, rather than as part of a regulatory methodology addressed at gas network operators. The regulatory methodology should be open to support any pilot initiatives that is based on hydrogen integration, without ex-ante choice of any specific solution.

More generally, the impact of hydrogen-based solutions on energy efficiency is often positive, but it depends on complex life cycle analysis of each of them. There is certainly more to understand on this respect (Čeković et al., 2020).

It is recommended that any regulatory methodology that promotes EE of gas networks should also consider and potentially allow for cross-vector solutions.

[1] See several studies at https://fsr.eui.eu/energy/gas/sector-coupling/

Related issue 4 – Smart grids

The development of smart gas grids, and particularly of smart meters, has been significantly addressed by research and policy initiatives, although less than in the electricity sector. In fact, the energy efficiency potential of smart grids, notably for gas distribution, is lower than for electricity, as the scope of load management and domotic applications is limited. However, Cervigni et al. (2011) and Cervigni & Larouche (2014) found that a key factor for benefit/cost indicators of smart meters to turn positive is just their connection to (and use for) a more efficient use of space heating systems.

In fact, the implementation of smart metering in gas distribution seems limited in Europe, and mostly restricted to medium and large customers. Where undertaken, its goals seem to lie mostly in (i) reducing measurement costs by remote reading and (ii) providing a more accurate and timely measurement, which can reduce errors in gas market balancing and settlement processes, hereby facilitating the swift functioning of markets. The first point has some energy efficiency relevance.

In some countries, adoption of smart meters is also fostered by the desire to stem gas theft, which is often carried out by manipulation of traditional meters. As this objective involves in fact a correct (and higher) average gas pricing, it would also have a gas saving impact[2].

A more recent benchmarking of cost-benefit analysis and (where positive) requiring and implementing the introduction of gas (and electricity) smart meters has been carried out by Tractebel (2019), on behalf of the EC-DG Energy.

Even though the energy efficiency potential of smart gas meters is limited, it seems appropriate not to neglect it, as it may be significant in a few countries. Whereas their energy efficiency potential does not probably justify any general installation policy, EE-enhancing regulatory measures should reckon that contributions from smart meters may be included among promoted actions, where appropriate.

Related issue 5 – Methane emission policies

Reduction of methane emissions is certainly one of the key objectives of energy efficiency policies in the gas sector, though not the only one. It is not surprising that energy efficiency policies largely overlap with those aimed at the reduction of methane (and CO2) emissions, and that some governments and stakeholders may find the introduction of separate policies and measures for gas networks redundant. In particular, gas networks (as most of the energy industry) are subject to ETS obligations, and may take part in more general energy efficiency schemes, like those envisaged by Article 7a of the EED. Thus, it may be tempting to regard any additional measure as useless.

The gas industry is already actively tackling methane emissions. Marcogaz and GIE (2019) have recently provided an outline of the state of the art.

However, the very existence of Article 15(2) clearly points at the need for a separate set of measures. Yet, any such measure should be aware of other, more general policies and possibly add further incentives, penalties and standards that may foster more gas network operators' action.

This Report will not deal with any related GHG emission policies, but final proposals will consider their existence and ensure consistency.

[2] This point is mentioned in several National Reports on the Implementation of Article 15(2), notably for Hungary.

3 Technical options for energy efficiency improvements in gas networks

From gas production and processing plants to industrial and retail customers, gas is passing through a complex transmission and distribution pipeline network. A detailed mapping of gas losses, own gas consumption and own electricity consumption must be carried out to unlock the potential for energy efficiency improvements. In other words, energy losses and own consumption, as well as energy efficiency measures to minimize them, must be analysed separately for transmission grids, compressor stations and distribution grids.

Unlike high-pressure gas transmission pipelines that are usually (but not always) made of coated steel and are subject to cathodic protection, distribution pipelines are medium to low pressure, made of very different materials (cast iron, steel with or without cathodic protection, plastics, etc.) depending on the localization, pressure and network age. Compressor stations (units that ensure that gas remains pressurized) are placed at regular interval along the transmission and sometimes distribution networks. Gas can be compressed in the unit with either gas-fuelled engines, turbines or electric motors.

Gas losses can occur due to multiple reasons. Therefore, they are grouped into three categories: vented emissions, fugitive emissions and emissions due to incidents and accidents. Vented emissions are direct gas releases due to regular process operations, equipment design, maintenance activities and emergency, while fugitive emissions are unintentional gas leaks from piping and associated equipment components. Emissions due to incidents and accidents are caused by inadvertent damages to pipelines.

A study by Tractebel Enginnering and Ecofys (2015) provides the most complete available study about energy efficiency opportunities in gas networks and is the source of most information in this section. A detailed list of identified energy losses is presented in Table 1. Compressor stations are the largest sources of gas utilization and are significant sources of electricity consumption on a gas transmission and distribution network.

Energy efficiency measures are classified into the three following categories: measures for transmission grids, measures for compressor stations and measures for distribution grids.

Besides, the potential of the measures is quantified (small, medium and large), and key factors that have an impact on the loss level are identified (Tables 1-2). Opportunities to improve energy efficiency are mainly related to gas losses (transmission network), technical solutions or optimized work practices (compressor stations) and replacement or repair / relining of old pipes to reduce emissions or third-party damages (distribution networks).

This study also provides hints about the economic assessments of technical options:

- Analysis of cost-effectiveness of the major energy efficiency measures is presented for transmission grid, compression stations and distribution grid as well
- It is emphasized that the presented data only give an order of the magnitude of the costs, but they cannot be precise as costs differ from one network to another.
- There are three types of costs that are analysed within identified measures to improve energy efficiency: capital costs, operational costs and labour costs. Cost level of each is quantified (small, medium or large).

Tables 1-2 also summarise, for each measure, a qualitative assessment of its EE potential, type of cost and cost level, provided by the Tractebel (2015) study.

Whereas this source is based on expert assessment, Member States are another source of proposed technical measures. Pursuant to Article 15(2) of the Energy Efficiency Directive, Member States were required to undertake (by 30 June 2015) an assessment of the potential for energy efficiency of the gas and electricity infrastructure in their territories. A few Member States have provided National Reports of this assessment, and some of them have also been published.

Among available Reports, only two (Great Britain and Lithuania) provide quantitative estimates of the EE improvements, either from already valid measures or from potential ones (OFGEM, 2015; UAB Ekotermija, 2015). Table 3 summarises the main proposed options and their assessment. For unpublished Reports, only summary statistics are presented, based on the author's understanding.

Table 1- Mapping of energy losses and energy efficiency measures in transmission networks incl. compressor stations.

1A – Subsector: Transmission grids

	GAS LOSSES			**GAS OR ELECTRICITY OWN CONSUMPTION**	
Item	Vented emissions	Fugitive emissions	Emissions due to incidents	Gas consumption	Electricity consumption
Source	Maintenance operations	Permanent losses due to age/ gas grid type	Third-party damages	Fuel to heat facilities – heaters at regulation stations	Cathodic protection
Measures	Reduction of vented gas	Inspection and maintenance programs	Mapping, relation with contractors, emergency call centres, etc.	Improved burner design and heating should be avoided whenever possible	/
	Recompression		Automatic shut-off valves		
Measure potential	Middle	Small	Small	Small	/
	Middle		Small		
Key factors	Pressure level and the volume of vented pipe (both measures)	Length and age of the network	Length of the network, pressure level,	Number and efficiency of heaters, the necessity of burners	/
Type of cost	Capital costs (minor facility modifications), operating cost (maintenance), labour costs				
	Capital costs (pump-down compressor), labour costs				
Cost level	Small				
	Large				

Source: Elaboration on Tractebel (2015)

1B – Subsector: Compression stations

	GAS LOSSES			**GAS OR ELECTRICITY OWN CONSUMPTION**	
Item	Vented emissions	Fugitive emissions	Emissions due to incidents	Gas consumption	Electricity consumption
Source	Compressor: Startup/shutdown and blowdown procedures	From: Compressor equipment not in compression	/	Gas to fuel engines and gas turbines	Electric compression
	Pressure safety valves Gas-driven pneumatic devices				
Measures	Optimal strategies for cycling on- and off- line Reduction of vented gas	Inspection, maintenance and replacement of seals	/	Optimization of equipment dispatch Replacement with a more efficient unit	/
	Replacement of high bleed devices Installation of compressed air/electric system	Inspection and maintenance			
Measure potential	Large	Middle	/	Middle / Large	/
	Small /Middle	Small		Small	
Key factors	Base or peak load compressor (both measures)	Inspection frequency, type of seals to be replaced	/	Number, capacity and efficiency of compressors (both measures)	/
	Number of high bleed and gas-driven devices	Inspection frequency			
Type of costs	Labour costs No costs	Capital costs (seals), operating costs (maintenance)	/		
	Capital costs (compressed air/electric systems)			Small / Middle	
Cost level	Small	Middle	/	Large	
	Middle				

Source: Elaboration on Tractebel (2015)

Table 2 - Mapping of energy losses and energy efficiency measures in distribution networks.

	GAS LOSSES			**GAS OR ELECTRICITY OWN CONSUMPTION**	
Item	Vented emissions	Fugitive emissions	Emissions due to incidents	Gas consumption	Electricity consumption
Source	Maintenance operations	Permanent losses due to age/ gas grid type	Third-party damages	Fuel to heat facilities - heaters at regulation stations	Cathodic protection
	Pneumatic emissions	Permeability of materials and joints			
Measures	Reduction of vented gas Recompression	Inspection and maintenance programs Pressure management	Mapping, relation with contractors, emergency call centres, protection of pipes in sensitive areas, shut-off valves	Improved burner design and heating should be avoided whenever possible	/
	Reduction of vented gas	Replacement or repairing/relining of old pipes			
Measure potential	Small Small	Middle /	Middle	Small	/
	Small	Large			
Key factors	Pressure level, the volume of vented pipe (both measures)	Length and age of the network (both measures)	Length of the grid, pressure level, the sensitivity of the pipe area	Number and efficiency of heaters, the necessity of burners	/
	Number of gas-driven pneumatic devices	Length an age of the grid, pipe and joint material			
Type of costs	/	Operating costs (maintenance), labour costs. Capital costs (new pipes or liners), operating costs (maintenance)	Mainly labour costs. Capital costs for protection of pipes and shut-off valves)	/	/
Cost level	/	Small / Large	Variable	/	/

Source: Elaboration on Tractebel (2015)

Table 3 – Measures for gas network efficiency improvement: own summary of National Reports issued on implementation of Article 15(2) of the EED. Source: JRC 2020

MEASURE	LT	GB	Others (^)
Improved transport system & market organisation		Low	Low (1) Medium (1)
Transmission pipeline coating/upgrading	>320* toe/y		Medium (1)
Improved transmission maintenance operation	500* toe/y	Low	Low (2)
Compressor switch to electricity		80 GWh/y	Low (3)
Compressor heat recovery & other EE improvement	200-250 toe/y		Low (2) Medium (1)
Biogas / Nat. gas conditioning		Low	Low (1)
Distribution leaks & other energy loss reporting			Low (2) Medium (1)
Promotion of micro (co-) generation incl. expanders	500 toe/y	NQ	Low (2) Medium (1)
Improved pre-heat systems of pressure reduction stations	105 toe/y	Low	Low (1) Medium (3)
Replacement of older distribution pipeline and pressure control	135* toe/y	80 / 2000** GWh/y	Low (3) Medium (1)
Improved metering & gas theft reduction	5* toe/y	Low	Medium (1) High (1)

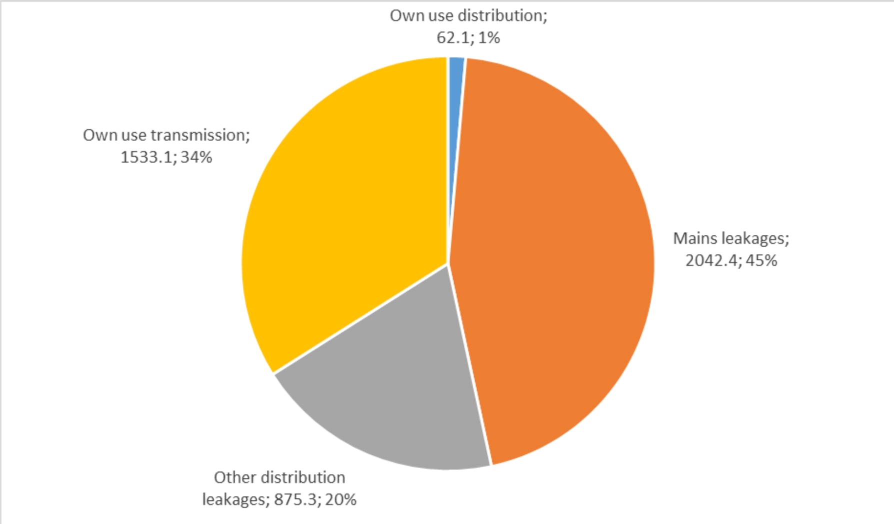
(^) No. of Member States mentioning the Measure and qualitative assessment
(*) Assessed as not economically efficient;
(**) committed / potential;
NQ = mentioned but not quantified

To understand the role of the main measures within the EE potential, it is useful to examine in some detail the British case, which provides the clearest overall picture (Figure 1).

It is clear that distribution mains leakage and transmission own use, mostly compression gas, are by far the largest items. According to a 2017 Marcogaz study, reported by Marcogaz-GIE (2019), EU28 distribution losses represented 59% of total gas value chain CH4 emissions (514,700 tons as of 2015, or 0.32 % of total anthropogenic GHG emissions). Transmission was responsible of 20% (mostly from compression activity), underground storage 5%, production 16% and LNG terminals less than 1%.

Distribution leakages are largely (almost 90%) attributed to low pressure iron mains, which can be substituted by PPE mains, cutting such leaks to almost zero. If all such mains (estimated by the GB Report to about one third of the total) were replaced by PPE, the potential savings would be close to 2 TWh/year, or about 0.23 % of the total gas consumption of the country.

Figure 1 - Estimated gas own consumption plus losses of the British gas transmission and distribution system, in Gas Year 2013/14 (GWh).



Source: OFGEM (2015)

In the case of Lithuania, data are provided as energy saving potential from several measures, rather than current consumption. However, the replacement plan of iron mains by PPE, carried out by the main operator of the Lithuanian distribution system, is similar, and referred to replacement of 1.57% of the existing network. If it was extended to one third of the network (as proposed in Britain, for comparison), it would yield a saving of about 33 GWh/year, or about 0.14% of Lithuania's gas consumption. Considering that a smaller share of gas consumption is channelled through the distribution system in Lithuania (compared to Britain), the estimate can be regarded as broadly consistent with the British one, although totally independent. This result reinforces the significance of both estimates.

Both the British and the Lithuanian studies dismiss as minor losses from maintenance operations and external interference, which are at least one order of magnitude lower.

Since distribution leakages appear to be the main network consumption area, as well as the area where current policy initiatives are regarded as economically justified and under implementation in both countries, it seems justified to deepen the analysis of this issue, in terms of quantitative estimation and known policy measures.

4 Network losses

In general, losses are defined as the absolute difference between the volume of gas entering the system (metered or estimated at the point of entry) and the customer related amount of gas withdrawn from the system (metered or estimated at the point of exit).

The specific definition of distribution losses varies across countries. Nonetheless, for comparative purposes, the following categories of losses are normally included:

1. DSO's own consumption for pre-heating at pressure reduction stations, own buildings and other uses;
2. gas leakages (sealing systems, cracks in the pipes due to corrosion, discharge of gas through protection valves);
3. adjustment error of meters (mostly due to different atmospheric pressure and temperature at time and place of recording), in case of lack of correction devices;
4. construction works (extensions, upgrades and maintenance of the distribution networks);
5. damages caused by the third parties (constructions, agricultural activities and so on);
6. gas theft;
7. natural disasters.

However, several countries normally consider only some of these categories, as seen in the following Table 4. There has been no attempt so far to harmonise these issues in the EU, and several countries report no regulation at all. Available information is not consistent.

Moreover, the definition of losses sometimes includes differences of measurement between meters at city gates or other metering stations and measures at consumers' sites. Since the latter are only metered few times every year and their readings are scattered across times, end user official measurements at the time of city gate reading are in fact the results of interpolations, which depend on (more or less precise) algorithms.

Based on CEER's 6th Benchmarking Report on the Quality of Electricity and Gas Supply (2016), the following Table 4 provides a benchmark for EU countries' approach to losses. Only 19 Member States contributed to the 6th Benchmarking Report.

As we can notice, the interest in this topic is not general: about half of the 19 NRAs taking part in the poll did not report a methodology for network loss calculation or any regulation aimed at reducing them. In fact, interest in this topic was originally linked to their relevance for gas use safety, and has been somewhat raised by its environmental relevance, as methane leaks contribute to global warming. Several gas distributors (or their parent companies) are now including estimation of losses in their Environmental Reports, but they do not necessarily follow a harmonized methodology.

Table 4 - Distribution losses regulation in the EU (No. of member states).

Issue	**Yes**	**No**	**No info**
Is there a methodology to compute network losses?	9	8	2
Classification available for gas leaks:			
By degree of danger	7	0	12

Issue	Yes	No	No info
Localised after planned inspection	7	1	11
Reported by third parties	7	1	11
Is there any regulation in force aimed at reducing losses?	8	9	2

Source: CEER (2016)

Before considering any quantitative estimation of losses, it is worth looking at the definition of *gas leaks* in the different Member States (Table 5). Gas leaks are only one category (No. 2 of the above list) of losses. Discrepancies of definitions explain why quantitative comparisons are hardly feasible and meaningful.

More general definitions are described in the following Table 6.

Table 5 - Available definitions of gas leaks in the EU.

Czech Republic	Gas leaks are uncontrolled. Unmetered loss of gas from the gas facility, technical rules for gas TPG 905 01.
France	Any unintentional release of gas.
Germany	Unwanted gas release.
Italy	Gas leak calculation is detailed and defined for gas transmission system in Gas Network Code and for balancing equation. Gas leak or "dispersion" is the uncontrolled release of gas from the distribution system.
Latvia	Uncontrolled gas outflow from the gas network into environment, when it is required to perform specific activities in order to ensure safe operation of the facility.
Netherlands	Unintended outflow of gas, caused by a failure of a component of the gas distribution network (NEN 7244-9).

Source: CEER (2016)

Table 6 - Available methodologies to compute network losses in gas networks in the EU

Croatia	Annual gas losses are determined as difference of the total amount of gas that is taken into the distribution system and the total amount of gas that is delivered from the distribution system to end customers. The total amount of gas that is delivered to the distribution system is calculated as the total measured amount of gas entering the distribution system for a period of 6 hours of June 30 last year to 6 pm on June 30 of the year in which annual gas losses are determined.
France	The Gas Losses and Diverse Discrepancies (LDD) of GrDF equals to the difference between: the Quantity of energy injected by the TSOs at the entrance of the DSO (Removals from the TSOs) and the Quantity of energy metered by the DSO to its

	customers (metered energy to the customers). Real GrDF LDD = Σ (Removals from the TSOs – metered energy to the customer[3].
Hungary	High pressure system: the TSO measures continuously the entry and exit volumes. The metering differences and the transmission losses are defined in a balance sheet form on a daily basis, taking into account the transmission system operator's own consumption and change in its line pack, as well as the input to and off-take from the system. Medium and low-pressure system: the losses are computed with the help of an expert model which defines several subcategories of losses.
Ireland	GNI calculates gas shrinkage losses on a monthly basis across the network. Shrinkage gas includes both fuel gas usage in compressor stations and water bath heaters on the transmission network as well as unaccounted for gas.
Italy	High pressure system: gas transmission network codes define losses (measured, calculated and estimated). Balancing equation takes into consideration losses. Tariff regulations recognise average losses.
Latvia	JSC "Latvijas Gaze" uses 5 methodologies: methodology for technological losses calculation in distribution system, methodology for technological losses in transmission system, methodology for technological losses calculation for Incukalns UGS, methodology of technological losses calculation in user's gas supply system, methodology for calculation of non-balance of technological losses.
Spain	Yearly balancing among entries and exits to the transport and distribution grids.
Sweden	Annual gas losses are determined as difference of the total amount of gas that is taken into the distribution system and the total amount of gas that is delivered from the distribution system to end customers.

Source: CEER (2016)

Methodologies are also very different and clearly have various purposes. In some cases, there is simply a concern to limit the amount of losses that can be included in the DSO's allowed revenues. For example, Italy allows average losses, i.e. DSO's are only allowed to include in their allowed revenues the costs of the national average of distribution losses (less than 0.5%). This approach can be regarded as a simple implementation of benchmarking, where allowed costs are set to the level of industry average.

In other cases, losses are considered as part of a more complex process, which aims to define allocations of gas flows to several network users, in the framework of retail market opening. The French and Irish methodologies of Table 6 are examples of this approach, which has however been necessarily pursued in most EU Member States (even though it was not described in CEER's 6th Benchmarking Report) as part of the balancing and settlement process. Within this framework, the relevant concept is not so much that of technological losses, but rather *Unaccounted For Gas* (UFG), a broader definition that includes losses but also other categories of differences between gas entering distribution grids (measured at city gates) and that delivered by it (measured at consumer sites). For a swift working market, it is necessary to minimise and settle UFG as close as possible to consumption time, as it is always a component of balancing equations. The need for EU Member States to address this problem originates from implementation of the Balancing Network Code, which is a binding EU Regulation[4], and hence it is crucial for the take-off of short term trading under the entry-exit market model.

[3] See CEER (2016) for further details

[4]a Commission Regulation (EU) No 312/2014 of 26 March 2014 establishing a Network Code on Gas Balancing of Transmission Networks, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0312

The UFG concept applies to network users (*shippers*) rather than to network operators, even if it includes network losses. Since tight balancing requirements apply to transmission networks (and not to distribution), UFG is calculated and contributes to transmission imbalances, even though most of it actually originates in distribution networks or in the consumer, premises, i.e. "after the meter". UFG typically includes not only physical losses (mostly occurring in distribution grids), but also measurement errors (mostly but not entirely fixed in advanced systems) and theft. However, theft, measurement errors and other differences are not relevant for EE purposes, but can be confused in measurement and data reporting processes..

On the other hand, losses are hardly a key parameter for tariff setting in the EU, or an important subject of benchmarking. Given the relatively low value (and hence, the limited cost) of losses, several EU Member States ignore the issue or simply define a maximum percentage of allowed losses, which can be considered as allowed cost. Others have implemented regulatory mechanisms to foster loss reduction: the next section will outline how this is carried in two of them.

Before this is done, a quantitative overview is presented, with a view to show the relevance of the issue across Europe.

For this purpose, two main sources are available:

1. Eurostat data on gas distribution losses (https://ec.europa.eu/eurostat/data/database);
2. European Environmental Agency - Annual European Union greenhouse gas inventory 1990–2016 and Inventory Report 2018.

Table 7 shows the evolution of declared gas distribution losses in EU Member States (2009-18), from the Eurostat database[5], as a percentage of their total gas consumption.

Although the Table shows a slightly decreasing trend, the evolution is not linear. However, these data present a number of issues, which are worth considering in the definition of a regulatory methodology concerning losses:

I. Several Member States do not provide data;
II. Values are very different across countries. This may depend on a number of reasons:
    a. The definition of transmission and distribution is not homogeneous across countries;

[5]https://ec.europa.eu/eurostat/data/database?p_p_id=NavTreeportletprod_WAR_NavTreeportletprod_INSTANCE_nPqeVbPXRmWQ&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_pos=1&p_p_col_count=2 . Distribution losses are available by selecting Database/Energy statistics/quantities-annual data/Energy flow - Sankey diagram data (nrg_bal_sd) and then selecting "Distribution losses" under the Energy balances (NRG_BAL) dimension.

Table 7 - Gas distribution losses as percentage of gas consumption in EU Member States, 2010-18

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
European Union - 28	0.67%	0.62%	0.63%	0.57%	0.57%	0.57%	0.47%	0.46%	0.49%
Belgium	0.13%	0.13%	0.13%	0.12%	0.19%	0.18%	0.21%	0.20%	0.19%
Bulgaria	0.56%	0.29%	0.42%	0.44%	0.48%	0.50%	0.34%	0.40%	0.30%
Czechia	1.66%	1.86%	1.80%	1.68%	1.94%	1.78%	1.57%	1.27%	1.28%
Denmark	0.08%	0.09%	0.10%	0.10%	0.13%	0.12%	0.12%	0.11%	0.11%
Ireland	1.85%	1.92%	1.82%	1.99%	2.03%	1.95%	1.21%	1.15%	1.28%
Greece	0.54%	0.40%	0.52%	NA	NA	0.30%	0.27%	0.22%	0.25%
Spain	0.50%	0.45%	0.55%	0.59%	0.63%	0.42%	0.40%	0.43%	0.51%
France	0.84%	1.18%	1.02%	1.29%	1.36%	1.32%	1.15%	1.13%	1.16%
Croatia	1.88%	1.90%	1.78%	1.45%	1.19%	1.26%	1.28%	1.07%	1.08%
Italy	0.72%	0.54%	0.71%	0.72%	0.54%	0.48%	0.48%	0.53%	0.54%
Latvia	0.44%	0.94%	0.99%	0.54%	1.30%	0.73%	0.98%	1.14%	1.08%
Hungary	1.73%	1.53%	1.56%	1.57%	1.51%	1.36%	1.18%	1.26%	1.26%
Malta	NA	NA	NA	NA	NA	NA	NA	4.17%	0.09%
Austria	0.02%	0.03%	0.03%	0.04%	0.04%	0.03%	0.03%	0.03%	0.03%
Poland	1.21%	0.24%	0.83%	0.34%	0.20%	0.19%	0.18%	0.08%	0.08%
Portugal	0.63%	0.10%	0.47%	0.13%	0.12%	0.20%	0.12%	0.12%	0.13%
Romania	3.15%	2.94%	3.06%	1.31%	0.83%	0.80%	1.00%	0.80%	0.74%
Slovakia	NA	NA	NA	NA	1.96%	2.02%	2.03%	2.00%	1.98%
Finland	NA	NA	NA	NA	NA	NA	0.08%	0.36%	0.60%
United Kingdom	1.17%	1.09%	0.92%	0.88%	0.89%	1.04%	0.60%	0.61%	0.75%

Source: Elaboration on Eurostat data

b. The role of distribution also varies, as countries where natural gas is more widely used by households and other small customers usually present a relatively larger role of distribution, which in turn is related to higher loss values;

c. The interpretation of losses may not be consistent. In some countries, this definition may include measurement errors, non commercial losses (like theft), and other UFG items;

d. Own consumption of transmission (including transit) and distribution networks may have been included, even though a different item is foreseen by Eurostat[6];

e. Countries where transit of gas is dominant (e.g. Czech Republic and Slovakia) may have higher losses as percentage of their consumption, which is small compared to transit. However this does not occur for other important transit countries like Austria.

For these reasons, the interest of this Table is limited. Yet, the low reliability (and missing countries) entail that any regulatory methodology based on cross-country benchmarking and harmonisation of distribution losses can hardly be proposed unless a preliminary, substantial harmonization of accounting practices is undertaken.

This point is reinforced by looking at the second source, namely the *EEA GHG Emission Inventory Report*[7]. This Report estimates emissions by using three main methodologies, described by GIE & Marcogaz (2019) as follows:

"Tier 1: It is the simplest approach; it comprises the application of appropriate default emissions factor to a representative activity factor (usually throughput). Default emission factors for a set of activity data are listed in the IPCC Guidelines.

Tier 2: Similar to Tier 1 approach. However, instead of default emissions factors, country-specific emission factors (developed from external studies, analysis measurement campaigns) are used.

Tier 3: The most detailed approach based on a rigorous bottom-up assessment at the facility level, involving identification of equipment-specific emission sources, equipment inventory, measurement of emission rates per equipment type, etc."

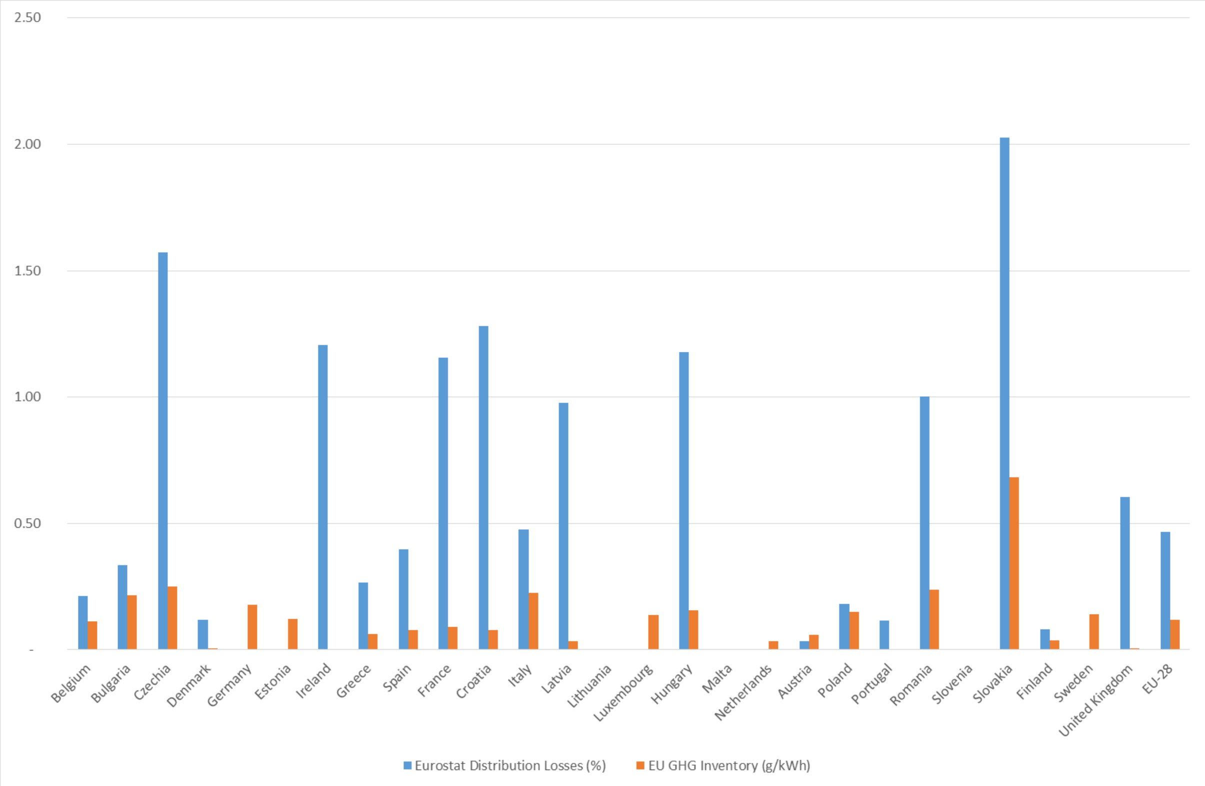
Methane emissions from transmission and distribution, which should be close to gas leakages, are reported under sub-category 1.B.2.b of the Inventory Report (Table 3.120). These estimates use not only different Tier approaches but also different criteria for the calculation, usually gas consumption, distribution or network length. Moreover, several countries are missing or their calculation criteria are not reported.

Notwithstanding these caveats, we report total transmission and distribution emissions as reported in the Inventory Report and compare them with distribution losses reported by Eurostat for the same year 2016 (Figure 2).

The rather limited correlation (0.60) between the two sets of data reinforces the need for further harmonisation before a common methodology addressing network loss reduction can be envisaged.

6 Eurostat data about own consumption have not been included, because they are related to the whole energy industry rather than gas transmission and distribution only. For example, losses in Denmark are close to what is reported by the Danish National Report implementing Article 15(2), but these do not include leakages.
7 The GHG inventory is also summarised by GIE & Marcogaz (2019).

Figure 2 Gas distribution losses according to Eurostat and EEA sources, 2016



Source: Eurostat (2016)

The low level of losses in many countries explains why regulatory interest is not widespread, and only about half of the countries have enforced regulations aimed at controlling them, mostly by setting a maximum level. It is interesting that CEER's 6th Benchmarking Report has a limited interest in the topic and does not include any general information about the (percentage) level of allowed losses. It is likely that lack of harmonised definitions (and of any legal requirement to undertake it) leads to such different results that regulators (unlike Eurostat) have preferred to avoid a hardly meaningful comparison.

Notwithstanding these caveats, losses appear much higher (sometimes over 2%) in several Central and Eastern European countries (Slovakia, Czech Republic, Croatia, Romania, Hungary). Even higher values occur in Energy Community Contracting Parties: Moldova (6.03% as of 2016), Georgia (6.02%), Ukraine (3.74%), Serbia (3.62%).

The prevalence of high losses in Central and Eastern Europe (both in EU Member States and others) depends largely on the fact that in most former centrally planned economies natural gas was often regarded as an almost free commodity, with limited interest in system efficiency. Prices were very low and there was often no metering at consumer sites or along the distribution chain. It is likely that the relatively high level of losses in the Eastern part of Europe also depends on old and inadequately maintained networks, lack of (or old, inaccurate) meters, and some theft. These countries have often fallen in the typical trap of subsidised energy consumption, which is well known throughout the developing world and largely studied: very low prices lead to lack of customer care, use of inefficient consumer appliances and waste, whereas the related lack of financial resources hampers EE-related investments by network operators.

5 Case studies of regulatory measures addressing distribution losses

5.1 Great Britain[8]

Although OFGEM, Great Britain's regulator[9], did not take part in the poll that led to the 6th CEER Benchmarking Report, its approach to losses is very transparent, although quite complex. The British experience is well documented, proposes an interesting procedural approach, and explicitly considers technical as well as commercial losses. Therefore, Great Britain can be a source of interesting lessons.

The British distribution system consists of over 280,000 Km of pipelines, is divided into 8 Local Distribution Zones (LDZ), run by four DSOs. It supplies over 21 million customers.

In the British regulatory system, a key concept is that of *shrinkage.* Shrinkage includes technical losses, own use gas, and unaccounted for gas. Distribution shrinkage is the difference in energy between the gas entering each distribution system and the total used by customers. If this amount of gas were not quantified, it would not be possible to assess how much gas is transported through the network on behalf of Gas Shippers, which is crucial for balancing purposes and underpins key gas market arrangements. Therefore, achieving the utmost precision in the evaluation of Shrinkage has been the key driver of its estimation and assessment process. Yet containment of gas network losses is also important, as they represent abo-ut 1% of all greenhouse gas emissions in the country.

The treatment of shrinkage in the British distribution system consists of a procedure, where DSOs, shippers and the regulator significantly interact. It consists of two key stages:

- Estimation, conducted before the Gas Year
- Assessment, conducted after the Gas Year

DSOs may also propose to shorten the period of the procedure below the year: in this case, all deadlines are adjusted consistently.

The procedure is better understood by considering its time development and players. It is described in the following Table 8, for the basic case of an annual estimation and assessment.

Table 8 - Procedure for estimation and assessment of distribution shrinkage in Great Britain

When	**Who**	**What**
1 January before Gas Year	DSO	Estimation of Shrinkage for the next Gas Year and outline of the methodology by which it is estimated
1 February before Gas Year	Shippers and other stakeholders	Comments and observations about the Shrinkage estimation methodology and results
1-15 February before Gas Year	DSO	Considers comments, may hold consultations and meetings with shippers
1 March before Gas Year	DSO	Submits final Shrinkage estimation to shippers and OFGEM

8 This section is partly based on a private Report that was prepared by MRC Consultants and Transaction Advisers on behalf of NARUC and USAID.

9 OFGEM (Office for Gas and Electricity Markets) is responsible for Great Britain (England, Wales and Scotland). Northern Ireland has a different regulator and is not considered in this section.

When	Who	What
15 March before Gas Year	OFGEM	Approves or rejects DSO Shrinkage estimation; if rejected, the previous year's applies
1 April – 31 March		Gas Year
1 July after Gas Year	DSO	Shrinkage assessment

The estimation is typically based on a function of technical parameters of the network equipment including: length, diameter and age of pipes, type of meters and their location (e.g. in living apartment vs. public building). Usually, the parameters for each piece of equipment are set by the regulator, but the above described procedure allows DSO some flexibility. The estimation is however subject to regulator's approval.

The assessment is based on several elements, including:

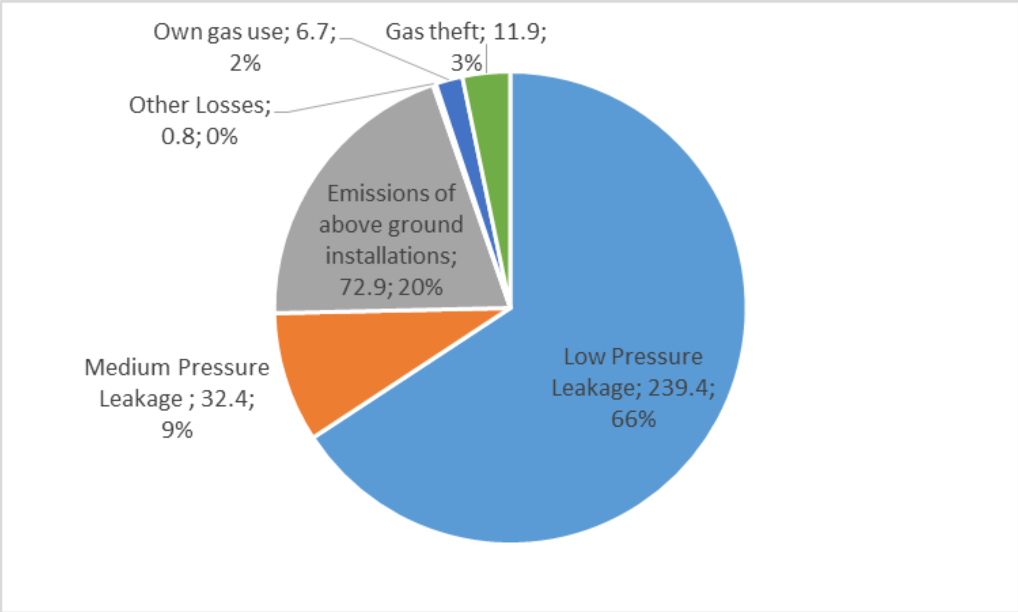
- Meter readings in respect of preheating facilities (where available);
- Evidence of significant changes in theft;
- Consumer profiles;
- Replacement work of old pipelines;
- Number and characteristics of meters and above ground installations;
- Damage caused by third party interference;
- Calorific Value shrinkage (including errors of measurement due to lack of correction devices, etc.);
- End customers' consumption.

Figure 3 provides a cumulative estimation of the main Shrinkage components. Low pressure pipeline leakages are clearly the most important factors.

In Gas Year 2017-18, the final assessment of total leakages was 350.4 GWh, or 1.4% more than the ex-ante estimation.

In fact, the British approach focuses on distribution leakages and own consumption of the transmission system. This may seem at odds with the conclusion of (e.g.) the GIE-Marcogaz Report (2019:p. 59), where transmission losses are estimated as a significant source of methane emissions for Europe, although less than half those of distribution. This neglect is shared by other Western European countries, which seem to believe that gas transmission losses are too small to be worth further action. Both the British and Lithuanian Reports seem to consider action on compressors as a more appropriate focus of energy efficiency measures in gas transmission.

Figure 3 - Composition of gas distribution shrinkage in Great Britain, Gas Year 2017-18 (Gwh)



Source: LDZ Energy Loss Initial Proposals Financial Year 2017/18, WWU (2016)

5.2 Italy

In general, the Italian distribution tariff regulation allows an average loss percentage in all distribution zones. The percentage is revised for each regulatory period (every 5 years).

However, the most interesting feature of the Italian regulation of technical quality of supply is the widespread use of an incentive and penalty system (also known as a *sliding scale* mechanism). Technical quality of supply focuses mostly on safety, including issues like network inspection for the detection of leakages, emergency intervention and odorisation. Continuity of service and gas calorific value are also addressed.

In particular, the sliding scale mechanism applies to network inspection. The regulation[10]:

- sets a minimum standard;
- issues a penalty if the standard is not met;
- foresees a "neutrality zone" above the minimum standard;
- rewards the company if performance exceeds the neutrality zone.

This mechanism is described in Figure 4, where the regulated quality performance is the percentage share of the network subject to annual inspection. In the Figure, the minimum standard is set at 50%, the neutrality zone between 50 and 75%, and the maximum reward is granted for a 100% annual inspection.

This approach is also used in Italy for other quality parameters, including punctuality of emergency services, gas odorisation and others. Here we focus on network inspection, because it is strictly related to the issue of technical losses. Indeed, a higher inspection share led to detection of more leakages, which must be repaired if found. Therefore, this is an active policy for loss reduction, also known as Leak Detection and Repair (LDAR)[11].

[10] Decision 775/16/gas "Testo Unico delle disposizioni della regolazione della qualità e delle tariffe dei servizi di distribuzione e misura del gas per il periodo di regolazione 2014-2019", www.arera.it

[11] See Marcogaz and GIE (2015), section 3.2.2.

Figure 4 - Example of a sliding scale scheme for network inspection activity

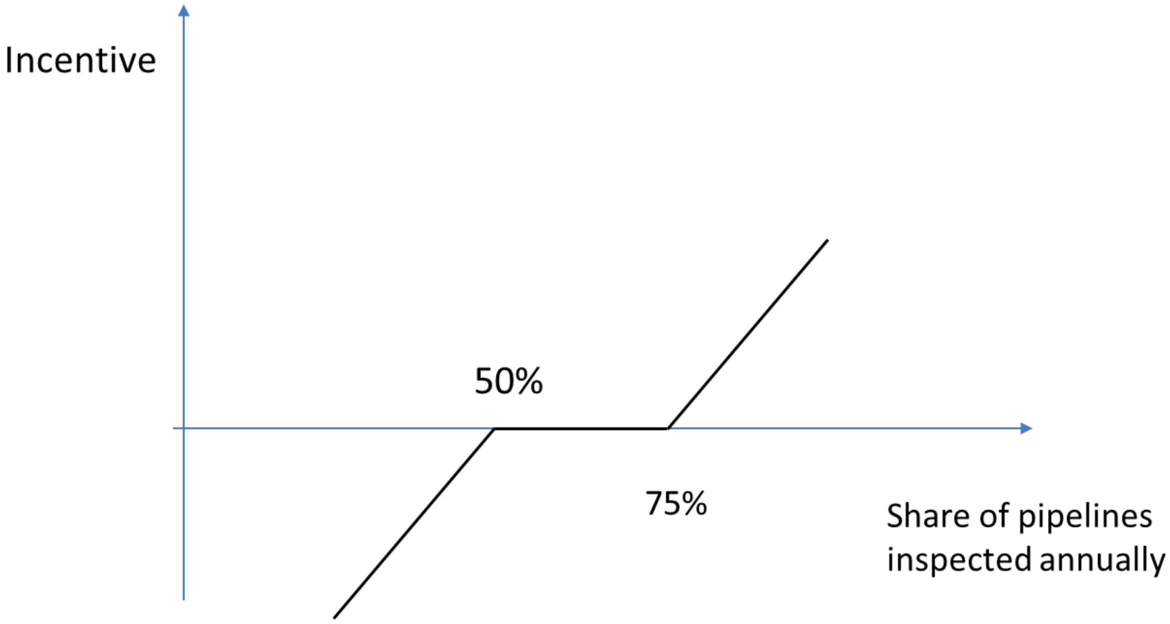
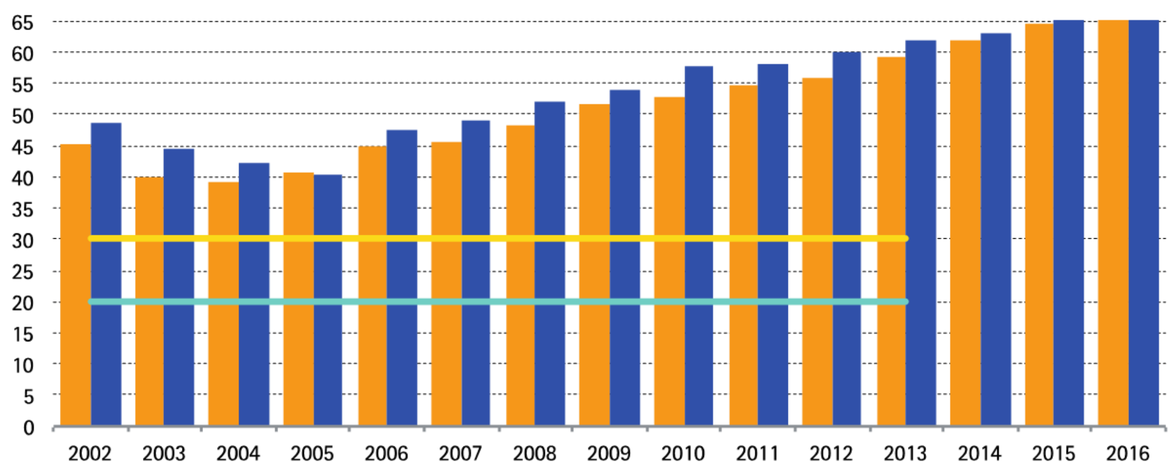


Figure 5 shows some results of this policy. In fact, the Minimum annual inspection requirement was 20% (light blue horizontal line) for Low pressure and 30% for Medium/High Pressure pipelines (yellow horizontal line). Since 2014, this has been turned into a 3-year moving average of 25% for low pressure and 33.3% for medium/high pressure.

This penalty and reward mechanism has clearly been successful in triggering more network inspections. However, the risk of such mechanism lies in its cost, both as rewards and as actual cost of network inspection.

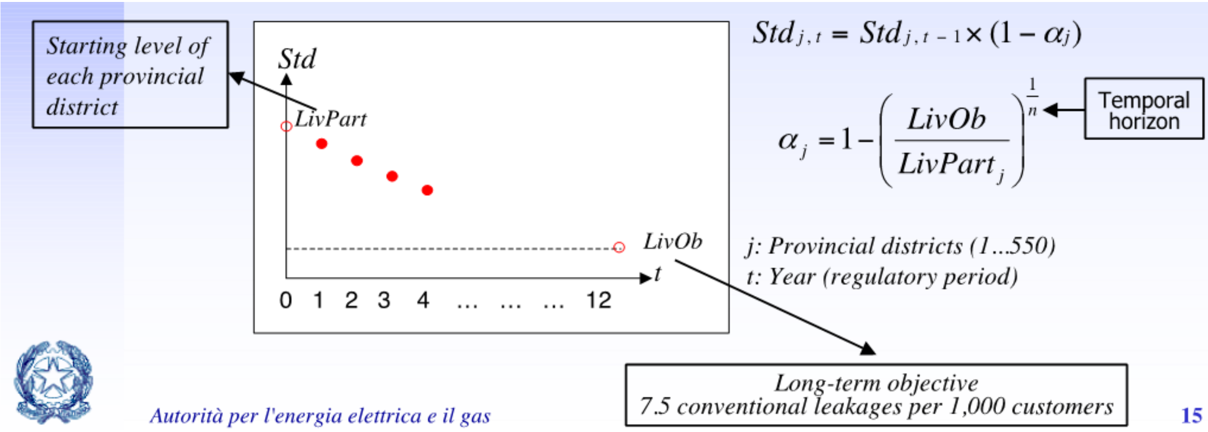
Figure 5 - Percentage of network inspected on a yearly basis (orange: low pressure; blue: medium and high pressure)



Source: ARERA Annual Report 2017

In Italy, a slightly different approach is applied to another, related indicator, i.e. the Number of leakages reported by third parties (per distribution plant, LIV: Figure 6). In this case, a target is defined, as "best practice", which is assessed by the regulator after parties' consultation. In each provincial district, the DSO must reduce conventional leakages detected by third parties in a way to reach the objective by the end of the regulatory period (5 years).

Figure 6 - Mechanism for reduction of leakages detected by third parties in Italy

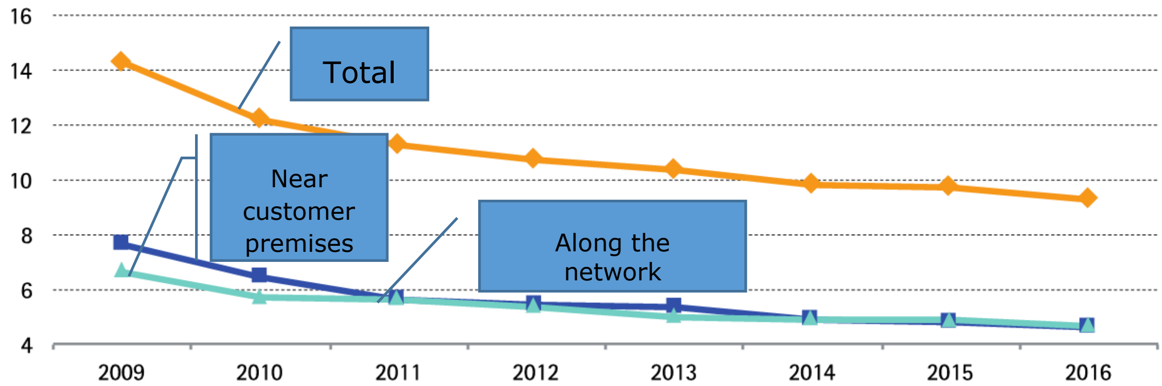


Source: ARERA Annual Report 2017

In the Figure, orange dots on the left show starting points of each of the 550 distribution districts, which clearly differ. A single, common objective is set at the horizontal dotted line. Each company is required to improve its standard at a rate that would lead it to meet the objective line within a predetermined time (e.g. 12 years). The objective is set at the level of the best company, and the time to achieve the objective is decided after consultation of stakeholders and experts. This is clearly an example of a benchmarking-based approach to quality parameters, as all companies are required to improve toward the level of the best performers, within a reasonable time.

Incentives are provided in case DSOs reduce leakages detected by third parties below the level foreseen by the formula of Figure 6. Penalties are applied if objectives are not achieved. Results of this policy are shown in Figure 7.

Figure 7 - Leakages reported by third parties in Italy (No. / 1000 end customers)



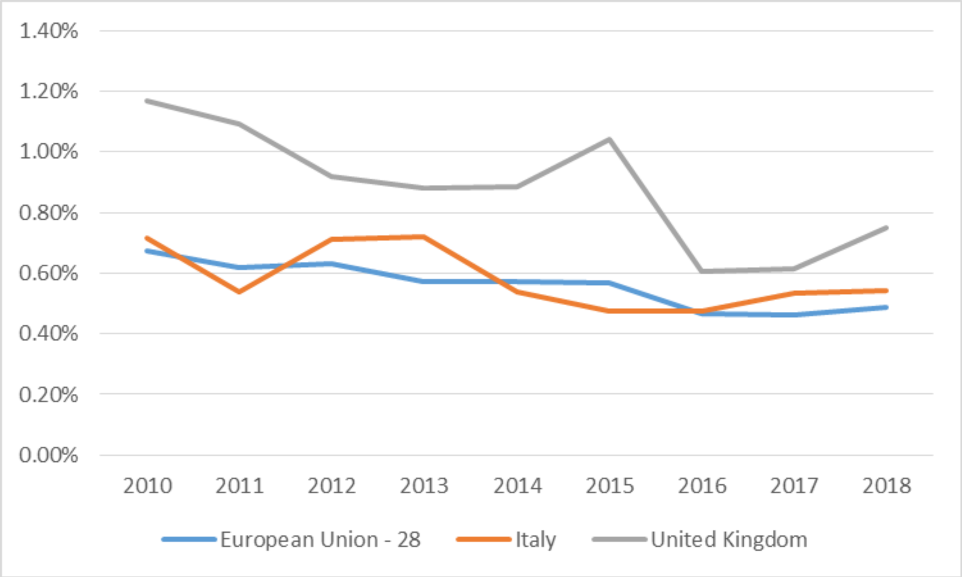
Source: ARERA Annual Report 2017

The objective of this mechanism is not just to reduce total losses but particularly those detected by third parties, typically gas leaks "smelled" by consumers and bystanders, which can be a source of danger. The main concern is to enhance safety rather than reducing network losses for economic reasons. It is likely that success of this policy also leads to a decrease of total network losses. The evolution of distribution losses in Italy and the UK between 2010 and 2016 is shown in Figure 8.

The Italian mechanisms are clearly based on a benchmarking of DSOs: they set common standards based on best industry performances and require all companies to achieve them.

The process is fostered by a reward and penalty mechanism, which indirectly affects tariffs: for example, if a reward is granted, this represent an increase of the allowed revenue, and hence of average tariffs. A tariff decrease occurs if penalties prevail. Unfortunately, the Italian regulator does not provide detailed information about the amount of penalties and rewards, but the latter prevail. Every year tariffs are updated (among other reasons) to allow for a special component that covers the balance between rewards and penalties aimed at quality of service improvements. In 2017, this component amounted to 1.53 EUR/thousand cubic meter for customers up to 200,000 cubic meter/year (mostly households, apartment blocks and small shops) and 0.77 EUR/thousand cubic meter for higher consumption levels.

Figure 8 - Evolution of distribution losses in EU, Italy and UK (% of total consumption)



Source: Elaboration on Eurostat data

5.3 The British and Italian approaches: some lessons

The British approach is very interesting, notably for countries with relatively high losses. It is based on a transparent process for the definition of losses (including commercial ones). The DSO would be required to clearly present its estimation of losses, based on its own objective methodology, which must be however discussed by network users (shippers) and other stakeholders, with a final decision taken by the regulator.

Where possible, the regulator may also estimate a benchmarking equation for DSOs or distribution districts, based on such factors as pipeline length, age, diameter and others that are typically monitored. This could set a benchmark for the estimation of losses by DSOs, and possibly determine their maximum allowed level.

As for the Italian approach, both above described policies, featuring incentives to network inspections and the reduction of leakages detected by third parties, may be interesting for other countries.

In particular, reduction of gas losses could be achieved by more frequent (above the established norms) inspection of gas networks in order to detect leaks. At a level above the average, a reward for the DSO would be granted.

However, such mechanisms require a preliminary collection of data about current practices, including available technologies for network inspection, the definition of those accepted as a basis for incentives, and actual number of leakages detected by third parties. In fact, implementation of such mechanisms may take a couple of years' preparations.

Other case studies of LDAR processes, including some details of technical tools, are provided in the Marcogaz-GIE (2019) Study, notably in Annex V, including France, Italy, Germany, The Netherlands, Poland and Spain. The Study reports company practices and technologies, but does not mention regulatory provisions (except for Italy).

6 Outline of a regulatory methodology for the enhancement of energy efficiency of gas networks

6.1. Conclusions of the study

The outline of a regulatory methodology for the enhancement of energy efficiency in gas networks starts from the following preliminary conclusions, drawn from the analysis conducted in the previous sections.

1) There are several technical options that may lead to improvements of energy efficiency of gas networks. These solutions have different characteristics and probably different benefit-cost ratios, depending on the underlying conditions of the network, features of the served territories, and costs of inputs. Therefore, it is inappropriate to prescribe general solutions for all countries and for all network operators.

2) In general, technical solutions involve investment by network operators. Therefore, it seems appropriate to root any regulatory methodology within the process of approving and/or incentivising network investments, as already foreseen at EU and national level. Natural candidates are (for transmission) the preparation of Ten Years Network Development Plans, with the related, harmonised Cost-Benefit Analysis. Similar processes may be extended to distribution investments, with the necessary adaptations.

3) The limited available quantitative assessments of the EE potential of gas networks highlight that the main areas of potential improvements are:

    a. the reduction of distribution leakages, notably by the substitution of older iron pipelines with modern plastic ones, and

    b. the improvement of the efficiency of transmission compressors, including their substitution with electrically fed ones, and redesign including heat recovery.

In both cases, any general assessment of benefits and costs would be misleading, as these heavily depend on local operational conditions, quality of existing assets, and operational costs. The above conclusion is mostly derived from Reports published for the Czech Republic, Great Britain and Lithuania, which provide useful hints but can by no means be extended to other cases. Therefore, the regulatory methodology should recommend a case by case assessment.

4) Interventions in the transmission sector, notably regarding compressor units, should consider that these activities are also subject to other EE-enhancing policies, like the ETS, and are also often subject to the Industrial Emissions Directive. Therefore, the proposed regulatory methodology may consider, in due time, the adoption of specific provisions for distribution networks, but should only incentivise transmission-related EE investment within the current framework of investment decisions of the gas transmission sector. Any provided incentives should also consider benefits that Operators may achieve from participation in the ETS and other, broader Energy efficiency obligation schemes.

5) Whereas the reduction of leakages has probably the largest potential among EE-enhancing measures for gas networks, any related policy should consider that:

    a. In most EU Member States, DSOs are incentivised to reduce leakages (as well as non commercial losses) by tariff regulation mechanisms, as far as DSO revenues do not depend on the level of leakages. Therefore, in these cases, DSOs are incentivised to reduce losses as a way to cut costs as far as economically justified. This regulatory approach should be generalised and implemented where approaches based on recognition of the cost of actual losses still obtains;

    b. Data about actual network leakages are not homogeneous across EU Member States. It seems justified to promote further harmonisation of the processes of loss estimation, with a view to benchmark them within each country and across Europe. Work already undertaken on this respect, e.g. by Marcogaz and GIE (2019, 2020), should be the basis of further effort. Regulatory coordination of efforts may be useful, also by further dissemination of best practices and the definition of deadlines;

c. The lack of consistent data about network losses, comparable across Member States, hampers the early establishment of generalised quantitative objectives. Indicative or mandatory objectives may be considered at a later stage, provided that sufficiently comparable data are made available;

d. Policies aimed at reducing leakages are already widely implemented in order to improve gas use safety, notably by promoting Loss Detection and Repair practices. These policies fall under the responsibilities of different authorities of Member States. Therefore, detailed loss reduction policies should be defined within each Member States, consistently with its own safety legislation. An EU wide regulatory methodology may however require harmonised reporting of policies, objectives, regulatory mechanisms, and results;

6) Effective EE enhancing policies may benefit from:

   a. Transparent interaction between regulators and operators regarding the definition of quantitative objectives;

   b. The adoption of sliding scale mechanisms, incentives and penalties fostering increased adoption of LDAR practices.

7) Regulators should be allowed to adopt regulatory measures, as foreseen in Article 13 of Regulation (EU) 347/2013 for the promotion of merit investments, including:

   a. The adoption of higher rates of return on selected EE investments;

   b. Early inclusion of EE investments into regulated asset bases;

   c. Accelerated depreciation; and

   d. Others, as deemed appropriate.

8) The methodology should include, in its scope, *cross-vector measures* i.e. measures involving other energy sources, to the extent that they enhance energy efficiency. Such measures may include (e.g.):

   a. the joint management of natural gas and electricity networks;

   b. the involvement of other energy sources and vectors (e.g. LNG, LPG, hydrogen) in energy supply;

   c. Measures related to the improvement of the energy efficiency of storage sites and LNG terminals. However, any Regulation adopted pursuant to Article 15 (2a) of the EED should not address the development of renewable and other synthetic gas, which are covered by other legal and regulatory provisions.

6.2 Outline of a regulatory methodology fostering energy efficiency improvements in gas networks

The following outline falls short of drafting a legal text that could be adopted by a binding *Commission Regulation for the implementation of Article 15(2a) of the EED* (henceforth: the Regulation). It is limited to proposing the pillars of a methodology, which could be turned into the recitals of the Regulation, and (with the appropriate legal provisions and style) into Articles. Several proposals could become tighter or looser, in relation to the policy decisions.

Thus, the following proposals translate the above outlined considerations into proposals that could be the basis of the consultation process that is likely to be carried out, as it is customary in the EU due legislative process. In some cases, alternatives are suggested for further discussion.

(1) Definitions

The Regulation should include legal definitions of at least the following terms, or (where possible) refer to other legal norms where they are defined:

- Transmission technical losses
- Distribution technical losses
- Non technical losses
- Unaccounted for gas, as the sum of technical and non-technical losses and measurement errors
- Energy efficiency enhancing investment
- Cross-vector measures

(2) Harmonisation of the calculation of technical losses

The Regulation should require the definition of a common methodology for the calculation of technical and non-technical losses, to be implemented by network operators throughout the EU. This common methodology should be based on current work by EU-wide technical bodies and be developed in a transparent way, by considering contributions from relevant National technical bodies and associations of network operators and other stakeholders, as well as from existing National Regulations. It should be also consistent with provisions of the relevant Network Codes, notably those covering Balancing and Interoperability and Data Exchange.

Responsibility for the development of the common methodology could be attributed to ACER, which could choose the appropriate technical bodies (e.g. Marcogaz, in collaboration with industry representatives like GIE and GEODE). If deemed that the process is already advanced, so that it could be agreed by the time the Regulation is issued, allowed technologies for loss detection and assessment could be directly included into an Annex to the Regulation.

The common methodology may also include the estimation of own consumption of key network facilities, like compressors and pre-heating boilers of pressure reduction stations.

(3) Reporting of network losses

Network operators should be required to implement the common methodology as defined in the previous paragraph, on an annual basis. The Regulation may require that NRAs collate the results by a common format and send them to ACER for the preparation of a common Report.

Smaller DSOs (e.g. below 100,000 end users) may be allowed to adopt a simplified methodology, e.g. by using coefficients that are defined by the common methodology in relation to technical characteristics of the network.

Reporting may be extended to other facilities covered by the common methodology, as suggested above.

(4) Reduction of technical losses

Upon consideration of the results of the first EU common Report, ACER may be allowed to issue maximum standards for network losses, to be achieved through an economically suitable path. Otherwise, ACER could issue a proposal by for the inclusion of an Annex in the Regulation, to be approved by a comitology procedure.

Standards may be referred to suitable network indicators, like network length and transmission or distribution throughput.

The Regulation should refrain from pointing at any specific technical solutions, in the interest of economic efficiency and innovation.

(5) EE enhancing investment

Within the process of presenting their Ten Years Network Development Plans, TSOs should present proposals for EE enhancing investments, accompanied by a Cost-Benefit analysis conducted in line with the common methodology developed by ENTSO-G and ENTSO-E pursuant to Article 11 of Regulation (EU) 347/2013.

TSOs and other proponents should report on the expected energy-efficiency impact of any investment that is proposed pursuant to Chapter V of the CAM Network Code (Commission Regulation (EU) 2017/459).

DSOs should present similar proposals upon submission of any investment proposal when required to do so, in particular within the framework of periodical tariff setting processes.

Both TSOs and DSOs should be allowed to propose cross-vector measures, in collaboration where appropriate with electricity TSOs and DSOs. Joint proposals by several TSOs and DSOs, including those involving more than one Member State, should be also allowed and submitted to joint consideration of the concerned NRAs. Where necessary, CBCA procedures pursuant to Article 12 Regulation (EU) 347/2013 may be activated.

NRAs may foresee standardized criteria for the assessment of the most common measures (e.g. substitution or refurbishment of pre-heating boilers, iron pipelines, meters, or compressor units), in particular (but not only) for smaller DSOs.

NRAs should be allowed to accept any investment proposals that passes the customary decision criteria (i.e. a positive NPV, a B/C ratio above unity, or an IRR above the Community-wide Social Discount Rate (4%), calculated over the expected lifetime of the assets. Related costs would be included in the cost base for tariff setting purposes.

EE enhancing investments should be eligible for co-financing by the CEF or other Union instruments, without prejudice for their procedures. On this respect, financing should be consistent with the guidelines for implementation of the *Energy Efficiency First* principle that are currently under preparation and are expected to be finalised in 2021.

More generally, investments should be consistent with the decarbonisation objectives of the EU (as agreed by the European Council on 12.12.2019) and shall not lead to sunk costs, as could be the case of investments based on controversial solutions.

(6) Incentives

NRAs may adopt special incentives for EE-enhancing investments, as defined by Article 11 of Article 13 of Regulation 347/2013.

NRAs may adopt measures fostering the improvement of energy efficiency of gas networks, including the adoption of legal standards, incentives and penalties, also by including the related cost in the cost base used for tariff setting purposes.

When assessing the provision and application of incentives, NRAs should consider any other incentive arising from participation of operators in the Emission Trading Scheme, Energy Efficiency Obligation Schemes, and other measures implemented by Member States.

(7) Other energy-efficiency policies

Any regulatory measure adopted under the Regulation should be without prejudice to their submission to other energy efficiency instruments, foreseen by the EED, to the ETS, or to other environmental policy measures. However, NRAs may consider the costs and benefits accruing to network operators under such instruments within their tariff setting procedures.

References

Bergaentzlé C., Clastres C., Khalfallah. H. (2014), "Demand-side management and European environmental and energy goals: An optimal complementary approach", Energy Policy 67, 858-869

California Public Utility Commission (2001), "California Standard Practice Manual. Economic Analysis of Demand-Side Programs and Projects, October 2001, www.cpuc.ca.gov

CEER (2016), 6th Benchmarking Report on the Quality of Electricity and Gas Supply, www.ceer.eu

Čeković I, Conti I, Jones C. and Piebalgs A., Hydrogen Technology Workshop Summary, Florence School of Regulation, https://cadmus.eui.eu

Cervigni G. et al. (2011), Costi e benefici dell'introduzione di un sistema di"smart metering" nel settore italiano del gas, Research Report No. 8, www.iefe.unibocconi.it

Cervigni G., Larouche P. (2014), Regulating Smart Metering in Europe. Technological, Economic and Regulatory Challenges, CERRE Report, www.cerre.eu

Gas Infrastructure Europe (GIE), Marcogaz (2019), Potential ways the gas industry can contribute to the reduction of methane emissions, Report for the Madrid Forum (5 - 6 June 2019), https://gie.eu/index.php/gie-publications/methane-emission-report-2019

Gas Infrastructure Europe (GIE), Marcogaz (2020), Guidelines for methane emissions target setting, https://www.gie.eu/index.php/gie-publications/methane-emission-report-2019

International Confederation of Energy Regulators (2010), A Description of Current Regulatory Practices for the Promotion of Energy Efficiency, www.ceer.eu

National EED Implementation Reports (2016), in Concerted Action – Energy Efficiency Directive, http://www.ca-eed.eu

OFGEM (2015), Energy Efficiency Directive: An assessment of the energy efficiency potential of Great Britain's gas and electricity infrastructure, www.ofgem.gov.uk

Tegen S., Geller H. (2006), "Natural Gas Demand-Side Management Programs: A National Survey, 2006 ACEEE Summer Study on Energy Efficiency in Buildings, https://www.aceee.org/conferences/2006/ssb-1

Termini V. (2011), "Climate Change and Energy Efficiency Policies. A European Regulator's Perspective", https://www.ceer.eu/documents/104400/-/-/075bef82-6342-b0dd-57c9-aa0d0b78152a

Tractebel Engineering, Ecofys (2015), Identifying Energy Efficiency Improvements and Saving Potential in Energy Networks, Including Analysis of the Value Of Demand Response, Study in support of the implementation of article 15 of the energy efficiency directive (2012/27/EU), European Commission, DG Energy.

Tractebel (2019), European smart metering benchmark, Study on behalf of European Commission DG Energy, https://ec.europa.eu/energy/studies/benchmarking-smart-metering-deployment-eu-28_en

UAB Ekotermija (2015), Assessment of the energy efficiency potential of the gas infrastructure, in particular regarding transmission, distribution, load management and interoperability, and connection to energy generating installations, including access possibilities for micro energy generators, Study performed on behalf of the Ministry of Foreign Affairs of the Republic of Lithuania, https://enmin.lrv.lt/uploads/enmin/documents/files/Veikla/Veiklos%20sritys/energijos-naudojimo-efektyvumas/EVE-priemoniu-diegimas-Ekotermija-2015.pdf

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