2009 – 2012 Triennium Work Report

June 2012

WORKING COMMITTEE 4: DISTRIBUTION

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Abstract

Gas distribution companies are the part of the gas chain with the highest visibility to customers, whilst playing a key role in the progressive development of the gas industry. So their performance in terms of quality, safety, reliability and accountability of service is crucial for the overall success and image of the gas industry.

Nowadays gas distribution activities are deeply influenced by various factors, arising both from within and outside the industry, such as:

- Market liberalisation, entailing new activities and competencies;
- Regulatory bodies, providing rules that deeply affect business;
- Improved economic performance needs;
- Increasing demands of customers;
- New stakeholders with different demands and influence.

The primary role of IGU Working Committee 4 – Distribution has been be to support the promotion of industry efficiency and accountability, with a particular focus on stakeholders. To carry out this role, members of Working Committee 4 have met together six times since 2009, exchanging data, analysis, best practices and experiences on the current status of the distribution industry on the topics under study. This has been done not only during meetings, but especially with a continuous exchange and debate throughout the entire triennium.

The topics under study were:

- Distribution Safety Management Systems:

Distribution operators are expected to improve the quality of their operations in terms of safety without compromising on cost and efficiency. Their performance are monitored by regulatory bodies based on a series of performance indicators. Therefore, operators must develop a comprehensive and effective approach to safety management. Furthermore, with increasing attention and pressure from society for safety, companies must demonstrate their efforts and results on safety management to the public very clearly.

- Smart Metering Systems

The frequency and accuracy of meter reading activity at customer's premises has been an issue with growing interest in the industry. Technological improvements are making available solutions that can enable easy and less costly operations, which will benefit both the service companies and end customers by providing other value added services. The adoption of "smart" metering systems has the potential to provide a sound database for gas balancing, reduce operational cost and thus produce a high satisfaction level for the final customers.

- Unaccounted For Gas

The accurate management of the quantities of natural gas is a subject of increasing attention in the gas industry. Gas balancing and emissions control are concepts that nowadays involve all players of the gas chain. Therefore it is necessary to have a thorough understanding of all events affecting gas quantity in each part of the value chain, to allow the proper development

of the gas market. In this context, Unaccounted For Gas (UFG) in distribution plays a more significant role.

The result of the work is this Report, that represents the finalisation of the activities of WOC4 members, that I want to personally thank for the time and energies spend to reach this goal. The Report is indeed the “tip of the iceberg” of the work and the efforts put in place by each single member: as said before, inside the Committee we have had a huge activities of information exchange, analysis of best practices, collection of information and data management.

A special thank goes to Ben Lambregts, Kim Vrancken and Barbara Jinks, that have been charismatic leaders of the Study Groups that specialised on each specific topic and devoted their energies in finalising the work of their teams.

As common in IGU activities Working Committee 4 has collected information on the topics from the entire gas distribution sector through a questionnaire, prepared by the Committee, that requested data and opinions from every member organisation registered with Working Committee 4.

The web-based questionnaire received 56 responses: this figure represents a record number, 20% more than past triennium, providing a substantial source of information for the work of Study Groups. Working Committee 4 is really satisfied with the high response that it received on its questionnaire, and thanks all members and colleagues who contributed to this success sending their answers. Through the contribution of so many companies it is possible to make reliable statements about best practice in gas distribution.

Moreover during the triennium Working Committee 4 has organised two workshops, one open to general public, the other dedicated to members, on Smart Metering Systems and Unaccounted For Gas. These two workshops gave highly valuable inputs that constituted elements upon which Working Committee 4 is now able to present this valuable Report, with its contents of analysis, conclusions, recommendations and best practices.

Executive Summary

Theme and objectives of the studies

During triennium 2009-2012 WOC4 has devoted in developing an in-depth analysis of three subjects that we believe are of great relevance both for distribution activities and for the whole gas chain. The subjects are:

- Distribution Safety Management Systems:
- Smart Metering Systems
- Unaccounted For Gas

These subjects have been selected taking into consideration the various factors that nowadays deeply influence gas distribution activities, arising both from within and outside the industry, such as:

- Market liberalisation, entailing new activities and competencies;
- Regulatory bodies, providing rules that deeply affect business;
- Improved economic performance needs;
- Increasing demands of customers;
- New stakeholders with different demands and influence.

Following the objectives, main key findings and recommendation for each Study Topic.

Distribution Safety Management Systems

Introduction

Gas distribution companies are quite rightly expected, by many stakeholders, to improve the quality and safety of their operations, and are indeed monitored by multiple Regulatory bodies against multiple safety and performance indicators. At the same as improving quality and safety time they must also strive for ongoing efficiencies with a great attention to cost reduction and cost control.

Furthermore, as a result of an increasing interest from society in safety, distribution companies must be able to transparently demonstrate their efforts and results to the public and other stakeholders.

The challenge is to balance safety with efficiency and meet the expectations of society in an environment of cost reduction. To further complicate this challenge gas distribution companies have to take into account that fact that safety in the eyes of the general public might differ from their own point of view.

In response to this challenge distribution operators can develop a comprehensive and effective approach to safety management, defining a safety management system that can become a tool for excellence and efficiency.

The study reviewed the processes and methodologies used to develop safety strategies for managing gas distribution pipeline systems, building upon the Asset Management study from the previous triennium and focussing upon the following five key areas:

- Process safety leadership
- Human factor, competence
- Emergency arrangements
- Inspection and maintenance.
- Audit, review

Key findings

Regarding the objectives and goals of the study, the study group concluded that it was not possible to establish uniform set of definition and define specific metrics for KPI's for safety management strategies and practices to be used around the world. Definitions vary per country or continent. This is most likely a consequence of different regulation and objectives around the world. We are sure that best practices, for example to develop and maintain competences, developed in companies as an answer to effective safety management system need to anticipate to the evolution of legislation and regulation. Safety regulation is more and more influenced by an increasing non acceptability of gas accidents by the public and society in general. The safety level of our industry today will not be sufficient tomorrow. Nevertheless, we think, from an expert's point of view, that incentive regulation of tariffs related to safety investments is not appropriate.

From the report the following major conclusions and recommendation can be drawn.

Conclusions:

1. Safety management is a number one priority for gas distribution companies all over the world.
2. Human factor seems now to be the major risk of gas distribution industry after third part damages.
3. Gas companies are using the progressive competence development solutions only in a limited way
4. A large proportion of respondents used excel based reporting to provide KPI's. This could present a risk in terms of data quality and thereby value of the reporting.
5. Emergency arrangements are different between the countries because they are determined and influenced by national legislation and regulation in accordance with national rules.
6. There is no world wide standard for a holistic safety management system. ISO9001 is widely used.

Recommendations

1. It is recommended that companies bring a balance between leading and lagging process indicators and continually review their set KPI values in order to ensure they are fully relevant in a changing environment.
2. Because of the risk it is recommended to introduce a human factor KPI in the Board Survey: "% of incidents with human factor identified as a cause" should be a good proposal

3 Where possible, an end to end system that draws the data from a “core” system is recommended thereby limiting the “human” interaction and manipulation.

4 Professional periodical emergency training is necessary. Trainings for all staff (in sourced and outsourced) in cooperation with fire brigades and professional organizations should be organized.

5 Whether or not there will be a world wide standard for a safety management system in the future, we recommend companies to invest firmly in the attitude and competence of its employees and create a safety culture in the organisation in which safety is regarded a part of the organisations DNA.

Smart Metering Systems

Introduction

The frequency and accuracy of meter reading activity at customer’s premises has been an issue with growing interest in the industry. Technological improvements are making available solutions that can enable easy and less costly operations, which will benefit both the service companies and end customers by providing other value added services.

The adoption of “smart” metering systems has the potential to provide a sound database for gas balancing, reduce operational cost and thus produce a high satisfaction level for the final customers

The study investigated five main areas in the field of gas smart metering:

- The actual process of metering and meter reading;
- The involvement of Regulation in Gas Smart Metering Systems;
- Gas distribution network (and meter) operators view on Gas Smart Metering Systems;
- Technologies considered by operators now and in the future;
- Cost assessment of a Gas Smart Metering Project

Key findings

There is no generally commonly accepted definition for a smart gas metering system. In terms of guiding principles, any smart gas metering system should be based on:

- Remote communication of metering information;
- Helping the end user to manage its gas consumption by providing better quality information;
- Quality information;
- Facilitating the end users to switch energy suppliers;
- Offering the right balance between cost and additional functionalities;
- Offering functionalities through communication.

Conclusions/recommendations

Talking about Smart Metering, it is fundamental to consider a system, not only a meter.

1. In Europe a legal framework concerning smart gas metering systems is developing and standardisation is in progress. Already a few decisions to deploy smart gas metering systems have been made and more will follow in the future. Therefore a distribution network operator should consider how to implement smart gas metering systems to gain knowledge and experience.
2. The majority of the distribution network operators will be responsible for implementing smart gas metering systems. Many of them are currently undertaking pilot test projects. In relation to this there is no doubt that financing such projects is the most critical issue. Therefore a high-quality cost/benefit analysis is a crucial parameter in the decision process. The less resource cost for index meter reading is indicated as the most important benefit.
3. A list of possible additional functions are being considered by the gas network operators in conjunction with all the stakeholders (Regulators, Consumers, Energy Suppliers, etc). There is no one additional function that is seen as a priority by every company. Every distribution network operator has to evaluate which additional functions are important and how to implement them in their own national context.
4. Concerning technology and system infrastructure, the major focus is on communication architecture. Regarding the measurement principle ultrasonic meters could be an alternative for the classical diaphragm meter. Overall the reliability of a future gas smart metering system is indicated as the most important technical issue to be considered.
5. At the time of writing this report it is a little bit too early to foresee new functionalities, but the study group can however conclude that there will be a strong link between smart gas metering systems and smart gas grids.

Unaccounted For Gas

Introduction

Unaccounted For Gas (UFG) is the term used to describe the difference between the quantity of gas purchased/produced and the quantity of gas sold.

UFG can be sourced from a large number of core operations along the value chain of distribution business, including:

- network operations including commissioning and decommissioning practices;
- meter accuracy, reading and management practices;
- accuracy of heat value calculations, measurement and allocation;
- allocation of volume or energy quantities information; and
- consumption estimation methods.

Hypothetically the amount of gas purchased should equal the amount of gas sold but, due to metering errors, leaks, theft and other factors, this hypothetical scenario never occurs.

UFG strongly impacts financial performance, public safety and ultimately the image of DSOs. UFG can be seen as an overall performance indicator of the efficiency and effectiveness with which DSOs lead their operations.

Understanding UFG – the concept, impact of its components and of the decisions that may influence them – is paramount for a successful gas distribution business.

Key findings

1. Understanding UFG is important to a business success in the gas distribution industry. It is only possible to reduce it if you can estimate or measure it, and this is only possible if you understand how it is caused;
2. UFG is not a simple issue, but is a complex mix of factors caused at all stages of the gas distribution chain. It is not only an accounting problem nor is it just a technical issue, but a part of business that can result in large or small impact to a DSO's financial, safety, environmental and social performance. It can ultimately affect the value of a company and its reputation;
3. UFG can also be affected by the specifics in a regulatory regime – either the regulatory framework does not include UFG or it does and provides incentive to reduce it;
4. UFG can be difficult to manage, even if it has been identified and measured. It can only be managed well when it is looked at as an integrated, whole-of-business, long-term approach. To reduce it many different parts of the business may have to be altered (it is not a single or quick fix);
5. Management of UFG is a key issue for the business of the future and should be included in any DSO business agenda. UFG issues become more relevant if a gas distribution business becomes unbundled, as the commercial relationship between shipper and buyer becomes more defined and UFG must be understood and allocated. In addition UFG is a key consideration in the estimation of emissions to comply with national/international obligations to reduce airborne contaminants and greenhouse gases.
6. On an ongoing basis, the impacts of UFG are expected to increase due to growing social, commercial and environmental pressures on DSO operations. DSOs will more and more being required to demonstrate that they understand and can manage UFG.
7. Sources of UFG and their impact on business are not uniform across companies or countries and are dependant on type of DSO, regulation and culture. The top drivers to address UFG are replacement of leaking mains, meter inaccuracy, gas loss from third party damage and theft.
8. Due to the complex and variable nature of UFG it is not possible to design a single tool or create a "one formula fits all" for use by distribution companies to approach a value of UFG. As it is only possible to estimate UFG, not calculate it, no technical formula can be written, but rather estimating methods can be put forward.
9. Good management of meters is crucial to identify and measure UFG. One cannot improve what one cannot measure. Adopted accuracy of meters can have a significant impact on UFG; on the other hand, the way that meters, metering conditions and reading procedures are set and handled – including reading frequency, pressure regulation, reading procedures to minimise error and periodic accuracy checks – may greatly impact UFG and result in measurable improvements.
10. The installation of smart meters is one way to reduce UFG by being able to measure gas on real time, but is a long-term exercise, is currently technologically uncertain (although improving) and involves large capital expenditure.

11. The exercise of managing UFG provides a good opportunity for DSOs to share best practice. Currently best practice is focussed on specific UFG aspects such as metering and replacement of cast iron networks. A high level management approach is required.
12. UFG will continue to be an important aspect of managing emissions for compliance with national/international obligations to improve energy efficiency and reduce airborne emissons and greenhouse gases.

Recommendations

1. It is more benficial to look for best practice to reduce UFG rather than look for methods to quantify it.
2. Workshops on UFG should be held between DSOs to disseminate knowledge and look for best practice.
3. DSO senior management should consider UFG as an integrated strategic issue across all parts of the business. Business success strategy should include a plan that is tailored to the DSO to identify all sources of UFG and their management.
4. Incentives should be created by regulators on a country basis to study the problem of UFG and introduce practice in the industry to reduce it, such as frequency of leakage survey, replacement of networks and schedule to check the accuracy of gas meters.
5. DSOs should seek funding for innovation and research under the heading of UFG as it is an important commercial, safety, social and environmental concern.

2009 – 2012 Triennium

Study Group Work Report

June 2012

STUDY GROUP 4.1:

Review of Safety Management Strategies and Practices

Chair: Ben Lambregts

The Netherlands

1 Foreword and introduction

Gas distribution companies are quite rightly expected, by many stakeholders, to improve the quality and safety of their operations, and are indeed monitored by multiple Regulatory bodies against multiple safety and performance indicators. At the same as improving quality and safety time they must also strive for ongoing efficiencies with a great attention to cost reduction and cost control.

Furthermore, as a result of an increasing interest from society in safety, distribution companies must be able to transparently demonstrate their efforts and results to the public and other stakeholders.

Balancing Safety and Cost

The challenge, as depicted in figure 1, is to balance safety with efficiency and meet the expectations of society in an environment of cost reduction. To further complicate this challenge gas distribution companies have to take into account that fact that safety in the eyes of the general public might differ from their own point of view.

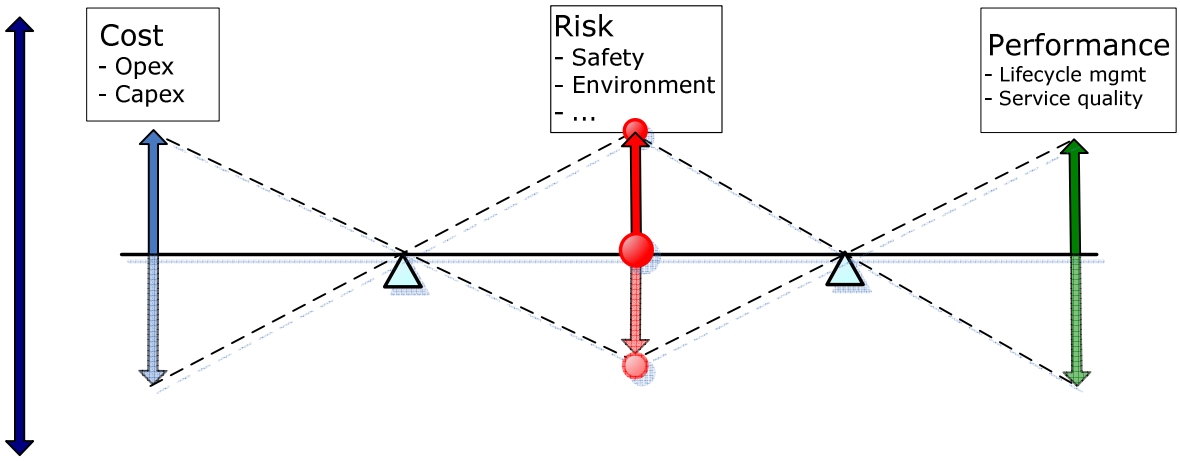


Figure 1

In response to this challenge distribution operators can develop a comprehensive and effective approach to safety management, defining a safety management system that can become a tool for excellence and efficiency.

This study reviews the processes and methodologies used to develop safety strategies for managing gas distribution pipeline systems, building upon the Asset Management study from the previous triennium.

Gas distribution companies must be able to reach high level output results through a comprehensive approach to safety management.

1.1 Objectives and Goals

The study group started its work with the following objectives in mind:

1. To evaluate and where appropriate make recommendations in the following areas:
   - The identification of ingredients and milestones of a management system devoted to safety
   - The identification of KPI's related to safety management
   - The definition of a specific metric for KPI's
   - The influence of regulation and legislation
   - The possibilities and role of certification.

2. To set-out as a guide the basic steps required to implement a Safety Management System and to provide a list of the most common KPI's and relative metrics.

Safety management and safety culture journey

Prior to setting out on the journey to implement a Safety Management System it is important that a company is clear of the commitment required and the key steps. The following diagram shows one example of the journey a company will need to take in order to establish a Safety management and safety culture.

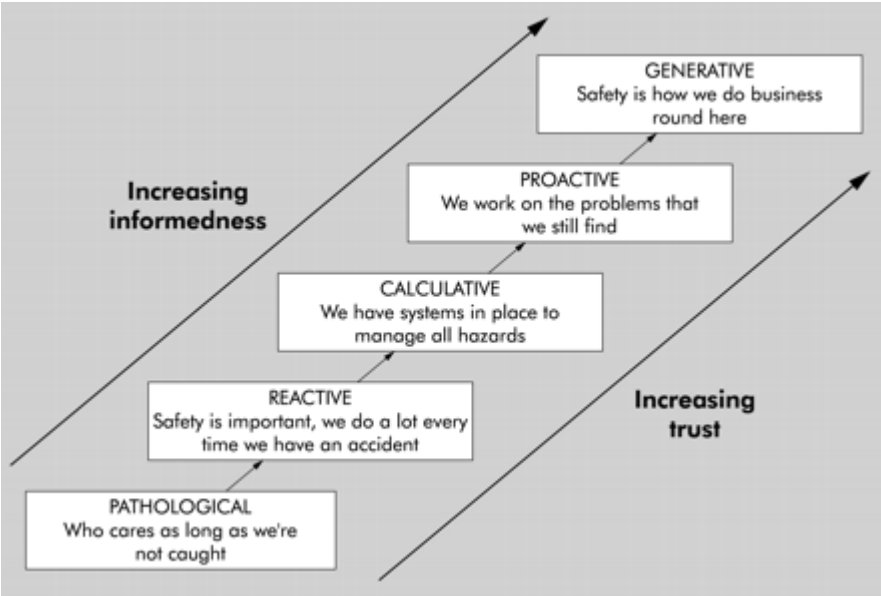


Figure 2 : Hudson PTW. Safety management and safety culture: the long, hard and winding road

In order to be successful it is also critical for the gas distribution industry and therefore individual companies to be aware on what step of the stairs they are currently on and what is required to climb up this ladder.

1.2 Safety Management systems

A holistic safety management system has several key ingredients and consists of a number of sub systems like Process Safety and Occupational Health.

Process safety focuses on preventing major accidents and incidents in gas distribution systems. Occupational safety and health primarily covers the management of Personal Safety, for example the use of PPE (Personal Protective Equipment).

Given the scope and scale of a safety management system Study group 4.1 has focused this report on Process Safety as the group considers it one of the most important aspects.

The gas industry uses the "Swiss cheese model" from the work of James Reason[1] in the health care and nuclear industry to understand how risk works and how to keep a potential hazard from becoming an accident.

Safety Barriers

Each barrier to the hazard is represented by a slice of Swiss cheese. The holes in a slice represent imperfections in that barrier. Since each slice can (theoretically) prevent the hazard from escalating to an accident, it is only when a set of holes align that catastrophe happens.

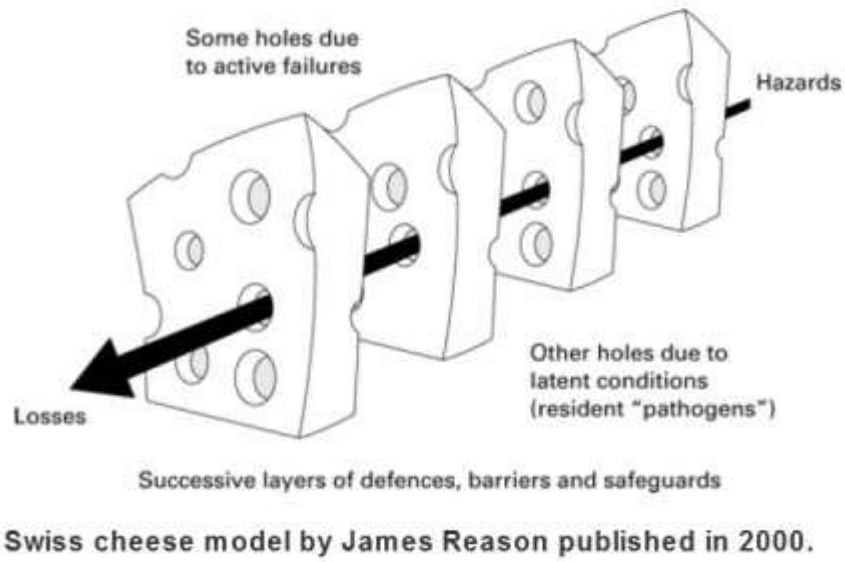


Figure 3 Cheese model by James Reason

[1] Reason J. *Managing the risks of organizational accidents.* Aldershot: Ashgate; 1997.

In the gas industry the following are the typical layers of defence understood by those involved in process safety:

- Process safety leadership
- Design and modifications
- Operating procedures
- Workforce competence
- Human factors
- Emergency arrangements
- Protective devices, instrumentation and alarms
- Inspection and maintenance
- Permit to work
- Asset records and data quality
- Third party activities
- Audit review and close out

And whilst individual companies might cluster there activities differently or add some extra layers, in the Study Group's opinion the list above includes the most important parts.

Since the number of layers of defence are numerous, and because other issues like asset records, data quality and third party activities were analyzed in previous studies (WOC4.1 and WOC4.3 2007-2009, see IGU website for more information), the Study Groups questionnaire has concentrated upon the following five key areas:

- Process safety leadership
- Human factor, competence
- Emergency arrangements
- Inspection and maintenance.
- Audit, review

In the next chapters the general purpose of the layer is described (based on the experience of the experts participating in the Study Group) followed by the results from the questionnaire and conclusions and/or recommendation.

2 Process Safety Leadership

2.1 General Purpose and comments

Without any doubt senior management has to play an active role and has to be really involved when it comes to safety management. It is responsible to create the right safety culture in the company by facilitating discussion, convincing middle management and creating an environment where mistake leads to a learning process and so to improve Deming's Plan Do Check Act (PDCA) circle. It should encourage employees to do the right things and is careful not to introduce conflicting targets.

2.2 Questionnaire

This section of the questionnaire was focused on the organisation of the companies for the safety management process, the roles and positions of different leading actors.

The questionnaire also sought opinions on what was currently considered as the most important aspects of the processes, procedures and tools. The questionnaire looked at the following elements.

- Who are the major actors and the supporting organisation for safety management
- What is the level and way of downstairs communication in the company and with contractors
- What are the most important KPI's and their influence on employees remuneration

2.3 Response from the questionnaire

The responses of the questionnaire show a direct correlation between safety processes, communication and leadership across all the countries that participated. The conclusions are based on the answers to several pre-selected questions and they confirm the following good practices.

Safety as a Priority

The vast majority of companies surveyed in the questionnaire regarded safety as a number one priority issue and have a dedicated safety department in their company.

The survey confirmed that more than 75% of all companies sign off and approve the approach to Process Safety at the most senior levels in the organisation (i.e. Company board, CEO/COO, Director of Safety).

Over 80% of companies have a separate Safety Department and those companies that responded positively on a separate Safety Department have situated this department in the organisation as per the following diagram, with the safety department is linked directly to the board in almost 60% of the companies.

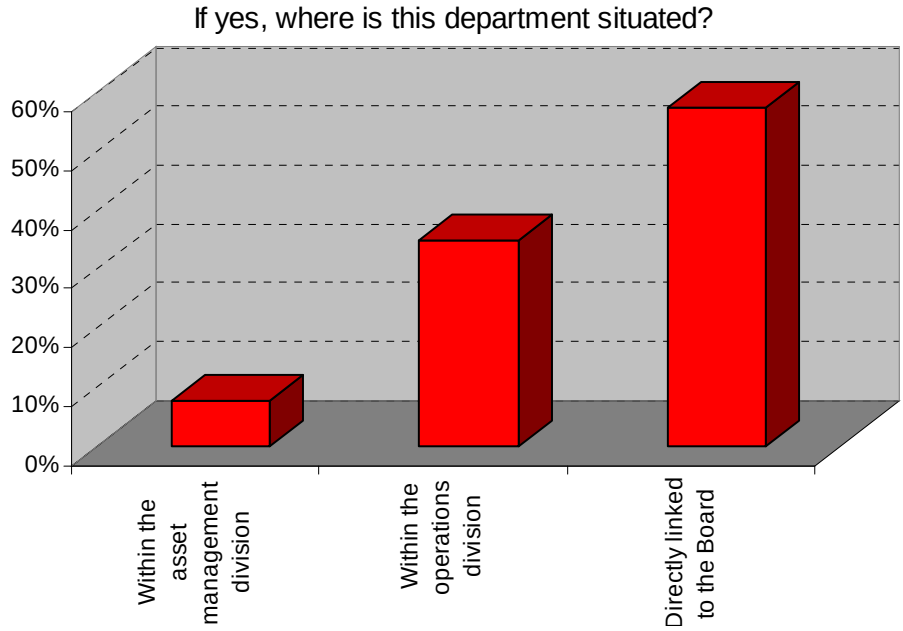


Figure 4 Situation of Safety Department

Communication

Communication of safety strategies is not limited to the management, but goes down to the team member level of the organisation in 76% of the respondents.

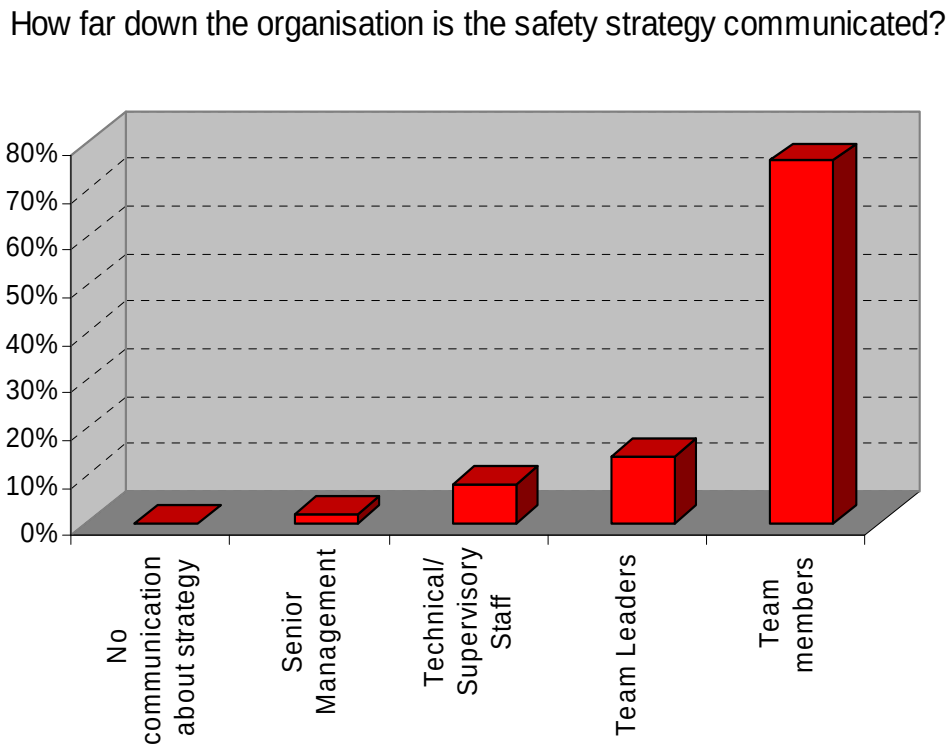


Figure 5 Communication of Safety Strategy

And 86% of all contractors and sub-contractors are included in communication about safety strategies.

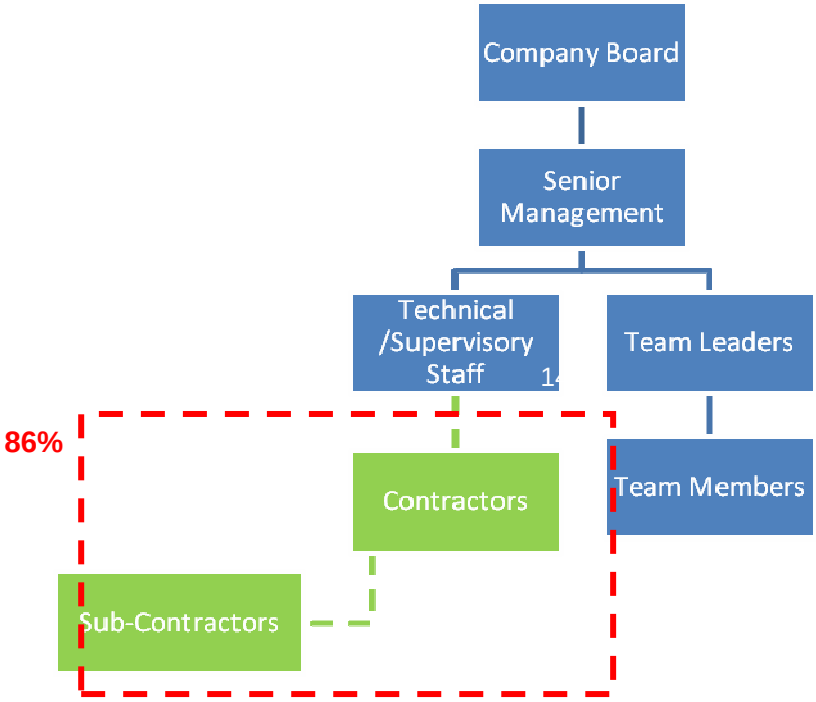


Figure 6 Communication includes Contracters

The instruments used for communication are very diverse. The most popular being direct briefing and training, however, e-mail and company websites are widely used.

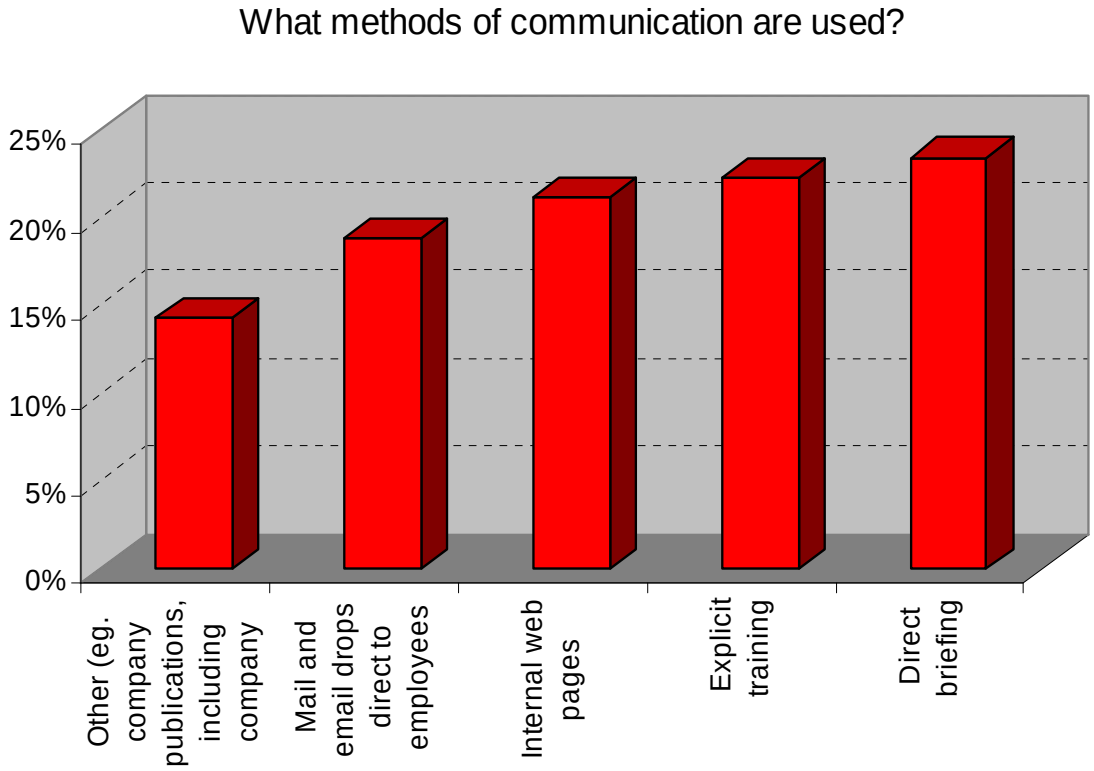


Figure 7 Methods of Communication

Performance Monitoring

In addition to pro-active communication about the safety strategies, performance monitoring is also used by management to ensure relevant parties are informed of the safety management results.

All companies confirmed that they use management information to monitor safety. With 84% of the companies stating that they have a dedicated information management system. The remaining 16% include it as part of their normal reporting procedures.

KPI's

The following diagram shows the ranking of the most important KPI's on the management dashboard.

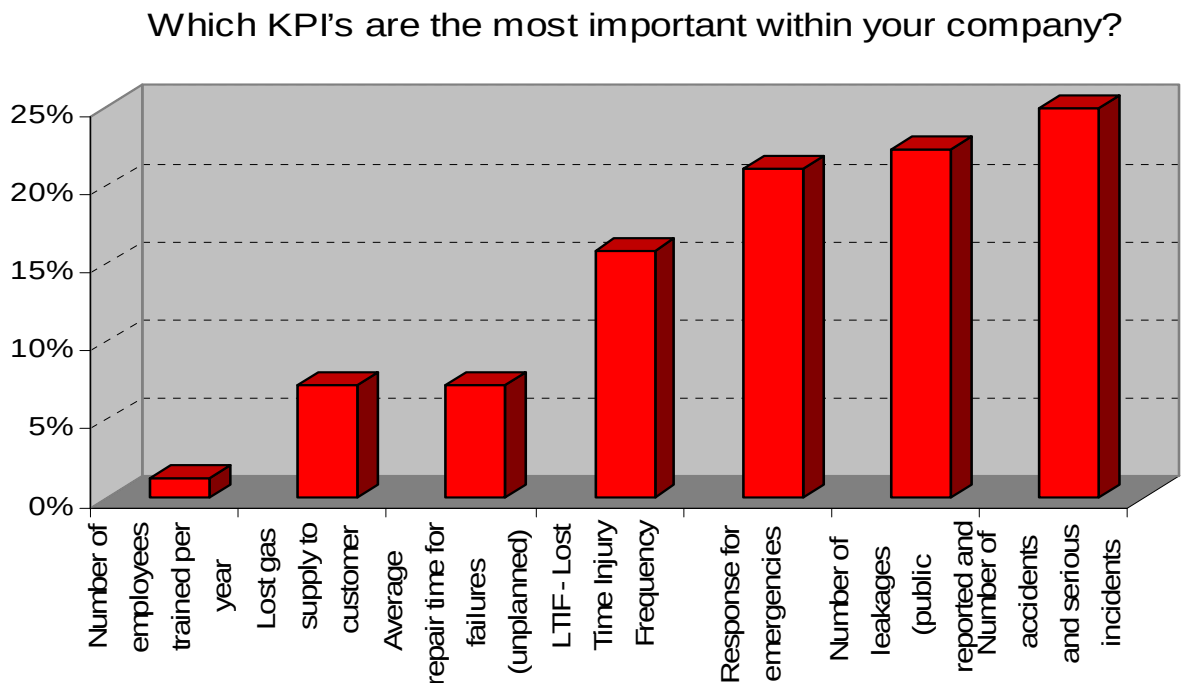


Figure 8 Safety KPI's

The top 3 Key performance Indicators (KPI's) are as follows:

- number of accidents and serious incidents
- number of leakages (public reported and own activities)
- response time for emergencies

Analysing the questionnaire the results show no geographical differences around the world.

2.4 Conclusions and recommendations

The overall conclusion is that Safety Management within the gas distribution industry is regarded as very important and is typically integrated or embedded within the organisation at all levels.

Safety management is a number one priority for gas distribution companies all over the world.

Because of the diversity of gas distribution companies there was no unique set of KPI's found on process safety management. It is striking that the top 3 KPI's mentioned are all lagging indicators and the less important are leading indicators. It is recommended that companies bring a balance between leading and lagging process indicators. When companies improve their safety management and safety records this will most likely goes hand in hand with a shift to more leading indicators instead of lagging as a result of a more proactive approach.

An example of an indicator to be used as lagging as well as leading indicator is the numbers of leakage. If the number of leakages per kilometre of pipe is in the first place a lagging indicator. In this case a simple division of the total number of leakages and length of the grid is used. An improvement, although still a lagging indicator, can be achieved if the leakages are plotted on a map.

To use information on leakage as a leading indicator the information has to be processed first. The data should be linked to different populations. For instance: for steel service pipes a population could be based on age. In this way the quality (based on the numbers of detected leakages) of steel service pipes with time can be found. The found relation can be used to predict the quality of a specific service line. Such a method already exists and is called Leak Forecast Method (LFM). [2]

A number of the KPI's mentioned will certainly be personal targets for managing directors.

Almost 50% of companies have a reward/remuneration policy linked to safety performance. It is recommended to be very accurate and reserved when using this instrument to encourage employees to do the right things. One should hold in mind that safety is a long term goal which needs long term indicators.

[2] LFM; Leak Forecast Method is developed by Kiwa Technology in cooperation with some Dutch DSOs.

3 Human Factors and Competence

It is clear from both the feedback from the questionnaire and indeed from the study group members own experiences that critical to achieving and maintaining a sound and safe gas distribution network, good workmanship, commitment and skills are necessary. This chapter considers two important factors associated achieving this goal, “human factors” and “competence”.

3.1 Human factor

3.1.1 General Purpose and comments

The human individual is perhaps the most important part in the safety management chain, as is it arguably the most difficult to truly manage and control. In addition it can be shown that all incidents as some point can be put down to human interaction or error, be it at the design phase, at a management decision level or during operational activities.

That said companies who embrace the monitoring and more importantly the engagement of their employees, for example through employee surveys, can create an environment where employees thrive and become an integral part of the company’s safety management systems.

In context for safety, creating a transparent environment where feedback is a part of daily work and is appreciated will positively contribute to safety awareness and acting.

However, for this to be sustained it is critical that this feedback process is focused on “open” learning and it must not be seen as punishment or judgement.

3.1.2 Questionnaire

This section of the questionnaire was focused on understanding the tools and techniques used by the respondents to manage and measure the human factors associated with safety excellence.

The questionnaire also sought opinions on what was currently considered as the most important aspects of the processes, procedures and tools. The questionnaire looked at the following elements.

- Which phases of an activity were employees and processes observed or checked
- What are the key of success of such processes
- What are the most effective KPI’s

3.1.3 Response from the questionnaire

Although all functions and activities that are part of the gas distribution process influence safety, the results from our survey show that in practice the most emphasis is placed during “physical work” on the network, for example live gas works.

Safety Monitoring

Only 40% of the respondents considered safety an important human factor in the engineering stage, whereas more than 65% considered safety an important human factor during operations during an emergency (see figure 9).

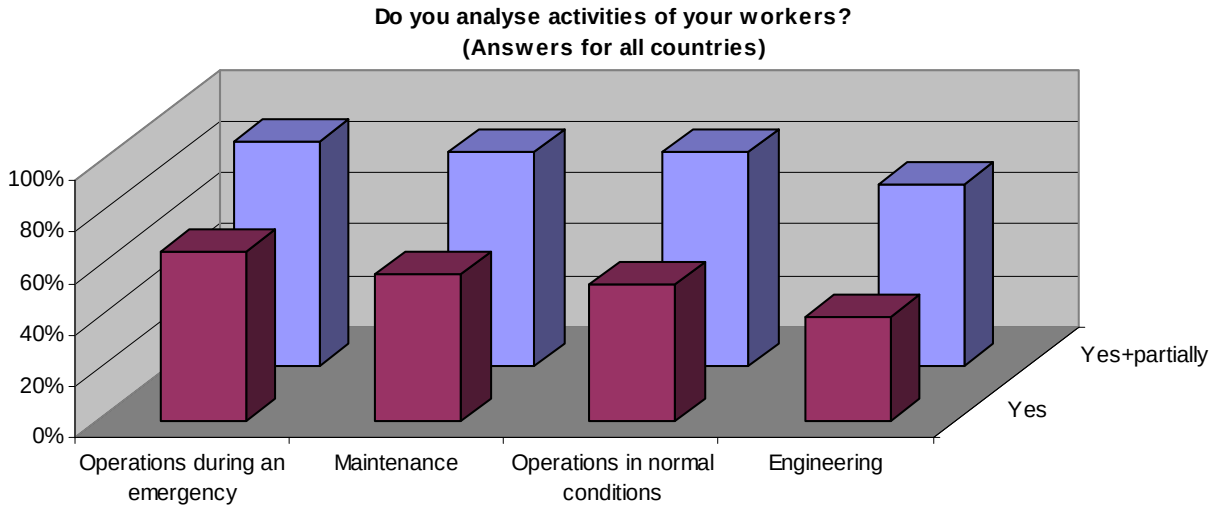


Figure 9 Importance of the human factor in relation to process

This relatively low figure (40%) could represent an opportunity within the industry to improve safety, given that an important part of the ultimate level of safety is determined during the design of the gas distribution network. Consequently more attention or awareness to safety during this phase is recommended.

Types of process and procedures (active vs. reactive)

Almost all respondents confirmed that direct feedback after a technical incident was used (see figure 10). In contrast only a limited number of respondents used a more reactive process like a questionnaire after work.

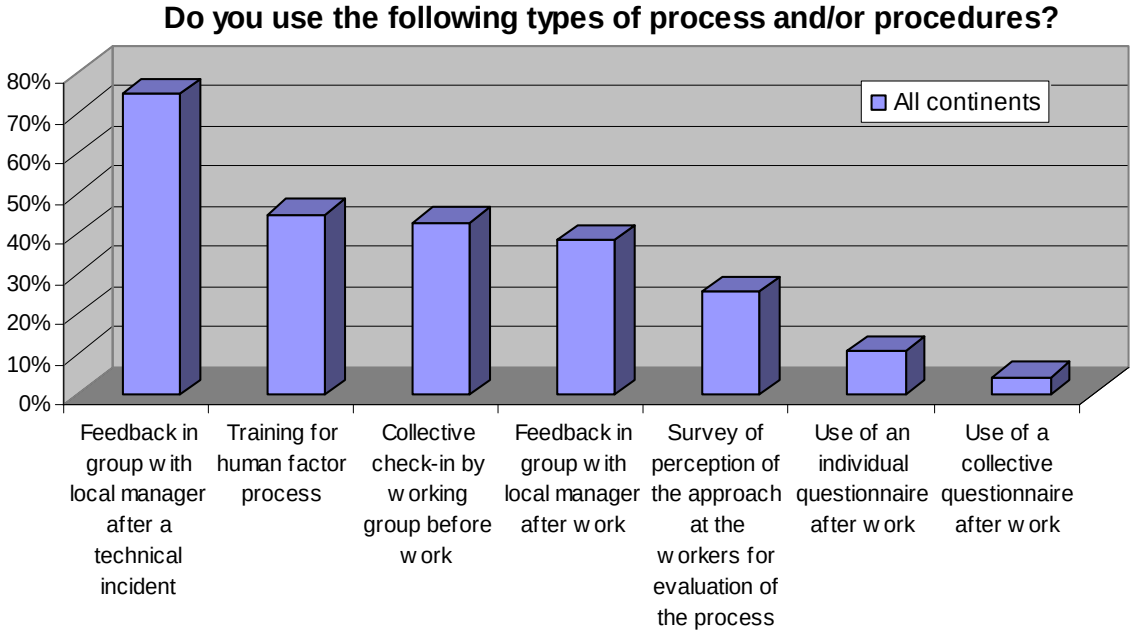


Figure 10 Ranking types of processes

Experience from the study group members shows that active feedback in a timely manner after an incident is the most effective and efficient way of learning from an incident.

Training, collective check-in and feedback after standard activities under normal conditions can also be seen as active processes as both workers and management are directly involved in these processes.

Interestingly only [40%] of respondents confirmed that they used proactive check-in before work commenced, again a potential area of improvement, particularly when considering that often the best way to avoid incidents is through good work preparation.

What is clear is that active communication between manager and workers is qualified as very useful to achieve a higher standard in safety.

Ranking Human Factor Processes and Procedures

The following figure shows the key elements of human factors processes and procedures ranked in order of importance.

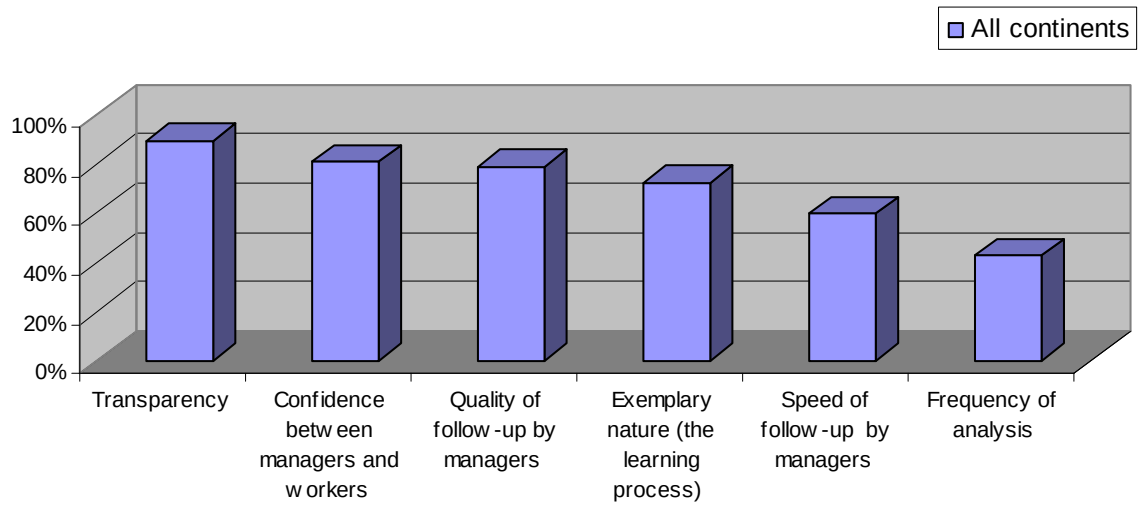


Figure 11 Ranking Human factors

Not unexpectedly transparency and confidence between managers and workers rank the highest although arguably this could be seen as conflicting The point here is the link to a learning environment, i.e. where employees are not going to be unduly punished for reporting on items that could inevitably led to improvements in overall safety.

Interestingly the frequency of analysis has been deemed the least important, however, this is understood when considering quality of follow-up and speed of follow-up given these are much more likely to realise value from the process.

One of the most important KPI used in practice to measure the efficiency of the human factor process is the number of incidents communicated by the workers as well as % of incidents with human factor identified as a cause. The figure below shows that more than 60% of the companies use these two KPI's.

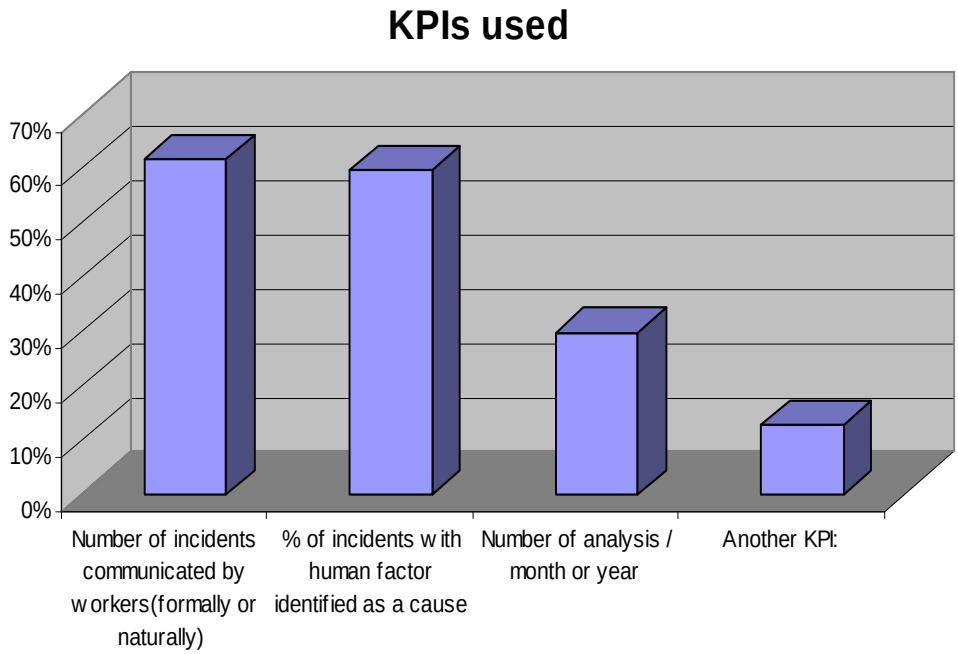


Figure 12 Measurement of Human factor process

3.2 Competence

3.2.1 General Purpose and comments

Training to develop and maintain competence is an ongoing activity. There are many training and development methods deployed across the gas industry using multiple mediums, from 1 to 1 coaching, group training and e-learning to name but a few.

Technological advances have fundamentally changed the way in which training and development is delivered, expanding the plethora of methods available, the study group believes these advances will only increase in the future.

On this point in order to meet current and future competence requirements, particularly future requirements, the use of modern techniques will be paramount in attracting young personal, which based on the age profile of many of the respondents will be an absolute necessity.

That said the study group are keen to stress that they see a “toolbox” of training which will include a spectrum of techniques, from traditional training, for example, class room based through to more modern techniques including virtual training and simulations. It will not be a “one size fits all”.

3.2.2 Questionnaire

This section of the questionnaire was focused on understanding where training and competence is currently deployed. The questionnaire looked at the following elements.

- Which phases of an activity were employees competences processes developed
- Which type of new training technologies are used
- Which type of insurance for competences of workers

3.2.3 Response from the questionnaire

Commitment to Safety

The will to pursue a high level of safety is paramount, the competence of employees is also absolutely critical to achieve a sufficiently high standard of safety.

Figure 6 clearly shows a strong bias toward the validation, checking the competencies of employees undertaking operational activities, and whilst not as low as the previous section (ie. human factors) there still remains a distinctly lower proportion, across all respondents, for employees working in the up front design and engineering activities.

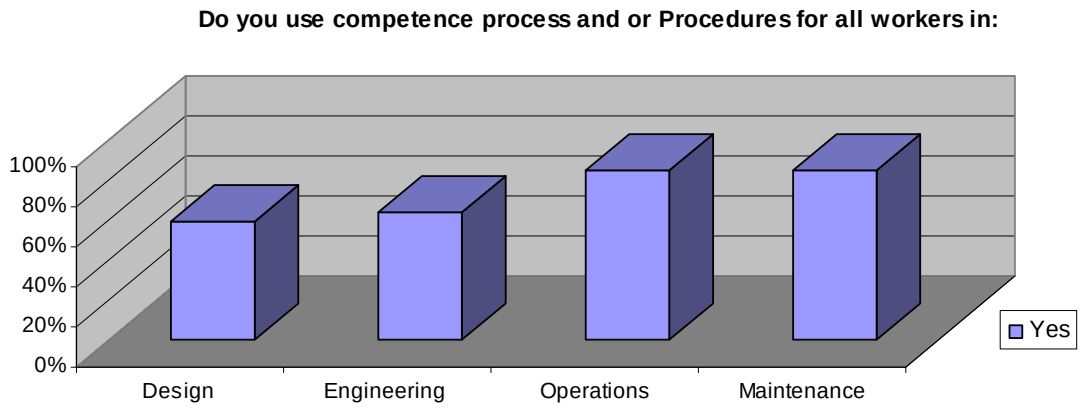


Figure 13 The use of "Competences" in processes and procedures

This distinction is understandable, but it is stressed that choices made in the design and engineering phase will affect the maximum achievable security level in practice.

From these results it could be concluded that in general terms the gas industry is more focused on the shorter term, and is more "tactical" in terms of thinking, potentially this indicates a more reactive management approach rather than a longer term more strategic approach. It would be interesting to compare these results to Transmission companies to see if there is a variance across the four categories.

Developing and maintain competence

The responses to the questionnaire show that many different tools are used to develop and maintain the competence of employees (see figure 14).

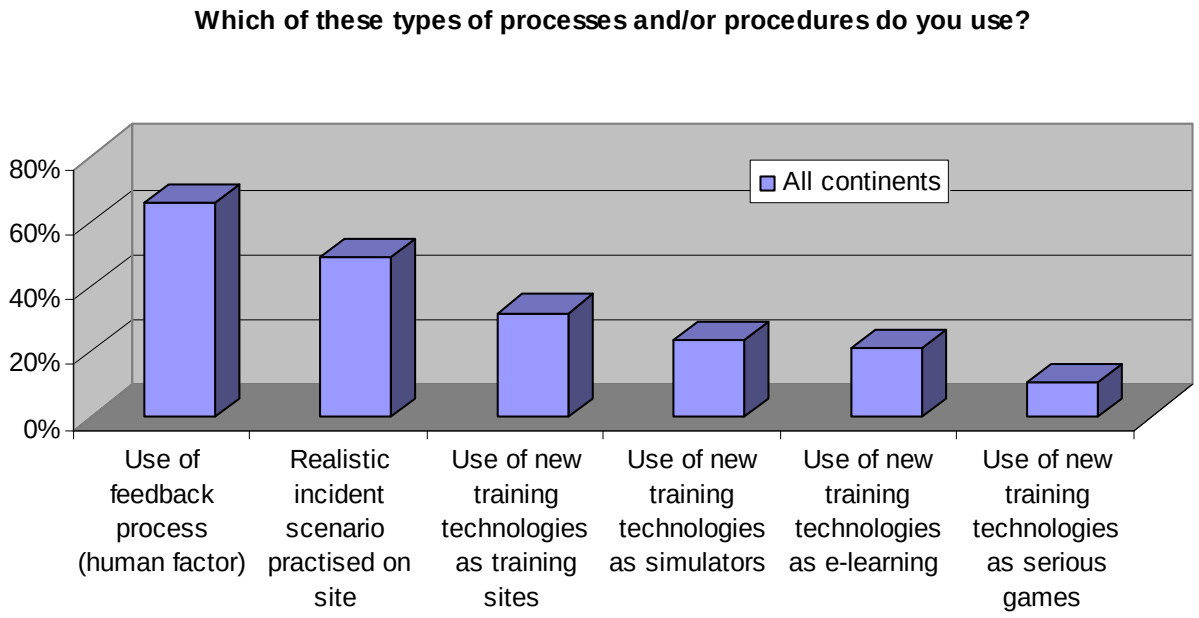


Figure 14 Developing and maintaining competences

That said, by far the most prevalent is the “use of feedback process (human factors)”; “realistic incident scenario practised on site” is also used extensively across all respondents. Interestingly both of these methods are well established approaches and in contrast, newer methods such as, E-learning and serious games show a relatively limited application, it is plausible that this will change as these tools become more available.

Looking at the responses in more detail there is a distinct differences between the six continents defined within IGU (Europe, CIS countries, North America, Latin America & Caribbean, Asia and Asia Pacific).

Figure 15 shows that use of feedback process (human factor) is well developed in all continents with a little less level in Europe. This could mean that some of the companies in the older gas countries consider that they have already achieved a high standard in safety procedures control so incident scenario practise on site is not worthwhile.

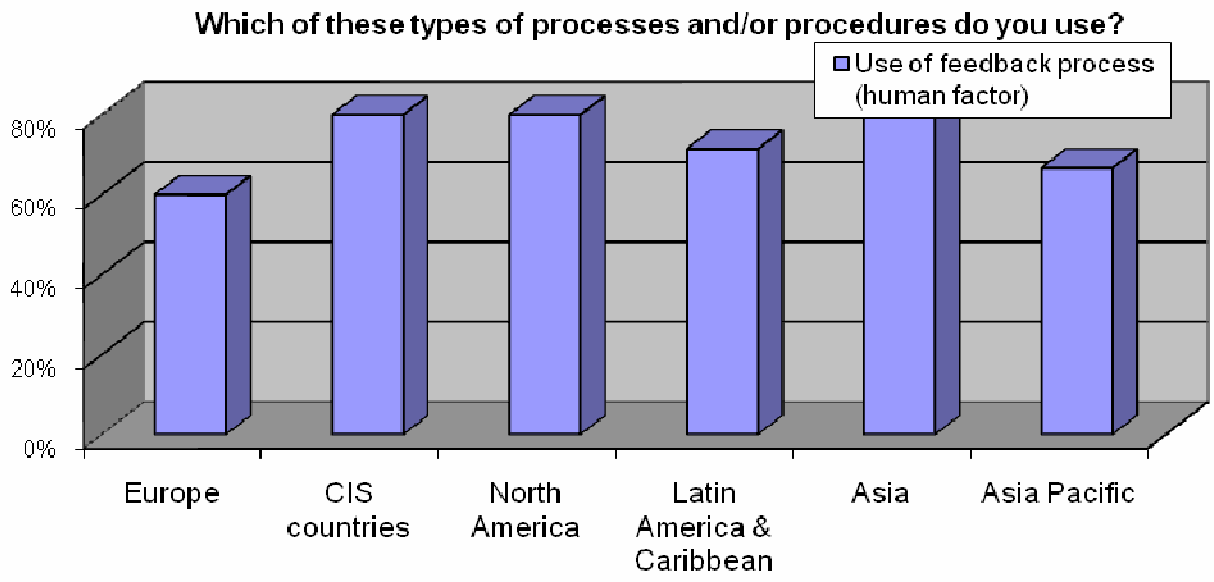


Figure 15 Feed back processes used in different regions

Further analysis shows that the high level of use of feedback process (human factor), related to number of responses from Europe confirm the maturity of those gas industry concerning pure technical competences assurance.

New Training Technologies

E-learning is essentially used to develop or maintain technical competences. For serious games it is more difficult to conclude because it can be used to observe human reactions in different cases of simulation.

As can be seen from the Figure 16 newer technologies like E-learning and serious games are mainly used in the newer gas countries like those in Asia and Asia Pacific.

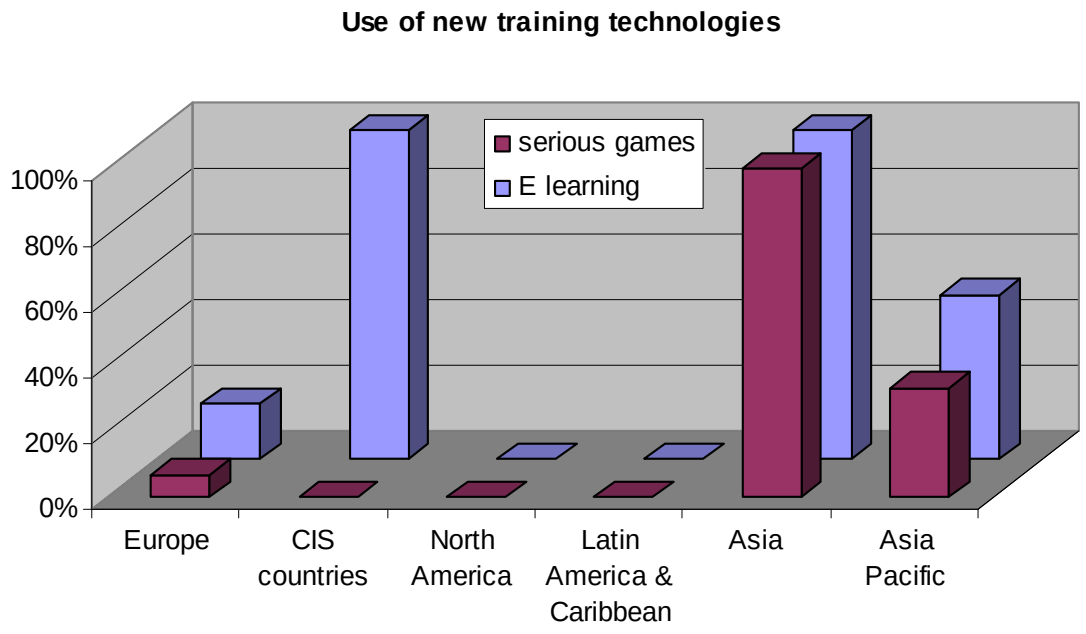


Figure 16 Use of new training technologies

The other continents could be qualified as more conservative in their choice of tools to enlarge the competence of their employees in the field of safety.

New Technology Example

The following shows example of new technology used in GrDF (French gas distribution company): Simulator used in national centre for training of employees of the same operation office.

	
A view of the room of simulation with three trainees stemming from the same operation office and unit: a leader of operation and his two assistants. They have the same computing tools as on their workplace. In 1,5 day, they are subjected to two scenarios, one of the warm-up and one more complex to manage with simultaneous incidents. Every time, a sequence of analysis with the trainers at the end of scenario.	A view of the control room of the trainers with at the bottom the internal glazing allowing observing the behaviour of the trainees during the scenarios. Two trainers send successively computing or phone messages translating events on the network and the third trainer is only observing the way the trainees get organized to manage the feigned crisis.

*: IGU World Gas Conference – Kuala Lumpur 2012 – Paper n°288.00 – "Development of safety management processes: feedback, analysis of human and organizational factors, and creation of a simulator to enhance collective competences in operational activities" - Jean-Yves Pollard – Network Performance Delegate – Gaz Réseau Distribution France (GrDF) – France

Ensuring appropriate levels of competence

From figure 17 the conclusion can be derived that relying on known rules and procedures is favourable above acting on observations of real practice. This leads to the conclusion that the gas industry is more static than dynamic. This leads to a big hurdle when changes have to be made. Especially when certification is anchored in (national) law it is understood that change procedures will take much time (big time lag). Countries without a strict regulation might be in favour as they can change their own company procedures without much time loss. Adoption of their procedures is therefore often more easy. This leads to a more modernized set of procedures for those countries.

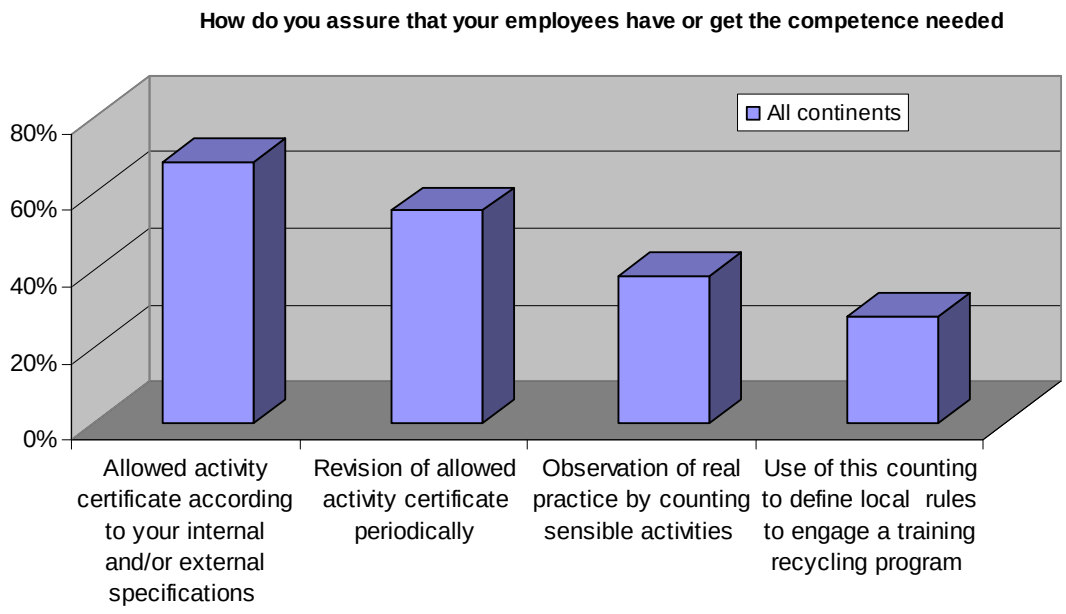


Figure 17 Ensuring appropriate levels of competence

3.3 Conclusions and recommendations

Regarding the human factor and competence the following conclusions are drawn. Gas industry companies are:

- now more focused on collective and individual comportments of managers and workers (human factor influence),
- static more than dynamic,
- more focussed on the short term than the long term,
- more reactive than proactive,
- conservative in competence solution,
- using the progressive competence solutions only in a limited way, the use is more favourable in the newer gas countries.

Human factor seems now to be the major risk of gas distribution industry after third part damages. As seen during last IGU Triennium WOC4 studies on Third part damages, we think that human factor analysis for stakeholders, subcontractors and network companies is also a major answer to progress on this subject.

Such conclusions conduct to recommend introducing a human factor KPI in the Board Survey:

"% of incidents with human factor identified as a cause during feedback" should be a good proposal.

4 Inspection and Maintenance

4.1 General Purpose and comments

Inspections are used to gain insight into the current quality and safety level of the gas system.

This insight is a critical ingredient for the quality of decision making in the safety management system. If the quality and safety performance of the gas distribution system does not meet the criteria maintenance (and in the end replacement) will be needed.

It is therefore very important to know what the right KPI's are on different level of abstraction.

For example the number of leaks per km will be a useful high level KPI when there is also a breakdown in more detail, including for example: environment (city versus open field) mains versus service lines, type of material, etc.

4.2 Questionnaire

This section of the questionnaire was focused on understanding how the safety management performance indicators are set, monitored and managed. The questionnaire looked at the following elements.

- What systems the companies to implement and administer
- Who is involved in setting the companies KPI's and
- What types of inspection strategies are used?

4.3 Response from the questionnaire

Quality Management Systems

As can be seen from the figure below over half (54%) of distribution companies systematically approach improvement of their safety and reliability KPI's through the adoption of a Quality Management System (QMS).

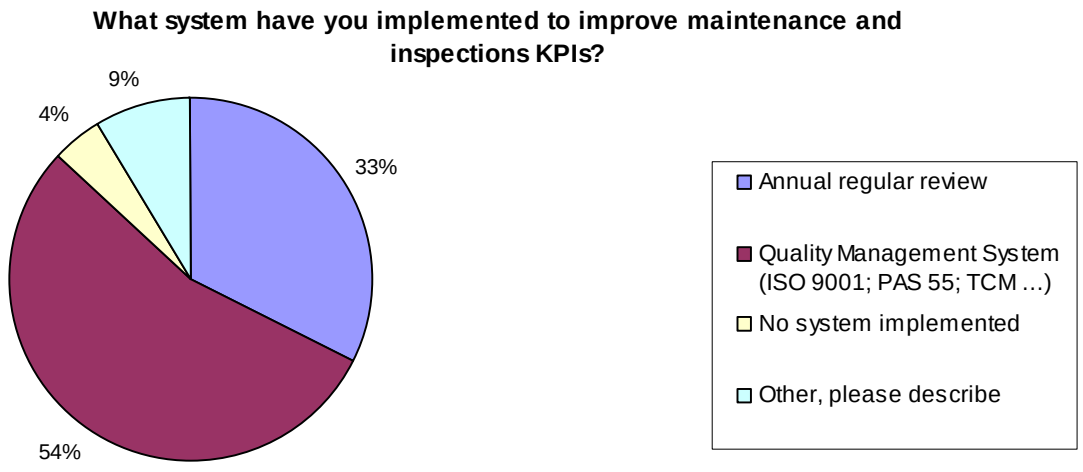


Figure 18 Use of management systems for Maintenance and Inspection

This approach is usually highly demanding in terms of the documentation of processes, and requires for example the company to clearly show alignment to missions and objectives.

That said if they are successfully deployed, this approach can provide stakeholders of the company the assurance that core business process – maintenance and inspections of gas facilities within gas distribution companies are systematically reviewed, validated and will potentially undergo continuous improvement.

Information Systems

The extent and diversity of the assets within gas distribution sectors usually requires the support of a strong information management system.

These systems can enable the gathering and management of large volumes of information and thus be used to leverage the management of safety and inspection process (its planning, control of conduct, documentation, improvement of process).

This is confirmed in the results to the study group's questionnaire. The following figure shows the systems that are current used to support the administration of safety KPI's.

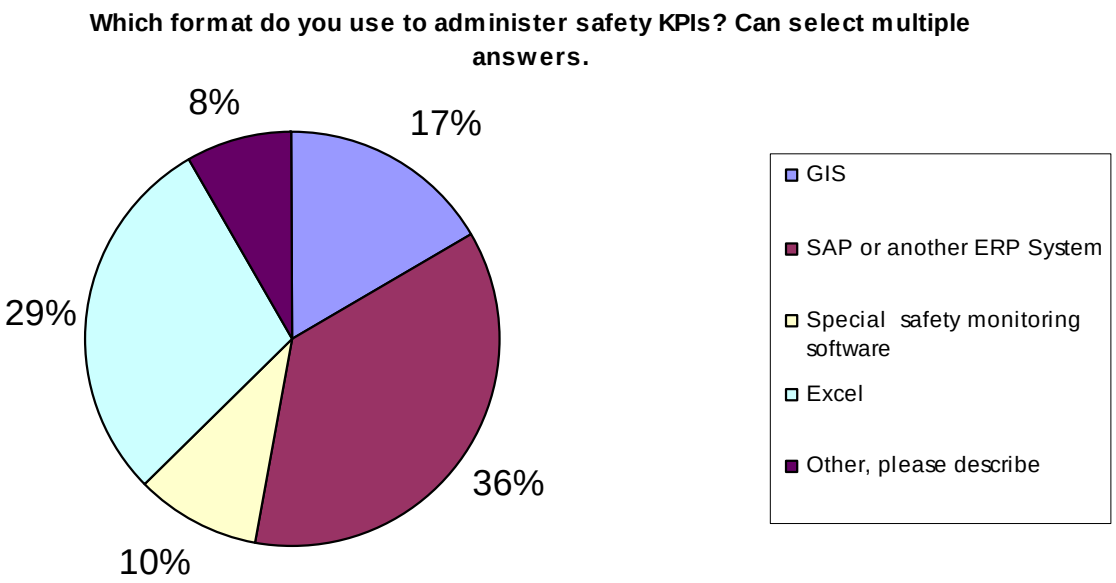


Figure 19 Information Systems

With the exception of smaller network companies, it is surprising that a large proportion (29%) of the companies use Excel software or similar featured spreadsheet software to administer their safety Kip's.

Assuming that Excel is not used solely to manipulate data for presentation and analytical purposes but also for data gathering, administering and archiving, there is a potential risk relating to information quality (usually time issue, human factor errors, completeness issue etc) and possibly an indication that management of the network safety is fragmented.

Setting KPI's

Establishing the "values" of the KPI's, as with any performance measure is a crucial part of any safety management system. The diagram below shows how and who in the company contributes the definition of KPI's.

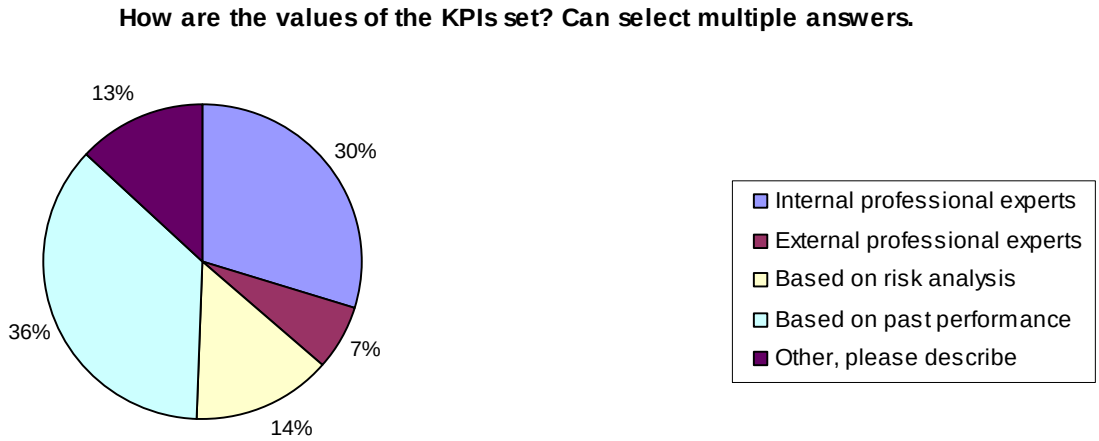


Figure 20 Setting KPI's

What is clear from the responses is that the biggest single influence on setting of KPI's comes from past performance (36%). That said, input from a combination of internal and external professionals equates for the highest figure 37%.

One can conclude that by taking the internal professional experts (30%) together with risk analysis (14%) and finally past performance (36%), that definition of KPI's is almost entirely driven by a companies' own expertise and experiences.

Such a statement was concluded assuming the following – if an acceptable external entity existed (beside professional associations) which was able to provide qualified assistance, in terms of safety and reliability of network operation, it is likely that more companies would choose this approach, on the basis that beside technical competence (inclusive risk assessment techniques) this approach would offer, when compared to internal expertise a degree of independence.

This is perhaps a natural consequence of sector specialization combined with a natural dominance within state boundaries. This scenario does however bring several key questions.

If the gas distribution companies belong to one of the most regulated private business companies, then concentration of expertise related to the safety of the operation within gas distribution sector, will be biased toward the company, resulting in the absence of this competence on Regulatory side.

As a consequence this imbalance can could result in a framework where there is a dominance in objectives toward the company and safe and effective management of distribution assets will diverge rather than converge.

This point is also the supported by diagram bellow, with only 44% of rules and standards for maintenance and inspection is being set by National energy legislation (Government) or directly by National Energy Regulator.

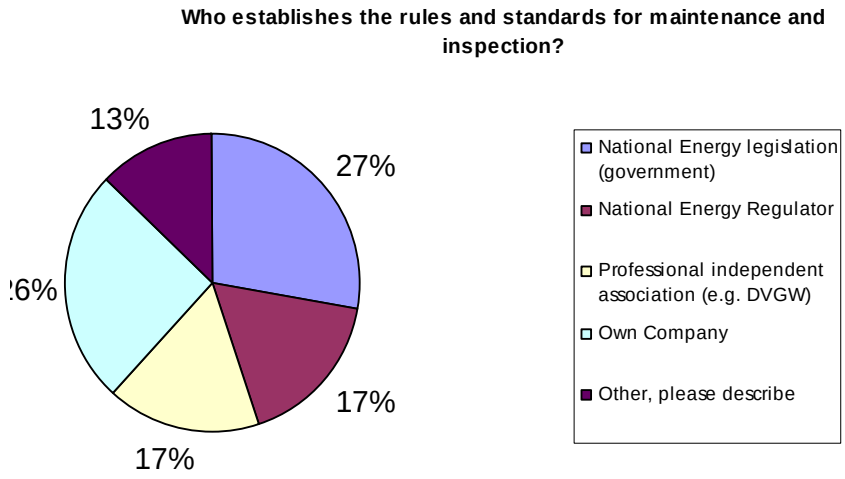


Figure 21 Setting rules and standards

This is against a backdrop of 69% of the companies operating within fully liberalized markets and 17% of the companies operating in partially liberalized market.

So the key question is, how responsible is decision making within Regulatory authorities when deciding upon distribution tariffs, quality standards, business conditions and hence form the whole economic framework of grid operators?

It can be translated to simple question: How do National Regulators incorporate into their decisions knowledge about distribution networks safety and reliability and how capable are Regulators to make objective judgments?

There is one interesting finding, when rules and standards from maintenance and inspection activities are set by National Energy legislation or the Energy regulator, it usually results in preventive (proactive) maintenance programs, rather than risk based maintenance and inspection programs.

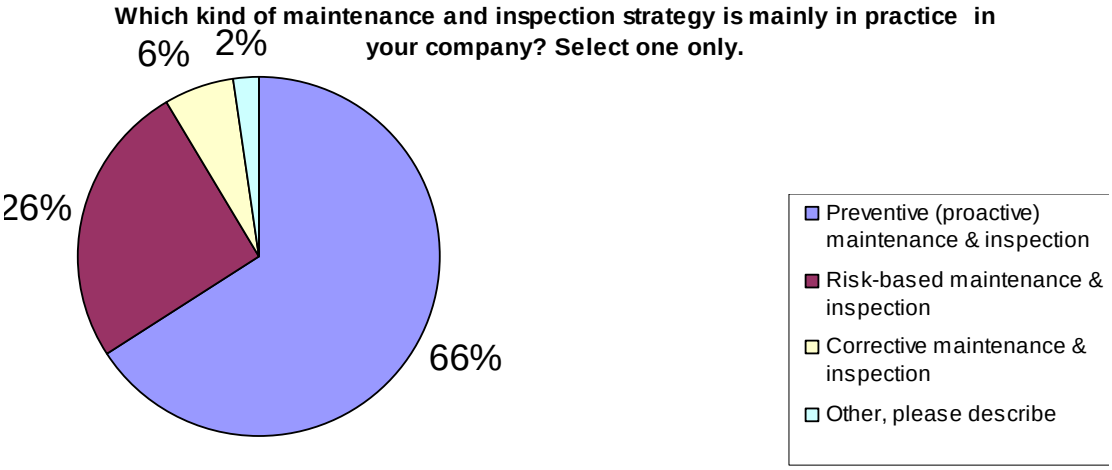


Figure 22 Maintenance and inspection strategy

4.4 Conclusions and recommendations

Audit and inspection are an integral part of any safety management system that supports Process Safety; refer to the C in PDCA

The following are the key finding from the Study Groups survey:

Quality Management Systems are complimentary

There are a number of available standards that can be deployed to support the development and maintenance of an audit and inspection regime; however, as things stand there is not a single solution as such for full coverage a company will need to adopt a number of the standards.

It is recommended that in order to deploy regime successfully a company clearly understands the commitments required in the set-up and then on an ongoing basis.

Setting Process Safety KPI's should be an inclusive process

The setting of what is to measured is clearly very important, in most cases this process seems to be an internally focused activity.

In order to maximise the value of this process it is recommended that key stakeholders are engaged in at least the output KPI's and where possible the setting of company KPI's

Reporting and *administering KPI's needs control and validation*

A large proportion of respondents used excel based reporting to provide KPI's. This could present a risk in terms of data quality and thereby value of the reporting.

Where possible, an end to end system that draws the data from a "core" system is recommended thereby limiting the "human" interaction and manipulation. If this cannot be achieved, as part of the inspection is it recommended that data quality is validated to ensure

that the information is as accurate as possible, arguably this could even be reported as one of the KPI's.

5 Emergency Arrangements and Response

5.1 General Purpose and comments

Although all gas distribution companies try to avoid emergency situations it is necessary to have an adequate organisation to deal with emergencies. This organisation has to consign people and develop the applicable procedures and processes.

In order to have the right resources, procedures and to maintain standby training with third parties like fire brigade is essential to reach efficiency and the intended response time.

5.2 Questionnaire

This section of the questionnaire focused on understanding what emergency response arrangements each of the companies used. The questionnaire looked at the following elements.

- Who is involved in setting emergency response arrangements
- The funding arrangements and
- How the processes are resourced

5.3 Response from the questionnaire

Influencing Factors

In general Regulation and Legislation have a great influence on the way the gas industry arranges emergency organisations.

As can be seen from the following diagram, the KPI's related to emergency arrangements are in most cases set by the authorities, with Safety issues strongly influenced by legislation and significantly more than issues relating to technical or health.

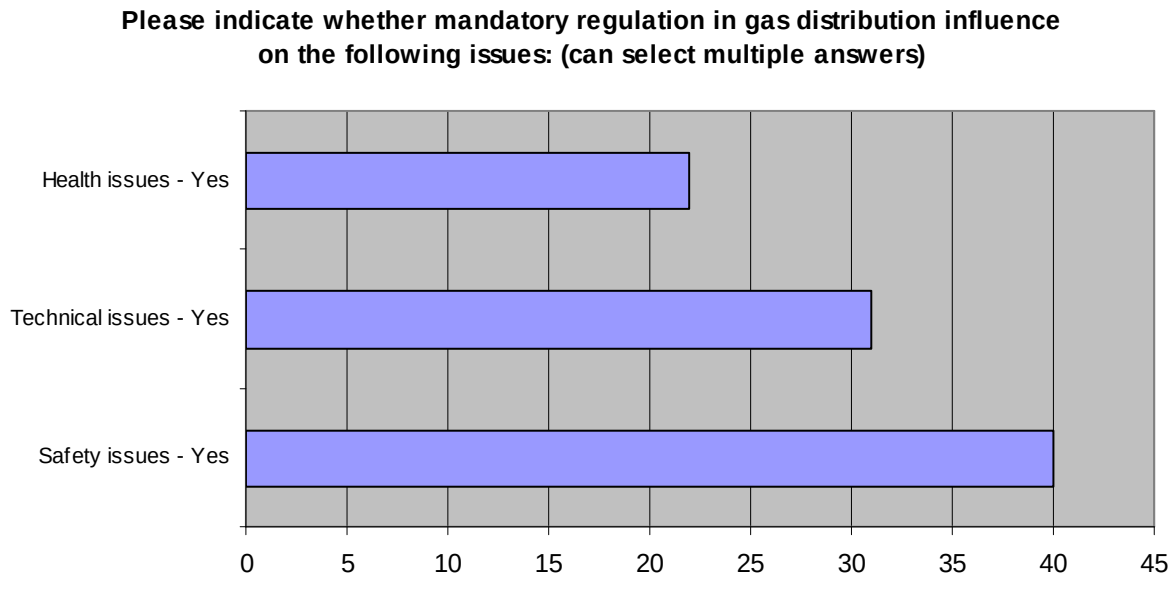


Figure 23 Influence of mandatory regulation

Funding

It is surprising that over 50% of the companies that responded to the questionnaire stated that the cost related to emergency treatment is not covered in the network tariffs (or indeed that it can be charged to the third party who caused the accident in the first place).

Besides acting on network failures, the majority of the companies (70%) are by law obliged to act as the first level of respondent to all customer installation devices.

Resourcing the Emergency activity

Staffing the emergency organisation is mainly done by the companies itself and the majority of companies have their own call centre. Not unexpectedly none of the respondents have fully outsourced its emergency operations, however, a third of the companies do choose for a mixed solution of in- and outsourced teams.

Typically outsourcing can also be seen in response to a very large emergency or where specialist skills are required for example for deep excavation or for high pressure emergencies.

Over 70% of the organisations send out one person for the first intervention to solve the incident. With the remainder deploying two person teams and in a very small percentage, (<5%) large teams, greater than two persons are used.

Since (large) incidents are very rare within the gas distribution industry the companies are aware that training is very important to keep the organisation and procedures valid and up to date. Over 90% will train their staff at least once a year to retain skills. This training is set up in collaboration with external organisation such as the police and fire brigade.

5.4 Conclusions and recommendations

The expert from the committee experienced great differences when speaking about KPI's on this subject. It is recommended to work on getting the same definitions and understanding per country, continent or even worldwide. Standardisation of these definitions and term makes benchmarking possible and useful. At this moment a best practice is hard to distinguish.

The awareness for operating emergency organizations exists in all surveyed companies. The standards are different between the countries because they are determined and influenced by national legislation and regulation in accordance with national rules.

Using KPI's assessment for result rating from the emergency training is not standard. To climb up the "ladder of maturity" it will be necessary to evaluate the training and to set the required improvements.

The acceptance of expenditures by the regulator is the requirement for high standards. If the costs are not covered by tariffs the performance of the emergency organisation or even the safety level in general may decrease.

Tracking the KPI´s should provide appropriate data, information and analyses for continuous improvement and development of the emergency system vice versa in reaction of the gas market rules and benefits.

KPI´s can help to benchmark between companies and valuated appliances, devices and processes (e.g. pipelines, regulation stations, take off points, emergency calls).

Professional periodical training is necessary because accidents happen rarely. Trainings for all emergency staff (insourced and outsourced) in cooperation with fire brigades and professional organizations should be organized. It helps to develop skills of emergency staff, discover gaps, weakness and potentials for further effectiveness. Quick reaction on incidents and accidents needs direct communication between all involved partners. The best way is centralisation of emergency call system and implementation one call point (e.g. directed to dispatching department or customer care department). Customer and gas company partners need to have direct communication with gas supplier or gas operator due to unbundling processes.

6 Audit and review

6.1 General Purpose and comments

All management systems which can recognise a PDCA (Plan Do Check Analyze) circle will also include some form of audit and review. The evaluation of a safety management system has to improve this system and confirm that it complies with regulatory demands.

This can be supported by the use of management system standards like ISO 9001, OHSAS 18001 or PAS55.

Auditing and review the system is therefore a key input for improvement of safety management. This activity will in the end help to improve the effectiveness of all the other layers in the Swiss Cheese model, and if applied successfully could actually reduce the holes in the different layers of defence.

6.2 Questionnaire

This section of the questionnaire focused on understanding what processes companies use to validate their safety management systems. The questionnaire looked at the following elements.

- What external standards are used to provide a framework for the safety management systems and
- How the systems, including processes and procedures are tested and validated.

Applicable standards

ISO 9001

The ISO 9001 Quality management systems can be viewed as a basic standard. It strongly focuses on service quality and the clear structuring of processes within the company and at the interfaces to suppliers and customers. Basically, ISO 9001 is meaningful for and can be applied by all companies. Most companies initially opt for the introduction and certification of quality management systems according to ISO 9001.

While this standard does contain requirements in terms of environmental and occupational health and safety management, it does not address these in great depth.

However, since this makes ISO 9001 comprehensive, it is appropriate for all kinds of companies. A company with an established and effective quality management system in accordance with ISO 9001 can expand this management system with reasonable expenses to ISO 14001 and/or BS OHSAS 18001. All three standards (ISO 9001, ISO 14001 and BS OHSAS 18001) are well matched to each other and similarly structured. ISO 9001 will soon be revised and published as the new ISO 9001:2008. As part of the revision, compatibility with ISO 14001 and BS OHSAS 18001 was further improved.

The effective introduction of a quality management system in accordance with ISO 9001 increases awareness of the quality of a company's work, resulting in the development of a "quality culture."

PAS 55

PAS55 is the British Publicly Available Specification for the optimized management of physical assets. The standard was first published in 2004 and reviewed in 2008.

Pas 55 consist of two parts:

- Part 1 - Specification for the optimised management of physical infrastructure assets
- Part 2 - Guidelines for the application of PAS 55-1

The standard is not only used in the gas and electricity industry, but also by water utilities, road, air and rail transport systems as well as in the public as in the private sector.

ISO 55000

A safety management system for gas distribution has to start with safe assets and asset management. Around the world there are several management systems related to assets. In the UK PAS55 is widely used. In Australia IIAM (International Infrastructure Management Manual) is a good foundation as well as the US ASTM E53 Property Management Systems. The UK took the initiative to bring these all together and start to work on an ISO on Asset Management.

Early 2011 the project group iso/pc251 was established. The goal of this group is to develop three international standards on asset management:

ISO 55000: Asset management – Overview, principles and terminology

ISO 55001: Asset management – Management systems – Requirements

ISO 55002: Asset management – Management systems - Guidelines on the application of ISO 55001

It is likely that these documents will be an umbrella standard. These standards can be followed by more specified standards per industry in the future.

A typical ISO standard programme runs over three years which means publishing in early 2014.

6.3 Response from the questionnaire

As we saw in the previous chapter, authorities have a great influence on safety management systems of the distribution companies. Over 70% of the companies experience some form of monitoring by the Regulator mainly focussed on safety followed by technical and health issues.

Although this attention is high, the active use of incentives by the regulator is low. We see the highest percentage used related to safety (40%) followed by technical (30%) and Health (17%). The results from the questionnaire did not give the reason for this but the experts of the study group believe that incentives on safety can result in the opposite effect.

The majority of the companies use some sort of management standard to support the safety management system, with a third of the companies using ISO9001 for this purpose. The DVGW TSM Technical Safety Management system was mentioned by a number of (mainly German) distribution companies.

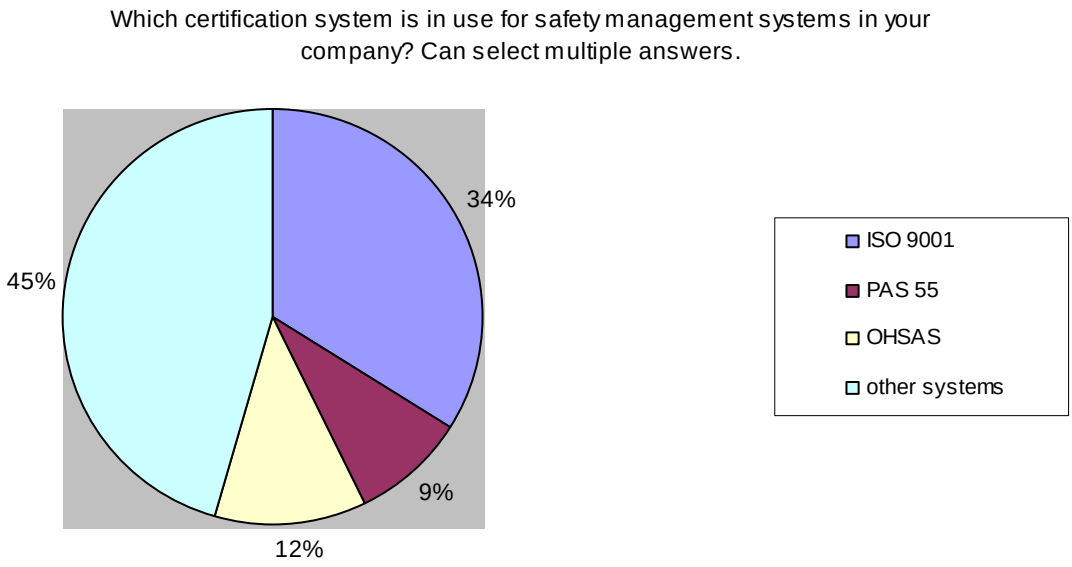


Figure 24 Use of certification for safety management systems

The companies who participated in the questionnaire stated that they are at the second highest step of maturity based on the model of Hudson[3].

(Proactive approach to Safety, see figure 2, page 4). 15% think that they reached the highest stage of maturity (Generative approach). None of these companies is located in Europe.

[3] P. Hudson, Centre for Safety Research, Department of Psychology, Leiden University, Netherlands

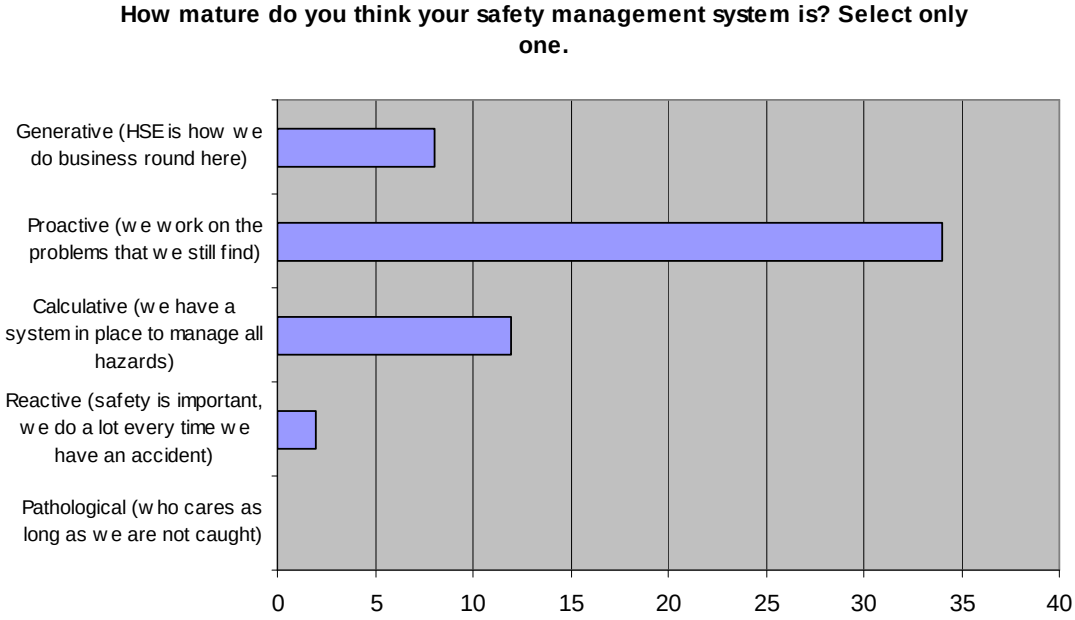


Figure 25 Maturity of Safety management system

The majority of the companies use a combination of internal and external auditors to review the performance of the management system. If an external party is involved, most of the time this will be an independent organisation instead of a regulatory or legislative agency.

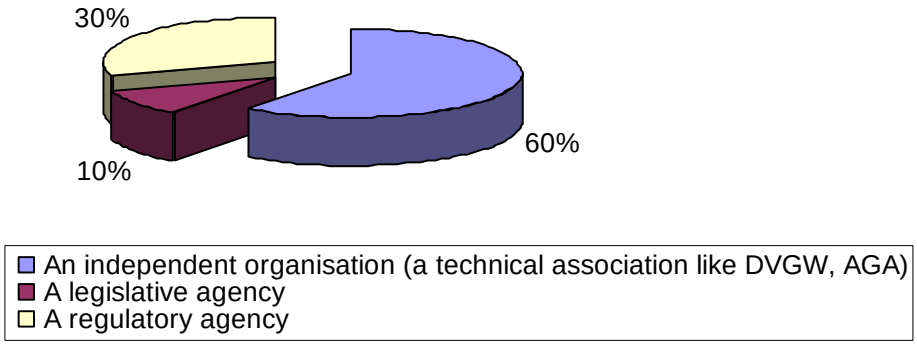


Figure 26 Auditors

Example from the Netherlands

PAS 55 was the basis for the Dutch Technical Standard: NTA 8120- Asset management - Requirements for a safety, quality and capacity management system for electricity and gas network operations, published in December 2009. This standard was developed in close collaboration between the distribution network companies and the Regulators, among them The State Supervision of Mines, the safety regulator for the gas distribution network

companies. This standard does not set values for safety related KPI's but focuses on improving the safety management systems. The first companies in the Netherlands have reached a voluntarily certification based on the standard certified by external auditors. Common goal of the companies and the regulator is to achieve an environment of System Monitoring.

6.4 Conclusions and recommendations

There is no world wide standard in use for safety management like there is for other management systems. By the absence of such a system many companies use ISO 9001 instead. There was a discussion between the experts of the study group about the positive (and negative) effects of dedicated management standard. Besides dedicated attention a standard could give the wrong (short term) incentives. Instead of a separate system and attention safety should be fully incorporated in the management of asset and be a part of the DNA of the organisation.

The industry is rather positive about its safety records. The experts from the study group see this as a potential risk for overestimation and unjustified satisfaction.

7 Summarised conclusions and recommendations

Regarding the objectives and goals of the study as mentioned in chapter 1.1 the study group concluded that it was not possible to establish uniform set of definition and define specific metrics for KPI's for safety management strategies and practices to be used around the world. Definitions vary per country or continent. This is most likely a consequence of different regulation and objectives around the world. We are sure that best practices, for example to develop and maintain competences, developed in companies as an answer to effective safety management system need to anticipate to the evolution of legislation and regulation. Safety regulation is more and more influenced by an increasing non acceptability of gas accidents by the public and society in general. The safety level of our industry today will not be sufficient tomorrow. Nevertheless, we think, from an expert's point of view, that incentive regulation of tariffs related to safety investments is not appropriate.

From the report the following major conclusions and recommendation can be drawn.

Conclusions:

1. Safety management is a number one priority for gas distribution companies all over the world.
2. Human factor seems now to be the major risk of gas distribution industry after third part damages.
3. Gas companies are using the progressive competence development solutions only in a limited way
4. A large proportion of respondents used excel based reporting to provide KPI's. This could present a risk in terms of data quality and thereby value of the reporting.
5. Emergency arrangements are different between the countries because they are determined and influenced by national legislation and regulation in accordance with national rules.
6. There is no world wide standard for a holistic safety management system. ISO9001 is widely used.

Recommendations

1. It is recommended that companies bring a balance between leading and lagging process indicators and continually review their set KPI values in order to ensure they are fully relevant in a changing environment.
2. Because of the risk it is recommended to introduce a human factor KPI in the Board Survey: "% of incidents with human factor identified as a cause" should be a good proposal
3. Where possible, an end to end system that draws the data from a "core" system is recommended thereby limiting the "human" interaction and manipulation.
4. Professional periodical emergency training is necessary. Trainings for all staff (in sourced and outsourced) in cooperation with fire brigades and professional organizations should be organized.

5. Whether or not there will be a world wide standard for a safety management system in the future, we recommend companies to invest firmly in the attitude and competence of its employees and create a safety culture in the organisation in which safety is regarded a part of the organisations DNA.

As chairman of Study Group 4.1 I wish to thank all the companies who contributed to the survey by responding to the questionnaire and the study group members for their work and fruitful discussions. Without their support this work was not possible. Finally, I wish to thank Alessandro Soresina, chairman of Working Committee 4 Distribution for his guidance.

2009 – 2012 Triennium

Study Group Work Report

June 2012

STUDY GROUP 4.2:

Smart Metering Systems

Chair: Kim Vrancken

Belgium

1. Introduction

1.1. Purpose and objectives

The terms of reference of Study Group 4.2 (SG4.2) was to determine the process necessary for the evaluation and determination of leading practices used in the industry for Gas Smart Metering Systems. Leading practices were to be based on a review of commonly defined metrics of operational performance.

The committee also sought to identify “Best Practices” in Gas Smart Metering Systems and to review existing and newly emerging operating procedures for Gas Smart Metering Systems.

With the above Purpose and objectives in mind, SG4.2 formulated a questionnaire that focused on five separate areas, namely:

- General information;
- How is regulation involved in Gas Smart Metering Systems;
- How are Gas distribution network (and meter) operators today viewing Gas Smart Metering Systems;
- What kind of technologies are Gas distribution network (and meter) operators considering now and in the future;
- How are Gas distribution network (and meter) operators assessing the costs related to a Gas Smart Metering Project.

Within each of the above 5 separate areas, SG4.2 asked specific questions of companies, to determine the best practices used by the operators.

Reading this report and a study of its conclusions will let Gas distribution network (and meter) operators judge for themselves where they are placed when benchmarked against other Gas distribution network (and meter) operators.

Beside the findings based on the questionnaire, each area contains some general or specific comments on the findings as noted by the study group committee members.

1.2. Scope of the survey

The study covers only meters up to and including G6 (Qmax 10m³/h)

1.3. Definition of a smart gas metering system

There is no generally commonly accepted definition for a smart gas metering system. In terms of guiding principles, any smart gas metering system should be based on:

- Remote communication of metering information;
- Helping the end user to manage its gas consumption by providing better quality information;
- Facilitating the end users to switch energy suppliers;
- Offering the right balance between cost and additional functionalities.
- Offering functionalities through communication.

Note that we have considered not only a meter but a system.

1.4. A 2010 survey

Smart metering is today a hot topic in the utility market. A lot of manufacturers and other parties are working on smart metering. Because of that, technologies, legislation and the overall understanding of smart gas meters is evolving rapidly. So, when reading this report, it is very important to know that this report is a result of a questionnaire carried out in 2010. The reader should be aware that the regulatory environment, especially at national level, is changing rapidly.

1.5. Point of view of distribution companies

Smart metering involves a number of stakeholders:

- Distribution network (and meter) operators,
- Energy suppliers,
- Metering industry,
- Energy Regulators,
- Government,
- Consumers.

Therefore it is important to understand that this report is a result of a questionnaire answered by Gas distribution network (and meter) operators. So the results are representing only the point of view of gas distribution network operators.

Consider for example just the question: “why are you thinking of / using a smart gas metering system” and you will probably get different answers depending on the type of stakeholder.

2. Data analysis

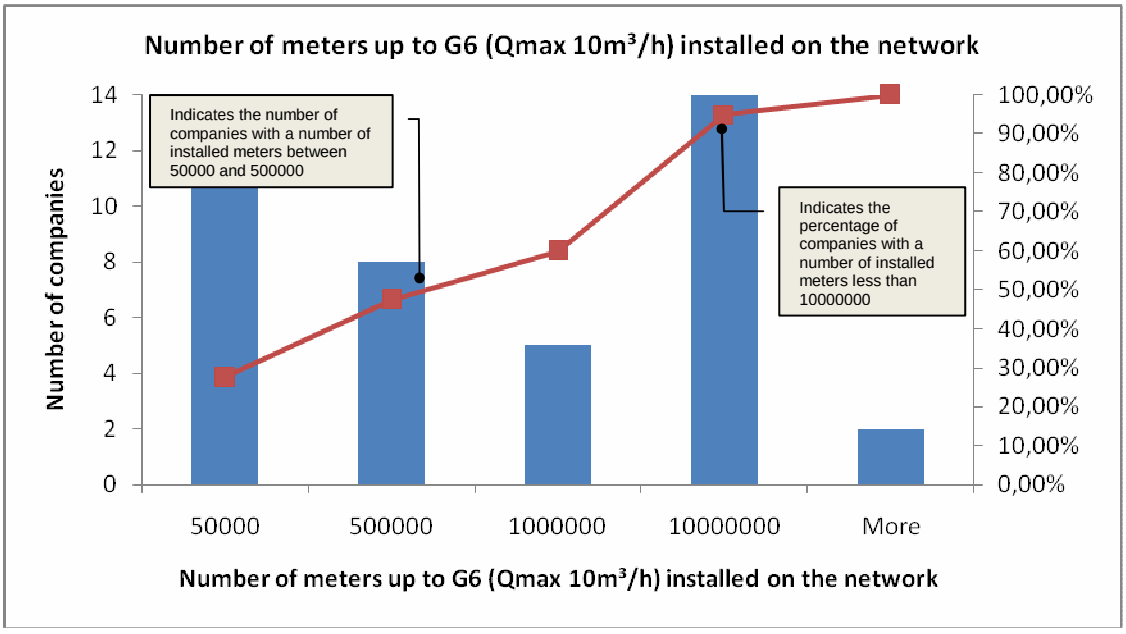
In this section, an analysis of the data received in answer to the questionnaire is presented and general or specific comments made on observations by the committee.

2.1. General

Company profiles, ownership and population of meters

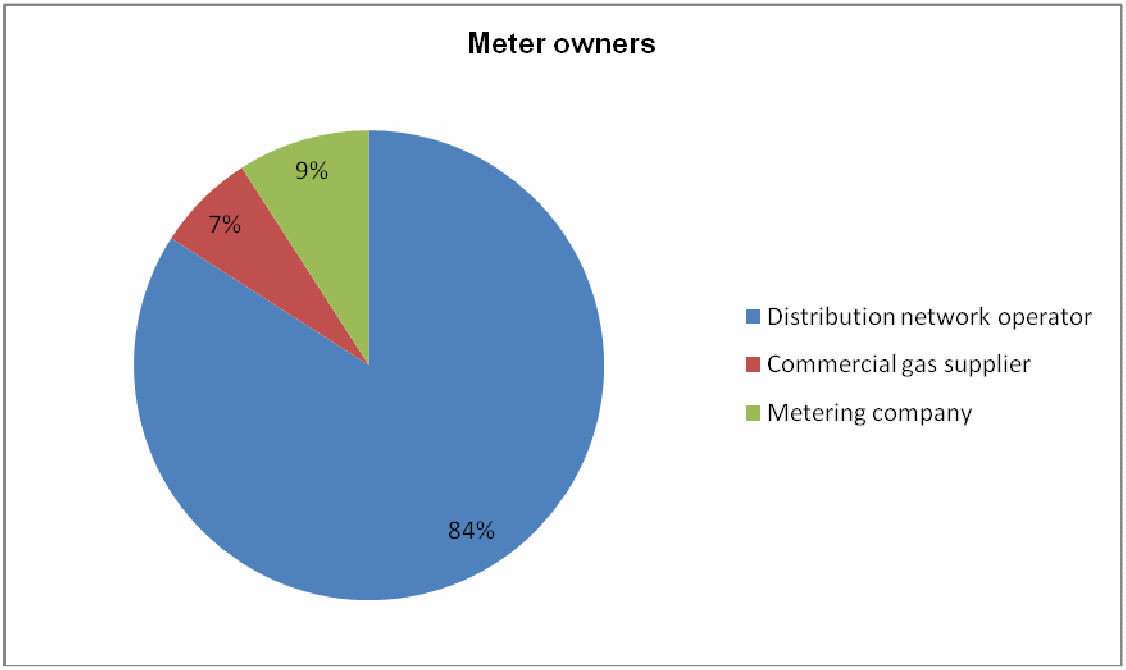
The graph below shows the number of meters up to and included a G6 (Qmax 10m³/h). The graph teaches us 2 important facts to consider when reading further this report:

- 50% of the companies who have answered the questionnaire have less than 500.000 meters up to G6 installed.
- 14 companies (about 40%) who have answered the questionnaire have between 1 and 10 million meters up to G6 installed.



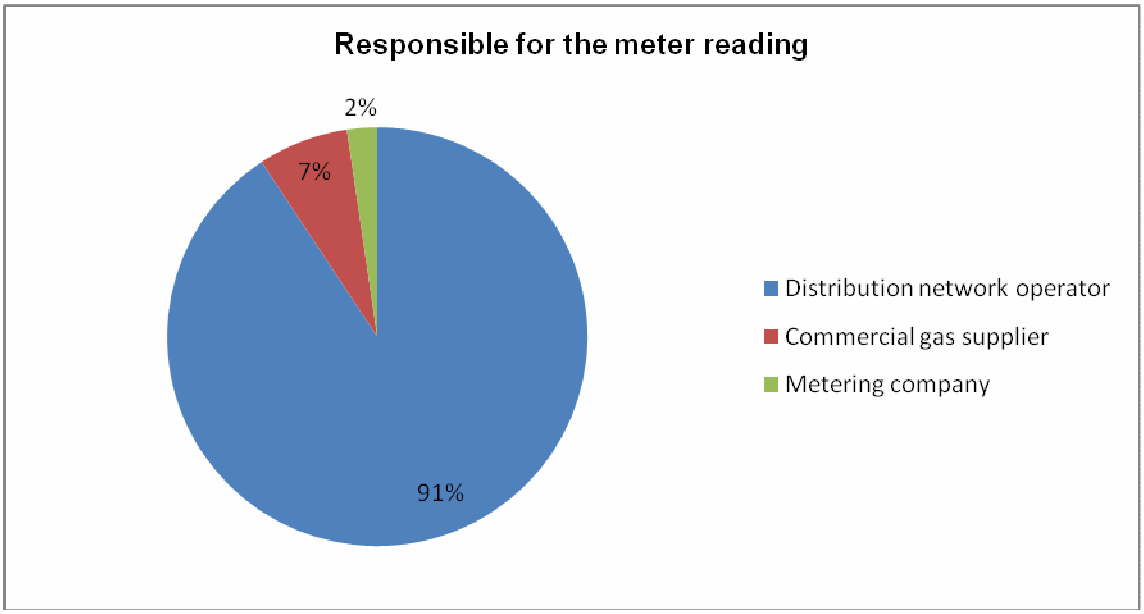
Meter owner and responsibility

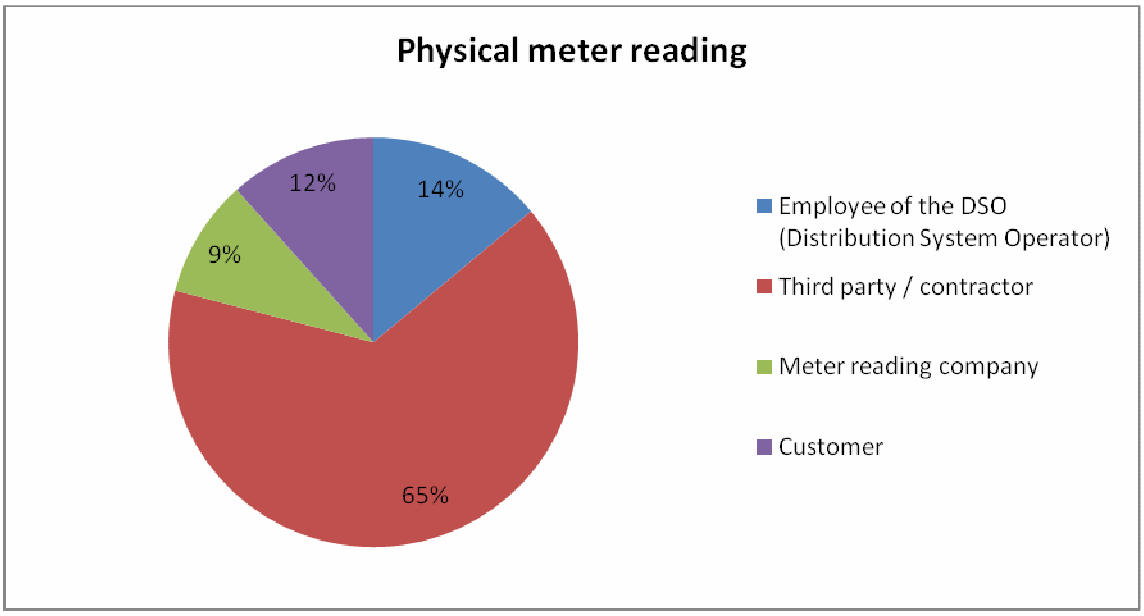
The graph below shows that in 84% of cases the distribution network operator owns the gas meter. Only in 9% of the cases the meter is owned by a dedicated metering company. In a few cases, 7%, the domestic gas meter is owned by the commercial gas supplier.



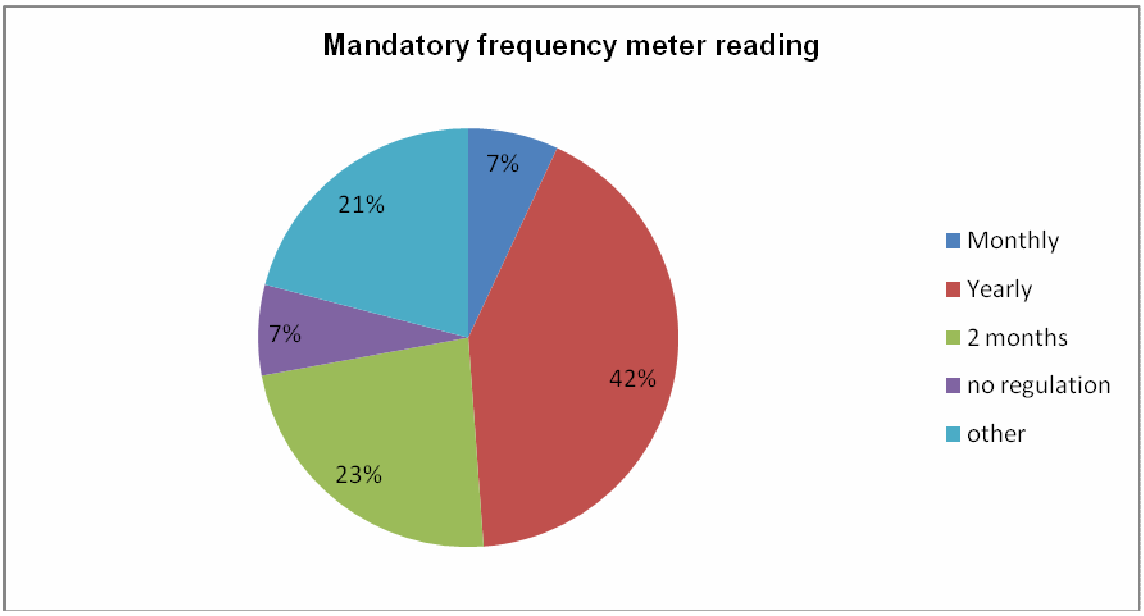
Meter reading

First it is worth mentioning that in 91% of the cases the distribution network operator is responsible for the meter reading. When you compare this graph with the graph in the previous section, it is clear that they are not equal. The reason is that the party who owns the meter is not always responsible for the meter reading. In 65% of the cases the physical meter reading is done by a third party or a contractor. As you can see in the graph some companies have a system were the customer is allowed to do the meter reading themselves. The results of the questionnaire show that companies use 3 media: letter, phone and Internet to obtain the meter index from the customers.





Based on the data, most of the companies have a yearly mandatory meter reading frequency. However, there is a significant amount of companies where the mandatory meter reading frequency is monthly or every 2 months. Please note that in Japan there is no specific regulation on this topic but meter reading is done monthly.



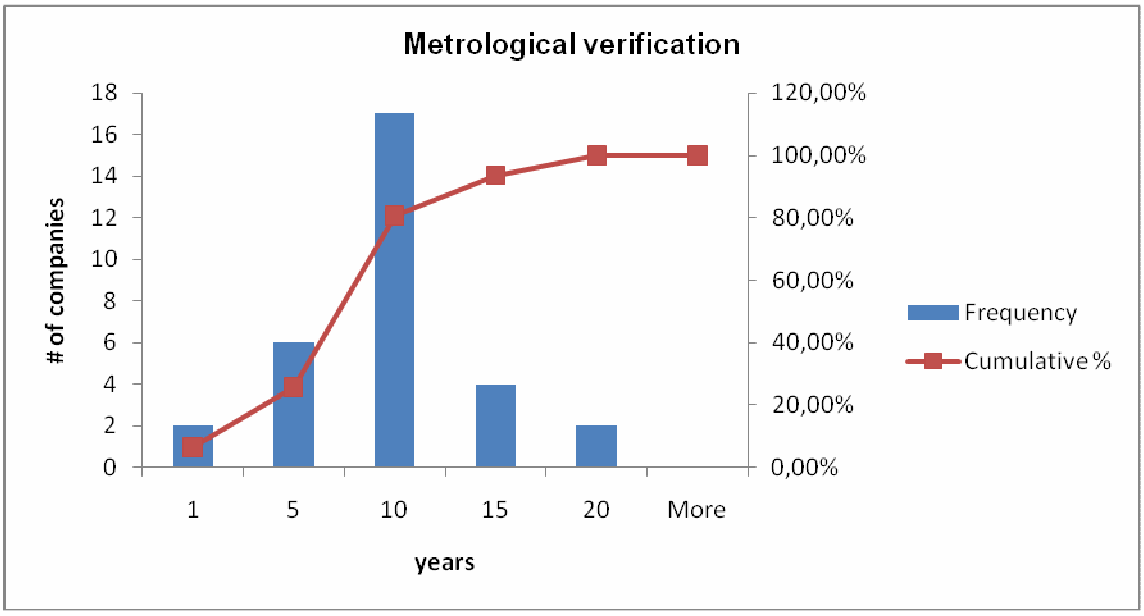
Verification and lifetime

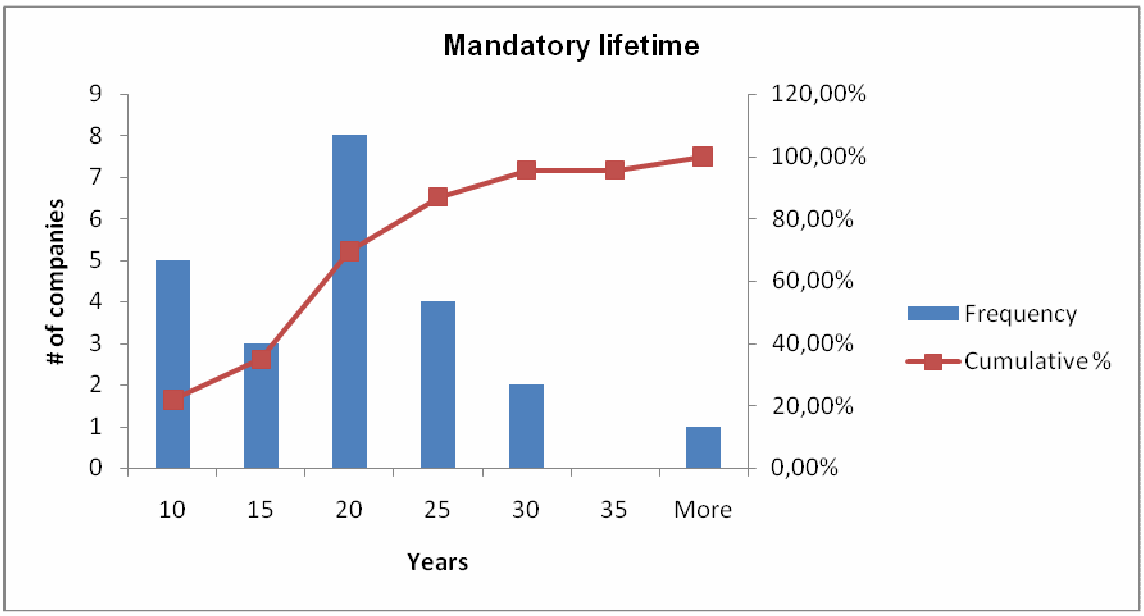
In this section the study group sought to establish if meters are subjected to metrological verification and if they have a maximum lifetime. 4 companies responded that there is no

obligation to verify the metrological properties of the meter. A summary of the results is set out in the next graph. Most of the respondents carry out a metrological verification every 10 years.

Organisations were also asked if their meters have a mandatory lifetime. 40% of the companies confirm that their meters have a mandatory maximum lifetime. The mandatory lifetime is spread between 10 and 30 years.

In some cases metrological verification is done by sampling.

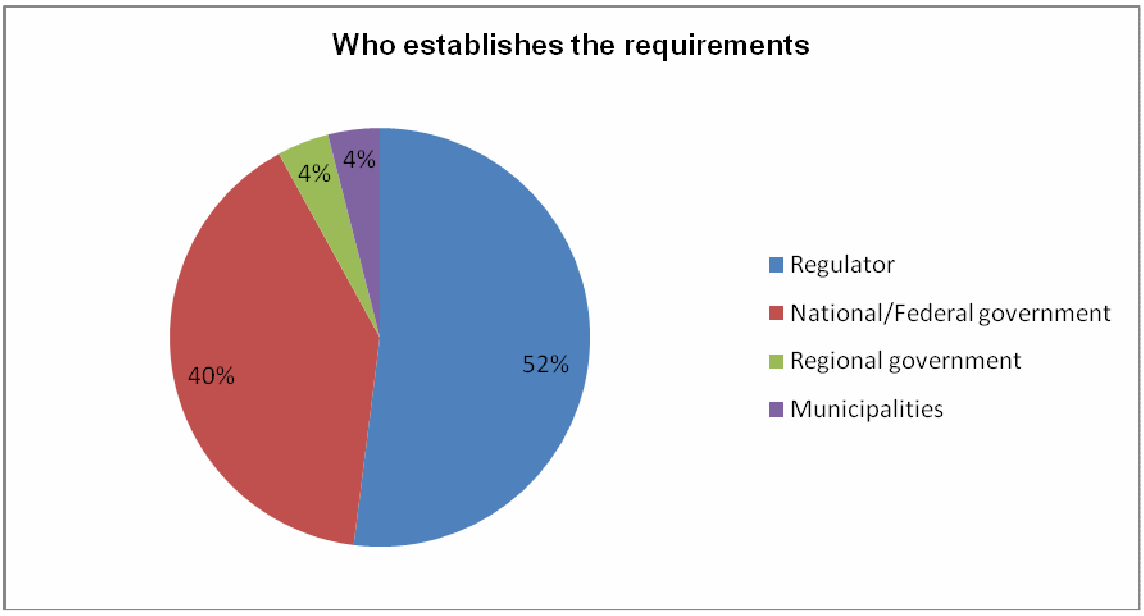




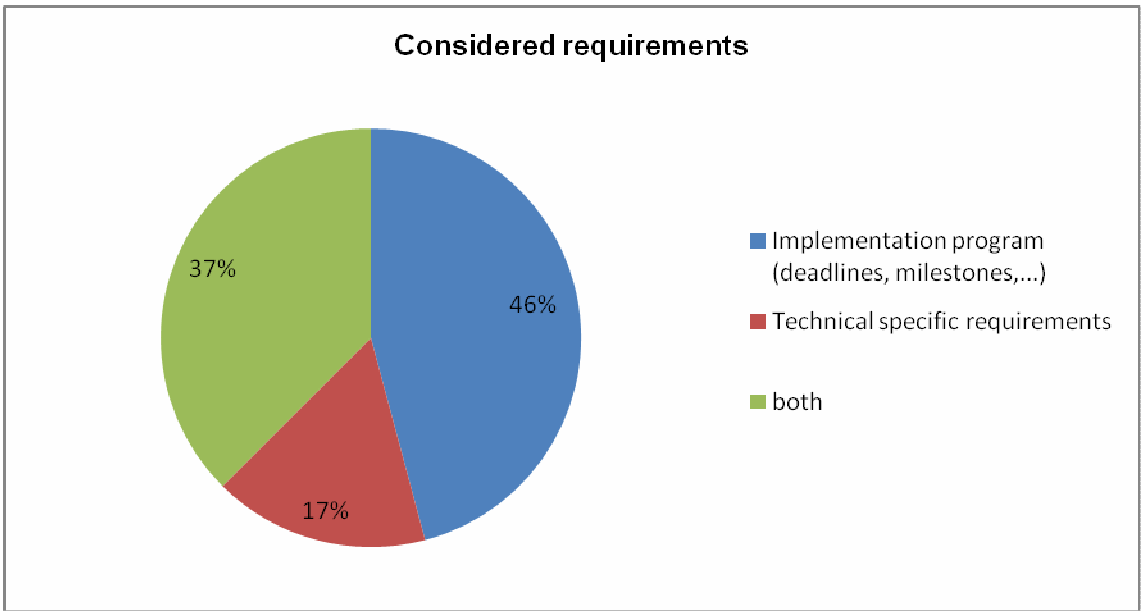
2.2. Regulation

Involvement of Regulator / Government

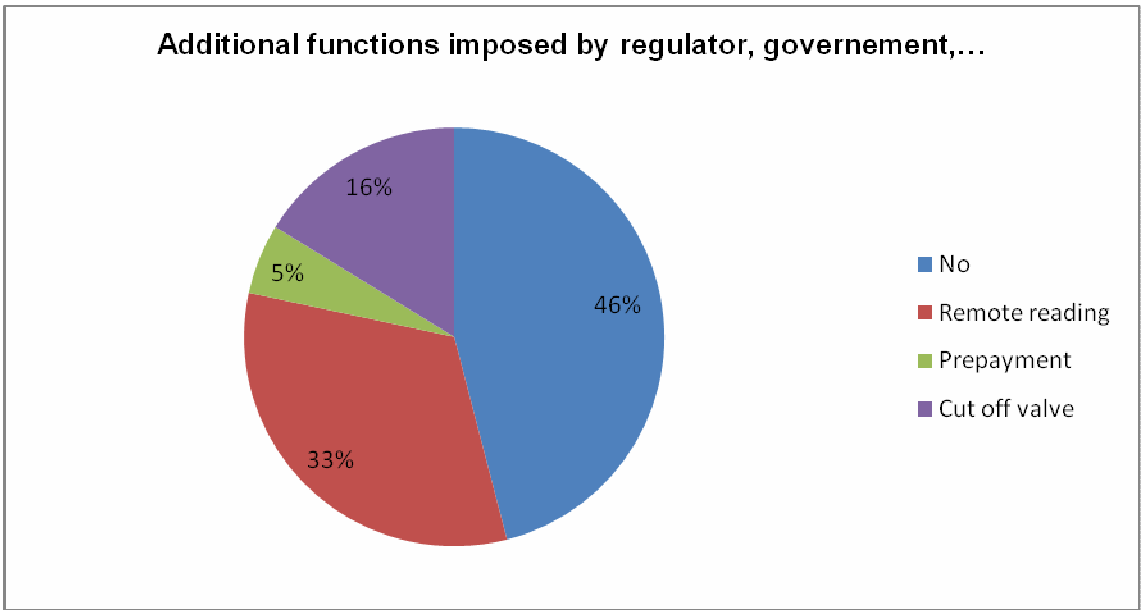
In this section the distribution network companies were asked if there are specific requirements imposed by the government or regulator concerning smart gas metering systems. It will be apparent that a specific requirement is an important element when companies make decisions about smart gas metering systems. The results show that in about 40% of cases a specific requirement from the government or a regulator has already been established. To have a more detailed answer on this topic we asked which party establishes the requirements for a smart gas metering system. The results are shown in the graph below. There is no question about it, the regulator and the government represents about 90% of the total.



The study group sought to determine from Distribution Network Companies the main requirements the regulator or government are considering for gas smart metering system projects. The graph below illustrates the findings.



More interesting are the responses to the question of whether the regulator or government impose additional functions. The graph shows that in almost 50% of cases the regulator or governement does not impose specific additional functions. Remote reading clearly ranks as the highest priority followed by the integration of a shut-off valve. The integration of a prepayment function is clearly not popular.



The specific regulatory situation in Europe (by the end of 2011)

The Energy Services Directive (2006/32/EC) and the Electricity and Gas Market directives (2009/72/EC and 2009/73/EC) adopted in 2009 are the framework for smart metering systems implementation in Europe.
The main reason given in the EU regulations for installing smart metering systems is to help consumers to optimize their energy consumption.

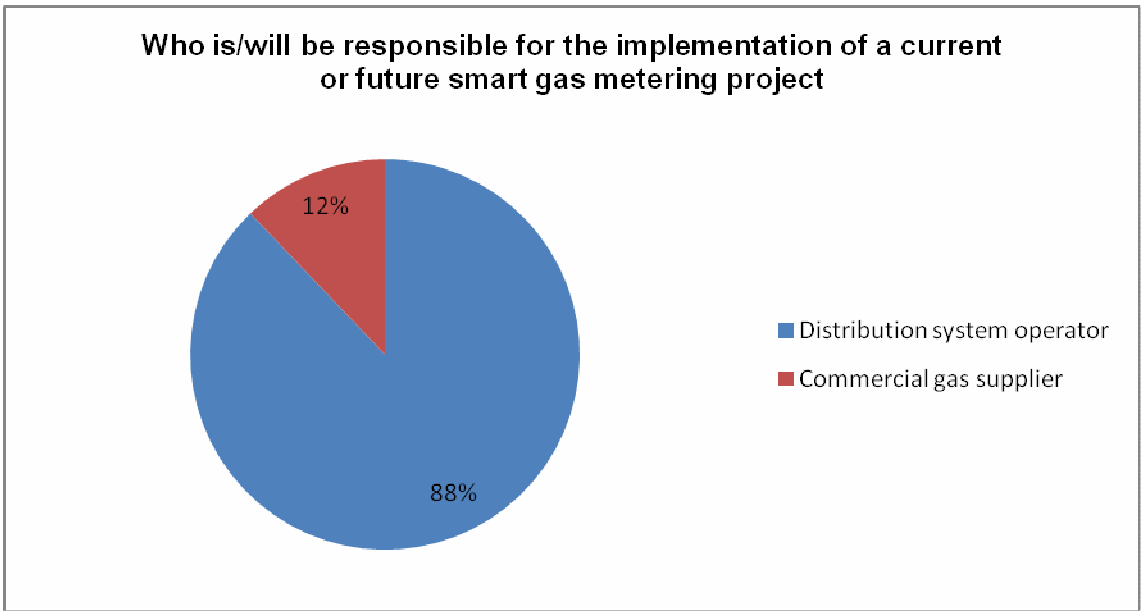
For electricity, the directive requires the implementation of *'intelligent metering systems that shall assist the active participation of consumers in the market'.* Such systems must be in place for 80 % of electricity consumers by the end of 2020 (unless an economic assessment shows that a lower figure is appropriate).
For gas, there may be an economic assessment of such metering systems (by September 2012) but there is no specific target date by which they have to be installed, although this should be achieved within a reasonable period of time.
The number of electricity and gas meters potentially required to be replaced over the coming decade makes this standardization work urgent.

The Measuring Instruments Directive 2004/22/EC (MID) covers the essential (metrological) requirements of meters and is currently being reviewed.
Smart meter standardization undertaken in response to the standardization mandate M/441 deals with additional functionalities not of a metrological nature which are not prohibited by the MID provided they do not affect the metrology required by the MID.
Consideration should be given at the design stage of any smart metering system to such functions as real-time clocks or tariff schedule registers which may need to be synchronized through external communication. This is to ensure that the metrological characteristics of the meter are not influenced in any inadmissible way by the connection to it of another device, by any feature of the connected device itself or by any remote device that communicates with the meter.

In this context, most of the EU Member States are currently working at presenting to the EU in 2012 their plans to roll out smart meters. For the time being, only very few Member States have decided/announced their will to widely install gas smart meters in their territory. But many experiments are being carried out to test possible metering/communication technologies.

Responsibility

In order to help the interpretation of the following findings, we wanted to confirm who is/will be responsible for the implementation of a current or future smart gas metering project. It can be seen that in about 90% of cases the Distribution system operator is/will be responsible.

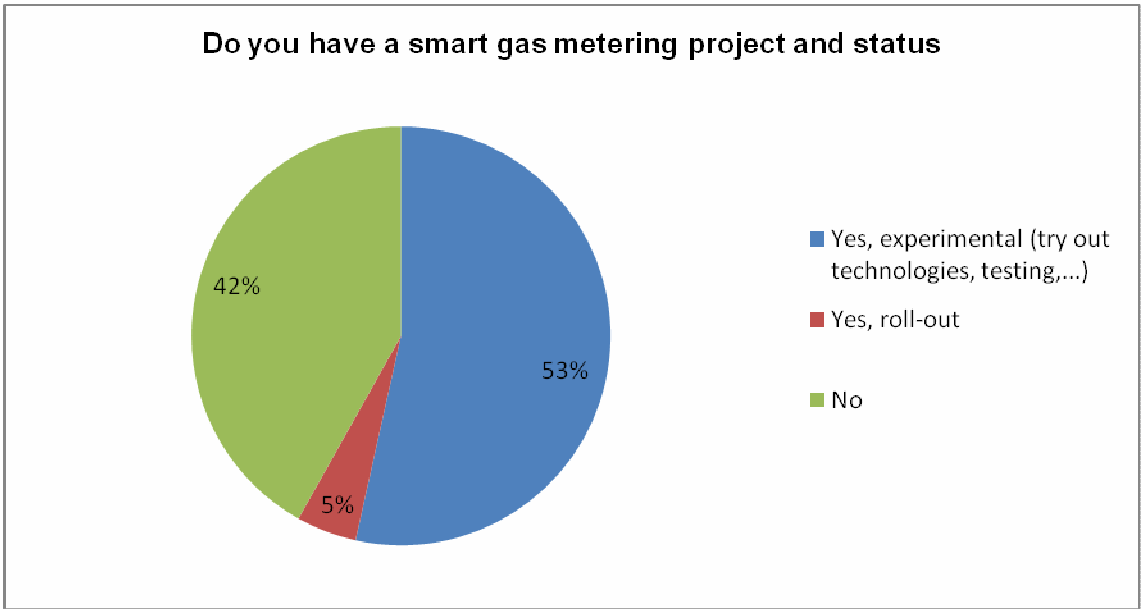


2.3. Smart Meter

Project status

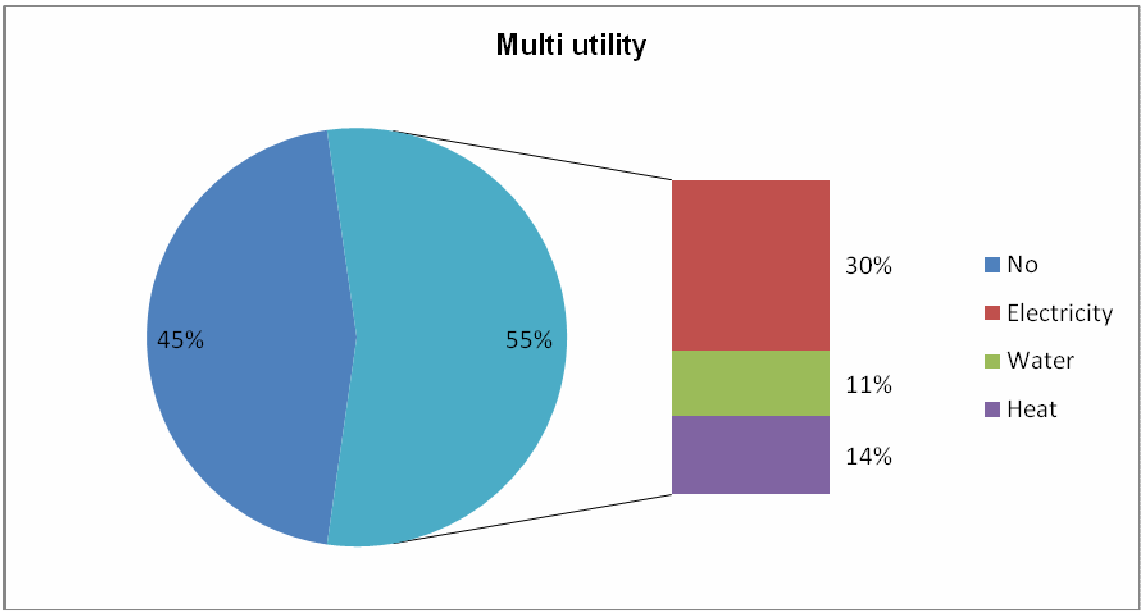
Before going into detail about smart gas metering systems we want to point out that almost none of the companies have a rolled out current smart metering project, except in Japan where about 10% (1,2 million) of the customers are already equipped with a gas smart metering system.

About 50% of the companies are currently undertaking a test / pilot phase. The graph below shows these findings.



Multi utility considerations

About 40% of the companies are considering not only gas for current or future projects, but also electricity, water or heat. Of course almost all of these 40% of companies are multi utility companies. So for them it is easier to integrate other utilities in their project. However, non multi utility companies could also consider synergies with other utility companies. Electricity is mentioned most as to be included in the project, but even water and heat are mentioned 5 times.



Additional functions

Organizations were asked to indicate if they are considering the following "additional functions":

- Remote reading of metrological register(s) and provision to send to designated market organisation(s);
- Two-way communication between the metering system and designated market organization(s);
- To support advanced tariff and payment systems;
- To allow remote disablement and enablement of supply;
- Communicating with (and where appropriate directly controlling) individual devices within the home / building;
- To provide information via web portal/gateway to an in-home/building display or auxiliary equipment.

It should be said that the above list of additional functions is not a compulsory list of functions to be included in any smart gas metering system. There is no single additional function that is mentioned by all the companies.

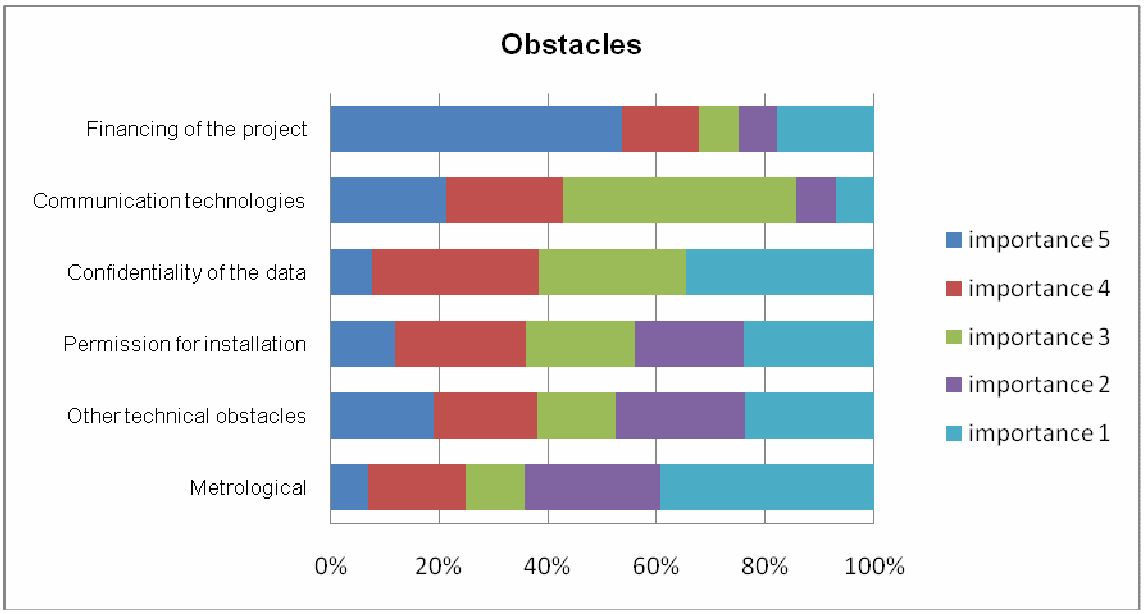
Obstacles

This paragraph tries to identify possible obstacles to implementing a smart gas metering system. As a study group we anticipated and suggested a company's 6 pre-defined possible obstacles:

- Communication technologies
- Metrological
- Other technical obstacles
- Confidentiality of the data
- Financing of the project
- Permission for installation

Every company had to rank those obstacles from most important (5) to least important (1). There is no doubt about it that financing the project is seen as the most important obstacle for a gas smart metering project. Also the question about communication technologies is seen as an important issue to handle.

Note: remote re-opening of the meter; the study group wishes to draw attention to the fact that the re-opening procedure should meet relevant safety requirements.



2.4. Technologies

Meter technologies

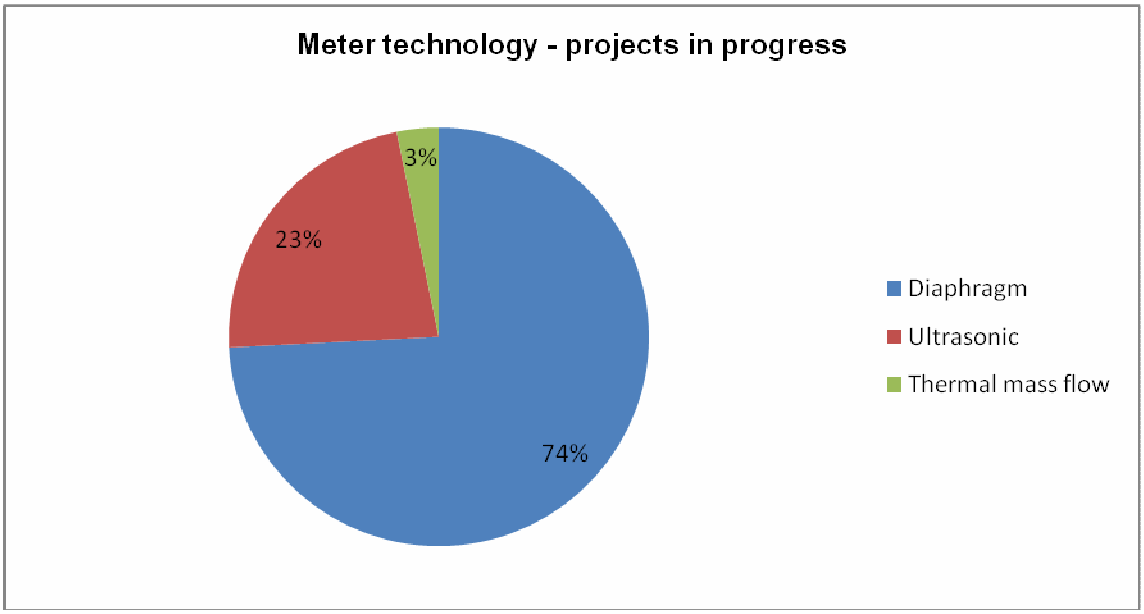
Concerning meter technologies the study group sought to determine which meter measuring technology is preferred for a smart gas meter project. First we asked the companies which meter technology they use in smart gas meter projects in progress. The results show that the classical diaphragm meter is still very popular. Up to 75% of the companies responded that they use the diaphragm meter for their (pilot/test) projects in progress. The most common reasons they give for this decision are indicated below:

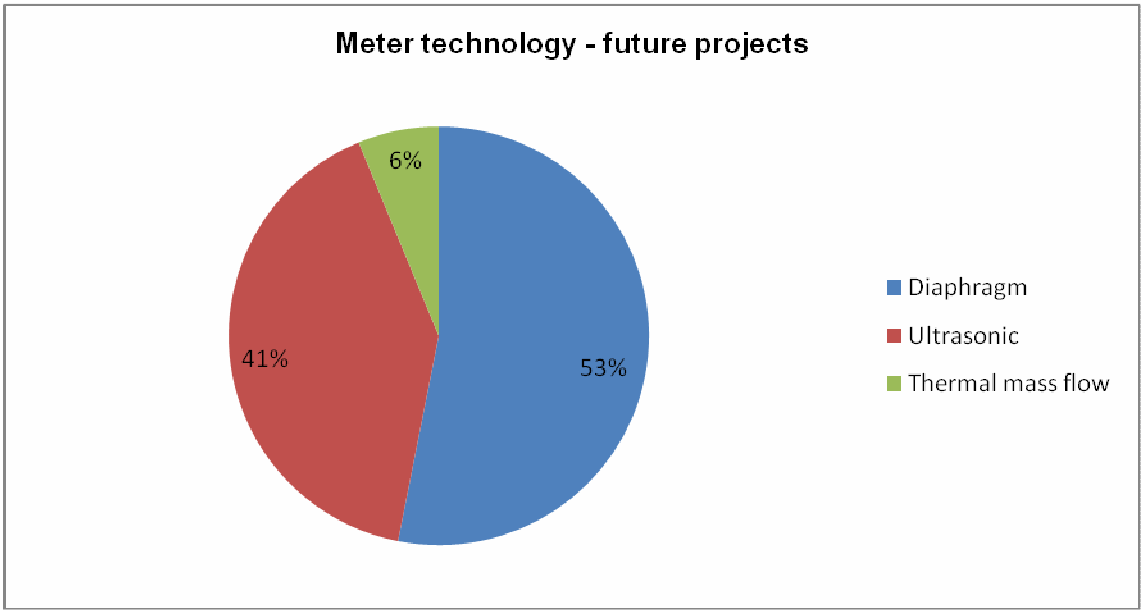
- Reliability
- Low cost
- Proven technology

The results are different if we ask the same question but for future projects. Here we can conclude that companies indicated the ultrasonic meter as an alternative to the diaphragm meter. The reasons why the ultrasonic could be a future alternative to the diaphragm meter are indicated below:

- Reliability will improve
- Mass production will lower cost
- Technology will be more mature

The gas meter based on the principle of thermal mass flow is clearly not seen as an appropriate technology for domestic smart gas meters.

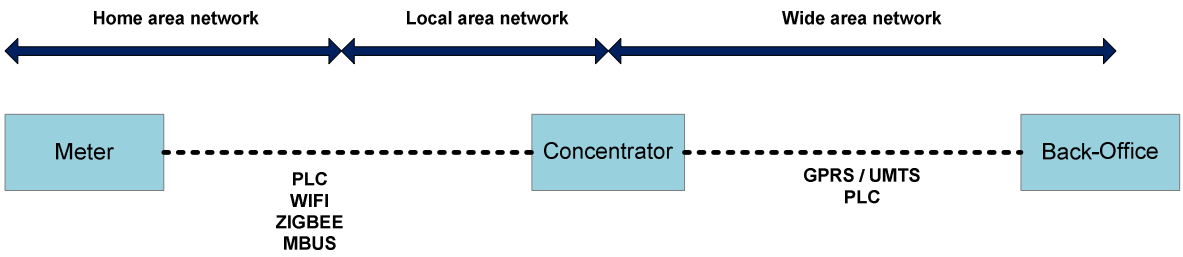




Communication technologies

Concerning communication technologies companies mention the following technologies as suitable for smart gas metering systems :

- GPRS / UMTS
- Power Line carrier (PLC) (only mentioned once)
- M-bus
- Wifi
- Zigbee



The study group asked companies to mention standards if they foresee them being used. Nevertheless the lack of an appropriate answer on this question indicates that gas distribution companies do still have a lot of questions about the communication technologies suitable for smart gas metering systems. This is changing, however, as there are now some standards available for Europe (beginning 2012).

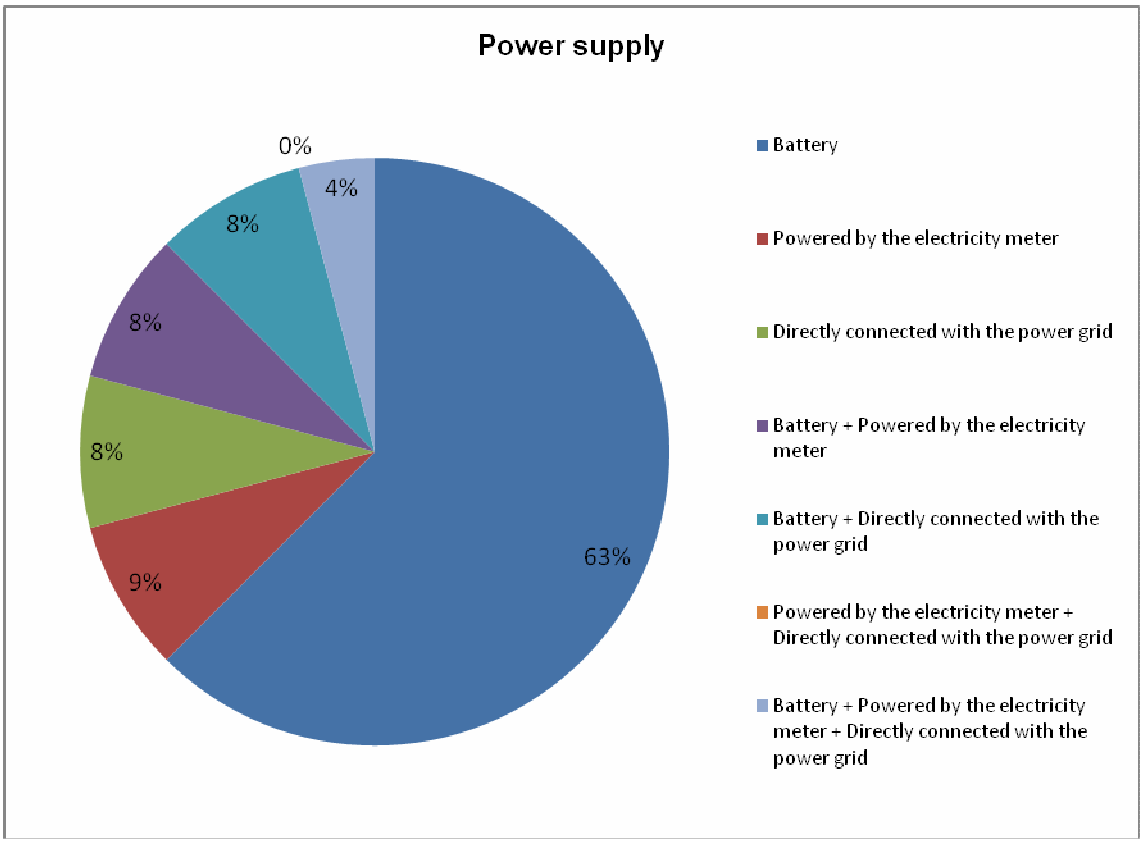
In 2009 in Europe, a standardization mandate (M/441) was given by the European Commission to the 3 European Standardization Organizations CEN, CENELEC and ETSI to produce harmonized standards which ensure interoperability of smart meters. This work aims at creating a European Union wide market for smart metering systems. Gas, Electricity, water, heat and cooling systems are included. In order to manage the process a coordination Group (Smart Meters Coordination Group) comprising all interested stakeholders has been set up.

Power Supply

The study group was interested to learn what kind of power different companies use or will use for smart gas metering projects. 63% were convinced that the smart gas meters will only be powered by a battery, so a long battery life will be a key factor for a smart gas meter. The other 37% is divided between “powered by the electricity meter”, “directly connected to the electricity grid” or a combination.

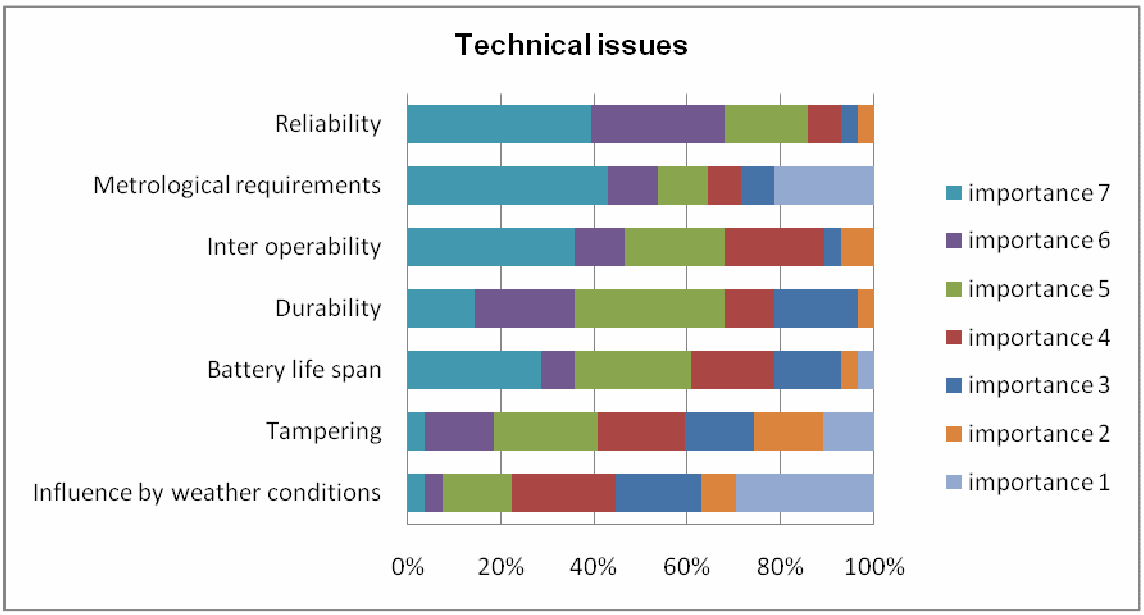
The fact that companies foresee a battery-powered smart gas meter means important implications for:

- all communication related aspects;
- the location and installation of the meter



Other technical issues

Besides the power supply of the smart meter, it is clear that there are possibly other technical issues to overcome. The study group identified 7 specific technical issues and asked the companies to rank them from most important (7) to least important (1). The reliability of a smart gas metering system is indicated as the most important issue, closely followed by the metrological requirements and the inter operability. The influence of weather conditions and tampering are indicated as less important.



Link with intelligent home systems

In addition to the above our study group was wondering if companies foresee a link with intelligent home energy systems. Today only 25% of the companies are considering a link with such systems. But the results show that for future projects this number rises up to 50%.

2.5. Cost / Benefit

Because of the fact that financing the project will be an important issue during a smart gas metering project, we asked the different companies to indicate which kind of costs and benefits they include in their cost benefit analysis:

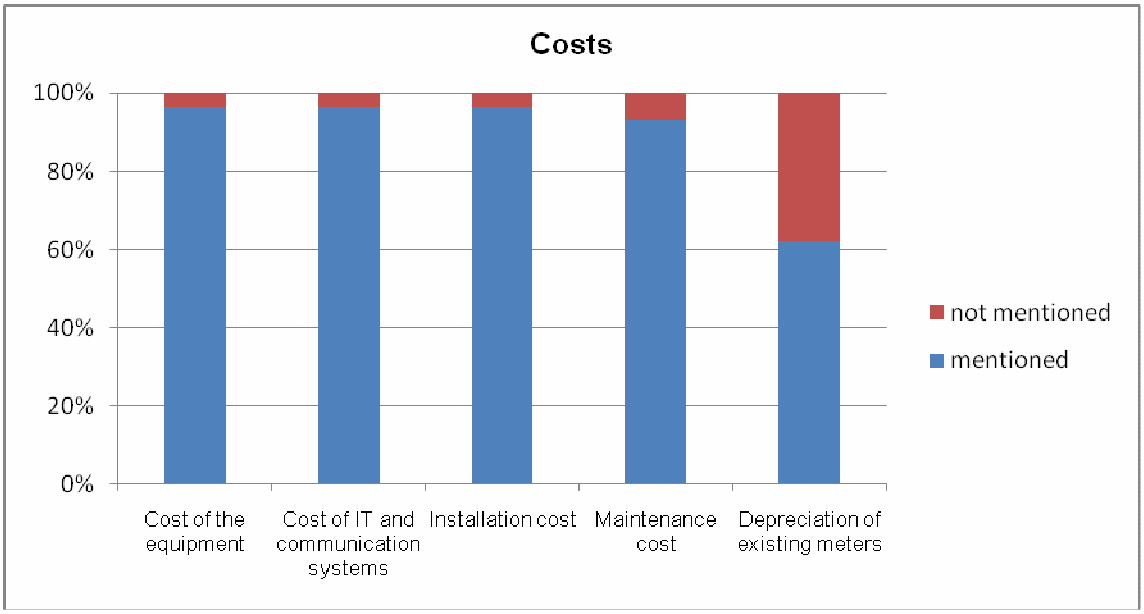
Costs:

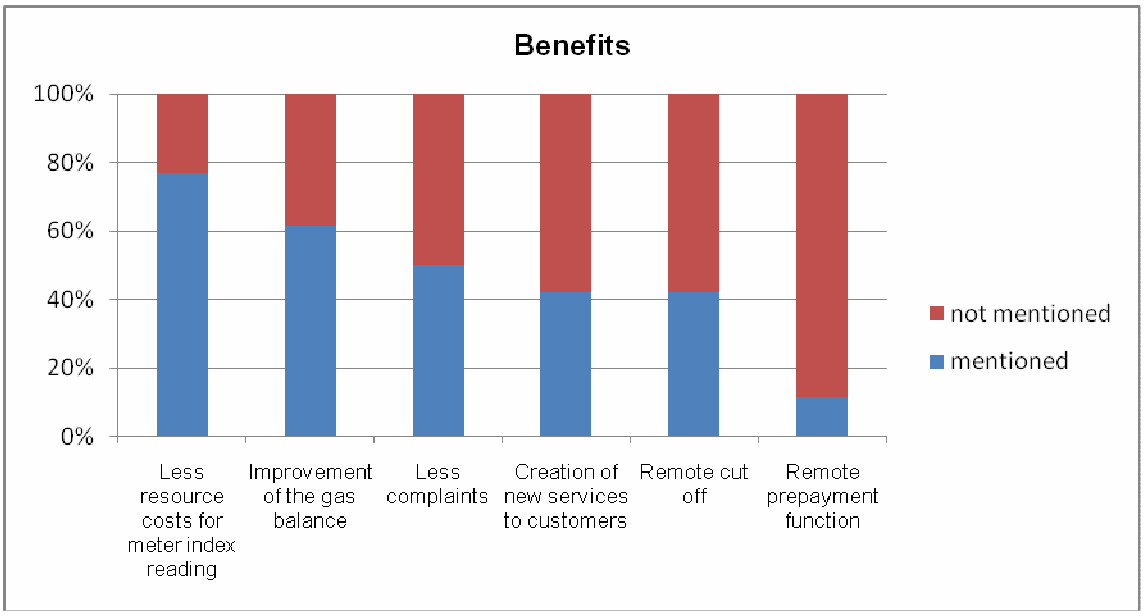
- Cost of the equipment (smart meter)
- Cost of IT and communication systems
- Installation cost
- Maintenance cost
- Depreciation of existing meters

Benefits:

- Remote prepayment function
- Remote shut off
- Less resource costs for meter index
- Less complaints
- Improvement of the gas balance
- Creation of new services to customers

Almost all of the companies consider the mentioned costs as important for a cost-benefit analysis. Depreciation is the least considered cost. The less resource cost for meter index reading is indicated as the most important benefit. In the view of a distribution network operator this is a logical result. Also here the remote prepayment function is not indicated as an important benefit. All companies who answered the questionnaire, with one exception, are considering including the investment cost in the tariff.





2.6. Possible developments

Besides the results of the questionnaire the study group wants to give an overview of the opportunities identified during the analysis.

- Temperature compensation;
- Gas leakage detection;
- Pressure drop detection, over pressure protection;
- Protection in case of earthquakes;
- Tampering.

Smart metering systems may be part of a smart grid. It is therefore sensible to take account of smart gas metering systems if the concept of smart gas grids is studied.

3. Conclusions

In Europe a legal framework concerning smart gas metering systems is developing and standardization is in progress. Already a few decisions to deploy smart gas metering systems have been made and more will follow in the future. Therefore a distribution network operator should consider how to implement smart gas metering systems to gain knowledge and experience.

The majority of the distribution network operators will be responsible for implementing smart gas metering systems. Half of them are currently undertaking pilot test projects. In relation to this there is no doubt that financing such projects is the most critical issue. Therefore a high-quality cost/benefit analysis is a crucial parameter in the decision process. The less resource cost for index meter reading is indicated as the most important benefit.

A list of possible additional functions are being considered by the gas network operators in conjunction with all the stakeholders (Regulators, Consumers, Energy Suppliers, etc). There is no one additional function that is seen as a priority by every company. Every distribution network operator has to evaluate which additional functions are important and how to implement them in their own national context.

Concerning technology and system infrastructure, the major focus is on communication architecture. Regarding the measurement principle ultrasonic meters could be an alternative for the classical diaphragm meter. Overall the reliability of a future gas smart metering system is indicated as the most important technical issue to be considered.

At the time of writing this report it is a little bit too early to foresee new functionalities, but the study group can however conclude that there will be a strong link between smart gas metering systems and smart gas grids.

Besides of the above conclusions it was observed by the study group that there are 2 main objectives of any smart gas metering system:

- enhancing energy efficiency
- supporting the free market

Note that in Japan the main objectives were:

- improving business efficiency
- providing a safe and secure service

See the chapter “field experiences” for more information.

4 Field experiences

Company name	Tokyo Gas CO., LTD. Osaka Gas CO., LTD.
Number of gas customers	10 million 6,9 million

Micom-Meter

In order to reduce gas accidents, Japanese gas utilities developed Micom - Meter, the meter controlled by micro computer.

- 1983- equipped with safety and shutdown functions using an internal shut-off valve
  - Seismic
  - Unusual gas flow
    - Huge gas flow
    - Constant flow continuing for a long time
  - Low pressure
  - Warning function; gas leak detection of more than 3 L/h continuing for a month

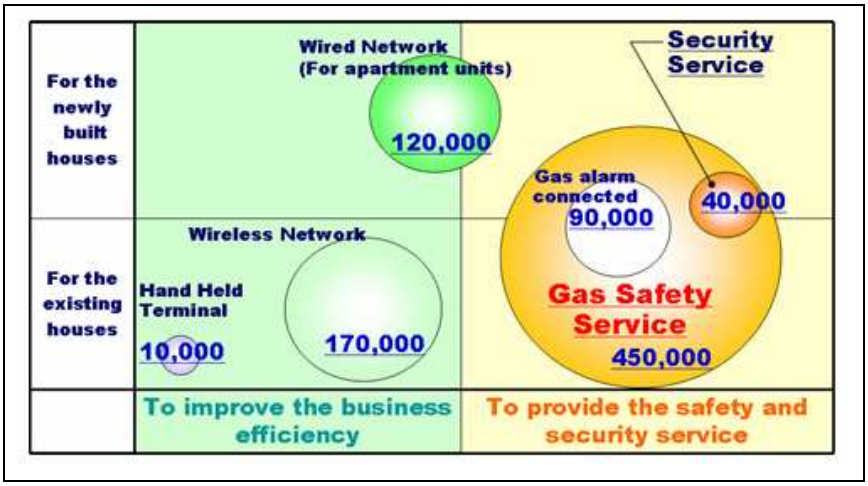
- 1990- equipped with communication function, low power consumption(300 bit per second)
- 1998- equipped with bi-directional valve: open / Shut-off remotely

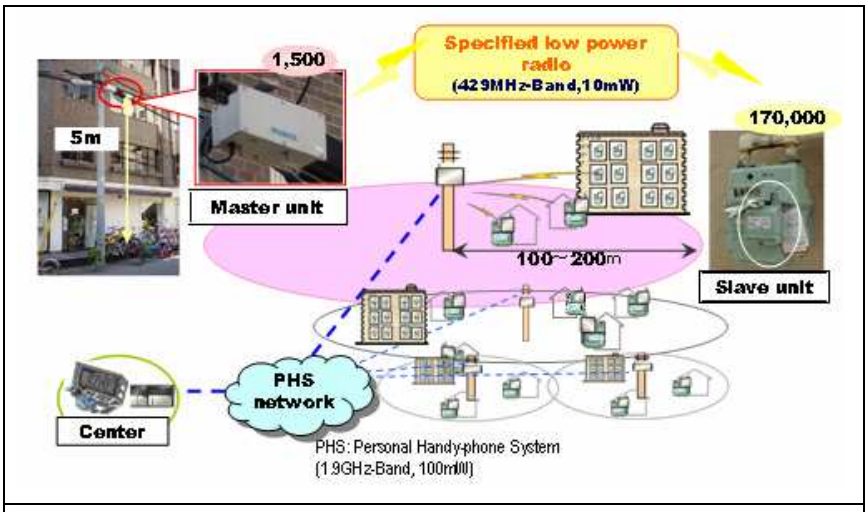
Automatic Meter-Reading (in practical use)

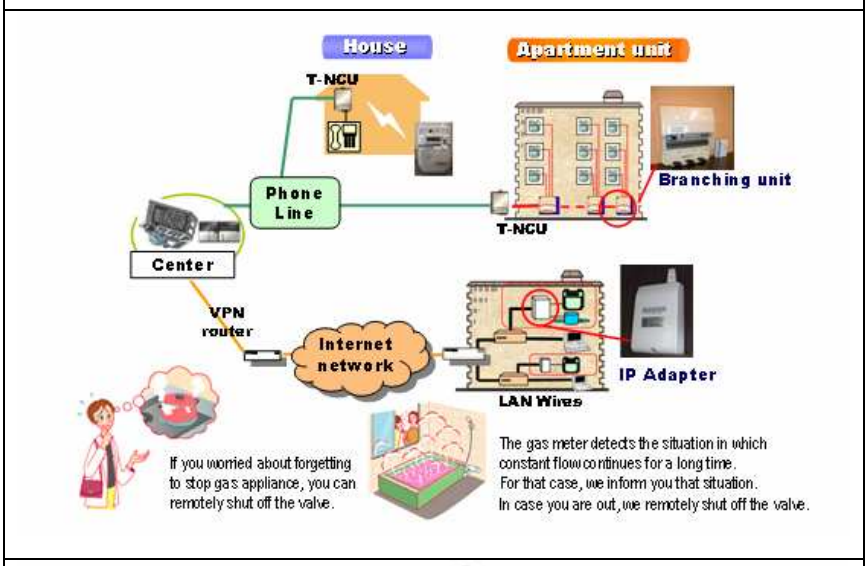
Japanese gas utilities started an automatic Meter-Reading in 1990, which is widespread to more than 1,2 million now. There are 2 objectives to install AMR.

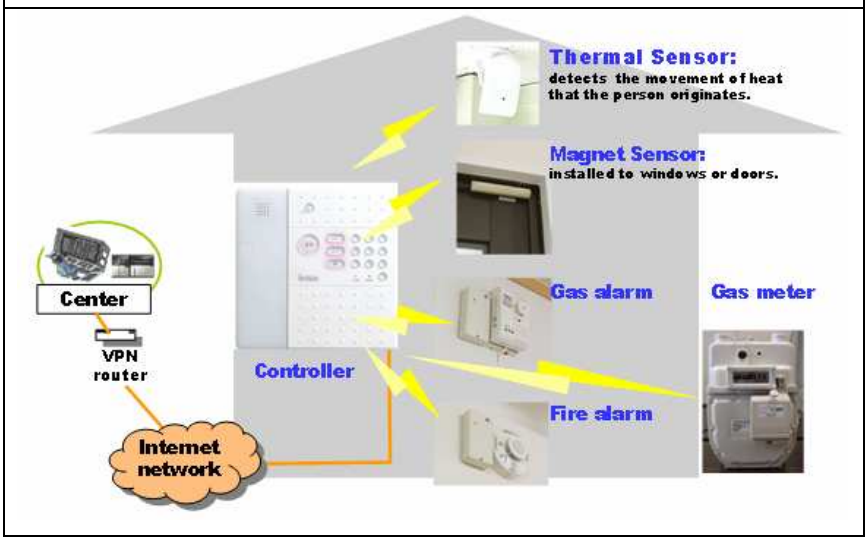
- To improve the business efficiency: in some areas a lot of meters are set up inside the house and their index are hard to read. In other areas many customers tend to delay due date for payment. To improve the business efficiency, area-wide AMR(Automatic Meter Reading) network is applied for these areas.

- To provide the safety and security service.
    - Gas Safety Service: we connect our computer server with the gas meter through the phone line or Internet network, and are providing service that remotely stops the gas supply according to customer needs for a fee.
    - Gas Safety and Security Service: for 40,000customers, we connect our computer server with not only the gas meter but also thermal sensor, magnet sensor, gas alarm etc., through the Internet network, and are providing the home security service.




Specified low power radio
(429MHz-Band,10mW)
1,500
5m
Master unit
170,000
100~200m
Slave unit
PHS network
Center
PHS: Personal Handy-phone System
(1.9GHz-Band, 100mW)


House
Apartment unit
T-NCU
Phone Line
Branching unit
T-NCU
Center
VPN router
Internet network
IP Adapter
LAN Wires
If you worried about forgetting to stop gas appliance, you can remotely shut off the valve.
The gas meter detects the situation in which constant flow continues for a long time.
For that case, we inform you that situation.
In case you are out, we remotely shut off the valve.


Thermal Sensor:
detects the movement of heat that the person originates.
Magnet Sensor:
installed to windows or doors.
Gas alarm
Gas meter
Fire alarm
Center
VPN router
Controller
Internet network

Advanced Metering Infrastructure (under development)

The next generation AMI in Japan which is referred to as the Ubiquitous Metering System (UMS), is composed of 3 main components, which are 1) Wide Area Network (WAN) devices, 2) ad hoc mesh networks, and 3) ultrasonic gas meters interfaced with a next-generation communication line (called U-Bus). The major competitive edge of Ubiquitous Metering System is its strength in the robust and low energy-consumption wireless network technology by using the efficient multi hop method, which is called "U-Bus Air" and now proposed as an International Standard IEEE 802.15.4g Smart Utility Networks.

Figure: Ultrasonic gas meter with U-Bus

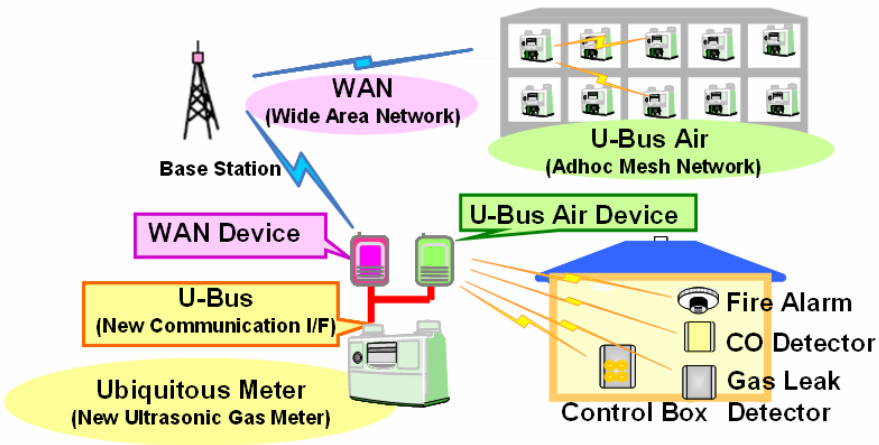


Figure: Concept of the Ubiquitous Metering System

Company name	GrDF
Number of gas customers	11 million

Coordinated approach for the definition of functionalities of the French future Automatic Meter Reading system:

In order to define the functionalities of smart metering systems for residential customers, the main Gas Distribution company GrDF has co-lead a national working group with the French gas association and the regulator . This group has gathered from 2008, all stakeholders concerned by meter reading such as gas suppliers, representatives from consumers, representatives from local energy public authorities, gas meters manufacturers in order to define the most appropriate functionalities required for the automatic meter reading (AMR).

Conclusions of the group has been directly used by the regulator to propose guidelines (September 2009) about the future system and its roll-out. The group get the result of the first experimental roll out made by GrDF in order to help decision making about deployment of gas smart meters, precise the future requirements, study the economical and organisational impact of AMR and facilitate the relationship between the different stakeholders in a possible future roll out.

This method was very efficient to avoid misunderstanding about the use and position of AMR and is a support for assessing its acceptability on the technical, economical and social issues.

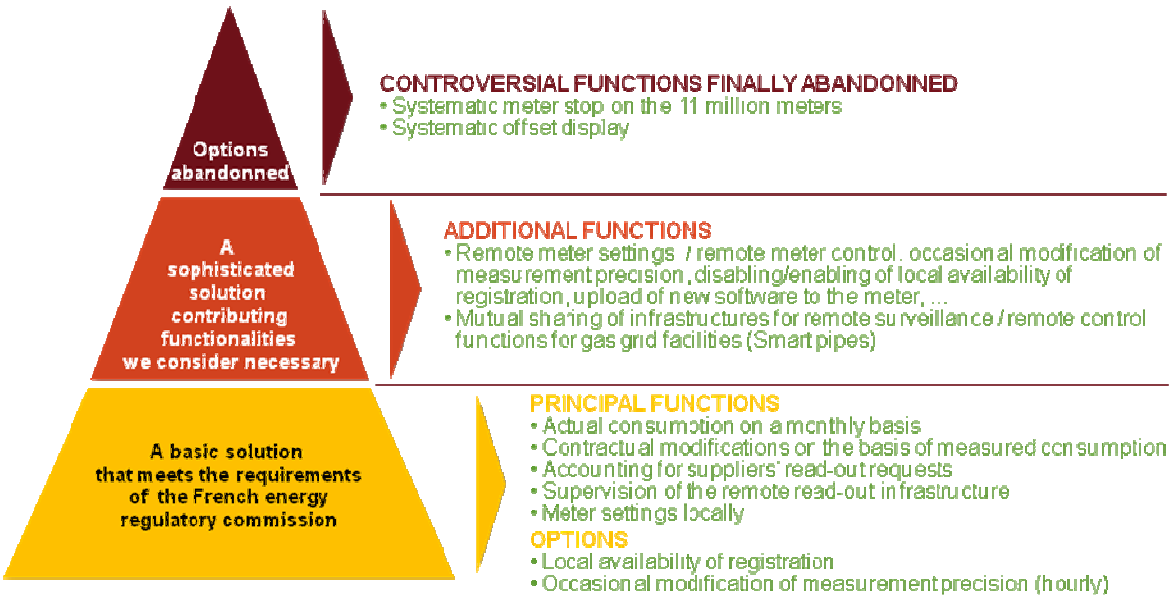
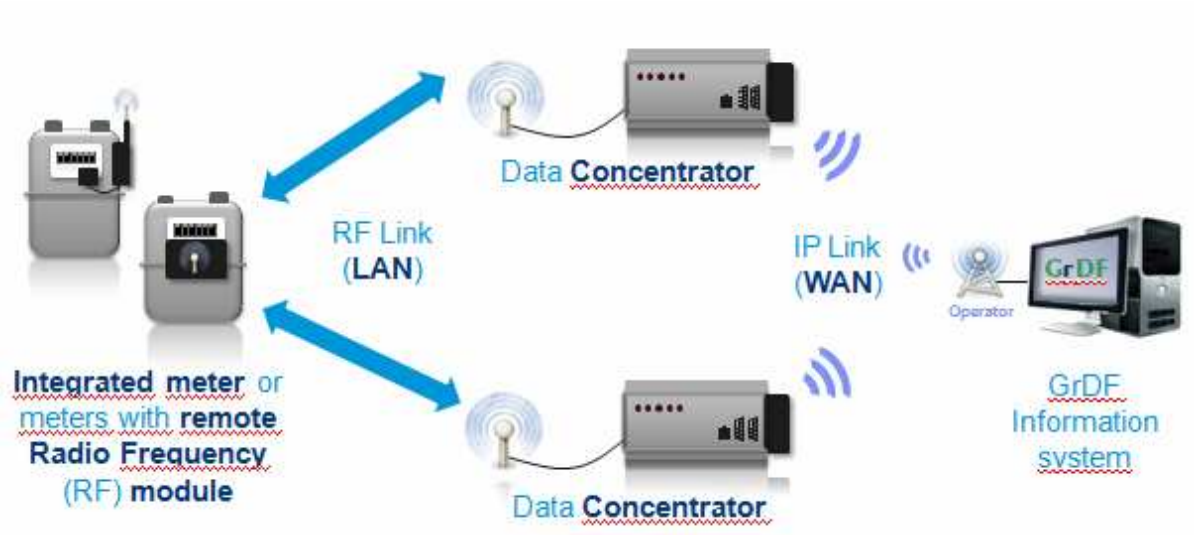


Figure: Ranking of functionalities to be applied to the French future AMR system

GrDF conducted in 2010 and beginning of 2011 four experimental roll out operation using different technologies and representing more than 20 000 meters.

On the basis of the results of these experiments, the French regulator proposed officially in July 2011 to the government to approve the launch of the roll out phase for all residential consumers.



The cost benefit analysis completed by the regulator has shown that the project has globally a positive NPV, that is much improved if energy savings are taken into account.

The regulator noticed following points:

- the benefit will be for final consumers who will have billing based on regular monthly measurements and therefore a better information about their consumption
- the system will ease the switching of suppliers and encourage new offers with tariffs based on the knowledge of the consumption profile
- the new metering system is considered as the first phase of the development of smart networks
- new competences and offers will be encouraged for services concerning energy management and savings.

Last but not least, the GrDF project is an appropriate answer to the requirements of the European Commission and of the European Regulators Group for Electricity and Gas.

At the beginning of 2012, the French Ministries of the Energy and the Consumption support the project, but the final decision to launch mass roll-out is yet to be made.

2009 – 2012 Triennium

Study Group Work Report

June 2012

STUDY GROUP 4.3:

Unaccounted For Gas

Chair: Barbara Jinks

Australia

1 Introduction

Unaccounted For Gas (UFG) is the term used to describe the difference between the quantity of gas purchased/produced and the quantity of gas sold.

UFG can be sourced from a large number of core operations along the value chain of distribution business, including:

- network operations including commissioning and decommissioning practices;
- meter accuracy, reading and management practices;
- accuracy of heat value calculations, measurement and allocation;
- allocation of volume or energy quantities information; and
- consumption estimation methods.

Hypothetically the amount of gas purchased should equal the amount of gas sold but, due to metering errors, leaks, theft and other factors, this hypothetical scenario never occurs.

UFG strongly impacts financial performance, public safety and ultimately the image of DSOs. UFG can be seen as an overall performance indicator of the efficiency and effectiveness with which DSOs lead their operations.

Understanding UFG – the concept, impact of its components and of the decisions that may influence them – is paramount for a successful gas distribution business.

To address the increasing problems from UFG, Study Group 3 of Working Committee 4 (SG3.3) of the International Gas Union distributed a questionnaire to its members. Fifty six companies submitted responses. This report provides the results of the analysis of the answers provided.

The purpose of this report is to understand how companies around the world deal with unaccounted for gas, what the main factors are that can contribute to increment the amount of unaccounted gas and how to minimise their effects.

1.1 Aims of Study Group 4.3

The aims of SG4.3 during the research triennium 2009-12 were to:

- identify the main components of UFG;
- define proper metrics to measure or calculate UFG: and
- review approaches adopted for UFG management (technically and commercially).

In addition, the study group was asked to consider whether a tool could be designed for use by distribution companies to approach measurement or calculation of UFG.

1.2 Global survey

A survey was issued to members of WOC4 in the first year of the research period, 2010. The survey asked companies for their definition of UFG, their experiences with UFG and methods of measuring and managing it. Questions were asked on network operations, billing, metering, custody transfer, research, carbon tax and regulation.

In addition questions were asked on what aspects of UFG were the most important and whether they experienced seasonal or cyclical effects.

1.3 Overview of respondents

The length of mains and number of customers supplied by the 56 companies that took part in the survey are shown below. The majority of the mains and customers are located in Europe, which reflects the nature of liberalised distribution markets.

The throughput of gas is not proportional to the number of customers or total length of mains operated.

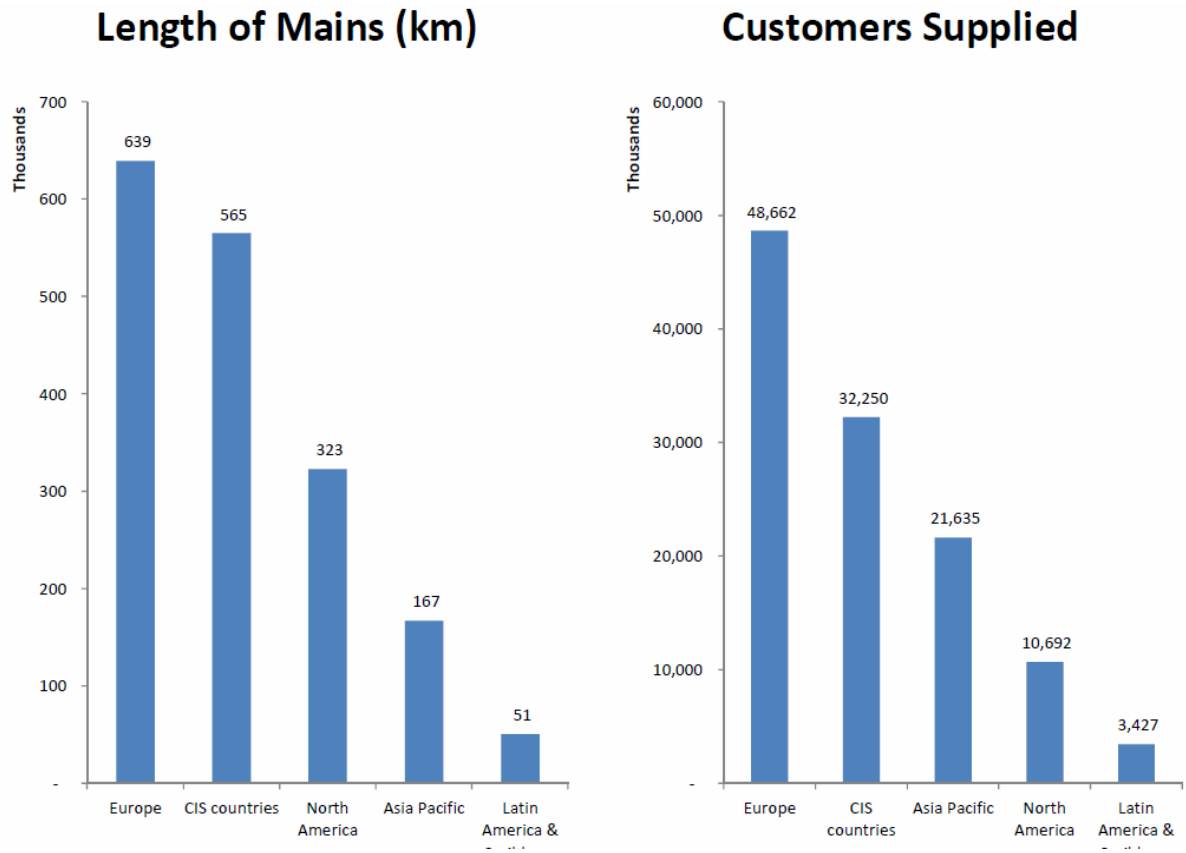


Figure 1 – Length of mains and number of customers supplied

The gas volume delivered by respondents totals more than 400 bcm. 60% of respondents do not transport biogas in their network.

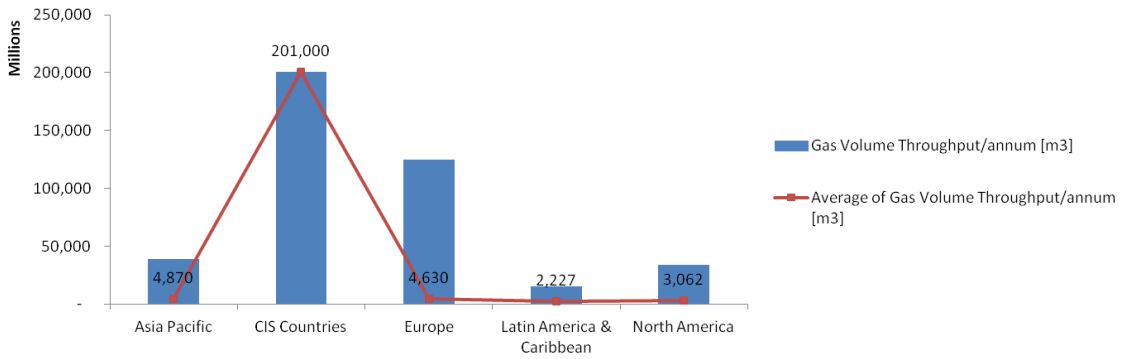


Figure 2 – Gas volume throughput (m3 pa)

Most of the respondents operate in liberalised markets. Of the 77% of the companies that operate in liberalised markets (totally or partially) all customers can choose their supplier. In only 25% of companies that operate in non-liberalised markets is there a national program to introduce liberalisation in the mid-term.

In a liberalised market the commercial relationship between shipper and distributor requires that discrepancies (UFG) have to be quantified.

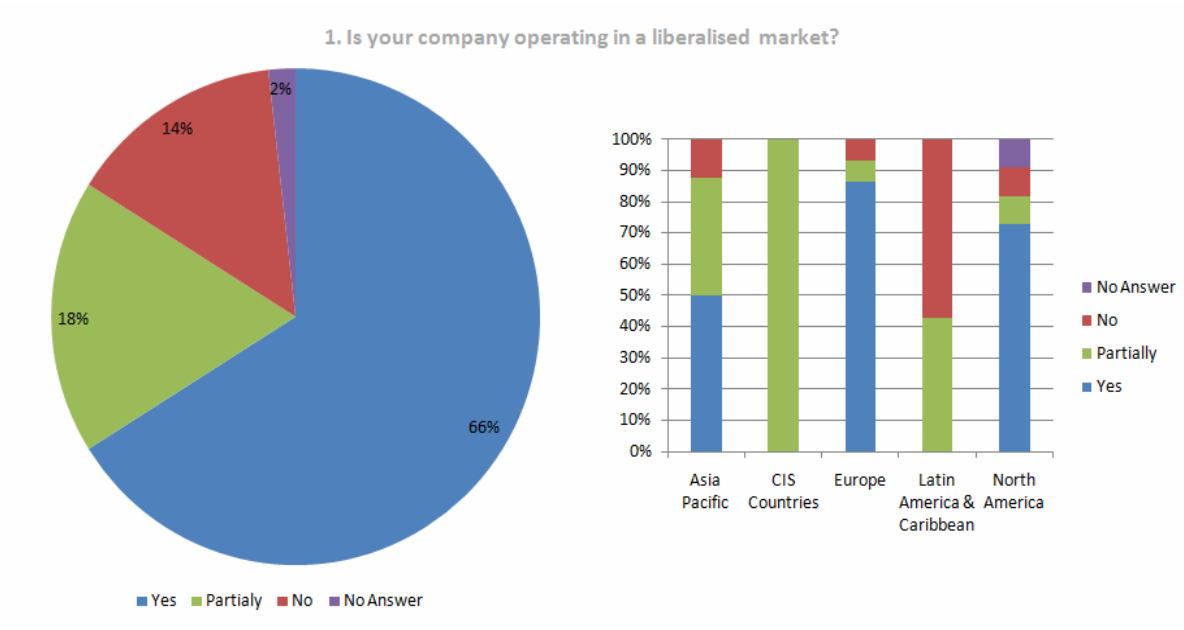


Figure 3 – Liberalised or non-liberalised markets

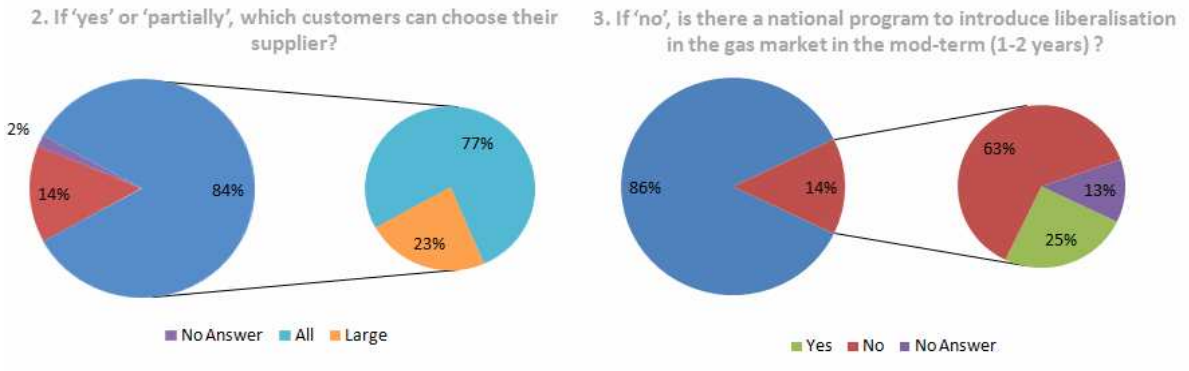


Figure 4 – Markets: other considerations

Half of the respondents are privately owned. The remainder is equally divided between public and mixed companies.

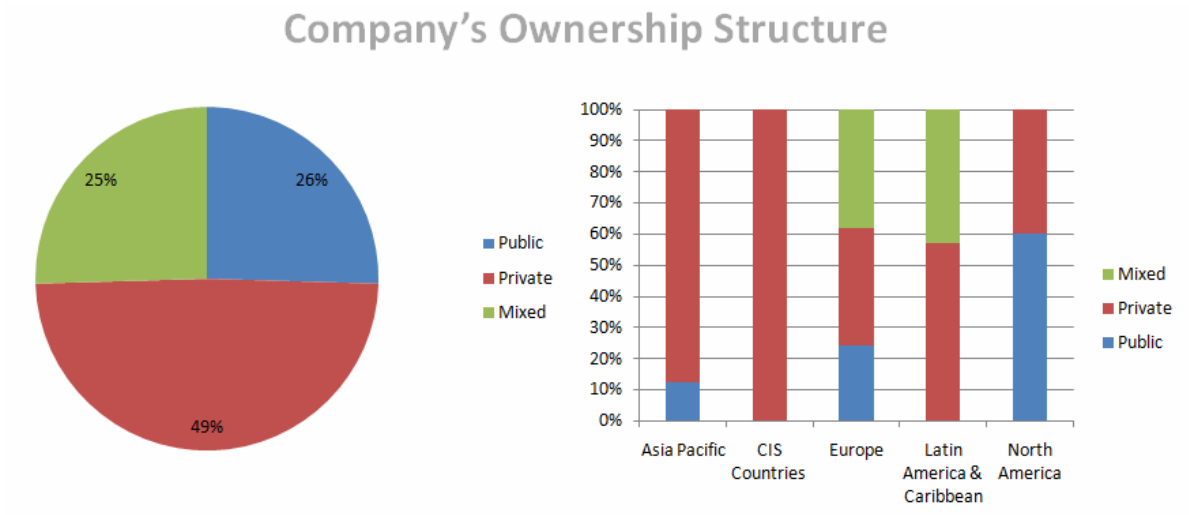


Figure 5 – Company ownership structure

The majority of the pipelines operated by respondents are made from polyethylene or coated steel, as shown below. Of those companies that operate cast iron mains or older, troublesome pipes, permanent leakage is still experienced.

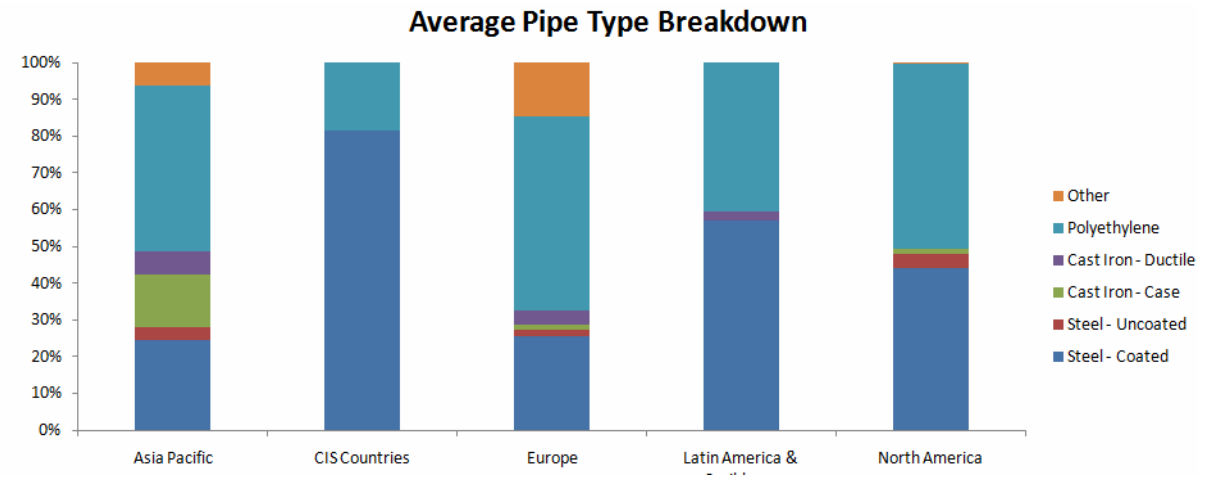


Figure 6 – Average pipe type

2 Results and Observations

2.1 Definition of UFG

Companies were asked if they agreed with the following definition of UFG:

> *UFG is the difference between gas entering a distribution system at the point of custody transfer and that which can be measured and billed at all delivery points over a defined period of time.*

There was broad agreement with this definition from respondent companies.

2.2 UFG components

There are many factors that contribute to UFG including errors in measurement, theft, gas balance connected to time lag and calorific value measurements, and gas consumption for own operations. UFG during own operations is the volume of gas used by the company to perform its own operations. Activities include purging, heating gas before/after pressure reduction stations, producing electricity and powering fluid for pneumatic actuators.

UFG can be caused by factors in network operations, the billing system and metering methods and equipment. Components that have been were identified and categorised are tabled below.

Category	UFG component
Network operations	Stock variation
	Leakage as a result of third party damage
	Permanent leaks from network (e.g. cast iron and valves)
	Leakage from client-owned piping upstream of meter
	Planned purging
	Other operational losses
Unbilled	Unauthorised consumption (theft)
	Own gas use
	Billing lag; unsynchronised billing for gas volume fluctuations
	Energy calculation and allocation to the consumption points
Metering	Meter inaccuracy
	Meter error from uncompensated temp/pressure
	Meter malfunction
	Missing meter readings
	Estimation methodology accuracy
	Incorrect meter reading
Custody transfer	Custody transfer reconciliation

Table 1 – UFG components

A complete picture of UFG through the distribution business is shown in the figure below.

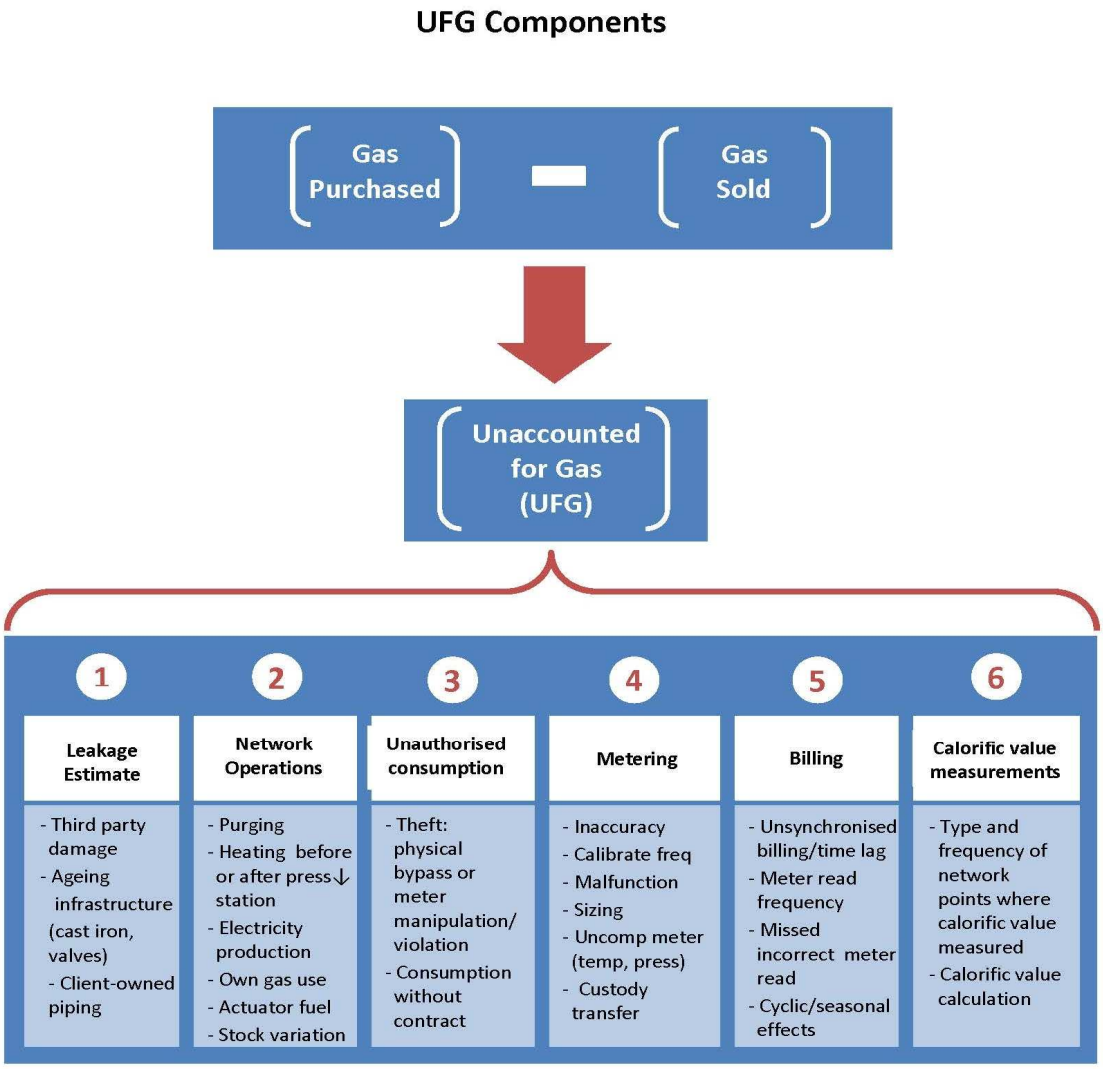
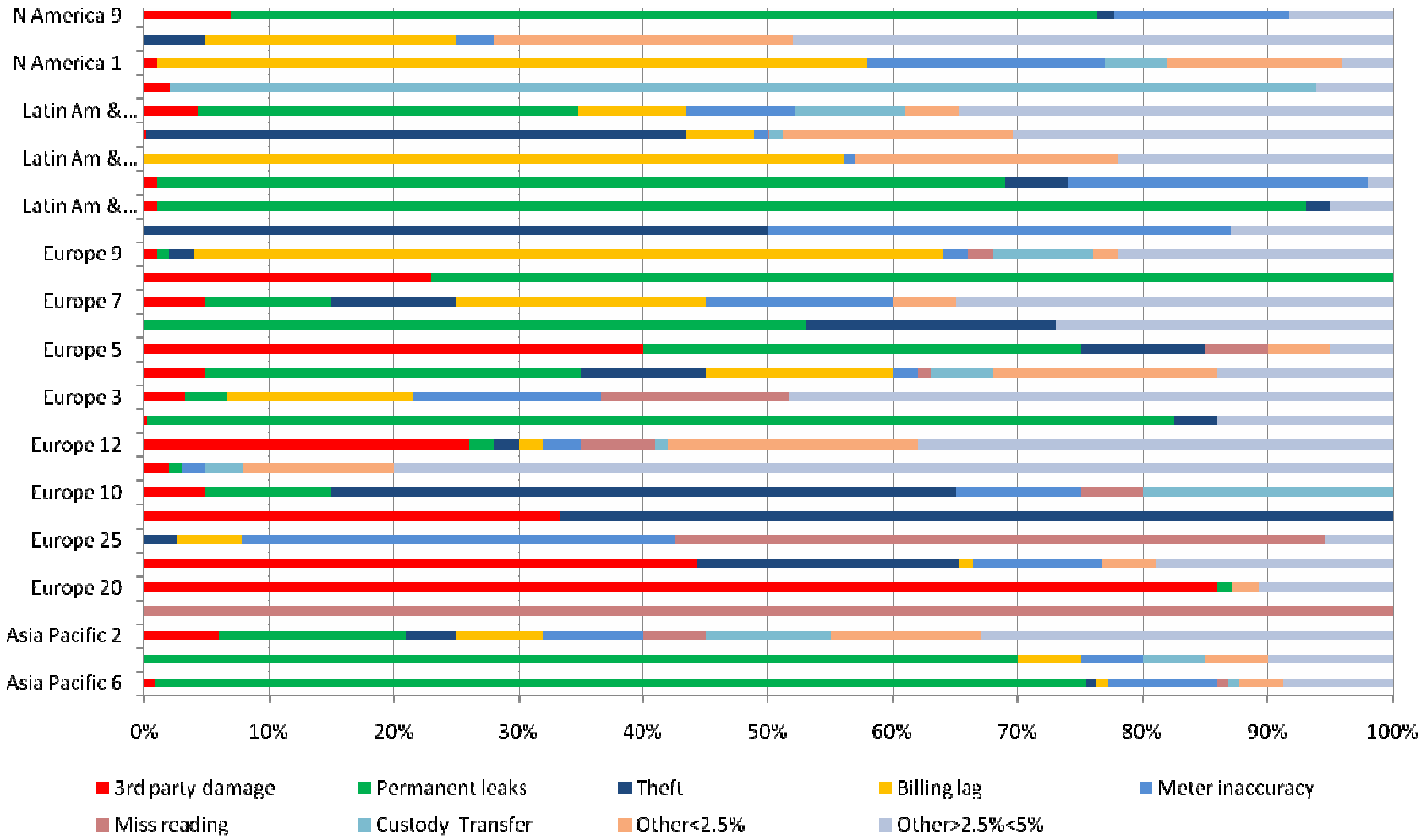


Figure 7 - UFG components throughout distribution business

2.3 Drivers to address UFG

Companies were asked to provide an estimate of what percentage each component contributes to their overall UFG, the results of which are shown below. It is clear that different companies experience a wide range of UFG issues; some have a range of causes whilst others have overriding single causes such as UFG in companies with cast iron mains being dominated by permanent leakage.



Other<2.5% = Stock Variation + Client pipe leaks + Energy calculation + Incorrect reading

Figure 8 – Breakdown of total UFG

Companies were asked to rank the top three most important factors that cause UFG and to list which UFG components are actively being addressed.

The top three drivers for addressing UFG are:

- leakage reduction:
- meter accuracy: and
- cost and efficiency.

However the most common factors being addressed are:

- leakage from third party damage and meter inaccuracy:
- leakage reduction (investigation of the data showed that leakage was an issue for companies that operate networks with significant lengths of older or troublesome prone materials such as cast iron): and
- theft.

UFG is not uniform across company models, regulatory regimes or countries, as evident by the range of UFG components experienced around the world, which includes the following examples of company experience:

- South America - majority cast iron mains, leaking 92% of UFG;
- South America - gas theft 67% of UFG;
- Europe - unsynchronised billing system 60% of UFG;
- Europe - 66% of unsold gas used for own operations; and
- North America - discrepancies in custody transfer meter readings with the gas transporter, 60% of UFG.

Almost 60% of respondents conduct research into reducing UFG, the most common topics being meter accuracy, leakage and theft. Although cost and efficiency are most important drivers for addressing UFG, they are not listed by any company as being a separate area of research. This is due to the fact that cost and efficiency are by-products of areas of research already in progress.

Six respondents conduct research into meter inaccuracy, which is consistent with its position as one of the most common drivers. Five respondents carry out research into leakage reduction. Research or studies into theft are listed by two respondents.

The list of topics being researched by respondents is provided below.

- meter accuracy, availability and temperature compensation;
- leakage, cast iron leakage and gas loss due to older mains and metering errors;
- theft;
- state reference calibration laboratory;
- funds contributed to the Gas Technology Institute on new product development;
- billing;

- measurement, overall system loss;
- custody transfer;
- network seasonal behaviour;
- decommissioning;
- purging during maintenance;
- smart meter with remote reading;
- technological losses;
- emergency emission;
- upgrading operational and calibration systems;
- monitoring customer areas; and
- best use of gas for own operations.

The rank of top UFG drivers, components, percentage UFG and topics being researched are tabled below.

	Rank			
Driver or UFG Component	**Most common UFG factor being addressed**	**Most important driver**	**Largest single UFG component**	**UFG topic being researched**
Meter accuracy	1	2		1
Leakage reduction	2	1	1 (cast iron) 97%	2
Cost and efficiency		3		
3rd party damage	1			
Illegal consumption	3		3 (67%)	3
Accuracy of CT meter			2 (90%)	

Table 2 – Rank of UFG drivers, components and topics being researched

Leakage reduction

The survey showed that leakage reduction is the most common driver for addressing UFG. Many countries around the world operate significant lengths of older metallic mains such as cast iron, in particular in North America and UK. Ageing of this material increases UFG as well as the risk of leakage arising from fractures potentially leading to explosions.

To cope with this, companies can renew or replace the network or model the pressure and/or condition the gas. The most effective way to reduce gas loss is by replacement, however this involves large amounts of capital expenditure. The most common type of material used for replacement is polyethylene.

Options to replace or adopt operational practices to reduce leakage are largely influenced by the regulatory regime in which the company operates – renewal of the network and pressure modelling or gas conditioning.

Renewal of the network - renewal is a complicated operation, as the network is already in operation with connected end-users, requiring significant investment. This consists of reducing the network pressure at off-peak periods of the day (such as during the night). In order to model the pressure the DSO must be able to change the pressure reducing station's set point in the mornings and evenings. This can be achieved with clocks placed in each station or by using a more sophisticated system that can be controlled remotely alongside a telecommunications process to communicate with field equipment.

Pressure modelling and gas conditioning - these are two ways of reducing leaks without carrying out major investment. It requires the introduction of liquid in the gas stream in order to raise the moisture content of the gas and keep the joints of the network hydrated. The liquid can be water or ethylene glycol. The points of injection of the liquid should guarantee that no accumulation of condensates takes place and that the moisturised gas reaches the joints to be treated. However there is the possibility that this treatment may not be compatible with some uses of the gas such as vehicle compressor stations.

In some countries the regulatory framework allows a maximum percentage of UFG leading operators to assess which of the above options allows compliance.

Meter accuracy

Although metering accuracy was listed as one of the top three drivers and one of the areas being addressed, only 11 respondents out of a total of 56 indicated that they were attempting to measure it, 20%.

The survey data shows that the allowable UFG is close to the technical uncertainty of current gas measurements - the average gas meters accuracy is 1.7%, the average UFG percentage allowed by regulators is 1.5% and the average accuracy of custody transfer meters between transport and distribution networks is 1.2%.

Although meter accuracy applies directly to gas volume measurement two other factors bring uncertainty to the estimation of gas consumption - the ability to take pressure/temperature conditions into consideration at meter locations and the fact that in most countries buying and selling gas and UFG evaluation are measured in energy, not volume (this raises the subject of accuracy of the calorific value of the gas applied at each delivery point).

Two thirds of WOC4 members are conducting programs to improve gas meter accuracy, reflecting the importance of this issue, even if not indicated as one the top three drivers to reduce UFG. 60% report that they have programs in place but only 15% select meter accuracy as one of the top three measures to address UFG.

Since meters are of capital importance to the determination of consumption their accuracy will always be of interest to the DSO, the consumer and the retailer in unbundled operations. This explains why so many respondents have reported that they have accuracy check and improvement programs in place

To improve the accuracy of meters, DSOs take the following measures:

- annual accuracy tests according to pre-defined criteria such as year of manufacture or brand/model;
- replacement programs according to year of manufacture (in some countries the replacement is mandatory after a defined period of use (such as 15 or 20 years) or as a result of accuracy tests; and
- annual calibration of important meters such as custody transfer meters for large consumption users.

Cost and efficiency

UFG is an important issue that can impact a company's market value.

DSOs are accountable for the gas received into their networks. Several indicators are used to measure performance, UFG being an important one. As an external benchmark tool, comparisons can be made with other companies and UFG used as an internal trend indicator of the behaviour of the company as a whole.

UFG can cause the DSO to incur financial compensation for gas loss, penalties from the regulator and taxes such as carbon tax, all of which take a toll on company results.

Dealing in a market where safety and reliability are very important a large UFG may be understood as a sign of poor operation practices, affecting the image of the company.

UFG component being researched	Frequency
Leakage as a result of third party damage	30%
Permanent leaks from network (cast iron/valves) Meter inaccuracy	29%
Unauthorised consumption (theft)	23%
Planned purging	16%
Custody transfer reconciliation Meter error from uncompensated temp/pressure	14%
Other operational losses	12%
Unbilled: Billing lag; unsynchronised billing for gas volume fluctuations	11%
Meter malfunction Missing meter readings Estimation methodology accuracy Incorrect meter reading Leakage from client-owned piping upstream of meter Own gas use Energy calculation and allocation to the consumption points Stock variation	1% or less

Table 3 – Top three UFG factors being addressed

2.4 Regulation and Carbon Tax

Most respondents do not have a maximum UFG set by the regulator (61%). Of those that do, it ranges between 0.24% and 5%.

In general, of the companies with a regulator-set maximum allowable UFG, the company is accountable for UFG amounts greater than the maximum set and can benefit if it is below.

Only 23% of respondents that operate in a country with a carbon tax or reduction scheme state that this has influenced their UFG management. The main drivers to reduce methane emissions are compliance with company policy and national/international obligations to reduce airborne contaminants and greenhouse gases (GHG). Carbon trading is ranked high as a driver to address UFG only in countries with a carbon tax or trading scheme, but is of interest to DSOs in other countries due to the implications of future tax/trading schemes.

Inventories of GHG emission sources made in Canada in 2009 found that emissions from gas distribution occurred mostly from flaring, which is largely manageable (compared to stationary combustion, venting and fugitive gas loss). Similarly, studies in Russia reveal that vent stacks contribute 83% of gas emissions from distribution systems, which are largely manageable.

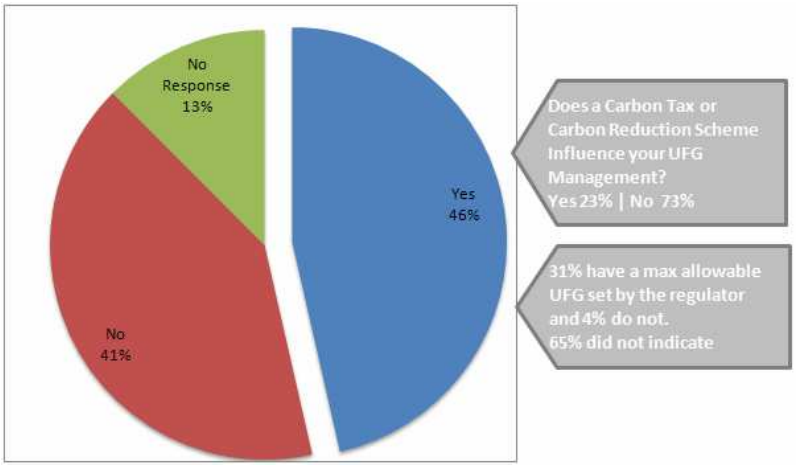


Figure 9 – Carbon reduction scheme and UFG

2.5 UFG Measurement

For UFG from third party damage, the most common method of estimation was the use of a gas loss calculator based on data such as diameter, hole size, pressure and duration of leak.

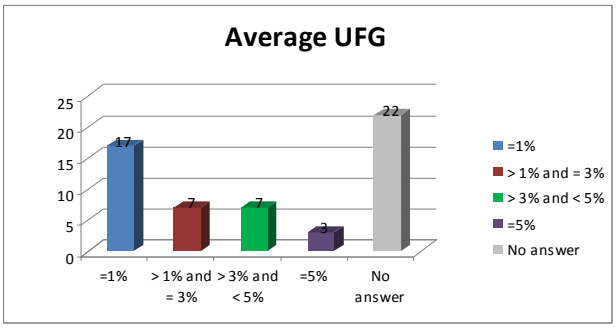
The method of measurement of gas loss from theft was less clear – some respondents utilise usage patterns to identify theft whilst others use theoretical calculations. It is clear that whilst theft is a main concern, it is difficult to address or measure.

Where a method was listed for meter inaccuracy, the most common response was statistical sampling. The methods listed for the measurement of UFG from permanent leaks were results from a sampling test program or applying an average-sized leak to the number of known escapes.

The figures in this section include only data for which there were responses.

The average UFG is 1.53%.

UFG is monitored by volume by 84% and by energy by 65% of the respondents. A smaller number of respondents utilise both methods.



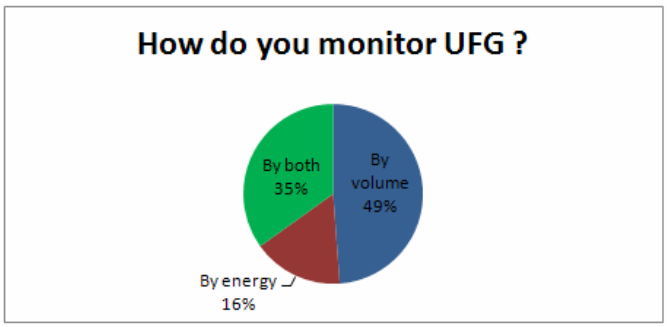


Figure 10 – Average UFG

Figure 11 – Average UFG

The majority of respondents do not experience change in UFG. For those that do (39%) UFG is increasing.

The main reasons for UFG decrease are pipe replacement and meter replacement. This reflects the fact that safety is the main concern for gas leaks and something that is often directed by the regulator.

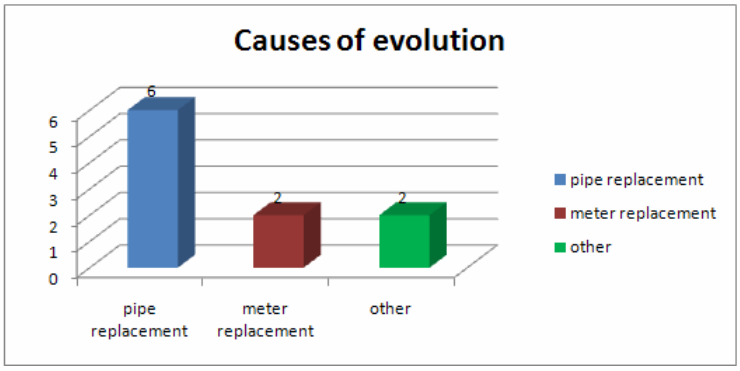


Figure 12 – Causes of UFG evolution

The majority of respondents do not experience seasonal effects on their UFG levels. For those that do (12%) the main solution is to look at UFG on an annual basis, not monthly.

2.6 Operations

The majority of respondents do not take stock variation into account when calculating UFG. In some instances however stock variation is taken into account but this is mostly in the case of new mains and high pressure pipelines.

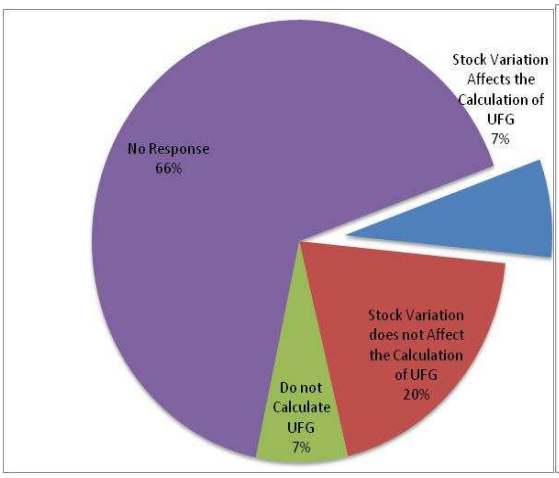


Figure 13 – Effect of stock variation on UFG

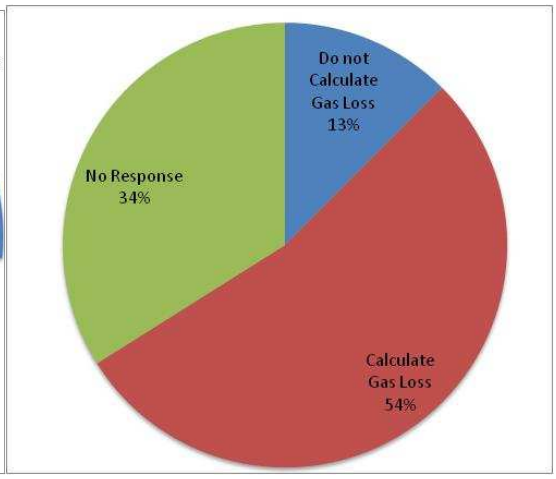


Figure 14 – Calculation of gas lost from own ops/ third party damage

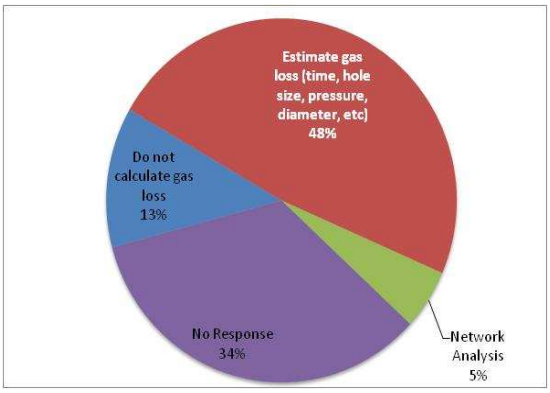


Figure 15 – Calculation method used to estimate lost volume

Over half the respondents indicated that they do calculate the volume of gas lost from operations and third party damages. The majority of these companies estimate the volume of gas lost based on the duration of gas leak, the size of the hole and the pressure and diameter of the pipeline.

Of the respondents that did answer the question of how they recover the gas value and other costs from such gas leakage from unintentional damage, approximately 60% seek to recover costs from the responsible party. 40% of respondents do not recover the cost of lost gas from unintentional damage leakage.

Discussions within the study group revealed that in general cost recovery is not the primary concern when addressing third party damage and leaked gas. Rather, respondents that attempt to recover these costs are more interested in encouraging damage prevention in the future.

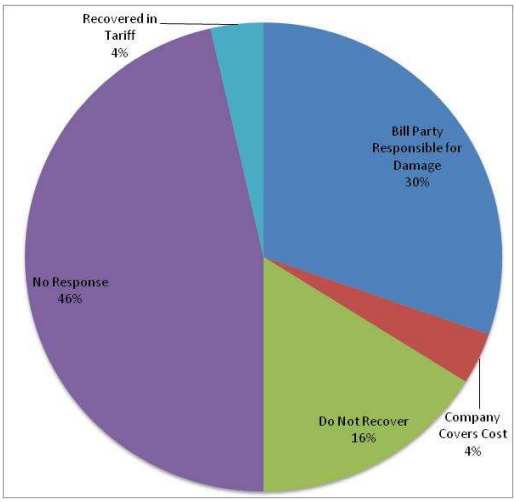


Figure 16 – Cost recovery from damages

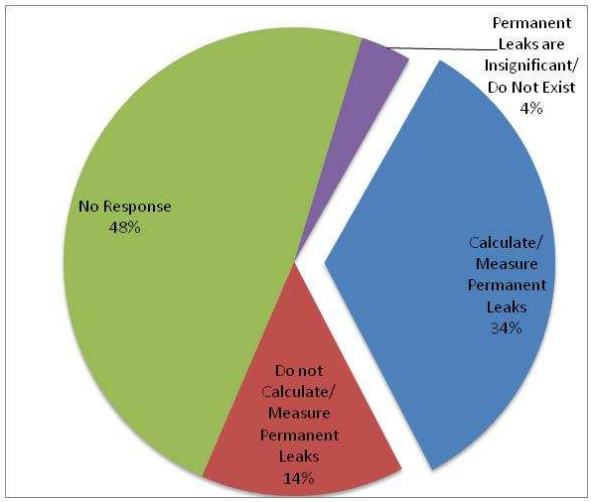


Figure 17 – Measurement of permanent leaks

Approximately one third of the companies do calculate or measure permanent leaks on their distribution systems. There are two main approaches adopted:

- calculation using emission factors that are based on the different distribution system components; or
- independent calculation that takes into account the material of the pipe and any appurtenances on the pipe (such as joints and attachments).

When asked how they manage the problem of permanent leaks, 73% of respondents either did not answer or stated that they do not have a problem with permanent leaks. These companies have newer networks or have conducted replacement programs.

Of the companies that stated they do experience UFG caused by permanent leakage, most have a leak survey program in operation to identify and monitor problem areas in the distribution system. As cast iron pipelines are a large contributor to permanent leaks, all companies with this material are in the process of replacing it.

Safety is the main driver for replacement of pipes that leak or other system components.

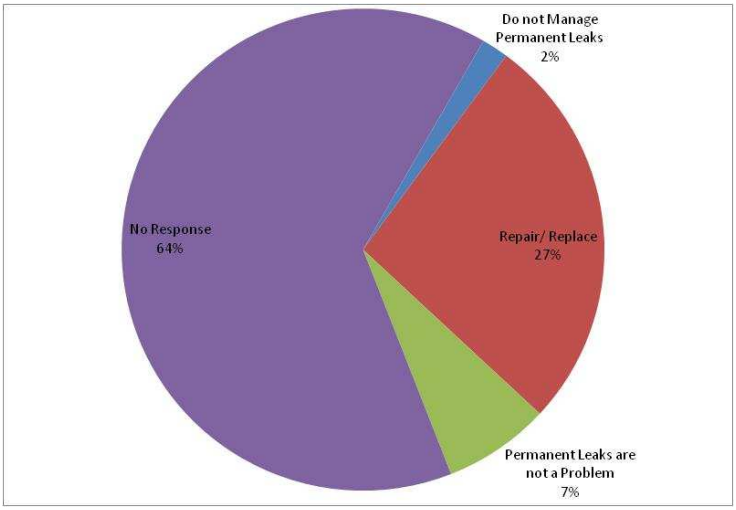


Figure 18 – Management of permanent leaks

A majority of respondents do not adopt default methods for calculating emissions due to carbon trading. Of the 13% of companies that indicated they do, there is no single common method, however all methods are adopted from a gas/pipeline organisation or through independent research.

Only 16% of respondents have piping owned by the client upstream of the meter. Of these, over half retain the responsibility for gas loss due to leaks from client-owned piping.

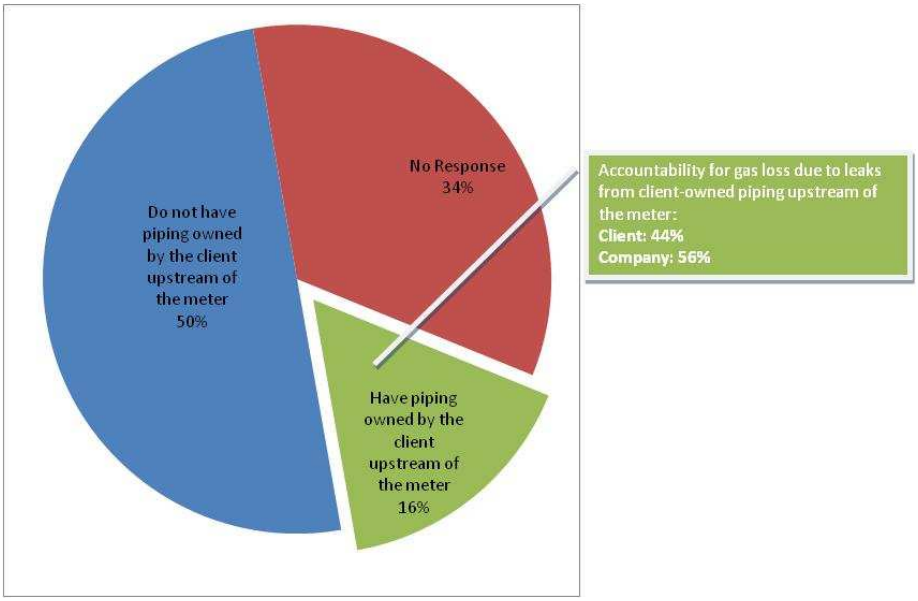


Figure 19 – Piping owned by client upstream of meters

Of the companies surveyed, 36% use a method to reduce the need for purging and gas lost during purging and 18% do not have a method. Two methods commonly used to reduce gas lost during purging are reducing the pressure in the line and using the minimum safe purging volume (for example a hot tap procedure).

21% of respondents calculate or estimate the volume of gas lost through purging activities, most commonly by using simulation software and theoretical calculation using pipe pressure, diameter and length as well as the time to purge. 13% of respondents do not calculate gas lost during purging.

Only 5% of companies identified operational losses in addition to those outlined above. Examples of these losses include meter installations and replacements, natural gas vehicles and testing relief valves.

2.7 Gas theft, own consumption, gas balance and billing

This section of the report shows survey results in relation to gas theft, own consumption, errors in gas balance and calorific value billing. It includes the ways that these factors can impact UFG and an outline of the most common practices to control them.

Theft

Theft is a large contributor to UFG for some respondents and is typically a hidden activity that can present serious difficulties for its identification and control. In addition there are

asset integrity risks associated to any gas theft activity as damage to meters and pipe is often inflicted.

Almost half of the respondents confirmed that they have a method in place to estimate gas loss from theft. The most common methods of theft identified are: physical bypass, meter manipulation/violation and consumption without a contract.

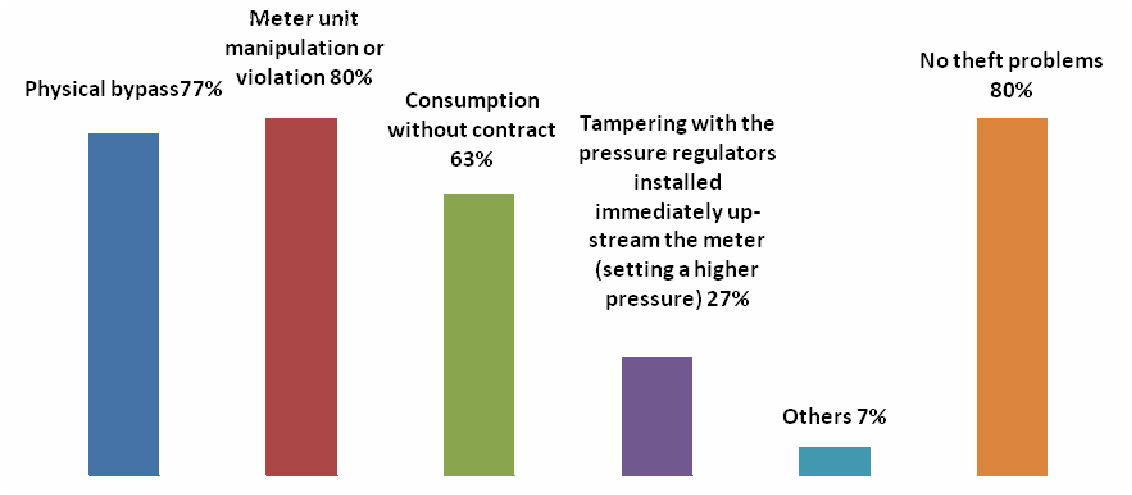


Figure 20 – Frequency and method of gas theft

Similarly, just over half of the respondents employ methods to prevent theft. Methods are similar between companies and can be categorised as follows:

- Use of seals or locks on the meter. Secure the gas meter by installing a cover or steel houses.
- Use of sensors, cameras or security surveillance of all areas, whether meters are fixed or not.
- Act on third party reports and install a public information line for whistle blowing.
- Frequent meter readings and inspection or random inspection and field operational reports, with trained operations staff.
- Disconnect the service line if the client has no supplier/shipper, or remove meter.
- Monitor the network to identify anomalies in consumption. Monitor UFG.
- Monitor client's average monthly consumption to identify anomalies or monitor EVC data consumption, especially zero flow trending.
- Estimate consumption based on customers appliances and compare with actual meter readings.
- Use of radio-frequency meters with operations staff training.
- Meter exchange programs.

Participants were asked if they seek to recover the cost of gas loss and damage caused by theft. Some respondents reported that gas theft is not an issue, however almost half the companies that responded to this question informed that they always pursue cost recovery via legal action.

Gas consumption for own operations

Another cause of UGF is the volume of gas used by operators for their own activities. These activities include purging, heating gas before/after pressure reducing stations, producing electricity and power fluid for pneumatic actuators.

Metering is the most common method to calculate gas consumed for heating before and after pressure reducing stations, for producing electricity and for heating operations facilities. The second one is estimation. It was reported in some cases the Operators do not calculate gas used for their own purposes. The gas used for purging is either estimated or not calculated. The volume of gas used as power fluid in valves actuators is commonly estimated. An interesting observation about this usage is that the majority of respondents do not use this kind of valve.

Errors in Gas Balance

Differences between the amount of gas purchased and sold are closely related to the frequency that meters are read. The less often customers' meters are read, the larger the difference between the gas purchased and sold - this term is known as "time lag".

Approximately 40% of respondents do utilise a methodology to calculate errors caused by time lag.

Some respondents reported that there is a cyclic/seasonal impact on the gas balance but did not specify any method used to minimise this error. Answers from participants were very similar and all respondents claimed that some kind of historical/statistical model is used to minimise cyclic/seasonal errors.

The survey explored the relationship between meter reading frequencies and time lag per customer segment; industrial, commercial and residential.

Industrial

Most respondents reported that industrial meters are read every hour. 30% of respondents read industrial meters on a monthly basis. One of the companies reads industrial meters both once per hour and once per day.

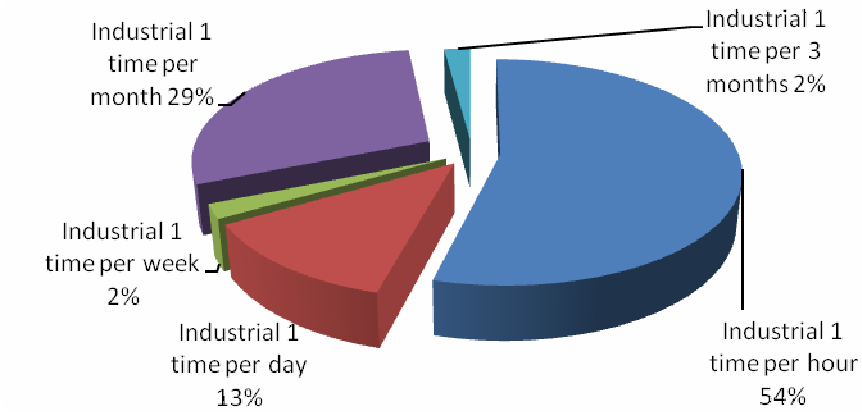


Figure 21 – Frequency of meter reading - industrial

Commercial

70% of the companies that responded this question measure commercial gas consumption once per month.

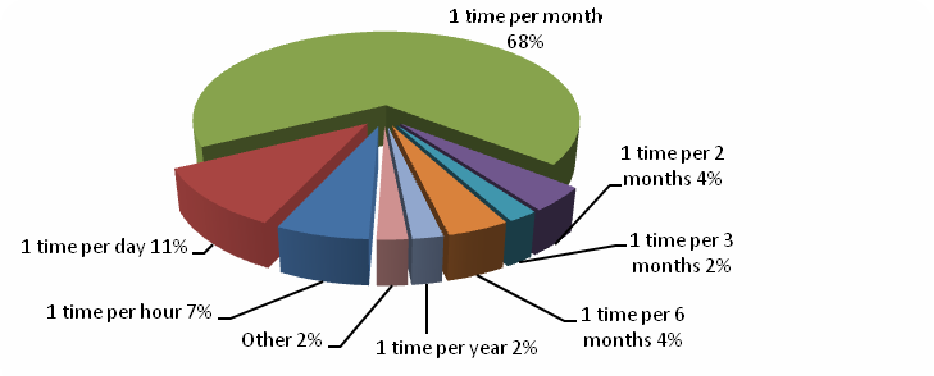


Figure 22 – Frequency of meter reading - commercial

Residential

60% of respondents measure residential meters once per month or once every two months. One quarter of respondents measure residential meters only once a year.

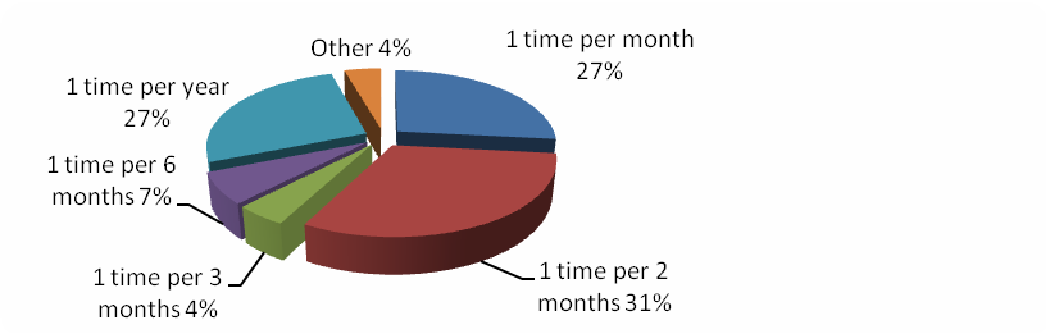


Figure 23 – Frequency of meter reading - residential

Calorific value

In some places gas customers are billed on the energy they use and not volume of gas. Energy is typically calculated by multiplying the metered amount of gas by factors including calorific value of the gas. It is therefore important to know the calorific value of the gas supplied. Participants were asked at which points of their networks they measure calorific values.

The most common points of calorific value measurement are city gates and delivery points. Some operators do not measure calorific value and some use values provided by gas suppliers.

Almost 30% of respondents measure calorific values at delivery point of large or important customers.55% of respondents calculate the calorific value average based on the relative weight of each source of gas.

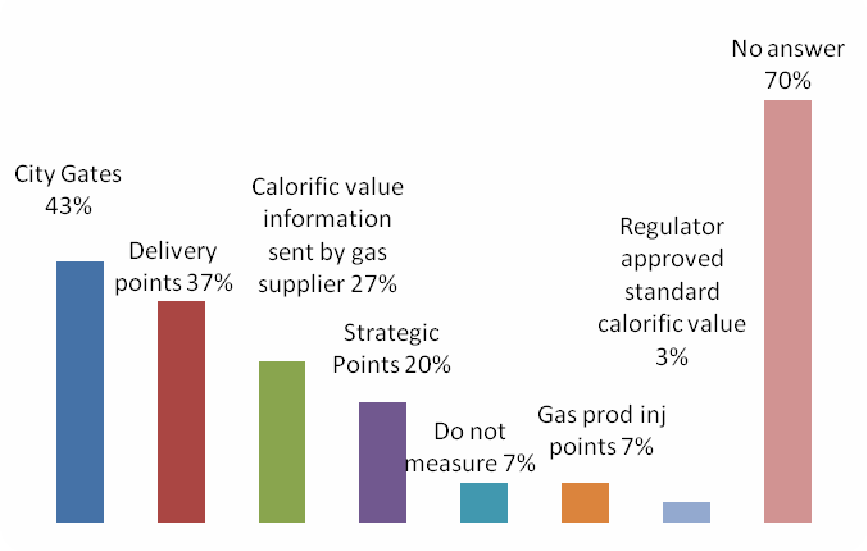


Figure 24 – Points of calorific value measurement

2.8 Metering

WOC4 member companies were asked several questions relating to metering accuracy as this can have a significant impact on UFG.

The diagram below shows how the acceptable level of meter accuracy varies between residential, commercial and industrial meters. For both residential and commercial meter types, the greatest number of responses fell into the category between 1% and 2%. For industrial meters, although the greatest number of responses also fell into the 1-2% category, there was a similar number of responses within the 0-1% category, showing that the acceptable level of meter accuracy on industrial meters is likely to be more stringent than that for commercial or domestic meters.

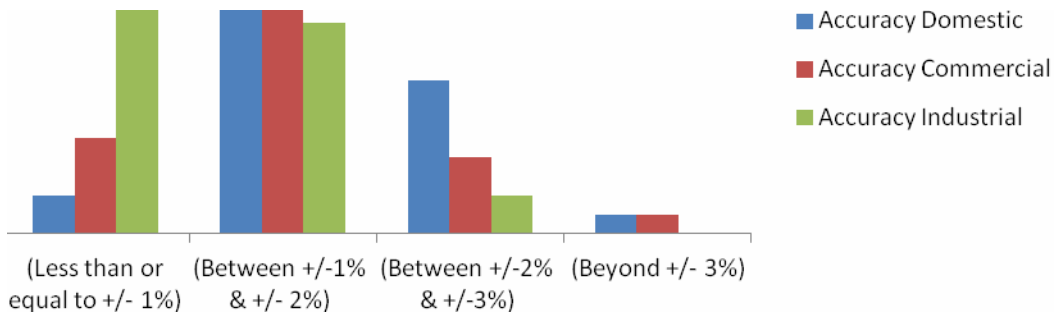


Figure 25 – Acceptable meter accuracy

In response to being asked if an external authority influences meter accuracy, almost all respondents commented that authorities *do* influence how they manage meter accuracy. However around 35% do not have any program to improve the average accuracy.

When asked about schemes which do improve accuracy, companies provided responses on the frequency of meter calibration, for domestic/commercial and industrial meters. This is shown in the graph below. There is no obvious pattern between responses, but about 40 % of respondents do use a verification system based on statistical methods with sampling inspections.

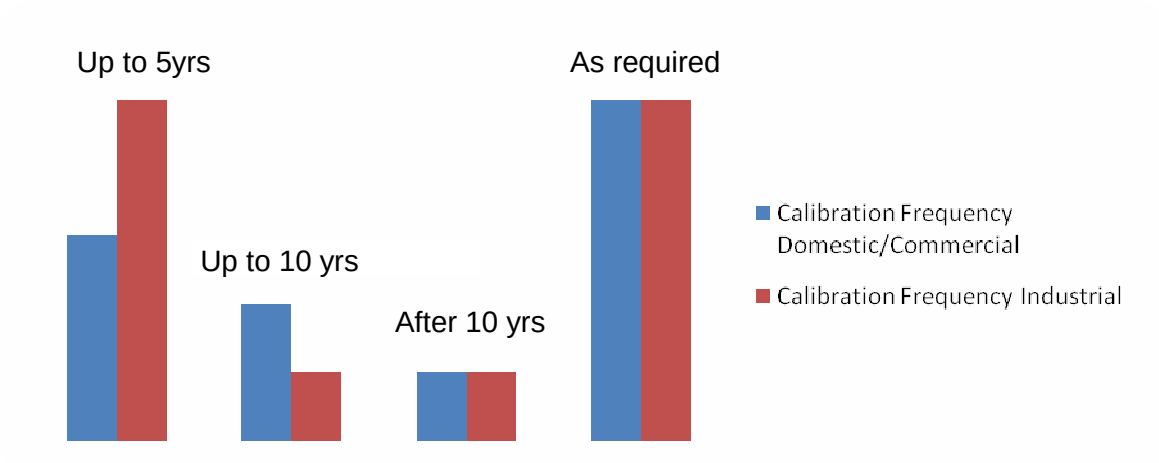


Figure 26 – Programs to improve average accuracy of meters

For respondents who do not currently have a programme to improve meter accuracy, about 46% are planning to implement a program in the next five to ten years.

In response to being asked how companies minimise inaccuracy when sizing meters for a consumer with varying demand, a number of approaches were listed, as shown in the figure below. Around 40% of respondents prefer to select the size of their meters based on a wide range of measurement (high turn-down ratio) with reasonable acceptable accuracy.

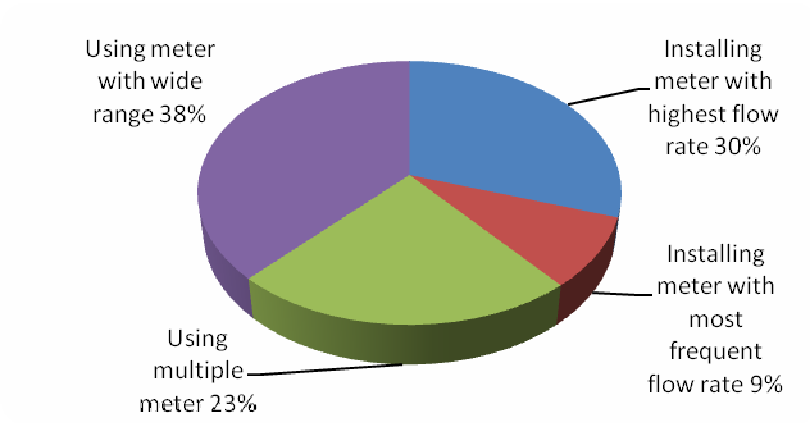


Figure 27 – Sizing meters for customers with varying demand

Around 40% of respondents have confirmed that more than 90% of their residential meters are installed within the building to minimise the effects of ambient temperature. In contrast, it has also been noticed that more than 30% of companies have less than 10% residential meters installed within the building.

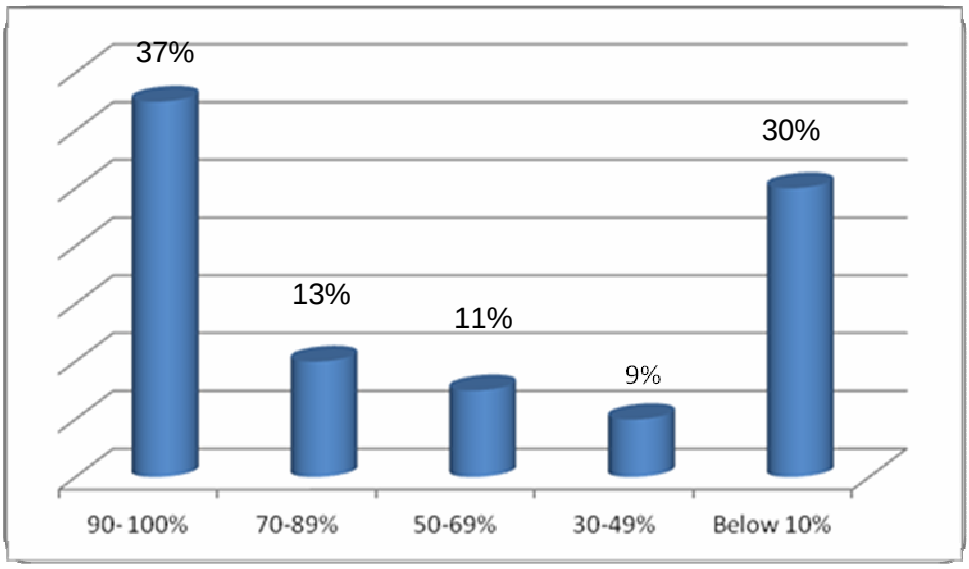


Figure 28 – Percentage of company meters inside buildings

The following graph shows the responses regarding the percentage of consumers with compensated meters. Most of the respondents confirmed that more than 80% of their industrial meters are compensated, whereas less than 10% of their residential meters are compensated.

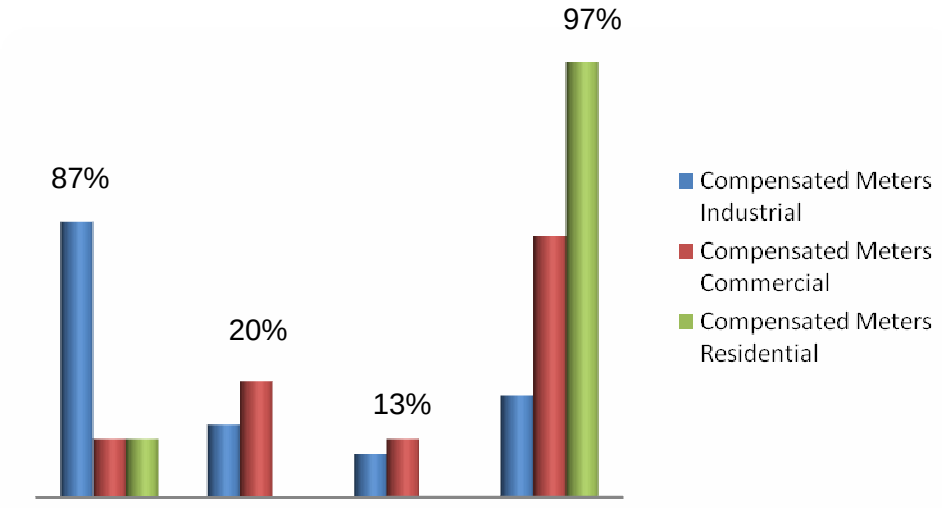


Figure 29 – Percentage of consumers with compensated meters

In response to being asked to estimate the percentages of total gas distributed through compensated meters, for different types of consumer, the following responses were collated:

- Industrial 60 %

- Commercial 20 %
- Residential 20 %

Respondents were ask to list what are the conditions of gas measurement assumed when there is no compensation and if it varies with the part of the country (colder or warmer), or with the season (summer/winter).

There were many different answers for this question. The value of correction factors depends on many variables and it is not possible to identify any simple correlation between companies.

For instances when gas companies use a correction factor, the following figure shows those who were listed as being included. Around 25% use gas pressure and temperature only for calculating the correction factor. However 17% use all factors (outside temperature, gas pressure, gas temperature and barometric pressure) for calculating the correction factor.

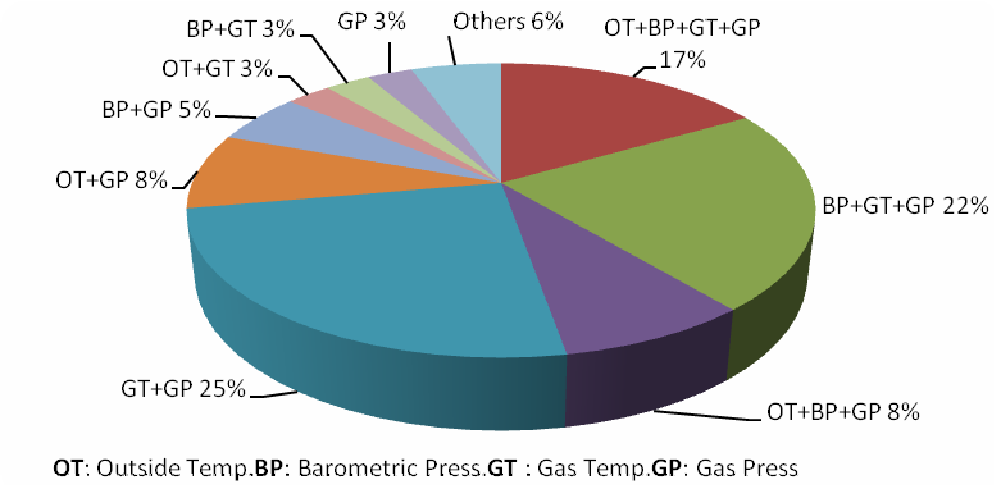


Figure 30 – Factors considered for correction factor calculation

Most respondents average temperatures either monthly or yearly.

More than 70 % of respondents use pressure regulators upstream of each meter, out of which more than 58% confirm that they have a regulated methodology for pressure regulation, either internally controlled (60%) or controlled by an external authority.

More than 90% of the respondents replied that they monitor meters that do not read any consumption.

In response to being asked how they identify meters which do not read any consumption, around 90 % of companies responded that they get an indication of meter malfunction by either zero consumption or abnormally low/high consumption

The following graph shows the split in differing methods of meter reading across respondents. More than 50% obtain meter readings by utilising staff or contract agencies. At present, only 6% replied that they are using smart metering for this purpose.

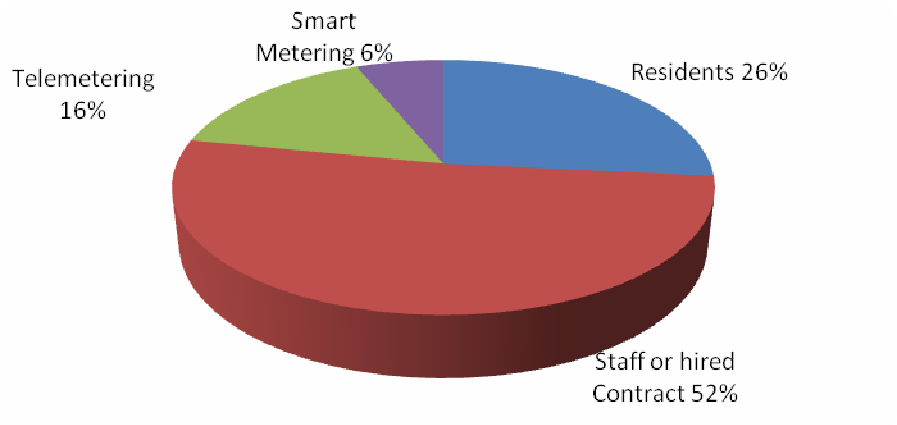


Figure 31– Method to obtain meter readings

Respondents were asked to list their most common reasons for missed meter readings and what measures they were taking to mitigate against these.

Reasons for missed readings include being unable to access the meter(52% of respondents).Remote meter readings (through telemetering or smart metering) are efficient ways to mitigate against this.

Other reasons include operational staff failing to make a visit, staff being unable to locate the meter and the meter not being registered.

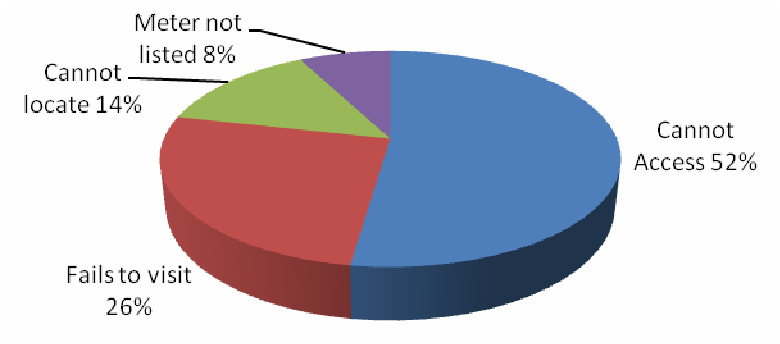


Figure 32 – Reason for missed meter reading

In terms of other mitigation measures, there were many different actions listed to manage/mitigate problems with meter readings. In cases where the meter could not be accessed, billing based on estimated values and notification to the customer are the most common actions. When the person fails to visit the meter, there are two common actions: training and revisiting. For the situation where the customer or meter reader could not find the meter, more information is sent to the reader. Meters not listed on the register are included when discovered.

In response to being asked what KPIs are set for meter reading, the responses were all very similar. The most common responses were percentage of missed readings, percentage of billing error, percentage of readings made/readings scheduled, and readings per day.

In general, the acceptable period between consecutive readings of each meter varied according to the size of the customer as shown below:

- Residential Up to 1 year
- Commercial Between 1 and 2 months
- Industrial Up to 1 month

In terms of estimating readings, most respondents use historical data to estimate the billed quantity when a meter reading is missed. The most common method is averaging the previous three months' consumption.

More than 90% of respondents use the typical consumption pattern when calculating missed meter reading gas volumes.

More than 60% of companies adjust profiles for weather or temperature.

The most common answer to the question regarding how much of the total gas volume is affected by estimated readings is up to 10% of the total gas sold.

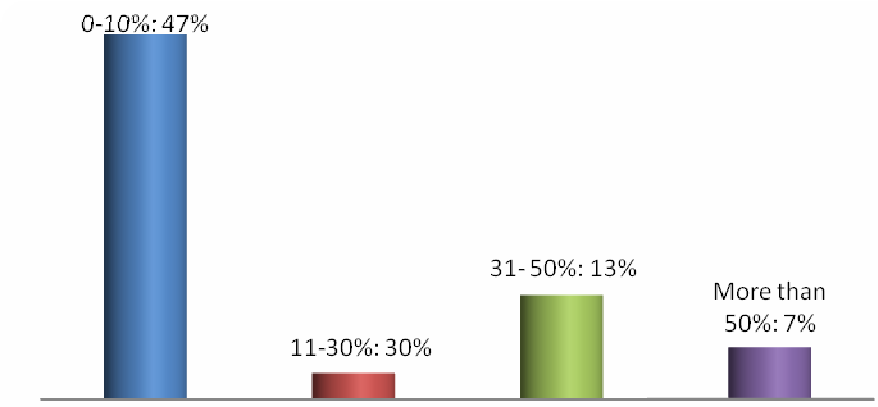


Figure 33 – Percentage of total gas volume estimated with profiles

Companies were asked how they become aware of incorrect meter readings. A variety of different responses were recorded, shown in the figure below. Around 40% of respondents get information either through their own software, customer complaints or through audits.

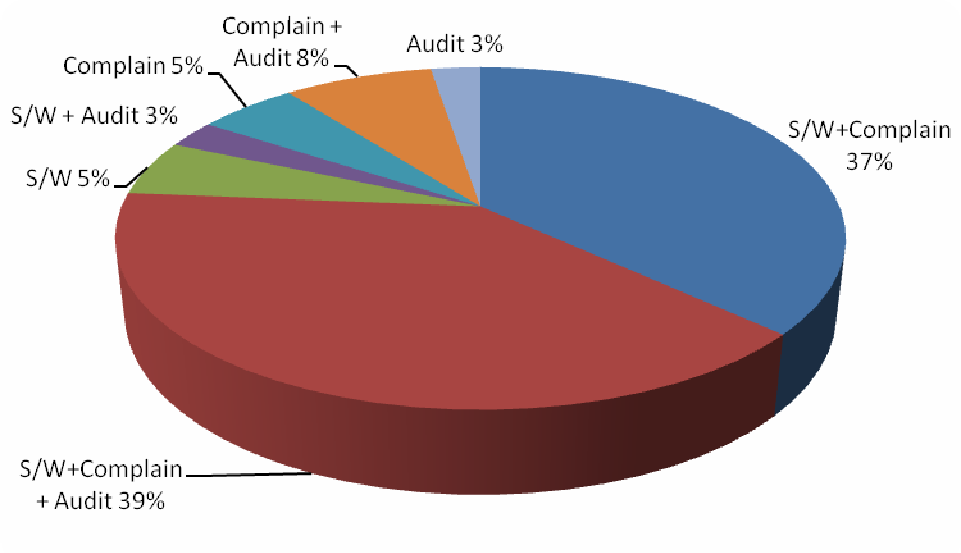


Figure 34 – Awareness of incorrect meter readings

Case study – residential meter testing by Dong Energy, Denmark

Purpose

The purpose of the system is to ensure that the consumptions included in the basis of the settlements sent to the customers have got a satisfactory quality and meet the tolerances in the delivery terms. The system is based on a division of the stock of meters into inspection lots consisting of similar meters.

By using periodical sample surveys of the inspection lots the quality of the meters is monitored. The plan for the random sampling is drawn according to the standard DS/ISO 2559.

The sampling is randomly drawn from the inspection lot. Therefore it is likely that the error rate in a meter lot does not exceed a fixed limit, AQL (Acceptable Quality Limit) = 4%
If the sample indicates that the quality is not acceptable the inspection lot is dismantled.

The running of the system aims at ensuring that the meters included meet the fixed tolerances to a reasonable extent.

Inspection lot

An inspection lot must consist of a maximum of 5000 meters. Small inspection lots of the same manufacture can be added into one inspection lot. However the difference in purchase year must not exceed 3 years. Meters of the same manufacture, type and three actual purchase years in a row can be added into one inspection lot.

The age of the inspection lot is determined from the purchase year which is also the initial operation year.

As regards meter lots bought over several years the second year is chosen as the nominal purchase year.

Meters from an inspection lot which are reinstalled after having been dismantled (for example as part of a random sampling) will be included in the inspection lot again. However the meters have to meet the requirement for accuracy for new meters.

Identification of inspection lots

Each inspection lot is given a unique description consisting of:

i) Unique title

ii) Time of latest ordinary test and the result

iii) Time of the next test.

Individual meters in the inspection lot must be statistically available so that the individual meters in the inspection lot can be drawn as a simple random selection.

Test log

A test log is prepared for each inspection lot. The log is updated with each ordinary and renewed test.

For each test the log must include the following:

i) identification of all meters included in the test;

ii) results of the technical evaluation and Qmin functional tests of individual meters; and

iii) results of measuring technical tests of individual meters in the sample.

Test frequency and approval of inspection lots

An inspection log is controlled by random sampling with ordinary tests with a maximum interval of 5 years.

When an ordinary test results in a measuring technical approval of an inspection lot this is considered approved and the meters can remain in use until the end of the next ordinary test of the inspection lot - this means in the next 5 year period.

If the ordinary test shows that an inspection lot cannot be approved, the meter lot must be dismantled.

The dismantling must be finished no later than the second year after the ordinary test has been started. The dismantled meters are disposed of without individual test.

Sampling and treatment of the samples

The sample drawn out is used for 2 purposes, the ordinary technical evaluation of the inspection lot and a measuring technical control, including evaluation of the error indication of the meters.

The measuring technical control is aimed at meters which are in normal condition. Meters which have functional defects are not included in the measuring technical sample.

The basis for a sampling is an inspection lot. A sample is drawn out from the inspection lot in accordance with test regulations.

Inspection lots with fewer than 1000 meters, the measuring technical sample must consist of 32 meters. If the inspection lot consists of 1000 to 5000 meters, the measuring technical sample must consist of 50 meters.

Meters which are included in the inspection lot must be drawn out for sampling with a simple random selection from the inspection lot. All meters must have the same probability of being included into the sample.

A list is prepared for the meters drawn out for the sample. The list must contain a unique identification of the meters so that the meters can be traced back to the inspection lot.

Technical evaluation and Qmin functional test

Before the sample is submitted for accuracy control, the individual meters must be inspected for functional ability.

This technical inspection includes, in particular:

- the condition of the sealing;
- marks from impacts or transport damage;
- exterior leaks;
- defected index; and
- index has marks or shows signs.

Meters which are not able to function and which have been exposed to deliberate overload, vandalism or similar are described "technical defective". These meters are not part of the measuring technical sample.

The remaining meters in the sample are functional tested at Qmin. The test consists of detecting whether the meter registers consumptions at this flow.

Meters which do not register consumption at this flow are described "Qmin defect". These meters are not part of the measuring technical sample.

Measuring technical control

The meters in the measuring technical sample are calibrated at two flows. The calibration must be carried out as an accredited calibration.

Flows are selected with one flow in each of the two areas:

i) $0.1\ Q_{max}$ - $0.3\ Q_{max}$

ii) $0.7\ Q_{max}$ - $0.1\ Q_{max}$

For each meter, the error level and error variation are calculated with the expressions:

$$\text{error level } X_1 = \frac{1}{2}(F_1 + F_2)$$

and

$$\text{error variation } X_2 = \frac{1}{2}(F_1 - F_2)$$

F1 and F2 indicate the errors found in connection with the calibration in % of the nominal volume for flows i) and ii) respectively.

Approval criteria

<u>Error level and error variation</u>

The values of error level and error variation found in connection with the calibration are used for an evaluation of the measuring technical capabilities, particularly for evaluating whether the inspection lot can be approved or not.

The approval criteria are based on an acceptable tolerance of + 3% for error level as well as error variation.

The company can chose between an approval criterion based on a simple counting of the number of meters exceeding the tolerance in the measuring technical sample or a statistical calculation of the estimated number of meters in the inspection lot exceeding these tolerances, calculated from the measured values in the measuring technical sample.

Approval based on the number of meters with exceeded tolerance

For the measuring technical sample the following are determined:

i) Number of meters with an error level exceeding the acceptable tolerance.

ii) Number of meters with an error variation exceeding the acceptable tolerance.

For a measuring technical sample of 32 meters the number of meters allowed to exceed the tolerance is two, and for a measuring technical sample of 50 meters the number of meters allowed to exceed the tolerance is three.

If the number of meters with an error level exceeding the acceptable tolerance as a maximum is equal to the numbers allowed, the inspection lot is considered level approved.

If the number of meters with an error variation exceeding the acceptable tolerance as a maximum is equal to the numbers allowed, the inspection lot is considered variation approved.

Approval based on statistical adjustment

This approval criterion is based on a homogeneous sample. At the outset, it must therefore be examined to determine whether the sample contains allocation deviators. This is carried out for error level (X1) as well as (X2). For a measuring technical sample of 32 meters, up to two allocation deviators can be left out, and for a measuring technical sample of 50 meters, up to two allocation deviators can be left out.

If the number of allocation deviators for error level or error variation exceeds the number allowed, the approval criterion described in this section (approval based on statistical adjustment) cannot be used. The criterion described in the previous section (approval based on the number of meters with exceeded tolerance)must be used instead.

If the number of allocation deviators (for error level or error variation) does not exceed the number allowed, the average (xm) and the deviation (s) for the non-deviating recording in the sample are determined.

The value of the average (xm) and the deviation (s) of the non-deviating records are drawn at the graph shown in Figure A corresponding to the used sample size and the relevant acceptable tolerance.

If the drawn point (xm, s) for the error level of the sample lies within the approval area, the inspection lot is considered as level approved. If the drawn point (xm, s) for the error variation of the sample lies within the approval area, the inspection lot is considered as variation approved.

Measuring technical approval

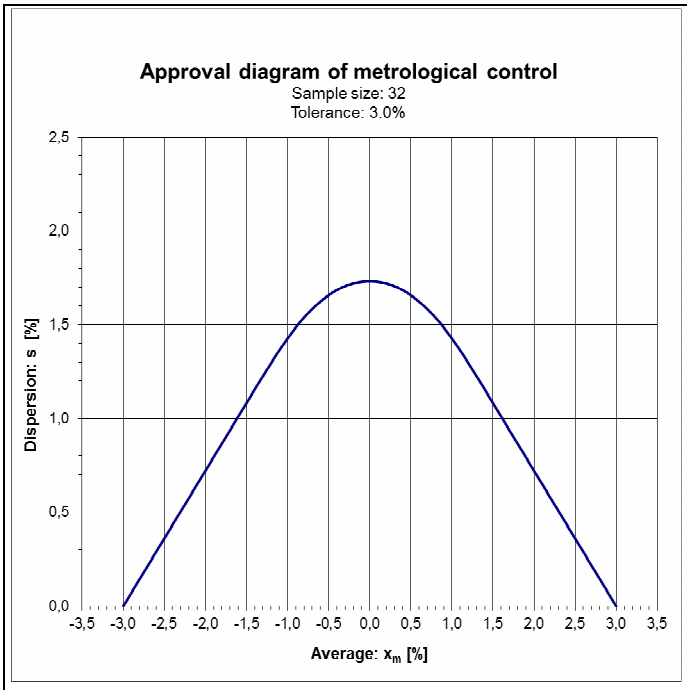
An inspection lot which does not fulfil the requirement is not classed as technically approved.

Conclusions

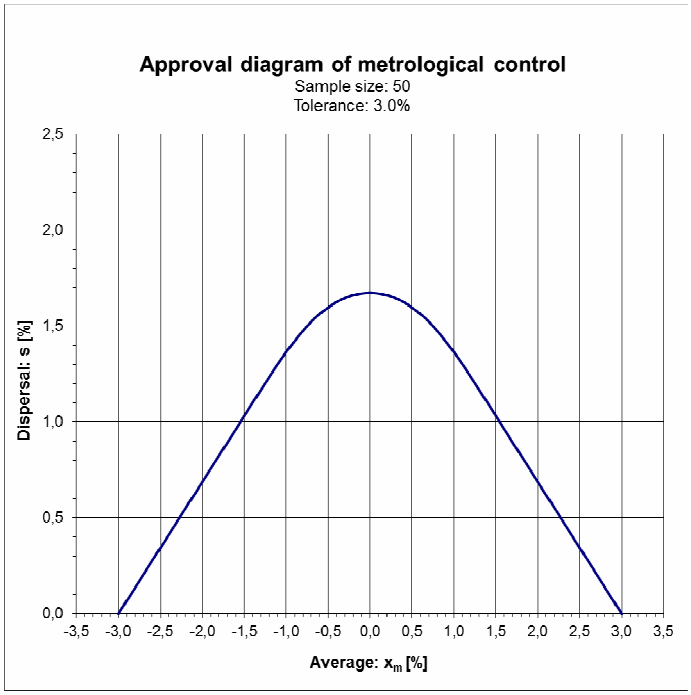
The sample model has been used successfully in Denmark for 12 years.

A sample model is attractive compared to the expenses connected with an examination of the entire inspection lot.

From the samples carried out, the trend in meter accuracy for meters in an inspection lot can be followed. In that way you can estimate the time of a necessary exchange at an earlier state.



Case study Figure A – Approval of metrological control, sample size 32



Case study Figure B – Approval of metrological control, sample size 50

2.9 Custody Transfer

Custody Transfer (CT) refers to the measurement of the quantity of gas entering a distribution network and defines transfer of custody of the gas transported. The quantity can be measured in volume terms or energy terms (requiring the measurement of volume and calorific value at each delivery point).

As shown in the chart below most respondents do not know how much CT metering contributes to their overall UFG. It is reasonable to assume that CT could be a factor in UFG for more companies than the responses indicate.

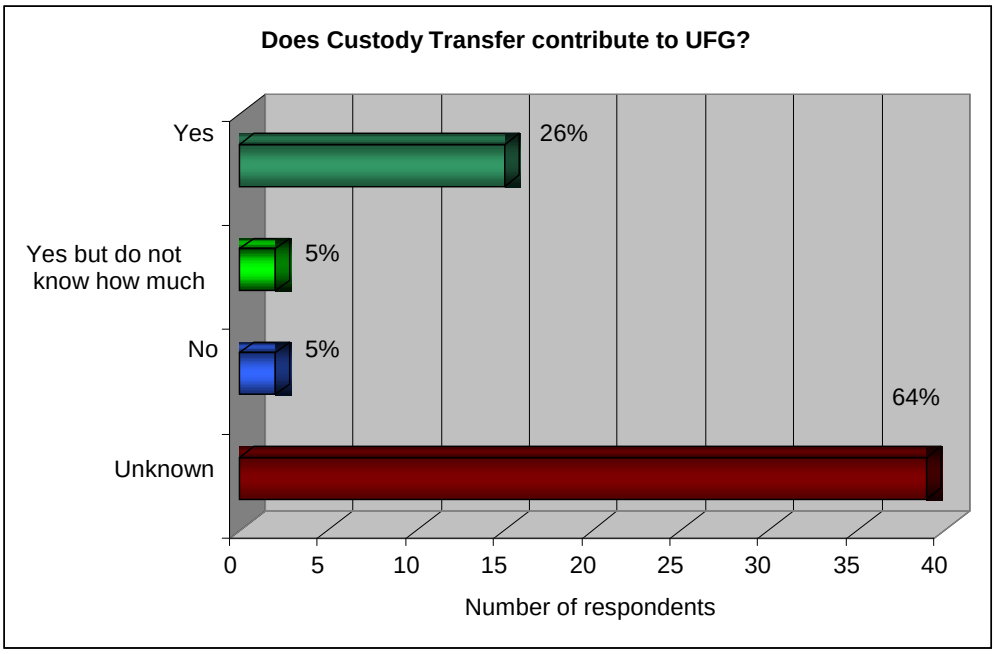


Figure 35 – Contribution of CT to UFG

25% of respondents calculate or measure UFG as a direct result of CT (45% do not and the remaining 31% claim it is not applicable). Of these, half indicated that CT is recognised as an important component of their UFG.

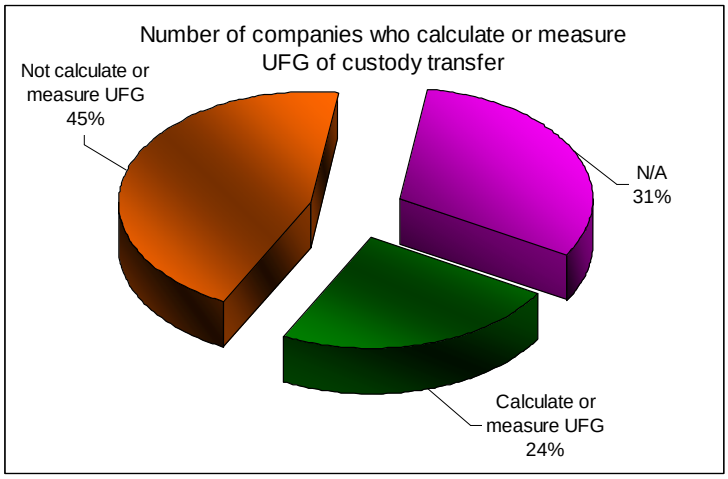


Figure 36 – Measurement of UFG from CT

More than 75% of respondents confirmed that the ownership of the CT meters on their networks is with the gas transportation operator.

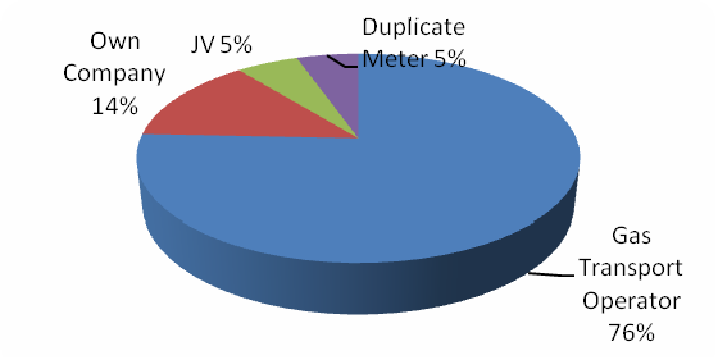


Figure 37 – Ownership of CT meters

The portion of UFG arising from CT varies widely between companies from 0%to 90%.The largest CT share of overall UFG is reported by companies that use CT meters that are owned by the transport company (90% of UFG). However some companies reported low CT portions even when the CT meter is also owned by the transport company.

Approximately 20% of CT meters operate with an accuracy of ±0.5 % or better, and 42% of CT meters have an accuracy between ±0.5% percent and ±1 %. Overall more than 60% of CT meters operate with an accuracy of ±1 % or better.

Data from the survey did not allow an interpretation of correlation between CT meter accuracy and the CT share of UFG, as shown in the figure below.

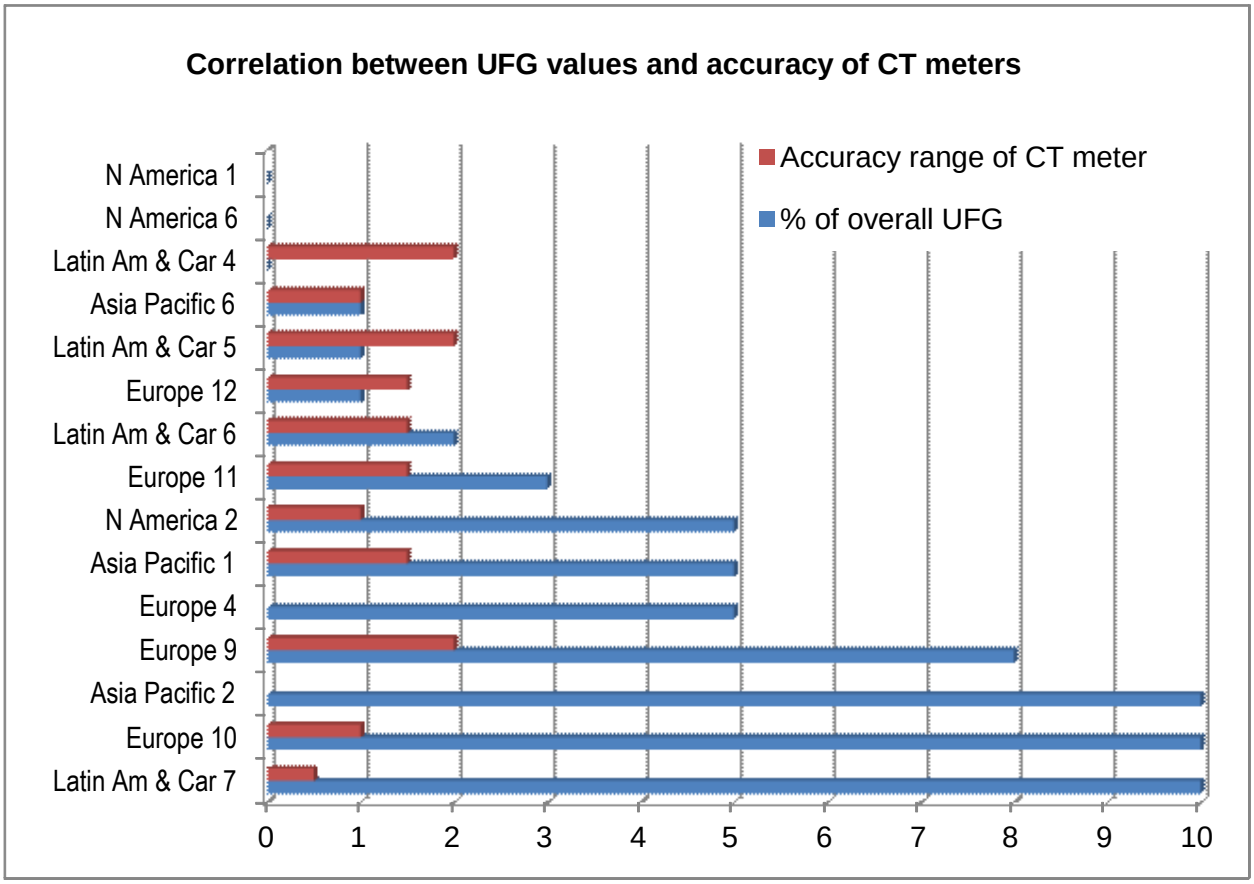


Figure 38 – Correlation between UFG and accuracy of CT meter

46%of CT meters in use are turbine type while approximately 20% are USM type. More than 15% are orifice, vortex or diaphragm type meters. There does not seem to be a relationship between the kind of CT meter used and the attributable share of UFG.

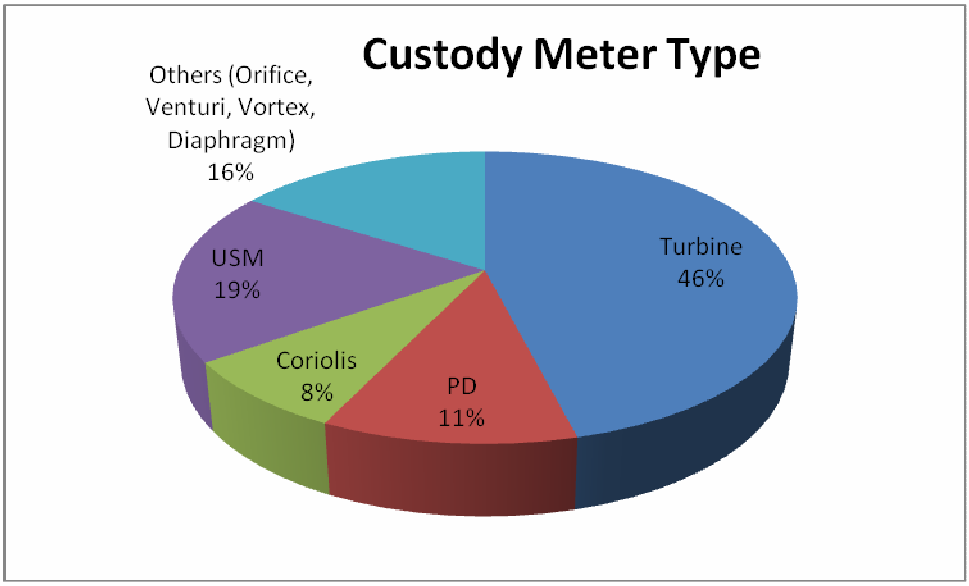


Figure 39 – CT meter type

Approximately 35% of companies calibrate their CT meters every five years. Approximately 50% calibrate them yearly or more frequently.

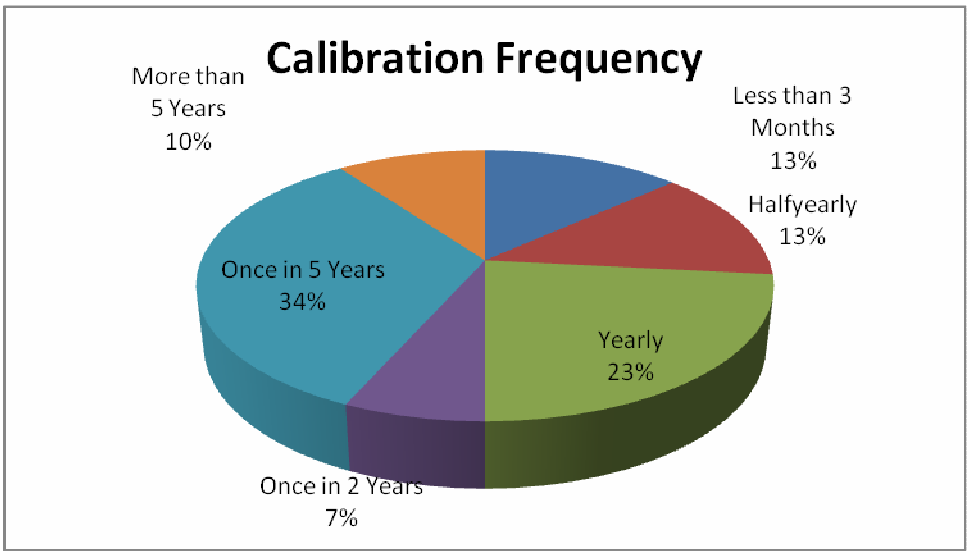


Figure 40 – CT meter calibration frequency

More than 62% of companies calibrate their CT meters using gas at normal operating pressure, whilst the remaining companies use air at atmospheric pressure. Most companies follow either international American standards or European standards.

Approximately 85% of respondents use gas chromatographs, of which 76% are the online continuous type. 15% use calorimeters for the measurement of heating value.

Approximately 22% of respondents calibrate their equipment used for heating value calculation on a daily basis. 33% calibrate yearly.

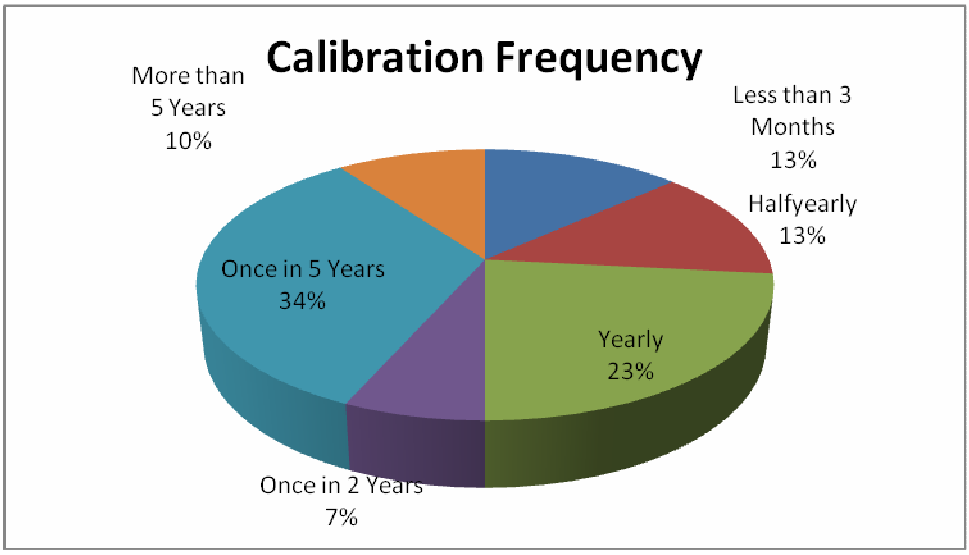


Figure 41 – Calibration frequency of gas chromatograph

The majority of companies use negotiation to resolve discrepancies between meter readings for CT gas quantities. Other methods include calibration, historical trending or applying contractual agreement terms.

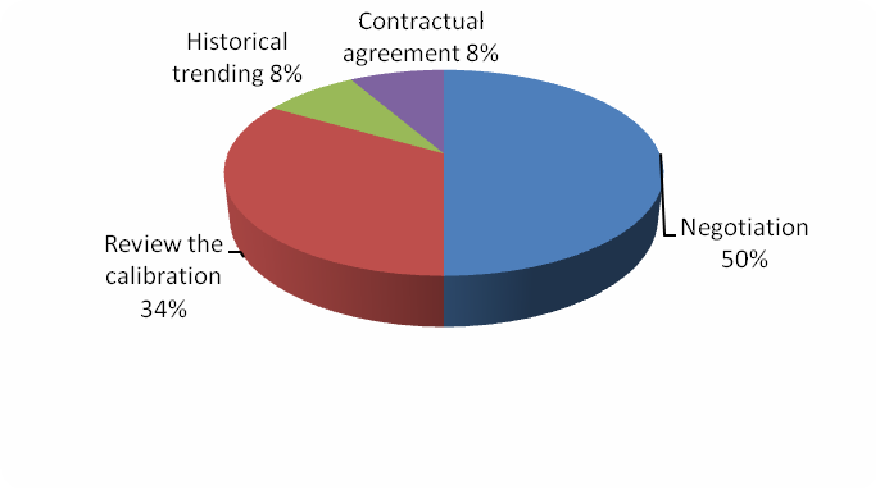


Figure 42 – Methods of resolving CT discrepancy

Analysis of the data shows that for companies that experience significant CT UFG values, resolving a discrepancy between two meter readings is managed by the gas transport operator. Companies with low CT UFG values indicate the following examples of good practice in resolving discrepancies:

- planning for a control reading;
- checking by independent accredited calibration laboratory;
- controlling or reviewing both meters in the case of discrepancy;
- effective negotiation with the gas transport company;
- early troubleshooting even at low discrepancy; and
- observing the terms of the contractual agreement.

3 Conclusions and Recommendations

3.1 Conclusions

Understanding UFG is important to a business success in the gas distribution industry. It is only possible to reduce it if you can estimate or measure it, and this is only possible if you understand how it is caused.

UFG is not a simple issue, but is a complex mix of factors caused at all stages of the gas distribution chain. It is not only an accounting problem nor is it just a technical issue, but a part of business that can result in large or small impact to a DSO's financial, safety,

environmental and social performance. It can ultimately affect the value of a company and its reputation.

UFG can also be affected by the specifics in a regulatory regime – either the regulatory framework does not include UFG or it does and provides incentive to reduce it.

UFG can be difficult to manage, even if it has been identified and measured. It can only be managed well when it is looked at as an integrated, whole-of-business, long-term approach. To reduce it many different parts of the business may have to be altered (it is not a single or quick fix).

Management of UFG is a key issue for the business of the future and should be included in any DSO business agenda. UFG issues become more relevant if a gas distribution business becomes unbundled, as the commercial relationship between shipper and buyer becomes more defined and UFG must be understood and allocated. In addition UFG is a key consideration in the estimation of emissions to comply with national/international obligations to reduce airborne contaminants and greenhouse gases.

On an ongoing basis, the impacts of UFG are expected to increase due to growing social, commercial and environmental pressures on DSO operations. DSOs will more and more being required to demonstrate that they understand and can manage UFG.

Sources of UFG and their impact on business are not uniform across companies or countries and are dependant on type of DSO, regulation and culture. The top drivers to address UFG are replacement of leaking mains, meter inaccuracy, gas loss from third party damage and theft.

Due to the complex and variable nature of UFG it is not possible to design a single tool or create a “one formula fits all” for use by distribution companies to approach a value of UFG. As it is only possible to estimate UFG, not calculate it, no technical formula can be written, but rather estimating methods can be put forward.

Good management of meters is crucial to identify and measure UFG. One cannot improve what one cannot measure. Adopted accuracy of meters can have a significant impact on UFG and is difficult to change as it could require the substitution of all meters that do not comply. On the other hand, the way that meters, metering conditions and reading procedures are set and handled – including reading frequency, pressure regulation, reading procedures to minimise error and periodic accuracy checks – may greatly impact UFG and result in measurable improvements.

The installation of smart meters is one way to reduce UFG by being able to measure gas on real time, but is a long-term exercise, is currently technologically uncertain (although improving) and involves large capital expenditure.

The exercise of managing UFG provides a good opportunity for DSOs to share best practice. Currently best practice is focussed on specific UFG aspects such as metering and replacement of cast iron networks. A high level management approach is required.

UFG will continue to be an important aspect of managing emissions for compliance with national/international obligations to improve energy efficiency and reduce airborne emissons and greenhouse gases.

3.2 Recommendations

It is more benficial to look for best practice to reduce UFG rather than look for methods to quantify it.

Workshops on UFG should be held between DSOs to disseminate knowledge and look for best practice.

DSO senior management should consider UFG as an integrated strategic issue across all parts of the business. Business success strategy should include a plan that is tailored to the DSO to identify all sources of UFG and their management.

Incentives should be created by regulators on a country basis to study the problem of UFG and introduce practice in the industry to reduce it, such as frequency of leakage survey, replacement of networks and schedule to check the accuracy of gas meters.

DSOs should seek funding for innovation and research under the heading of UFG as it is an important commercial, safety, social and environmental concern.

UFG should be included as a consideration in the WOC4 study groups during triennium 2012-15**:** smart grids in gas distribution; diversification of gas quality and non-conventional sources in a carbon-free future; and regulation on third party access to gas distribution networks.

Appendix 1

WOC4 Survey – General part

Introduction & Objectives

In order to establish a common dataset to support each of its study group's work, WOC4 prepared a questionnaire that requested data and opinions from every member organisation registered with WOC4. The survey was conducted under the auspices of the IGU during 2010. The main reasons to conduct this survey were to acquire data from each respondent on the topics under study, to have a sound basis in terms of operations, experiences, tasks, opportunities and risks upon which build a reliable work.

In terms or responses, WOC4 received fifty-six responses and is really satisfied with such a result, and thanks all members and colleagues who contributed to this success dedicating their valuable time and sending their answers.

The respondent companies are located in 24 different countries, distributed over 5 of the 8 regions defined by the IGU. This is the same level of response to the previous triennium 2006 - 2009 where a total of 24 countries responded. The countries that responded to the questionnaire are listed below and are grouped in their region.

Asia Pacific	Australia, Hong Kong, Japan, Malaysia
CIS countries	Russian Federation
Europe	Austria, Belgium, Bosnia, Czech Republic, Denmark, France, Germany, Ireland, Italy, Netherlands, Portugal, Slovak Republic, Slovenia, Spain, United Kingdom
Latin America and Caribbean	Argentina, Brazil
North America	Canada, USA

The following map below shows the regions and the number of countries/companies that responded.

Figure A1.1: World map showing questionnaire respondent nations per region

The three regions from which data was not able to be obtained are the Middle East, Africa and Asia.

Information was gathered from companies that operate gas networks that serve a total of more than 116 million customers, comprising 1.9 million km of gas mains. Compared to figures of past triennium questionnaire, we have a significant increase, from 85 to 116 million customers (+36%) and from 1.2 to 1.9 million km of gas mains (+58%). This confirms the significance of the information obtained.

As the diagram above shows, the European region accounts for 52% of the data gathered and, as such, dominates the data for gas mains length and number of customers serviced. Of course this influences the results of the survey, but we must always consider that the questionnaire is an input to the work and not the output itself.

The chart below shows the relative distribution of number of customers serviced by the responding companies per region.

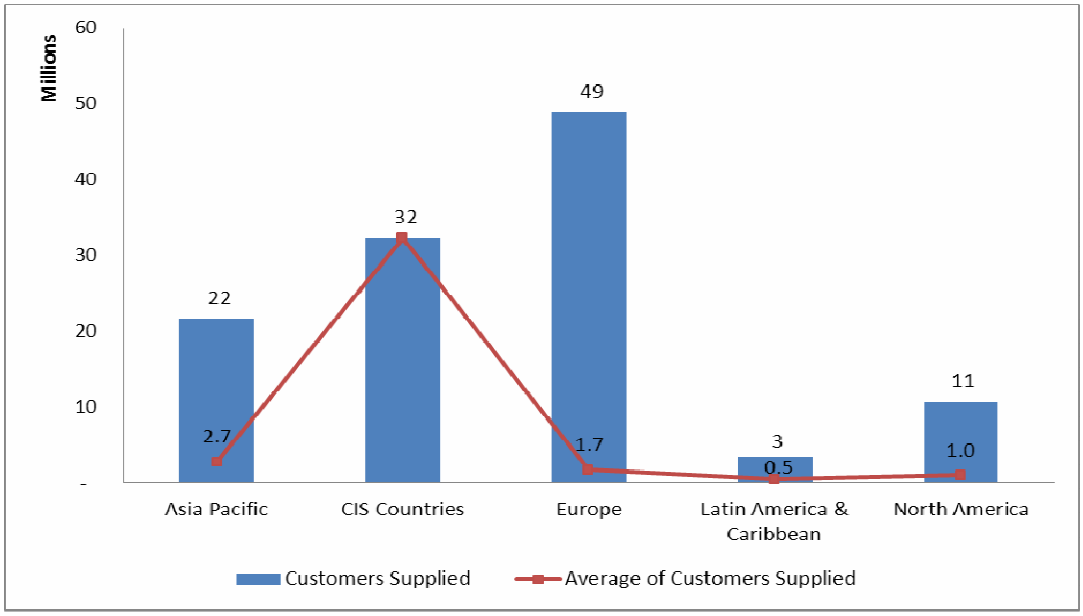


Figure A1.2: Customers supplied per Region

Average Company Profile

Based on the data an average distribution company has been defined. The tables below show key characteristics, such as materials and pressure.

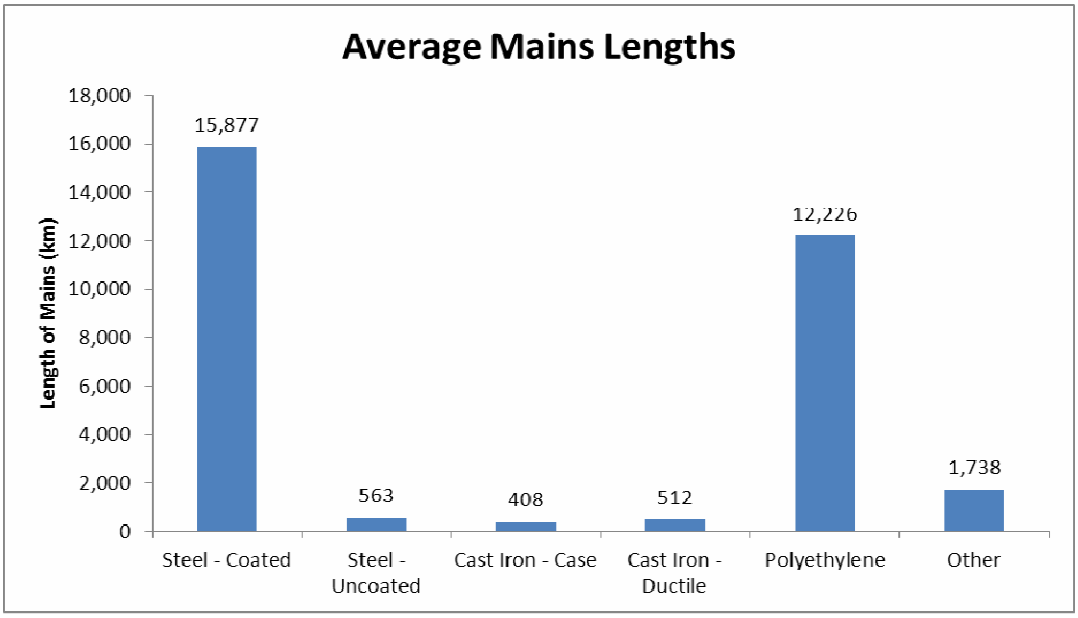


Figure A1.3: Average mains lenghts

For each respondent company an average of 2.1 million customers is served. The following charts shows pressure and material breakdowns for the 5 regions.

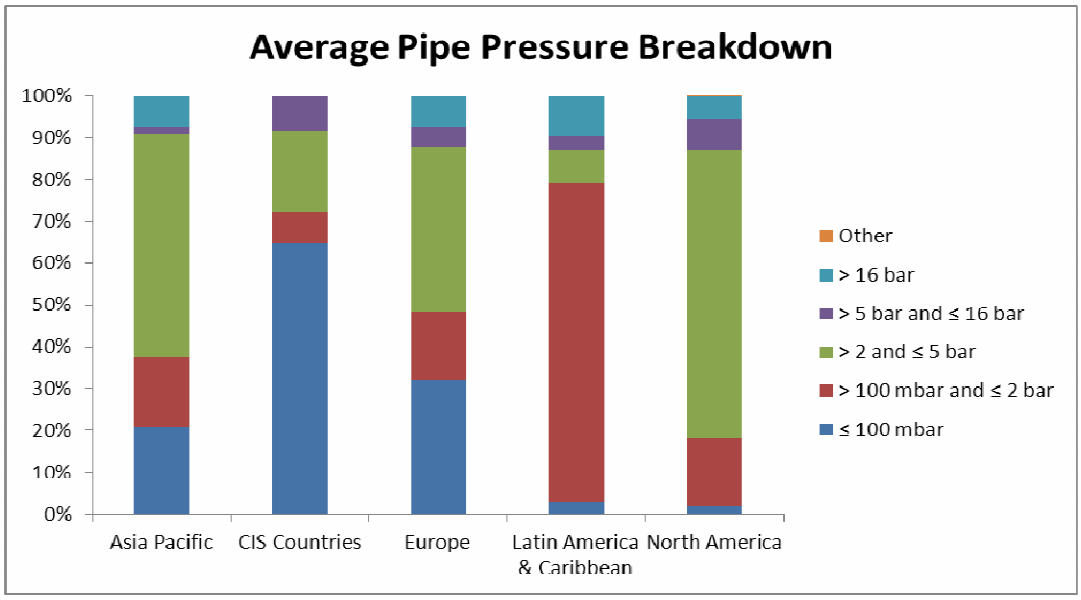


Figure A1.4: Average Pipe pressure breakdown

The following chart shows the average percentage breakdown by material for the 5 regions, for countries that provided data.

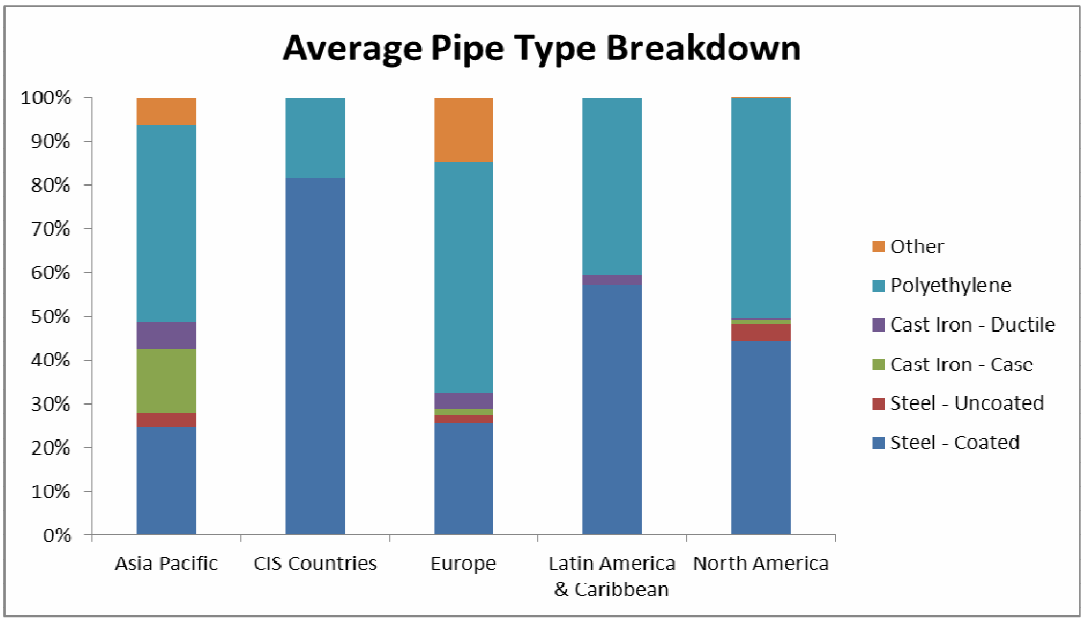


Figure A1.5: Gas mains material breakdown per region

There are many reasons why the composition of pressure and material breakdown differs between these regions, including: individual operators choosing a particular pressure regime based on engineering judgment and local circumstances; networks founded in town gas distribution (such as some countries in the north west of Europe); and age of network, with more recent installations transporting gas via newer materials such as polyethylene (PE) and at noticeably higher pressures.

Regions which have the greatest average percent usage of PE pipe (such as Europe at 53%) also have the greatest percent of 2 – 5 bar pressure. It would appear that countries are installing newer PE pipe not only for low pressure mains, but in mains with corresponding higher distribution pressures, particularly in the 2 - 5 bar range. CIS countries also show a strong correlation between PE pipe and the 2 – 5 bar pressure range (at 26%).

In Europe and Asia-Pacific, there is high utilisation of other materials (at approximately 9% mean) as alternatives to steel, cast iron and PE. (this happens in low pressure – up to 100 mbar – situations).

Appendix 2

WOC4 members

Alessandro Soresina (Chairman of WOC4), Dietmar Spohn (Vice-chairman) and Mario Pelizzoli (WOC4 Secretary) wish to thank all members of WOC4 for their contribution to the activities, and in particular those who took part actively in the life of WOC4 and of its Study Groups:

SG 4.1

Ben Lambregts - SG 4.1 Chairman – The Netherlands
Bodo Kipker – Germany
Christian Schicketmüller – Austria
Franc Cimerman - Slovenia
Hiroki Kikuchi - Japan
Igor Tverskoy - Russian federation
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José Maria Almacellas Gonzàles - Spain
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Valery Matyushechkin - Russian federation
Vladimir Klimenko - Russian federation
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William Kearney - Ireland

SG 4.2

Kim Vrancken – SG 4.2 Chairman - Belgium
Ahmad Hashimi Abdul Manap – Malaysia
Behzad Babazadeh – Iran
Birgitte Herskind – Denmark
Chayanin Aromrat – Thailand
Daniel Hec – Belgium
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Kenichiro Yuasa – Japan
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Saeid Momeni – Iran
Stefano Cagnoli - Italy
Steve Vick - United Kingdom
Yasuhiro Fujii - Japan

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Gotom Chakraborty - India
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José Carlos Broisler Oliver - Brazil
José Francisco Catela Pequeno - Portugal
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Lloyd Chiotti - Canada
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