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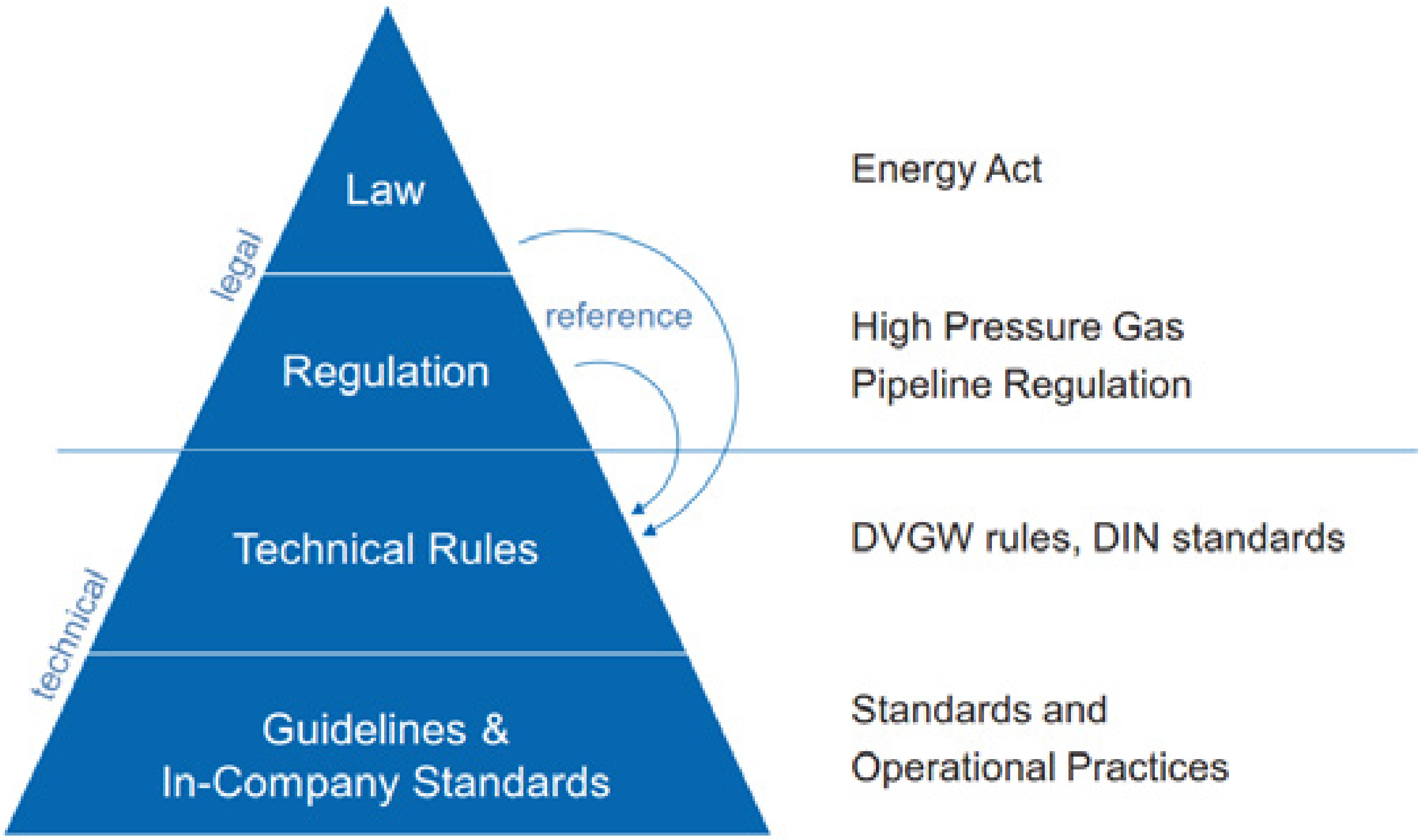

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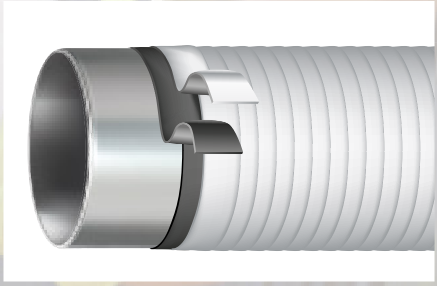

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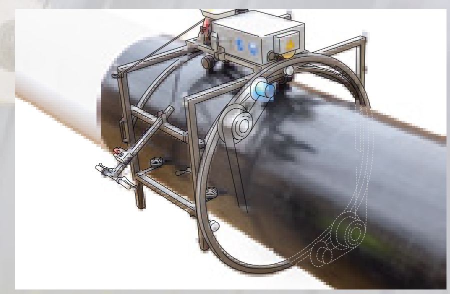

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Pipeline Safety in Germany
A Success Story

Prof. Dr. Gerald Linke
CEO DVGW

Pipelines are the lifeline of our society and our economy, thus they deserve our attention in order to work safely and reliably. Pipelines transport gas, oil, water and other products over long distances, mostly over thousands of kilometers, from production facilities to the user. On their way, pipelines traverse mountains, cross lakes and pass densely populated areas.

Dr. Klaus Ritter
President EITEP

Damages to pipelines threaten lives, can cause high costs and inflict harm to the environment. At the same time, more and more pipelines are crossing developing and emerging countries that do not have up to date technical standards, and this poses high risk.

International exchange of experience is therefore indispensable to transfer knowledge on how to apply the most reliable and safe technology. This is important for all steps along the value-chain of pipelines: planning, construction and operation. Especially in the case of gas and oil pipelines, mistakes can lead to catastrophic incidents with far-reaching consequences. Taking into account the fact that the pipeline network (high pressure) length totals about 4 million km, and is being extended by 25,000 km every year, we are obliged to exercise prudence and attention to safety.

The Pipeline Technology Conference (ptc) and its publication the Pipeline Technology Journal (ptj) are instruments for fostering an exchange of experience and best practice. During this, Europe's leading pipeline conference, latest technological developments are presented by scientists, operators, service providers and administrators.

Since the first ptc, more than 12 years ago, safety has been a core topic. Safety was also discussed prominently during the last ptc in May 2017. DVGW – the German Technical and Scientific Association for Gas and Water – has been asked to report in a special session about its technical set of rules, their implementation in the field and their positive impact on pipeline practice. The German gas supply system excels in its high level of technical safety, not least due to the constant advancement of technical standards in the course of the DVGW's work on the Set of Rules. The focus of this edition of the ptj is the statistical evaluation of damage incident and accident data, the holistic safety methodology of the DVGW and the further development of the Set of Rules, taking into consideration current case law and scientific investigations as well as enhancements of the Set of Rules review process.

The decrease in the number of incidents in the German gas supply network in the past 30 years by 90% is a remarkable result of Germany's safety process and leads - even though the pipeline network has increased considerably in length and has aged over the same period - to the current frequency of nearly 0.01 incidents per 1,000 km per year. Nevertheless, improvements have to be made in areas where incidents occur more frequently in order to systematically reduce incidents caused by technical or human error.

The technical papers of the DVGW safety session are provided in this special edition of ptj. Due to the international interest in the aforementioned technical session, we have decided to augment this edition with additional papers with related topics.

The Pipeline Technology Conference will continue to discuss latest safety-related technological developments. The Pipeline Technology Journal will keep you informed.

Dr. Klaus Ritter
President EITEP
Euro Institute for Information and Technology Transfer in Environmental Protection

Prof. Dr. Gerald Linke
CEO DVGW
German Technical and Scientific Association for Gas and Water

NOVEMBER 2017 / ISSUE 5

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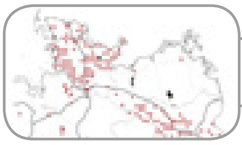

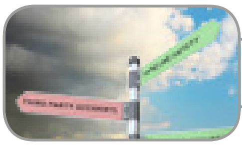

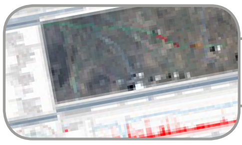

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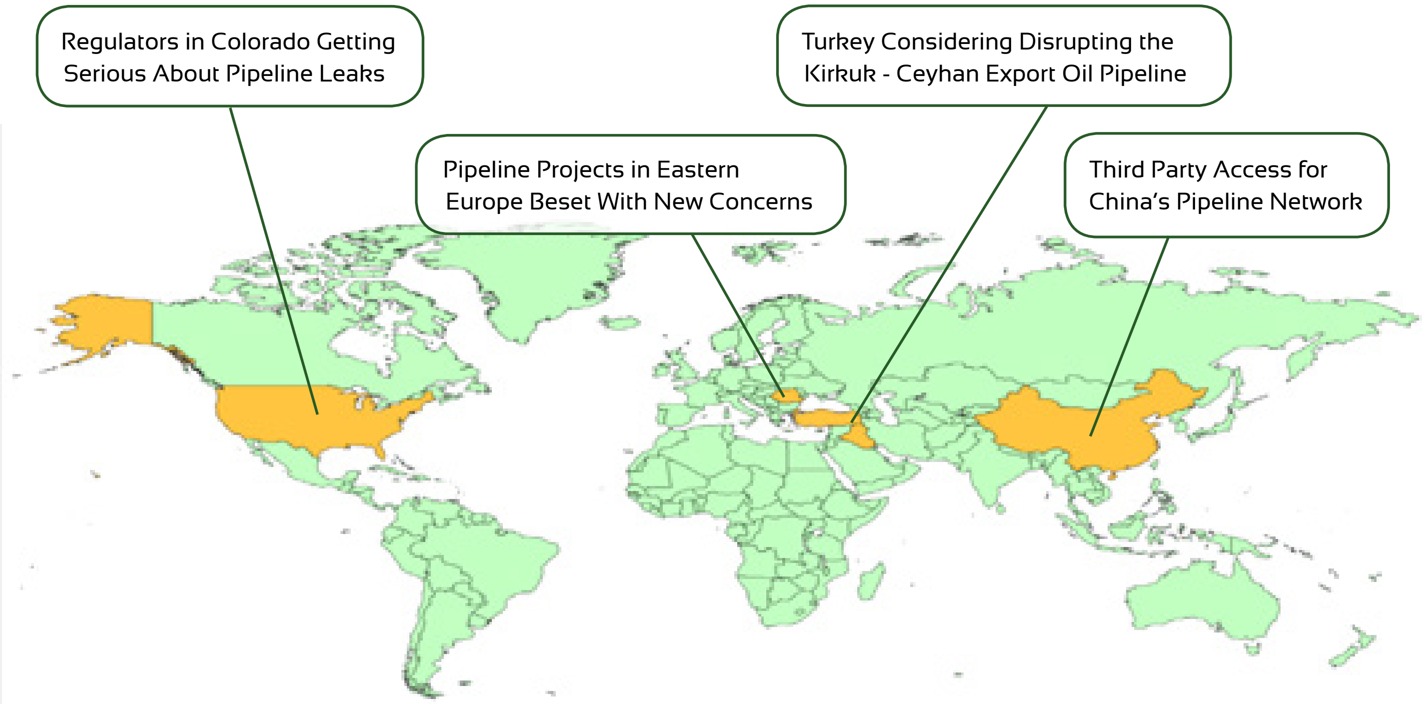

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Natural Gas Pipeline

- even if you don't see it

Alfred Klees / Anika Groos
DVGW – German Technical and Scientific Association for Gas and Water

ENSURING THE TECHNICAL SAFETY OF GAS INFRASTRUCTURES IN GERMANY

ABSTRACT

An extensive gas infrastructure system criss-crossing Germany ensures the high reliability of supply of heat and electricity to the civilian population, of process heat/heat energy and natural gas as a raw material for organic chemistry to the industry, of highly efficient primary energies to power plants, and of alternative environmentally friendly fuels (CNG/LNG) to the transport industry. The German gas supply system excels in its high level of technical safety, which is not least due to the constant advancement of technical standards in the course of the DVGW's work on the Set of Rules. The focus of this article is on the statistical evaluation of damage incident and accident data, the holistic safety concept of the DVGW, and on the further development of the Set of Rules, taking into consideration current case law and scientific investigations as well as an adjustment of the DVGW codification processes. It additionally discusses aspects that will affect the gas infrastructure in the context of the energy turnaround. This paper is the first of a series of technical articles that deal with the safety-related challenges facing the gas infrastructure.

The German gas grid currently consists of 550,000 km worth of closely intermeshed pipelines. Gas transmission lines cover nearly all of Germany (Figure 1). The structure shown in the figure has been built and expanded over the last two to three decades using cutting-edge technologies and materials.

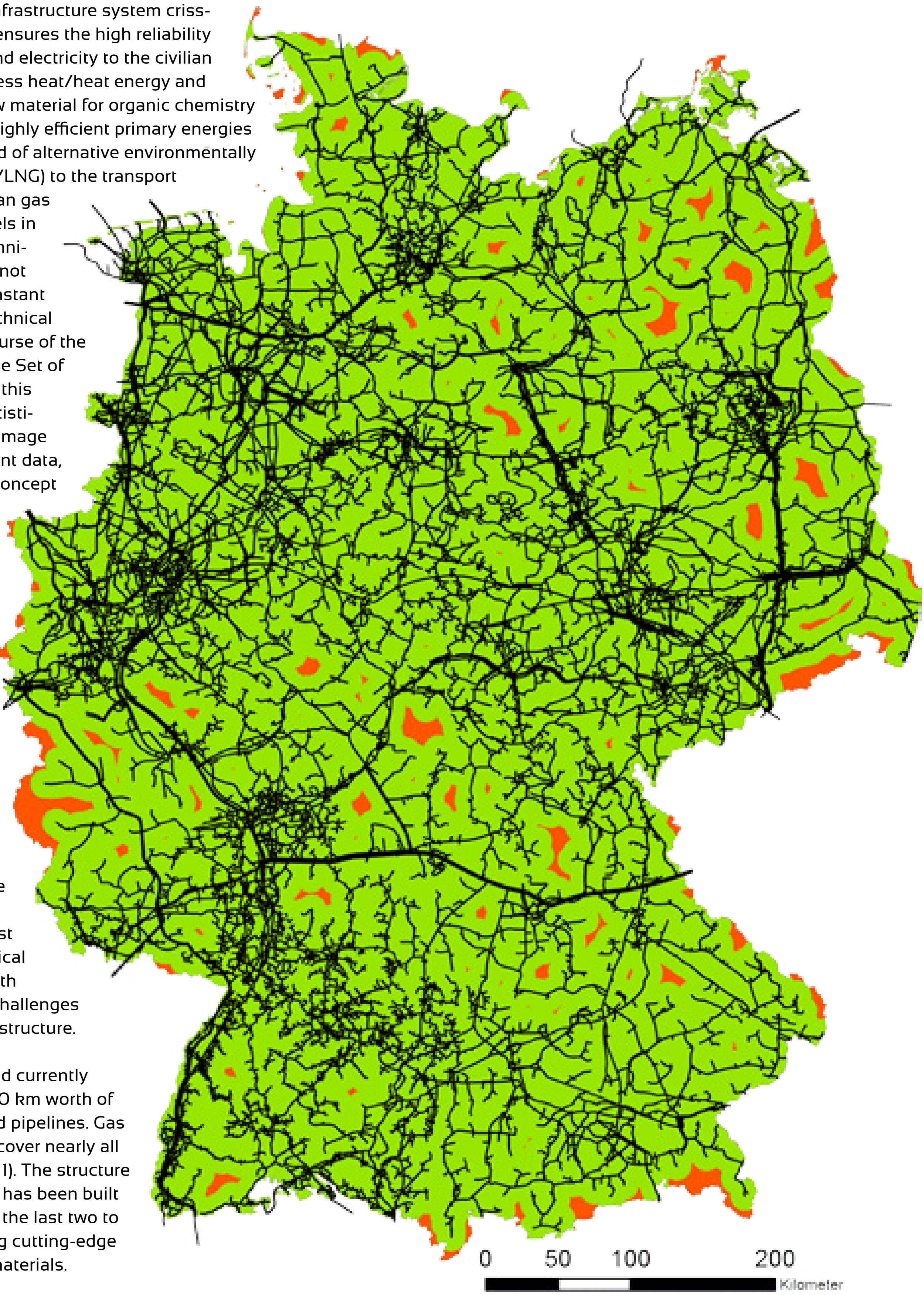

Figure 1: Germany's comprehensive gas infrastructure, this figure showing pressure classes > 4 bar
Source: GeoBasic-DE/BGK 2012/DBI

Figure 2: Its central geopolitical location makes Germany a gas import and export hub
Source: ENTSOG

Its geographical location makes Germany a hub for both gas imports and exports; as such, Germany plays a critical role in the European gas infrastructure network (Figure 2).

The German gas grid has a twofold task: first, to link import and export points and second, to link the main production and consumption points. This makes it one of the most complex technical structures in Europe.

Gas consumption is subject to strong fluctuations; it depends e.g. on the season, time of day, and economic cycles. Short-term supply and demand imbalances can be directly buffered in the transmission network.

Germany's geology provides for sufficient subsurface storage capacities so that even major fluctuations in consumption can be accommodated without difficulty [5].

ENERGY SUPPLY FOR GERMANY AS AN INDUSTRIAL LOCATION

Various energy carriers cover Germany's annual primary energy demand of currently about 3,644TWh (Figure 3), with 21 per cent of the primary energy coming from natural gas. Today 13 per cent of the energy demand is already covered by renewable energies; the intention is to substitute the remaining 87 per cent of fossil energies in the long run.

National energy policy is aimed at considerably reducing the primary energy demand across all sectors by 2040 by way of potential energy savings and/or efficiency increases.

Direct electricity generation from sun and wind does not produce waste heat, of which power plants such as e.g. coal-fired powered plants produce an amount greater than the generated electrical power. Assuming energy savings of approximately 3 per cent per year will still keep the use of primary energy at about 50 per cent.

Even assuming that energy demand could be reduced by as much as 3 per cent annually until 2040 as compared to the current trend, almost 50 per cent of today's energy consumption, i.e. almost 2,000TWh, will still need to be provided in a sustainable way [4].

Currently, the predominant renewable energy sources are wind power and PV. It is foreseeable that this trend will continue in the future as biomass, hydropower and geothermal are limited resources. National energy policy intends to increase the demand for "electrical power" in e.g. households and the industry, raising the impression that the world (of energy) is moving towards a fully integrated world of electricity, or all-electric-world, where energy is generated, transmitted, and consumed in the form of electricity.

Alternative gas technologies however can increasingly be found on the agenda of discussions on energy policy.

"The German gas grid has a twofold task: first, to link import and export points and second, to link the main production and consumption points. This makes it one of the most complex technical structures in Europe."

Alfred Klees

Only about 2,454TWh worth of final energy out of 3,644 TWh worth of primary energy will eventually reach the consumer on account of conversion and transmission losses. The heat energy sector (space heating, hot water, and process heating) accounts for almost half of that (1,214TWH), while the electricity and transport sectors require considerably less energy (515TWh and 725TWh, respectively). Potential process heat energy savings are comparatively low. Moreover, electrically powered heat pumps can be used only up to a point because of the high temperatures required for their operation. Heat energy demand management however offers a huge energy-saving potential [4].

The more stringent requirements of the German Heat Insulation Ordinance have already helped to sustainably reduce the demand for heat energy (Figure 4).

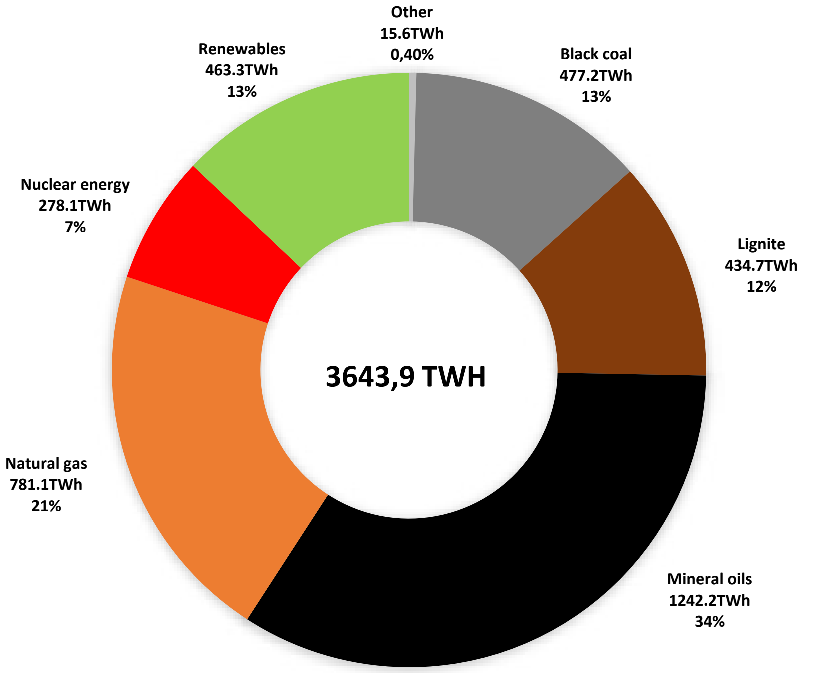

Figure 3: Primary energy consumption in Germany in 2015: 13 per cent of the energy is already obtained from renewable sources. Germany intends to substitute the remaining 87 per cent of energy from fossil sources in the long run
Source: AGEB 2016

Exploiting additional savings potentials offered by efficient appliance or insulation technologies could further reduce the current demand for primary energy. Highly efficient gas technologies, however, would make the most significant contribution towards drastically reducing emissions. Simply shifting from obsolete heating systems to gas condensing boilers could save 20 million tons of CO_2.

This would go hand in hand with potential financial gains generated through energy savings. A further reduction of emissions can be achieved using CHP and "gas-plus technologies" such as gas-powered heat pumps [7].

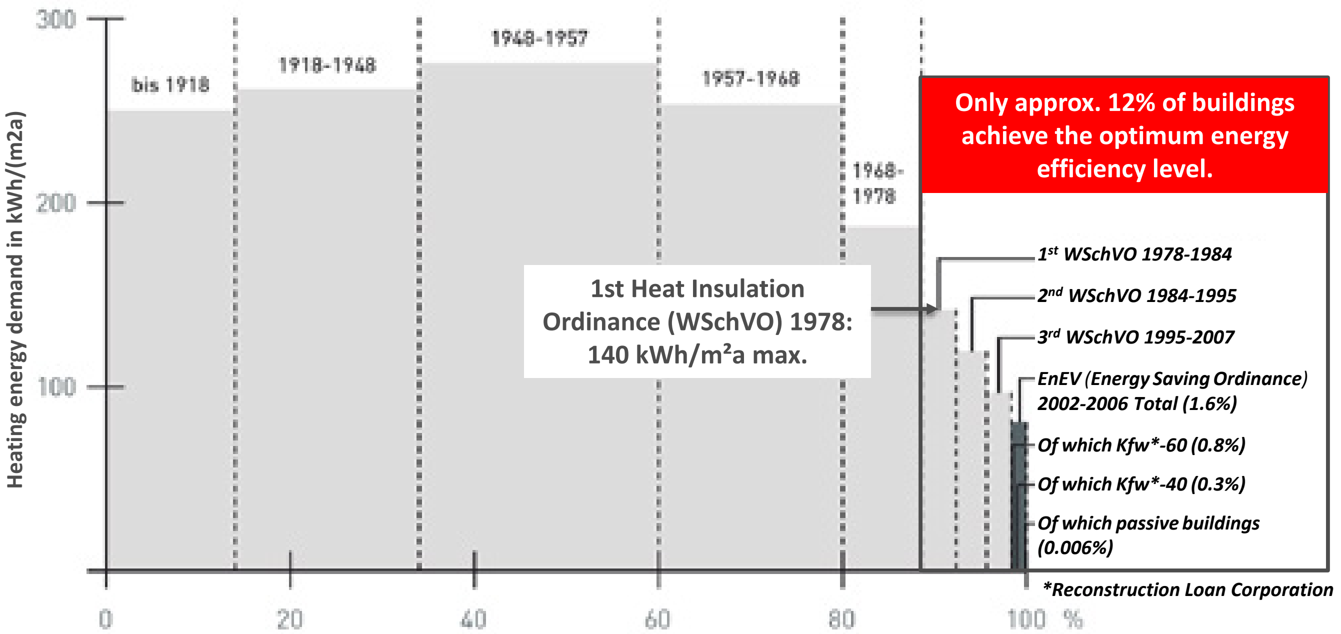

Figure 4: Heat energy demand of buildings. The energy turnaround in the heat market happens to the existing infrastructure

"By advancing the comprehensive safety concept that was developed in the early 1990's, the DVGW has set a milestone in the evaluation and reduction of damage and incidents in the gas supply sector by 90 Percent within the last 30 years..."

HOW SAFE IS GERMANY'S GAS IN-FRASTRUCTURE?

In the light of continuing national and pan-European gas market regulations, current structural changes in the business environment and the fundamental reorganisation of the energy supply systems in Germany and Europe, it is the primary aim of the national economic and business policy to maintain a high standard of technical safety of the gas supply systems. By advancing the comprehensive safety concept that was developed in the early 1990s, the DVGW has set a milestone in the evaluation and reduction of damage and accidents in the gas supply sector. The statistical/stochastic analysis of incidence data collected from the damage and accident statistics of the DVGW has served as a basis for the elaboration of the cause-oriented catalogue of measures. It has helped develop and introduce tangible technology and process improvements as well as additional training and information measures for each cause-relevant target group, ensuring a sustainable high level of safety in the German gas supply industry. Figure 5 documents the resulting considerable reduction of the specific incident rate in the German gas grid [3].

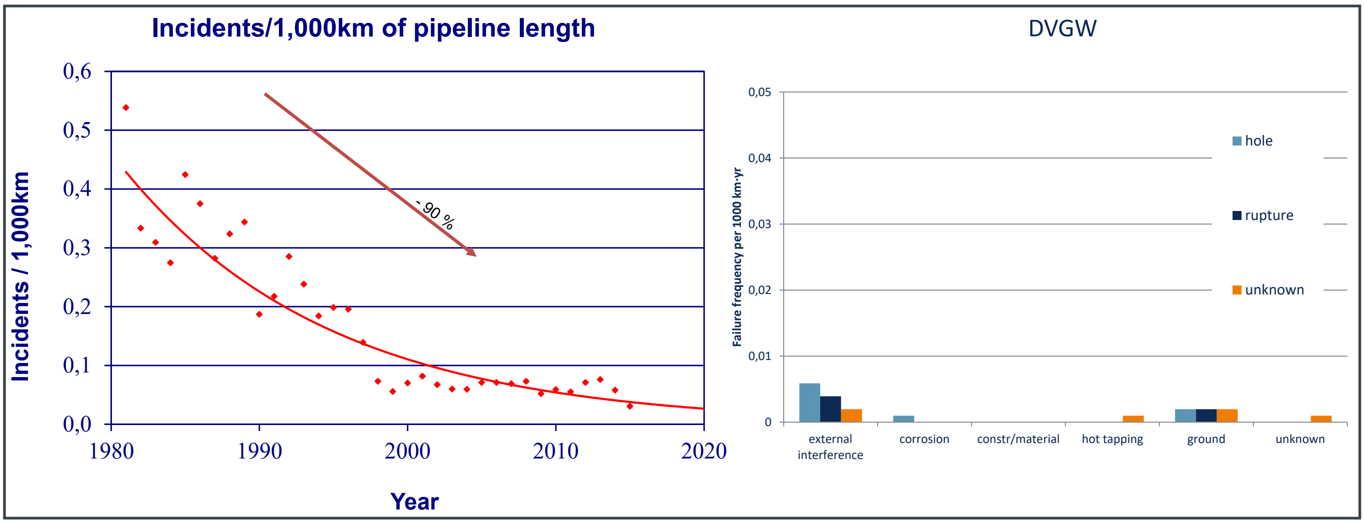

Figure 5: History of gas pipeline incidents in Germany. Since 1980 the incident rate has dropped by 90%

The measures derived from the incident analyses have been gradually integrated into the state-of-the-art technologies codified in the DVGW Set of Rules; they guarantee a comparatively high standard of safety, with the focus here on gas pipelines. External mechanical interferences account for the lion's share of incidents, followed by corrosion damage. Defective material and incorrect work, e.g. tapping, assembly and construction defects, rank third.

THE HOLISTIC DVWG SAFETY CONCEPT

As the DVGW's holistic safety concept is focused on suitable measures that can be implemented in all corresponding technical areas (Figure 7), it is not confined to the work on the Set of Rules. The qualification and certification of products, individuals, service providers and management systems as well as of companies consequently play an important role.

The following quality requirements, among others, have been defined to reflect the high standards of the Set of Rules:

- Gas supply and gas application technologies are governed by stringent legal regulations such as the German Energy Industry Law (EnWG), the German High Pressure Gas Pipeline Ordinance (GasHDrLtgV), the German Low Pressure Connection Ordinance (NDAV), and the German Model Building Regulations (MBO), in which observation of and compliance with the DVGW Set of Rules are anchored as generally recognised codes of practice and/or state-of-the-art technology.

- The products used in gas engineering, service-providing com-panies, and the specialists/experts who are responsible for the technical acceptance tests are examined and certified on the basis of the DVGW Set of Rules.

- Only companies/individuals who have proved their expert qualifications are allowed to carry out construction, modification or maintenance work on gas pipelines and gas facilities.

- In addition, and for the purpose of monitoring the compliance with the technical safety requirements stipulated by law and the Technical Rules, the DVGW provides the industry with guidance on practice-oriented Technical Safety Management (DVGW TSM).

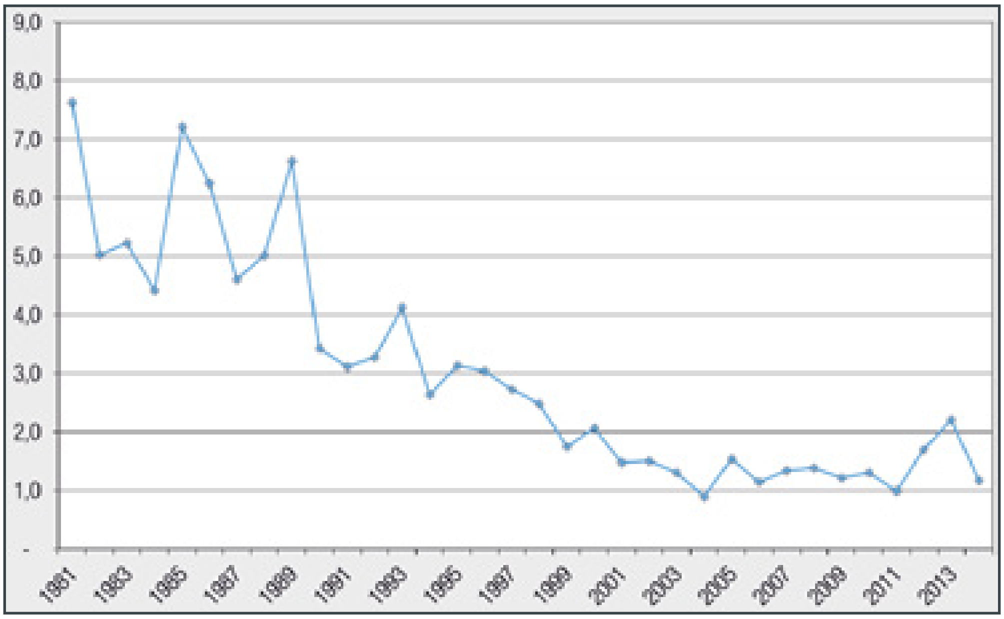

Figure 6: Decline of incidents in customer facilities since 1981 Source: BDEW, DVGW (Incidents in customer facilities per 1m natural-gas heated residential units)

line that were partially built and operated according to obsolete standards.

This is why for two decades the DVGW Set of Rules has backed two methods to ensure safety: Protecting the lines against third party interference and equipping them with sophisticated technical safety features.

The preference of safety distances over technical safety solutions is not congruent with the historic experience of the DVGW Set of Rules because frequently identical or even higher technical safety can be achieved by employing technological solutions other than distances.

OBSERVATION OF CASE LAW AND SCIENTIFIC RESEARCH

Ongoing technological progress keeps the Set of Rules of the DVGW constantly evolving, always with the aim of reflecting state-of-the-art technology. These evaluations also take into account case law developments.

For example, the expedited ruling of the Higher Administrative Court (OVG) of Lower Saxony in Lüneburg on 29 June 2011 led to an immediate construction freeze on some sections of the Northern European Natural Gas Pipeline.

The OVG simultaneously assessed the safety of gas pipelines - disregarding the usual risk assessment procedures employed for technical facilities - and defined more stringent safety measures in respect of such lines, employing a previously unknown safety technology - the distance from residential buildings. In “DVGW energie | wasser-praxis” 1/2012 the DVGW took a stance by making the following core statements:

- Supply lines shall be carefully guided up to residential and industrial areas.
- Protecting the lines is the most effective protection of the public at large.
- No further safety distances are generally required for lines running through a protection strip.
- Not only distances but also any other technical measures have to be taken into consideration.
- The analysis of the Federal Institute for Materials Research and Testing (BAM) [1] only looks at certain aspects and relates to worldwide incidents on pipe-

In this context, the following primary safety measures have proved especially successful:

- Pipeline design with a high safety factor (1.6);
- Installation of shut-off valves;
- 100 per cent check of construction site weld seams;
- Hydrostatic tightness and strength tests of the pipeline sections;
- Marking of the pipeline route with signposts;
- Passive and active corrosion protection;
- Checking of the protective sleeve by so-called intensive measurements;
- Short inspection intervals for surveillance on foot and by air;
- Inspection by modern pigging technologies;
- Tightness tests to determine the smallest of leakages.

The following additional safety measures, among others, are also applied:

- Higher depth of cover;
- Setting up of pipeline route warning tapes;
- Hydrostatic stress tests.

Even comparable Sets of Rules such as, for instance, the German Technical Rules on Long-distance Pipelines (TRFL) do not contain any information on distances from built-up areas, as evidenced by an enquiry from the state

"... The statistical / stochastic analysis of incidence data collected from the damage and accidents statistics of the DVGW has served as a basis for the elaboration of cause-oriented catalogue of measures."

Alfred Klees

parliament of Baden-Württemberg (Landtag) to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU):

(Landtag von Baden-Württemberg [Regional Parliament of the Federal State of Baden Württemberg]), Drs. 14/6687, p. 28): "In knowledge of the BAM research report the new TRFL will also not specify any minimum distances to be kept to built-up areas with residential buildings. The BMU communicated that the revised Technical Rules for Pipelines (TRFL) intentionally do without the definition of safety distances. It has to be decided on a case-by-case basis which specific action to take. Within the meaning of this definition, case-by-case refers to special situations as mentioned and described in TRFL no. 5.2.5. Since the individual measures listed under TFRL 5.2.5 are not exhaustive ("e.g."), an increase of the distance could be counted among these measures. This means that in a specific case it shall be tested whether one or more of the listed measures will/has to compensate for the concrete, higher potential risk. However, the proximity to residential buildings alone does not constitute such a special situation."

This goes to show that all in all, the TRFL defines 'state-of-the-art' differently from the expedited OVG ruling.

Moreover, it is noteworthy that the pipeline incidents evaluated by the BAM research report 285 partially date far back in the past. It is, therefore, extremely significant that most of the incidents that were evaluated are associated with lines built according to a now-obsolete state-of-the-art. Many other incidents occurred in non-European countries where other sets of rules apply.

Furthermore, the report focuses exclusively on damage impacts, completely ignoring the root causes of the incidents or the probability of damage occurrence. The determination of the severity of damage such as the blast radii mentioned in the research report or the calculation of risk arising from the operation of gas pipelines therefore are of very limited validity [6].

On 14 November 2011, the Administrative Court (VGH) of Mannheim [2] issued a formal decision in respect of the BAM research report, in which it refutes the contention that the research report would demand specific minimum distances. The decision moreover holds that the state-of-the-art can also be ensured without defining unambiguous minimum distances. Furthermore, the VGH Mannheim generally recommended not departing from the standards stipulated in the Set of Rules, unless in case of substantiated scientific and technological advances.

Although the DVGW's opinion - which was published in 2011 - on the expedited ruling of the OVG Lüneburg made clear that applying the DVGW Set of Rules ensured consonance with the state-of-the-art, the DVGW additionally evaluated the safety-related integrity of gas pipelines on a scientific level [6].

TECHNICAL REGULATION BASED ON SCIENTIFIC RESEARCH

The DVGW "Safety of Gas Pipelines" project group took part in the scientific investigations and summarised the findings for the concrete work on technical regulations by the DVGW expert panels. The following guidelines are now observed in the context of preparing technical regulations:

- The deterministic safety concept of the technical regulations will be maintained, however with the option of adding probabilistic statements.
- The Set of Rules shall protect man and nature; safety measures applied in the field today shall be integrated into the Set of Rules.
- The documents of the Set of Rules shall reflect the state-of-the-art and consider all sources of knowledge.
- Incidents and findings from damage statistics (DVGW damage and accident statistics (G410), European Gas pipeline Incident data Group (EGIG), etc.) shall be taken into account especially when drafting regulations.
- The worst-case damage scenario, e.g. total rupture, shall be taken into account.
- Mandatory technical safety measures shall be specified; their efficiency, availability and accuracy shall be evaluated and harmonised at regular intervals with new sources of knowledge.
- Risk potentials shall be taken into account regarding the type, number, and efficiency of the protective measures.

At the same time, the DVGW has developed a methodological approach with the intention being to logically represent the implementation of the above-mentioned guidelines; this procedure specifies binding goals, to be confirmed by the members, for each project group commissioned with elaborating a document that forms part of the Set of Rules.

The guidelines have also been incorporated into the current version of the Rules of Procedure GW 100 of February 2016 and thus constitute a binding guidance for the work of the DVGW committees with its main focus on taking into account new knowledge sources.

CONCRETISATION OF SCIENTIFIC FINDINGS AS STATE-OF-THE-ART

The DVGW Set of Rules feeds on the wealth of practical experience from companies as well as incident statistics analyses and other relevant sources of knowledge. Targeted scientific research completes the evaluation material for the codification of state-of-the-art technology.

Meanwhile, a large number of DVGW Sets of Rules has been adjusted (see information box) against the background of diverse scientific research as well as technological progress and the knowledge derived from it. Some of the fundamental changes are illustrated by way of example of DVGW Standards G 463 and G 495, as follows:

Crucial safety-relevant amendments in DVGW Standard G 463 "High Pressure Gas Steel Pipelines for a Design Pressure greater than 16 bar - Construction", July 2016:

- Specification in the scope of application that there is no upper limit on nominal diameters and design pressures;
- Increase of the pipeline depth of cover to at least 1.0 metres;
- Cathodic corrosion protection shall always include gas transmission lines;
- Gas transmission pipelines shall be piggable;
- Harmonised rate of use of 0.625;
- Stricter requirements for the marking of gas transmission pipelines in built-up areas.

Crucial safety-relevant amendments in the DVGW Standard G 495 "Gas Plants and Systems - Operation and Maintenance", November 2016:

- Consideration of the latest health and safety regulations in respect of the operation and testing of gas plants;
- Integration of requirements on the monitoring of heat transfer cycles in respect of corrosion;
- Further development of the requirements for the condition-based maintenance (CBM) of gas plants and extension of CBM to domestic pressure regulators based on the findings of the relevant research projects;
- Increased consideration of design features such as redundant safety features of devices and rails to increase their intrinsic safety and reduce the likelihood of failure;
- Inclusion of the requirements on the operation of mobile gas measurement and pressure reduction stations.

What is more, a large number of new papers published in 2015 and 2016 have been prepared applying the above-mentioned enhanced safety-relevant guidelines. The revised Sets of Rules are based on the scientific findings from various analyses, among other things, and, therefore, constitute key elements in continuing the scheduled publication series on ensuring technically safe gas supply to and in Germany.

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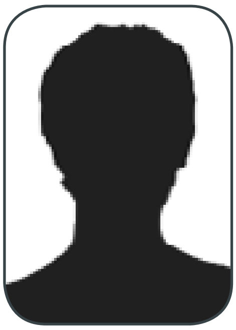

INTEGRATED SAFETY CONCEPT

OF DVGW IN TERMS OF STATISTICAL VERIFICATION OF INCIDENTS

Frank Dietzsch > DVGW – German Technical and Scientific Association for Gas and Water

ABSTRACT

The guarantee of a high safety standard of the gas infrastructure must be the highest goal of economic and operational action within the framework of proceeding national and European regulation and the organisational changes interrelated in the companies [1].

At the beginning of the 1990th DVGW, the German Association for Gas and Water, developed an integrated safety concept and thereby set a milestone for the evaluation and reduction of incidents and accidents in the German gas infrastructure. The basis for the development of the cause-oriented tool box was the statistical analysis of data coming from the incidents and accident statistics of DVGW. By means of this precise technical and process improvements as well as further trainings and awareness campaigns could be developed and introduced which have led to a high safety level within the German gas infrastructure.

In 2011 the damage and accident statistics were made state-of-the-art according to Section 49 of the Energy Industry Act by the publication of a code of engineering practice (cf. DVGW G 410 "Bestands- und Ereignisdatenerfassung Gas" - Registration of Asset Inventory and Incident Data of Gas Infrastructures). This makes the application of the code mandatory for all gas infrastructure operators. The data are published annually on an internet portal or interface (cf. GaWaS.strukturdatenerfassung.de).

Initial results of the data evaluation for the years 2011 to 2014 are presented in this article.

"Precise technical and process improvements as well as further trainings and awareness campaigns led to a high safety level within the German gas infrastructure."

Frank Dietzsch

DEVELOPMENT OF GAS DAMAGE AND ACCIDENT STATISTICS

In 1978 Germany's Ministry of Research and Technology commissioned a study into "Safety in municipal gas supply companies for households and businesses" [2]. The aim of the study was to develop proposals and concepts for improving the safety of public gas supply systems, and attempts were made in the analysis to establish a correlation between damage and accident events on the one hand and the occurrence of (unwanted) gas releases on the other. At that time the analysts only had access to information from heterogeneous data collections, e.g. derived from pipeline grid statistics from local supply companies or from quarterly reports in the Health Service series published by the Federal Statistical Office. An overview for the whole territory of the Federal Republic of Germany was just not available.

Then in 1979 the "Safety and Fire-Fighting" group of experts of the Ministry of Research and Technology recommended producing damage and accident statistics for the public gas supply system. This recommendation was taken up by the DVGW which invited its members to exercise their personal responsibility by taking part in a data survey to commence on 1 January 1981 [3]. This quasi mandatory requirement to participate in DVGW statistics continued right up until 2011.

The current energy-law framework and the fact that the assets held by supply companies have been continually expanding with the addition of new types of plant such as biogas entry and/or conditioning systems or natural gas service stations for example must receive reasonable consideration when it comes to the future formulation of technical rules and regulations. This is the background against which the DVGW "Registration of Asset Inventory and Incident Data of Gas Infrastructures" has been restructured. In 2011 the DVGW took up a recommendation by the joint national and regional "Gas Industry" committee to transform the damage and accident statistics which had been collected since 1980 into a code of engineering practice [1].

In the meantime, since 2012 the registration of asset inventory and incident data of gas infrastructures has been a firm part of DVGW's technical rules. The data registration criteria described in the technical rule G 410 comprise the following reports (cf. figure 1):

- inventory data for gas pipelines, gas service lines and gas-related facilities,
- incident data for gas pipelines, gas service lines and gas-related facilities and
- customer installations of domestic and industrial gas usage, gas odour notifications,
- indications of interruptions of supply according to the Energy Industry Act.

	Pipeline network	Pipeline facilities	Consumer installation
Asset data	Details on specific length of pipelines (for gas service lines: additionally amounts)	Details related to amounts	------
Incident Data	Detailled Information	Detailled Information	Detailled Information
Gas odour notifications			
Indications of interruptions of supply			

Figure 1: Data scope according to DVGW G 410 (A)

All operators of gas-technical energy systems as defined by the Energy Industry Act must now submit their inventory data to the DVGW each year. As in the past, incident data must be reported immediately after the occurrence of an incident to the DVGW, to the energy supervisor in the Federal 'Land' concerned and to the Federal Ministry for Economic Affairs and Energy. This requirement does not apply to incidents only involving a release of gas only from pipelines or service connections with no other consequences – these must be reported annually by a due date. The DVGW treats data supplied by operators as confidential (cf. Figure 2).

The DVGW publishes standardized reports at reasonable intervals. These reports contain only aggregated data from which no inferences can be drawn about individual system operators but which do reflect the general developments taking place in the German gas industry. The reports make statements about changes in pipeline and plant inventory and about trends in safety performance indicators. The first report was published in 2016 [4].

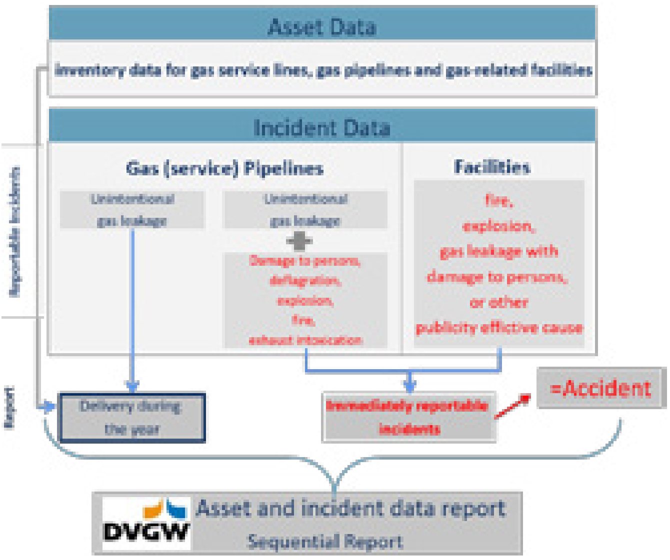

Figure 2: Data collection and reporting according to DVGW G 410 (A)

RESULTS OF DATA ANALYSIS FROM 2011 TO 2014

ANALYSIS OF PIPELINE AND SERVICE CONNECTION INVENTORY

Data is collected broken down by domestic service connections, pipelines operated by distribution system operators (DSOs) and pipelines operated by transmission system operators (TSOs). For pipelines an additional distinction is made between pressures of MOP ≤ 16 bar and MOP > 16 bar.

> *"All Operators of gas-technical energy systems must submit their inventory data to the DVGW each years. As in the past, incident data must be reported immediately after the occurrence of an incident to the DVGW, to the energy supervisor in the federal state and to the Federal Ministry for Economic Affairs and Energy."*
>
> **Frank Dietzsch**

For the first analysis, the released data for the data collection years 2011 to 2014 were averaged. A comparison of the sum of the pipeline lengths from the structural data collected by the DVGW (average for 2011 to 2014: 318,537 km) with the sum of the pipeline lengths of the 2014 network structural data of the Federal Network Agency BNetzA [5] (518,683 km) indicates a coverage of 66 %. For MOP > 1 bar pipelines the coverage is no less than 93 %.

Service connections are differentiated by their pressure (MOP), diameter and material. All in all, 7,987,656 service connections with a total length of 131,946 km are covered. Figure 1 shows the percentage breakdown by these distinguishing criteria. 72 % of all connections use PE as their material, reflecting the rapid system expansion in the last decades and a high rate of renewal of service connections in the gas sector.

Approximately 300,000 km of DSO pipelines have been surveyed. Here again the proportion of plastic now predominates, with 54 % of pipelines made from PE and 37 % from steel. With just 0.8 per thousand, grey cast iron is all but irrelevant in the overall pipeline inventory. If we look at the age structure of pipelines we find that 47 % were constructed or refurbished between 1990 and 2014. This bears witness to a young and modern gas grid, something which the material structure already indicated with PE and PE coating. The average age of the grid is around 30 years.

DVGW statistics show that transmission system operators own a reported pipeline inventory with a total length of 21,024 km. As well as MOP and year of construction, in their returns TSOs also differentiated pipelines in the MOP > 16 bar category by diameter, material, wall thickness and coating. In terms of possible comparability therefore, the DVGW has followed and applied the data collection criteria of the European EGIG statistics kept since 1970 (European Gas pipeline Incident data Group, cf. www.egig.eu). Similarly to the DSOs, the average age of these pipelines is something over 35 years. In statistical terms, the most frequent material used in TSO pipelines is StE 480 (40%), with a wall thickness of over 5 and up to 10 mm (47.1%) and with equal proportions of PE or tar/bitumen coating (approx. 33% each).

ANALYSES OF PIPELINE AND SERVICE CONNECTION INCIDENTS

During the period from 1981 to 2010, leaks and damage incidents – divided into six categories of cause – were reported within DVGW damage and accident statistics. Starting from the 2011 reporting year, the definitions given in DVGW code of practice G 410 apply, with only incidents involving an unintended gas release being reported.

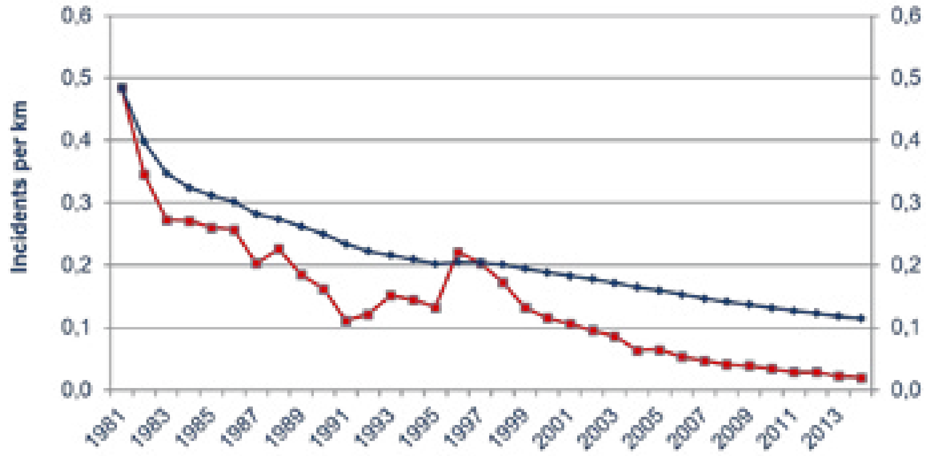

Figure 3: Trend in incidents from 1981 to 2014 on all gas pipelines

Figure 3 shows that the incident rate on all gas pipelines has decreased by a factor of ten in the last two decades. The temporary rise in the incident rate in the late 1990's was put down to an increased rupture hazard with grey cast iron (see also Figure 4), a trend that was countered with appropriate measures (a nationwide programme of grey cast iron rehabilitation). From the year 2000 onwards the incident curve falls more uniformly compared with previous years, and this should be down to the improved quality and quantity of the collected data.

The total number of incidents has been standardized to the corresponding total operational experience so as to ensure comparability with the European EGIG database [6]. The term 'operational experience' here refers to the cumulative total pipeline length which increases year on year by the current total pipeline length.

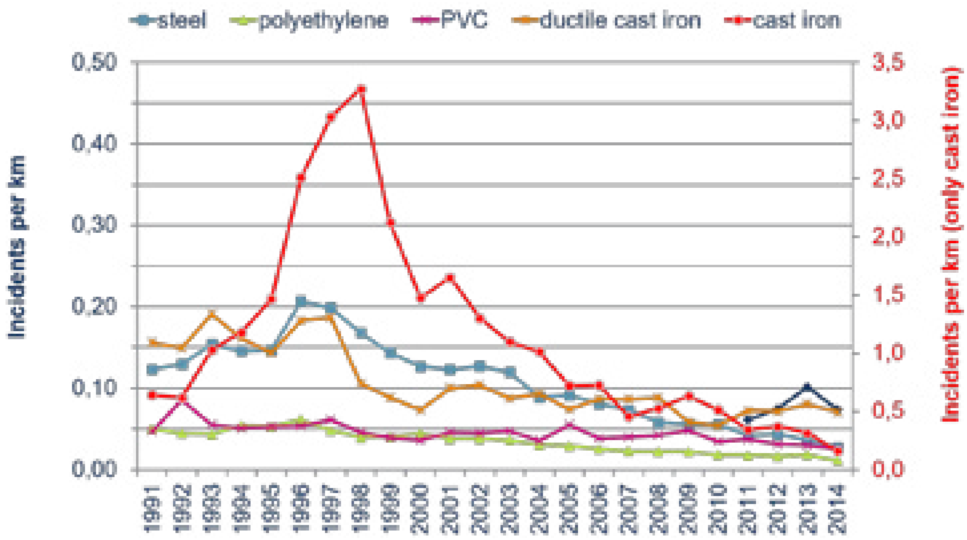

Figure 4: Trend in incidents between 1991 and 2014 on all gas pipelines by material groups

Incidents on gas pipelines during the period 1991 to 2014 are shown in Figure 4 by pipe material. The peak in grey cast iron already mentioned is clearly visible between the years 1995 and 2000. In more recent years there has been a clear tendency for material-specific damage rates to fall within the range of 0.1 incidents per kilometre (except for ductile cast iron).

An analysis of the data also shows that mechanical third-party intervention (e.g. damage caused by excavators) is the main cause of incidents involving service connections and supply lines made of plastic. With service connections made of metal materials, a high percentage of corrosion is found to have been the cause of the incident. Compared with all other materials the damage rate of 0.8 incidents per kilometre for service connections made from ductile cast iron (GGG, cast iron with globolitic graphite) is the highest.

The metal supply lines show a high proportion of corrosion as the cause of incidents, with the percentage for bituminised steel lines being around 80 %. The proportion is significantly less with younger steel pipelines with a PE coating. On average the incident rates for steel pipelines with a bituminised coating and cathodic protection (CP) are about one sixth of those with a bituminised coating but no CP. Compared with plastic-sheathed steel pipelines the positive influence of CP

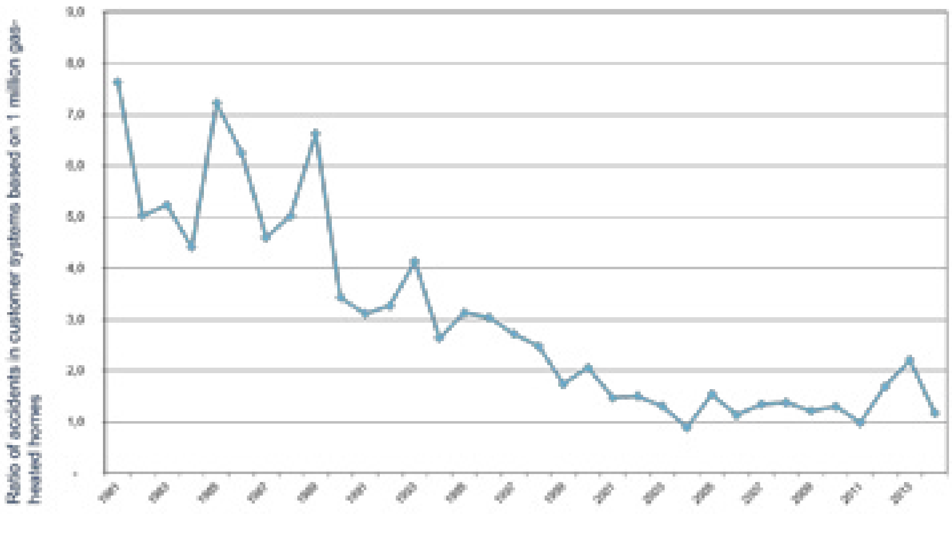

Figure 6: Ratio of accidents in customer systems based on one million gas-heated homes

can be clearly seen here, not least a consequence of the greater age of the lines. Among the supply pipelines too, grey cast iron (untreated) returns the highest incident rate (0.363 incidents per kilometre).

For TSO pipelines the number of incidents is a mere 2.2 per thousand of the number reported for DSO supply lines, and so the statistical analysis is limited to a consideration of the cause of the incident. Corrosion has the biggest share of incident causes, followed in second place by third-party mechanical intervention. Material defects and incorrect working (e.g. drilling, assembly and construction defects) follow together in third place.

An analysis of the distribution of all incidents with a recorded leak size indicated for the period under review that approx. 56 % of incidents are very small in size (e.g. corrosion leaks), whereas only 1.4 % of incidents involved a very significant release of gas. Approx. 30 % of all incident reports were unable to give any qualified leakage size (meaning an unknown size of leak).

IMMEDIATELY REPORTABLE INCIDENTS
WITH OPERATORS' OWN SYSTEMS

Trends in immediately reportable incidents involving systems owned by TSOs and DSOs since 1981 are shown in Figure 5. The rate of immediately reportable incidents shows a continuous reduction, especially for the number of incidents based on operational experience in the past 20 years.

In the period under review – 2011 to 2014 – third-party mechanical intervention was the main cause of all immediately reportable incidents, with 39 %, followed by third-party thermal intervention with 25 %.

IMMEDIATELY REPORTABLE INCIDENTS
WITH CUSTOMERS' SYSTEMS

The ratio of immediately reportable incidents per annum to the number of gas-heated homes [7] for the period since 1981 is shown in Figure 6.

Just as with the immediately reportable incidents in system operators' own plants, the immediately reportable incidents in customer systems also reflect a continuous decrease. In the past 15 years overall there have been between 1 and 2 accidents per million gas-heated homes per annum.

In the period 2000 to 2014, the immediately reportable incidents broken down by causes are distributed between component defects "technical defects", e.g. gas piping, gas appliances or waste gas systems (34 %), installation-related defects "in-

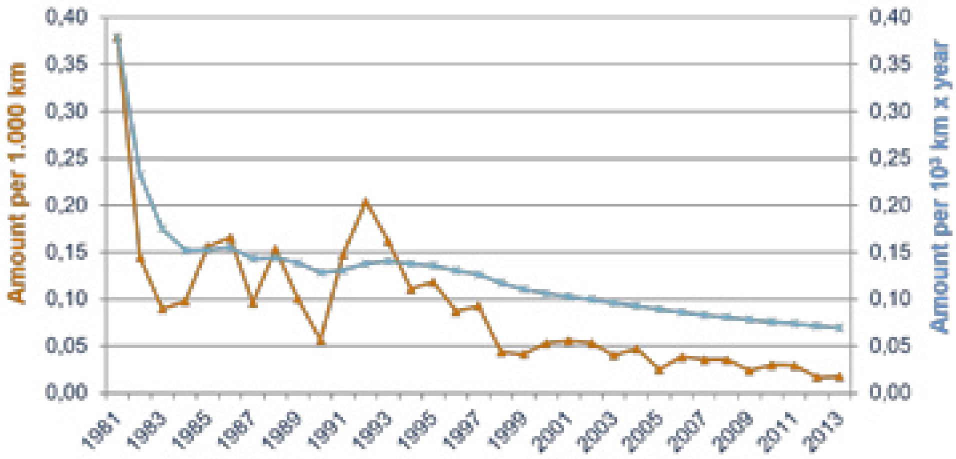

Figure 5: Trend in immediately reportable incidents since 1981

"In the period from 1981 until today the tendency of the absolute total incident rates has been decreasing by 90 Percent and is presently moving on a low historical level of 0.01 incidents per 1,000 km per year."
Frank Dietzsch

stallation errors" (10 %) and faults caused by customers such as "deliberate interference with the gas system" (28 %), "operator error/lack of maintenance" (14 %), "incorrect intervention in the gas system" (11 %) and "inadmissible changes in the set-up of gas appliances" (3 %). Defects caused by customers therefore account for 56 %.

SUMMARY AND CONCLUSIONS

In the period from 1981 until today the tendency of the absolute total incident rates has been decreasing and is presently moving on a low historical level. The normalised incident rates on gas pipelines (transport and distribution network) are also decreasing and have stagnated for at least ten years independent from the pressure range.

This can be interpreted as a steady improvement in quality and safety standards in the operation of gas pipelines according to the DVGW codes of practice.

The increased use of plastics as a material in pipeline construction by distribution system operators as well as the rehabilitation of pipelines made with grey cast iron is one reason for the general decline in incident rates. Incident analyses also indicate a significant reduction in corrosion incidents with steel pipelines that have cathodic protection (CP) as opposed to those with no active CP. We should emphasise the age-specific analysis of the incidents which shows that gas pipelines constructed prior to 1970 return an incident rate that is significantly higher than more recent construction years.

An analysis of all immediately reportable incidents shows the main cause as being mechanical intervention by third parties, followed by thermal third-party intervention. Thermal third-party intervention proves to be the main cause among domestic service connections while mechanical intervention by third parties is the predominant factor in high-pressure gas pipelines over 16 bar. It should be remembered here however that the level of incidents among transmission system operator pipelines with the greatest dimensions is very low, at just 2.2 per thousand of the rate for distribution system operators.

The quantity and quality of the statistical data that is now available means that the information that is to hand provides a vital framework for decisions on rehabilitation issues for gas system operators in Germany. Taking their lead from DVGW Bulletin G403 1), companies can match these changes in the rates of incidents with their own data with a view to updating their renewal and maintenance strategies if need be.

Furthermore, besides the evaluation and analysis of security-relevant operating statistics communication and reporting have a major significance. Regarding gas incidents and accidents the prompt availability of information is a substantial requirement in order to be able to give statements opposite market partners, the public and legal authorities and in order to specify causes and give professional assessments.

1) 'Decision Support For The Maintenance Of Gas Distribution Networks'

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Dr. Michael Steiner > Open Grid Europe

IMPLEMENTING THE INTEGRAL DVGW SAFETY CONCEPT AT

Open Grid Europe
The Gas Wheel

ABSTRACT:

The construction and especially the operation of high pressure gas pipelines has to be performed according to a very high safety standard considering economic aspects too. Hence the state of the art and relevant national and international experience should be used for the construction and operations of high pressure gas pipelines.

High pressure gas pipelines constructed and operated according to the rules of the DVGW are technically safe, but they have to be protected against impacts by third party interference or possible ground movement. To achieve such protection additional measures have to be taken especially for areas with additional need of protection because of possible hazards. For the construction of new pipelines technical measures are preferred whereas organizational actions should be selected for pipelines in operation.

In this paper the systematic assessment of hazards and measures is described in extracts for the construction of high pressure gas pipelines or for pipelines in operation. In particular technical measures like increase of safety factor, depth of cover or marker posts and organizational measures, e.g. repeated Inline Inspection, CP-measures and PIMS are discussed.

REVISED DVGW CODES OF PRACTICE

Under the High Pressure Gas Pipeline Ordinance (Gashochdruckleitungsverordnung - GasHDrLtgV) high pressure gas pipelines in Germany that are used to transport natural gas at pressures over 16 bar must be constructed and operated so that they do not compromise the safety of their surroundings or have a detrimental effect on the environment [1]. Section 2 of the Ordinance presumes that pipeline construction and operation will be state-of-the-art provided the DVGW codes of practice are complied with.

The required state-of-the-art is anchored in particular in DVGW codes G 463 (A) [2] and G 466-1 (A) [3] which give a very detailed and comprehensive description of the construction and operation of high pressure gas pipelines.

In the course of regular reviews a number of different project groups have analysed the safety philosophy of the DVGW codes for the transport of natural gas through underground high pressure gas pipelines and have generally updated it in line with the state-of-the-art. Taking due account of the safety-related, environmental and commercial framework they have looked at the entire process of transmitting natural gas through buried high pressure pipelines, i.e. from the alignment planning stage through design and construction to operation and maintenance. Consideration was given among other factors to other national and international standards and in particular an analysis of past failures and incidents.

"An evaluation of DVGW incident data collection up to 2014 indicates a very high safety standard and reliability as demonstrated for example by the sustained fall in the number of incidents. For example an almost 90% reduction in incidents on gas pipelines has so far been achieved since 1981 even though the total length of pipeline network has risen significantly."
Dr. Michael Steiner

The DVGW rules of procedure [4] have laid down guidelines for safety-related issues in particular, so for example the code of practice must ensure the safety of people and the environment. The deterministic safety concept is retained, although individual probabilistic additions are admittedly possible. The code of practice must reflect the state-of-the-art of transport using high pressure gas pipelines, and all sources of information and insights such as publications, international codes of engineering practice, experience, scienc e and opinions must be incorporated. Particular account must be given to the findings of failure statistics (e.g. DVGW failure and accident statistics according to DVGW G 410 [5], EGIG [6]) when setting the rules.

The worst case failure scenario must be taken into consideration for if it cannot be reasonably ruled out or if minimal effects are to be anticipated. The safety measures must be specified as being mandatory, their effect, availability and accuracy must be evaluated and they must be regularly reviewed in the light of new sources of information and findings. The potential risk should be considered with the nature, number and effectiveness of the safety measures, and the safety measures which are applied in practice must be incorporated in the engineering code [4].

The deterministic safety concept for high pressure gas pipelines has been proven over many years of operation and the pipelines which have been laid accordingly are technically safe, yet they must still be protected from external effects such as third- party interference or ground movements. The DVGW code of practice focuses on two main mechanisms for ensuring safety [7, 8, 9]. First there is the high level of technical safety equipment in high pressure gas pipelines, and second the protection of pipelines from external interference. To make sure that the selected safety measures can provide meaningful protection from possible hazards, a) all possible hazards must be analysed and b) the quality of the corresponding safety measures must be very high.

The revised Technical Rules for the Construction of New High Pressure Gas Pipelines DVGW G 463 (A) place the emphasis on structural measures. When planning the route of high pressure gas pipelines for example, consideration must be given to their safety and to protecting

people and the environment. Factors to be allowed for include the future operation of the pipeline, existing soil conditions and potential outside interference.
For the construction of high pressure gas pipelines the revised DVGW G 463 (A) has increased the following safety measures compared with other standards:

- Max. usage factor of 0.625 or min. safety factor of 1.6
- Minimum depth of cover 1 m
- 100% weld seam testing
- Additional marking and identification on construction sites
- Water pressure testing with stress test within the development

Where possible and proportionate, the pipeline should be routed in such a way that additional safety measures are not necessary. If a pipeline is being routed in areas with an increased need for safety, e.g. in built-up zones or areas where additional interference with the high pressure gas pipeline is expected, then targeted safety measures must be provided. These measures have to be balanced against one another depending on the type of area and the hazard potential. Such targeted individual measures may involve increasing the safety coefficient, depth of cover, pressure testing requirements, marking or the extent to which tests are carried out, or providing pipeline warning tape or geotextile [2].

The Technical Rules for the Operation and Maintenance of High Pressure Gas Pipelines DVGW G 466-1 (A) on the other hand place the safety emphasis on organisational measures such as condition-based inspection and more frequent inspections within the pipeline development. Potential safety-relevant aspects must be considered when planning and executing inspection and maintenance operations. These include external interference (e.g. from construction work), ground movements, corrosion, mill defects, leaks. Typical safety measures here include

- Pipeline routing and leak tests
- Monitoring cathodic corrosion protection
- Inline inspection
- Assessing ground movements
- Monitoring construction work near pipelines to a reasonable degree.

In areas with an increased need for safety, e.g. in built-up zones or areas which are to be developed or where additional effects on the high pressure gas pipeline are expected, shorter inspection cycles or improvement measures may have to be provided depending on the nature of the area and of the likely hazard potential. On the one hand, according to DVGW G 466-1 (A) the frequency of inspections and maintenance work must be condition-based and appropriate for local conditions, taking operating experience into account [3]. On the other hand, in areas with a heightened need for safety and protection, e.g. where other developments are approaching or have already approached and where additional effects on the gas pipeline are to be expected, denser marking with signposts, signs or marker stones and if necessary with additional warning notices and information must be provided. According to DVGW Code of Practice G 463 (A) these additional signposts, signs or marker stones must be positioned along the pipeline's axis and within sight of one another. If the markings are at a distance away from the pipeline's axis owing to local conditions then the direction and distance must be indicated [3].

The results of failure statistics (e.g. inventory and incident data gathering according to DVGW G 410 or EGIG]) must be taken into account so it is essential that all serious incidents involving an unintended loss of gas and all detected interventions within the pipeline's sphere of influence and which compromise safety must be analysed for their causes and measures designed to avoid future recurrence [10]. The revised DVGW incident data collection system for incidents involving an unintended loss of gas already takes account of the DVGW guidelines in its structural manifestation for the assessment of safety measures and for updating the state-of- the-art. An evaluation of DVGW incident data collection up to 2014 indicates a very high safety standard and reliability as demonstrated for example by the sustained fall in the number of incidents [11]. So for example an almost 90% reduction in incidents on gas pipelines has so far been achieved since 1981 (Figure 1) even though the total length of the pipeline network has risen significantly.

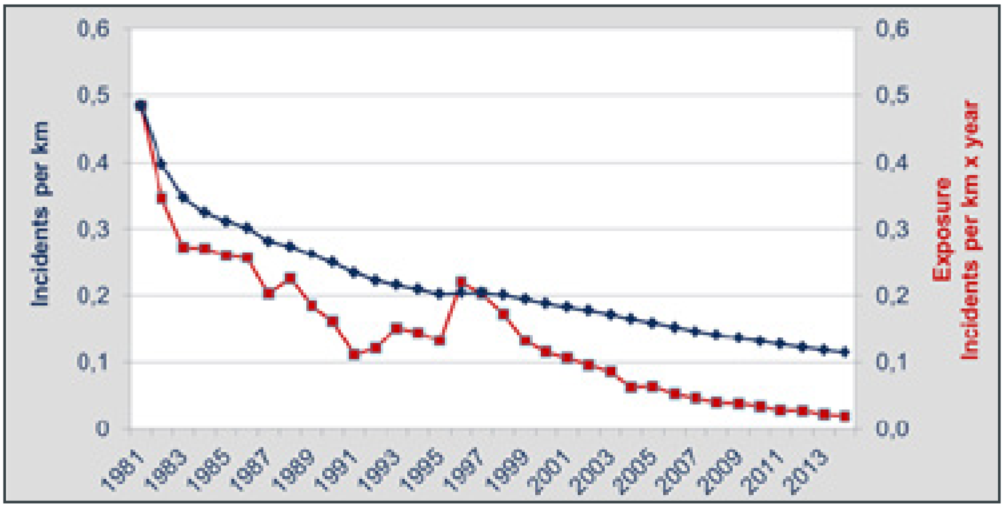

Figure 1: Change in level of incidents on gas pipelines of all pressures since 1981 [11]

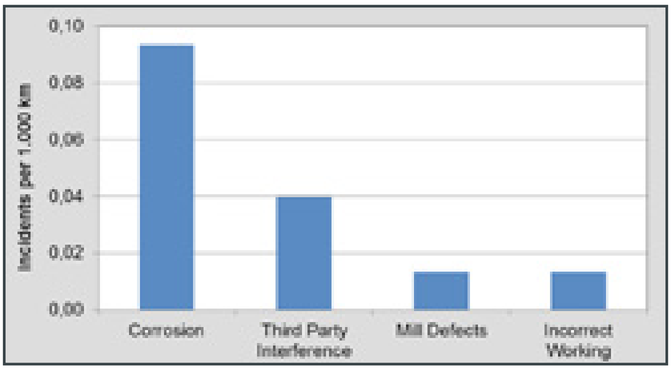

Figure 2: Incidents per kilometre for TSO pipelines of 16 bar and over [11]

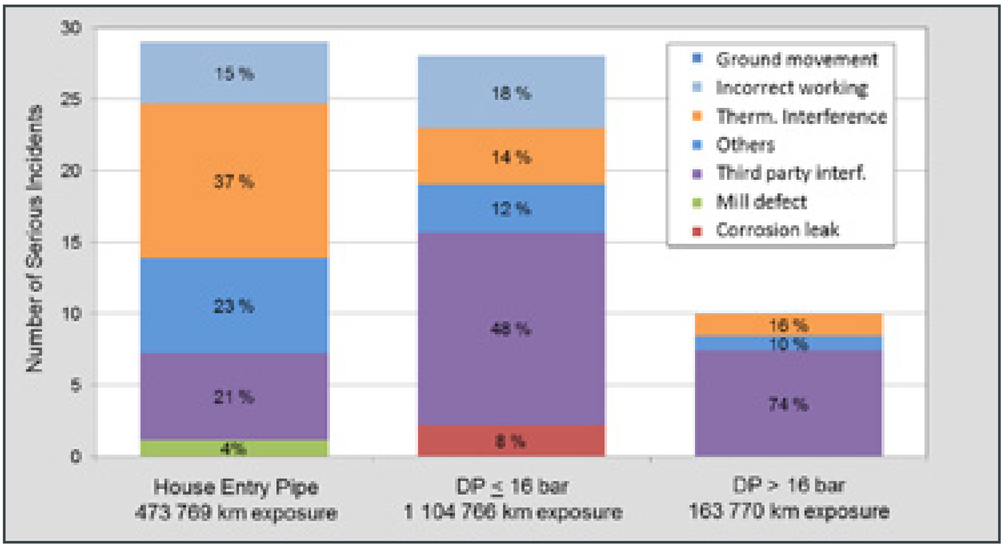

Figure 3: Distribution of all serious immediately reportable incidents on service connections and pipelines [11]

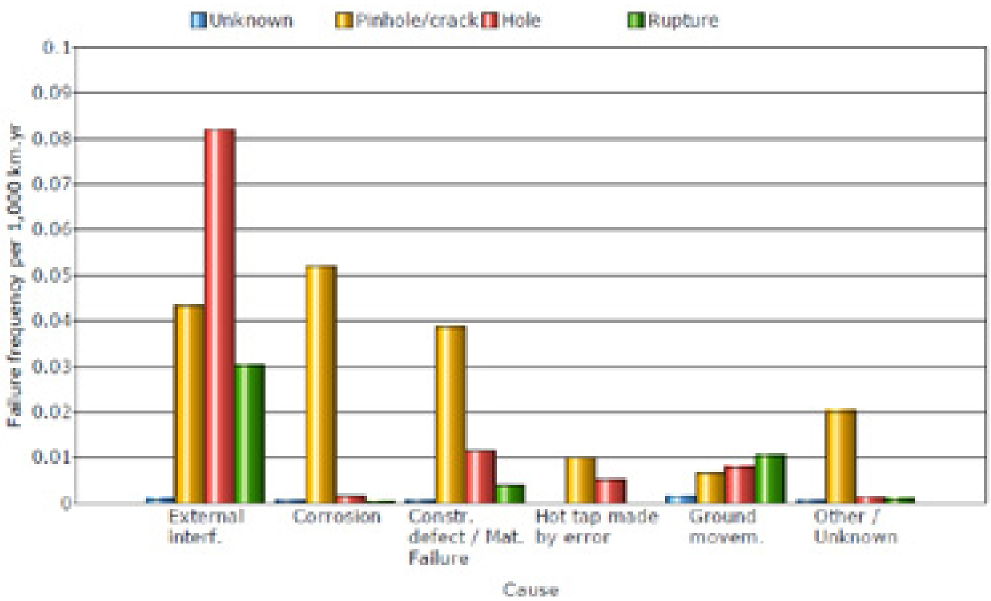

Figure 4: Failure statistics according to EGIG [6]

The distribution of incident causes for high pressure gas pipelines of over 16 bar is shown in Figure 2. Corrosion leaks and mechanical third party interference account for the first and second largest shares of incidents respectively. Material defects and incorrect working (e.g. drilling, assembly and construction defects) follow together in third place.

A detailed look at the distribution of incidents associated with personal injury, deflagration, explosion, fire, flying debris or other circumstances that affect the public and that must be reported immediately is given in Figure 3. It shows that the chief cause of immediately reportable incidents on high pressure gas pipelines over 16 bar is mechanical third party interference at 74%, with thermal third party interference in second place at 16%.

Just as with the serious incidents (ruptures) recorded in European failure statistics EGIG (Figure 4), serious, immediately reportable incidents for mechanical third party interference also occupy first place for German gas pipelines of 16 bar and over (Figure 3). Serious incidents due to ground movements and manufacturing defects on the other hand are not recorded in Germany in the period under review. Whereas external interference is the main cause of incidents for European gas pipelines of 16 bar and over, for DVGW pipelines of 16 bar and over this is corrosion leakage. This is accounted for by the in part very much older gas pipelines which exist in Germany.

At Open Grid Europe new high pressure gas pipelines are constructed according to the requirements of DVGW codes of practice – specifically DVGW G 463 (A) – in conjunction with DIN EN 1594. The latest state-of-the-art for high pressure gas pipelines is therefore being applied in Germany. A systematic hazard analysis is carried out for each individual new pipeline project based on the requirements of the codes.

"Open Grid Europe deploys a large number of different safety measures that are state-of-the-art for high pressures gas pipelines in Germany. These measures enhance the technical safety of high pressure gas pipelines by adding effective protection of the line from external interference, thereby creating one of the safest pipeline systems."

Dr. Michael Steiner

This safety review can result in additional safety measures. It is not normally possible to avoid densely populated areas when installing new high pressure gas pipelines, so structural safety measures are provided locally where required.

Examples of such measures include

- increased cover depth and pipeline warning tape where land cultivation is very deep,
- an increased safety coefficient for large diameter pipelines with a high nominal pressure if a worst case cannot be reasonably ruled out,
- qualitatively improved pipe properties (increased strength, documentation of grinding, digital certificates, applying a barcode [12]) or
- stricter requirements for the pipe coating testing by the Coating Inspector [13]

IMPLEMENTATION OF DVGW SAFETY CONCEPT AT OPEN GRID EUROPE

To ensure that high pressure gas pipelines are operated safely, Open Grid Europe places increased emphasis on organisational measures in line with DVGW G 466-1 (A). These inspection and maintenance operations are planned and carried out giving due regard to the possible safety-relevant aspects. These aspects are essentially damage from outside, external corrosion and possible ground movements as shown by our own failure statistics as well as those of the DVGW and EGIG. According to DIN EN 16348 [14] typical safety measures are surveillance, monitoring cathodic protection, pipeline inspection using inline inspection methods and monitoring construction work. The deployed safety measures are listed against the potential hazards in integrity matrices and brought together to create Open Grid Europe's Pipeline Integrity Management System (PIMS) [15]. The integrity matrix for inline inspection [16] is shown in Figure 5 by way of example. The frequency of individual measures can be increased in areas where there is a high safety requirement. The type of inspection is decided depending on the design of the high pressure gas pipeline (e.g. piggable or not piggable, Figure 6).

Type of Inspection	Baseline	Operation	Integrity Aspects
Geometry (Callipper)	✓	✓	• Dents • Ovalities • Expansions
MFL	✓	✓	• Corrosion • External damage • (Weld Anomalies) • (Mill Defects)
IMU (Mapping)	✓	✓	• Position
IMU (Strain)	✓	✓	• Displacements • Additional Stress/Strain
Interval	1 x	15 – 25 Years	

Figure 5: Integrity matrix for inline inspection

Open Grid Europe implements multiple safety measures in parallel so as to reduce the number of third party incidents in particular. In addition to the types of inspection referred to above, for groundworks close to pipelines these measures include the deployment of trained operators of excavation machinery according to the BALSibau qualification concept (the "National Consortium of Pipeline Operators for Minimising Damage during Construction", [17, 18]). Open Grid Europe also continues to support the ongoing expansion of the central portal for construction enquiries provided by "BIL" (the National Information System for Pipeline Research) [19].

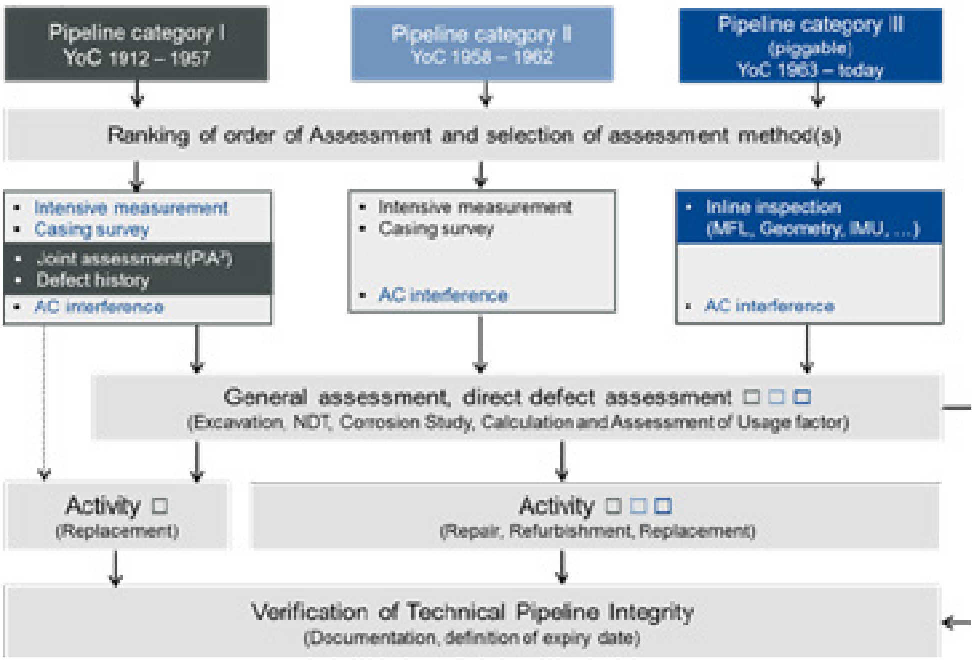

Figure 6: Integrity assessment method for different construction standards

SUMMARY

To sum up we can say that to offset the potential hazards which threaten pipelines, Open Grid Europe deploys a large number of different safety measures that are state-of-the-art for high pressure gas pipelines in Germany. In accordance with current DVGW codes of practice these measures enhance the technical safety of high pressure gas pipelines by adding effective protection of the line from external interference, thereby creating one of the safest pipeline systems.

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Jens Focke > BIL - Federal German Construction Enquiry Portal

A SHIFT OF PARADIGM

FOR CONSTRUCTION INQUIRIES

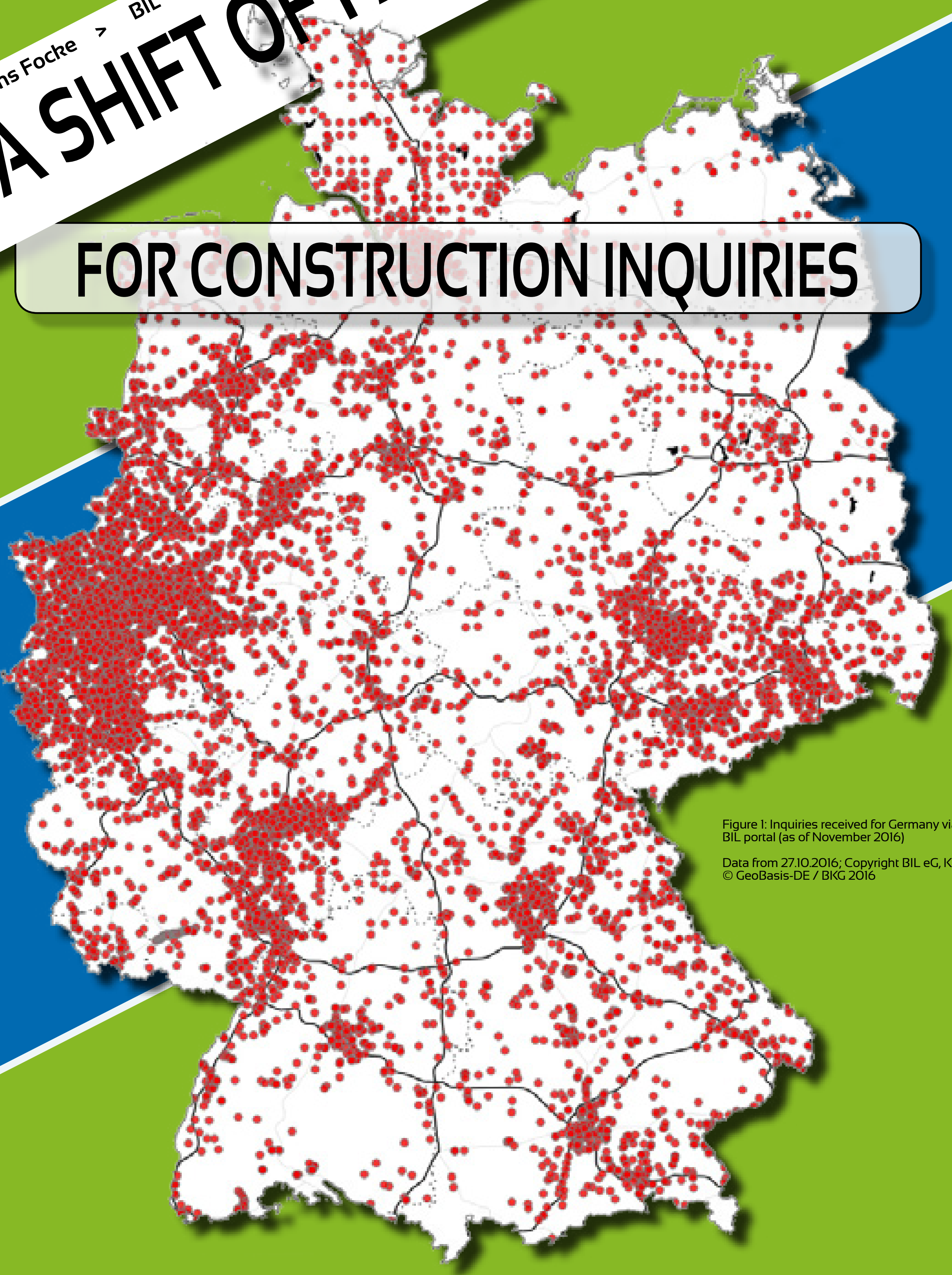

Figure 1: Inquiries received for Germany via the BIL portal (as of November 2016)

Data from 27.10.2016; Copyright BIL eG, Karten © GeoBasis-DE / BKG 2016

ABSTRACT

In macroeconomic terms, the cost of compensating damage to pipeline/cables and cables caused by construction work amounts to an estimated €2 billion per annum.

Much of this damage is due to a lack of information on the location of pipeline/cables during the site investigation phase prior to the commencement of construction. Indeed, both building contractors and pipeline/cable/cable operators seeking to obtain such information will often find that identifying pipeline/cable/cable routes and their operators is far from easy.

An all-digital process available online can go a long way to simplify such inquiries, contributing to the safety of all the players involved. The following report describes the current situation and requirements, and provides a proposal based on recent operative experience in this field.

SITUATIONAL CONTEXT

Digital business processes are on the increase in all industrial sectors. In general, the aim is to boost efficiency, eliminate redundancies and achieve a closer interlinkage of sensor technology and machine control with dedicated technical business processes. In general, commercial business processes are highly standardized and already largely automated without requiring adjustment to specific customer profiles. Widely accepted for private as well as commercial monetary transactions, online banking is a good example of this.

In the context of "Industry 4.0", the focus is on connected manufacturing which can be improved by using suitable sensor technologies and evaluation of measured data in order to optimize production cycles.

In the energy sector, the introduction of Industry 4.0 processes has not yet progressed quite so far. This is partly due to the fact that the focus is not so much on production schemes and that the human interface plays a dominant role in monitoring processes. Germany's digital association BITKOM demands for "digital ecosystems" to be developed in order to promote the digitalization of the German national economy.

"The cost of compensating damage to pipelines caused by construction work amounts to an estimated €2 billion per annum. Much of this damage is due to a lack of information on the location of these assets."

Jens Focke

To implement digitalization, Big Data analysis and automation in the context of Industry 4.0, the following requirements must be met:

1. The business process must be digitizable and comply with a standardized process comprising input and output data that lends itself to automatic processing.
2. The immanent transaction must generate a benefit that can be increased by automated processes which can be digitally supported.
3. The underlying logic of the business process ideally uses intranet - or possibly even internet - services for data storage and data provision/system deployment.

STATUS QUO OF PIPELINE/CABLE INQUIRIES

Most of the business processes of pipeline/cable operators in all domains nowadays serve to monitor critical infrastructures, for instance monitoring underground pipeline/cable networks. As statistically proven, there is a risk of pipeline/cables being damaged by excavators or at least of increased interference with pipeline/cable corridors. All these activities are undertaken without full knowledge of underground pipeline/cable locations. In the context of civil engineering, more than 100,000 instances of structural damage occur within a calendar year, which according to actuarial assessments amount to €500 million in damages paid. Much of this damage could be prevented by setting up a fully functional inquiry process. Providing information on the location of pipeline/cables and construction supervision are business processes that are crucial to safety and form part of a pipeline/cable operator's core competencies. In this context, safety is the overarching topic involving the following aspects:

- Pipeline/cable infrastructure safety to protect and keep pipeline/cables intact and prevent injury to persons or damage to resources
- Reliability of the inquiry process in which
    - the inquiry constitutes a legally secure claim to correct and full information and its exchange between the party pursuing the construction activities and the supervising operator(s)
    - an inquiry process that is transparent in case of damage and an ensuing lawsuit
- Data security in the context of data provision and archiving, also preventing the improper use of data

The afore mentioned aspects are explained in detail below as they contribute to safety in different ways. The requirement of generating a benefit (as listed under 2. above) can thus be met by means of a digitally supported business process.

When investigating a potential construction site, the party pursuing the construction activities is obligated to obtain information on the location of pipeline/cables if it wants to avoid liability for negligence in case of damage. Presumably, the party in question will even be aware of this, but it appears that in a rural area where pipeline/cable corridors are not clearly marked, the magnitude of not meeting this obligation is perceived as comparable to knowingly exceeding a speed limit while driving a car. The likelihood of damage occurring is perceived as low and readily accepted.

This would seem to be the only explanation as to why interference with pipeline/cable networks occurs time and again, without having inquired about their location.

This is essentially the reason why pipeline operators regularly incur substantial expenses to carry out site inspections, both on the ground and by helicopter.

Figure 2: Pipeline/cable inquiry process illustrating the leeway in terms of inquiry and archiving. It can be seen, that only the process to be implemented on the operator side has been standardized by the rules and regulations (code of practice GW118)

According to pipeline/cable operators, the number of inquiries on pipeline/cable locations has doubled since 2010, probably owing to the increase in building activities. While according to section 254 BGB [German Civil Code], pipeline/cable operators are required by law to respond to any inquiries received, there is no general legal duty to inquire.

On the inquiry side, this leads to a situation that is nothing short of absurd: The inquiry process involves time-consuming research in order to identify the pipeline/cable operators in charge of a certain area. Bigger companies have organized this task more or less efficiently while smaller companies tend to place inquiries via mailing lists that are often not exhaustive.

The information to be obtained and exchanged between inquirer and pipeline/cable operator is not subject to any standards and requirements, and thus varies greatly in terms of the content and details communicated. A meaningful communication, however, requires current knowledge of the situation inquired about. The emergence of new operators and new pipeline/cable routes in biogas, solar and cable grids, etc. does not make this any easier. Also, established operators may have changed names due to regulations, resulting in the formation of new corporate units and contacts.

In the interest of customer orientation, many energy utilities now provide a telephone number or email address to contact for pipeline/cable inquiries on their website. In some cases, construction information is requested, and very rarely a geographical description of the site. Download services are provided to known inquiring companies only upon prior registration. For municipal utilities, this is a feasible and secure solution. However, it means the inquirer has to know about this option. In big German cities, underground cables serve up to 40 services and operators, i.e. much more than just the conventional gas, water, power and district heating lines provided by the municipal utilities as commonly known.

In this confusing situation, inquirers often choose to proceed as follows:

- Place several inquiries on the various portals provided by pipeline/cable operators
- Set up a mailing list to contact operators known to them
- Send emails randomly to a list of recipients that is too exhaustive

or

- Outsource the inquiry process to a local company specialized in this field
- Use commercial services to obtain information on the local companies potentially in charge, and forward the inquiry if necessary

Based on the number of incidents caused by third-party interference in pipeline/cable networks, one must conclude that, as a third option, some consciously take the risk of not inquiring.

For the reasons outlined above, inquirers may feel that they are anyway unlikely to obtain exhaustive and reliable information on the location of pipeline/cables in the area. Accordingly, the unrecorded number of construction projects carried out without prior inquiry and involving an unknown risk potential can therefore be assumed to be significant.

Due to the complexity of the situation, inquirers need to

- automatically reach all operators without first having to identify who is in charge.
- submit a complete and fully specified inquiry, i.e. detailing all the information required.
- receive a timely response.
- archive the replies received from a multitude of operators in a structured way.
- receive status updates on the processing of their inquiry from the operator.

NEED FOR ACTION

Regarding interference with pipeline/cable routes, operators of the critical chemical, gas and oil pipeline infrastructures relate the following experiences:

- Incidents still occur on a daily basis, even though excavators should be well aware of the risk potential.

- Excavator damage to steel pipes results in corrosion which can be detected at some later stage in the course of regular in-line inspections, by which time it is impossible to determine who caused it, so operators are left to bear the rehabilitation costs.

- When it comes to planning and constructing new pipeline/cables, operators, too, require information on the underground facilities present in the area. Addressing municipalities in order to find out who is responsible in such matters will often disclose only those operators running pipeline in public space. Mostly, however, new cable routes and existing pipeline/cables are not located in public ground.

- Pipeline operators receive a large number of inquiries that are irrelevant in that they do not fall within their competence and domain of responsibility. This is due to the fact that many inquirers tend to include too many random recipients in their mailing lists.

PIPELINE/CABLE INFRASTRUCTURE SAFETY

To ensure safety during planning and construction projects, full knowledge of the local pipeline/cable infrastructure is needed. Operators also need to receive a full description of the measures planned, including those that may have a critical impact on safety. Local operators need to be in a position to assess to what degree they may be affected depending on the criticality of the measures planned. Naturally, the effect of local asphalt road works will be less critical than the erection of a solar power plant close to a gas pipeline/cable. Also, time and again, unknown underground cable routes are damaged, which mainly affects the connected data users.

With the new legislation in the energy sector and the development of new power utilities and an evolving private market of cable and communication companies, obtaining full information on local pipeline/cable locations has become increasingly difficult, if not downright impossible.

PROCESS SAFETY

The pipeline/cable inquiry process consists of a query and a reply which correspond to the input and output data of a business process. The centralized provision, transfer and archiving of data is in the common interest of inquirers and operators. In many cases, inquirers will receive information from more than just one operator. Both inquiries and replies must specify all relevant details, and the multitude of replies coming from the operators affected must be accessible for later reference.

As part of a legal transaction, this information must be managed digitally in a uniform infrastructure, ideally in a hosted application providing the same information to both parties via the internet. Also, both parties rightly demand traceability and status updates on the process steps throughout the work flow.

DATA SECURITY

Data security is of utmost importance, as underlined by the current legislation on personal data. Furthermore, according to the current special laws e.g. the current legislation of the Federal Office for Information Security (BSI), infrastructures critical to security – which include power supply lines – must be protected.

The European INSPIRE directive 2007/2/EC on the disclosure of public planning data also affects power utilities, standing in stark contrast to their need for data privacy. Apart from the importance of protecting their infrastructures, pipeline operators also assert the need to protect their data. They wish to disclose this detailed data only upon request, rather than making it available online where they would lose control over its use. Therefore, providing data only upon request also contributes to data privacy and security on the whole.

In the context of digitalization, "safety" no longer means just protection from damage, but also security in the sense of protection against threats. To take maximum effect in macroeconomic terms, this process, which varies from company to company, must meet the following requirements:

- A centralized inquiry and archive platform rather than an individual question-and-answer-based infrastructure that does not cover all operators.
- Disclosure of information in line with requirements. To determine local operators for planning purposes, detailed information on pipeline/cable locations often is not required.
- Data must not be disclosed and used randomly. Operators are liable for their infrastructure and therefore must know whom they are disclosing information to, what it will be used for and when. The currentness of data, information value and field of use are security-relevant.

In a centralized inquiry system, a multitude of construction projects will be stored. Data security must be guaranteed by using a suitable data center. The risk of information being spied out can be detected by big data analysis methods. For instance, systematic queries can be detected both geographically and when a certain party places inquiries repeatedly within a short time.

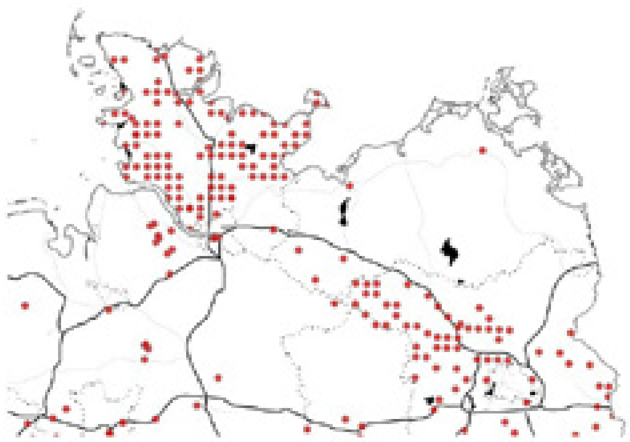

Figure 3: Systematic geographic inquiry pattern in the context of site investigations through dynamic probing. Data from 27.10.2016; Copyright BIL eG, Karten © GeoBasis-DE / BKG 2016

PROPOSED SOLUTION AND OPERATIVE EXPERIENCE

A centralized inquiry portal with a high level of user acceptance is the only solution. As a single point of entry, it has to meet the requirements outlined above. It must be noted that this should to be considered an approach still under development rather than a destination already reached.

With 1 million construction sites in Germany each year and figures rising, the construction industry is in need of information on pipeline/cable and cable routes both underground and aboveground. A simplified inquiry process can contribute to safety and effectiveness.

One year after going live, the BIL portal has recorded an annual number of over 800 inquiries per week. Pipeline/cable operators and inquirers from the construction sector rate this as a success. However, there is still a lot of potential to be tapped by getting even more operators involved, which will lead to an increase in inquiries from construction enterprises in the region as well as from operators.

In this regard, the microeconomic benefit that certainly exists is almost secondary, as the primary achievement is the increased safety in civil engineering that averts macroeconomic damage. BIL's cooperative form of organization is without alternative because it makes clear that there is no intention to generate profits and requires it to observe absolute transparency in the way its presents itself on the market.

See Figure 1 for Inquiries received for Germany via the BIL portal.

SAFETY AS AN OPPORTUNITY

Generating a benefit in terms of safety is a goal worth striving for in the interest of operators, regardless of whether stipulated by law or not.

Those who leave the introduction of necessary protective procedures and expedient safety measures to the legislator will run the risk of losing control over their core business.

The goal therefore must be a centralized and harmonized pipeline/cable information process consisting of the inquiry, the information provided and the archiving of both. A simplified process that benefits the inquirer will be generally beneficial and enhance safety in many respects. Conversely, when operators choose to realize a silo approach, this entails risks that inquirers alone can hardly mitigate.

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The intention of the approach proposed by BIL is to increase safety so as to generate a tangible benefit for all players involved, including insurance companies and claimants in case of damage. The approach is always assessed against the state of the art. An ideal scenario must not only be prescribed as a goal to strive for, but should also be taken as an invitation to get involved in a joint approach.

A joint approach mitigates risks and thus contributes to safety. An all-digital business process is transparent and quick. With solid arguments on its side, this is what BIL strives to achieve with its Germany-wide construction inquiry system.

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