METHANE
GUIDING
PRINCIPLES

Reducing Methane Emissions: Best Practice Guide
Transmission, Storage, LNG Terminals and Distribution

September 2020

Disclaimer

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Glossary

Blowdown
Removing natural gas from, or de-pressurizing, a pressurized pipeline or vessel. The gas can be released into the atmosphere directly or through control systems.

Distribution
The downstream part of the natural gas supply chain which contains mains, service lines, and customers' meters. This segment includes above and below ground piping and other equipment necessary to supply gas to customers.

Distribution mains
Pipelines, in distribution systems, that move gas from inlet gate stations to customers' service lines.

Hot tap
A method of making a new connection to an existing pipeline or pressure vessel without the need to interrupt the use nor empty the vessel or pipeline.

Inventory
A record of all known sources of emissions and emission rates. An inventory provides a summary of emissions over a given period of time.

Leaks
Unintentional emissions from pressurized equipment used in the natural gas industry. Leaks are usually caused by imperfections in or ordinary wear and tear of sealed joints, such as flange gaskets, screwed connections, valve-stem packing, or by poorly seated valves. Leaks can also come from the wall of a pressurized vessel or pipeline, as a result of corrosion or damage. Leaks are also sometimes called 'fugitive emissions'.

LNG
Liquefied natural gas.

Methane slip
Where some of the natural gas (which is mainly methane) that is used as fuel does not burn completely and so some methane is released as unburned gas

Pump down
A process where a compressor is used to remove pressurized natural gas from a pipeline or vessel, by pumping it into another pressurized natural gas system.

Purging
A process where air is removed from equipment or pipelines that have been open to the atmosphere, before returning them to service.

Service lines
The smaller pipes that move gas from distribution mains to individual customers such as residences and businesses.

sm3 (also scm)
Standard cubic meter. In the context of the SI system it is defined as the quantity of gas contained in a cubic meter at a temperature of 15 °C and a pressure of 1.0000 atm.

Stopple
A temporary seal, plug or stopper. They are used to repair pipelines, or to isolate (cut off) a section of pipeline where there is no existing shutoff valve.

Storage
The part of the natural gas supply chain that stores natural gas to be used when there is a high demand. Storage facilities include various types of underground storage (depleted gas reservoirs, salt formations, aquifers), as well as above-ground facilities such as LNG storage.

Supply (Value) Chain
The asset network of equipment and pipelines that allows produced natural gas to reach customers. The supply chain includes production, gathering, gas processing, transmission, storage, and distribution.

Third-party damage
Any accidental damage caused to a natural gas pipeline as a result of activities not associated with the pipeline. Examples are excavations or other private or public works not associated with the natural gas supply (for example, work on water mains). This is different from first-party and second-party damage, which is caused by employees of the pipeline or their direct subcontractors.

Transmission
The midstream part of the natural gas supply chain that contains compressors and large pressurized pipelines that move natural gas from production fields, from entry points to the system (such as international connection points and LNG regassification terminals), or from natural gas processing facilities to industrial customers, distribution systems or storage facilities.

UGS
Underground Storage.

Venting
Releasing the gas arising from a process or activity straight into the atmosphere.

Summary

Methane emissions in the natural gas supply chain arise from venting, fugitive emissions and incomplete combustion (methane slip). Good practice for reducing or eliminating emissions from these sources are described in separate guides developed by the signatories to the Methane Guiding Principles (MGP). However, the technical and economic characteristics of these best practices may vary depending on the characteristics of the segment of the supply chain in which the practice is applied.

This guide describes practices for reducing methane emissions (mitigation measures) from the natural gas transmission, storage, LNG terminals and distribution segments of the supply chain. This guide does not explore emission mitigation measures for emissions from: downstream of the customer meter, nor to LNG liquefaction and LNG transportation emissions.

Because of the large number of mitigation measures that can be used in transmission, storage, LNG terminals and distribution, some practices described in detail in other guides are briefly summarized in this guide, with links to the original guides. Mitigation measures that are unique to transmission, storage, LNG terminals and distribution, or that have different technical or economic characteristics than measures in other parts of the natural gas supply chain, are described in more detail in case studies towards the end of this guide.

Best practice for reducing methane emissions in transmission, storage, LNG terminals and distribution

- Keep an accurate inventory of emissions from all sources
- Prevent emissions whenever possible
- Reduce emissions that cannot be prevented
- Identify and repair equipment that is not working properly
- Track emissions and mitigation activities

Introduction

Natural gas supply chains extend from wellheads to customers in homes, industry, and businesses. Figure 1 shows the portions of the natural gas supply chain that are the focus of this guide. This guide does not explore mitigation options for emissions from:

- **Downstream of the customer meter**
- **LNG liquefaction**
- **Transporting LNG**

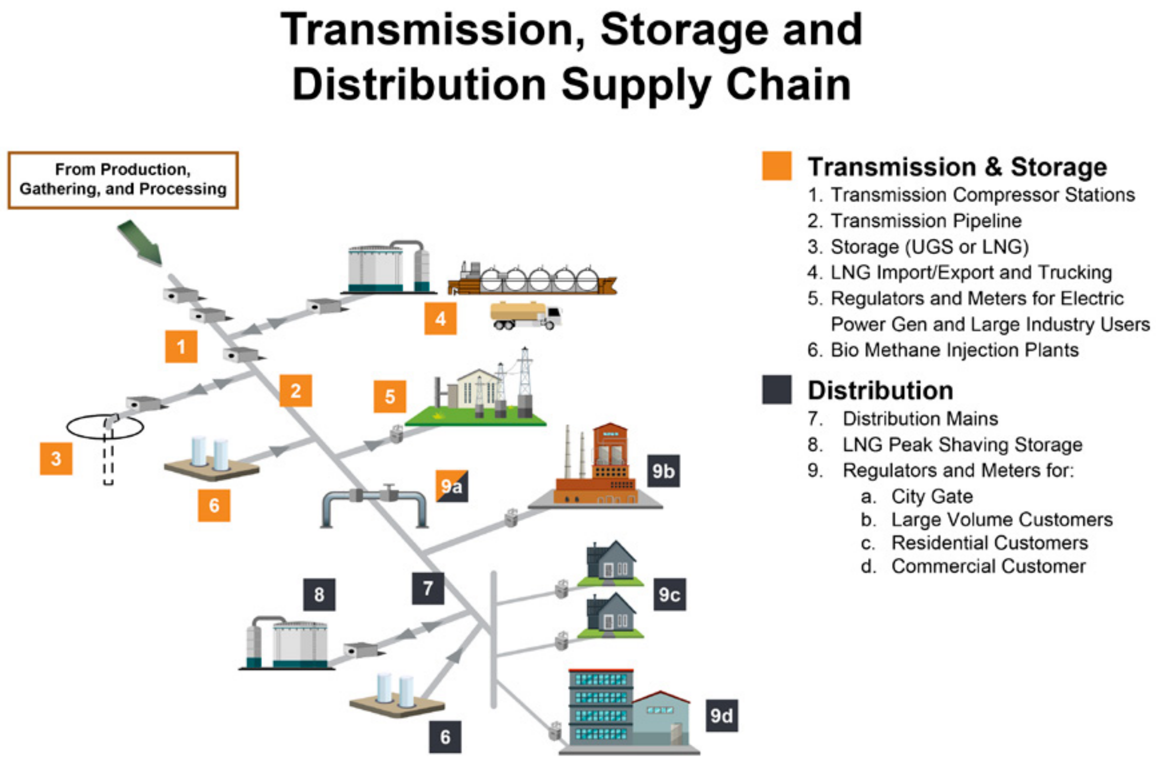
Methane emission sources in the transmission, storage, LNG terminals and distribution segments of the natural gas supply chain arise from various sources including venting, fugitive emissions and incomplete combustion (methane slip). Recent studies suggest that transmission and storage are responsible for approximately 14% of methane emissions from natural gas supply chains in the US, and 23% of emissions of natural gas supply chains in Europe. Distribution is estimated to account for 3% of emissions in the US, and 59% in Europe .[1,2] Information for the net contribution from LNG operations is limited.

Like other segments of the natural gas supply chain, the range in emission rates across sources in transmission, storage and distribution are highly skewed, with small sub-populations of high-emitting sources being responsible for the majority of emissions from a particular site or source type.[3]

Other guides, prepared by the signatories to the Methane Guiding Principles, describe in detail the best practices for reducing methane emissions from venting, fugitive emissions and incomplete combustion.[4] However, reducing emissions from these sources in transmission, storage, LNG terminals and distribution may require different mitigation measures. For example, leaks from buried pipelines can be more difficult to identify and quantify than leaks from above-ground sources, and the cost of accessing a potential leak makes the repair cost higher than for similar above-ground leaks.

Where mitigation measures described in other guides also apply to transmission, storage, LNG terminals and distribution, this guide briefly summarizes those measures and provides links to the appropriate guides.

Figure 1: Segments of the natural gas supply chain covered by this guide



Mitigation measures

Mitigation measures for natural gas transmission, storage, distribution and LNG regasification facilities are summarized in Table 1. For each mitigation measure, the applicable emission type, sector and facility type, and a brief description of the mitigation measure are provided.

Many of the mitigation measures listed in Table 1 are already described in other Methane Guiding Principles (MGP) guides.[4] In this guide, those guides are referred to in the final column of the table. If a measure is unique to transmission, storage, LNG terminals and distribution, or are applied to transmission, storage, LNG terminals and distribution in a specialized way, the table describes which case study to refer to in the next section of this guide for more detail.

Table 1: Mitigation measures in transmission, storage, LNG terminals and distribution.

Source of methane emission	Segment and facility	Emitting equipment or emission event	Mitigation measure	Relevant MGP guide and Case study
Venting from compressors	Transmission (compressor stations) Storage (compressor stations) LNG regasification terminals (compressors)	Centrifugal-compressor seals	Convert wet seals to dry seals Minimize emissions or re-route gas at lower pressure to a recovery unit, flare or low-pressure inlet	MGP Venting Guide
		Reciprocating-compressor rod packings	Regular replacement of rod packing (ideally based on measured emission rates) Re-route vents to recovery units or use as fuel Re-route vents to flare	MGP Venting Guide
		Compressor gas starters	Switch to electric motor starters and avoid gas starters in the design phase if possible Minimize starts if possible Route to gas recovery (preferred) or to flare (if allowed)	MGP Venting Guide and Pneumatics Guide; MGP Engineering Design and Construction Guide

Source of methane emission	Segment and facility	Emitting equipment or emission event	Mitigation measure	Relevant MGP guide and Case study
Venting	Transmission Storage LNG regasification terminals	Pumps (for example, odorant injection)	Use electrically driven chemical pumps	MGP Pneumatics Guide
		Gas-powered pneumatic controllers	Avoid during the design phase Eliminate high-bleed devices Switch to compressed air, electric or mechanically driven devices, or very low emitting devices	MGP Pneumatics Guide
Venting	Storage	Dehydrators	Switch to low- or no-emission dehydration (such as low-temperature separation) Optimize glycol circulation and flash tanks Pipe the dehydrator flash gas to vapor-recovery units or use as fuel Route regenerator vent to the flare, if possible	MGP Venting Guide Case Study 6
Venting	LNG regasification terminals	LNG truck loading	Install dry disconnect couplings Use of nitrogen to purge the LNG hoses Install a system to exchange vapors between tanks and tank vehicles	MGP Engineering Design and Construction Guide Case Study 7

Source of methane emission	Segment and facility	Emitting equipment or emission event	Mitigation measure	Relevant MGP guide and Case study
Venting	Transmission Distribution Storage facilities	Pipeline repairs Works and maintenance Depressurize and blowdown Purging and commissioning	Lower the pressure in the pipeline by allowing consumer drawdown Re-route the gas to an existing network with lower pressure or use it as fuel Recompression Mobile compressor stations Flaring, if allowed and planned.(but not always possible during an emergency) Install plugging equipment to shorten the segment of pipeline involved; use isolation valves to minimize impact Make new connections and repair with a hot tap Reroute the natural gas to a duct burner, thermal oxidizer or flares if possible Use in-line inspection (ILI), or 'smart pig' technologies instead of hydrotests	MGP Operational Repairs Guide and MGP Flaring Guide Case Study 1 Case Study 2 Case Study 3 Case Study 4
Venting	Distribution	Commissioning	Vacuum commissioning in distribution	Case Study 8

Source of methane emission	Segment and facility	Emitting equipment or emission event	Mitigation measure	Relevant MGP guide and Case study
Venting	Distribution	Third-party damage and resulting gas release	Programs and policies to avoid third-party damage, installing excess flow valves in service lines	Case Study 9 Case Study 10
Fugitive emissions and venting (storage well operations)	Storage (underground storage)	Well heads and downhole well components	Monitor the integrity of the well Leak detection and repair (LDAR) programs and directed inspection and maintenance (DI&M) programs	MGP Leaks Guide and Operational Repairs Guide Case study 5
Venting and flaring	LNG regasification terminals	Boil-off gas (BOG)	Boil-off gas recovery (for example, install high-pressure BOG compressors to inject non-recoverable boil-off gas into the gas network)	See European Standard[5] EN 1473. MGP Engineering Design and Construction Guide
Fugitive emissions	Transmission Storage LNG regasification terminals Distribution	Equipment and distribution pipelines	Leak detection and repair (LDAR) programs and directed inspection and maintenance (DI&M) programs Replace leak-prone equipment or pipes	MGP Equipment Leaks Guide MGP Operational Repairs Guide

Source of methane emission	Segment and facility	Emitting equipment or emission event	Mitigation measure	Relevant MGP guide and Case study
Incomplete Combustion (methane slip)	Transmission Storage LNG regasification terminals Distribution	Energy use in engines, turbines and fired heaters	Install automated air/fuel ratio controls Minimize the number of start-ups Increase the combustion efficiency of natural gas-powered engines	MGP Energy Use Guide
		Flares	Minimize flaring by using the gas Improve combustion efficiency by changing flare tips or installing flare ignition systems Flare pilot pressure regulation Use nitrogen instead of natural gas if a flare system is continuously purged	MGP Flaring Guide MGP Engineering Design and Construction Guide
All	Transmission Storage LNG regasification terminals Distribution	All	Achieve continual improvement in methane management	MGP continual improvement

Case studies

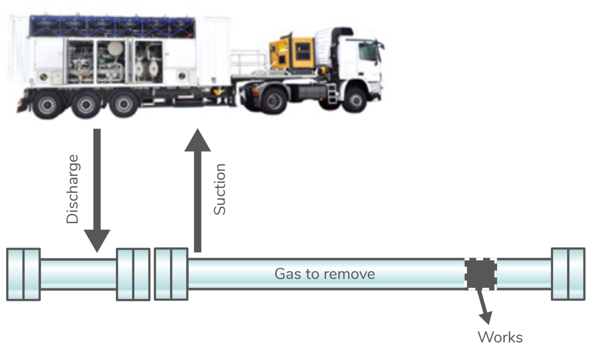
The following case studies describe mitigation measures for large compressor stations; large-diameter, buried, high-pressure pipelines, natural gas storage facilities, LNG regasification terminals, city-gate meter and regulation stations, buried mains (pipelines), service lines, and customer meters.

Table 2: **Case studies**

Case study	Description
Case study 1:	Pumping down pipelines with portable compressors before maintenance (transmission)
Case study 2:	Recovering blowdown gas at compressor stations using permanent compressors (transmission and storage)
Case study 3:	Flaring instead of venting for maintenance (transmission)
Case study 4:	Hot tapping for pipeline connections (transmission)
Case study 5:	Monitoring underground storage facilities (underground storage)
Case study 6:	Minimizing emissions from dehydrators by using vapor compression and low-temperature separation to remove water (underground storage)
Case study 7:	Minimizing emissions through the design of LNG terminals and LNG truck-loading systems (LNG terminals)
Case study 8:	Commissioning with vacuum pumps (distribution)
Case study 9:	Avoiding emissions caused by third-party damage (distribution)
Case study 10:	Installing excess-flow valves in service lines (distribution)

Case study 1: Pumping down pipelines with portable compressors before maintenance (transmission)

Case study:
Large transmission pipelines can pump down, using portable compressors, to lower the pressure in the pipeline pressure before maintenance work. Many companies use this technique.



Description of measures: When maintenance is needed on sections of pipeline, operators block the smallest possible section of the pipeline and depressurize it by venting natural gas to the atmosphere. For a high-pressure large-diameter pipeline, the volume of gas vented may be significant. For example, for each km of a 48" pipeline at 60 bar, 78.000 cubic meters of gas is vented. Where reasonably possible, pipeline operators can lower gas pressure by blocking a section of the affected pipeline and allowing customers to withdraw gas before venting.
For maintenance activities in high-pressure large-diameter pipelines, operators can also reduce venting by using a mobile compressor to remove gas from the section of pipeline to be vented and recompresses it into a nearby section. This is known as the recompression method.

Result: Some portable compressors can pull the line pressure down to 0 bar, reducing the emissions vented by very close to 100%. In 2018, Teréga used the recompression method four times and saved 57,000 sm3 of natural gas that would otherwise have been released into the atmosphere. In 2018, Snam used thirteen interventions with mobile compressors, saving 5,360,000 sm3 of gas. In 2019, Snam saved 3,380,000 sm3 of gas using mobile compressors (eight interventions). GRTgaz uses a combination of three techniques – lowering pipeline pressure through gas consumption, using a mobile compressor, and occasionally, if is too costly in time and energy to recompress the remaining small amount of gas in the pipeline, by flaring. In 2018 and 2019, GRTgaz saved 90% of the gas that would otherwise have been vented, which represents eight million sm3 in 2018 and five million sm3 in 2019, with 40% of the reduction due to consumption, 45% due to recompression and 5% due to flaring.

Costs: The costs of recompressing gas with a mobile compressor depends on the volume of gas recompressed and the duration of the process. An average cost for using one compressor is reported to be about €70,000. As this process takes time, often several days, it is not suitable for every situation.

Learnings: Using pump down to lower pressure in a pipeline before carrying out maintenance and repairs is an effective way to reduce emissions.

Source: Information provided by Snam, Teréga and GRTgaz.

Case study 2: Recovering blowdown gas at compressor stations using permanent compressors (transmission and storage)

Case study: Snam operates a large network of pipelines, including storage facilities. They have introduced a practice which reduces venting for maintenance by using a permanent compressor to deliver gas that might otherwise be vented into a high-pressure system.

Description of measures: When compressors or pipelines in compressor stations are taken out of service for operational or maintenance purposes, gas is depressurized by venting. This emission can be avoided by instead directing the gas to a connected or nearby low-pressure system, or by using an electric-powered compressor to reroute the gas.

Results: Where reasonably possible, Snam installs electric-powered compressors in compressor stations to reroute the majority of gas that might otherwise be vented during blowdown to a temporary storage tank in a high-pressure grid. This reduces venting to a few bars of gas pressure. The reduction in vented gas is about 90% for each intervention. In 2018, the volume of natural gas saved by avoiding venting was about 260.000 m3, and in 2019 the gas saved was about 229.000 m3. The costs and volume of gas saved depend on the operating conditions (typical gas saved is about 30-50.000 m3 per year per installation).

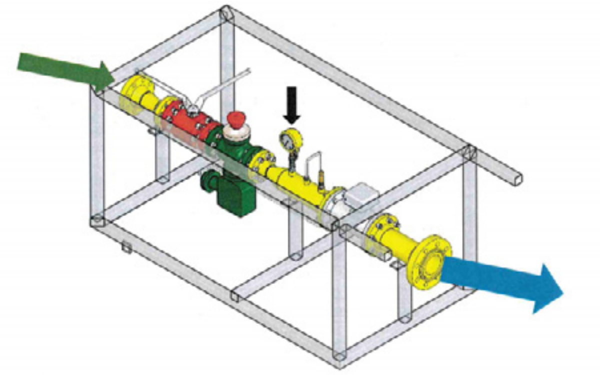
Costs: Up to about two million euro.

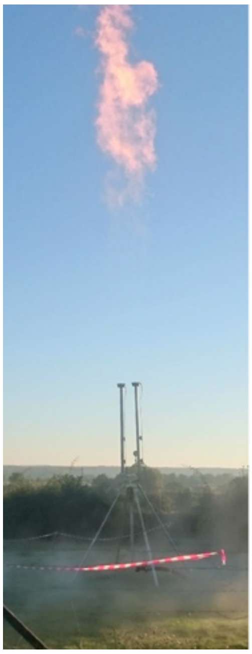
Learnings: This is an effective way to reduce emissions. However, the cost is high, and this measure is mainly approved for environmental reasons, rather than for the cost of the gas saved. Reductions in methane emissions are site specific and depend on the operating pressure of the compressors or pipelines that are blown down. The suitability of this measure could be limited due to the area needed for the compressor installation and the cost, which could be significant compared against the value of the natural gas saved.

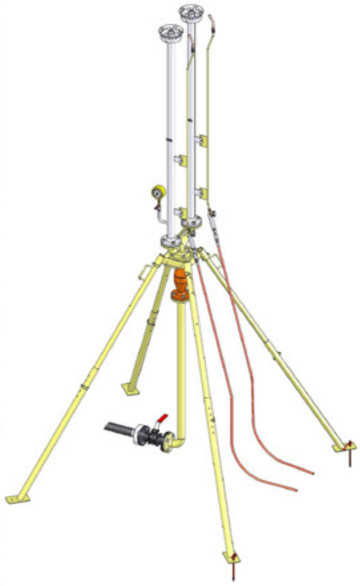
Source: Information provided by Snam.

Case study 3: Flaring instead of venting for maintenance (transmission)

Case study: Teréga flaring best practice







Description of measures: Teréga, a company that operates a transmission system, regularly performs work which requires gas to be vented from pipelines. If gas cannot be moved into another pressurized system, or there is gas left in a pipeline after a recompression, flaring reduces the greenhouse gas impact of the vented gas by converting methane to carbon dioxide.

Teréga has performed several tests to gain experience in flaring. Flaring is noisy and produces a flame several meters high, so it could only be used for small volumes of gas over a short period of time, usually less than two hours.

The mobile flaring system is made up of flexible pipes to connect to the gas network, a pressure reduction line (which expands gas to 8 bar and allows the flaring of 2,800 sm3 of gas per hour), and the flare itself.

Results: In 2018, the Teréga mobile flare was used three times. The total amount of gas flared was 39,800 sm3, which is equivalent to approximately 900 metric tons of carbon dioxide equivalent

Costs: Not reported

Learnings: Other recompression and blowdown methods are limited by a minimum technical pressure (delivery pressure for customers, suction pressure for recompression, etc.). Thus, gas remains in the pipe which may be released to the atmosphere. The tests confirmed that flaring was a way to help Teréga reduce its carbon footprint, and in 2018 Teréga invested in a mobile flare.

Source: Information provided by Teréga.

Case study 4: Hot tapping for pipeline connections (transmission)

Case study: Snam operates a large network of transmission pipelines and uses hot tapping to avoid the need for venting gas when making new connections to a pipeline.

Description of measures: New connections often need to be made to pipelines to expand or modify the existing transmission network. Historically, this required shutting down a portion of the network and releasing gas to the atmosphere. This procedure, referred to as a shutdown interconnect, results in methane emissions and loss of natural gas. Hot tapping is an alternative procedure that makes a new pipeline connection while the pipeline remains in service. Hot tapping involves attaching a branch connection and valve on the outside of the pipeline before cutting out the wall of the pipeline within the branch. This avoids the loss of natural gas, methane emissions and avoids disruption to customers.

Results: Snam applies hot-tapping techniques where reasonably possible, especially when a high number of customers are connected.
In 2018, six hot-tapping procedures saved 1.700.000 sm3 of gas (14% reduction of vented emissions). In 2019, hot-tapping saved 1.030.000 sm3 of gas.

Costs: The average total cost for each procedure, including labor costs, is €70,000.

Learnings: Although this technique is widely applied and considered as common practice in the oil and gas industry, each hot tap has to be evaluated individually. Specific welding procedures must be used to assure a safe process.

Source: Data provided by Snam.

Case study 5: Monitoring underground storage facilities (underground storage)

Case study: Implementing a 'well-integrity management system' and mitigation measures.

Description of measures: The well-integrity management system is based on the two-barriers principle, which implies that two barriers (between the gas inside the well and the outside of the well) should be guaranteed thorough all the stages of the well life cycle. This management system takes account of international standards such as NORSOK D-010 6, ISO 165307, EN19188, API RP 11719. The main objective of well-integrity management is safety, but it also prevents methane emissions. The management system defines roles and responsibilities, standards and policies, and practices and procedures for safely operating wells and minimizing the risk to the environment.

Practices include:

- **Enhanced monitoring**
- **Risk management**
- **Maintenance of the well**
- **LDAR programs at the well head**

Result: The processes involved in well-integrity monitoring and review and enhanced detection of methane emissions include the following.

- **Using pressure-monitoring systems** to detect downhole problems early
- **Optimizing the frequency of well-equipment maintenance** to account for corrosion
- **Frequent monitoring of emissions** from equipment above the ground
- **Defining key performance indicators** (measures to evaluate performance)
- **Compiling all available records** relevant to mechanical integrity of the well
- **Testing the integrity of the well**
- **Producing written risk-management plans**
- **Establishing safe-operating pressures** for existing casing and tubing
- **Assessing risk before working over wells,** or plugging and abandoning wells, and take account of old wells that are no longer in use.

Costs: The cost of implementing a well-integrity management system with external support is €100,000 to €500,000.

Learnings: Many of these monitoring steps are believed to be capable of identifying incipient issues, and so can avoid venting and even prevent catastrophic failures. Many operators already apply these risk-management practices in their operations.

Source: Information provided by Enagás, Snam and Teréga.

Case study 6: Minimizing emissions from dehydrators by using vapor compression and low-temperature separation to remove water (storage)

Case study: An alternative way to remove water from the gas withdrawn from an underground-storage facility is to use a condensate-removal process, instead of glycol dehydrators. Vapor-compression refrigeration or a low-temperature separator (LTS process) condenses the liquids and water in natural gas and removes them from the gas stream.

Description of measures: There are two ways to cool the gas stream being withdrawn from an underground facility. The first is a vapor-compression refrigeration process using a circulating refrigerant such as propane. Propane enters the refrigerant compressor as a vapor. The vapor is compressed and exits the compressor superheated. The superheated vapor is condensed into a liquid and the liquid is rapidly expanded, causing flash evaporation and auto-refrigeration. The cold liquid-vapor propane mixture is sent to a heat exchanger where heat is withdrawn from natural gas and the refrigerant is completely vaporized. The cooled gas with condensed water goes through a separator or 'water knockout' that removes water from the natural gas.

The second method is a low-temperature separator process using a Joule-Thomson (J-T) valve (pictured). The process is designed to force the gas stream through the J-T valve, where the gas stream drops in pressure and temperature. After the J-T valve, the cooled gas stream with condensed water flows through a low-temperature separator that removes condensed water from the gas. This process requires a high difference in pressure between the inlet to the J-T Valve and the outlet to the rest of the gas system.

Results: The LTS technique only applies in plants where there is a significant difference in pressure between storage wells and the pipeline (for example, a 120-bar well and 20-bar pipeline). Where reasonably possible, Snam uses a refrigeration system with propane, or a low-temperature separator process, instead of glycol dehydrators. Methane emission savings, compared to the use of glycol dehydrators, are estimated to be roughly 10.000 sm3 per year per storage site.

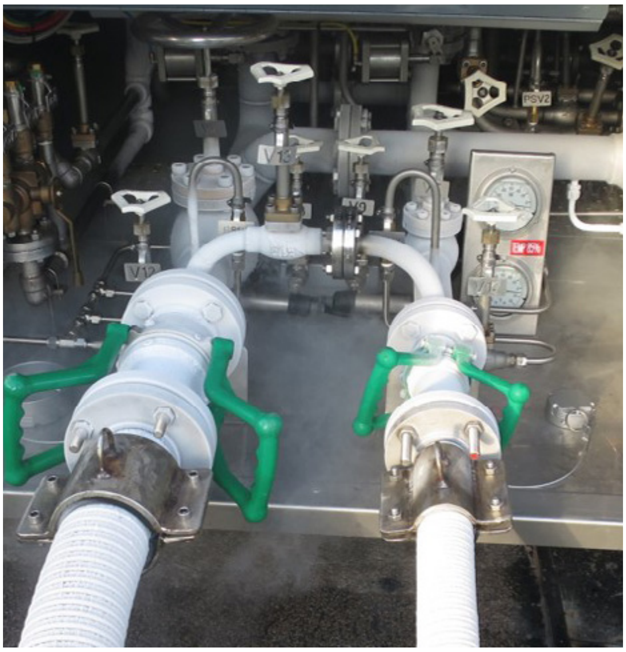
Costs: Not reported

Learnings: This approach is best used in the design phase.

Source: Information provided by Snam.

Case study 7: Minimizing emissions at LNG terminals and LNG truck-loading systems (LNG terminals)

Case study: Enagás used best practices to minimize emissions at three LNG regasification plants.



Description of measures: Enagás classify methane emissions in three categories: fugitive emissions, emissions from venting and incomplete combustion (methane slip). Depending on the type of emission and equipment involved, specific mitigation measures are applied in the LNG terminals.

- **Mitigation for fugitive emissions**
  Since 2020, LDAR programs are conducted every year at all the LNG terminals that Enagás operate in Spain (Barcelona, Cartagena, Huelva). During the LDAR programs, fugitive emissions are repaired in two ways:
  1) Parallel repairs – repairs carried out at the same time as detection and measurement activities (for example, retightening connections and quick adjustments).
  2) Planned repairs – repairs carried out after detection, which could not be repaired at the time and are included in a maintenance plan. These repairs are generally carried out before the end of the year, unless major work is needed. Enagás use a portable detector (a point sensor) in the daily operation of LNG terminals, during start-ups, and during maintenance.

- **Mitigation for emissions from venting**
  Enagás apply a large variety of mitigation from the design phase (eliminating pneumatics powered by gas), to optimizing tank pressure, monitoring rod packing (on the boil off gas compressor), LNG truck loading vapor exchange, purging hoses and LNG arms with nitrogen prior to disconnection, and dry disconnecting couplings (pictured) in the LNG truck loading facilities, and use of hot taps.

- **Reducing boil off gas (BOG) venting**
  During the design phase of their three LNG terminals Enagás implemented BOG recovery units to recover, compress and send the BOG to the recondenser to be converted to LNG. In 2015, Enagás installed high-pressure BOG compressors (pictured) to inject non-recoverable BOG into the grid during loading and unloading operations and zero or low send-out modes.

Result: Since 2013, total methane emissions have been reduced by 89%, fugitive emissions have decreased by 55% and emissions from venting by 98%.

Costs: The cost of LDAR projects in each LNG terminal is around €15,000 per year. The costs of equipment needed for the latest mitigation projects in Enagás LNG terminals are 7 to 10 million euro for each high-pressure BOG compressor and an average of €20,000 for the dry-disconnect couplings in each LNG truck-loading facility.

Learnings: In LNG terminals, where equipment operates under large variations of temperature, having annual LDAR programs is the main mitigation measure for reducing fugitive emissions. Mitigation measures to reduce venting and to recover BOG are effective ways to reduce emissions.

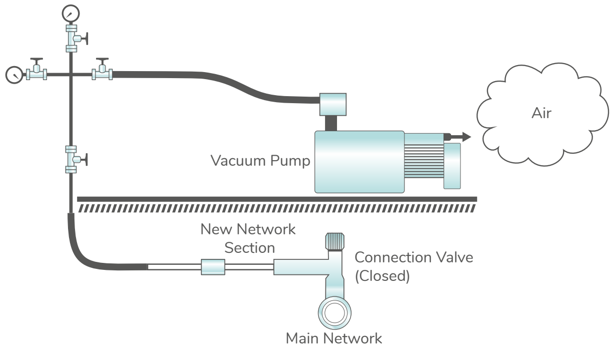
Source: Information provided by Enagás.

Case study 8: Commissioning with vacuum pumps (distribution)

Case study: NEDGIA (a gas-distribution company in Spain) established a practice for commissioning networks using vacuum pumps. This avoids the need to 'purge' natural gas to the atmosphere to remove air in new pipe sections before they are placed into service.

Description of measures: Constructing and commissioning a new network section gives rise to methane emissions during the purging process prior to pressurizing the new section with gas.

Once the tightness test on a new network section has successfully finished, but before commissioning, the inner air is purged using a vacuum pump, which extracts the air from the new section. Afterwards, the section is pressurized with gas without any gas being released.



Result: As a result of this practice, no methane is released to the atmosphere when a new section of main pipeline is commissioned.

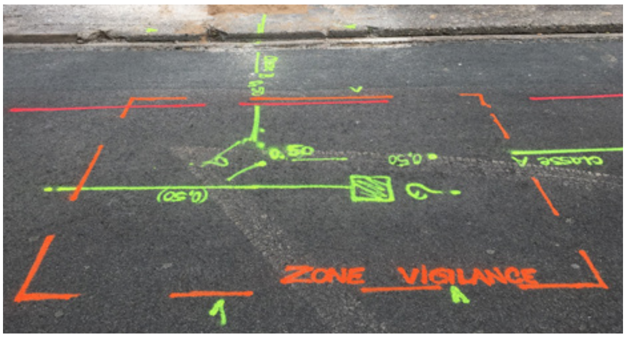
Costs: The costs are low, and are only for the cost of buying vacuum pumps and the operator´s labor costs.

Learnings: New sections of the main pipeline network can be commissioned without releasing methane to the atmosphere. There are important savings in the volume of natural gas that would have otherwise been vented during a purging process.

Source: 'Best Practices for Network Commissioning' presentations by NEDGIA.

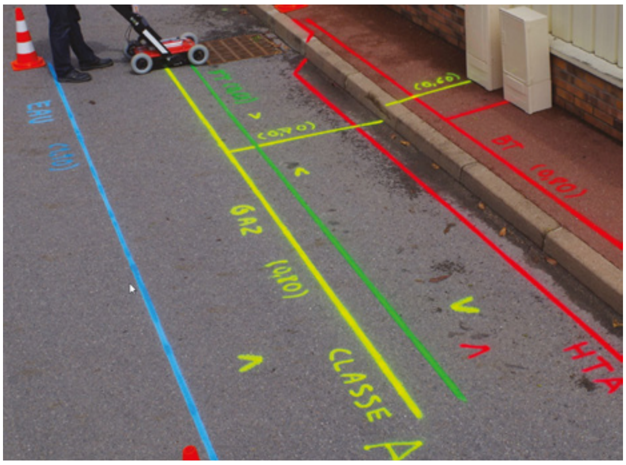
Case study 9: Avoiding emissions caused by third-party damage (distribution)

Case study: Gaz Réseau Distribution France (GRDF) takes preventive actions to avoid methane emissions caused by third-party damage (TPD).



Description of measures: GRDF's distribution mains and services lines can be damaged as a result of unrelated works in close vicinity. Approximatively one third of GRDF's methane emissions each year are linked to third-party damage. For several years GRDF have implemented a plan to reduce third-party damage. The main actions of the plan include the following.

- **Implementing analysis and feedback after third-party damage occurs**
- **Improving the accuracy of maps and geo locations for the network**
- **Creating partnerships** with relevant stakeholders such as the national federation of civil works (Fédération Nationale des Travaux Publics – FNTP) or local authorities
- **Raise public awareness** of the risk of third-party damage
- **Improving the criteria** for choosing external contractors to avoid first and second party damage, and sometimes using aspiration engines instead of mechanical shovels
- **Monitoring companies responsible for recurrent damage**
- **Signs to inform third parties about the presence of gas installations**
- **Defining key performance indicators to assess internal performance**
- **Reducing the impact of methane emissions** related to damage on a service line by using protection devices that automatically stop the gas flow.



Results: Since 2008, as a result of joint actions implemented by GRDF and stakeholders, the number of incidents of third-party damage on distribution mains and services lines has dropped by 50%, while the number of sites around gas networks increased significantly. The number of TPD incidents decreased to under 3000 in 2019.

Around 18,000 employees of local authorities and 56,000 employees of civil works companies have been trained.

Costs: Not reported

Learnings: GRDF are facing a continuous increase in civil works around the gas network. Although the internal performance ratio 'number of TPD/number of work declarations' significantly decreased as a result of GRDF's actions, the absolute value of TPD remained constant. GRDF pursues its actions on TPD, especially on services which represents 80% of global TPD.

Source: Information provided by GRDF.

Case study 10: Installing excess-flow valves in service lines (distribution)

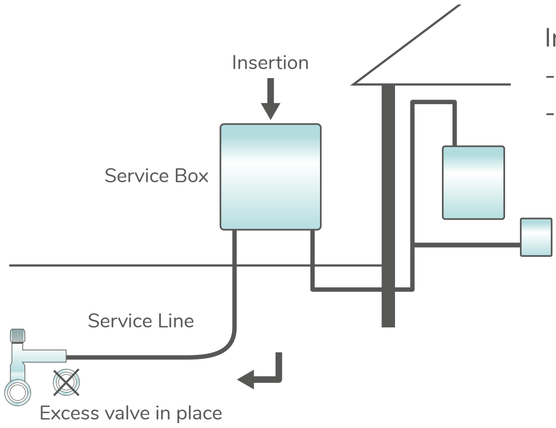
Case study: GRDF installs excess-flow valves in existing polyethylene (PE) service lines. These reduce emissions when service lines are damaged.

Description of measures: When a service line is damaged, the faster the flow of gas is cut off, the lower the emissions. An automatic cut-off is faster than sending a technician to respond to the emergency. GRDF installs automatic flow-cutting devices into their PE service lines to stop the flow when damage occurs. Since 2000, all new service lines are fitted with these devices. GRDF have also had a campaign to retrofit the devices in existing lines. This does not require a trench and the gas flow is not interrupted. GRDF selects the areas with the highest likely damage impacts for the first retrofits.

GRDF initially targeted areas of the network that would benefit the most. For example, GRDF chose areas known to be particularly exposed to malicious acts such as vandalism, urban areas with a high density of construction sites, and areas with a high population.

Excess flow valve for existing service lines in polyethylene

Results: In 2019, these devices stopped the flow of gas in 14% of cases of damage to the network. This avoided significant methane emissions, as damage to the network accounts for 30% of GRDF's total methane emissions.



Insertion in the Service Line
- Trenchless
- No interruption of gas flow

Costs: Not reported.

Learnings: GRDF continues to increase its investments on modernizing the network, and focuses on specific types of network to improve security by adding 10,000 new excess-flow valves to existing service lines each year, with an aim to increase to 20,000 per year by 2023.

Source: Information provided by GRDF.

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Checklist

The following checklist allows the operator to assess progress in reducing emissions in transmission, storage, LNG terminals and distribution. An operator may choose to implement these activities and measures across all facilities or begin only with a selected area.

Checklist		Completed	Percentage of facilities involved
General activities	Keep an accurate inventory of emissions from all sources		
	Prevent emissions whenever possible		
	Reduce emissions that cannot be prevented		
	Recover remaining flared gases to sell as natural gas or natural-gas liquid		
	Identify and repair equipment that is not working properly		
	Track emissions and mitigation measures		
Specific mitigation measures	Evaluate compressor sources for emission reductions (transmission, storage, LNG terminals)		
	Evaluate gas-powered pneumatics for emission reductions		
	Evaluate dehydrators for emission reductions (storage)		
	Implement pipeline maintenance for emissions reductions (transmission, distribution)		
	Implement damage-prevention programs (transmission, distribution)		
	Implement storage-system monitoring (underground storage)		

Checklist		Completed	Percentage of facilities involved
Specific mitigation measures	Implement leak detection and repair (LDAR) programs for emissions from above-ground equipment		
	Evaluate energy use in engines, turbines and fired heaters		
	Evaluate flaring practices to minimize flaring		
	Evaluate emissions during construction		
	Evaluate continual improvement in methane management		

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