Introductory document to the Best Available Techniques to Reduce Methane Emissions from Venting and Flaring Activities in the Mid-downstream Gas Sector[1]

June 2024

[1] https://www.marcogaz.org/publications/best-available-techniques-to-reduce-methane-emissions-from-venting-and-flaring-activities-in-the-mid-downstream-gas-sector/

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ABOUT MARCOGAZ

Founded in 1968, MARCOGAZ represents 28 member organisations from 20 countries. Its mission encompasses monitoring and policy advisory activities related to the European technical regulation, standardisation and certification with respect to safety and integrity of gas systems and equipment, rational use of energy as well as environment, health and safety issues. It is registered in Brussels under number BE0877 785 464.

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1. Context

Given the contribution of methane emissions to global warming, the European Commission has identified methane emissions reduction as one of the key priorities of the European Green Deal and the European Methane Strategy, published in October 2020. As part of the strategy, the European Commission adopted a proposal on 15 December 2021 on a regulation aimed at reducing methane emissions in the energy sector. The regulation aims for "improved measurement, reporting and verification of energy sector methane emissions and immediate reduction of emissions through mandatory leak detection and repair and a ban on venting and flaring" except "in case of an emergency or malfunction; and where unavoidable and strictly necessary for the operation, repair, maintenance or testing of components or equipment".

As a contribution to the technical implementation of the requirement to **minimise venting and flaring** and building on the technical experience of its members, MARCOGAZ proposes a short list of 9 Best Available Techniques (BATs) to Reduce Methane Emissions from Venting and Flaring Activities in the Mid-downstream Gas Sector.

Below a brief summary of the BATs is given:

- **BAT 1 - Reduce pressure before venting**
  The first BAT describes how assets can be depressurized and isolated from the total system to prevent the need for venting and flaring. Furthermore, this BAT introduces an evaluation framework for decision making to minimize methane emissions.

- **BAT 2 - Recover and recompress emissions in the process gas: mobile compressor** In the second BAT, mobile compressors are introduced to reduce the amount of gas in the to-be-emptied asset section. Although mobile compressors are a proven solution to avoid large amounts of methane to be emitted, also limitations regarding compression ratio, time and environmental impact are addressed.

- **BAT 3 - Recover and recompress emission in the process gas: stationary compressor** In the following BAT, stationary recompression is addressed for the recovery of emissions from dry gas seals, process vents and boil off gas at main infrastructure sites. Besides the advantages, from a safety perspective it is also mentioned that emergency process vents could not always be prevented due to time limitations.

- **BAT 4 - Flaring as replacement of venting (to reduce the environmental impact)** Flaring appliances are proposed in the fourth BAT as a more environmentally friendly solution before venting, after the asset has been depressurised (see other BATs). The BAT addresses two techniques related to flaring, namely natural draught and forced draught burner flaring systems.

- **BAT 5 - High bleed continuous pneumatics mitigation**
  In the fifth BAT, pneumatic control systems are described which are used as process control instruments to ensure safe operation of the gas networks. High bleed components are reported to be significant emitters and could be replaced by their air or electric counterparts. If due to practical or security of supply reasons this is not possible, also low bleed pneumatic components could be used.

- **BAT 6 - Electrical or pneumatic air starters**
  This BAT describes solutions to avoid vented emissions during the starting phase of

gas turbines. Where old design starting motors are equipped with expansion turbines and vent the process gas, two low emission solutions are proposed to avoid this. The first solution would be to replace the starting motor by an electric or hydraulic version. The second solution relates to the adaptation of the expansion turbine to handle pressurized air.

- **BAT 7 - Use of nitrogen to purge LNG pipes**
  The seventh BAT introduces nitrogen to purge temporary connections between the LNG receiving terminal and the LNG carrying ship. As a supply of nitrogen is often available at the terminal, implementation is considered good practice for environmental and safety reasons.

- **BAT 8 - LNG truck loading (dry coupling connectors)**
  This BAT addresses a dry cryogenic coupling technique, which enables LNG truck loading with minimal methane emission. The technique is reported to be safe and economically viable.

- **BAT 9 - Excess flow valves in new service lines**
  In the final BAT, excess flow valves (EFVs) are proposed to limit emissions in new distribution service lines. The EFV automatically shuts off the gas flow in the service line when the flow volume exceeds a threshold as in de case of a rupture. Although EFVs are very suitable to minimize emissions, limitations should be considered regarding pressure drop, volume flow and risk of malfunctioning.

In addition to this set of BATs and to comply with the European regulation and OGMP 2.0, operators are advised to **measure operational parameters (pressure, temperature, flow, etc, as relevant)** that allow **quantification of residual and avoided methane emissions for each operation**.

This entails parameters measurement at:

- the start of the operation
- at any relevant intermediate points during the operation
- at the end of the operation.

Intermediate points can refer for example to the start of the different steps proposed in the pipeline evacuation procedure illustrated in Fig. 2.
These data should be carefully archived, as it contributes also to MRV (Measurement, Reporting and Verification) requirements of the EU regulation.

2. Decision flow chart to minimize venting and flaring

2.1. Generic approach according to draft EU regulation, particularly Article 15

Based on the general requirements, and in particular, on Article 15 of the proposed Methane Regulation and the practical experience of their members, Marcogaz proposes to use a generic decision-making flowchart to minimize venting and flaring, as illustrated in Figure 1 below. Articles are quoted to avoid ambiguity.

Its steps are briefly explained below, applied to venting and flaring. The chosen approach is to reflect the technical decision-making process rather than the sequence in the regulation text, e.g. for Articles 15.4 and 15.5, but the outcome should be the same. Also the wording can differ slightly to improve interpretation. Please be aware of this slight change of perspective in order to avoid any confusion.

Equipment that vents shall be replaced by non-emitting alternatives when these are commercially available and if they meet the standards or technical prescriptions for the venting components and established pursuant to relevant standards and guidelines (Article 15.4a and 29a).

Where a site is built, replaced or refurbished in whole, operators shall utilise only commercially available zero-emitting pneumatic devices, compressors, atmospheric pressure storage tanks, sampling and measurement devices and dry gas seals. (Article 15.5a).

Appropriate measures taken by the operators to prevent and minimise methane emissions are those in which the societal impact of the emission reduction is larger than the societal impact of the mitigation measure.

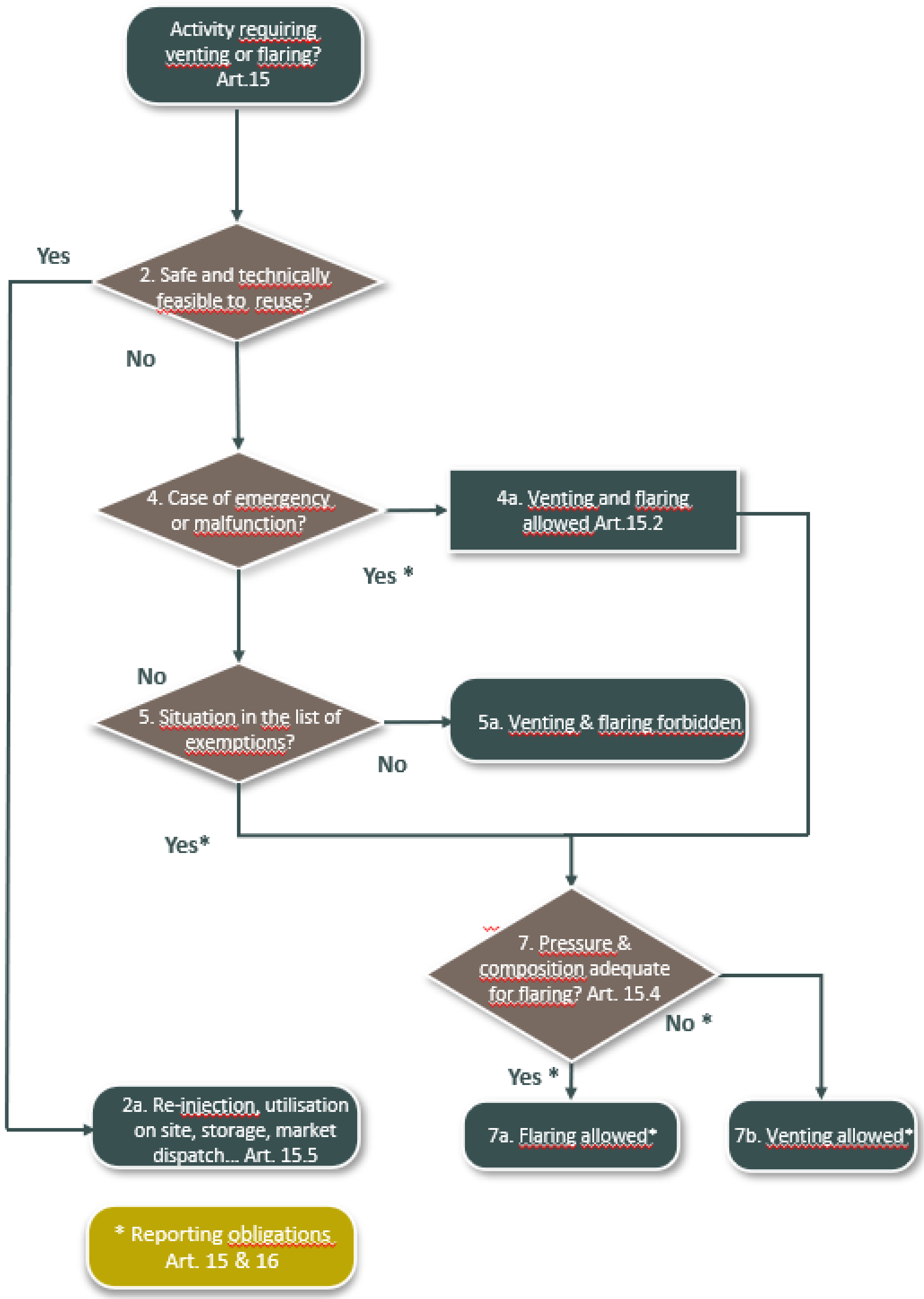

Figure 1: Generic decision-making scheme according to Article 15 based on Council version.

2.2. Explanation of the decision flow chart in Figure 1

In the event that there are still triggers for venting or flaring demands, the flowchart assists in making the correct decisions.
Regardless the cause of the venting demand, the first evaluation to perform is on preventing venting of flaring by safe and technical reuse of the gas that needs to be disposed by applying the BAT's referred to in this document.
Flaring shall only be allowed where either re-injection, onsite utilization, storage for later use, or dispatch of the methane to a market are not feasible for reasons other than economic considerations.
In case of emergency and or malfunction venting or flaring can be unavoidable and is permitted in those circumstances.
The list of situations in which venting or flaring is unavoidable is provided in Art. 15.3.a to 15.3.k, is taken up in Appendix 1. If not included in this list, venting & routine flaring are forbidden: *Venting & routine flaring forbidden Art 15.3*.

If venting or flaring cannot be avoided as described above, '*Operators shall vent only where flaring is not technically feasible* ***due to lack of flammability, inability to sustain a flame*** *or risks endangering safety of operations or personnel or leads to a worse environmental outcome in terms of emissions*. In such a situation, as part of the reporting obligations set out in Article 16, '*Operators shall notify and provide evidence to the competent authorities of the necessity to opt for venting instead of flaring'*:

a. If technical, environmental & safety conditions for flaring are met, then ***Flaring*** (is) ***allowed***, subject to reporting obligations demonstrating the necessity to opt for flaring.
b. If conditions for flaring are not met, ***Venting*** (is) ***allowed***, subject to reporting obligations demonstrating the necessity to opt for venting.

A common use-case of pipeline evacuation procedure provides a practical implementation example of this generic flowchart, also showing how different BATs are used for one particular operational task.

3. Pipeline gas extraction procedure

The pipeline gas extraction or evacuation procedure for e.g. maintenance work, may consist of one or more of the following BAT's:

- BAT 1 - Reduce pressure before venting
- BAT 2 - Recover and recompress emission in the process gas: mobile compressor
- BAT 4 - Flaring as replacement of venting (to reduce the environmental impact)

The starting point is that these BATs describe measures for temporary activities, often with a specific approach. This contrasts with the other BATs developed for stationary applications. And of course, stationary applications can utilize the methods outlined in this section. It is furthermore noted that pilot evacuation procedures with nitrogen displacement have taken place. Results suggest that especially for smaller volume pipelines this could be successful. Large pipe diameters carry the risk of stratified flow of nitrogen and natural gas, rather than a robust steady nitrogen front. See also "*BAT 7 - Use of nitrogen to purge LNG pipes*" for guidance on this topic.

The relationship between these BATs is shown in Figure 2 below.

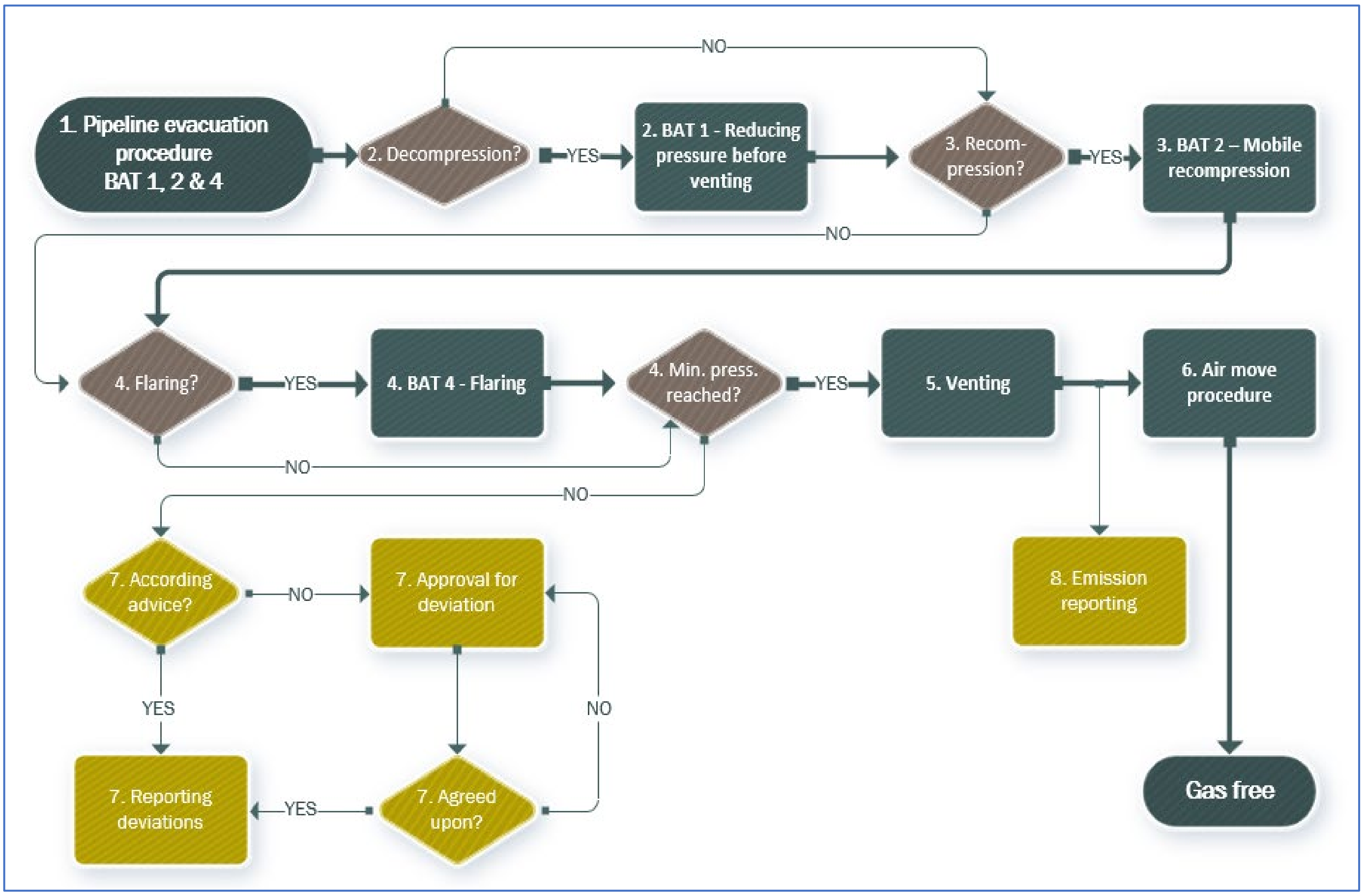

Figure 2 : A pipeline evacuation procedure, which makes use of BAT 1, 2 & 4.

The sequence of BAT measures in the above flow chart has been set up from the perspective of preserving the natural gas commodity in the first place, then making the pipeline gas-free with minimal environmental impact.

Comments to the example chart above:

1. **Evacuation procedure:** It is recommended to develop a company-specific work procedure;

2. **Decompression:** This step is the topic of the BAT 1. When the content of an asset has to be evacuated for works or decommissioning, the good practice, if possible, consists first in lowering the gas pressure by using the network gas consumptions;

3. **Mobile recompression:** This step is the topic of the BAT 2. This measure is possible until the final pressure reaches a pressure between approximately 1 and 10 bars.

4. **Flaring:** This step is the topic of the BAT 4. This measure can be done down to a final pressure of about 100-200 mbar.

5. **Venting:** When flaring is no longer feasible, residual volume evacuation remains. Venting is the final activity to remove gas from the asset, but shall be limited to minimum amounts.

6. **Air move procedure:** This is an air moving procedure to create a safe workplace.

7. **Deviations:** Field working conditions can sometimes necessitate deviating from the agreed working arrangements. It is recommended to develop an approval procedure for this in order to keep the vented quantities of unburned gas to a minimum.

8. **Emission reporting:** It is advised to develop a tool that aggregates the emissions and environmental costs of the entire pipeline evacuation procedure. This allows to make justified considerations on the work procedure to choose.

Coming up with the best solution or a combination of solutions is often a challenge. It is therefore advisable to develop a calculation tool that combines emissions, environmental costs, abatement costs and the time it takes to transfer gas from the pipeline by combining BAT techniques used in the entire pipeline evacuation process.

A detailed example is included in Appendix 2 for illustration purposes.

4. Data collection and pooling

Ideally operational parameters, effectiveness and costs data associated with the implementation of each BAT and procedures involving several BATs should be collected by each operator, and pooled at industry level.

This will allow developing reliable estimates of avoided and residual emissions, as well as documented ranges of effectiveness for the different technologies and procedures. Such evidence is likely to promote improvement of technologies and practices.

Cost data will also help with the benchmark mandated by EU regulations, as well as combined with effectiveness, produce methane emissions abatement costs, that will help update IEA's Methane Tracker figures.

To facilitate this data collection, setting up templates for operational parameters, effectiveness and costs would be helpful.

5. Appendix 1 – List of exemptions for venting (Art. 15.3. a-k)

The text that is included in this Appendix is made up of the version of the *Trilogue Draft Agreement of November 20th, 2023* and needs to be updated as soon as the final regulatory text becomes available.

15.2.(b) where unavoidable and strictly necessary for the operation, construction, repair, maintenance, decommissioning or testing of components or equipment and subject to the reporting obligations set out in Article 16.

15.3. *In addition to paragraph 2,* venting *and flaring shall also be allowed where unavoidable and strictly necessary and subject to the reporting obligations set out in Article 16. It* shall include the following specific situations where venting *or flaring, as applicable,* cannot be completely eliminated *or is necessary for safety reasons*:

(a) during normal operations of *pneumatic devices, compressors, atmospheric pressure storage tanks, sampling and measurement devices and dry gas seals, or other* components *designed to vent*, provided that the equipment meets *the standards or technical prescriptions established pursuant to Article 29a and is properly maintained* to minimize methane losses.

(b) to unload or clean-up liquid holdup in a well to atmospheric pressure

(c) during gauging or sampling a storage tank or other low-pressure vessel, *provided that the tank or vessel meets the* standards *or technical prescriptions established pursuant to Article 29a*;

(d) during loading out liquids from a storage tank or other low-pressure vessel to a transport, provided that the tank or vessel meets the standards set out in the delegated acts referred to in Article 29a (2);

(e) during repair, *maintenance, test procedures and decommissioning*, including blowing down and depressurizing equipment to perform repair and maintenance;

(f) during a bradenhead test;

(g) during a packer leakage test;

(h) during a production test lasting less than 24 hours;

(i) where methane does not meet the gathering
pipeline specifications, provided the operator analyses methane samples twice per week to determine whether the specifications have been achieved and routes the methane into a gathering pipeline as soon as the pipeline specifications are met;

(j) during commissioning of pipelines, equipment or facilities, only for as long as necessary to purge introduced impurities from the pipeline or equipment;

(k) during pigging, blow-down to repair**,** decommissioning or purging a pipeline for repair or maintenance, and only where the gas cannot be contained or redirected into an unaffected portion of the pipeline.

6. Appendix 2 – Examples of cost and environmental impact assessment for evacuation

6.1. Main gas pipeline case

Let us consider as an example the following case:

A **main gas pipeline** with a diameter of 36” and 10 km long needs to be fully evacuated for maintenance work. The pressure is reduced to 40 barg as part of the evacuation procedure with remaining volume of 248,000 m^3(n) natural gas. The following evacuation procedure is then considered:

1. **Decompression**: When the content of an asset has to be evacuated for works or decommissioning, the good practice, if possible, consists first in lowering the gas pressure by using the network gas consumptions. If the starting pressure for this case is 60 barg, then the starting volume is 372,000 m3(n), and at the end of decompression to 40 barg 248,000 m3(n).

2. **Recompression** to the grid will start at 40 barg until the to the technical minimum of 7 barg (as example) is reached in the pipeline. The end volume is then 43,400 m^3(n).

The evacuation time for recompression with two units is assumed be about 80 hours with a gas consumption of approximately 100 m^3(n)/h for both units;

3. **Flaring** will start from 7 barg up to let assume 200 mbarg which is about the technical minimum for large flare units. Remaining end volume is 1,240 m^3(n).

4. **Venting.** The remaining gas shall be expelled (vented) to the atmosphere in order to create safe working conditions. Expelled (vented) volume is 1,240 m^3(n).

6.2. Environmental greenhouse gas impact

The environmental impact is caused by gas consumption of the compressors and flare unit(s) (burned gas, 1,785 kg CO_2/m3(n)) and unburned gas due to venting the remaining gas (0.5834 kg CH4/m3(n), GWP_{100}=28[2]).
Figure 3 shows the total emissions for the different option chosen. It appears that the option with *recompression and flaring* is, as expected, the most optimal solution in terms of environmental impact. As shown, *Venting alone* has a high environmental impact.
To conclude, the lowest environmental impact can be achieved by combining recompression, flaring, followed by venting with the lowest possible starting pressure, thus minimising the vented gas.

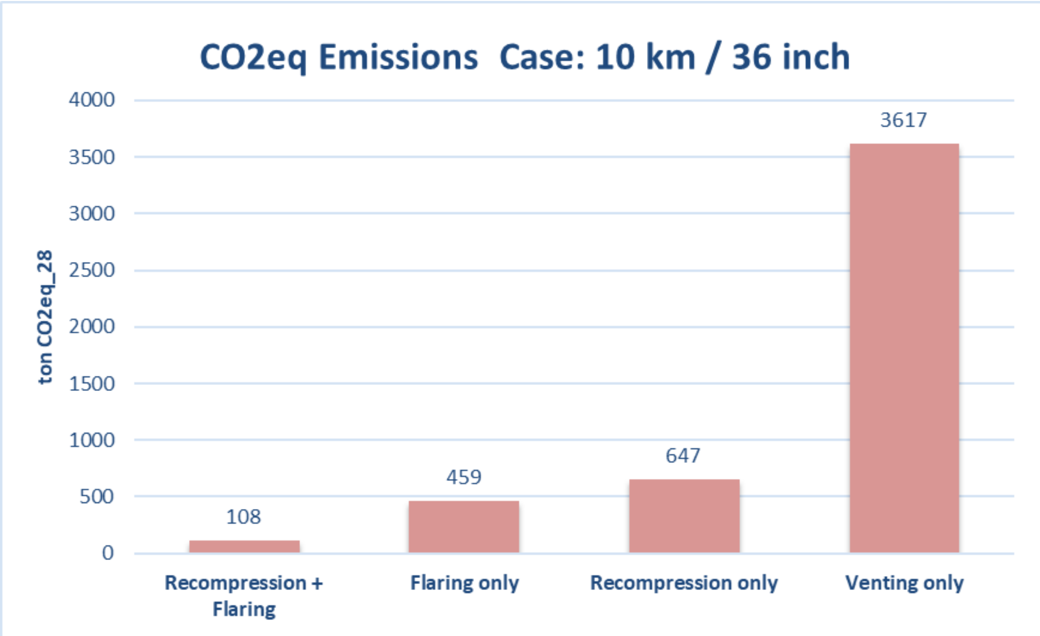

Figure 3 - Environmental impact of evacuation options – main pipeline

6.3. Environmental and commodity cost

An interesting perspective on the outcomes of various options could be gained by quantifying the financial impact of environmental damage and commodity loss. Some TSOs benefit from CO2 allowances, but the allocation of costs is not taken into account in this instance.
The commodity loss is also included, similarly following a societal perspective, as they are generally accounted for in the tariff alongside e.g. fuel gas. It is noted that recompressed gas remains in the system

2 According to IPCC Assessment Report 5

and is therefore not considered a commodity benefit.

The following has been taken into account for the calculation in this example case:

- The cost of commodity loss in the flare and vented gas is 0.37 €/m3(n);
- The environmental impact of the burned gas is recalculated to kg CO_2 (1.785 kg CO_2/m3(n)) and then settled at 200 €/ton (cost level by example only);
- The environmental impact of the unburned gas is recalculated in kg CO_2 equivalent (0.5834 kg CH_4/m3(n), GWP_{100}=28) and then settled at 200 €/ton.

The results for the total costs of the different options is shown in Figure 4 below.

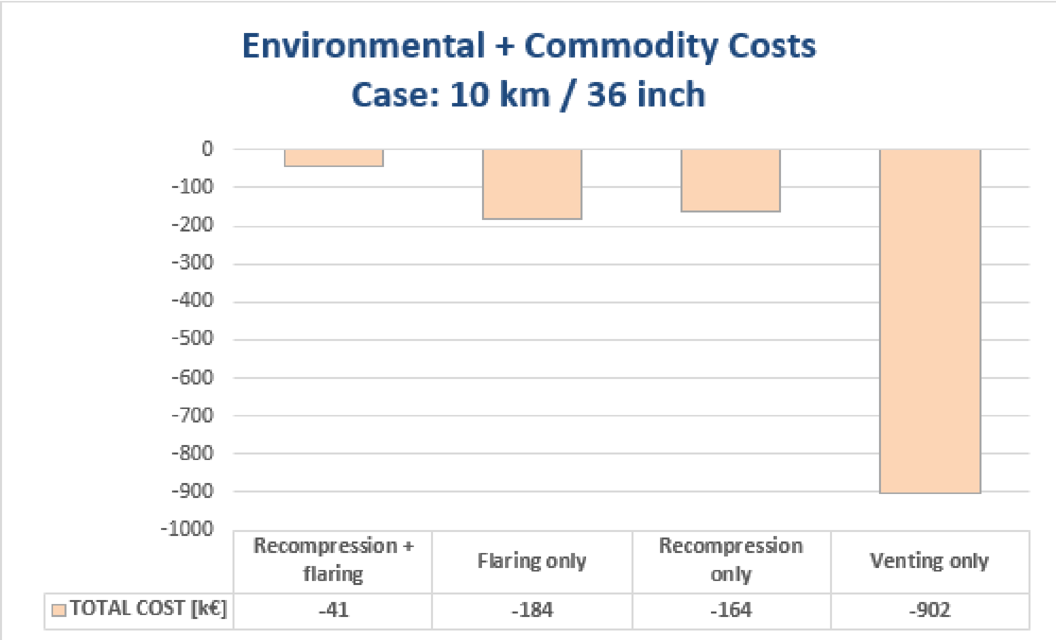

Figure 4 - Costs of evacuation options including environmental impact – main pipeline

The most cost-effective option is the one with recompression and flaring, as it keeps most of the natural gas in the system – it has the lowest total costs, has , 41 k€ in this example. Although flaring is the next best solution from the environmental perspective, financially it is not, due to commodity loss. Venting alone is the costliest option both environmentally and economically.

This calculation can be refined by accounting also for the cost of implementing the BATs, but the ranking of solutions would not be changed.
This calculation approach, along with costs of deploying, can provide solid support for decision-making. The values used can differ from country to country and company to company due to (company) policies and regulatory conditions. It is important to use authoritative sources for both the CO2 price calculation value and the commodity price calculation value (repetition at the end of the doc).

7. Regional gas pipeline case

Now let us consider as the next example a regional pipeline case:

A regional gas pipeline with a diameter of 12” and 10 km long needs to be fully evacuated for maintenance work. The pressure is reduced from 40 to 10 barg as part of the decompression operation. The evacuation procedure will start at 10 barg.

Because smaller compressor units are used, a final pressure of 100 mbarg is assumed. Also the smaller flare units have an assumed final pressure of 100 mbarg. In this case the 'recompression + flaring' option is not available; it is one or the other.

The following evacuation procedure is then considered:

1. **Decompression**: When the content of an asset has to be evacuated for works or decommissioning, the good practice, if possible, consists first in lowering the gas pressure by using the network gas consumptions. If the starting pressure for this case is 40 barg, then the starting volume is 30,000 m^3(n), and at the end of decompression to 10 barg, it is 7,520 m^3(n).

2a. **Recompression** to the grid will start at 10 barg until the technical minimum of 100 mbarg is reached in the pipeline. The end volume is then 75 m^3(n).

2b. **Flaring**. The other option is to use flaring. The technical minimum for small units is around 100 mbarg. The remaining volume at the end is also 75 m^3(n).

3. **Venting**. To ensure safe working conditions, the remaining gas must be vented to the atmosphere. The volume of expelled (vented) gas is 75 m^3(n).

Figure 5 shows that recompression has the lowest environmental impact, followed by flaring. Venting has a high impact.

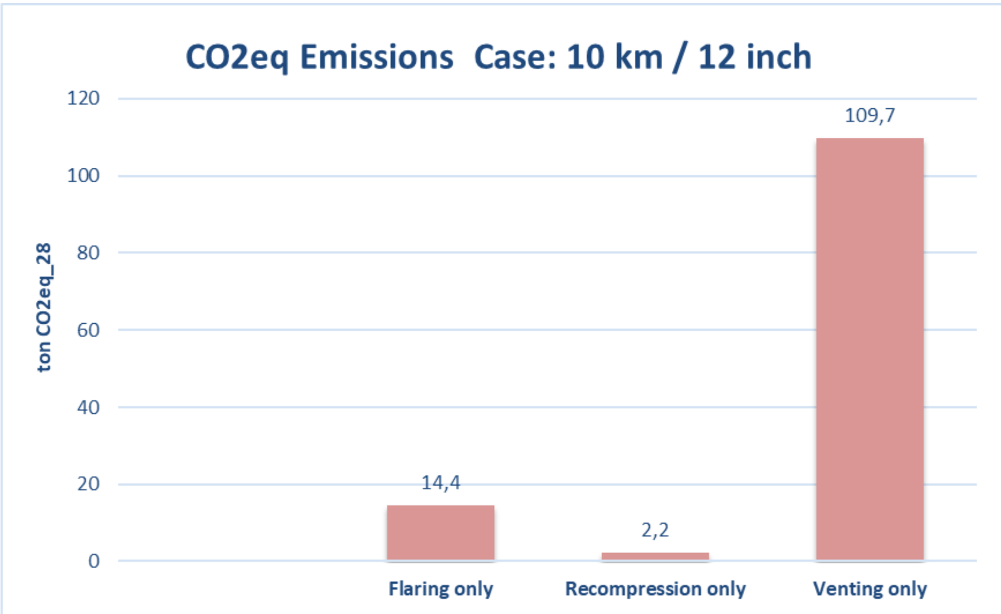

Figure 5 Environmental impact evacuation options evaluated – regional pipeline

In order to provide a comprehensive picture, costs of environmental impacts are included in the financial assessment. The loss or savings of the commodity are also included. Figure 6 shows that recompression has positive benefits, but flaring, however, leads to net costs. It's evident that venting leads to high costs.

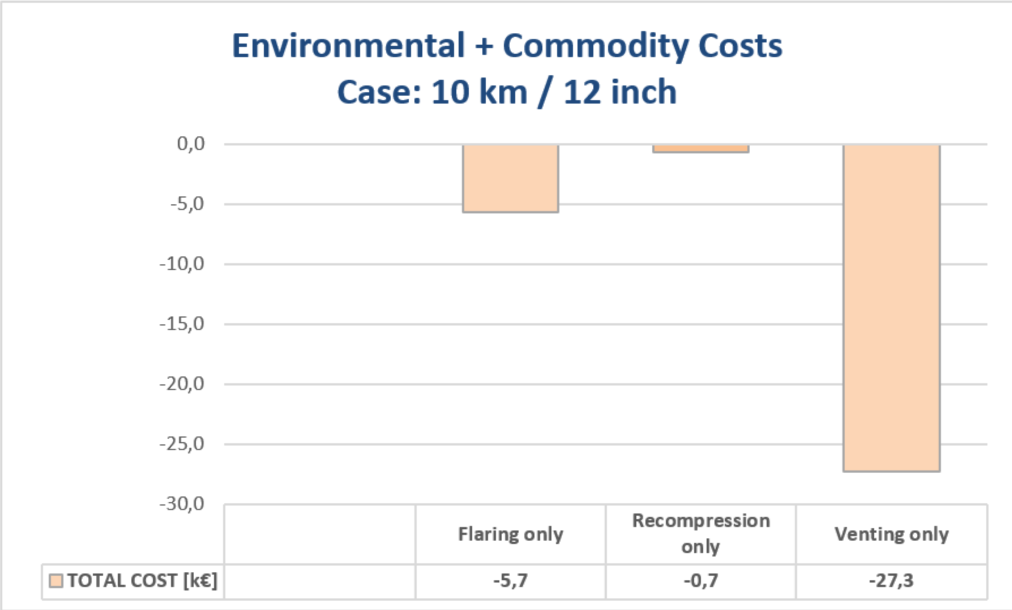

Figure 6 Costs of evacuation options including environmental impact – regional pipeline

8. Conclusion

The examples illustrate how an evacuation procedure can be evaluated for its environmental costs, including the use of natural gas and its impact on the environment. Specific situations and other methods of evacuation, like nitrogen displacement, necessitate customization.

More details should be added, like the implementation cost of all BATs.

It is advised to develop a calculation tool that aggregates all these costs, facilitating case by case assessment of the work procedure, and allows executive engineers to make informed choices.

In this way, a solid foundation could be established for decision-making support.