Re-Stream

Study on the reuse of oil and gas infrastructure for hydrogen and CCS in Europe

Executive Summary

DNV

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The project team thanks the Associations and their members for their trust, their participation in and their feedbacks on the Re-stream study.

Project title:
Re-Stream - Study on the reuse of oil and gas infrastructure for hydrogen and CCS in Europe – Executive Summary

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Carbon Limits works with public authorities, private companies, finance institutions and non-governmental organizations to reduce emissions of greenhouse gases from a range of sectors. Our team supports clients in the identification, development and financing of projects that mitigate climate change and generate economic value, in addition to providing advice in the design and implementation of climate and energy policies and regulations.

Executive Summary

In the European Green Deal, the EU has set itself the ambitious target of achieving climate neutrality by 2050, with an intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.[1] The ambition of the EU increases the necessity of decarbonizing the industry, energy and transportation in Europe. Carbon Capture and Storage (CCS) and carbon-free energy carriers based on hydrogen are technologies which could significantly contribute to achieving the EU goals. Both CCS and large-scale hydrogen usage require transportation infrastructure. Reusing existing oil and gas infrastructure can lead to more cost-efficient deployment of CCS and hydrogen technologies and limit the costs of achieving EUs climate ambitions. The aim of the Re-Stream study is to provide fact-based elements to this statement and to identify relevant infrastructure and define what technical adaptations and investments would be required to unlock its potential for reuse for both CO_2 and 100% H_2.

Note that for smaller H_2 production and for existing gas pipelines, there is also a potential for blending of H_2 in the natural gas network in the early phase of the H_2 economy development. This is however not the focus of this study and is only briefly discussed in section 3.3.

65 pipeline operators participated in the Re-Stream study, providing data that could be analysed within the Re-Stream project for approximately 58,000 km of pipelines[2] (+24,200 km assessed by operators themselves as suitable for H_2 reuse) representing half of the total offshore pipeline length and approximately 30% of the onshore oil and gas pipelines.

Initial technical screening

An initial technical screening was undertaken considering the data provided by the pipeline operators. This analysis does not replace a full pipeline requalification process that would require way more inputs for each pipeline.

The criteria used for this initial screening are the material of construction and pipeline design characteristics (e.g. for CO_2, to check the resistance against running ductile fracture), the internal pipeline condition, safety matters, age and transport capacity. For calculations, design pressures have been adapted according to standards and flow requirements.

Other parameters such as, among others, the chemical composition, the heat treatments of the material, the welding procedure specification, the way a pipeline has been operated over the years are also factors that play an important role in the possibility for reuse of a pipeline. However, these parameters could not be considered at screening level.

Of the approximately 58,000 km pipelines assessed in this project (around 41,700 km onshore + 16,300 offshore)[3] for which data were received, the initial screening showed that technically:

[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1828

[2] Several operators have been / are assessing internally the reusability of their pipelines for H_2 and CO_2. Results from the Re-stream study should not prevail on operators' results considering the operators have access to more detailed data than the Re-stream team.

[3] 28,800 km of onshore gas pipelines / 12,900 km of crude/product onshore pipelines / 16,300 km offshore pipelines of which 13,000 km of gas pipelines

FOR CO_2

- There are no showstoppers identified for transporting CO_2 in the gaseous phase in the existing onshore and offshore pipelines.
- CO_2 transport in dense phase is possible in more than half of the offshore pipelines considering the current state of knowledge/standards. An additional 40% of the offshore length would require more testing, analyses and/or update of standards to be reusable.
- A very small portion of the onshore pipelines would be reusable for CO_2 transport in dense phase considering the current state of knowledge/standards. Approximately one quarter of the onshore length could be reusable provided positive results from more detailed analyses and/or tests.

FOR H_2

- Most of the offshore pipelines can be reused for H_2.
- Onshore, close to 70% of the pipeline total length can be reused considering the current state of knowledge/standards. The remaining length of the pipelines is promising for reuse but would require more testing and/or update of standards to be reusable. None of the pipelines analysed can be categorically excluded from reuse as of today.

It is noteworthy that for the pipelines assessed to be reusable considering the current state of knowledge/standards, pipeline requalification processes should still be undertaken, and testing might be needed. Indeed, as mentioned earlier some criteria could not be considered for this initial screening. Running ductile fracture requirements for dense phase CO_2 pipelines, fatigue crack growth for H_2 service, detailed integrity status of the pipeline and timing (date of availability of the pipeline for other use) are some of the critical factors to be evaluated as a first step of the pipeline requalification process.

Initial business opportunity review

The locations of sources (CO_2 emitters / H_2 storage / H_2 producers) and sinks (CO_2 storage locations / H_2 storage / H_2 consumers) were identified and a minimum pipeline length for business opportunities was calculated. There are some clear opportunities:

FOR CO_2

- A minimum of around 70% of the existing offshore pipeline length is relevant for CO_2 transport as many of the long pipelines are linking harbours to CO_2 storage locations.
- Regarding onshore pipelines, a minimum of 20% of the pipeline length shows some business opportunities linking sources to sinks (harbours or onshore storage sites). It is very likely that this proportion would grow significantly if the automatic approach undertaken in the study would have allowed for only part of the pipelines to be reused or for pipeline connections to be better considered.

FOR H_2

- A SMR/ATR production scenario gives a higher degree of obvious business opportunities compared to an electrolysis production one as SMR/ATR production locations are linked to the current gas infrastructure.
- Depending on the demand/production locational assumptions, the minimum reusable offshore pipeline length for hydrogen is between 2% and 25%.
- With regards to onshore, based on the demand/production locational assumptions taken in this study, the minimum reusable pipeline length for hydrogen is 20% to 30%. As for CO_2, it is very likely that this proportion would grow significantly if the automatic approach undertaken in the study would have allowed for only part of the pipelines to be reused or if pipeline connections, the

security of supply and the benefits of an interconnected market had been considered[4]. According to the operators, the EU network is so well meshed that current infrastructures are likely to be enough to connect production with demand with only the last miles that would need to be added.

Case study results

For six selected cases representing various scenarios of reuse (H_2 / CO_2 gas / CO_2 dense - onshore / offshore pipelines), no technical showstoppers were found at this stage. The economic assessment of those cases confirmed the strong potential for cost reduction involving reuse of pipelines compared to their new build options. For both CO_2 and H_2 transport, 53% to 82% of cost reduction can be achieved with around 2 MEUR/km cost reduction for offshore cases and 1 MEUR/km for onshore cases. Those cost reductions are of particular importance in the initial phases of development of CCS and hydrogen infrastructure.

What's next?

A list of technical challenges for pipeline reuse, including some criteria that cannot be covered at screening stages, are listed and discussed in chapter 7. Those challenges are classified in 4 main categories: Regulatory, Integrity, Safety, Operability. Mitigation actions are identified for each of the challenges.

The objective of this assessment was to estimate an overall reuse potential at EU level of the existing infrastructure and, as such, this assessment does not prevent the operators to go through a full requalification process of their pipelines before reuse. The estimated potential within this project is likely to change as the knowledge basis for transport of both H_2 and CO_2 increases and as standards evolve depending on ongoing research activities, testing and studies.

[4] Indeed, several producers connected to several consumers is a better model for the development of a market and to ensure security of supply.