



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

Re-Stream

H_2 CO_2

June 2022

CARBON LIMITS

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- Several operators have been / are assessing internally the reusability of their pipelines for H₂ and CO₂. 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

Context and objectives

Is pipeline reuse technically feasible?

Are there some interesting business opportunities?

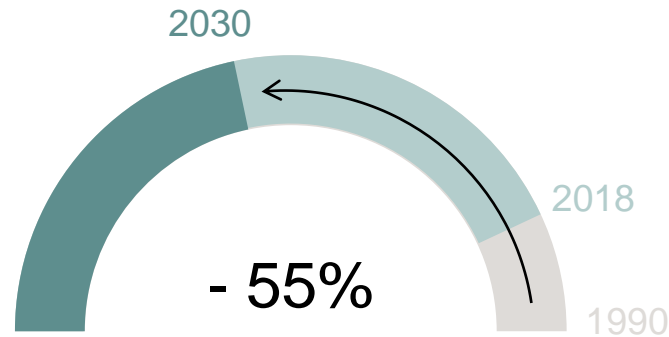
What's next?



The EU has set itself ambitious GHG emission reduction targets



EU



Climate neutrality by 2050

Achieving these targets will involve significant costs

CCS and carbon-free energy carriers based on **H₂** are technologies which could significantly contribute to achieving the EU emission reductions goals.

Both solutions involve the development of investment intensive infrastructure.

To achieve the EU GHG emissions reduction goals in a cost-efficient way, how can pipeline reuse contribute?



Offshore oil /gas pipelines

Onshore gas pipelines

Onshore oil/product pipelines

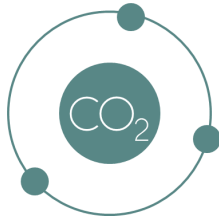
65 pipeline operators participated in the study

Aims of the study



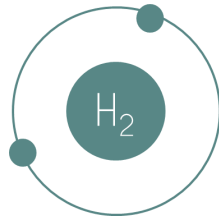
- 1 Is it technically feasible to reuse existing pipeline for 100% H_2 (*blending is not a focus of the study*) transport or for CO_2 (gas and dense phase) transport? – What is the potential for reuse?
- 2 If technically feasible, are there some business opportunities? What are the economic advantages?

Initial screening based on standards and recommended practices available as of the time of the study



Recommended practice *DNV-RP-F104 Design and operation of carbon dioxide pipelines* gives a framework for new build or requalification of existing pipelines for transport of CO₂




ISO 27913:2016 (Carbon dioxide capture, transportation and geological storage — Pipeline transportation systems)

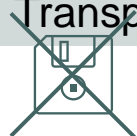


ASME B31.12 Standard on Hydrogen Piping and Pipelines: applicable to onshore pipelines (though initially developed for short H₂ transport pipelines)

Currently no standard specific to offshore H₂ pipelines. Ongoing Joint Industry Project for the development of a recommended practice specific to the design and operation of offshore hydrogen pipelines (Phase 1 including draft guideline and initial test program to be completed in 2022)

Pipelines have different characteristics and as such might not requalify to transport all fluids in all p

Criteria	 dense	 gas	
Material of construction	Resistance against running ductile fracture	<input checked="" type="checkbox"/>	Hydrogen embrittlement Material hardness*
Pipeline design characteristics (Diameter, thickness, MAOP)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Transport in dense phase (MAOP>80 bar)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Internal pipeline condition	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Safety matters (fluid / locations)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Age	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Transport capacity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>



Other parameters play a key role in the possibility for reuse of a pipeline such as chemical composition, heat treatments of the material, the welding procedure specification, the way a pipeline has been operated over the years. Could not be considered at screening level.

*The operators' material experts see existing standards as too conservative for high-grade steel. Related research is ongoing.

Main characteristics of the pipelines analyzed within the Re-Stream study



What is applicable offshore might not be applicable onshore

Parameter/Type of pipelines	Offshore oil	Offshore gas	Onshore crude/product	Onshore gas
Material of construction – main one	API 5L grade X65		Varied with almost 50% X52 steel grade, range of low-grade steel (X42) to higher grade steels (X70)	45% X60 steel grade, range from X52 to X80
MAOP* - median - bar	150	160	~70 (40-140)	~70 (40-100)
Diameter - inch	12-36	>24	12 to 24	<12 to >36

* MAOP: Maximum Allowable Operating Pressure

Data collection towards 65 pipeline operators

Data could be analysed for ~58,000 km pipelines (+24,200 km assessed by operators themselves as suitable for H₂ reuse)

50% total offshore pipeline length

30% onshore oil and gas pipelines length



3 categories of pipelines were defined



- A. The pipelines reusable considering the current state of knowledge/standards.
- B. The pipelines that would require more testing and/or update of standards to be reusable.
- C. The pipelines not reusable.

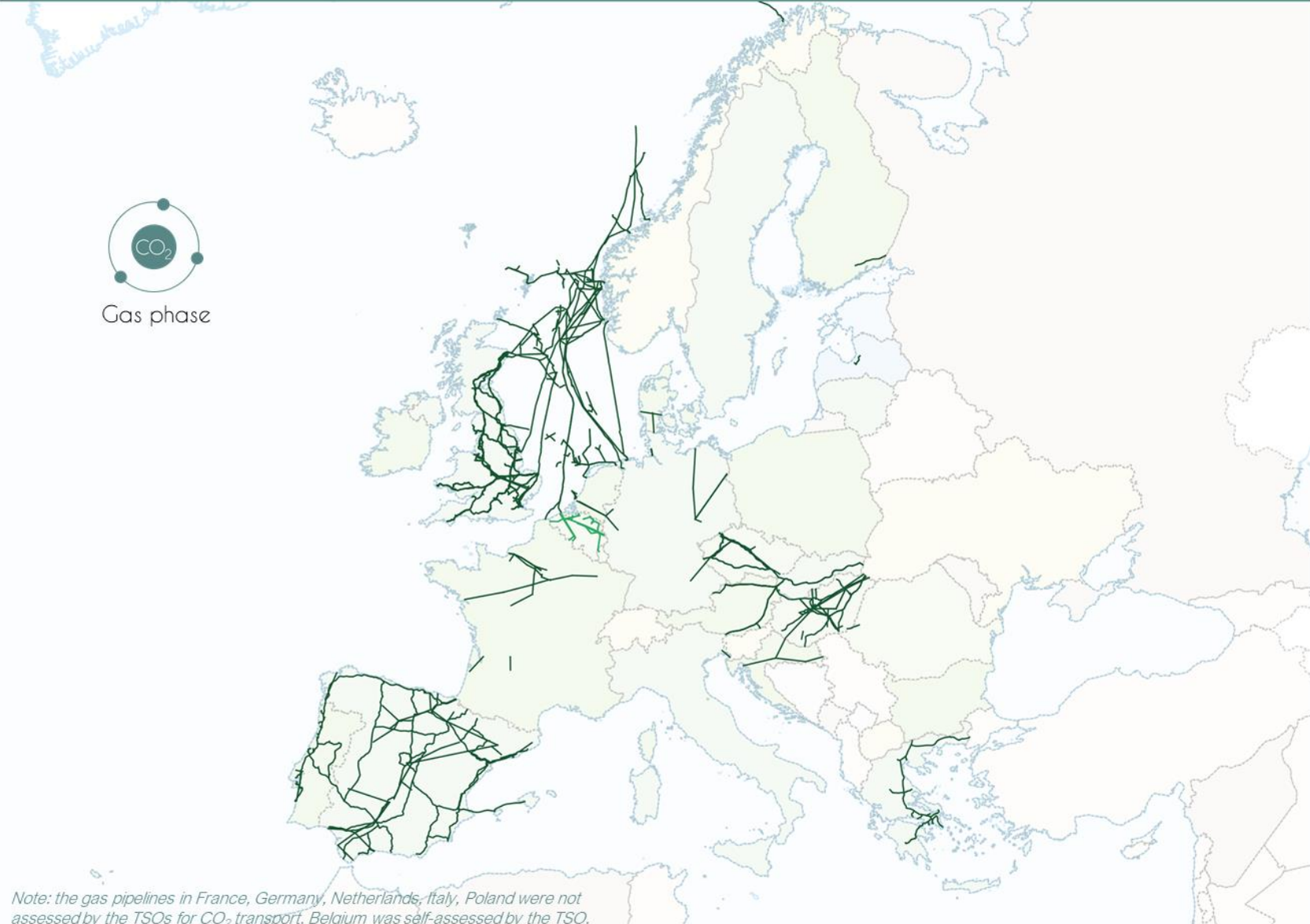
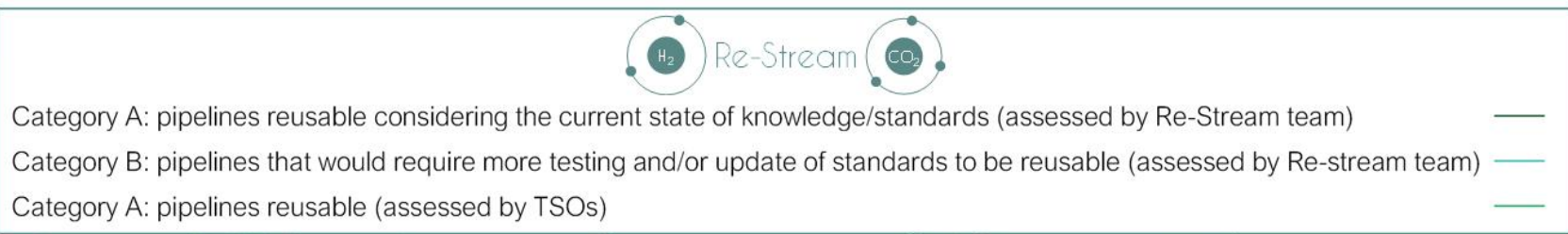
Some operators have self-assessed their pipelines and those falls in Category A: pipelines reusable.

Categories A and B pipelines still require a proper requalification process (including but not limited to a more detailed integrity assessment of the pipeline) to finally confirm their reusability for H₂ or CO₂ but are promising pipelines for reuse.

Results for CO₂

Gas Phase

No showstoppers
identified for
transporting CO₂ in the
gaseous phase in
existing onshore and
offshore pipelines



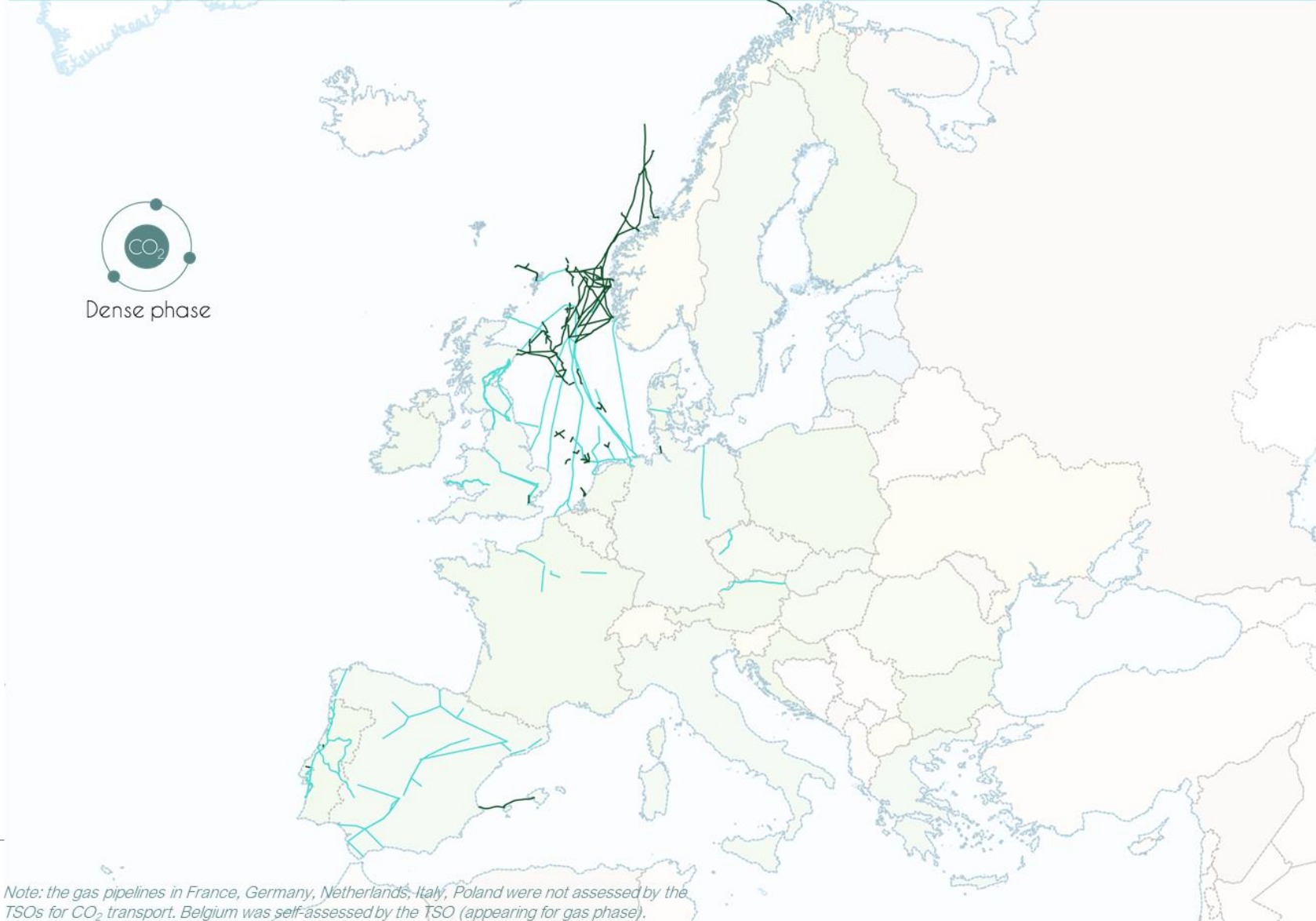
Results for CO₂

Dense phase

Possible in **>50% offshore** pipelines considering the current state of knowledge/standards

+40% of the offshore length would require more testing, analyses and/or update of standards to be reusable

~25% of the **onshore** length could be reusable provided positive results from more detailed analyses and/or tests.



Results for H₂

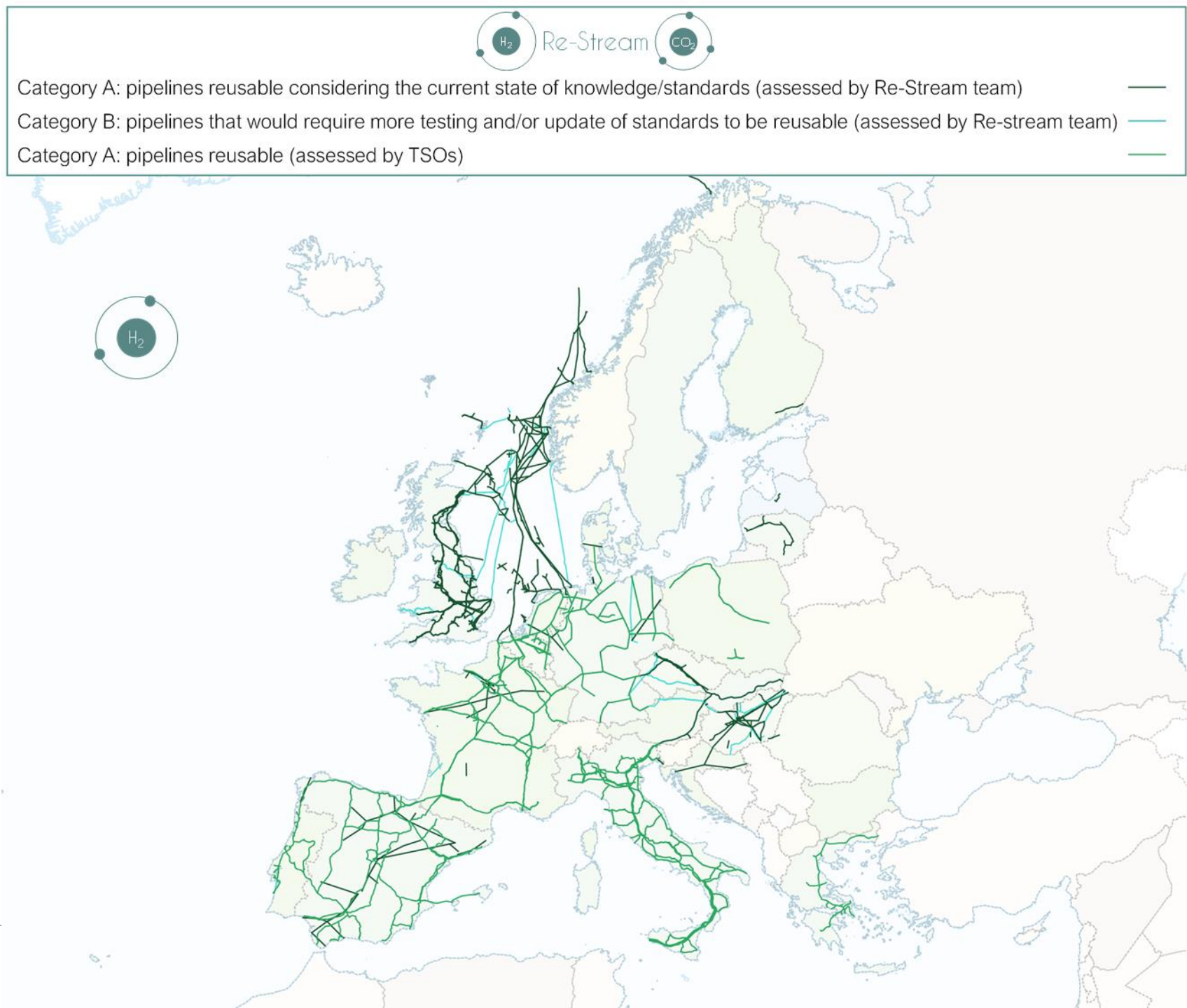
100% H₂

Most of the offshore
pipelines considering
the current state of
knowledge/standards

~70% of the onshore
length could be
reusable considering
the current state of
knowledge/standards

+ 30% provided positive
results from more
detailed analyses
and/or tests

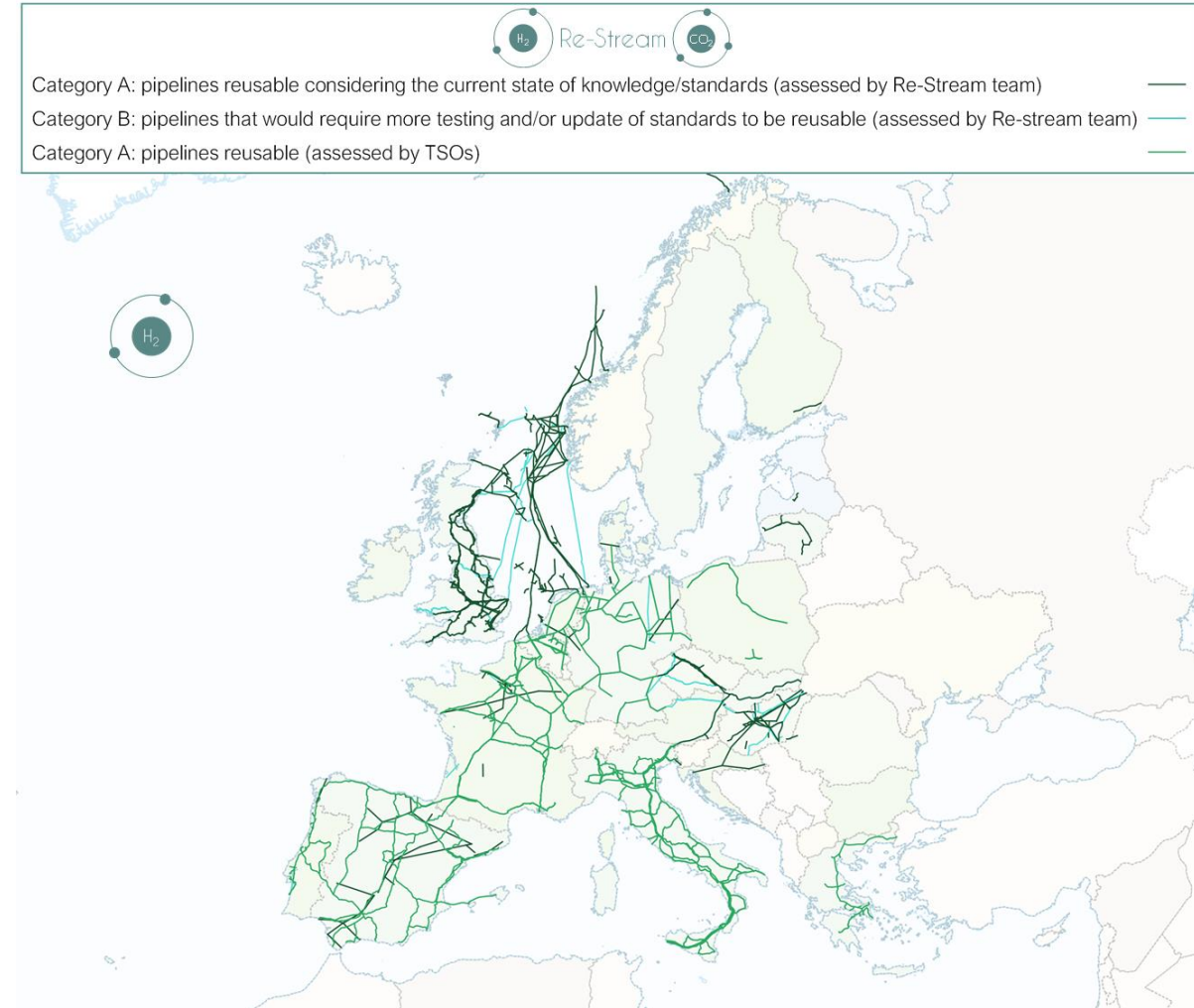
**None can be
categorically excluded
from reuse as of today**



Key results of the initial screening

- CO₂ in *gaseous* phase can be transported in all onshore and offshore pipelines analysed (no showstoppers identified)
- CO₂ in *dense* phase can be transported in approx. 25% of onshore pipelines and in >50% of offshore pipelines analysed
 - Key limiting factors are the maximum allowed operating pressure of the fluid they can transport and the resistance of the material to running ductile fracture
- H₂ can be transported in >70% of onshore pipelines (remaining ones require more testing) and in most offshore pipelines analysed
 - Key limiting factor is the potential impacts of hydrogen on the pipeline material (hydrogen embrittlement)

Results for 100% H₂



The initial screening shows that there are no obvious technical barriers to reuse oil and gas pipeline for transport of CO₂ (gas and dense phase) and 100% H₂

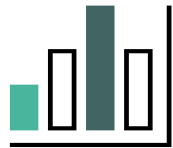
But are there some actual business opportunities?

To identify business opportunities, a source (production site/storage) sink (storage / consumption) matching was carried out

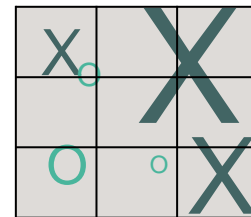
Methodology for mapping and quantification over time (2030, 2040, 2050) - Applied to H₂ consumption, H₂ production and CO₂ emissions



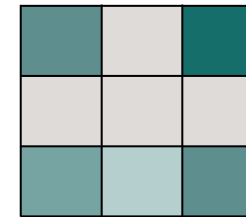
Location of data points and historic data



Data projections per sector

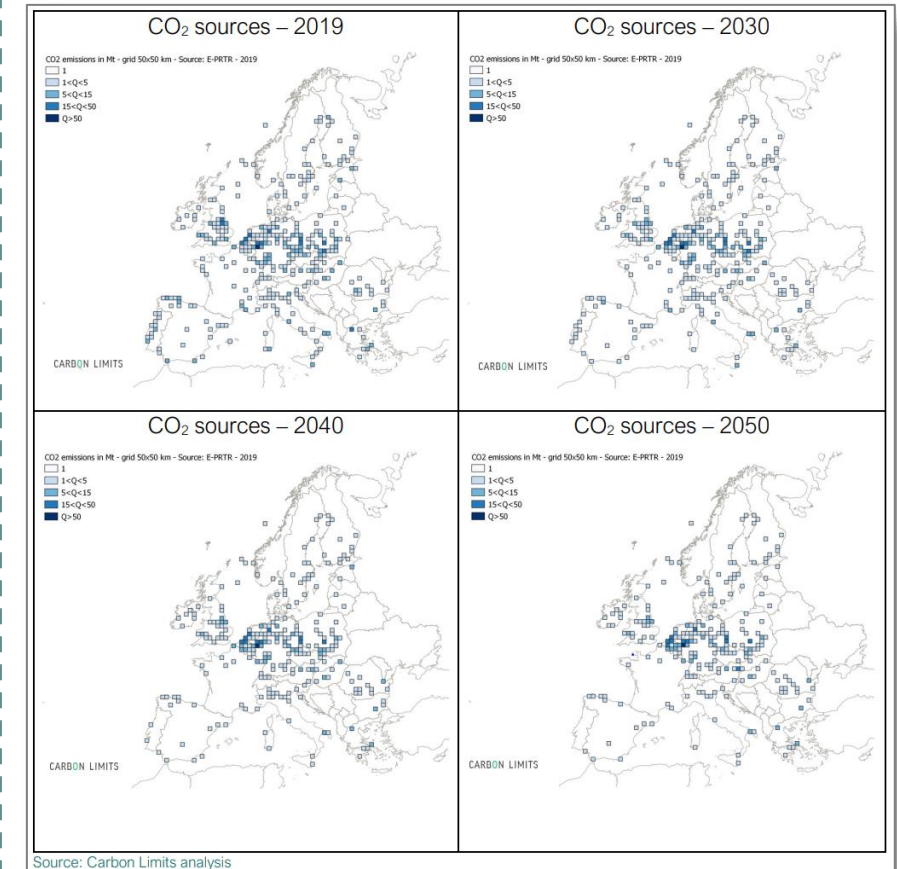


Data point projections depending on sector



Future density grid

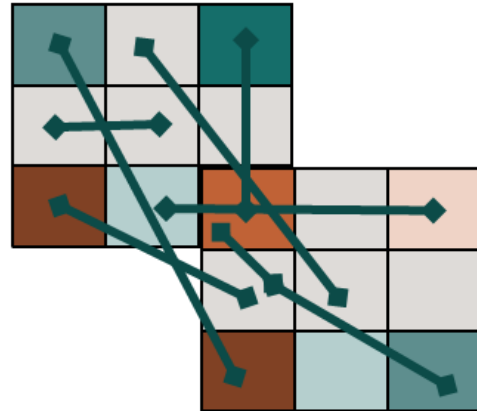
H₂ and CO₂ storage sites were also mapped on a density grid but as storage capacity does not vary over the time, no projections were required



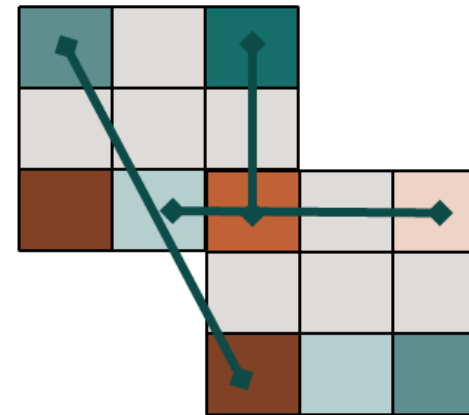
Source: Carbon Limits analysis

Pipelines were overlaid with potential future locations of sources and sinks

Overlay of the sources (production/storage) / sink (consumption / storage) grids + pipelines

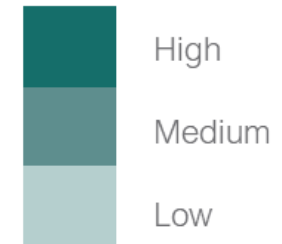


Selected pipelines

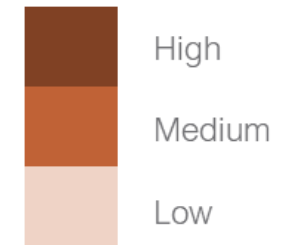


+ Check if a sink at the same location of a source and capacity enough for the source, then no need to transport

Sources (production/storage) grid



Sink (consumption / storage) grids



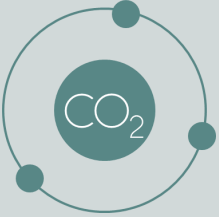
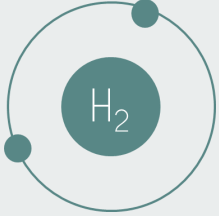
 Pipelines

 Cells with no source / sink

Initial business opportunity review

Results from the source – sink matching carried out in Re-Stream



Identified opportunities	Min % existing offshore pipeline length	Min % existing onshore pipeline length
	70% - linking harbours to CO ₂ storage locations	20% - linking sources to sinks (harbours or onshore storage sites)
	2% - 25%	20% to 30%

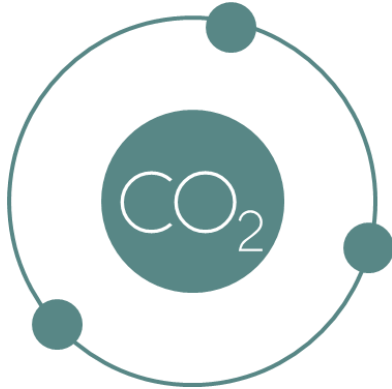
Very likely that proportions of opportunities would grow significantly

1. if the automatic approach undertaken in the study would have allowed for only part of the pipelines to be reused or,
2. if pipeline connections, the security of supply and the benefits of an interconnected market had been considered

There are some obvious business opportunities for oil and gas pipeline reuse

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, and several producers connected to several consumers.

6 cases were studied in more details

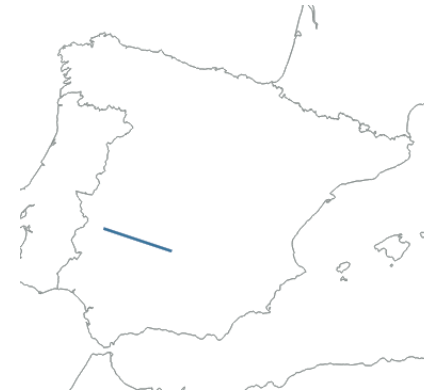
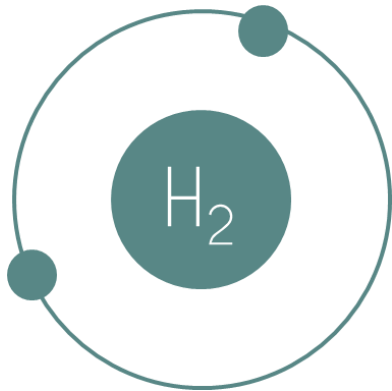


Case name

1 - Fulmar - St Fergus (UK)

2 - Paris - Port Jérôme (FR)

3 - Setúbal - Leiria (PT)



Case name

4 - P15 -D - Maasvlakte (NL)

5 - Almodovar - Merida (ES)

6 - Feeder 13 (UK)

The Portuguese gas network is set to be the future H2 national backbone, in accordance with the national energy policy. Any evaluation for CO2 management purposes is at this stage only for evaluation purpose.

No technical show-stoppers were identified for the case studied but actual repurposing is subject to individual tests

The economic assessment of the cases confirmed the strong potential for cost reduction (53% to 82%) involving reuse of pipelines compared to their new build options.

Those cost reductions are of particular importance in the initial phases of development of CCS and hydrogen infrastructure and that will help achieve the EU GHG emissions reduction goals in a cost-efficient way.

Pipeline reuse could save capital expenditures
> 70 billion EUR*

There is still some work to do with regards to standards (to update and make fit for purpose) and, before reuse becomes a reality, individual pipelines will have to be fully requalified.



Thank you for your attention

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

Public report available here: <https://www.carbonlimits.no/project/re-stream-reuse-of-oil-and-gas-infrastructure-to-transport-hydrogen-and-co2-in-europe/>

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