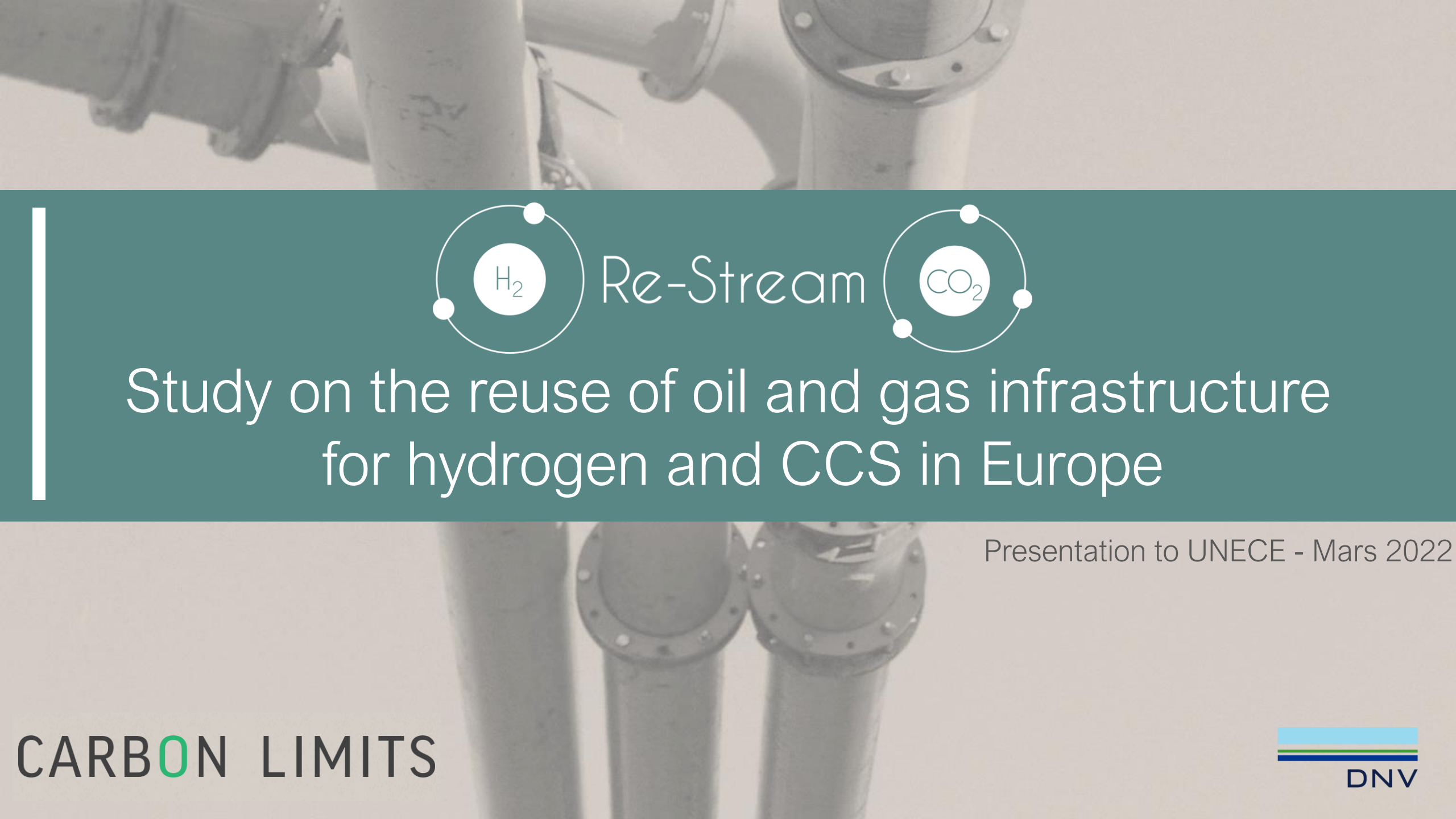

Re-Stream

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

Presentation to UNECE - Mars 2022

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- 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

Context and objectives

Is pipeline reuse technically feasible?

Are there some interesting business opportunities?

What's next?

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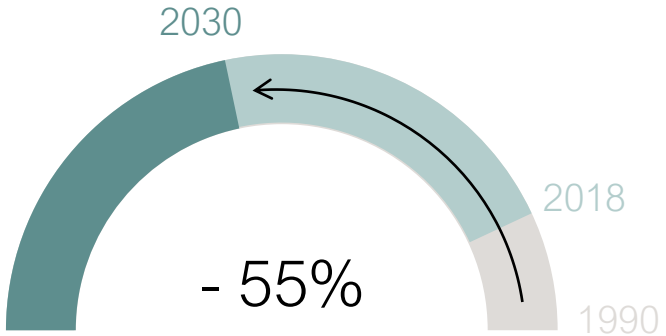
The EU has set itself ambitious GHG emission reduction targets

EU



Climate neutrality by 2050

Achieving these targets will involve significant costs

CCS and carbon-free energy carriers based on H_2 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?

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International Association of Oil & Gas Producers

entsog

GIE Gas Infrastructure Europe

Concawe Environmental Science for European Refining

Offshore oil /gas pipelines

Onshore gas pipelines

Onshore oil/product pipelines

65 pipeline operators participated in the study

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Aims of the study

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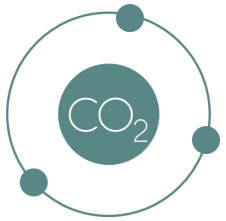
1 Is it technically feasible to reuse existing pipeline for 100% H_2 (*blending is not a focus of the study*) transport or for CO_2 (gas and dense phase) transport? – What is the potential for reuse?

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 CO_2

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

*ASME B31.12 Standard on Hydrogen Piping and Pipelines: a*pplicable to onshore pipelines (though initially developed for short H_2 transport pipelines)

Currently no standard specific to offshore H_2 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 phases

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Criteria	CO_2 dense	CO_2 gas	H_2
Material of construction	Resistance against running ductile fracture	☑	Hydrogen embrittlement Material hardness*
Pipeline design characteristics (Diameter, thickness, MAOP)	Transport in dense phase (MAOP>80 bar)	☑	☑
Internal pipeline condition	☑	☑	☑
Safety matters (fluid / locations)	☑	☑	☑
Age	☑	☑	☑
Transport capacity	☑	☑	☑

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.

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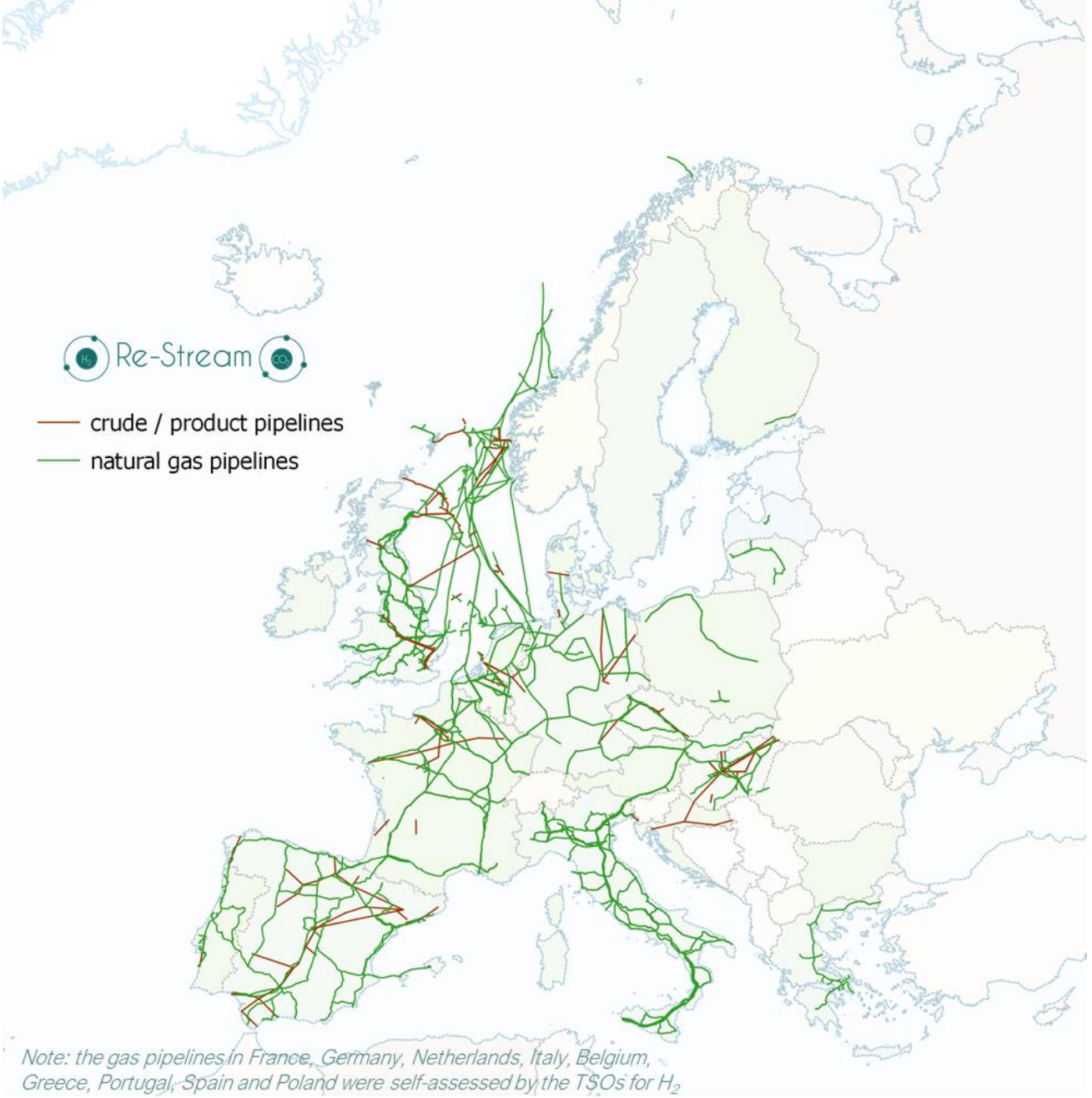
Data collection towards 65 pipeline operators

Data could be analysed for ~58,000 km pipelines (+24,200 km assessed by operators themselves as suitable for H_2 reuse)

50% total offshore pipeline length

30% onshore oil and gas pipelines length

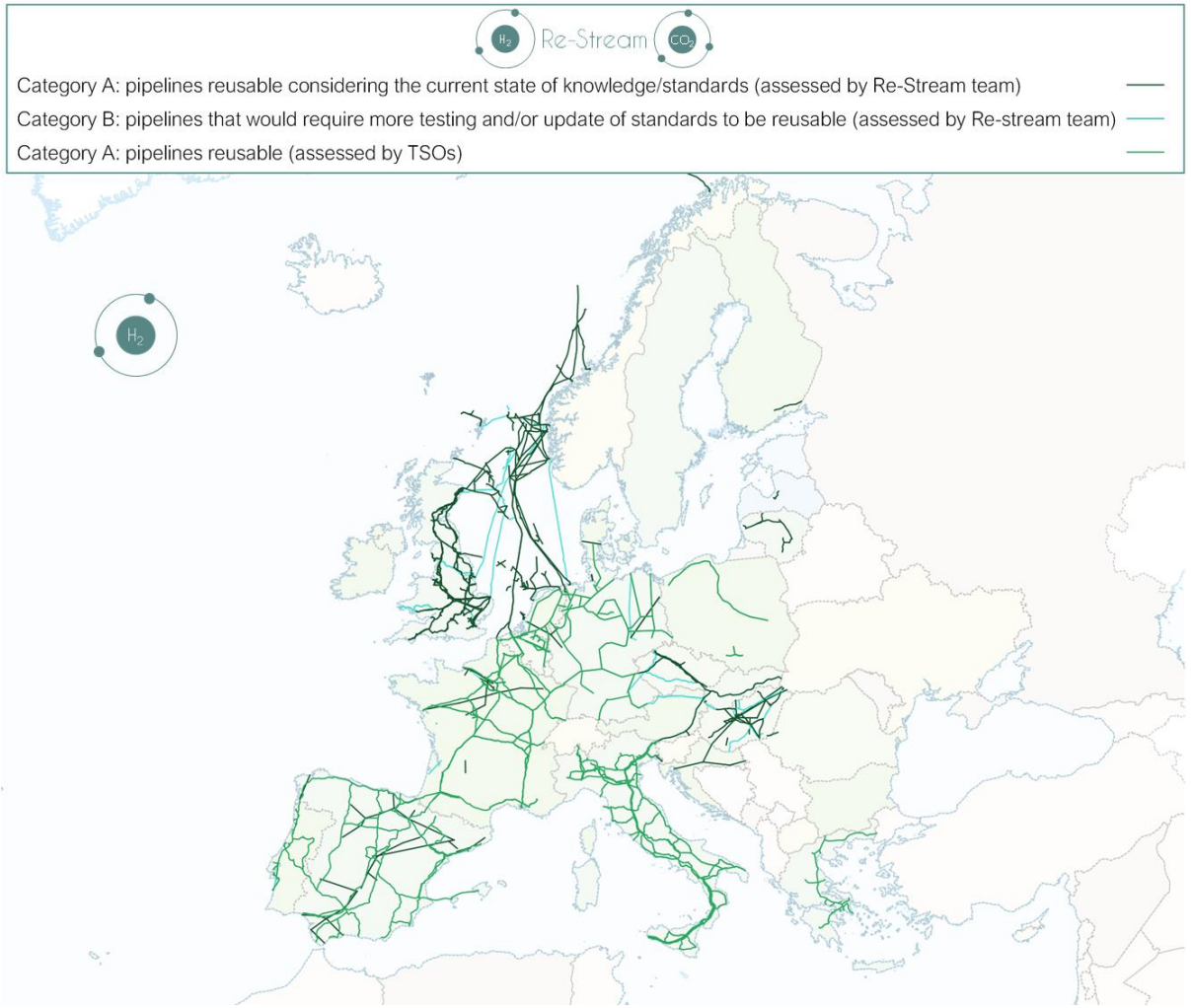


Note: the gas pipelines in France, Germany, Netherlands, Italy, Belgium, Greece, Portugal, Spain and Poland were self-assessed by the TSOs for H_2

Key results of the initial screening

- CO_2 in *gaseous* phase can be transported in all onshore and offshore pipelines analysed (no showstoppers identified)
- CO_2 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
- H_2 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% H_2



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The initial screening shows that there are no obvious technical barriers to reuse oil and gas pipeline for transport of CO_2 (gas and dense phase) and 100% H_2

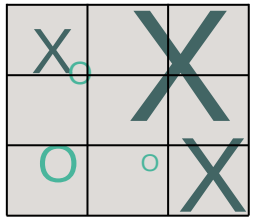
But are there some actual business opportunities?

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

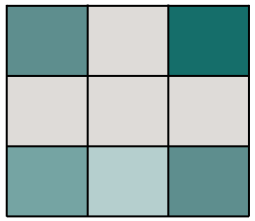
Methodology for mapping and quantification over time (2030, 2040, 2050) - Applied to H_2 consumption, H_2 production and CO_2 emissions

Location of data points and historic data

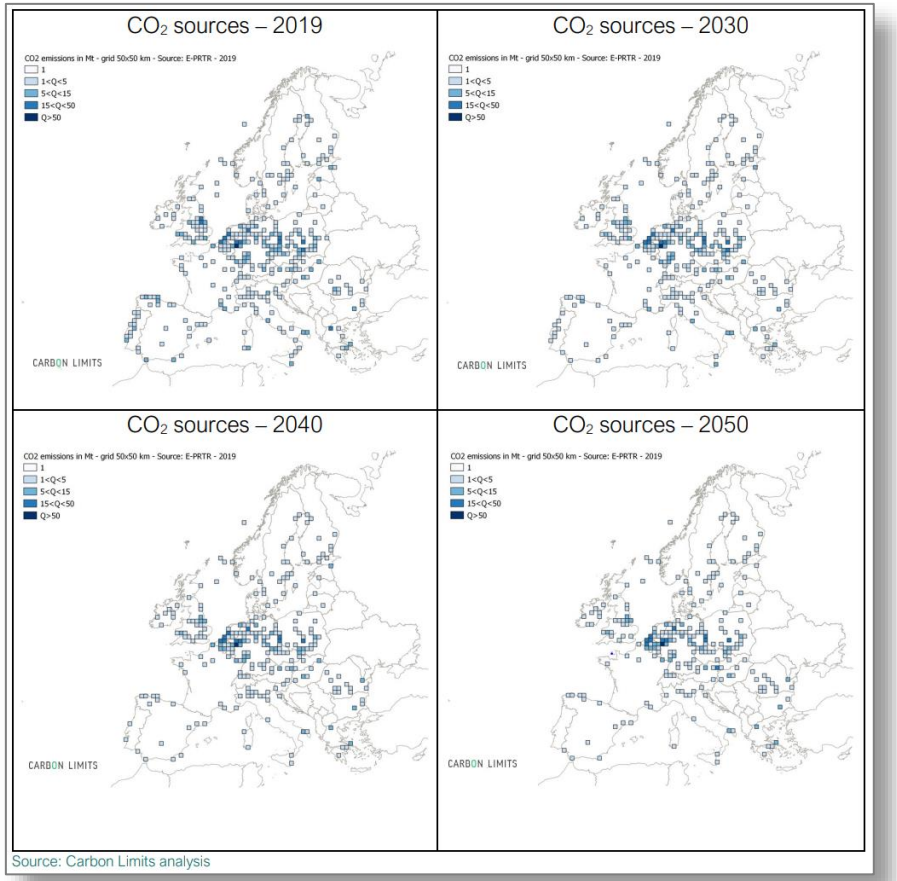
Data projections per sector



Data point projections depending on sector



Future density grid



Source: Carbon Limits analysis

H_2 and CO_2 storage sites were also mapped on a density grid but as storage capacity does not vary over the time, no projections were required

Pipelines were overlaid with potential future locations of sources and sinks

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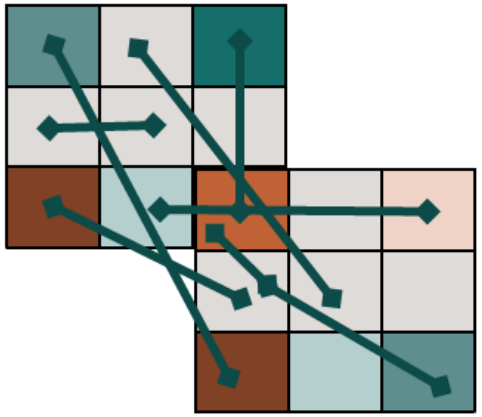
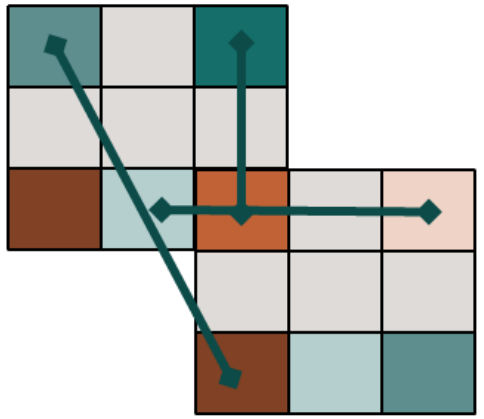
Overlay of the sources (production/storage) / sink (consumption / storage) grids + pipelines



Selected pipelines



Sources (production/storage) grid

- High
- Medium
- Low

Sink (consumption / storage) grids

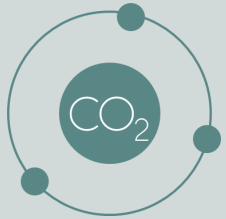
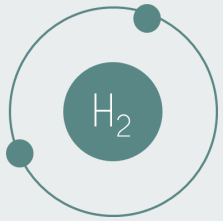
- High
- Medium
- Low

- Pipelines
- Cells with no source / sink

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

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.

*based on identified business opportunities within the Re-Stream study only

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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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