OFFSHORE PIPELINES FOR CCS SERVICE

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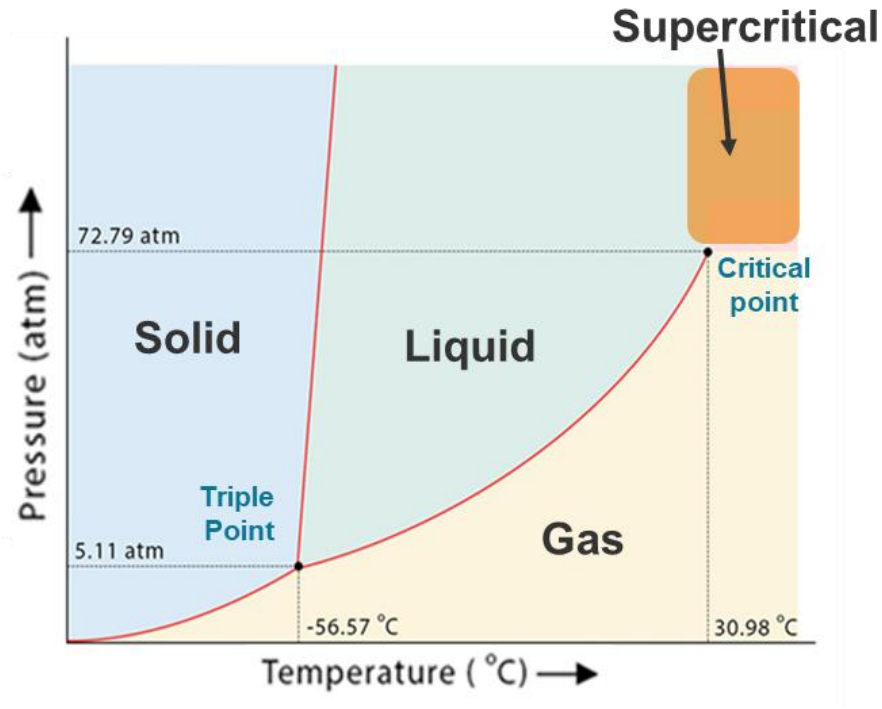
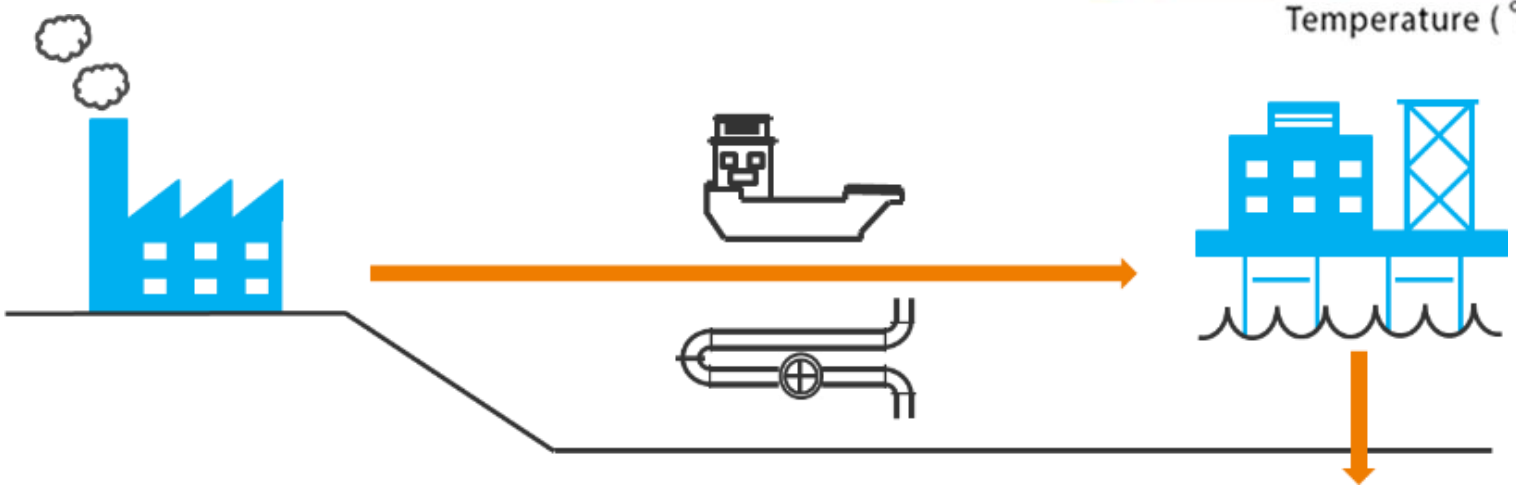
14/06/2023

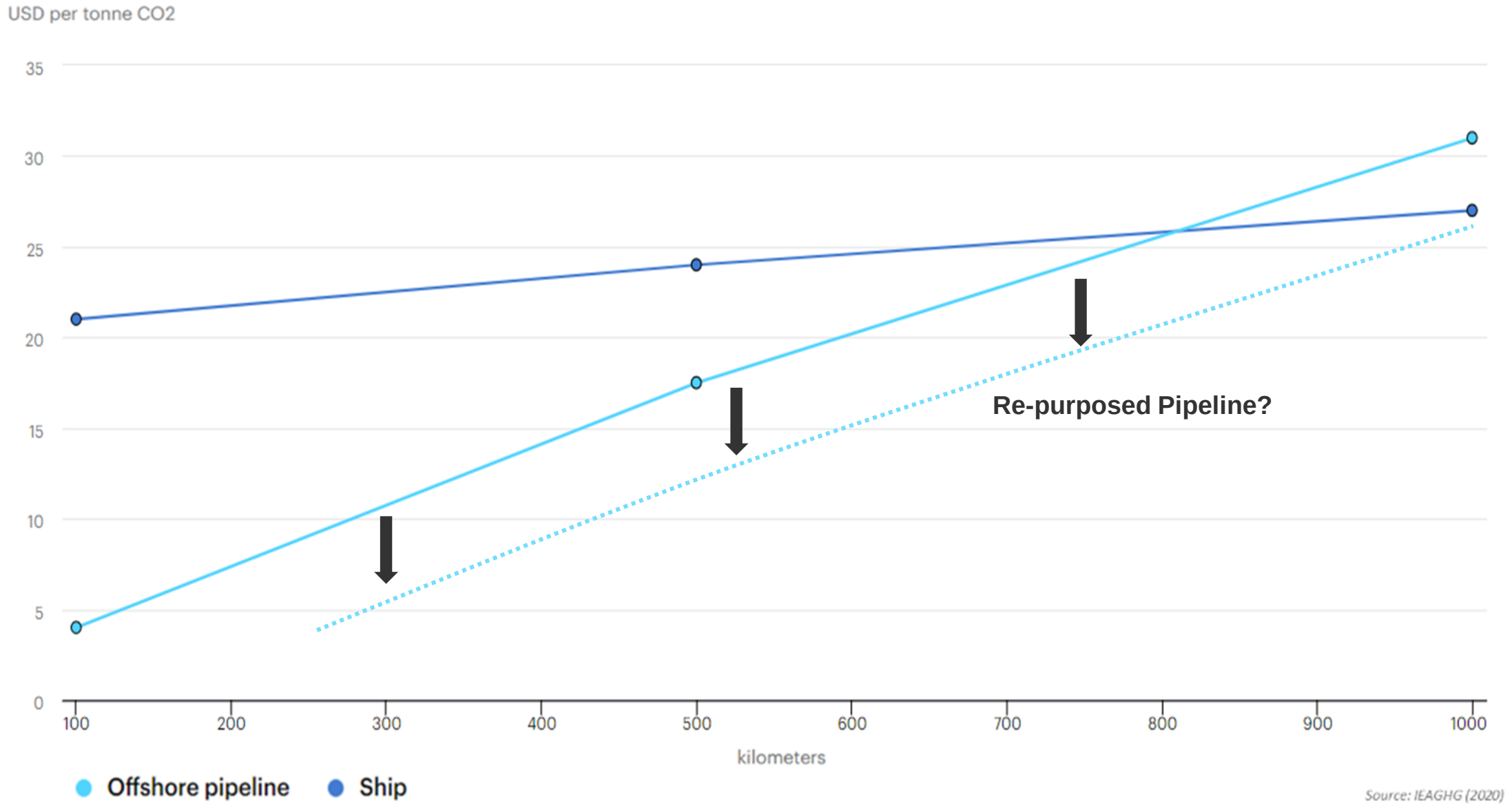
Introduction

- Can be collected from multiple sources
- Transport to underwater storage
- Supercritical fluid





Introduction



Current Knowledge

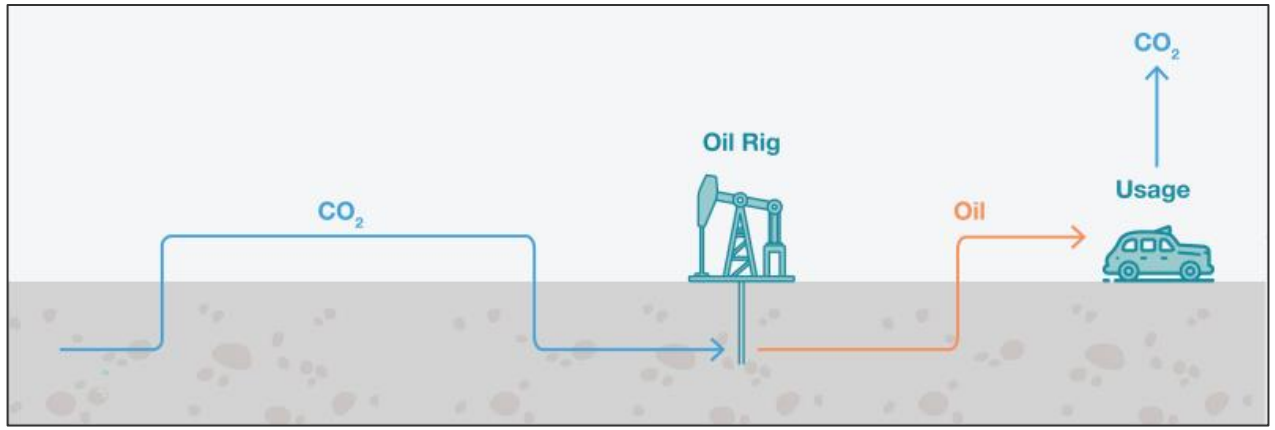
How much do we know?

- Existing CO_2 pipelines
  - 10,000 km
  - Mostly in North America / Europe
  - Majority used for EOR onshore
  - Single source

- Existing Standards
  - Historical subsea pipeline standards

  +

  - DNV-RP-F104 / ISO 27913 / ISO TR 27921



Source: https://energypost.eu/carbon-capture-can-co2-eor-really-provide-carbon-negative-oil/

Atteris

SUT
Society for Underwater Technology

Main Technical Challenges and Uncertainties

Main Technical Challenges / Uncertainties

Internal Corrosion

Material Compatibility

Ductile Fracture Propagation

+ Other conventional issues

Internal Corrosion

Internal Corrosion

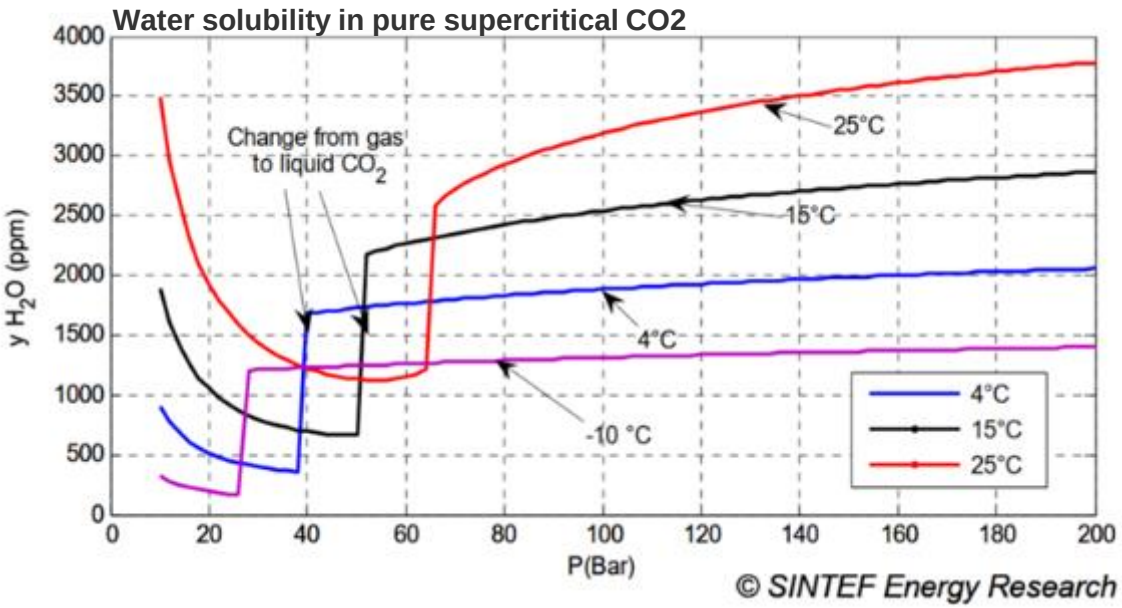
Material Compatibility

Ductile Fracture Propagation

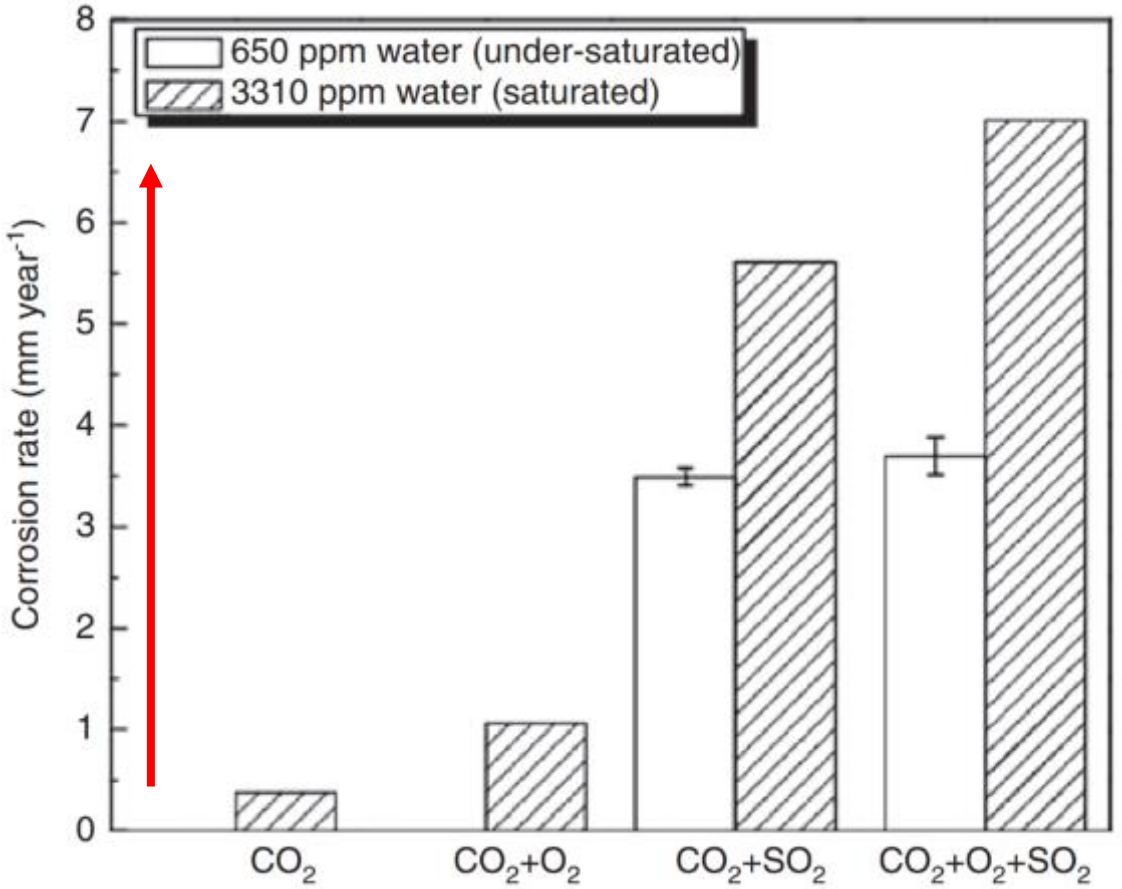
Internal Corrosion

- Corrosion rates can go up to 10 mm/year

- Excess water
- Type and concentration of impurities
- Combination of impurities



Carbon steel

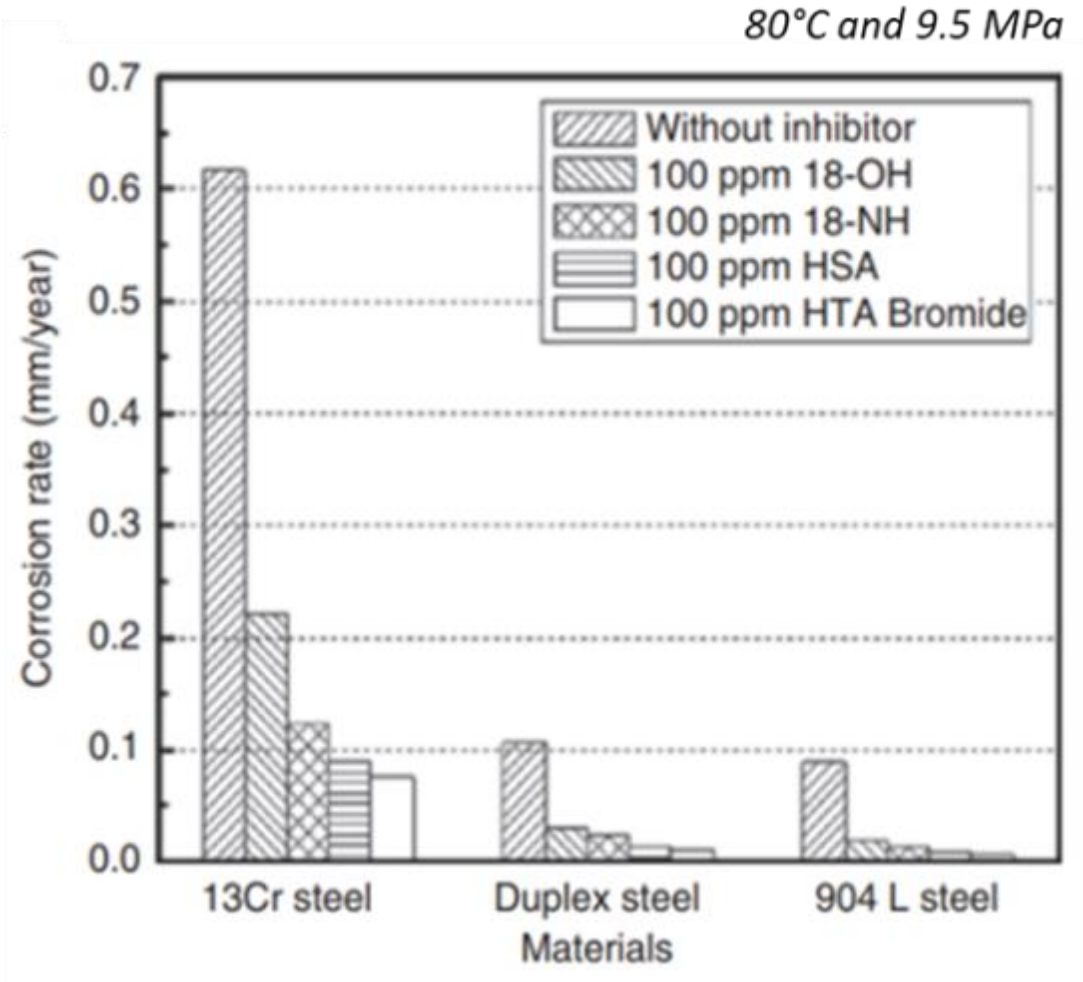


Source: L. Wei et al.: Corrosion behaviors of steels under supercritical CO2 conditions, CORROSION REVIEWS · July 2015.

Internal Corrosion

What can we do?
Use corrosion inhibitors
Increase wall thickness Use corrosion resistant steels

Expensive / Only for new pipelines



Source: L. Wei et al.: Corrosion behaviors of steels under supercritical CO2 conditions, CORROSION REVIEWS · July 2015.

Internal Corrosion

What can we do?
Prevent accidental water ingress
Control the CO_2 stream

- Tie-in
- Pre-commissioning
- Pigging (subsea launcher / receiver)

- Control internal conditions
- Dehydrate the CO2
- Monitor impurities

Identify all possible impurities

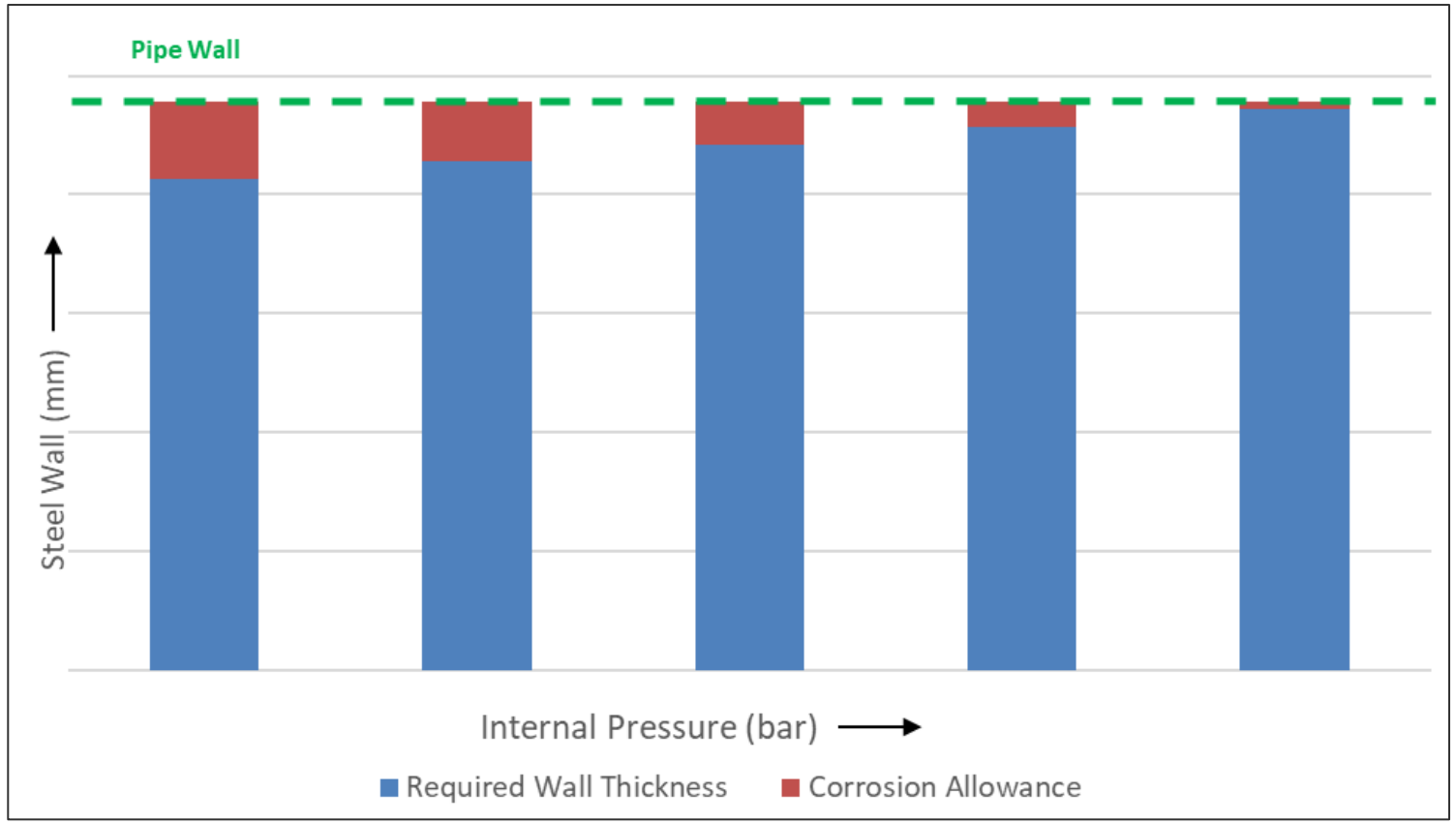
Define acceptance criteria

Internal Corrosion

Requirements for a re-purposed pipeline

- Know the condition of your pipeline
- Understand the impact of possible contaminants

Operating envelope
vs
Corrosion allowance



Sharing Knowledge

Future Fuel CRC (Atteris / Deakin University)

Purpose:

- Understand the synergistic effects of impurities
- Provide recommendations to avoid high corrosion rates
- Identify areas where knowledge and experience are limited

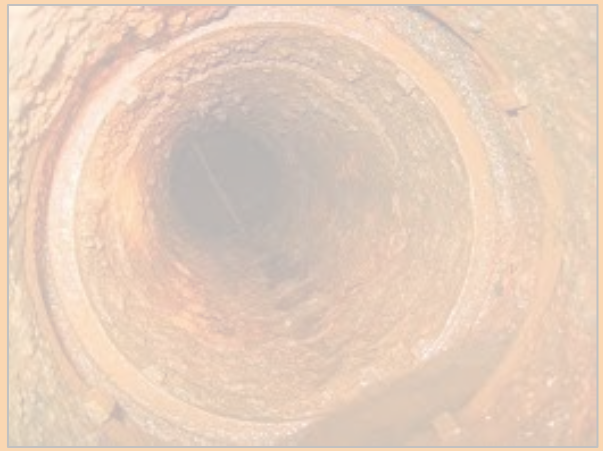
State of the art study

- Database of all available research / results to date
- Access to research papers and models not yet published

Atteris will present on the subject at the APGA Convention in October

Material Compatibility

Internal Corrosion



Material Compatibility

Ductile Fracture Propagation

Material Compatibility

CO_2
- Can reach low temperature
- Effective solvent / High permeation rate

- Adjust decompression rate
- Select suitable materials

➔ Lab testing based on CO_2 stream composition and operational conditions

https://www.graco.com/content/dam/graco/ipd/literature/misc/chemical-compatibility-guide/Graco_ChemCompGuideEN-B.pdf

Material Compatibility

Requirements for a re-purposed pipeline

- Identify all materials in the system (e.g. internal coating, seals)
- Understand the impact of past operations

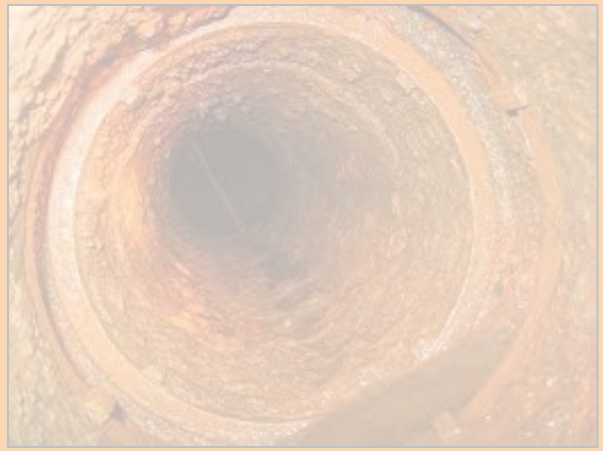
- Replace polymers where possible
- Extensive documentation review
- Sampling
- Laboratory testing

CHEMICALS	METALS					PLASTICS, ELASTOMERS & LEATHER																		
A: Excellent, B: Good, C: Fair to Poor, D: Not recommended - No Data	Aluminum	Carbon Steel	Cast/Ductile Iron	304 Stainless Steel	316 Stainless Steel	Acetal	Buna	CSM (Hypalon)	EPR, EPDM	Fluorocarbon	Fluoroelastomer (FKM)	Geolast (Buna & Polypropylene)	Hastelloy C	TPE	Leather	Nitrile (TS)	Nitrile (TPE)	Nylon	Polychloroprene	Polypropylene	PTFE	PVDF	Santoprene (EPDM & Polypropylene)	UHMWPE	Urethane
Caprylic Aldehyde	-	-	-	-	-	-	-	-	-	-	D	-	-	-	-	D	-	-	-	-	A	-	-	-	-
Carbamate	-	-	-	-	-	-	C	-	C	A	A	D	-	-	-	C	D	-	C	-	A	-	A	-	D
Carbitol	B	-	B	B	B	-	B	-	C	C	A	B	A	-	-	B	C	-	C	C	A	A	B	-	D
Carbolic Acid (Phenol)	B	D	D	B	B	D	D	D	C	A	A	D	A	D	D	D	D	D	D	C	A	B	D	B	C
Carbon Bisulfide	B	-	B	B	B	B	D	D	D	-	A	D	B	C	-	D	D	A	D	D	A	A	D	D	C
Carbon Dioxide	A	A	D	A	A	C	A	-	B	A	B	-	A	C	A	A	B	B	B	A	A	A	A	C	C
Carbon Dioxide (dry)	B	D	D	A	A	A	A	B	B	-	B	-	A	A	-	-	-	A	B	A	A	A	-	-	-
Carbon Dioxide (wet)	A	D	D	A	A	A	A	B	B	-	B	A	A	-	-	-	-	A	B	A	A	A	-	-	-

https://www.graco.com/content/dam/graco/ipd/literature/misc/chemical-compatibility-guide/Graco_ChemCompGuideEN-B.pdf

Ductile Fracture Propagation

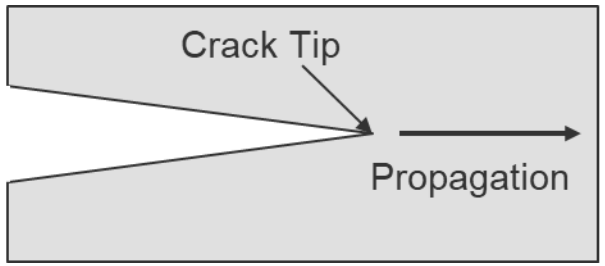
Internal Corrosion

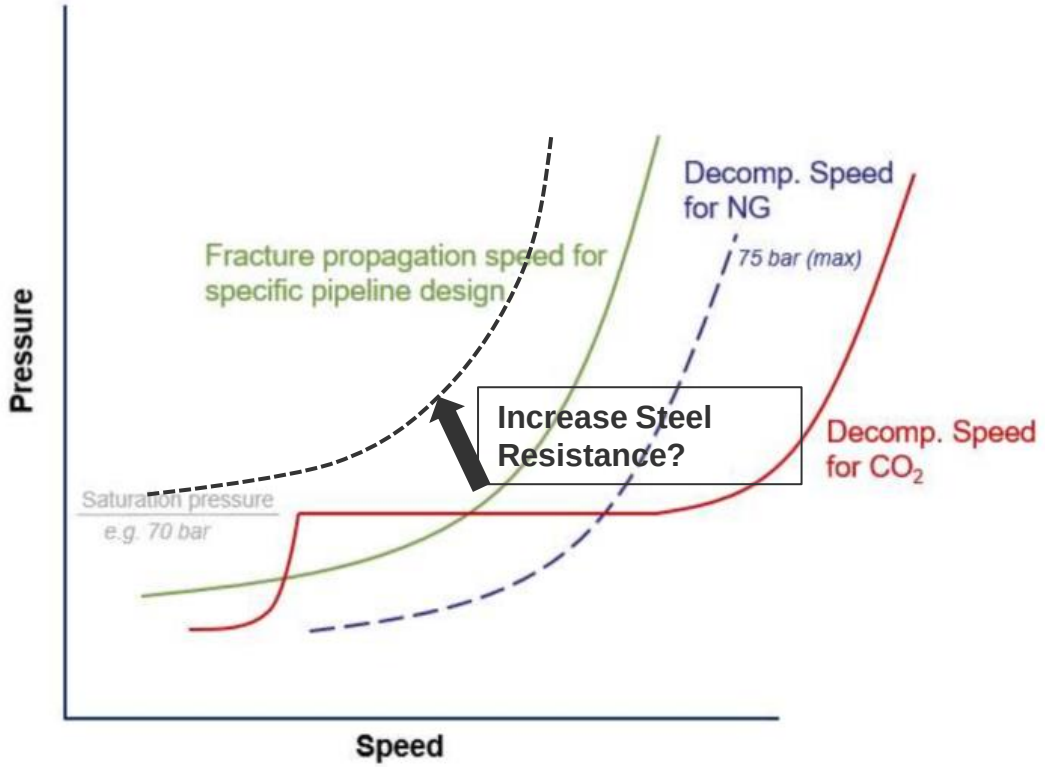


Material Compatibility

Ductile Fracture Propagation

Ductile Fracture Propagation





High susceptibility to fracture propagation for CO_2 pipelines

- Speed drop at phase change
- Fracture propagation speed > Decompression speed

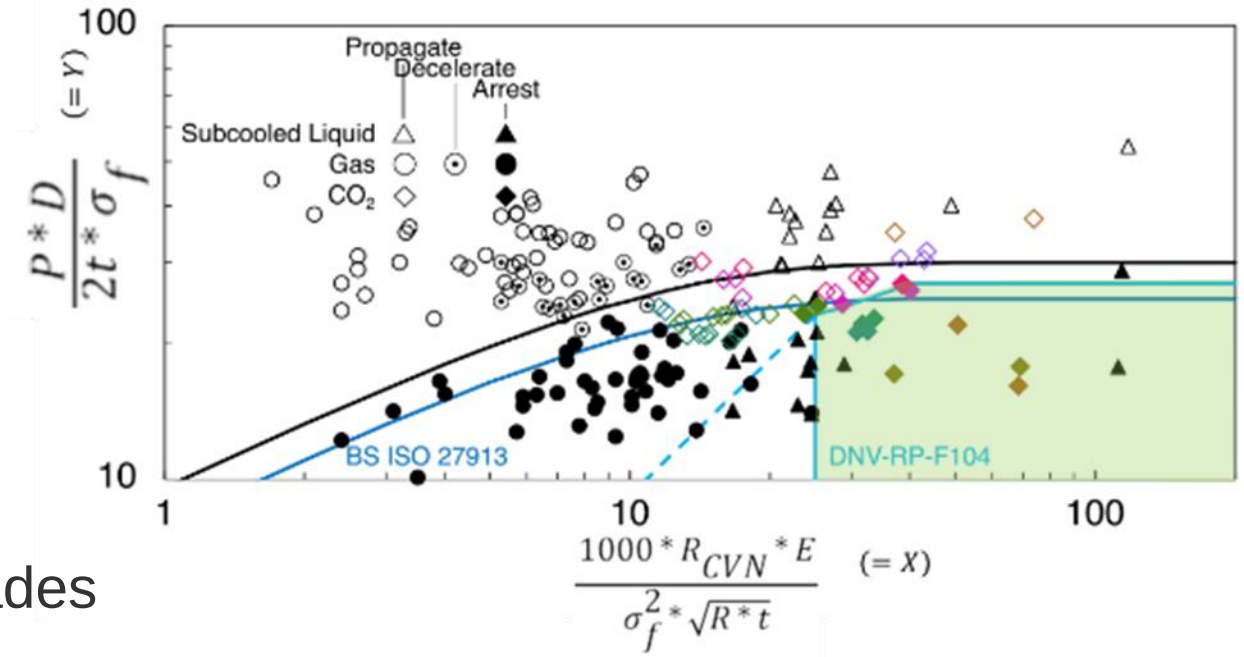
Source: N. Gallon, D. Sandana, P. Robson, CO2 pipelines – Back to the future?, Technology for Future and Ageing pipelines, 2022

Ductile Fracture Propagation

- Existing DNV method based on full-scale testing (limited)

New pipelines only

- Increase wall thickness
- Increase steel toughness
- Use crack arrestors



- Achievable with conventional steel grades

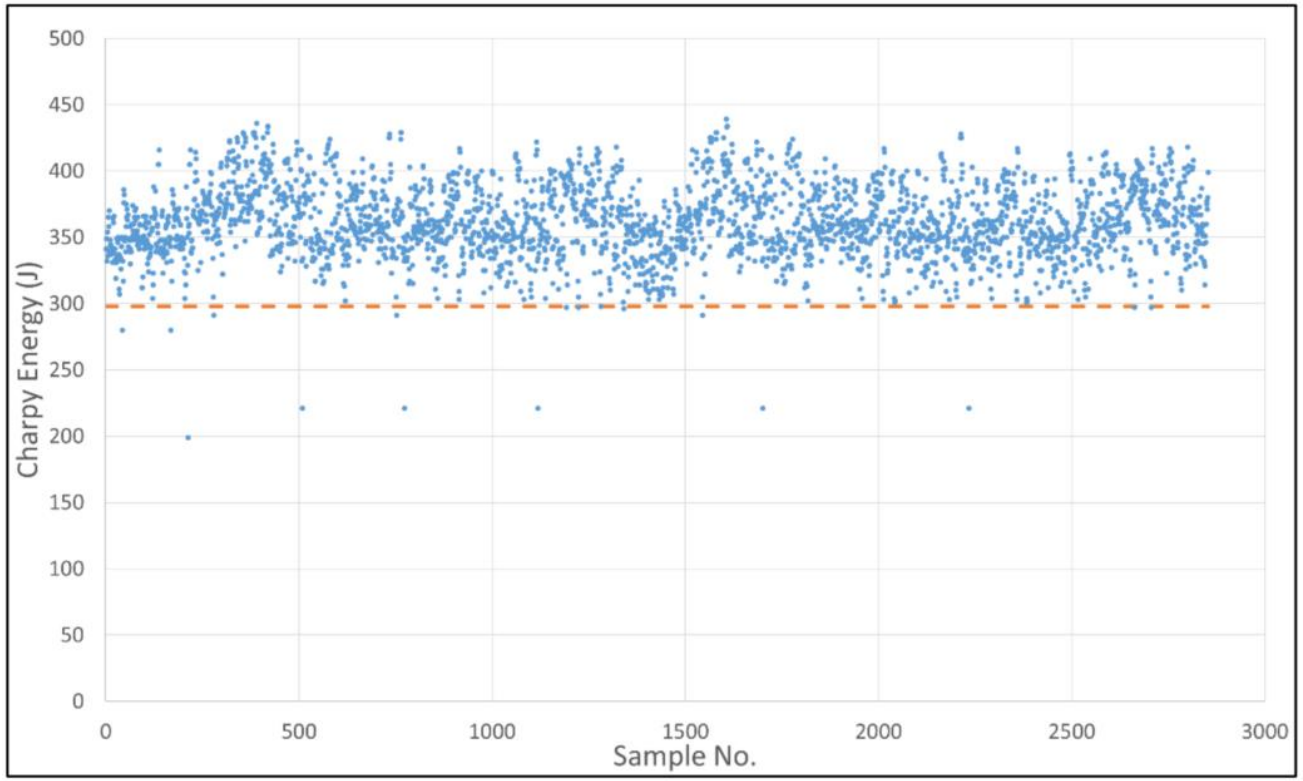
- Temperature and impurities levels impact the saturation pressure
- Reducing internal pressure does not help

Material Compatibility

Requirements for a re-purposed pipeline

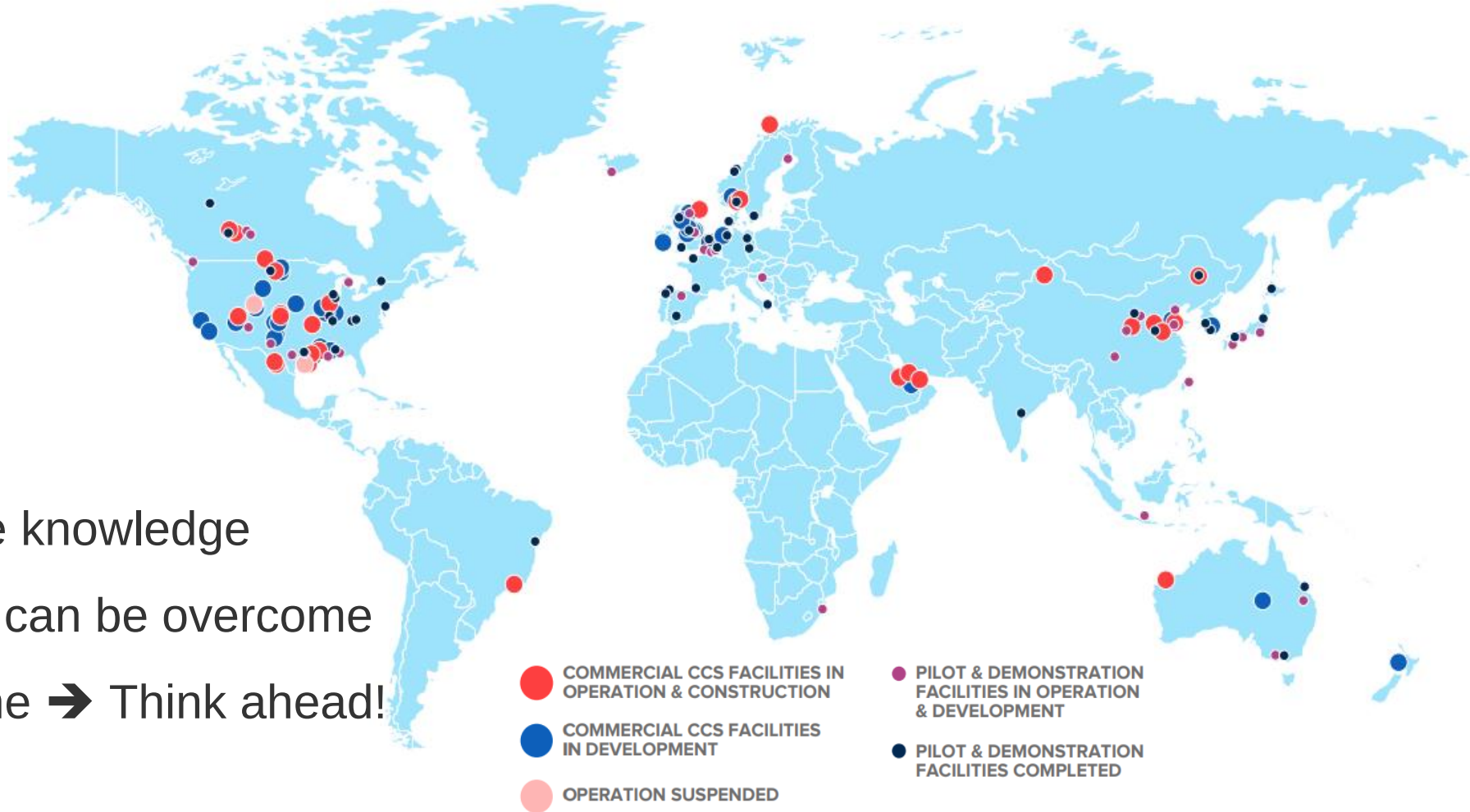
- Detailed inspection
- Extensive documentation review
  - Identify steel grades
  - Understand past requirements
  - Assess tests representativity

Risk-based approach



Conclusion

- Early stage of CCS submarine pipeline network development
- Industry is still learning / on-going research projects
- Fast-moving



- Lots of transferrable knowledge
- Specific challenges can be overcome
- Repurposing pipeline ➔ Think ahead!

Source: https://www.globalccsinstitute.com/wp-content/uploads/2021/09/Global-Status-of-CCS-Report-Jan-28-1.pdf

Thank You

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