Challenges for CO_2 transport

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Top-level Research Initiative

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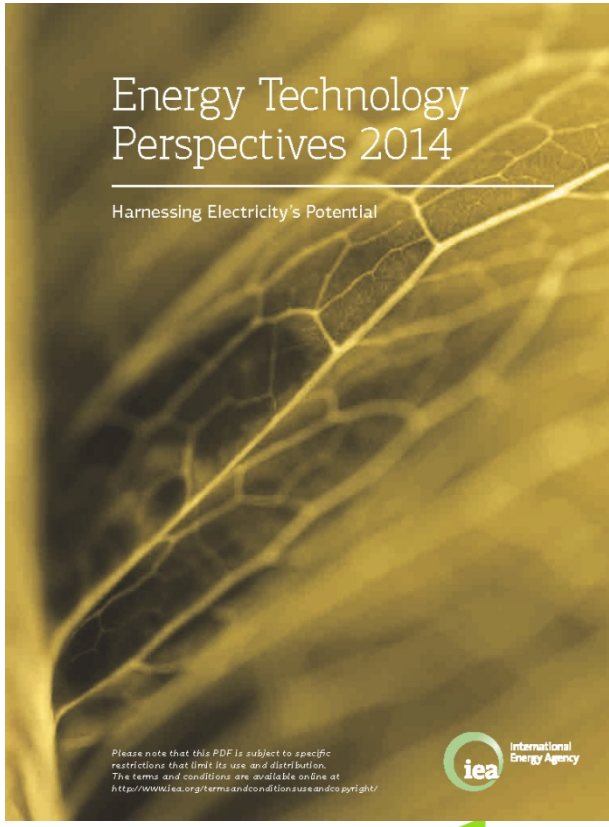
CO_2

Large-scale CO_2 transport and storage

- In the 2 degree scenario (2DS) of IEA
  - CO_2 emissions reduced by 43 Gt/year in 2050
  - CCS accounts for 6 Gt/year in 2050
- 6Gt/year equals…
  - 6000 Sleipner fields
  - 120 times the US EOR pipeline capacity
  - 80 times the Norwegian natural-gas export
- Transport must be safe and efficient
- Significant cost: 10–20 €/t



Offshore transport options

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Pipeline

- High investment cost
- Cheap to operate
- Good for large volumes
- Good for small distances

Ship

- Low investment cost
- Expensive to operate
- Good for small volumes
- Good for large distances

Pipeline transport

- CO_2 pipeline transport in the US
- CO_2 from CCS is different
- No mature commercial simulation tools
- Still need research on transient operation
  - Temperature during emptying/filling
  - Required steel thickness/toughness
  - Impact of impurities

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Ship transport

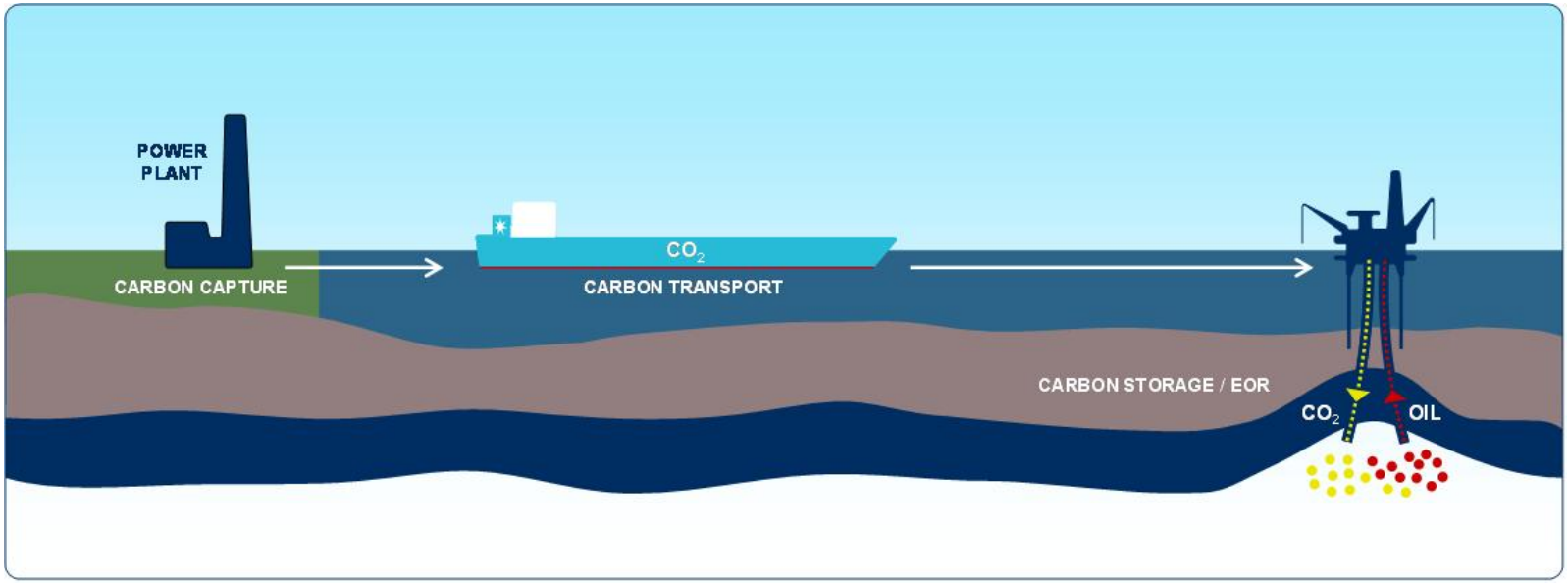


Figure: Maersk

- Loading and shipping is well-known
- Offloading and injection has more uncertainties

CO_2 ships

- CO_2 shipped at 7 bar and -50°C
- CO_2 ships will be similar to LNG/LPG tankers
- Yara has three CO_2 ships operating

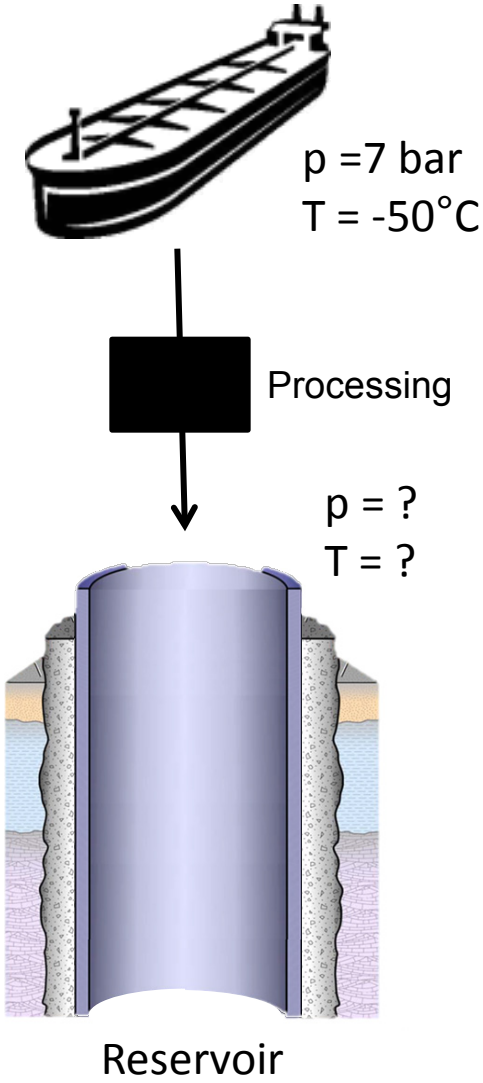
Photo: Wolfgang Meinhart

Photo: Yara

Unloading and injection

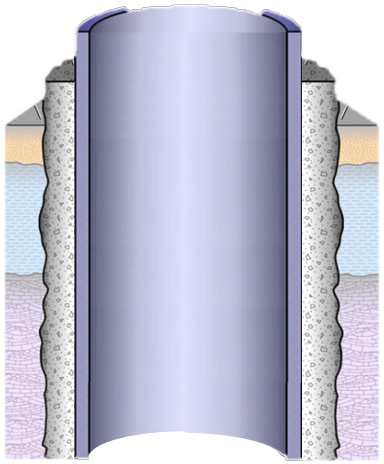
Injection from ships differs from pipelines:

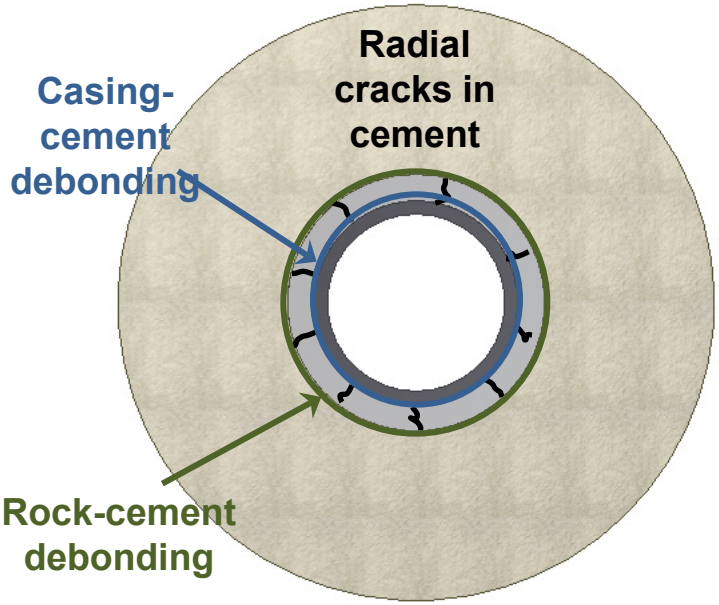
- Non-continuous injection
  - Might need buffering
- Colder fluid
  - Needs some heating



Thermal cycling

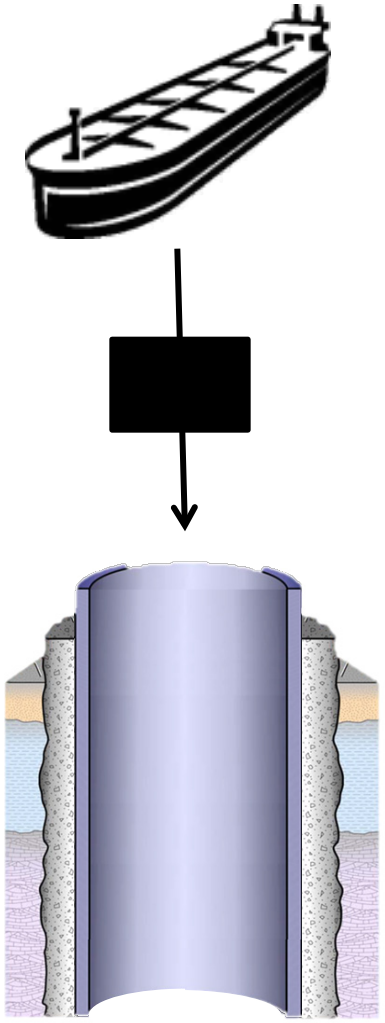
- Non-continuous injection gives large temperature variations
- Steel pipe expands and contracts
- Can lead to cracks and leaks
- CO_2 must be heated, but how much?





Non-continuous injection

- Salt precipitation
- Hydrates
- Corrosive brine in the well



Chain analysis

- Many assumptions in present studies
- Need simulation of whole chain
- Each part is rather well-known, need to put it together

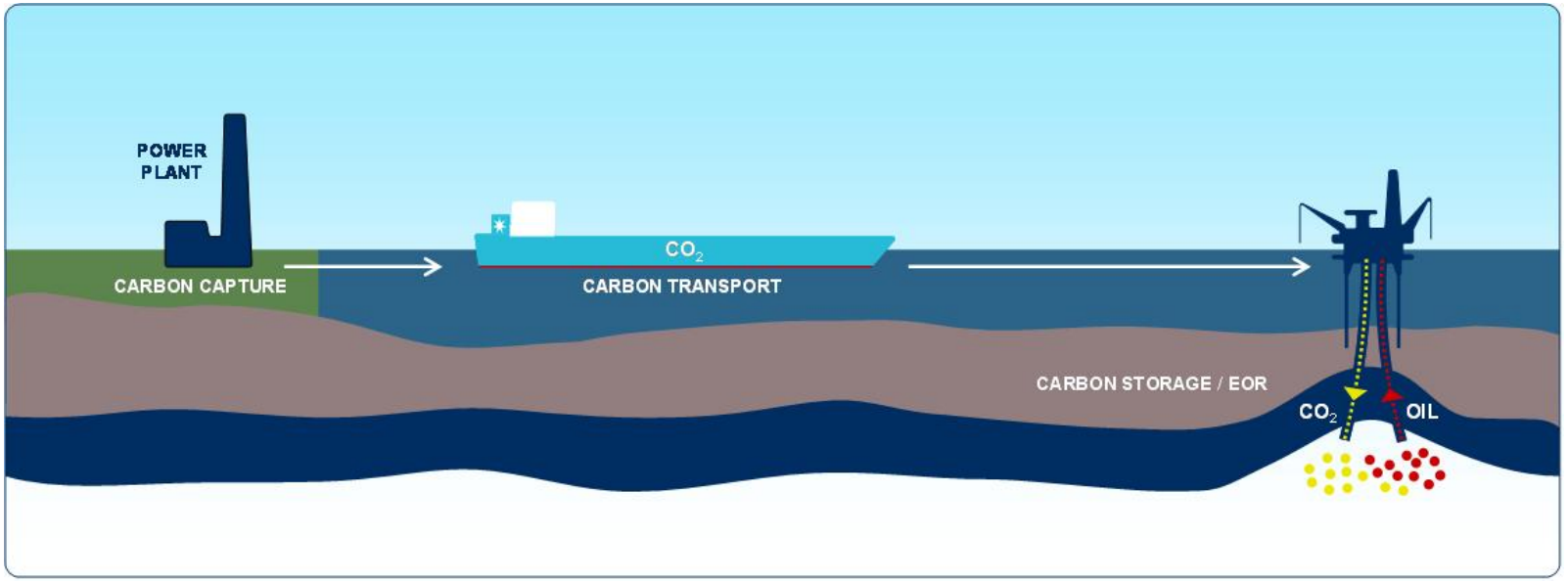


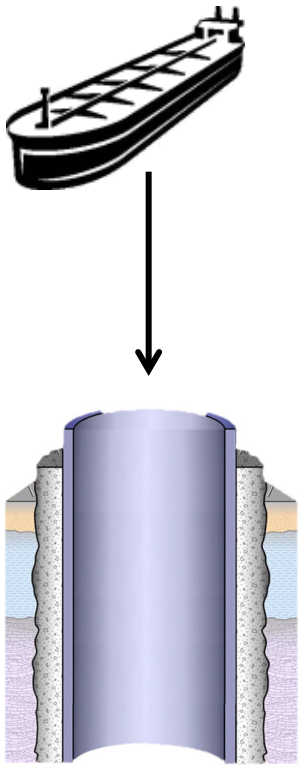
Figure: Maersk

Summary

- Many aspects of ship transport are well known
- Need to design safe injection procedures

- Better simulation tools for pipelines can give better and safer design

- Need optimization of the whole chain



Thank you for your attention