First steps towards standardization of the design of CO_2 pipelines

It is all about risk control!

Wim Mallon & Onno Florisson

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Introductory remarks

The importance of Carbon Capture & Storage (CCS): Crucial for meeting the EU-target on the reduction of CO_2 emission

A lot of work has been done on CO_2 capture and storage, but how about the connection between the CO_2 capture facilities and the storage facilities?

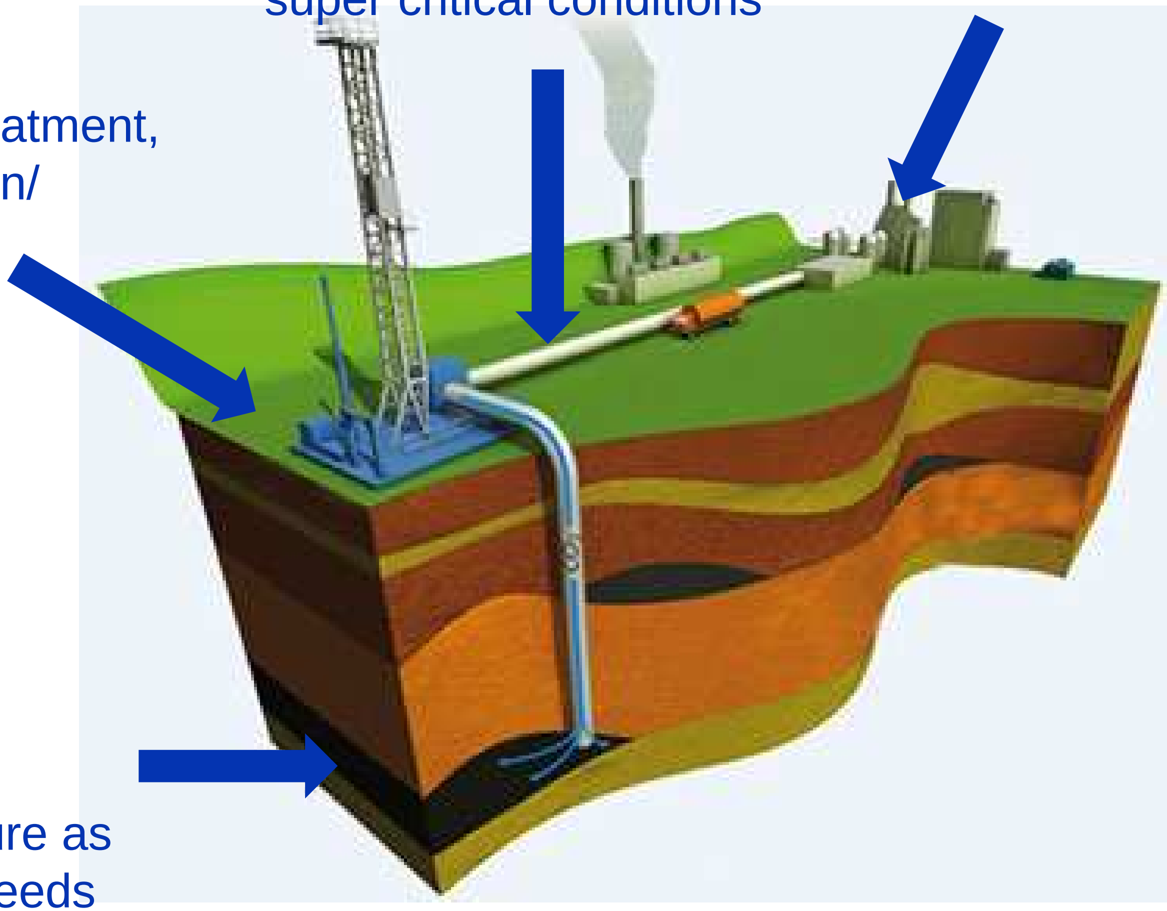
This presentation concerns the process towards a **safe** and **economic design** of a pipeline system between the CO_2 capture and the storage facilities

CCS chain with CO2 transmission pipelines (in case of injection in an empty gas field)

CO2 transmission as a gas, a liquid or under super critical conditions

CO2 capture, treatment and compression

CO2 injection: treatment, pressure reduction/ compression and heating/cooling



Empty gas field: increasing pressure as the injection proceeds ~10 - 30 bar at start

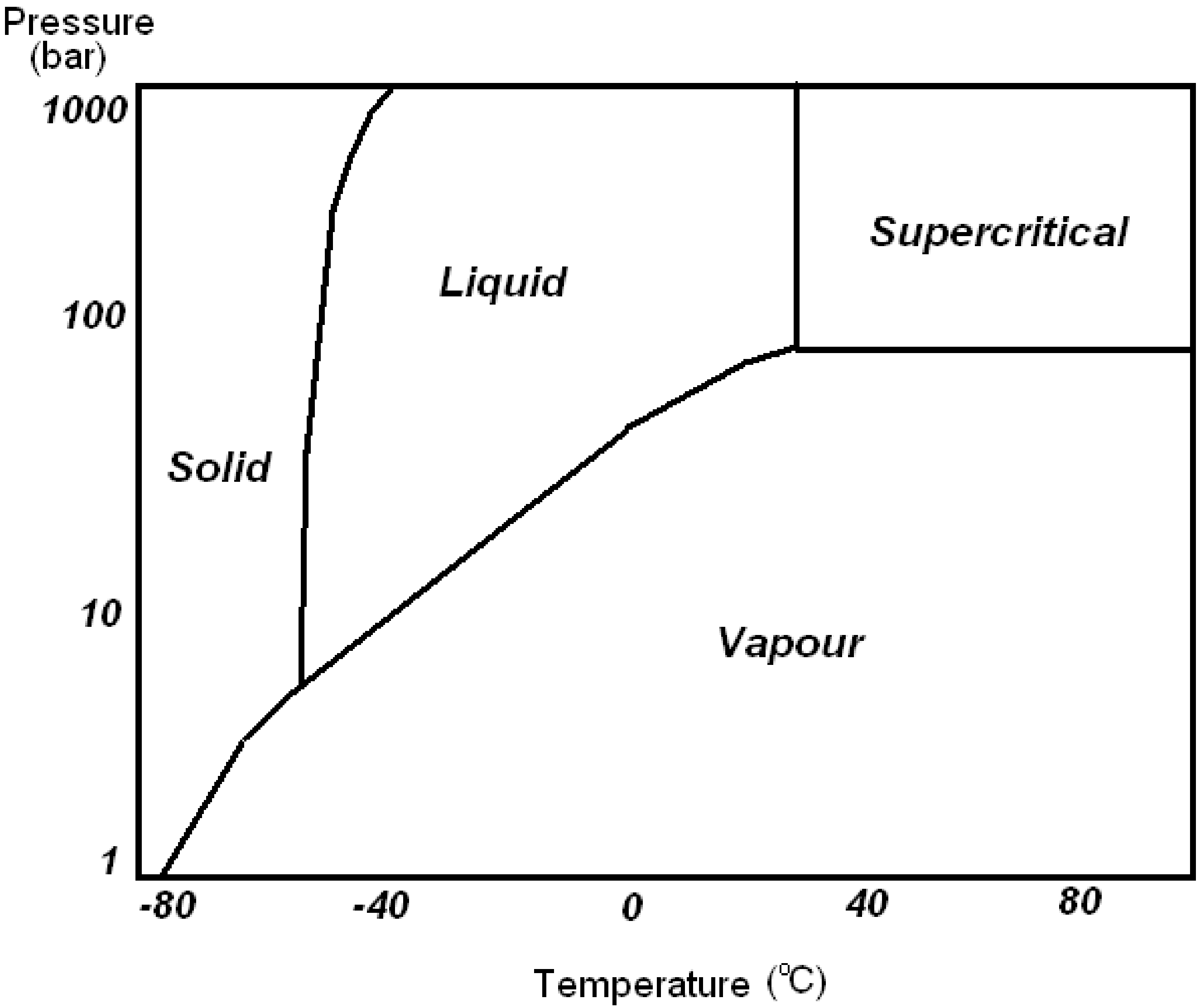
Facts on CO_2 (1)

- 0,038 % in the atmosphere on sea level
- Green house gas
- In combination with free water, corrosive for steel pipelines
- Health aspects:
  - 0,5% MAC value
  - 8 % Unconsciousness in 5 to 10 minutes, death after 30 minutes
  - >20 % Unconsciousness after a few breaths, death after a few minutes.
- Physical and chemical properties differ significantly from e.g. natural gas:

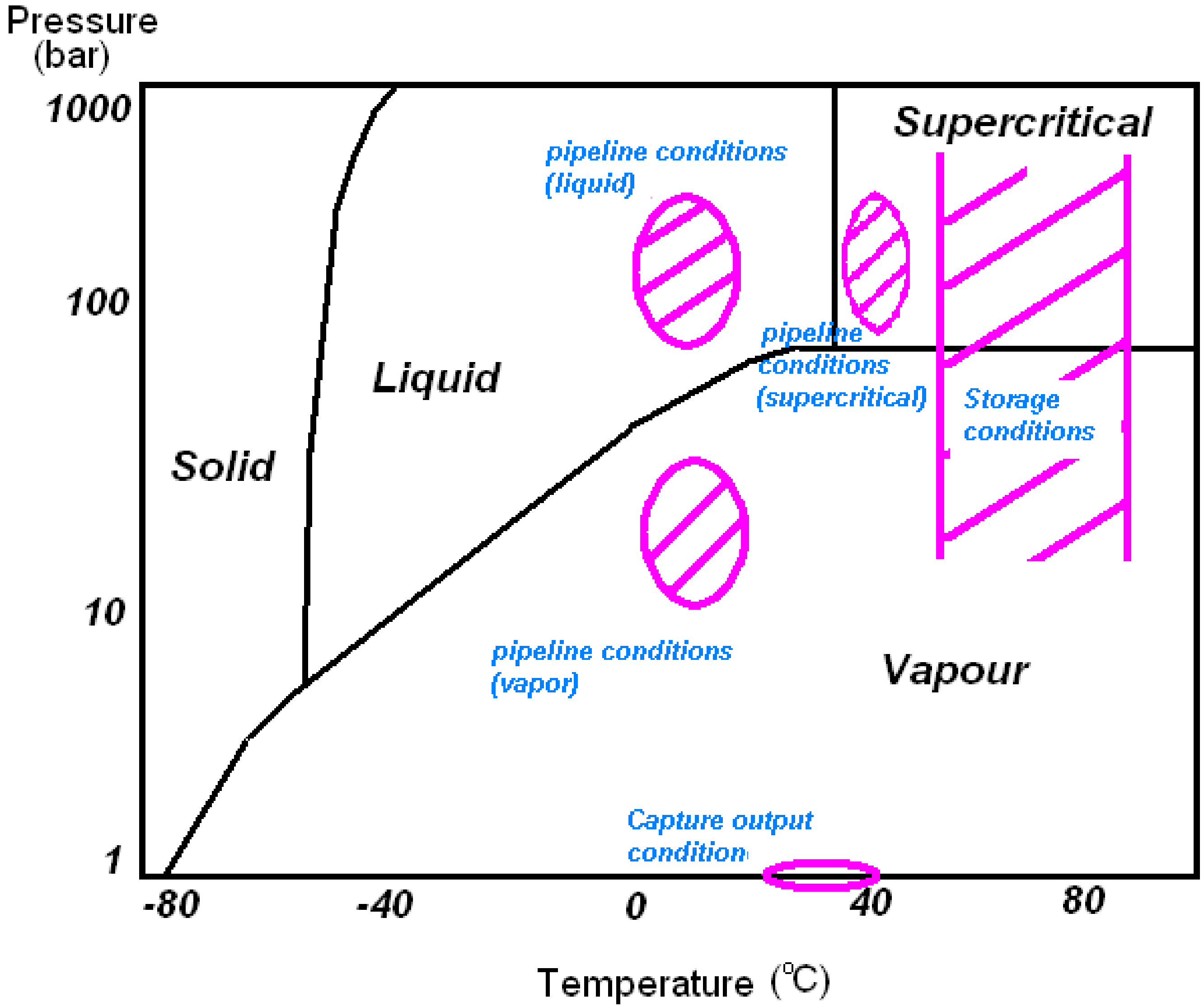
o Relative density 1,5 (n.g. ~0,6)

o The phase diagram (next slide)

Facts on CO2 (2): Phase diagram

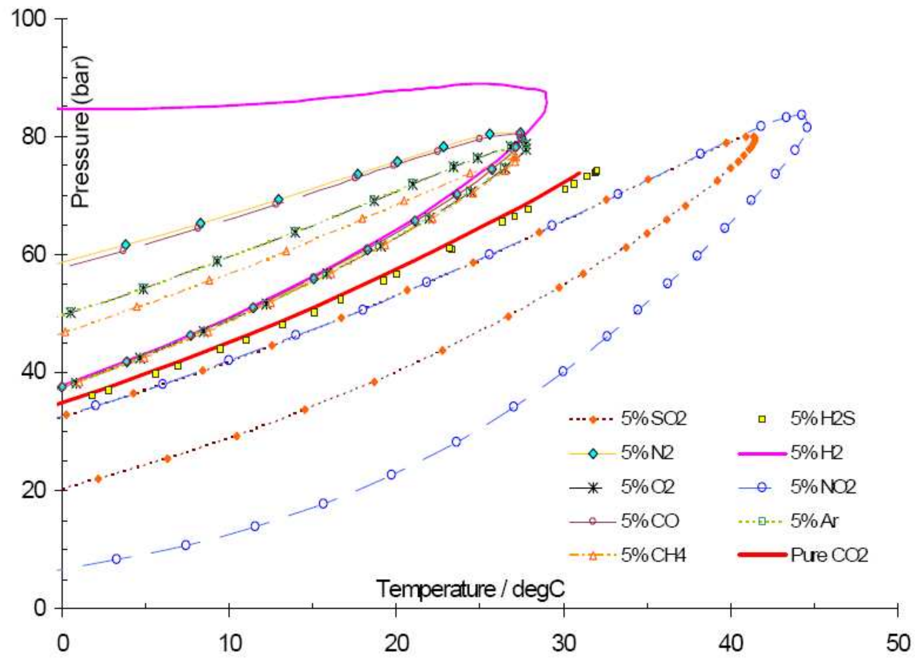


Facts on CO2 (3): Phase diagram + operational areas



Facts on CO_2 (4): Impact impurities

The presence of impurities influences the CO_2 (liquid-vapor) transition line



Existing CO2 pipelines

- ~ 5600km CO2 pipelines around the world (majority in the US and Canada)
- Used for CO2 Enhanced Oil Recovery (EOR).

Differences with envisaged CO2 pipelines in the EU:

- The existing CO2 pipelines are for the greater part in remote areas, while the pipelines in the EU will be in highly populated areas
- The design approach in the EU is different from the one in the US and Canada: US is practical, lets build and see, EU theoretical, thorough design, risk based approach
- Back pressure: oil wells are at high pressure, while empty gas wells are at 10-30 bar. (or even lower)

First steps to get prepared

Driven by risk management, DNV and many others investigate the key risk issues.

DNV initiatives under execution:

- Definition of a multi stakeholder project for developing a “recommended practice” (CO2PIPETRANS project):
  - To map out existing knowledge and gaps in knowledge
  - To further investigate the key issues releases, materials (corrosion, crack propagation, compatibility), hydrate formation, phase diagram
- DNV KEMA: COSHER project in the GERG framework, medium scale experiments for validation and improvement of safety models on CO2 transmission pipelines
- CATO 2 projects: release experiments, impurity research
- EDGAR project: measurement of water, measurement technology, dewpoint

Some DNV KEMA's initiatives on CCS under development

Focus on gaining knowledge of vital importance for the development of **safe and economic** CCS systems.

Raised in the framework of GERG.

- Broadly accepted safety models for CO_2 transmission by pipeline
- Guidelines for an optimised CO_2 Chain Design and Operation
- Injection of CO_2 in empty gas fields and aquifers

High probability of support by the EC

Initiative under development (1): Broadly accepted safety models for CO2 pipelines

Main objective:

Development of a tool to determine safety contours around high volume CO2 transmission pipelines based on/taking into account:

- Existing theoretical models
- Existing experimentally validated models for pipelines (small & medium diameters)
- Experimental data from large scale experiments to be executed.

Broadly accepted safety models for CO2 pipelines are crucial to enable CCS to be come a success!

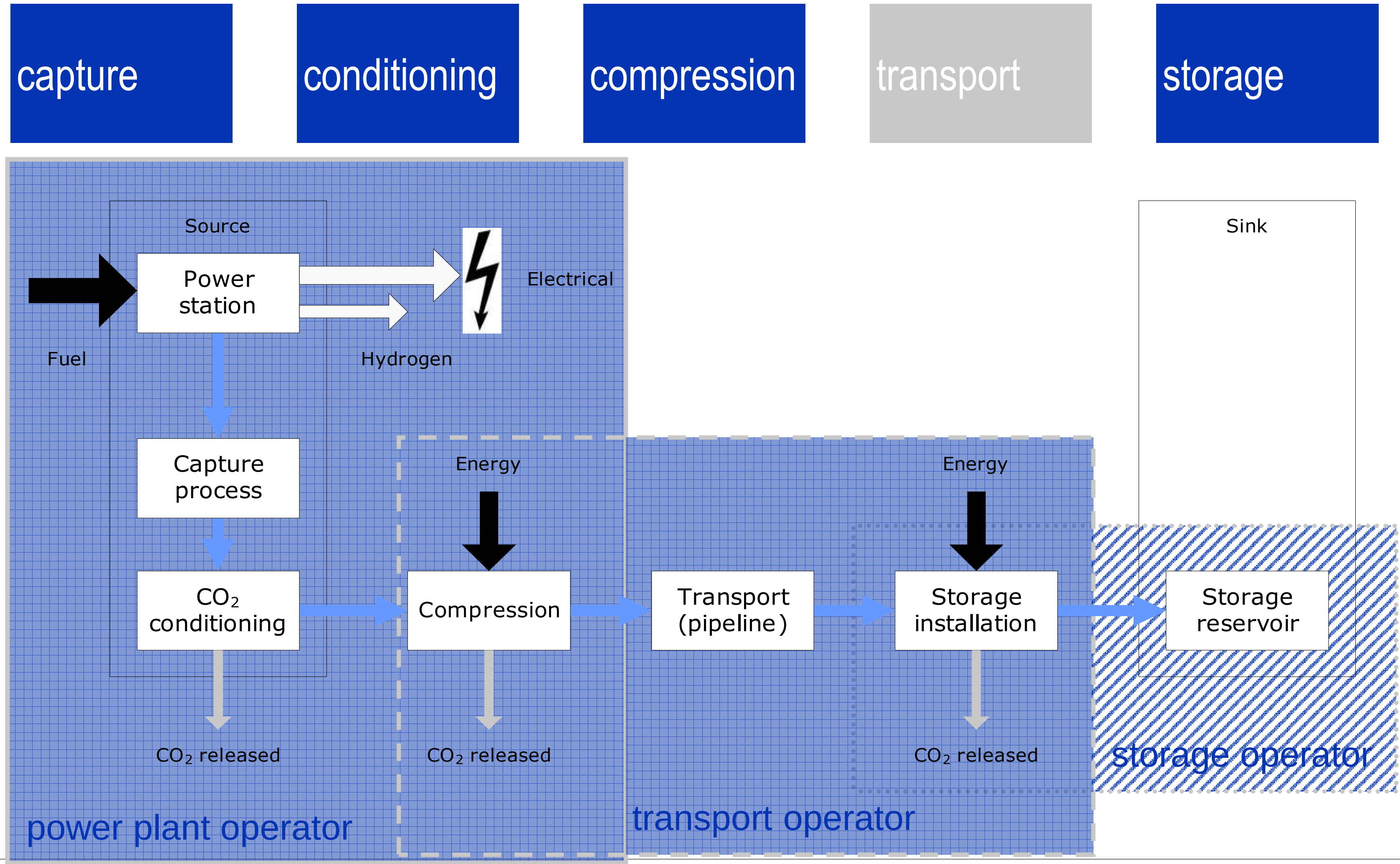
Interested organisations are invited to contact me

Or my colleague Onno Florisson*

* onno.florisson@dnvkema.com

Viewpoint varies along the CO_2 chain.

transport & infrastructure



system integration + optimization covered by KEMA

Initiative under development (2): Guidelines for optimised CO2 chain design and operation

Main objective:

Development of an optimised CO2 chain (capture, transmission & injection) design and operation guideline, taking into account:

- The evolution of the chain due to the raise of the back pressure in time
- The outcomes of large scale safety experiments
- Operational aspects like capture patterns over the day and seasons, and start up situations

Development of this initiative in the framework and with the support of the EC is crucial for its success!

Interested organisations are invited to contact me

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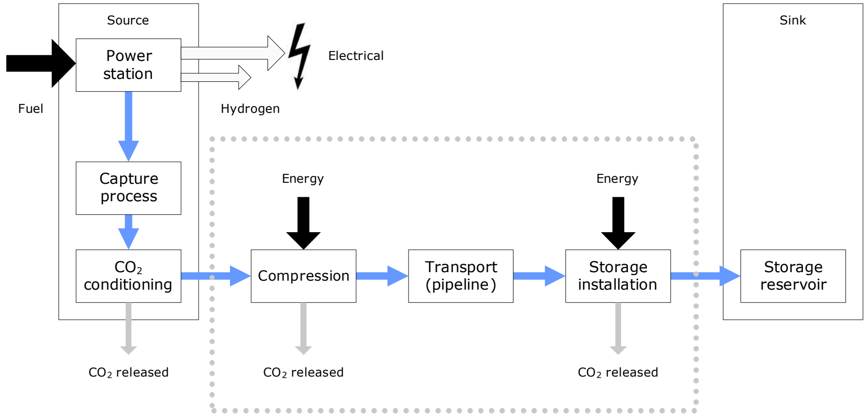
Design and Optimalisation.

transport & infrastructure

capture | conditioning | compression | transport | storage

Finding design optimum:

1. One chain
2. CCS network infrastructure



Design of transportation infrastructure

Design challenges:

- Liquid or Dense phase transport
- Injection pressure can change over time
- Smart combination of Unit operations
- Compression at capture or storage, or both? (on and offshore)
- Heat demand?
- Material selection / cost / risk

Thank you for your attention

Wim Mallon (wim.mallon@dnvkema.com)

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Onno Florisson (onno.florisson@dnvkema.com)