How to cope with the recent challenges in gas transport

4th Conference of the EURO Practitioners' Forum

Klaus Spreckelsen

OGE

Contents

OGE at a glance

2004
Established as Ruhrgas Transport
2010
Renamed Open Grid Europe

One of Europe‘s **leading gas transmission system operators**

Some **1,450 employees** across Germany;
Head office: Kallenbergstraße 5,
45141 Essen, Germany

Sole responsibility for the **operation, control, expansion and marketing** of the company’s pipeline network

Some **450 German and European customers**

Our pipeline network

approx. 12,000 km
of pipelines

17
border-crossing point

approx. 30
compressor stations equipped with 100 compressor units with a total capacity of approx. 1 GW

approx. 129 GW
annual peak load 2021

1,008
exit points

2
types of gas shipped:
H-gas/L-gas

Our pipeline network 2021

- Main supplier Russia
- Main entry Waidhaus in south-east Germany
- Main transport direction: north-east to south-west
- No German LNG terminals

● Compressor station/field site
— OGE transmission pipeline
➡ Flow direction

Our pipeline network 2023

- Main supplier Norway
- Waidhaus is now exit
- Main transport direction: north-west to south-east
- German LNG terminals
- New pipeline WAL

● Compressor station/field site
— OGE transmission pipeline
➡ Flow direction

The War and the WAL

- Wilhelmshavener Anbindungsleitung (WAL) was completed December 2022 in just nine months
- Connects the first German LNG terminal to the OGE network (currently there are three german LNG terminals)
- 26 km, 100 bar, ca. 6 GW, H_2-ready

OGE is going green

— Very ambitious corporate goal in the current situation due to the war-related changes in gas flows

— ESG* becoming increasingly important

Short-term approach (software)

— Hints for emission-optimized compressor use

— Intelligent user interface for controlling the compressor stations in a target-oriented way

Long-term approach (hardware)

— Transition to hydrogen

We will reduce our greenhouse gas emissions until 2025 compared to 2009 by

45 %

*ESG: Environmental, social, and corporate governance

GET H2 IPCEI* – Starting signal for European H2 economy

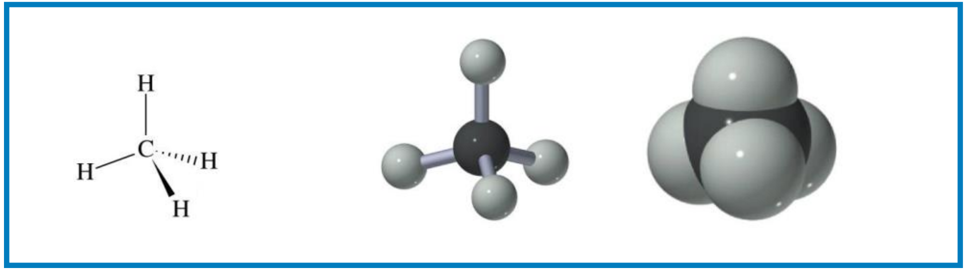
- Start of the hydrogen economy with the production, transportation, storage and supply of green H2 to industry as early as 2025
- By 2030, an H2 network is to be built stretching from Lingen to Gelsenkirchen and from the Dutch border to Salzgitter
- Electrolysis by 2026: 300 MW planned in Lingen and 100 MW in Salzgitter
- Public funding sought as part of the IPCEI programme

*IPCEI: Important Project of Common European Interest

Physical Properties of Natural Gas and Hydrogen

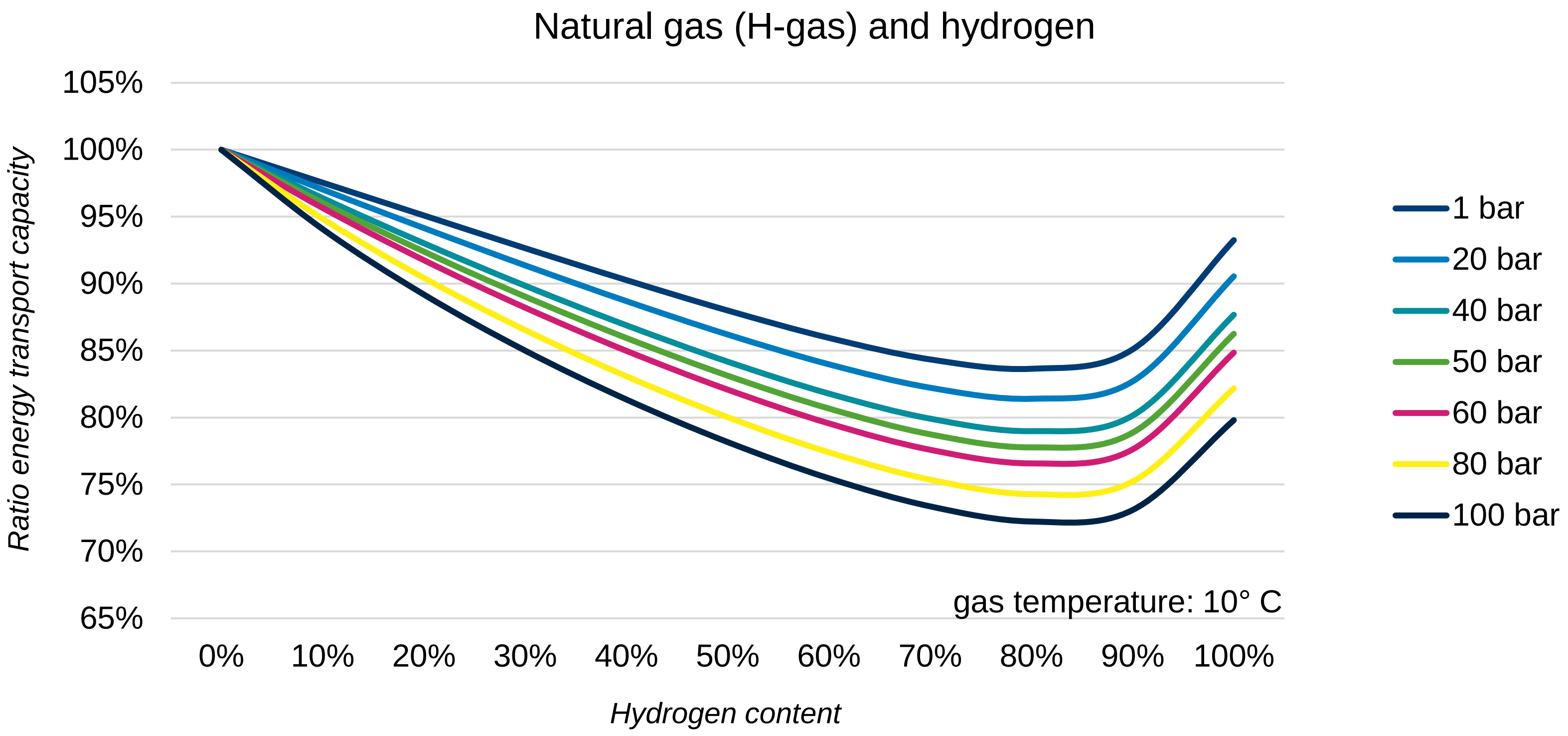
Property	Unit	Hydrogen	Norwegian H-Gas	Dutch L-Gas
Molar mass	g/mol	2.01	17.8	18.4
Calorific value	kWh/m³	3.54	11.3	10.2
Wobbe value	kWh/m³	13.4	14.4	12.8
Speed of sound*	m/s	1,283	414	409

* At 283.15 K (10 °C) and 1 bar



Source: Prentice-Hall,Inc.

Mixture of Natural Gas and Hydrogen



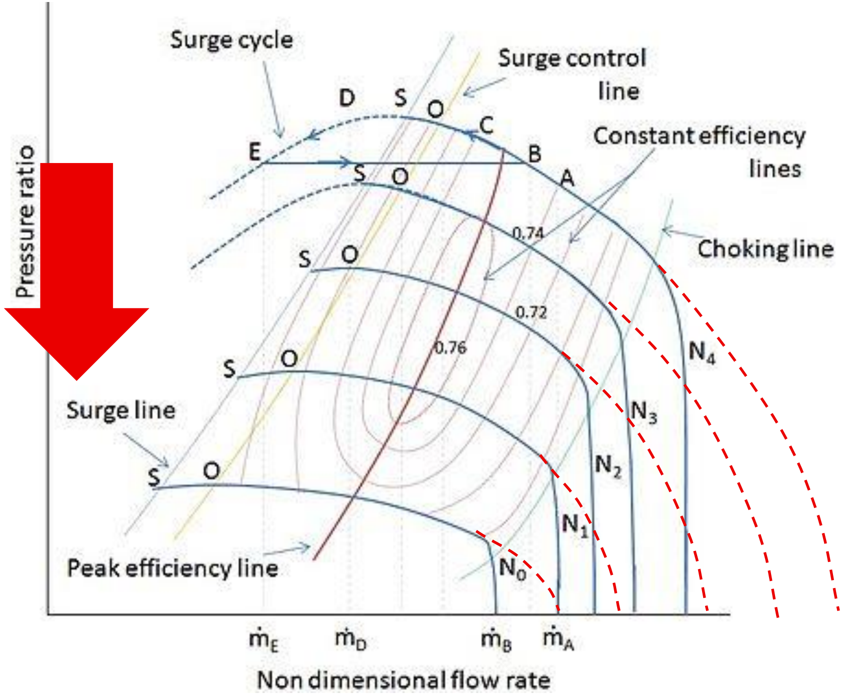
Problems with compressing hydrogen

1. Low energy density → more energy needed for compression
2. Low molar mass → more compressor stages needed for compression

Change of the Characteristic Map with Hydrogen

With the compression of hydrogen, the map becomes flatter and wider

Low pressure ratio



No capping of the speed lines with the speed of sound, because the speed of sound of hydrogen is about three times that of natural gas.

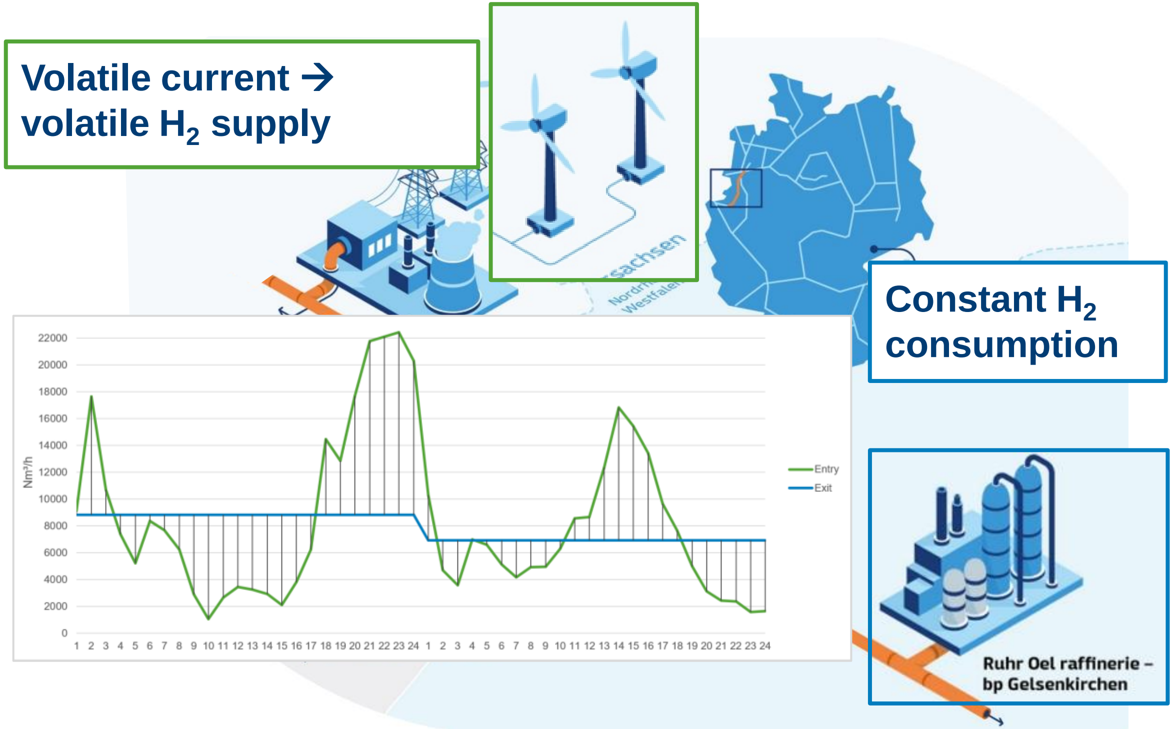
Source: Wikipedia

Turbo Compressors versus Piston Compressors

Compressor type	Large volume flow	Large pressure ratio
Turbo compressor	✓	✗
Piston compressor	✗	✓

- Several stages are required for the compression of hydrogen with turbocompressors.
- Piston compressors are very rarely used for natural gas.

Customers need with-in-day flexibility

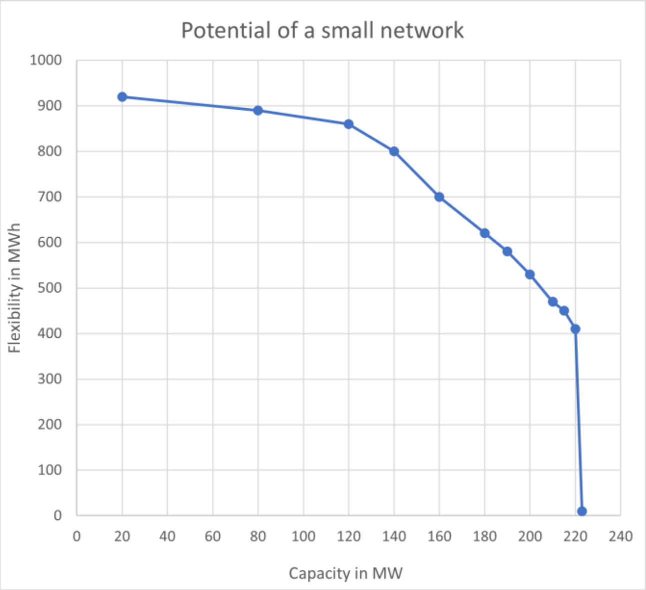


- The H_2 supply from electrolysers is volatile within a day, as it is directly coupled to the generation profiles of renewables
- Industrial customers require an exit from the hydrogen grid that is decoupled from the supply profile
- Customers want to transport hydrogen (**capacity**) and operate supply and consumption independently (**flexibility**)

Czech-German Hydrogen Interconnector: H2 corridor from the North and Baltic Sea via Czechia to southern Germany

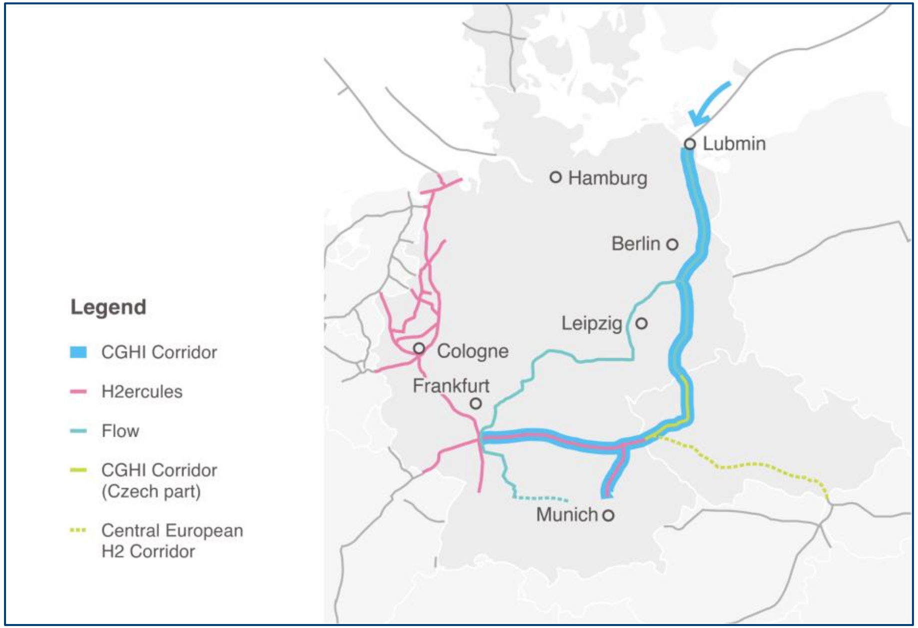
Problems:

1. Most of the network can be converted. What is the best order to convert pipelines from natural gas to hydrogen?
2. What is the best way to partition the potential of the network (capacity versus flexibility)?



Project initiative from three European TSOs

GASCADE NET4GAS OGE



Long-term Vision and Transformation from Natural Gas to H_2

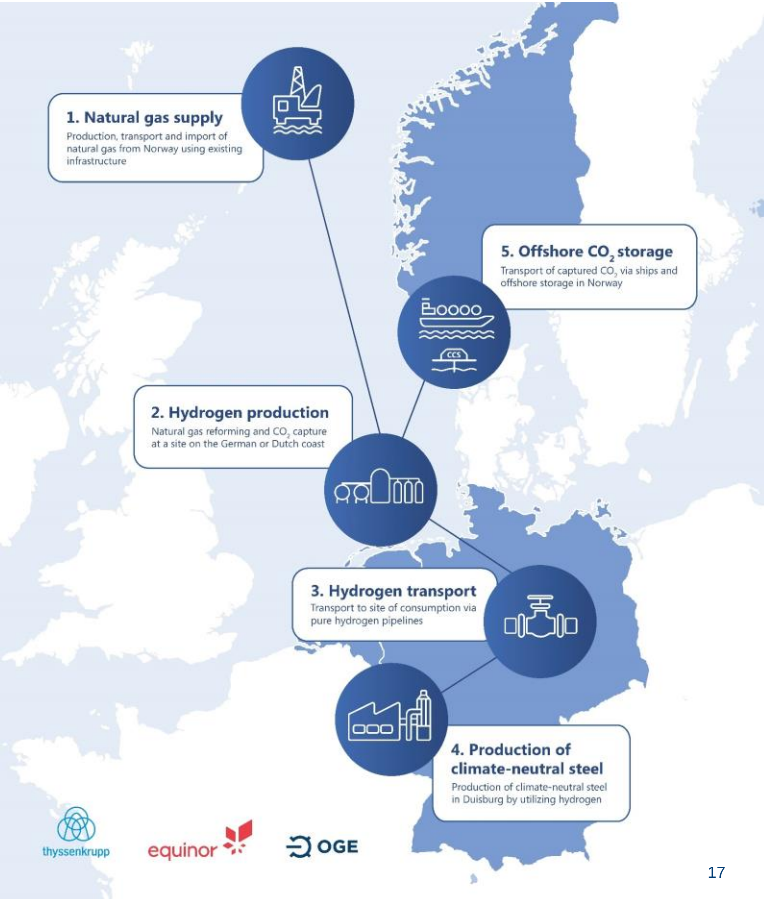
H2morrow steel

Joint initiative by Equinor, thyssenkrupp Steel Europe and OGE

— Develop pioneering project to supply energy-intensive industries and later on other end users with large quantities of climate-friendly hydrogen produced in the Netherlands.

— Initial customer for hydrogen will be the new direct reduction plants and planned activities of thyssenkrupp Steel Europe in Duisburg by end of 2026.

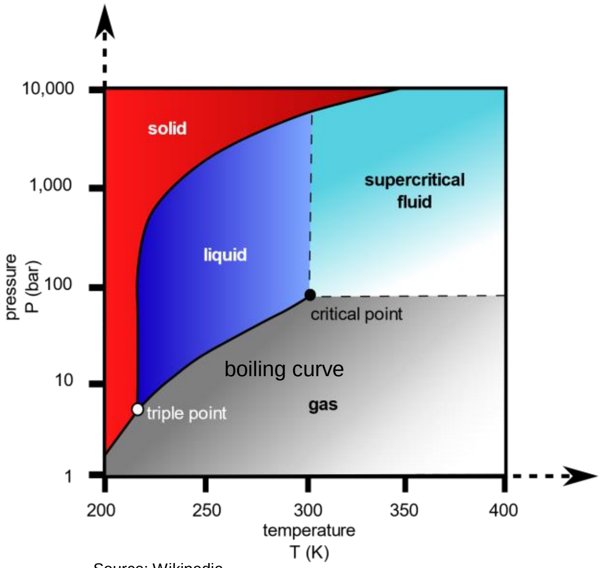
— Transporting both hydrogen and carbon dioxide



Carbon Dioxide CO_2

Produced by

1. burning organic material
2. chemical processes, especially producing cement: $CaCO_3 \rightarrow CaO + CO_2$



Source: Wikipedia

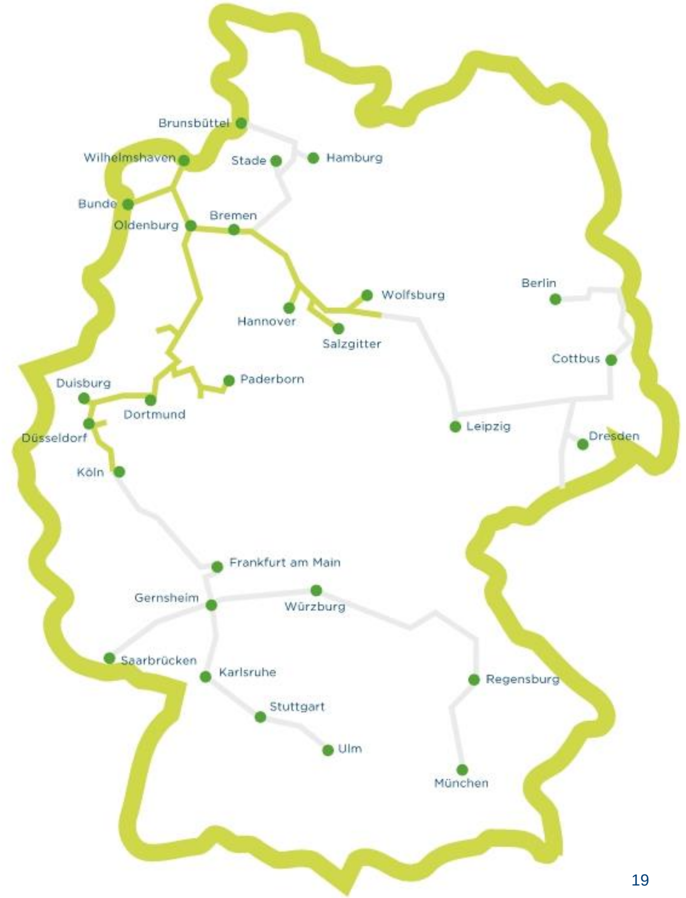
CO_2 Infrastructure: One Component for Climate Neutrality

The idea

- Construction of a CO_2 transport infrastructure
- Offer to the industry to tackle the last building block to climate neutrality: Climate-neutral handling of CO_2
- Network is open to all market participants

OGE

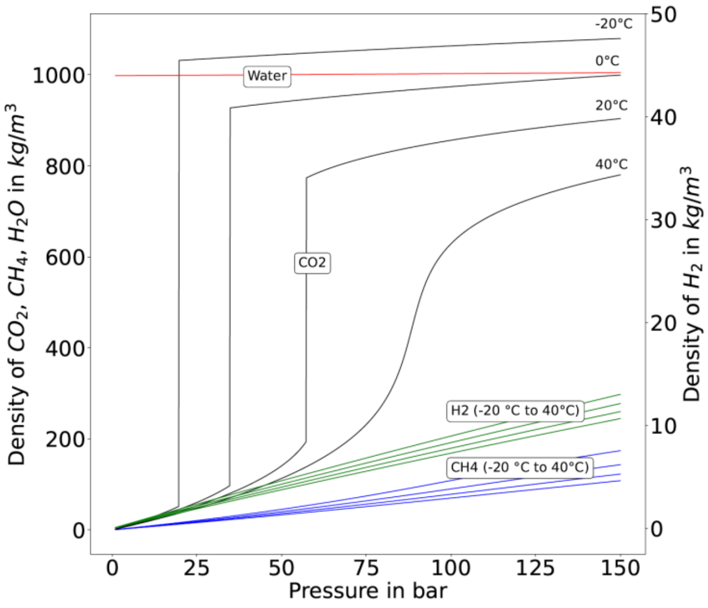
- Construction and operation of an initially approx. 1,000 km long transport infrastructure with a potential transport volume of 18 million t CO_2 per year
- First stage: One exit, several entries, no cycles, therefore the flow is known at every edge
- Main problem: optimization of diameters



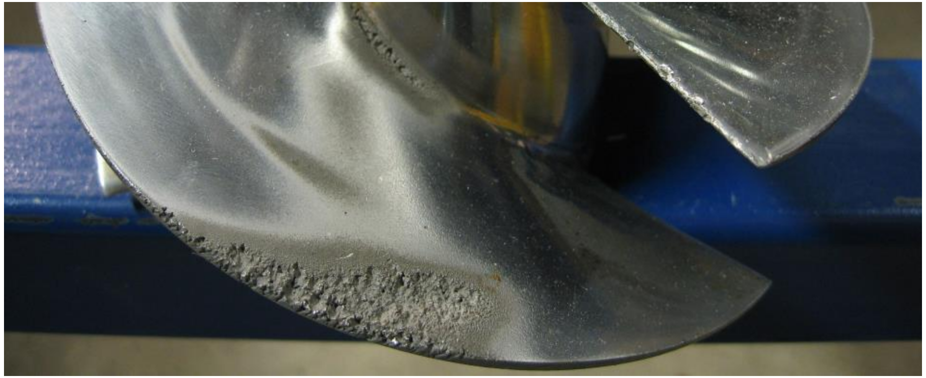
CO_2 Modelling

The transport of carbon dioxide near the critical point results in several problems

Modelling problems: All relevant physical quantities depend non-linearly on each other.



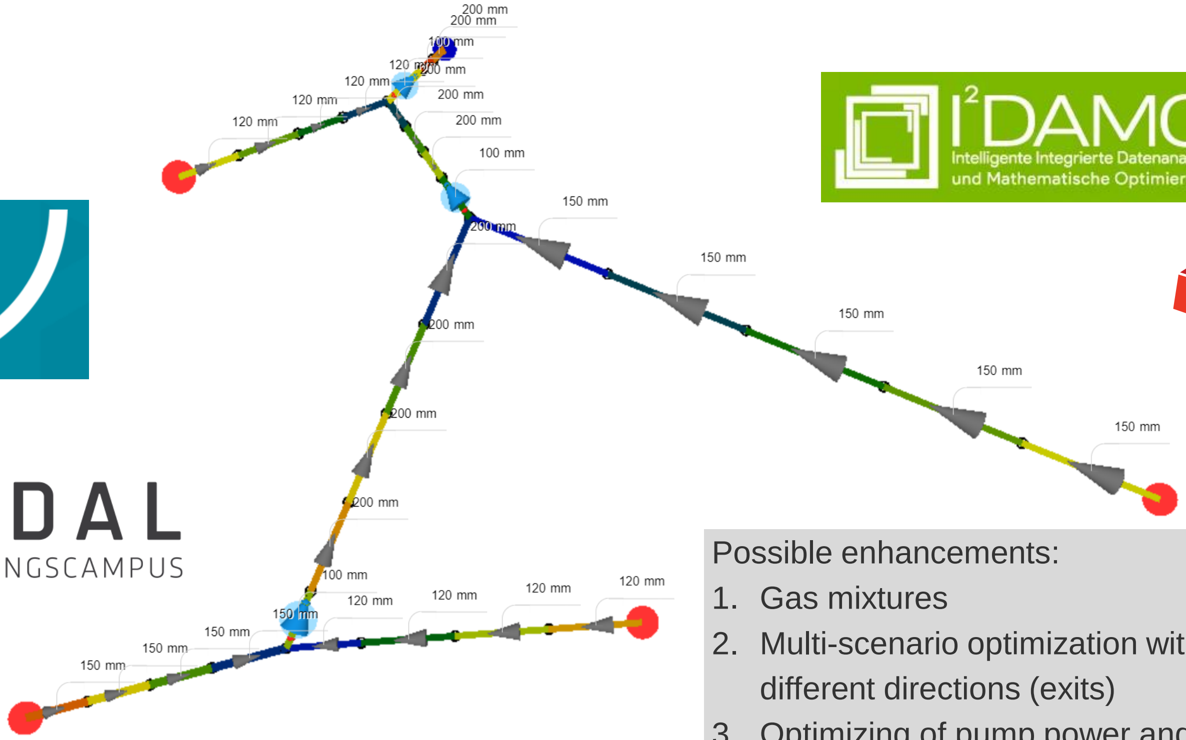
Operational problems: You must not cross the boiling curve!



Source: Wikipedia

COCOS: CO2 Configuration and Simulation Tool

Optimal (minimal) diameters for a given network with accurate consideration of fluid properties



Possible enhancements:

1. Gas mixtures
2. Multi-scenario optimization with flows in different directions (exits)
3. Optimizing of pump power and pump locations

We enable energy supply. Today and in the energy mix of the future.

OGE