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CO_2 removal at Sleipner

Carbon Sequestration Leadership Forum. CO_2 Capture Interactive Workshop
Bergen, Norway. June 14, 2012

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Outline

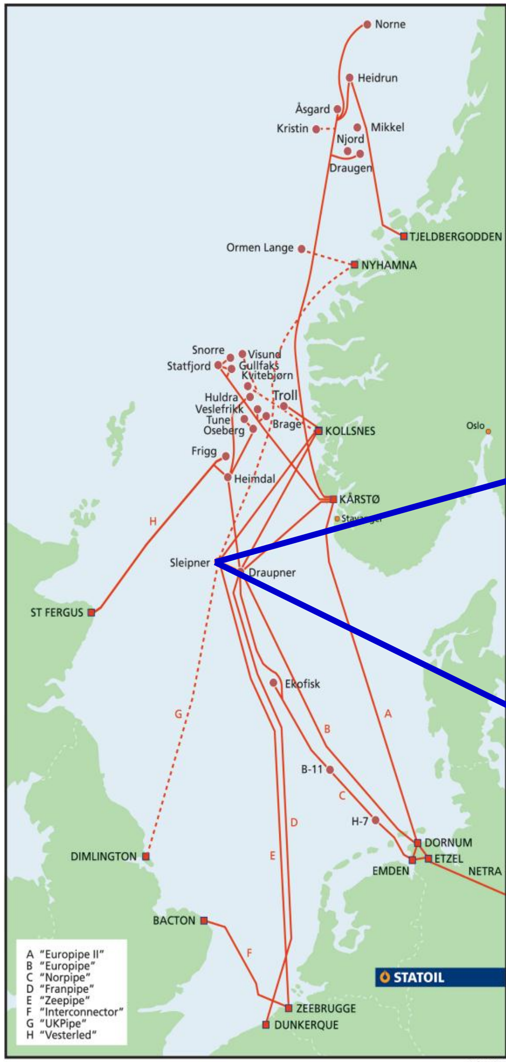
- **Introduction to the Sleipner field**

- **The CO_2 removal unit on Sleipner**
  - **Design**
  - **Operational experience and debottlenecking**

- **Improved understanding through Statoil R&D work**

- **Concluding remarks**

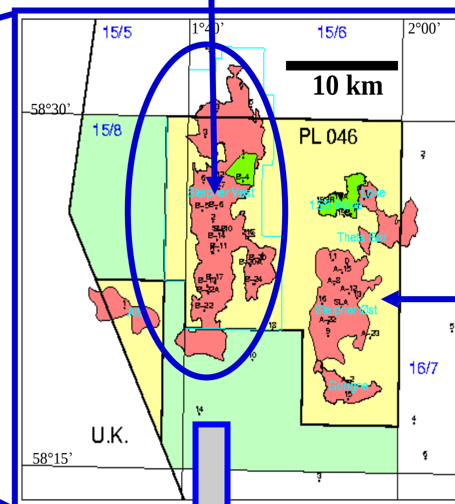
The Sleipner area



Sleipner Vest (SLT)

Production start 1996

Natural gas with
9 mole % CO_2



Sleipner Øst (SLA)

Production start 1993

Natural gas with
< 1 mole % CO_2

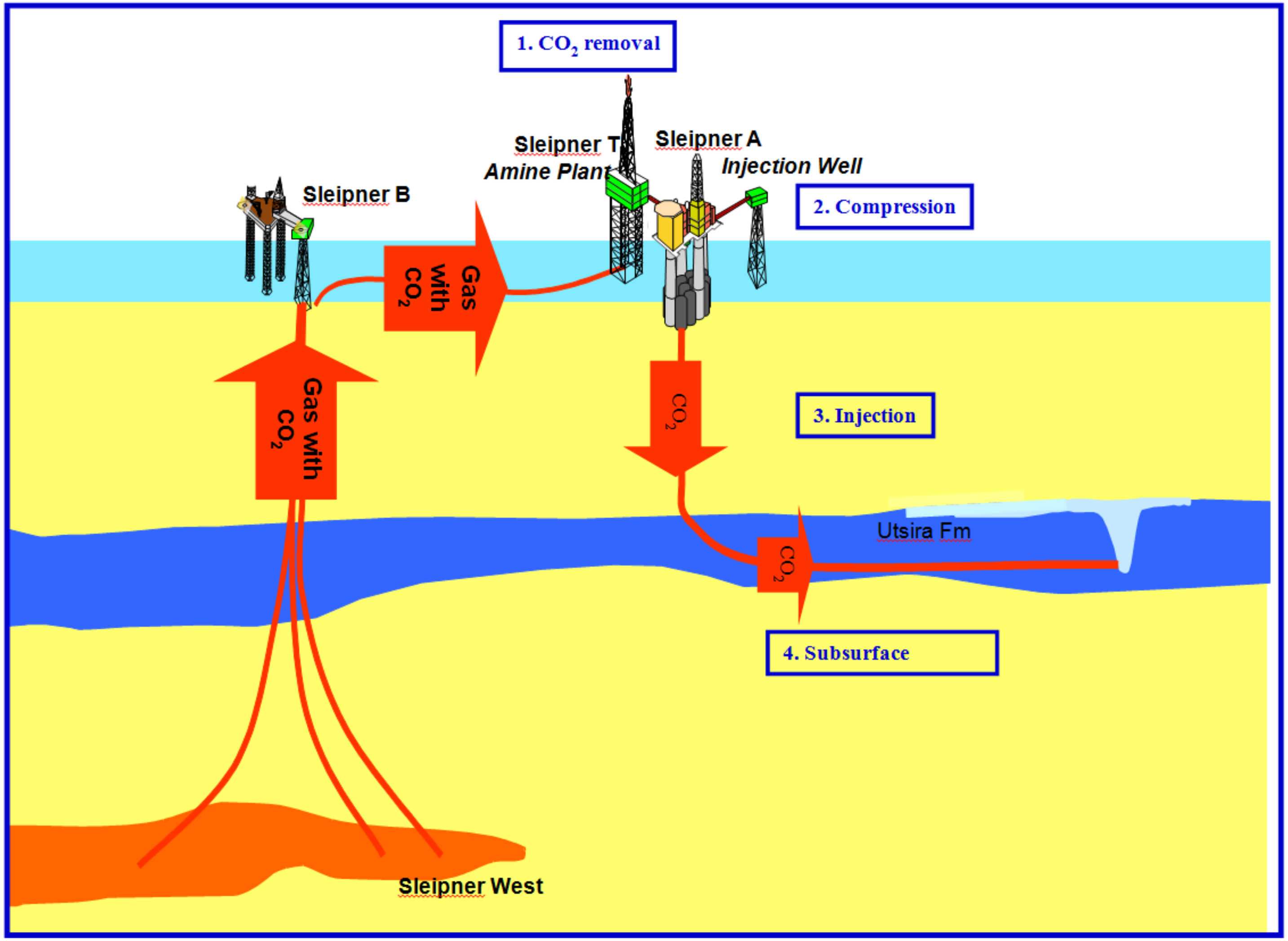
Sales gas specification:
< 2.5 mole % CO_2

The Sleipner Vest Field - Key Characteristics

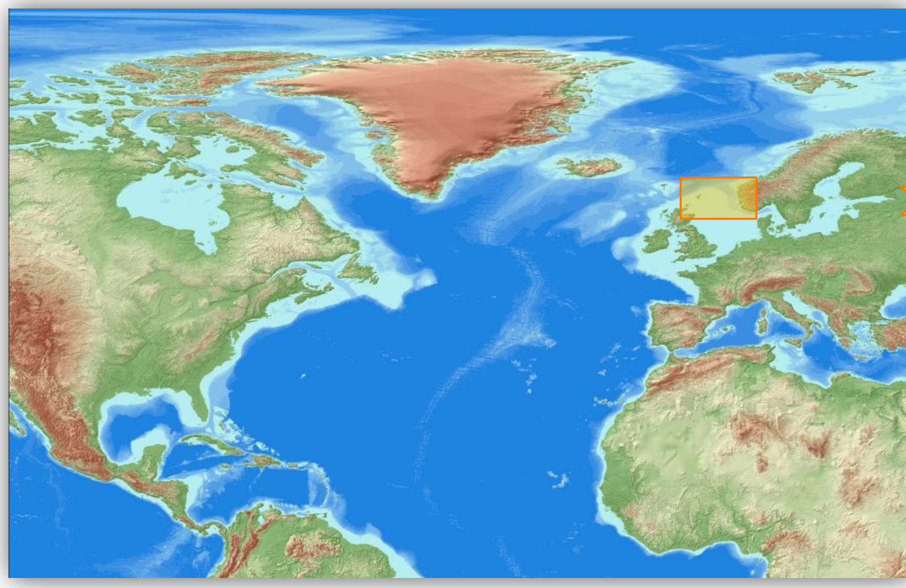
- Largest gas/condensate field in the Sleipner area (North Sea), on stream in 1996
- Partners: Statoil - operator (58,35 %), ExxonMobil* (32,24 %), Total** (9,41 %)
- Higher CO_2 content (4-9%) than the gas export quality specification allows (2,5%)
- Capture absorption at 100 bar, 60-80ºC, Amine 45wt% MDEA
- Decision to store geologically the captured CO_2 was based on willingness to try out new technology and the CO_2 tax incentive
- Sleipner CCS is an internationally-recognised benchmark project

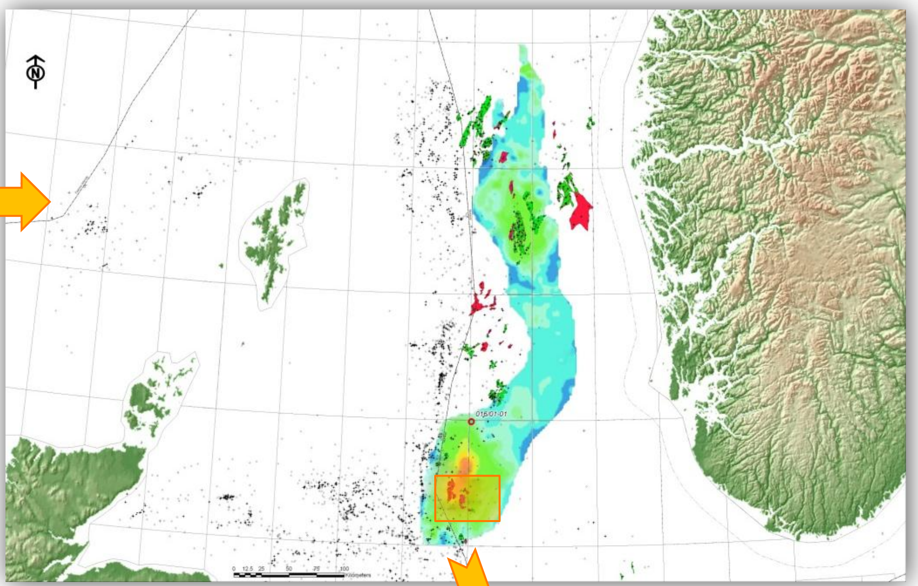
* ExxonMobil Exploration & Production Norway AS
** Total Norge AS

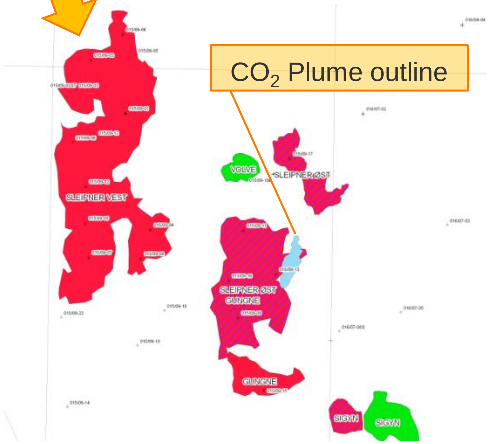
The CO_2 chain on Sleipner



Sleipner CO_2 injection site - Location

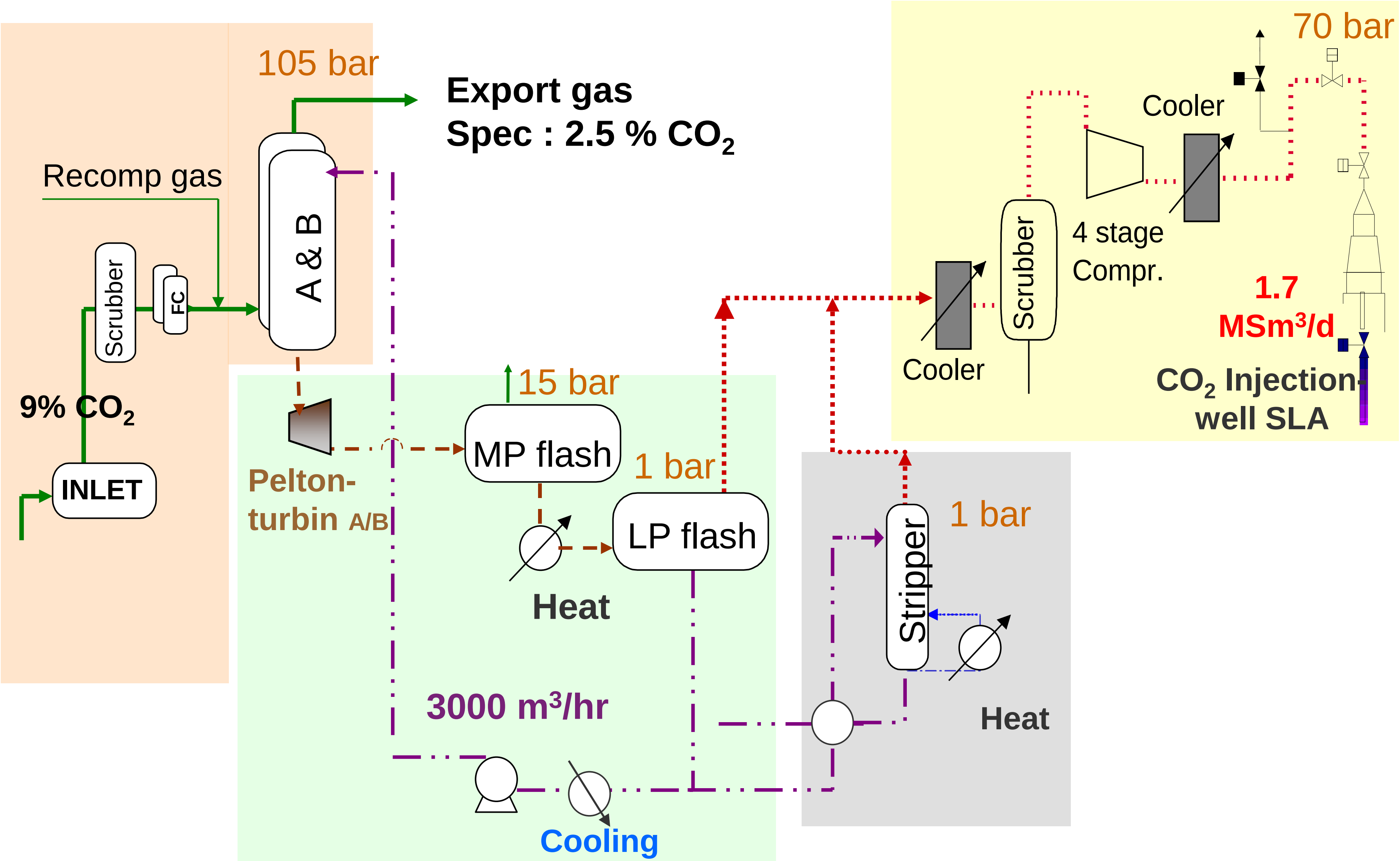






- CO_2 from the Sleipner field is stored in the Utsira Formation, North Sea
- Reservoir unit at 800-1100 m depth
- One CO_2 injector - 36 meter perforation at ~1012 meter (TVD)
- Injected gas is ~98% CO_2
- 13,5Mt CO_2 have been injected (as of May 2012, ~0,9M per annum)

Sleipner CO_2 removal : Design



Sleipner CO_2 removal operation - challenges and actions taken

Feed gas system:

Challenges

Liquid HC carry-over from scrubbers

- **foaming**
- **unstable absorbers**
- **reduced absorption rate**

Actions

- **Installed a new seperator/scrubber technology developed by Statoil**

CO_2 absorbers:

Challenges

- **hydraulic problems**
- **unstable operation**
- **liquid carry over**
- **gas carry under**

Actions

- **re-designed liquid/gas distributors**
- **improving degassing functions**
- **changing packing material from structured to random packed**

→ Increase in hydraulic capacity of liquid (140%) and gas (115%)

Amine regeneration plant:

Challenges

- **lack of CO2 cyclic capacity**
- **too optimistic vapour/liquid equilibrium data**
- **the rate activator was not working as intended**

Actions

- **no activator is used**

Summary:

- **The plant's stability has improved**
- **Production has increased to 110%**

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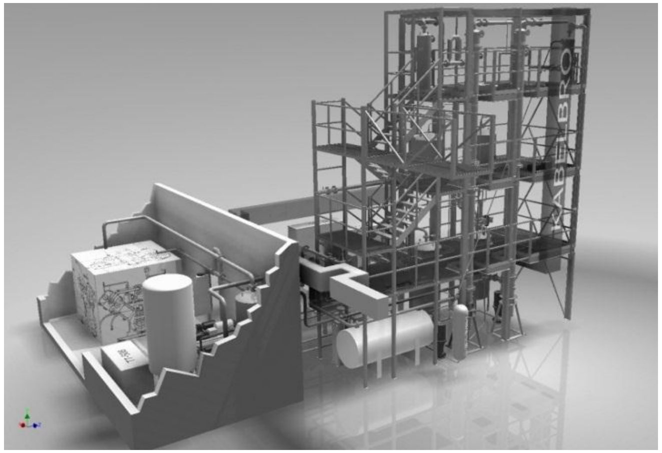
Design versus real operating conditions

	Original design	Capacity test
CO_2 in feedgas	100 %	95 %
Amine solution	aMDEA	MDEA
Amine circulation	100 %	138 %
Heat requirement	100 %	174 %
Cooling requirement	100 %	215 %
CO_2 in export gas	2.5 mol%	2.5 mol%

Statoil R&D: Solvent properties at actual conditions

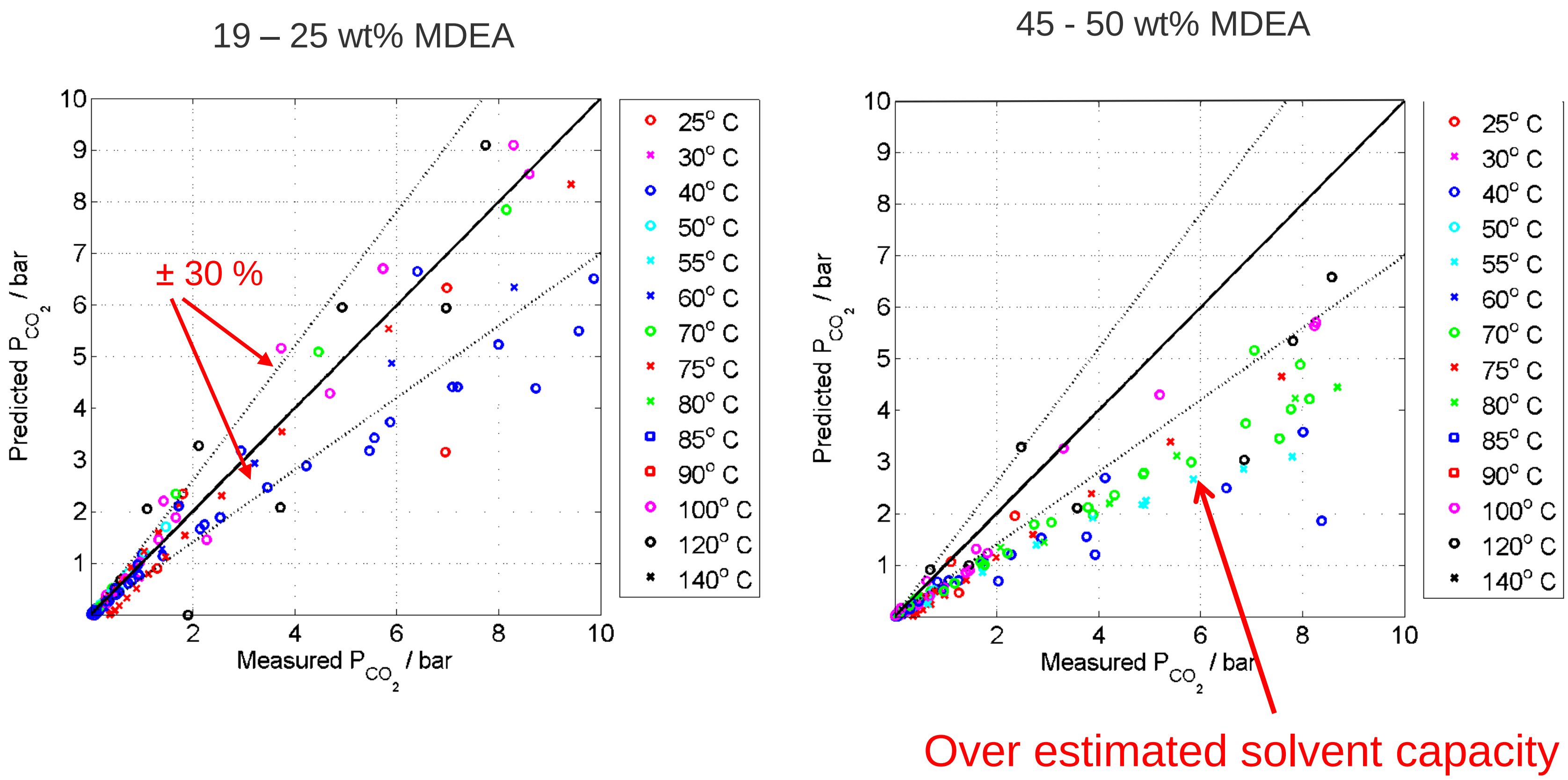
- CO_2 absorption capacity
- Mass transfer and kinetics

… at actual pressure, temperature and composition



Shortcomings in commercial simulation tools

Example: The effect of amine concentration



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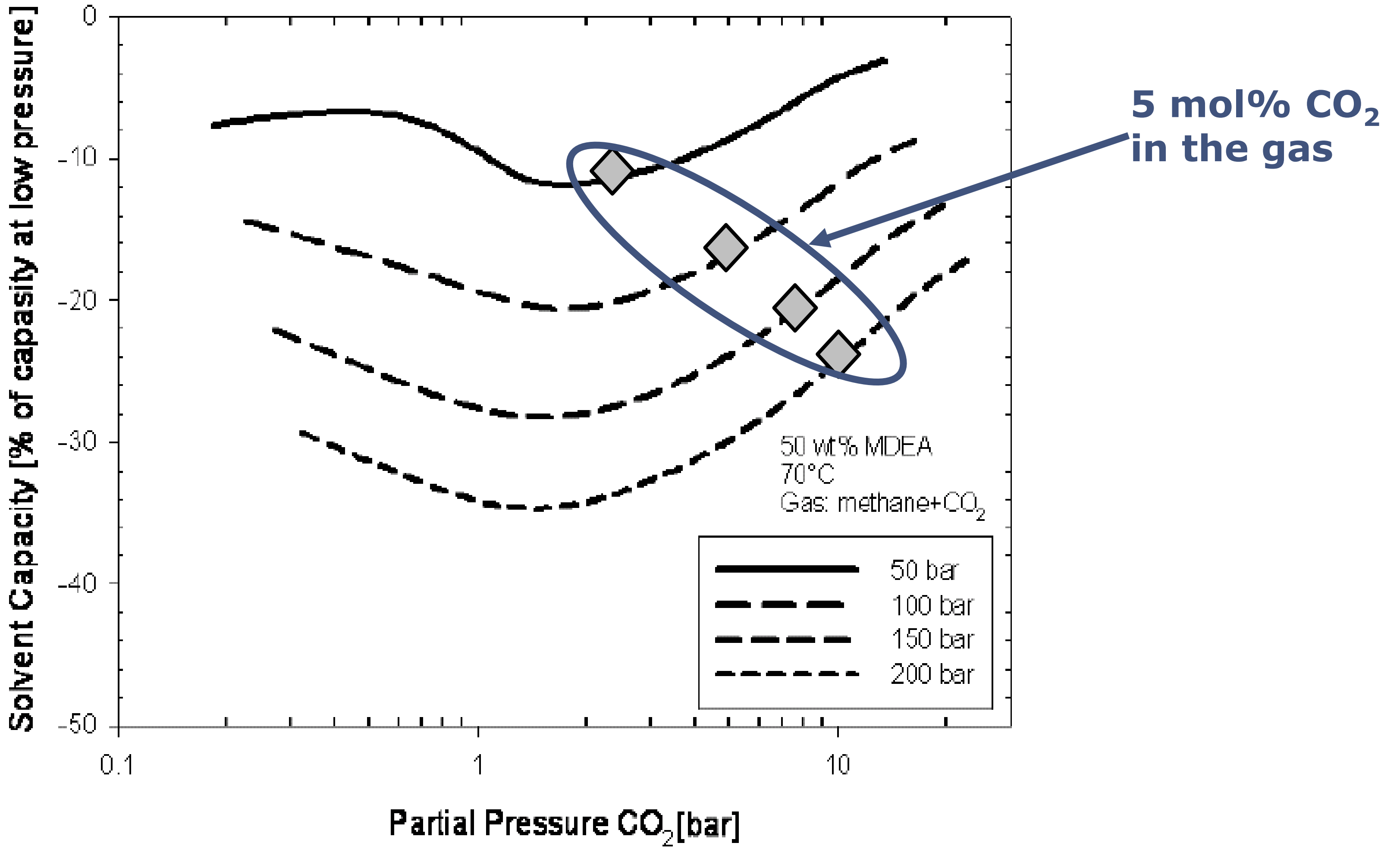
The effect of total pressure on the CO_2 capacity of the solvent



Concluding remarks

1) The optimal design of a CO_2 removal unit like the one at Sleipner is a trade-off between:

- Investment cost
  - reduced weight and space are favourable.
- Lost or reduced production
  - avoid bottlenecks by having large enough design margins
  - high availabilty

2) Compared to CO_2 capture from flue gases, operating cost plays a less significant role in CO_2 removal from natural gas.

  - Heat requirement is usually not counted as operating cost for the amine unit

3) Validated modeling and design tools are essential for optimal design of the CO_2 removal unit.

There's never been a better time for good ideas

CO_2 removal at Sleipner

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