BIGCCS Centre

Nils A. Røkke – Centre chair

TCCS-6 15 June 2011

BIGCCS Centre in a nutshell

- Duration: 8 years (5+3)
- Partners: 22
- Budget: NOK 450 mill, ~€57 million
- Funding: RCN: 50%, Ind.: 25%, Host: 25%
- Host inst.: SINTEF Energy Research
- Web: www.bigccs.no

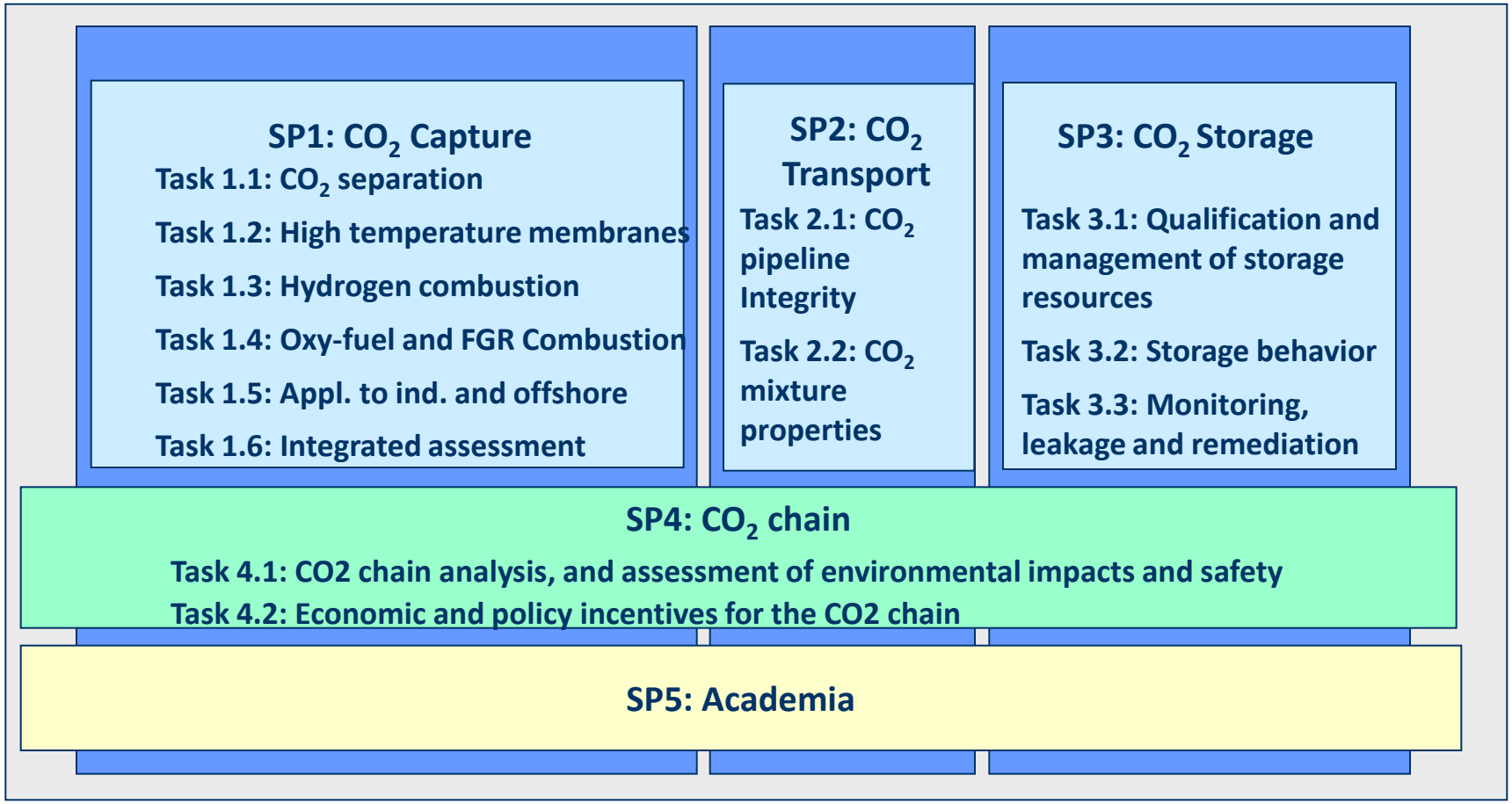
BIGCCS Vision

- The vision of the BIGCCS Centre is to contribute to the ambitious targets in the Climate Agreement Act adopted by the Norwegian Parliament in February 2008 – to increase the efforts in CCS.

BIGCCS Overall Objectives

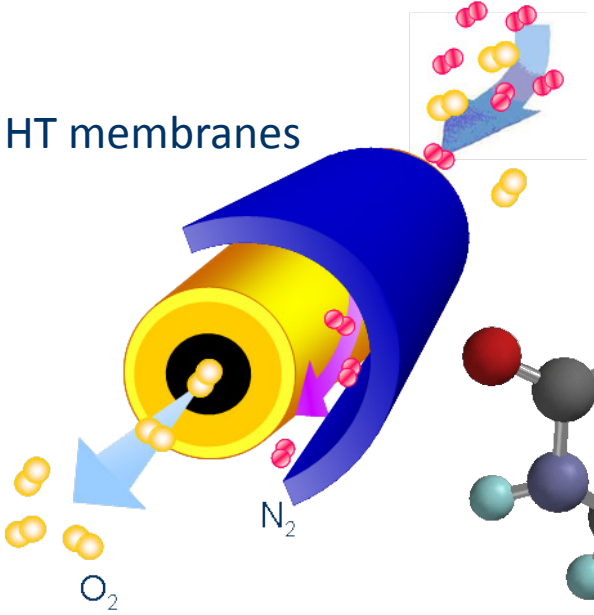
- The BIGCCS Centre will **enable sustainable power generation from fossil fuels based on cost-effective CO_2 capture, and safe transport and underground storage of CO_2.**
- This will be achieved by **building expertise and closing critical knowledge gaps of the CO_2 chain**, and developing **novel technologies** in an **extensive collaborative research effort.**
- **International co-operation, global CCS R&D provider and partner**

BIGCCS Centre structure

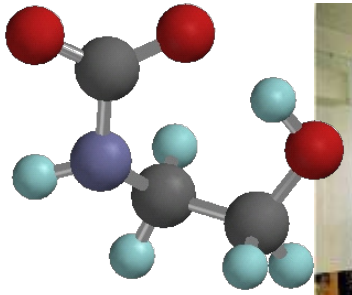


SP1 CO_2 capture

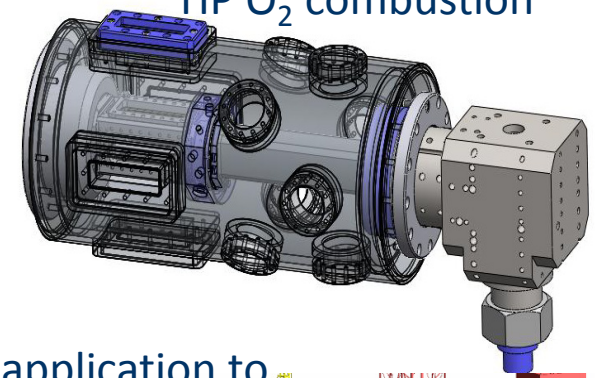
HT membranes



CO_2 separation



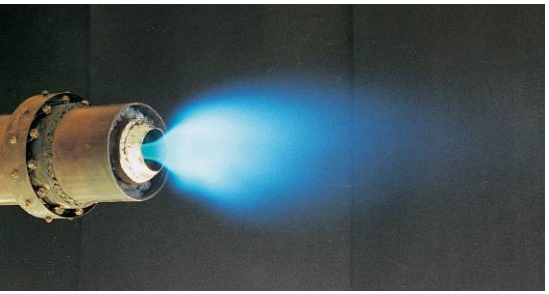
O_2 combustion & FGR
HP O_2 combustion



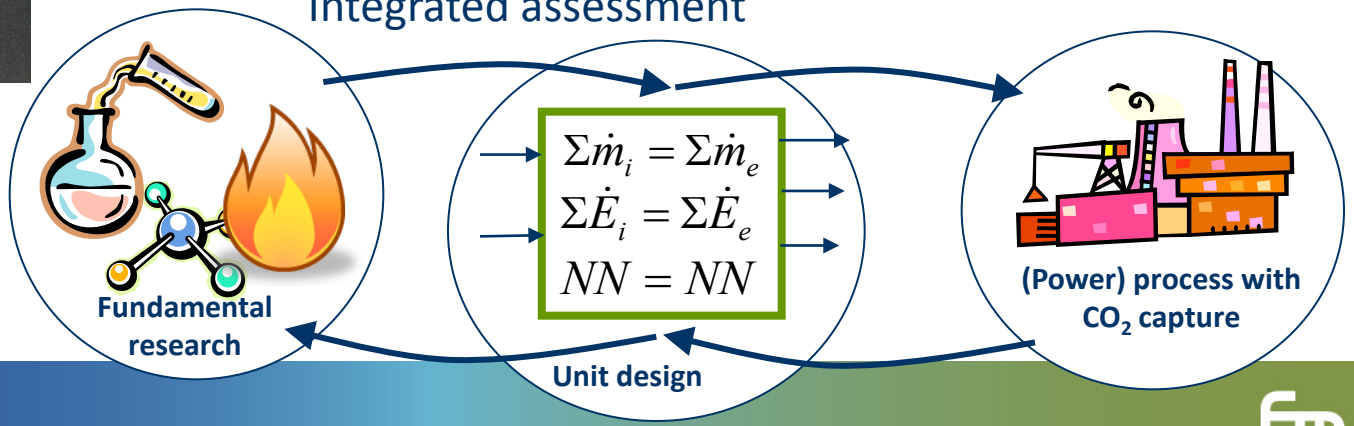
application to industry and offshore

Source: Aker Solutions

H_2 combustion



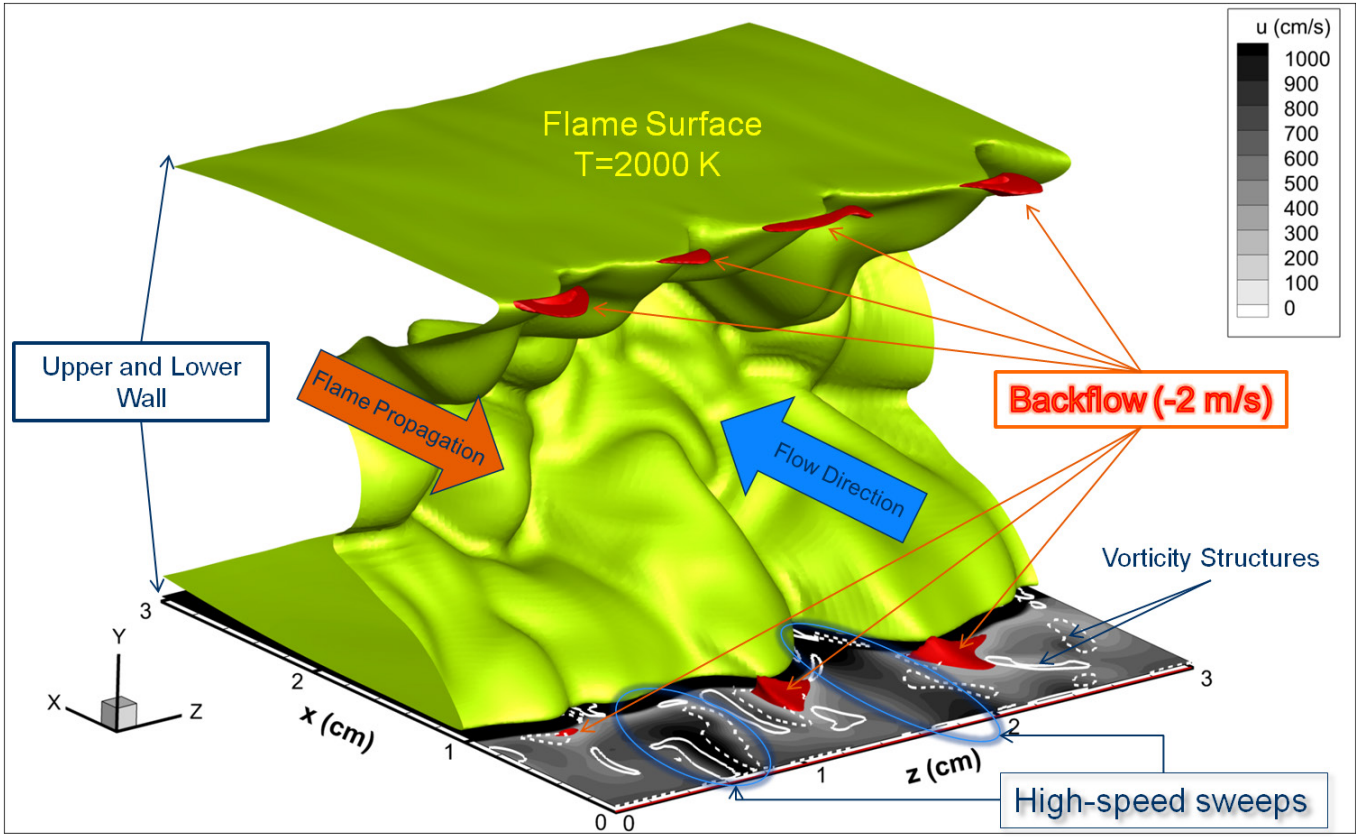
Integrated assessment



CO_2 Capture
Hydrogen Combustion

- Combustion of hydrogen rich mixtures, focus is on stable and safe flame propagation in lean pre-mixed (LPM) combustion at gas turbine condition

- **Achievements:** completed 1st direct numerical simulation (DNS) of a premixed H_2-air flame
- Revealed a previously unknown feature of near-wall flame propagation
- Also observed experimentally by laboratory PIV-measurements at TUM.

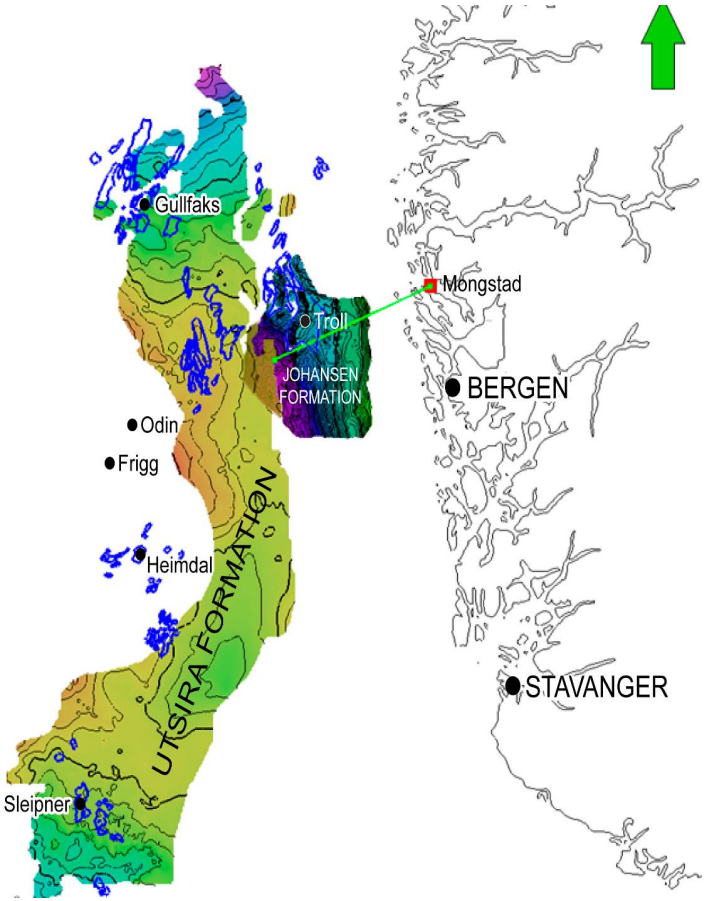


CO_2 Transport: CO_2 pipeline integrity

- The objective is to contribute to safe and cost effective CO_2 transport and avoid running ductile fractures in pipelines pressurised with CO_2 and CO_2 mixtures
- A fluid-structure fracture assessment model is under development:
  - Coupled structural and fluid models
  - Thermodynamical and fluid dynamical models
    - Thermodynamics for CO_2 and mixtures of CO_2
    - Phase transfer
    - Fluid dynamics
    - Numerical models
  - Fracture resistance models

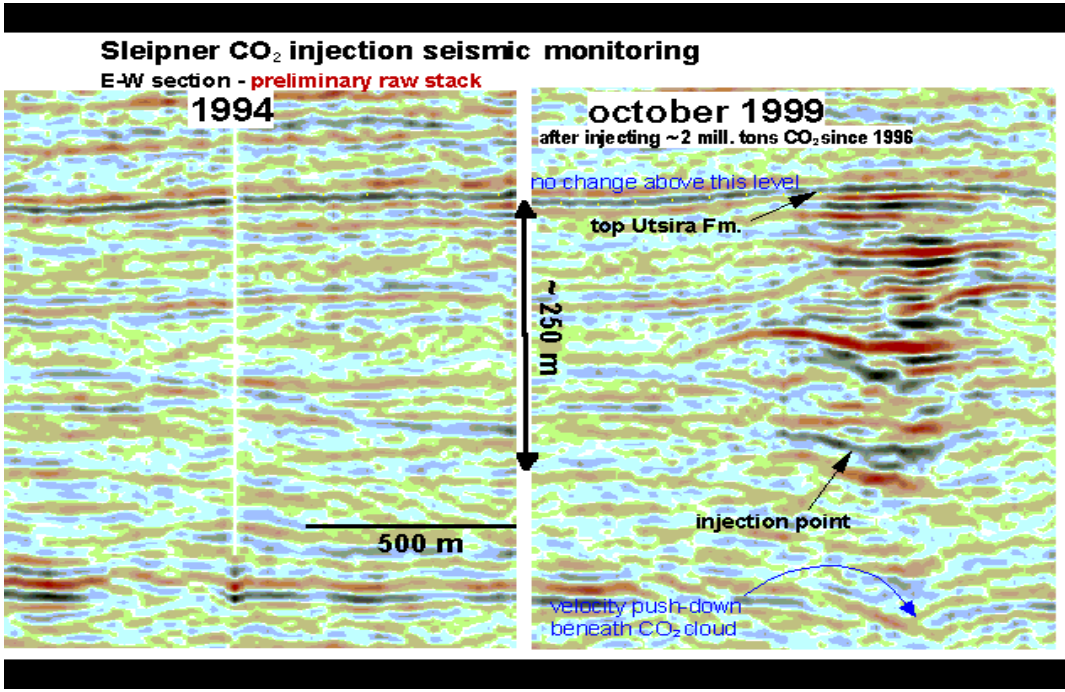
SP3 CO_2 storage

qualification and
management of storage



monitoring, leakage and
remediation

storage behaviour



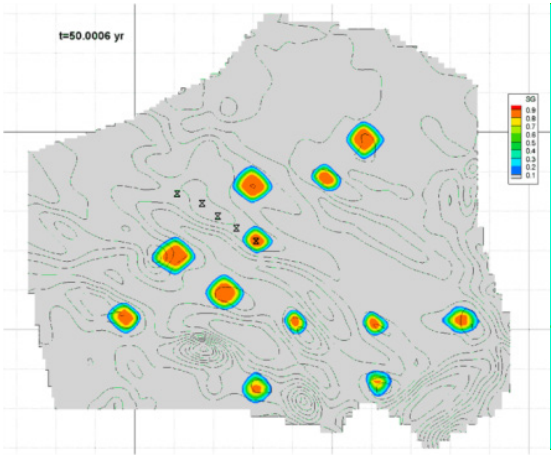
CO_2 Storage

Qualification and management of storage resources

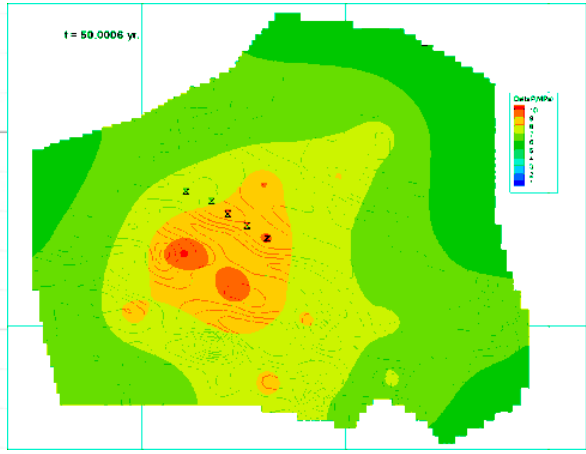
Storage capacity estimation

- Static and dynamic models for storage capacity estimations need improvements.
- Case studies on realistic storage sites show strong dependence on boundary conditions (open, closed, partly open).

Closed system (BGS)



CO_2 saturation around injection wells



Pressure development during same injection period

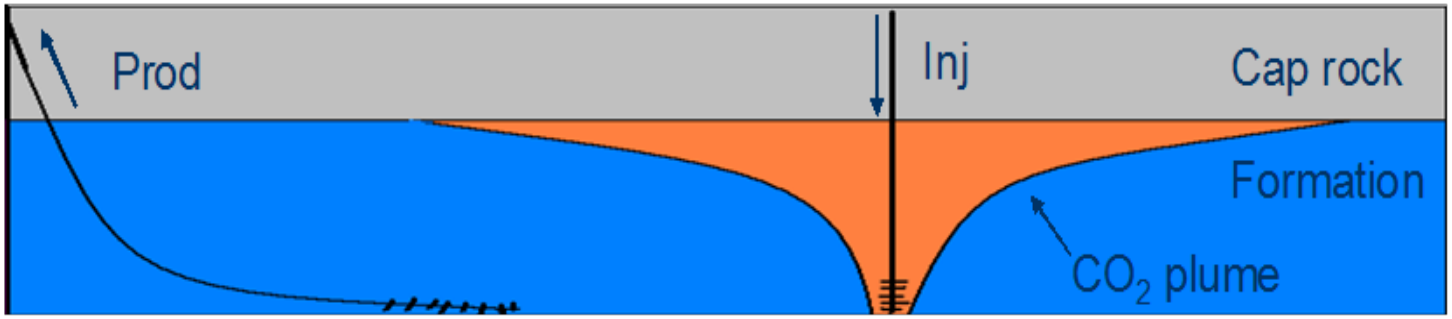
CO_2 Storage

Qualification and management of storage resources

Storage capacity improvement

- Water production for pressure management
  - Additional opportunities for monitoring and remediation of possible leakage
  - Case studies on pressure development (Johansen and Utsira) where pressure is being controlled by water production shows clear potential of improving storage capacity

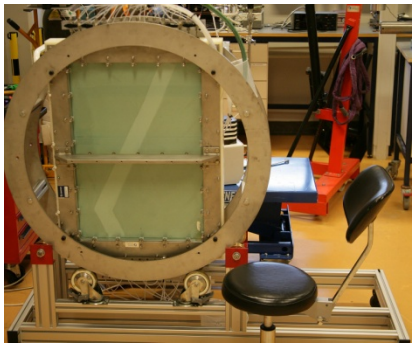
CO_2 plume development with simultaneous water production (SINTEF PR)



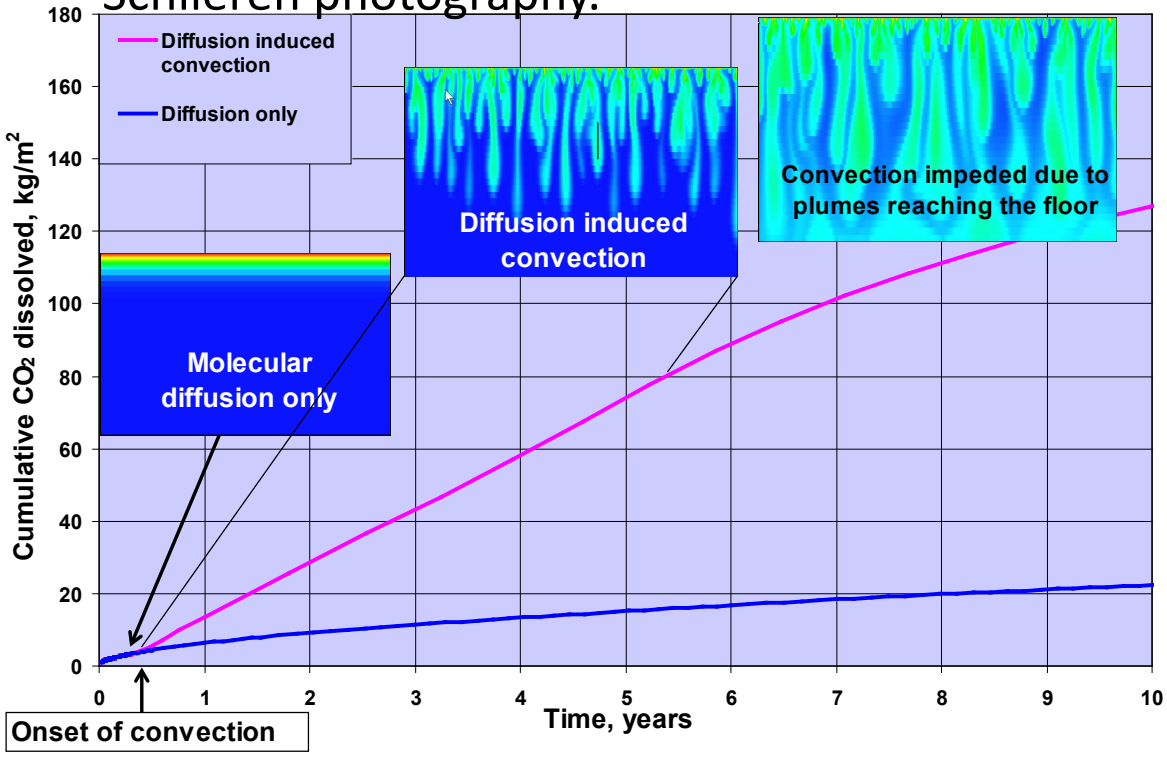
CO_2 Storage

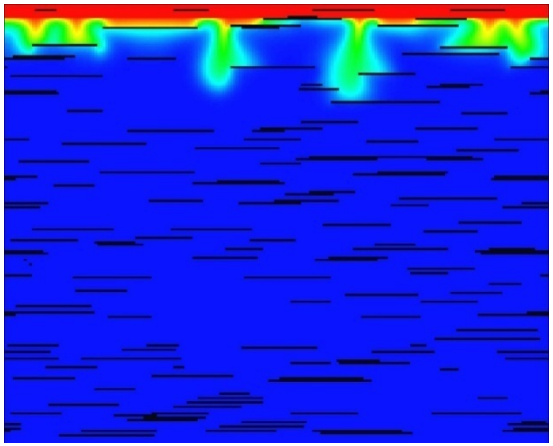
Storage Behavior - Convective mixing of CO_2

- New rigorous theoretical results for onset time for convection.
- Theoretical and numerical up-scaling studies of convective mixing for homogenous and heterogeneous media.
- Planned 2D movie of convective mixing in 2D cell using Schlieren photography.



2D cell





Onset of convection in layered aquifer

BIGCCS - Chemical Looping Combustion (BIGCLC)

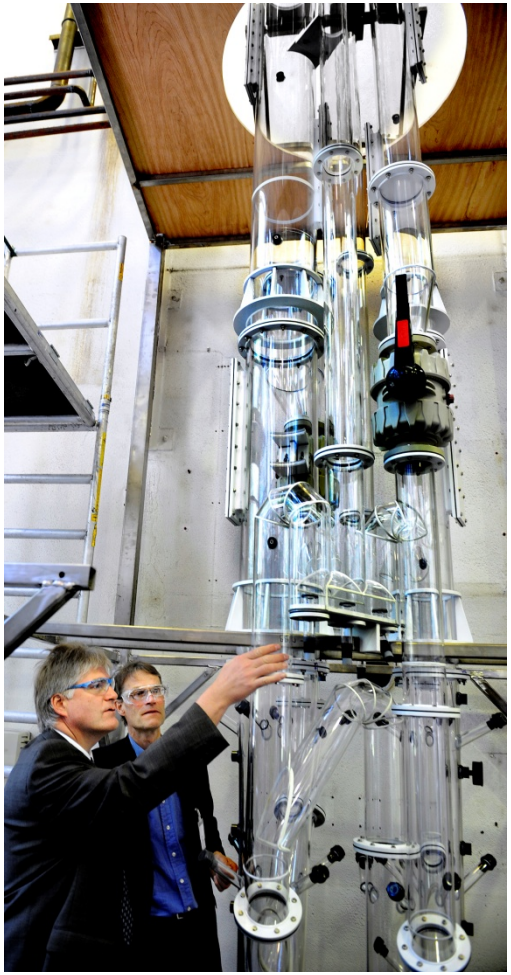
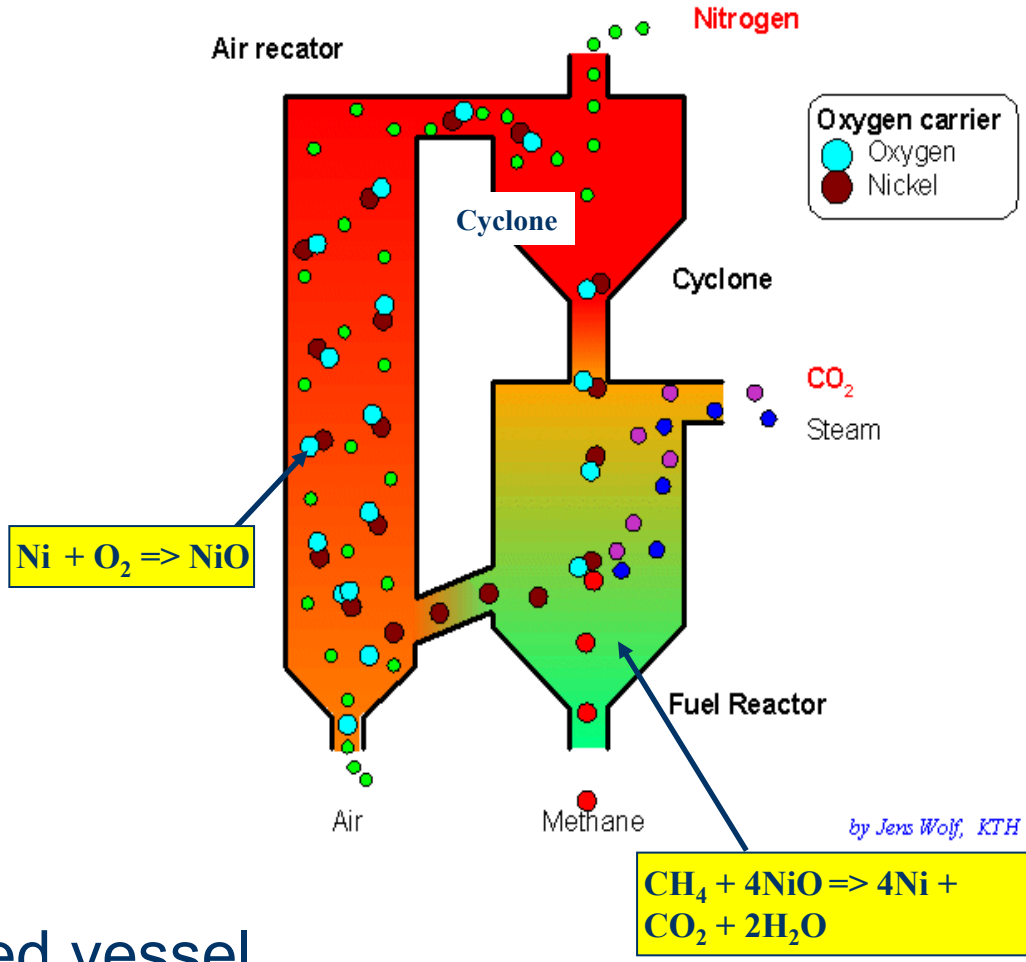


Foto:Steinar Fugelsøy, Adresseavisen



Target:150kW – pressurised vessel

SP5 BIGCCS Academia

BIGCCS Centre	Phase 1 2009	Phase 1 2010	Phase 1 2011	Phase 2 2012	Phase 2 2013	Phase 3 2014	Phase 3 2015	Phase 3 2016	Title - Short	Supervisor
SP1 - CO2 Capture										
Task 1.1: CO2 Separation				PhD					Absorption in precipitating systems	Andreassen
				PhD					Dyn. mod. of the absorption process	Hillestad
Task 1.2: High temp. membranes				PhD					Char. of mixed proton cond. materials	Haugsrud
				PhD					Membrane materials stability	Grande
Task 1.3: Hydrogen combustion					PhD				Efficient chemistry impl. hybrid comb.	Gran
					Post.doc				Valid. hybrid model against H2 flames	Gran
			PhD						Prevention of flame stabilization	Sattelmayer
							PhD		Improv. syngas-air fine scale mixing	Sattelmayer
Task 1.4: Oxy-fuel combustion				PhD					Oxy-combustion in CCS schemes	Gundersen
							Post.doc		Pressurized oxy-fuel combustor	Gran
Task 1.5: Ind. applic.				PhD					Nano-structured (low T) membranes	Hägg
Task 1.6: Integrated assessment			PhD						Mod. & integr. of reformer w/sorption	Jakobsen
						Post.doc			Benchmarking methods & processes	Bolland
SP2 - CO2 Transport										
Task 2.1: CO2 pipeline integrity		PhD							Thermo- & fluid dyn. mod. CO2 decompr.	Gran
					PhD				Mod. fracture resistance in pipelines	Thaulow
							Post.doc		Coupled struct.-fluid models for crack	Thaulow
SP3 - CO2 Storage										
Task 3.1: Q&M storage				PhD					Num.screening tool for analysis of frac.	Holt
Task 3.2: Storage behaviour			PhD						Basic mechanisms for CO2 in porous	Torsæter
			PhD						CO2 displ. & storage in water-saturated	Kleppe
			Post.doc						Optimal design of CO2 injec. operation	Torsæter
Task 3.3: Monitoring, leakage and remediation				PhD					Geophysical method for CO2 storage	Landrø
				PhD					Detailed imaging of gas chimneys	Arntsen
		Post.doc							Advanced geophysical monitoring	Landrø
				PhD					Rock-physical properties for monitoring	Holt
						Post.doc			Acoustic core measurem. 2-phase flow	Holt et al.
SP4 - CO2 Value Chain										
Task 4.1: Chain analysis			Post.doc						Extended value chain analysis of CCS	Gundersen

Summary BIGCCS

- A global centre of gravity for CCS research
- 22 partners, whereof 10 industrial
- Targets international co-operation and has many international links embedded – but by no means closed for new links
- Has been successful in attracting new projects
  - Thermodynamics of CO2 mixtures
  - Chemical Looping Combustion
  - Basis for EU proposals
- Open for new industrial partners and research collaboration

Acknowledgements

This publication is produced with support from the BIGCCS Centre, performed under the Norwegian research program *Centres for Environment-friendly Energy Research (FME)*. The authors acknowledge the following partners for their contributions: Aker Solutions, ConocoPhilips, Det Norske Veritas AS, Gassco AS, GDF SUEZ, Hydro Aluminium AS, Shell Technology AS, Statkraft Development AS, Statoil Petroleum AS, TOTAL E&P Norge AS, and the Research Council of Norway (193816/S60).