SINTEF's vision and experiences in Natural gas field development and CCS

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Director of the Gas Technology Centre SINTEF-NTNU

Bali, Indonesia, 17th March 2009

Outline

- Introduction
- Natural gas field development
- The role of CCS
- SINTEF's international position in CCS R&D
- R&D activities at SINTEF
- Market drivers and projects
- Participation in SINTEF projects - Benefits and terms
- Summary and conclusions

The Norwegian University of Science & Technology (NTNU) - and The SINTEF Group

Number of employees (2007):

NTNU	4.800
(Scientific	2.500)
SINTEF	2.000
(Scientific	1.350)

Students: 20.000
10.000 in Engineering & Science

Total externally financed research: 3.300 Mill NOK

A technological cluster with education, basic & applied research, innovations and business developments - of large importance for Norway

The Gas Technology Centre: Our mission

- Act as a common portal towards the market within R&D in the gas technology field
- Ensure top quality education, R & D, and solutions for the gas sector
- Promote large(r) research initiatives:
  - National Research Council
  - EU-projects
  - Laboratories
  - Strategic industrial research contracts
- External visibility
  - Influence the national agenda
- Recruitment of students & researchers
- Co-ordinate the gas technology R&D within the two organisations
- Ensure efficiency in our operations by working as a truly virtual organisation

Gas Technology Center NTNU - SINTEF

Researchers

NTNU

- 50 professors
- 134 Ph.D. researchers
- 15 post.doc. researchers

SINTEF

- 100 research scientists

Students

- Award 75% of all M.Sc. in Norway's gas-related industry

Cooperation

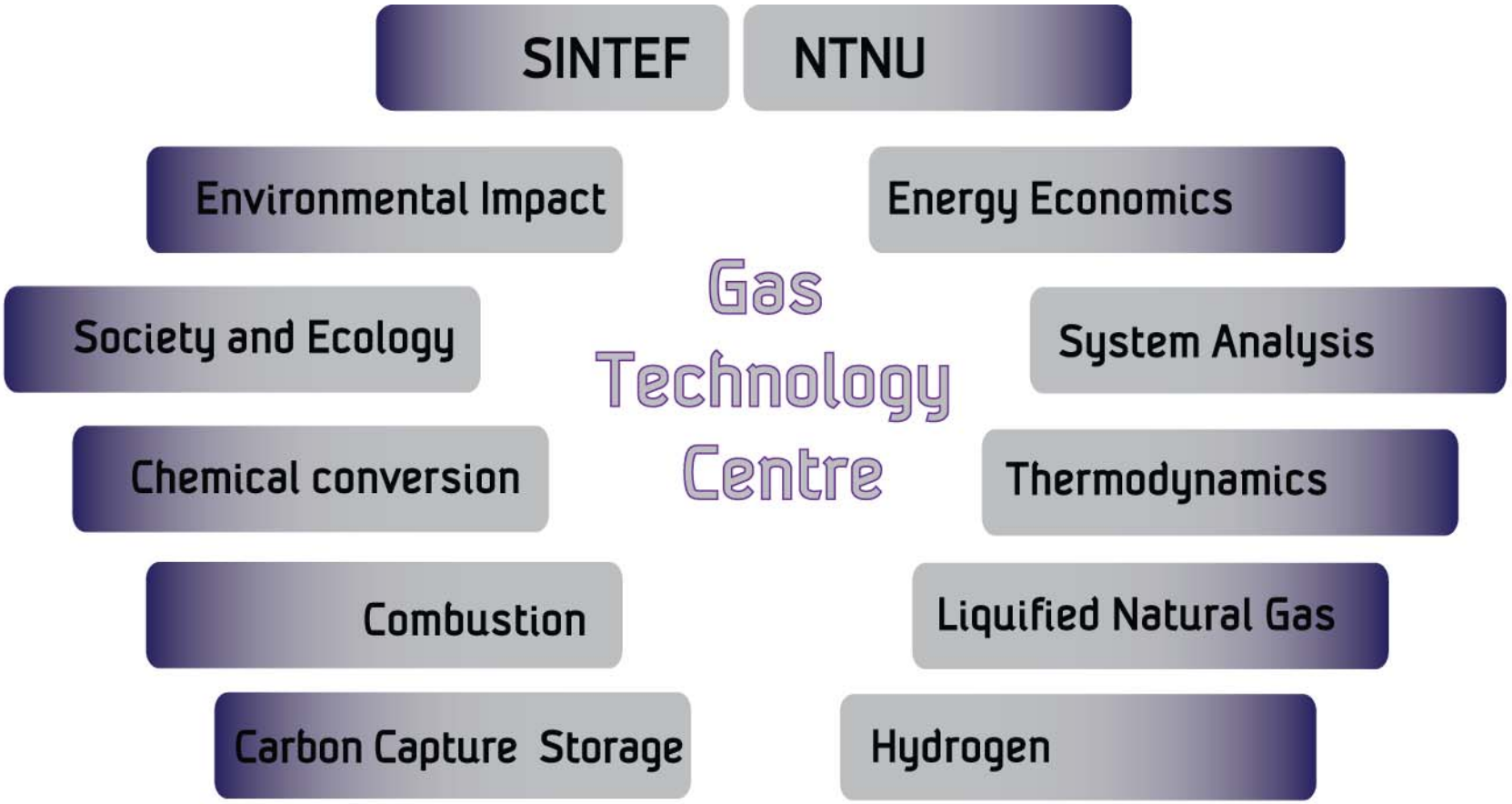
- Virtual organisation
- Tight links to industry
- International ties

Infrastructure

- 14 gas-related R&D laboratories

Funding

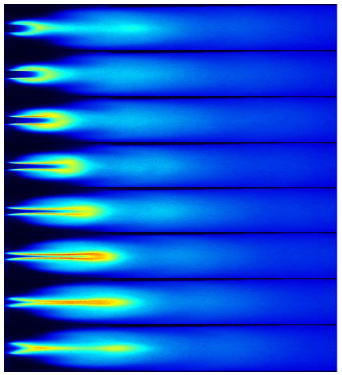
Disciplines around Gas Technology Centre



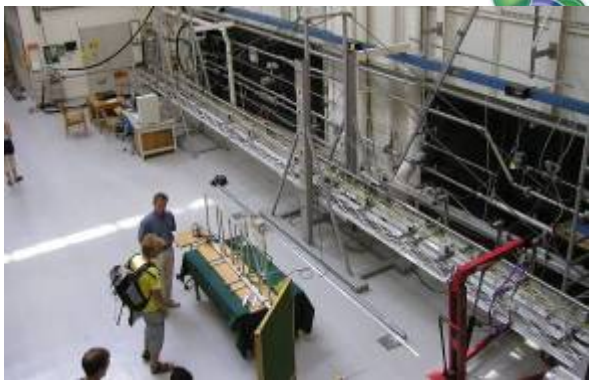
Gas value chain R&D

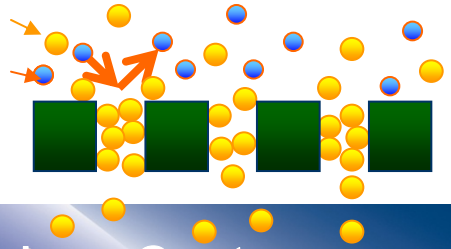
- Industrial gas processing and gas products
- LNG and gas to liquids (GTL) for the world market
- Gas engines and turbines
- CO_2-management and value chain
- Gas transport infrastructure and techno-economic optimisation
- Fossil fuel hydrogen production, storage and usage

Laboratory facilities

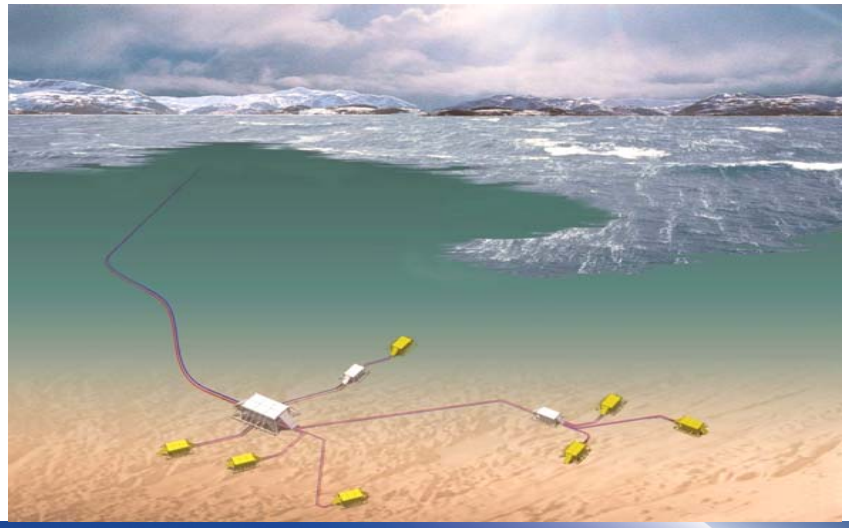


- Multiphase flow transportation of oil and gas
- Liquefied gas technology
- Combustion of hydrogen and hythane
- Absorption of CO_2, H_2S and NO_x
- Catalysts and absorbents
- Membranes for hydrogen and CO_2 separation
- Conversion of hydrocarbons to hydrogen
- Fuel cell technology
- Hydrogen production and storage





Gas technology – the whole chain



Oil and gas - a Norwegian perspective (1)

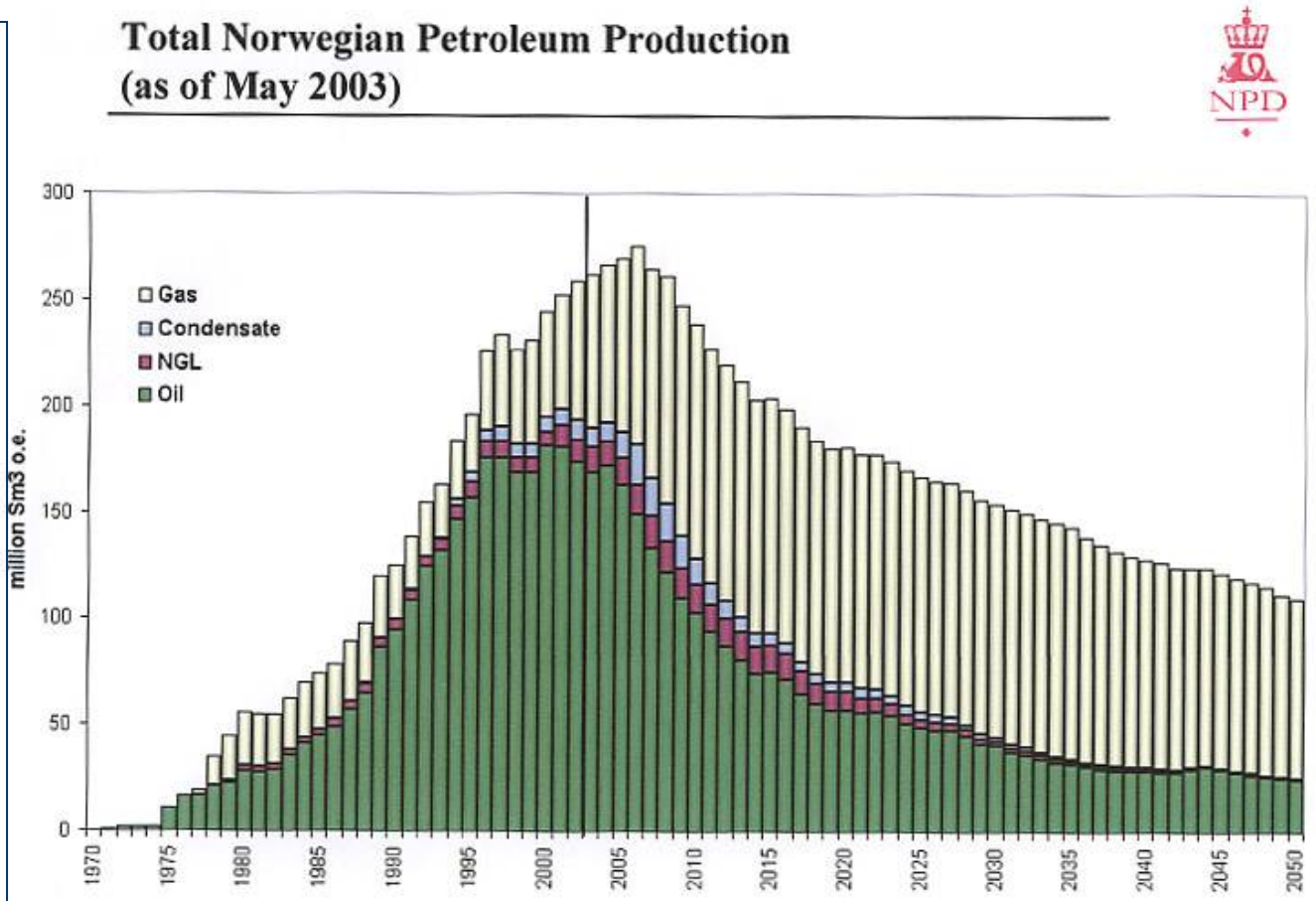
Main oil and gas regions

- The Barents Sea province
  - virtually undeveloped
- The Norwegian Sea province
  - partially developed
- The North Sea province
  - mature region

/www.atlapedia.com/

Oil and gas - a Norwegian perspective (2)

- The oil and gas sector is vital for Norway – accounts for 21% of GDP
- The fairy tale started 35years ago
- Gas will dominate from 2010 onwards

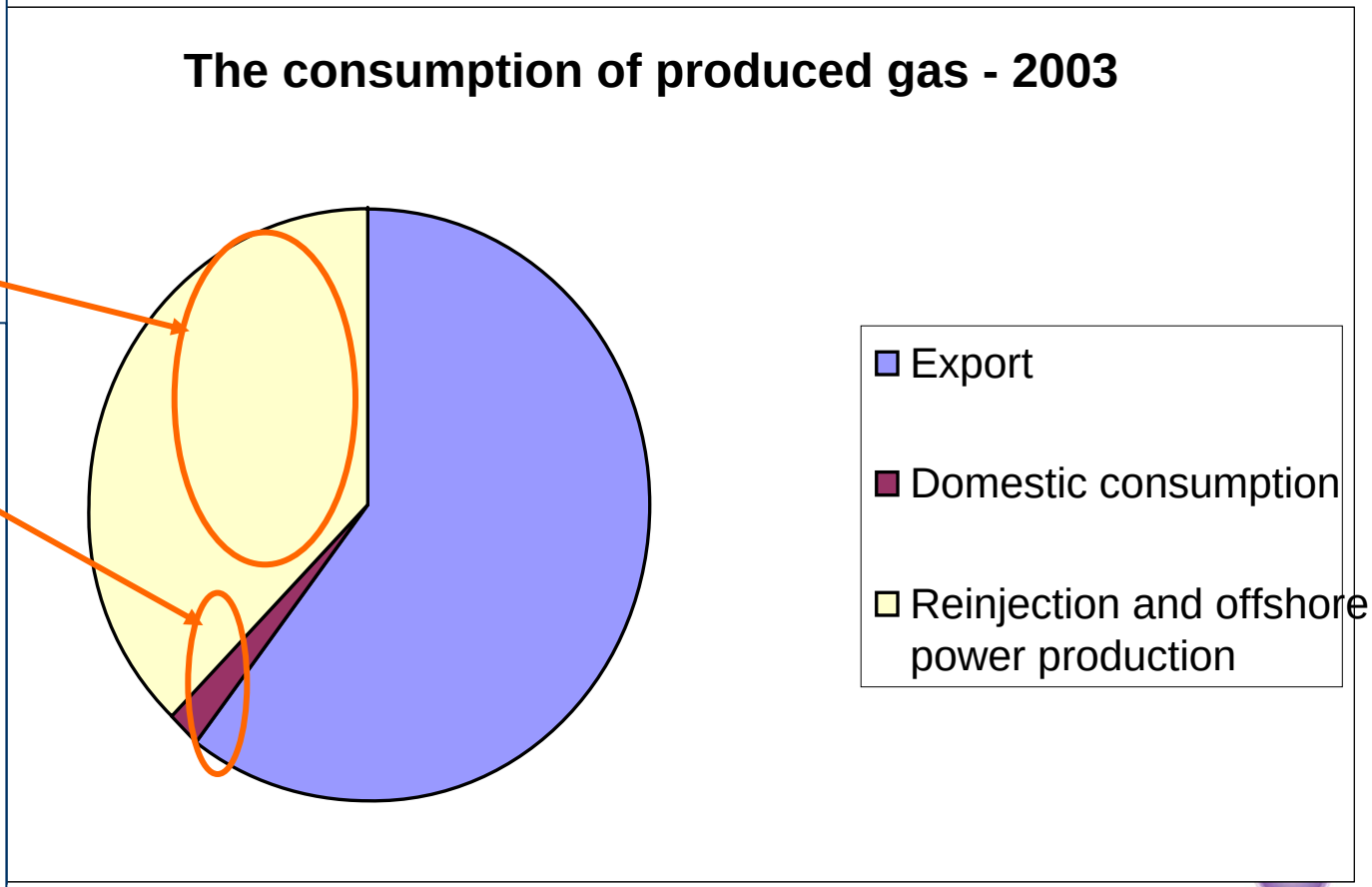


/Norwegian Petroleum Directorate – RMC2003/

How does Norway manage its natural gas ?

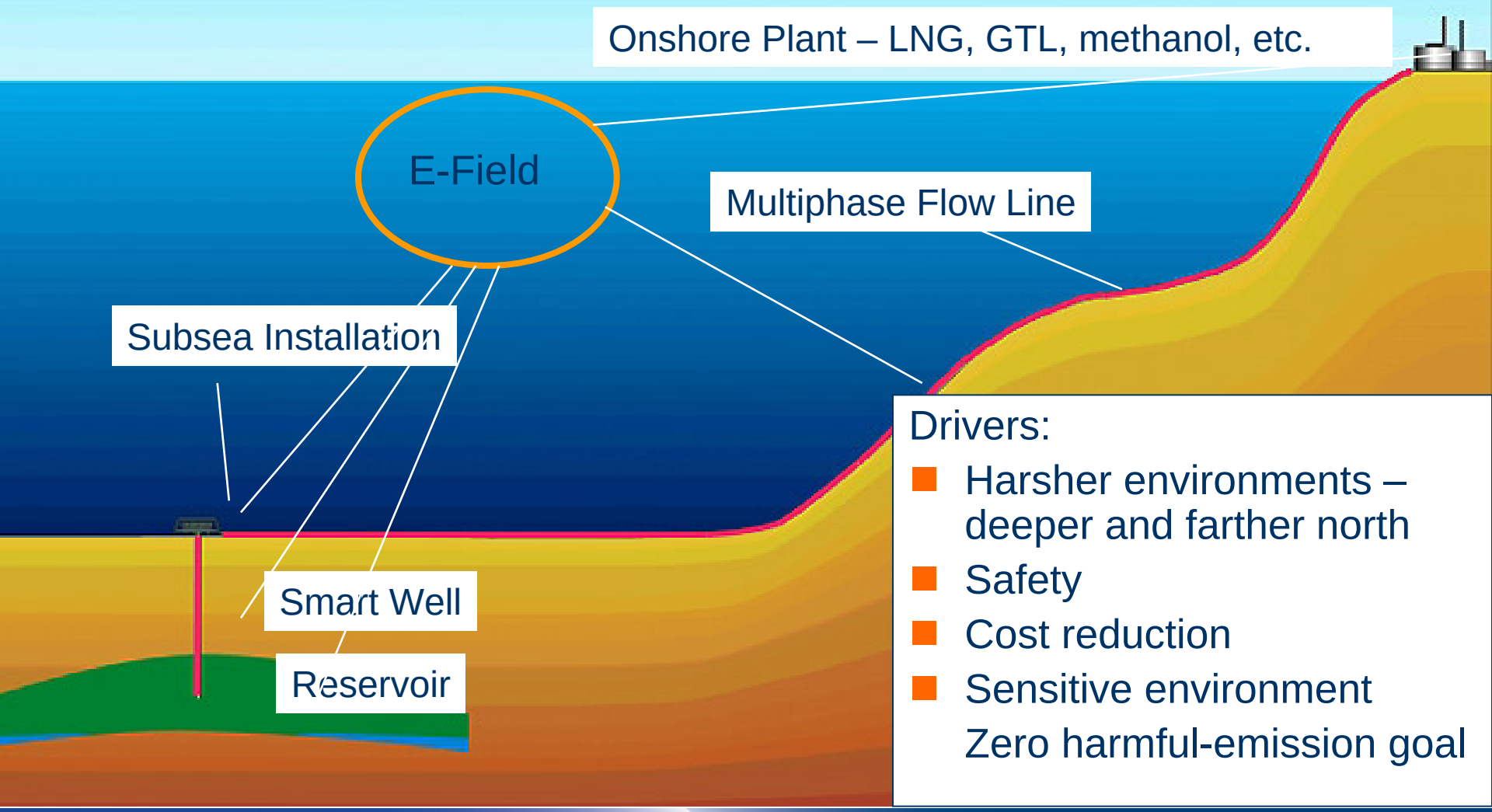
Opportunities

- Substitute natural gas with CO_2
- Increase domestic value creation
  - ”Clean” power production
  - New downstream chemical products



Gas production of the future

One integrated production chain



Drivers:

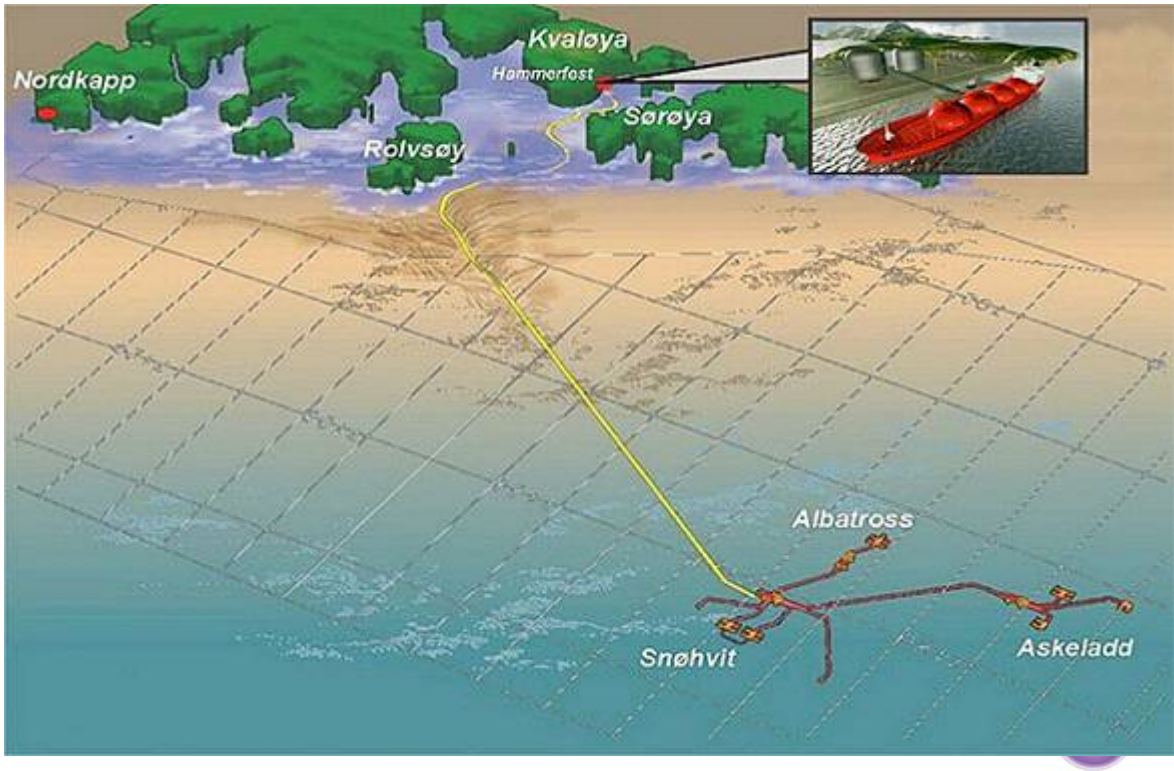
- Harsher environments – deeper and farther north
- Safety
- Cost reduction
- Sensitive environment

Zero harmful-emission goal

Gas production of the future - the Snøhvit field

Key factors

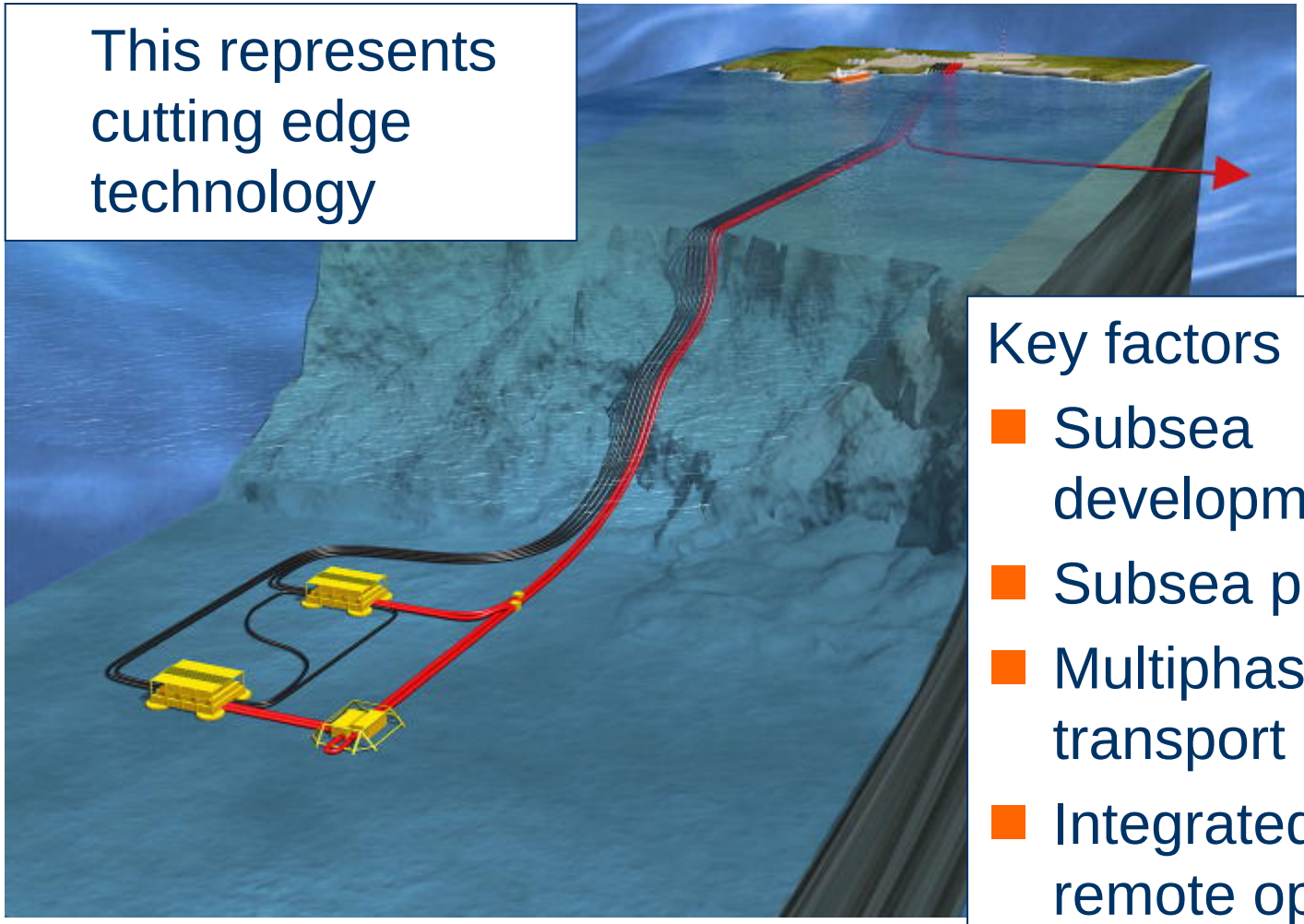
- Subsea development
- Multiphase transport
- Proprietary LNG – technology
- CO_2 separation and storage
- Integrated and remote operations



/www.Statoil.com/snohvit/

Gas production of the future - Ormen Lange field

This represents cutting edge technology

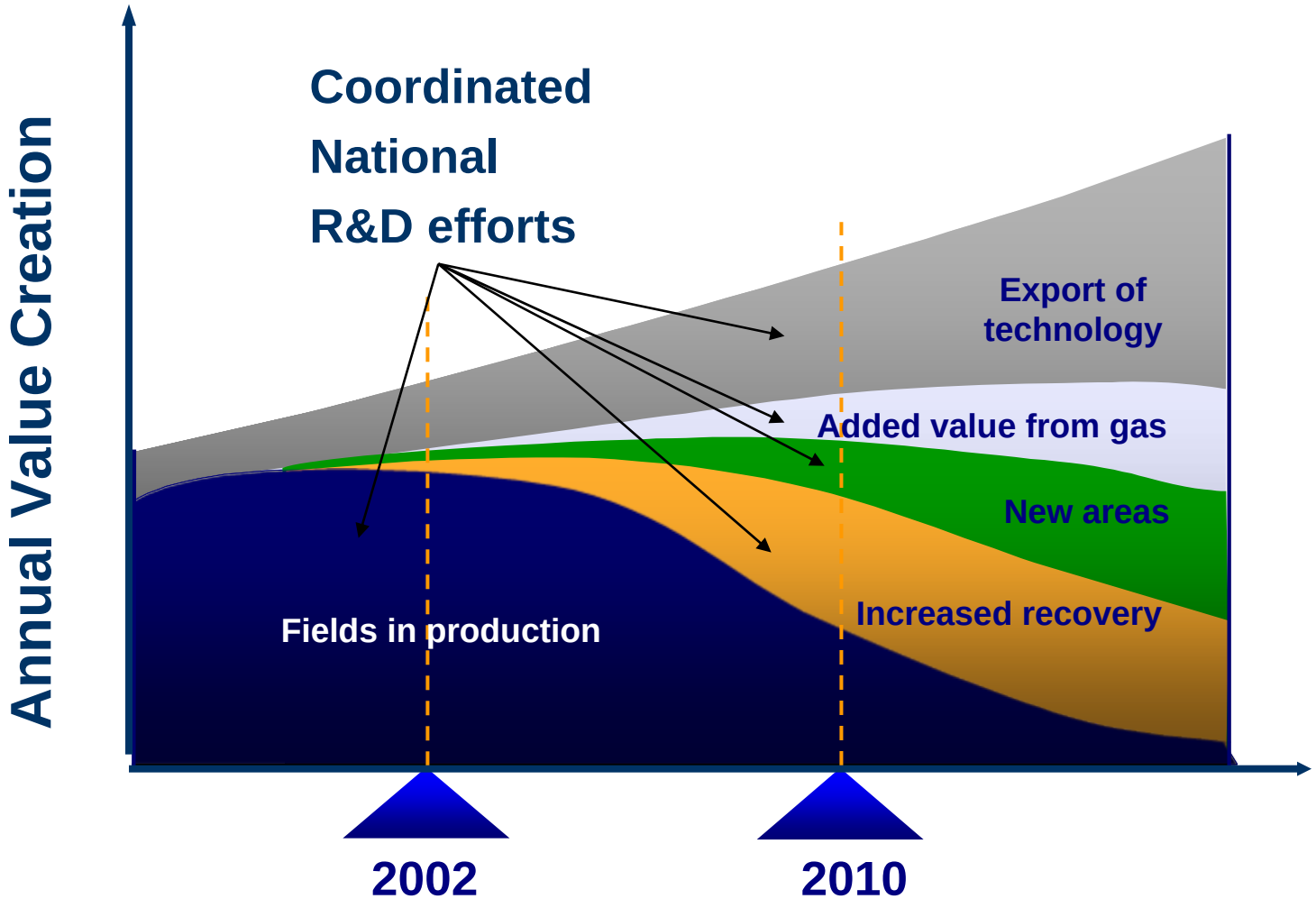


/Hydro/

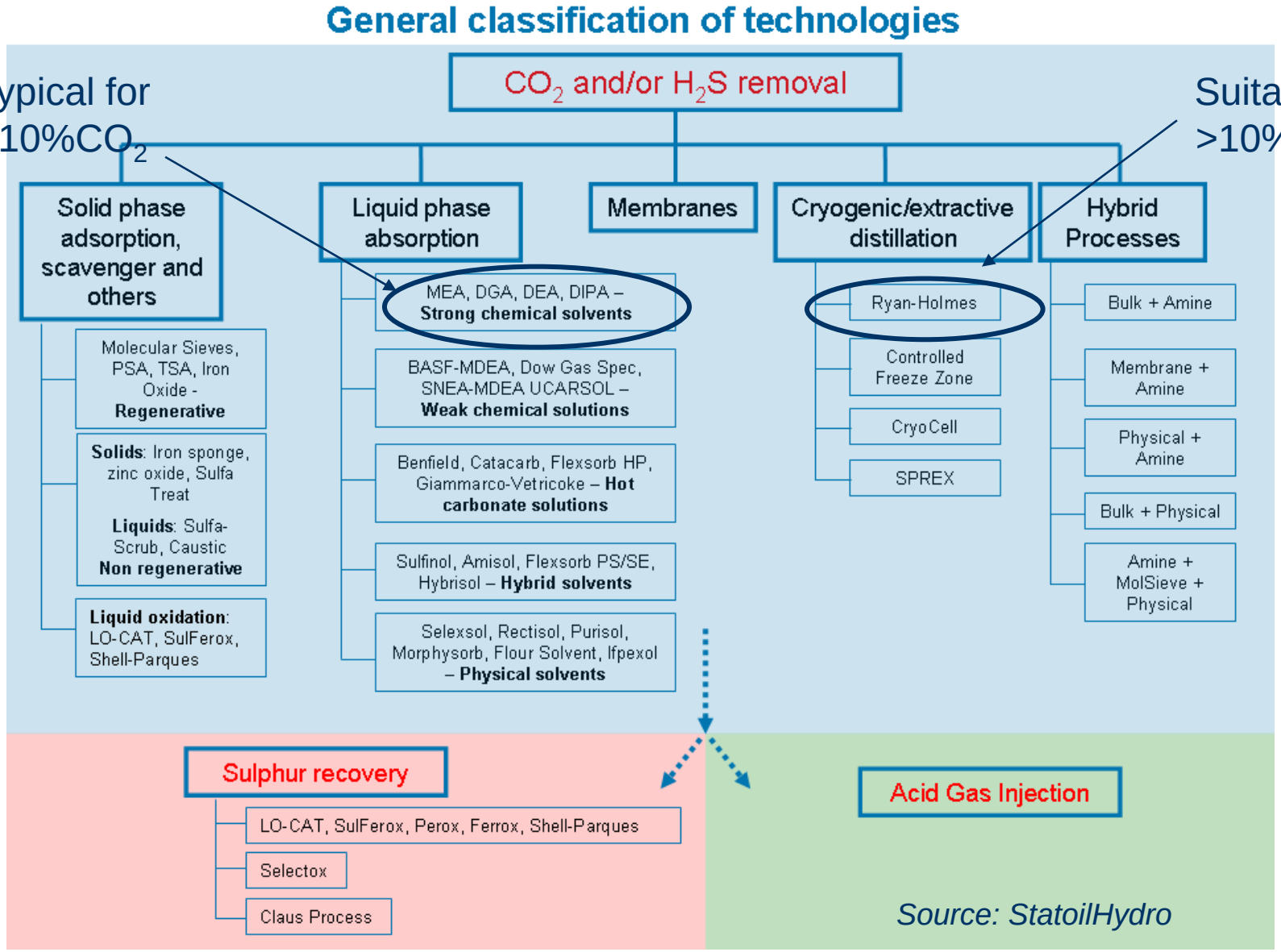
Key factors

- Subsea development
- Subsea processing
- Multiphase transport
- Integrated and remote operations

Development perspectives for value creation from the Norwegian CS and petroleum industry

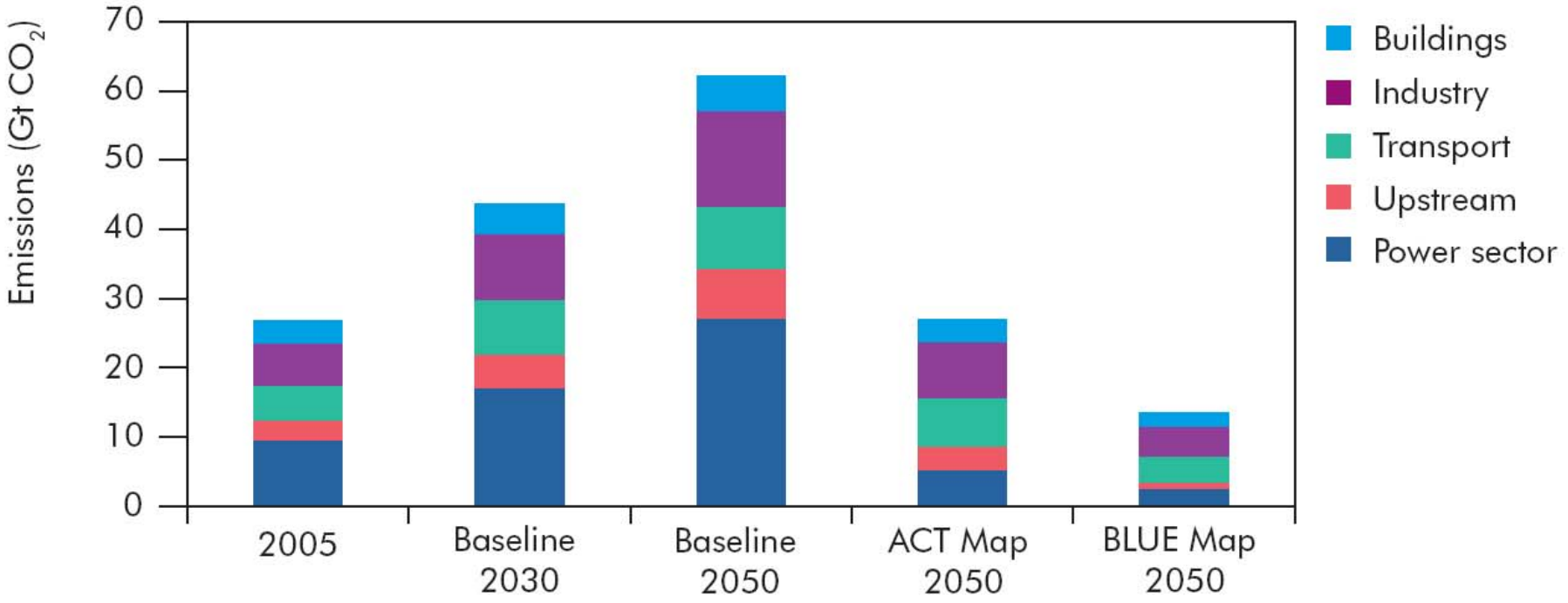


Acid gas removal: Background



The Role of CCS

Figure 2.1 ▶ Global CO_2 emissions in the Baseline, ACT Map and BLUE Map scenarios

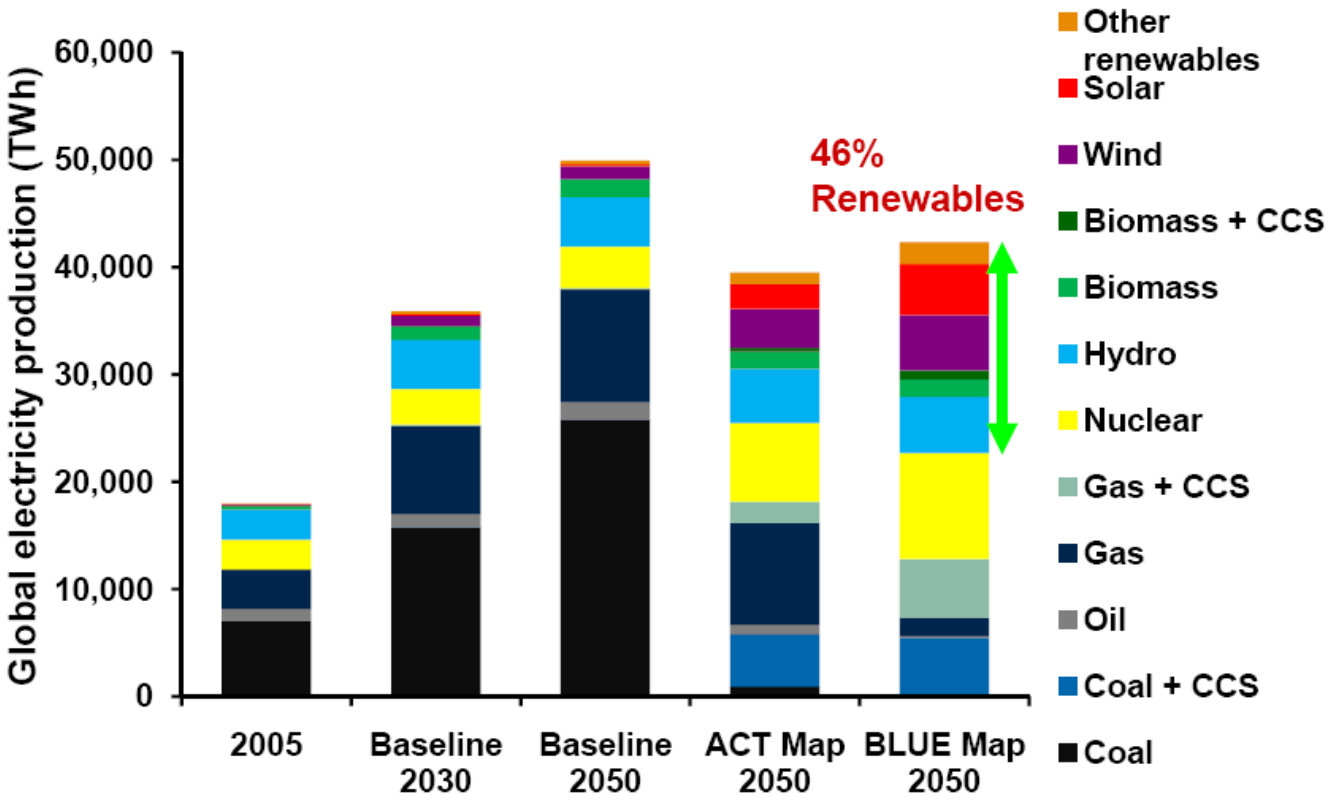


Key point

ACT Map implies deep emission cuts in power generation and the fuel transformation sector; BLUE Map implies deep emission cuts across all sectors.

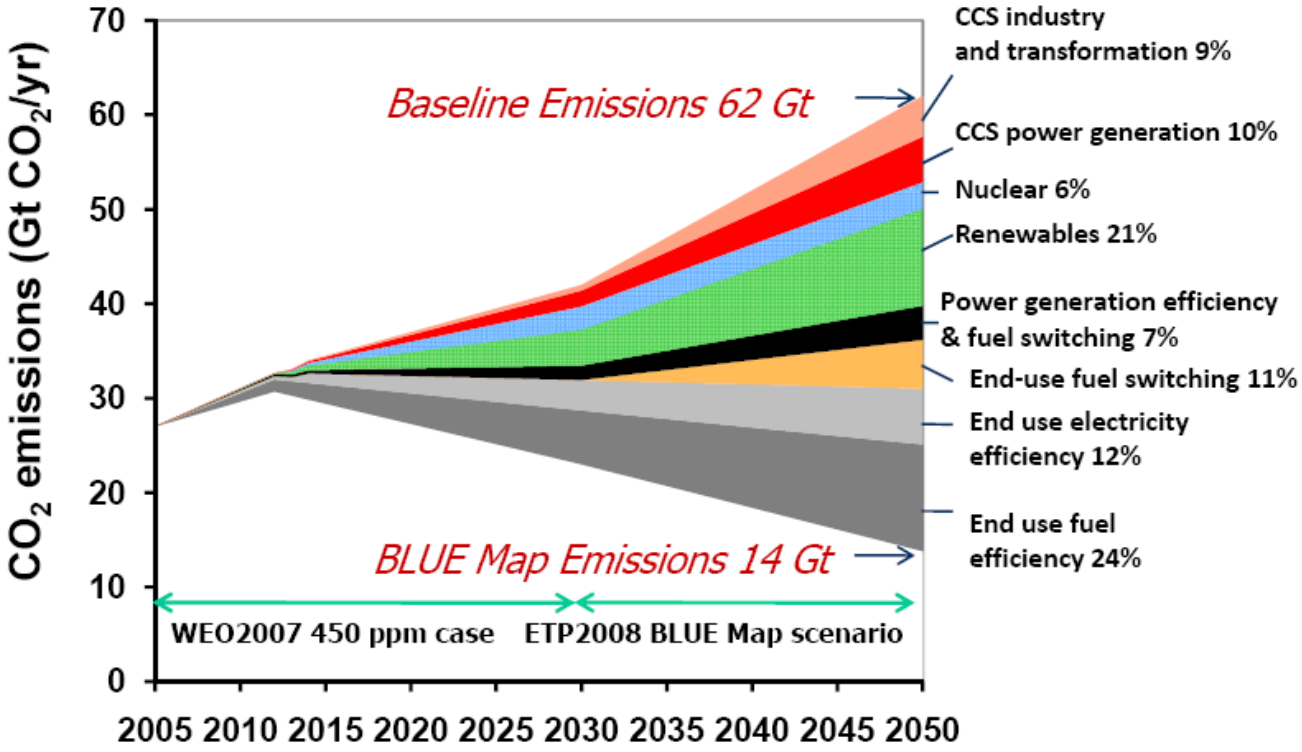
Source: IEA Energy Technology Perspectives 2008

Power Generation Mix



In support of the G8 Plan of Action

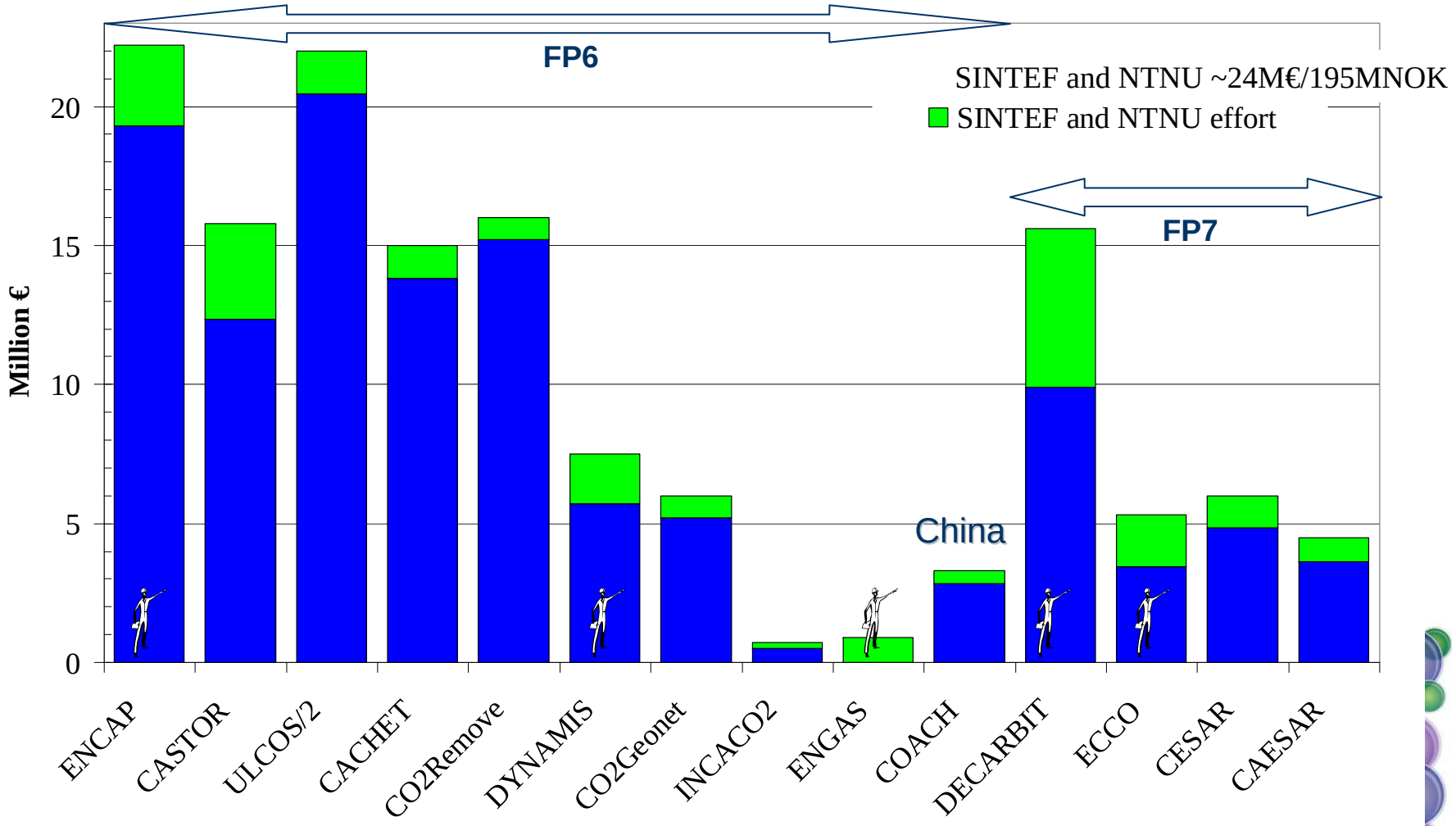
A New Energy Revolution: Cutting Energy Related CO_2 Emissions



In support of the G8 Plan of Action

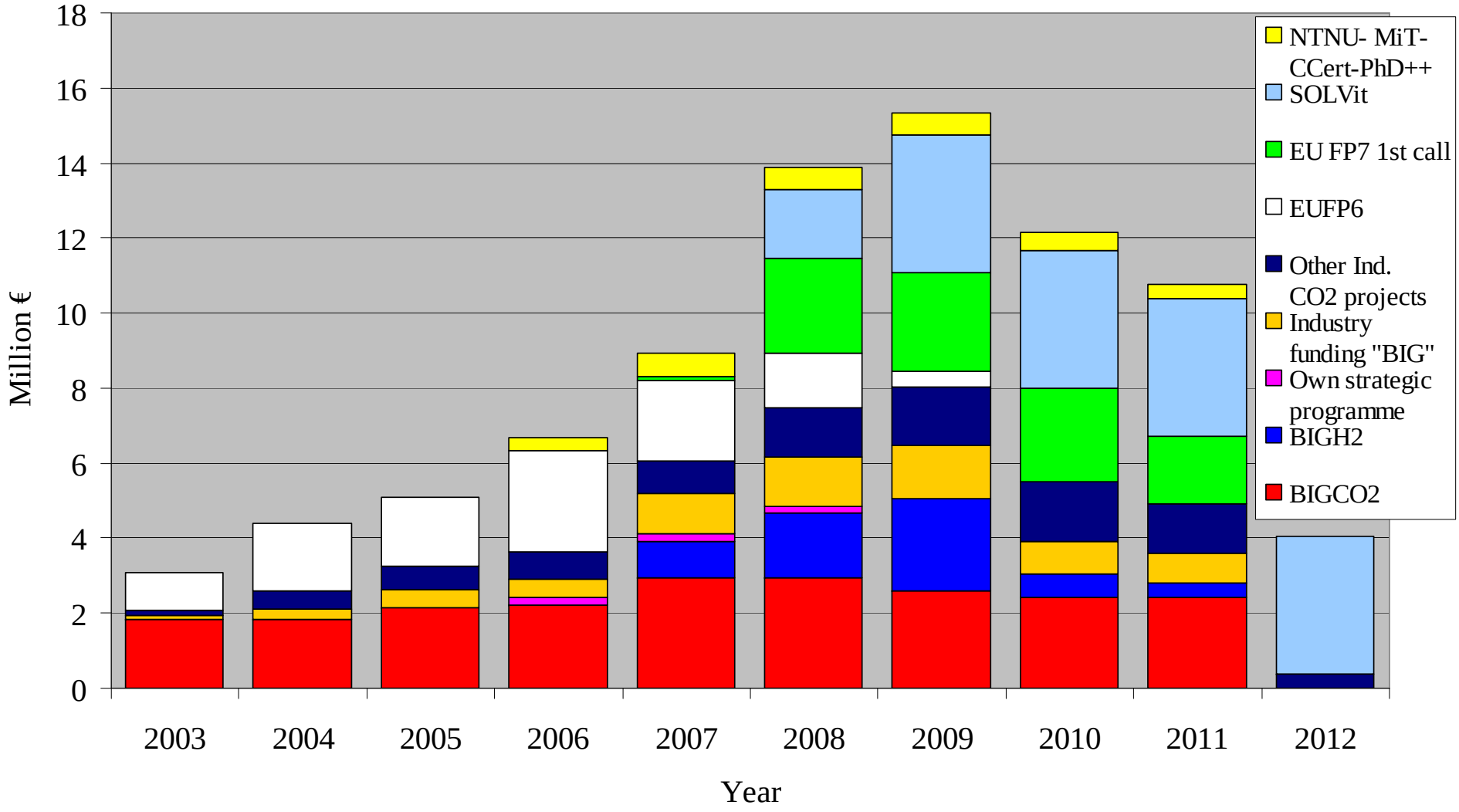
SINTEFs international position in CCS R&D

European R&D – Our Involvement in CCS



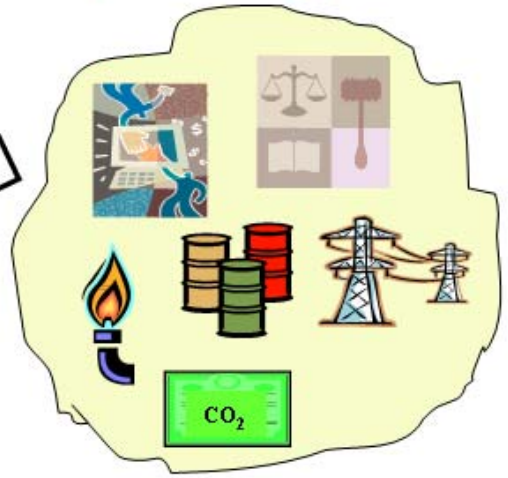
Our partners: Vattenfall, RWE, Statoil, Hydro BP, Rohoel, Siemens, Alstom, Lurgi. L'Air liquide, Linde, Progressive Energy Mitsui-Babcock, DLR, DONG Energy, Elsam, PPC, E.ON, SNSK, ENEL, ENDESA, E.ON, Schlumberger, IFP, TNO, RF, NIVA, OGS, ISFTA, Fraunhofer, IEA-GHG, GEUS, ARCELOR, Corus, BGS, BGR, BRGM, ECOFYS, JRC, Societe Generale, Universities of Twente-Ulster-Chalmers-Stuttgart-Delft, TU- Sofia, KTH, Corning, EDP, ECN, TIPS…

SINTEF and NTNU CO_2 project portfolio

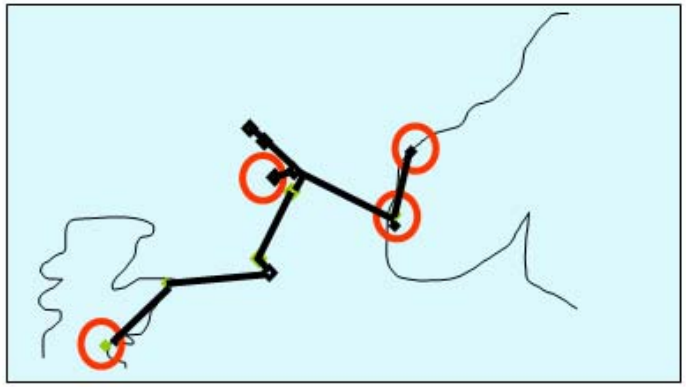


ECCO: CO2 value chain

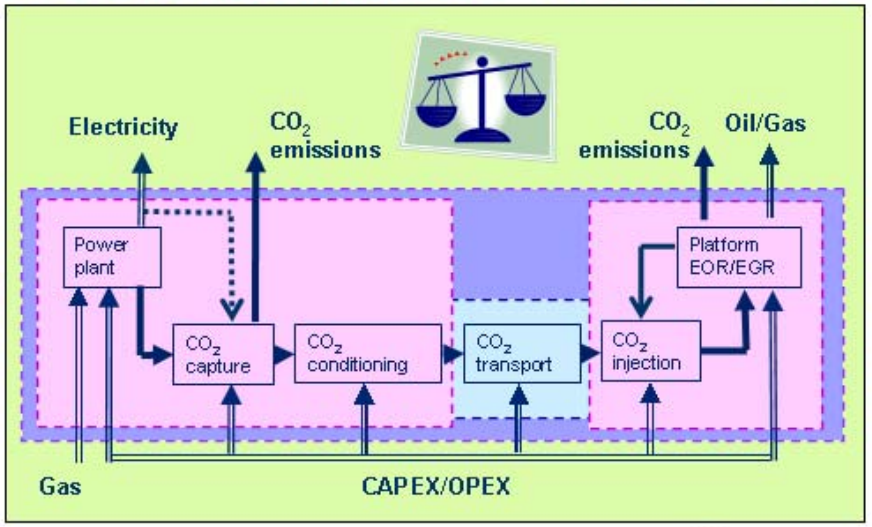
1. Scenario – "predicting" future CO_2 world



2. Case study – defining options



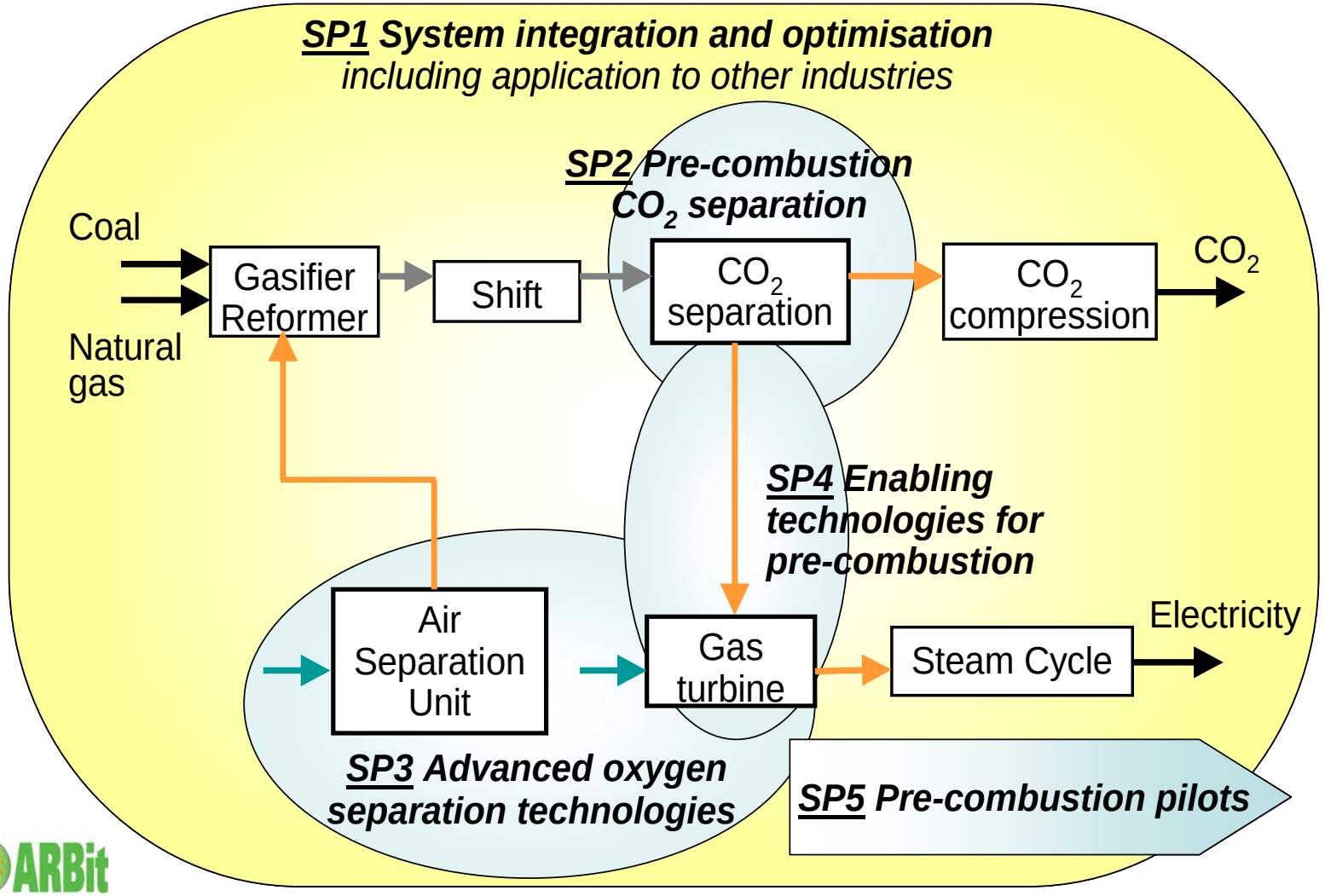
3. Economic analysis – profit vs. costs



4. Case study – evaluating options & recommendations

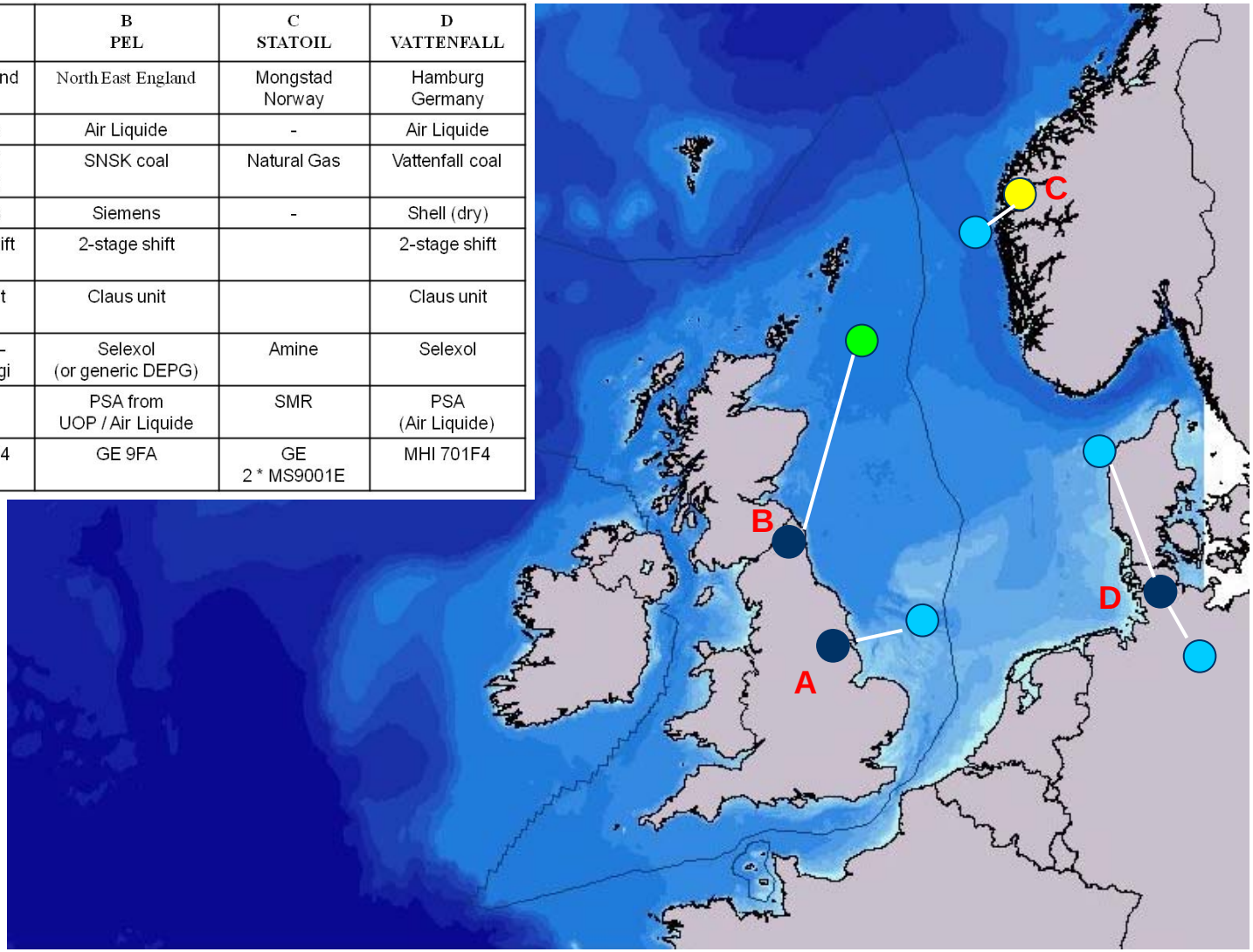
J. P. Jakobsen SINTEF

DECARBit – Integration of the tasks



DYNAMIS Case Studies: outlines and locations

Case Study	A EON	B PEL	C STATOIL	D VATTENFALL
Location	East England	North East England	Mongstad Norway	Hamburg Germany
ASU	Generic	Air Liquide	-	Air Liquide
Feedstock	Eon - El Cerrejon	SNSK coal	Natural Gas	Vattenfall coal
Gasifier	Siemens	Siemens	-	Shell (dry)
Shift / Conversion	2-stage shift	2-stage shift		2-stage shift
Sulphur Removal	Claus unit	Claus unit		Claus unit
Acid Gas Removal	Rectisol – Linde/Lurgi	Selexol (or generic DEPG)	Amine	Selexol
H_2 Separation / Production		PSA from UOP / Air Liquide	SMR	PSA (Air Liquide)
Gas Turbine	MHI 701F4	GE 9FA	GE 2 * MS9001E	MHI 701F4



Host for CCS laboratory infrastructures

- Affordable CCS Technologies
  - Through making available the right “tools”

- Accelerate CCS through providing the missing link between infrastructure and research on an European level

- Contribute to global infrastructure network development

- Provide us with the right resources to tackle the world’s most worrying issue: global warming

Provide a virtual infrastructure of excellence within CCS

NTNU and SINTEF to ho the European CCS test labs

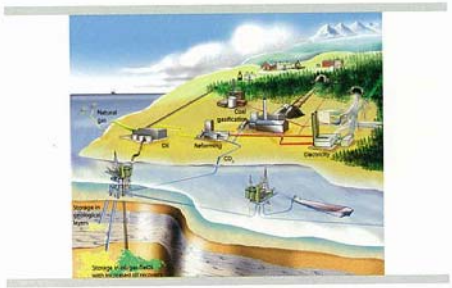
- Officially put on the ESFRI Roadmap 8 Dec. 2008 - Versailles
- 81 M€ investment
- Pan-European research infrastructure for CCS
- Open access for researchers
- www.ntnu.no/eccsel

>Energy

ECCSEL – European Carbon Dioxide Capture and Storage Laboratory Infrastructure

The facility:

The ECCSEL facility combines three approaches to capture (pre and post combustion and O_2/CO_2-oxyfuel- recycle combustion capture) and three approaches to carbon storage (aquifers, depleted oil/gas fields, coal bed methane). The project includes the upgrading of existing national infrastructures to European level. The upgraded facility is composed of distributed parts in different countries and a coordination centre in Norway.



Background.

Carbon dioxide capture and storage (CCS) is identified as a key technology for reducing emissions from fossil energy use in the future. The demand for it is globally large, in particular in emerging economies. Europe lacks presently a large research infrastructure in this field. There is a very strong need for activities in this field and this topic is highly relevant for the EU Strategic Energy Technology (SET) plan. The core consortium of the upgraded facility consists of 10 European partners, but the network behind CCS is much broader.

What's new? Impact foreseen?

The ECCSEL infrastructure will be unique world-wide in its comprehensiveness for research in CCS and will be open to researchers through a joint management structure. It builds up on developments of the partners' specialised labs in course of national and EU programmes. The core hub of ECCSEL will be in Norway with partner institutions in Germany, the Netherlands, France, Denmark (including Greenland), Poland, Hungary, Switzerland and Croatia. The planned research infrastructure meets the different needs from basic research to experimental activities. In particular it will enable more advanced levels of research in post combustion absorption (needed to address the more near term options), new materials and processes (needed to reduce the cost and reliability of next generation CCS processes), combustion facilities (to enable oxy-fuel CCS processes and efficient hydrogen combustion) and storage facilities (needed for improving the knowledge of storage in aquifers and to develop qualification methods and mitigation strategies). These are all highly relevant to reduce the costs of CCS, improve the reliability of the various concepts and in particular to improve the knowledge of CO_2 storage and to develop qualification methods and mitigation strategies.

By facilitating international research and development ECCSEL will contribute substantially to the targets brought forward in the Road Map for EU Zero Emission Fossil Fuel Power Plants (ZEP) Technology Platform to achieve CO_2 reduction costs of less than 20€/ton, reduce efficiency loss to less than 6% and to help develop and implement competitive and sustainable CCS technologies.

>Timeline.

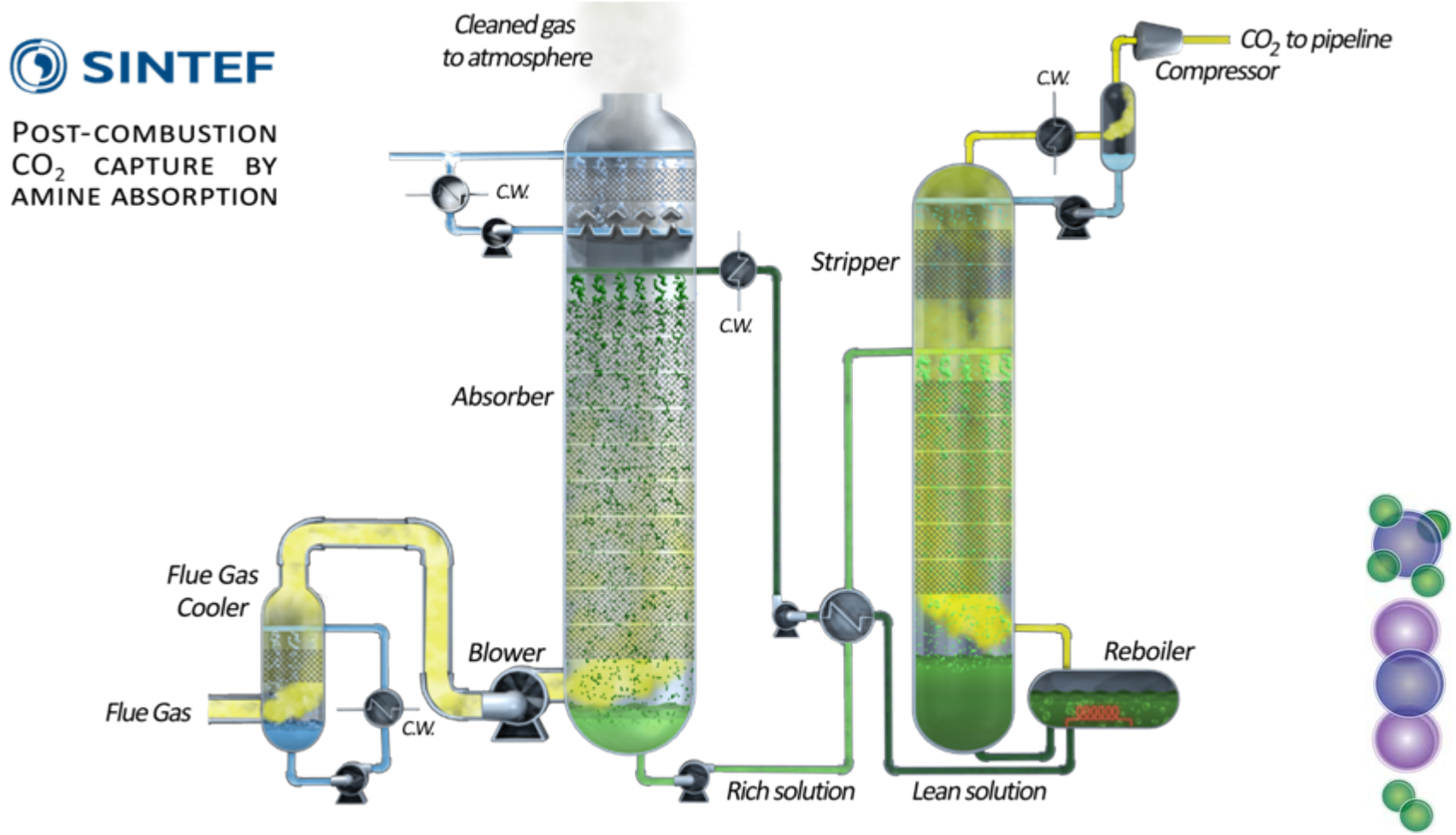
The facility will be in operation in 2011 and will meet the urgent needs in this field.

>Estimated costs.

Preparation costs:	3-4 M€.
Total construction costs:	81 M€.
Operation costs:	6 M€/year.
Decommissioning costs:	2 M€.

>Website: www.ntnu.no/eccsel

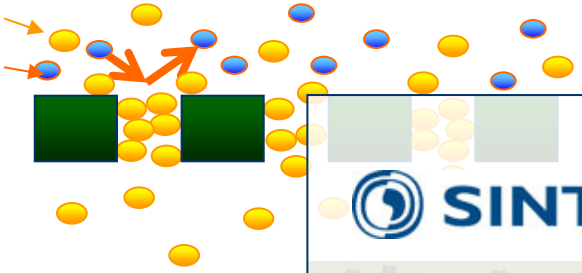
National R&D Activities at SINTEF

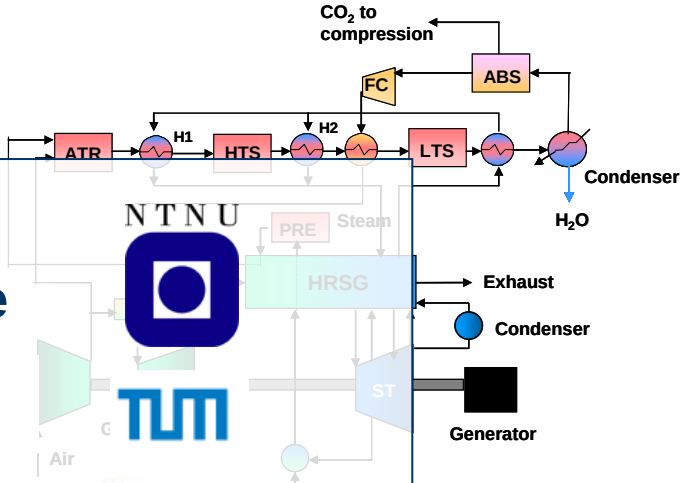


BIGCO$_2$ National CCS R&D Platform

Absorption and desorption studies

Membranes





25 Million€

8 year programme

SINTEF

NTNU

DLR

CICERO

UNIVERSITY OF OSLO

The Research Council of Norway

GASSNOVA

H_2 and De-N_2 combustion

cycle analysis

Statkraft

AKER KVÆRNER

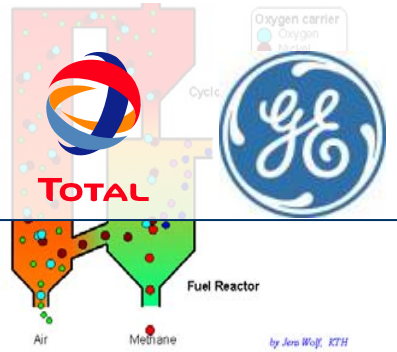
ConocoPhillips

ALSTOM

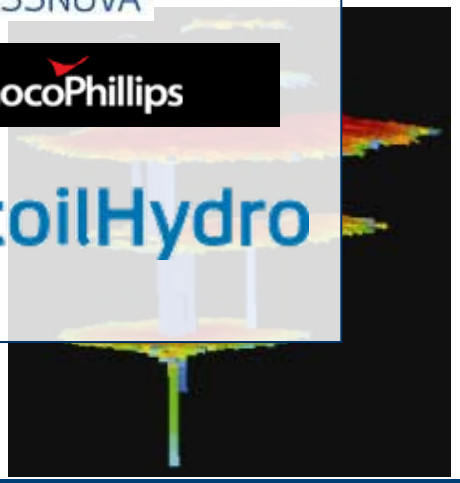
StatoilHydro

TOTAL

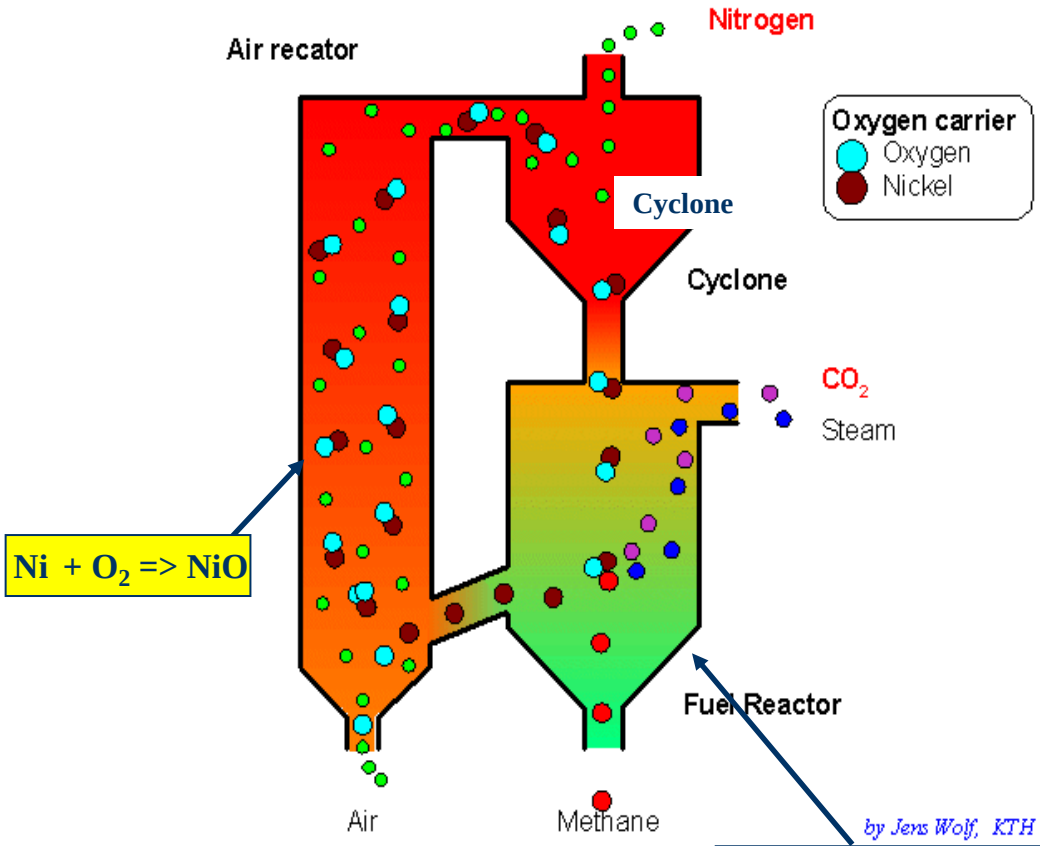
Chemical Looping Combustion



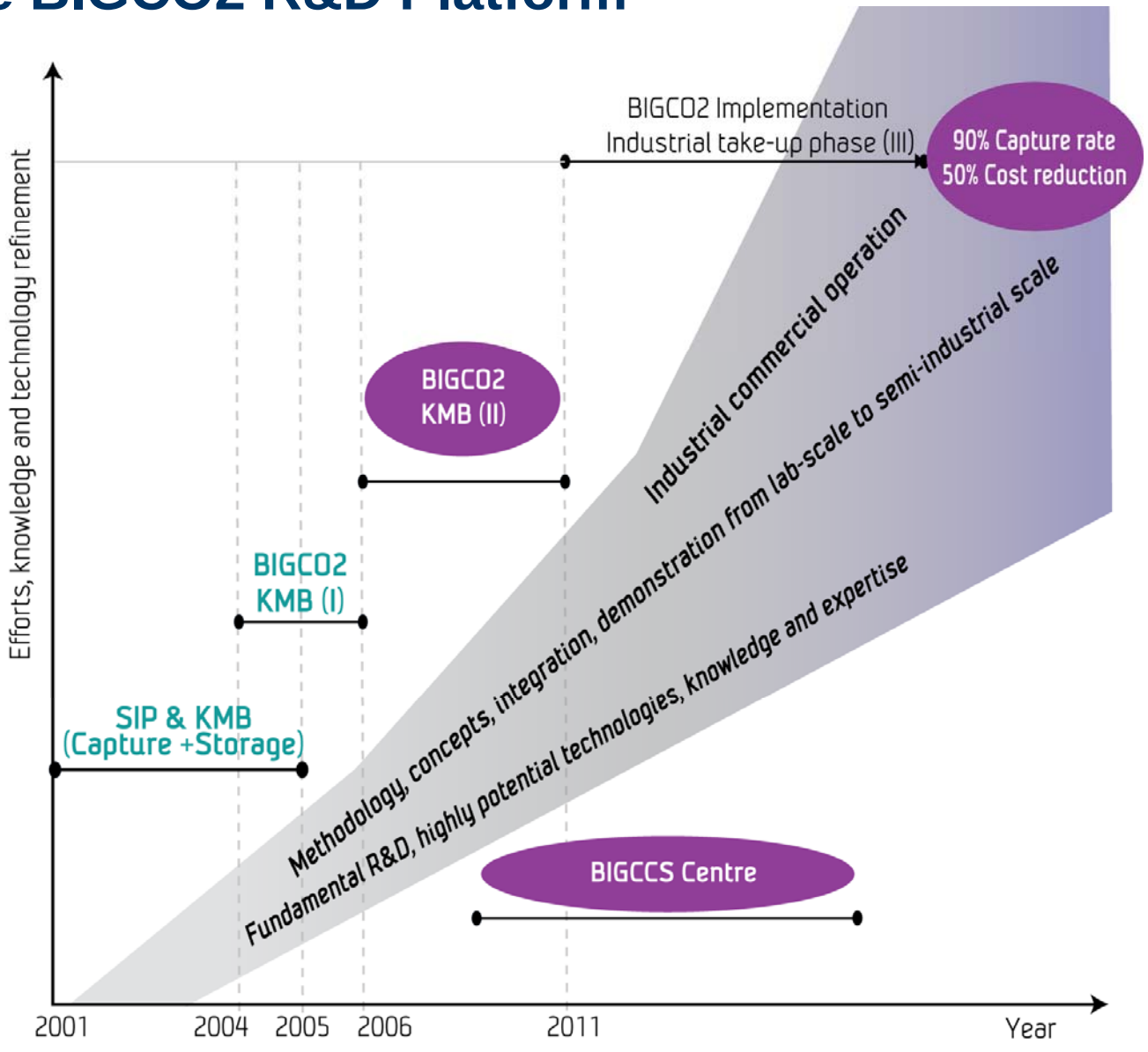
Geological storage



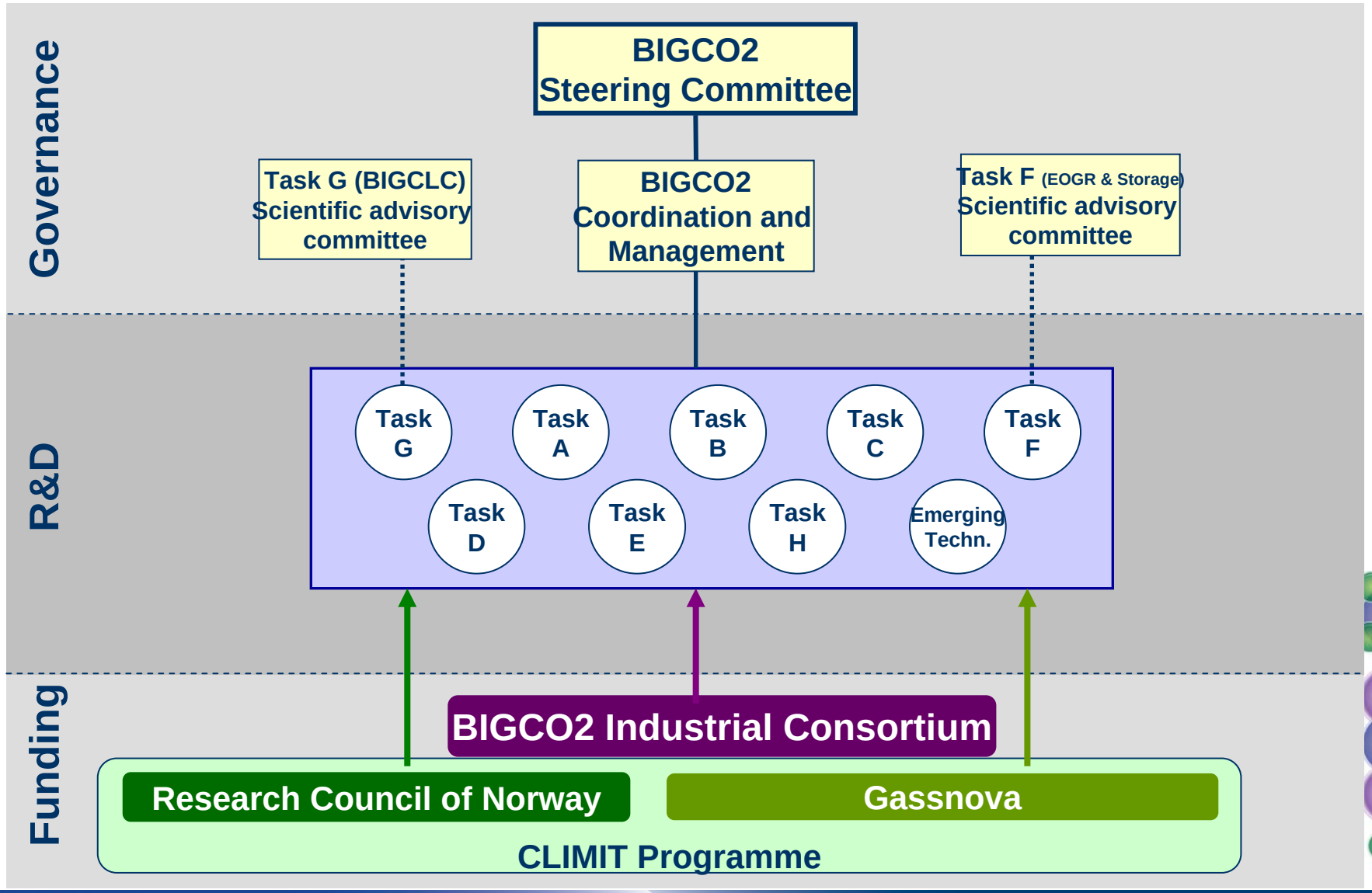
Chemical Looping Combustion



Build-up of the BIGCO2 R&D Platform



BIGCO2 Organisational structure



BIGCCS Centre

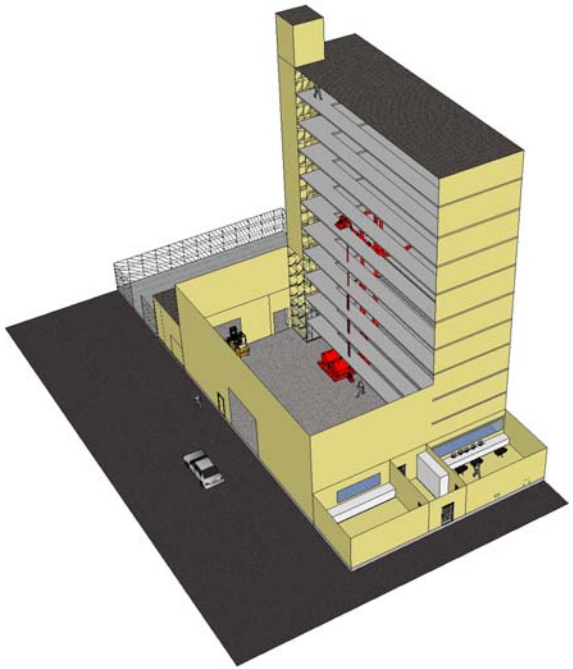
Centre coordinator: Nils A. Røkke

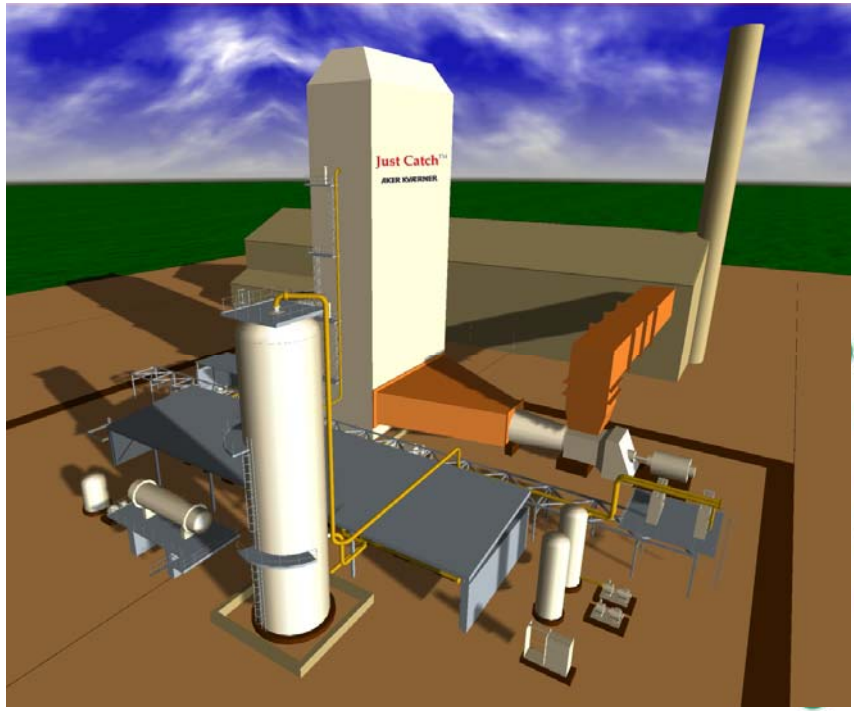
6 mill EURO/year in 8 years

The SOLVit Programme

Solvent development for next generation Post combustion systems
8 yrs, 317 MNOK (~40M€)

GASSNOVA

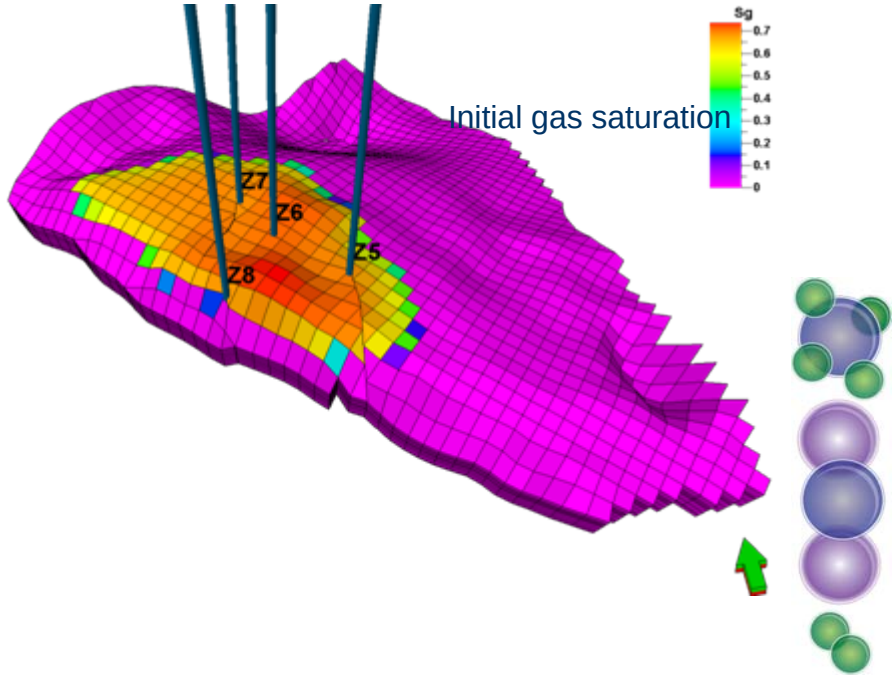




Recent and ongoing efforts - Storage

- Projects
  - CO_2ReMoVe, CASTOR, ULCOS, DYNAMIS, CO_2GeoNet, BIGCO2,
- Reproduction of CO_2 from Utsira, including experimental imbibition rel. perm and simulations (Statoil)

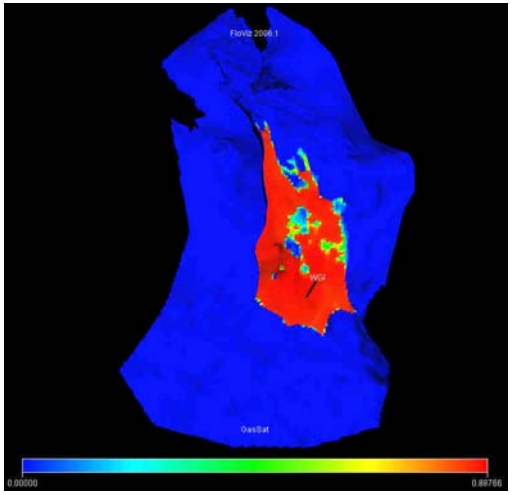
- Feasibility study on use of Groothusen depleted gas field for permanent storage of CO2 (Phase I finished, Phase II on going, Statoil) Picture: Initial gas saturation in the field



Recent and ongoing efforts - Storage

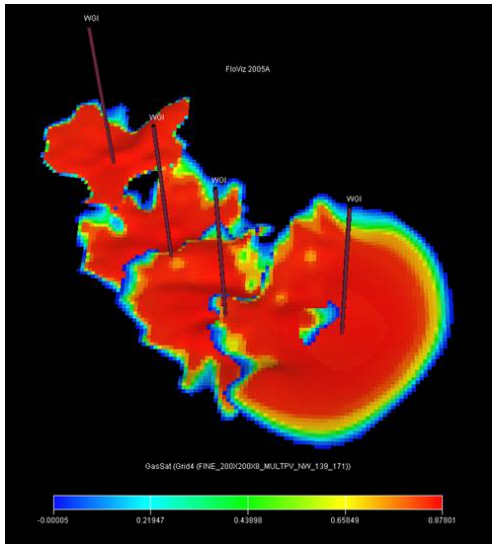
- Feasibility study on Johansen formation as sink for Mongstad CO_2 (NPD)

  (Picture: Distribution of CO_2 after injection of 300 million tonne $CO_{2,,}$ year 2119)



- Feasibility study on Utsira South as sink for Kårstø CO_2 (NPD)

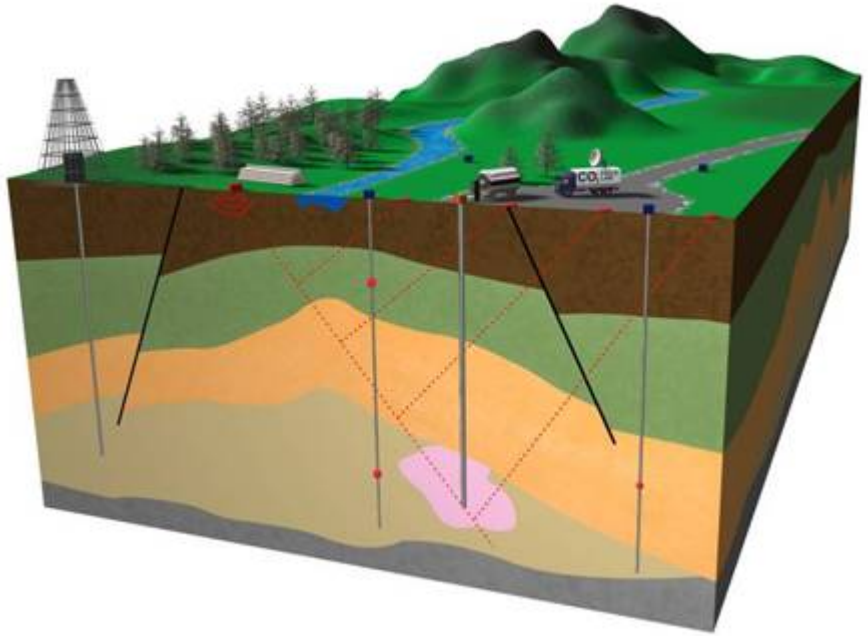
  (Picture: exploring various injection sites)



Recent and ongoing efforts - Storage

Idea: Inject CO_2 in a onshore location for studying migration paths and monitoring techniques in a location prone to cause migration.

- Field laboratory for monitoring of CO_2 (StatoilHydro, Gassnova etc.)
- Location discussed at Svelvik- south of Norway
- Open for new entrants

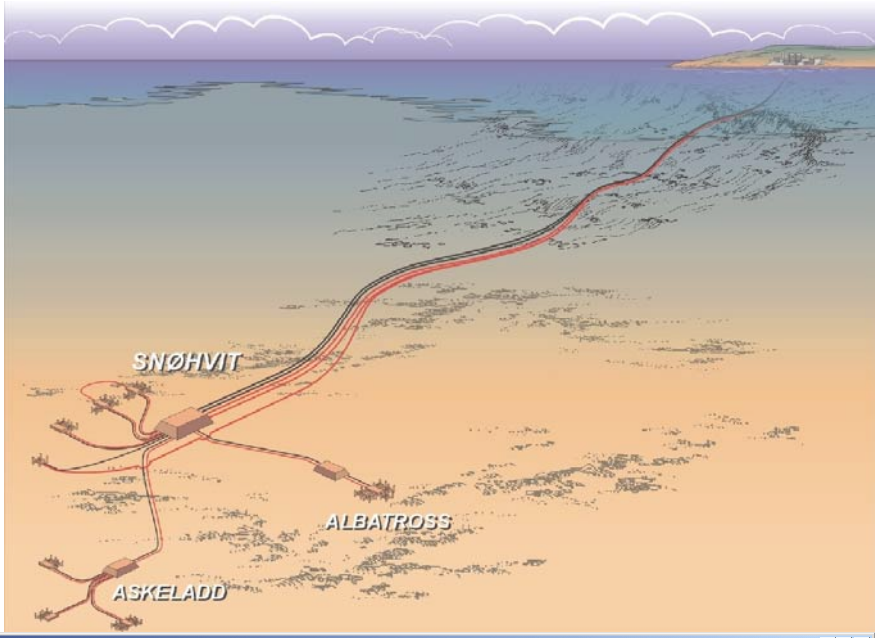


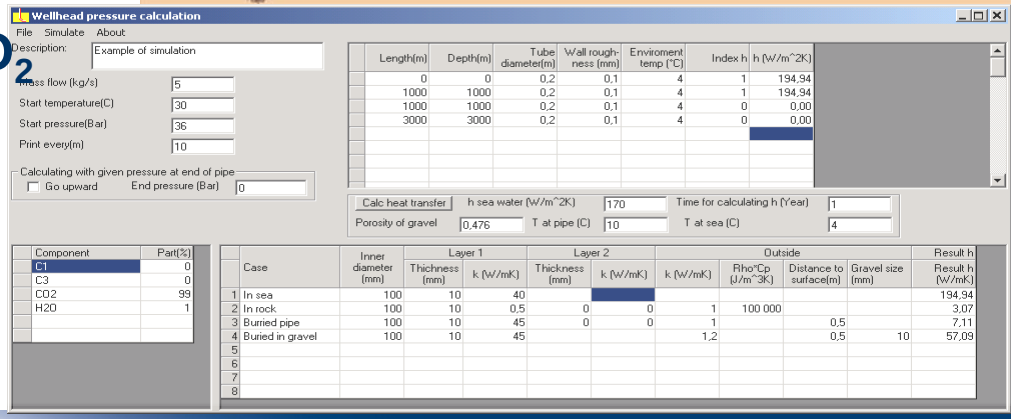
CO_2 transport
The link between CO_2 capture and storage

Challenges:

To perform design and safety calculations for transport systems for CO_2 with impurities

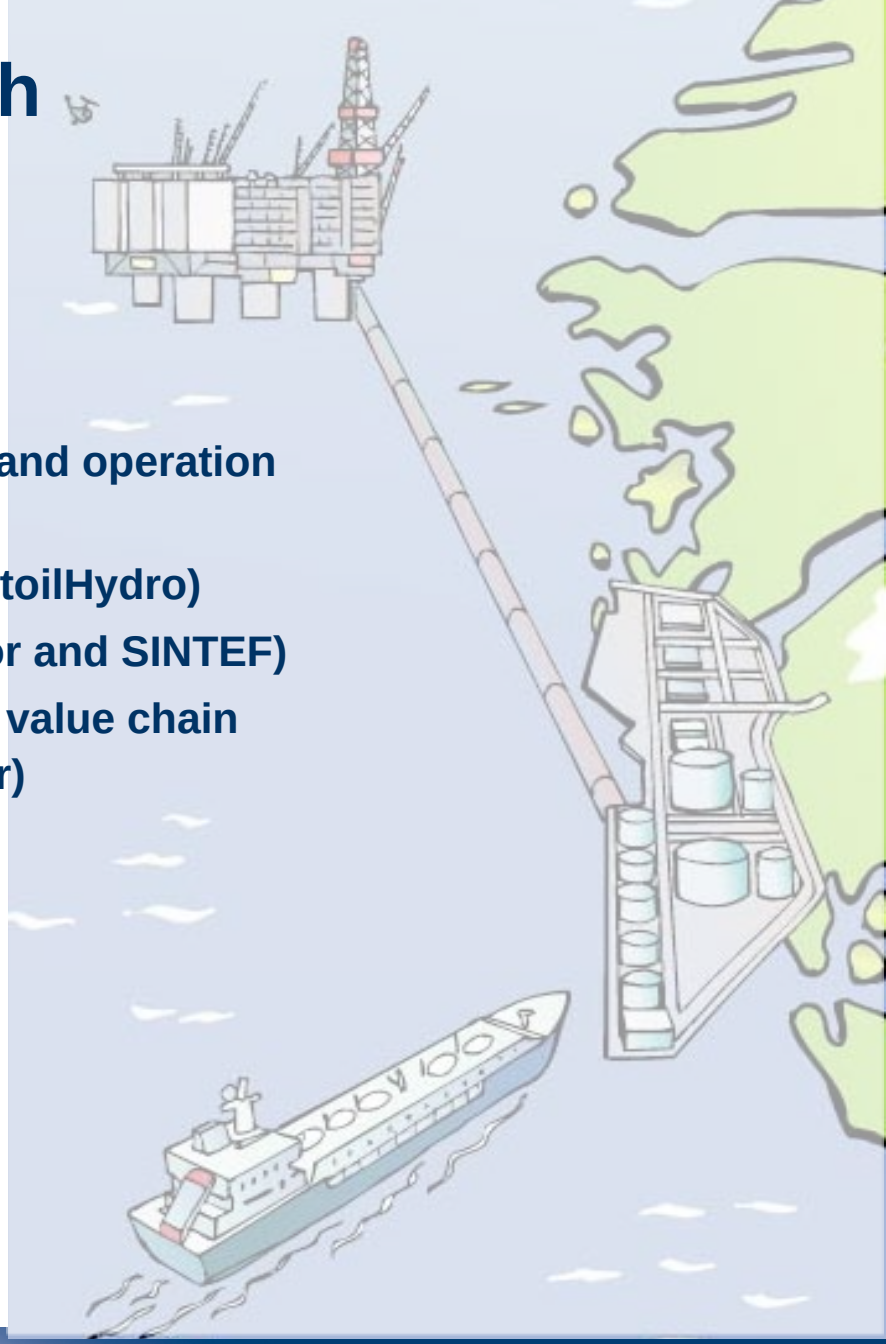
- Transient, multi-component, two-phase flow
- Flow models
- Thermodynamic models for CO_2 mixtures
- Cost-effective solutions for pipeline- and ship transport





CO_2 transport – projects with SINTEF involvement

- Dynamis - CO_2 quality recommendations
- CO_2 thermodynamics - CCP project/Statoil
- Transport and operation – pipeline design and operation studies (Statoil projects)
- Snøhvit CO_2 pipeline (CO2 ventilation) (StatoilHydro)
- Ship transport of CO_2 (Statoil, Teekay, Vigor and SINTEF)
- CO_2 Halten project: Capture, transport and value chain analysis (Shell, StatoilHydro, Aker Kværner)
- CO_2 value chain (BIGCO2)
- ECCO
- Large scale CO_2 transport in the North Sea
- CO2 IT IS (BIP, StatoilHydro)
- CO_2 Dynamics (SINTEF)



The 5th Trondheim Conference of CCS, 16-17 June 2009

NTNU
SINTEF

The 5th Trondheim Conference on CO_2 Capture, Transport and Storage

16-17 June, 2009, Trondheim Norway

SINTEF Energy Research
NTNU

- Homepage
- Scope and Conference Target
- Call for Abstracts
- Committees
- Programme
- Presenter information
- Venue
- Practical information
- Registration and fees

The 4th Trondheim Conference on CO2 Capture, Transport and Storage

webmaster

TRONDHEIM CCS CONFERENCE

CO_2 CAPTURE, TRANSPORT AND STORAGE

The Trondheim CCS conference series have grown to become a leading scientific CCS technology conference. The 4th Trondheim Conference on CCS held in 2007 was successful in attracting over 60 abstracts of which 46 were presented in 10 oral sessions.

The contributors at the conference were invited to submit a paper for a Special Issue of the Journal of Greenhouse Gas Control Technologies which is currently online (Issue 2, 2008).

A total of 215 delegates from 19 countries attended the 2-day TCCS-4 conference.

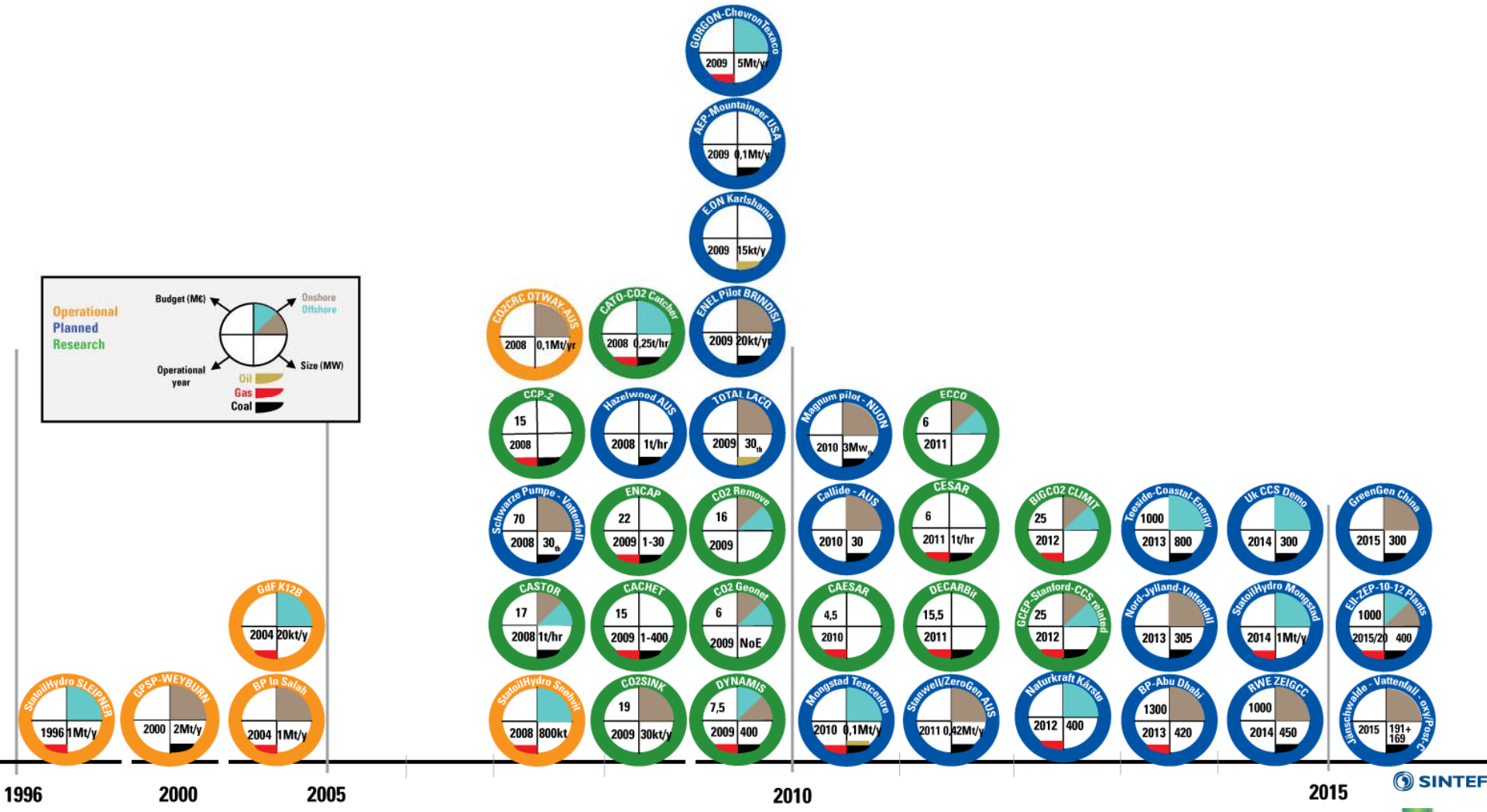
Building on this success, the TCCS-5 is now planned for June 2009, and targets an even wider international participation.

Arranged by:
Gas Technology Center NTNU – SINTEF

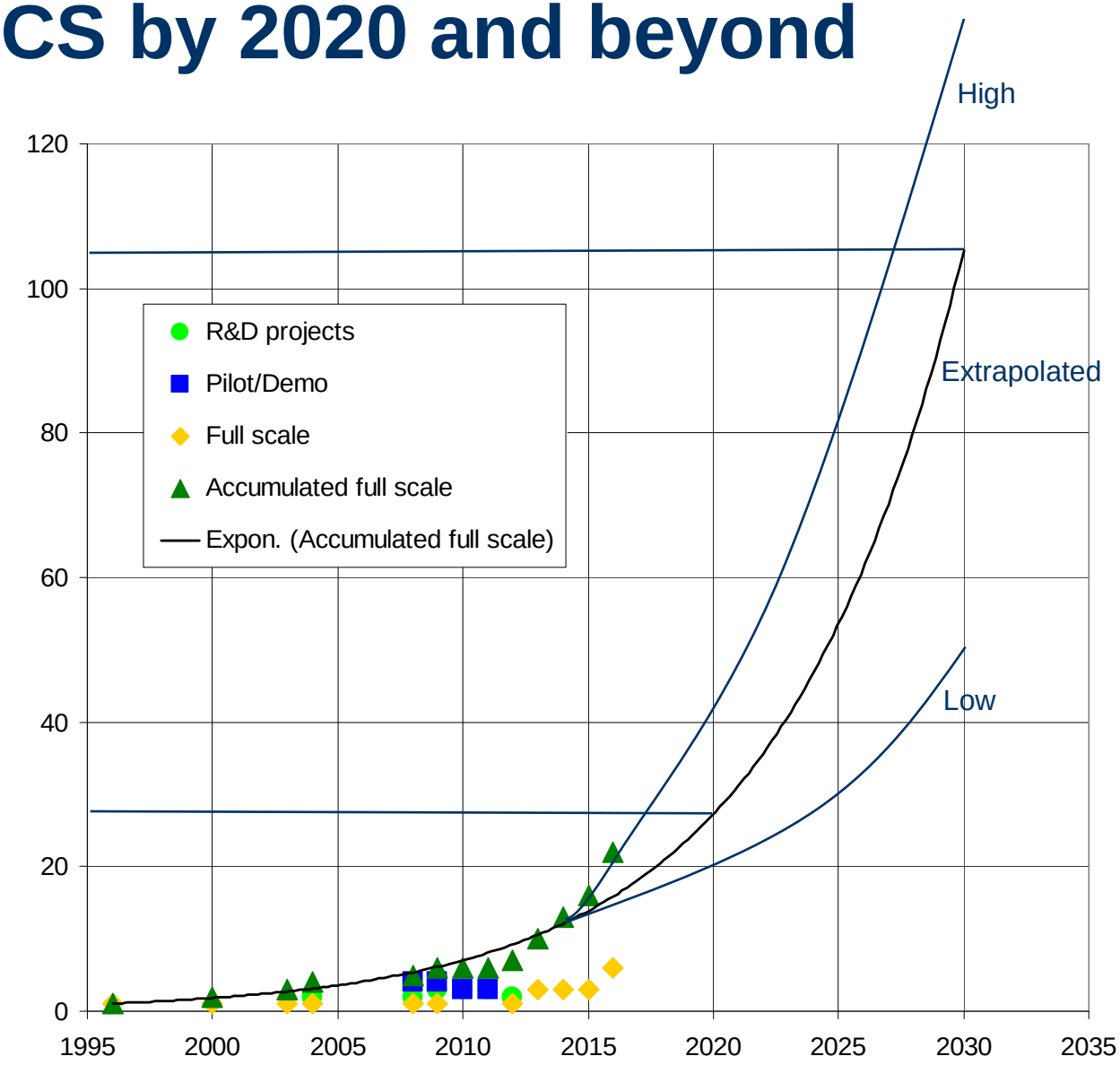
www.ntnu.no/tccs5

Market Drivers and Projects

Project Timeline – R&D, Demo and Full Scale



CCS by 2020 and beyond



Likely to see 10's of plants by 2020 in operation.

Likely to see 50-150 plants by 2030

G8: 20
ZEP: 10-12
IEA: 400 GW in 2030~400 plants

By 2100: 5000 plants?

Participation in SINTEF Projects - Benefits and Terms

Benefits and terms (I)

- Possibility to get access to a world leading CCS R&D environment and team up with leading industrial players within CCS
- Recruitment opportunities
  - Connection/exchange of PhD students
  - People with high competence within CCS
- Give direction to research through Board participation, active partners can influence the contents of the sub projects, topics and work packages

Benefits and terms (II)

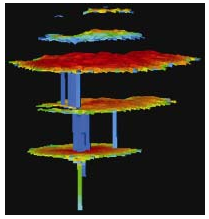
- Deliverables and results
  - Access to project results
  - Rights, regulated through;
    - Consortium Agreement (CA)
    - IPR and dissemination level of work/results is regulated by CA
- Spin-offs can be generated for the industry partner's own technology needs and interests
- Access to world class R&D labs

Benefits and terms (III)

- Opportunity to include own work within the projects as in-kind contribution in addition to cash/IPR sharing/data sharing- joint development and use of R&D facilities
- Contribution varies between 50-500k€/yr dependent on type of project, duration, topics etc.
- Favourable terms
  - Leverage ~1:30 (typically)
  - Opportunity to influence research topics, priorities and organization

Summary





- Norway is promoting CCS as a key carbon abatement option
- SINTEF is a major CCS R&D provider in Europe and on a global scale
- Our portfolio of active projects exceeds 125 M€

- International partners are invited to join in our existing and new initiatives within CCS on a broad basis utilising:
  - Bilateral funding schemes
  - European funding agencies (FP's)
  - Industrial lead consortia (JIP)
  - University co-operation and exchange

Thank you!

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CO_2 capture, transport and storage – main routes