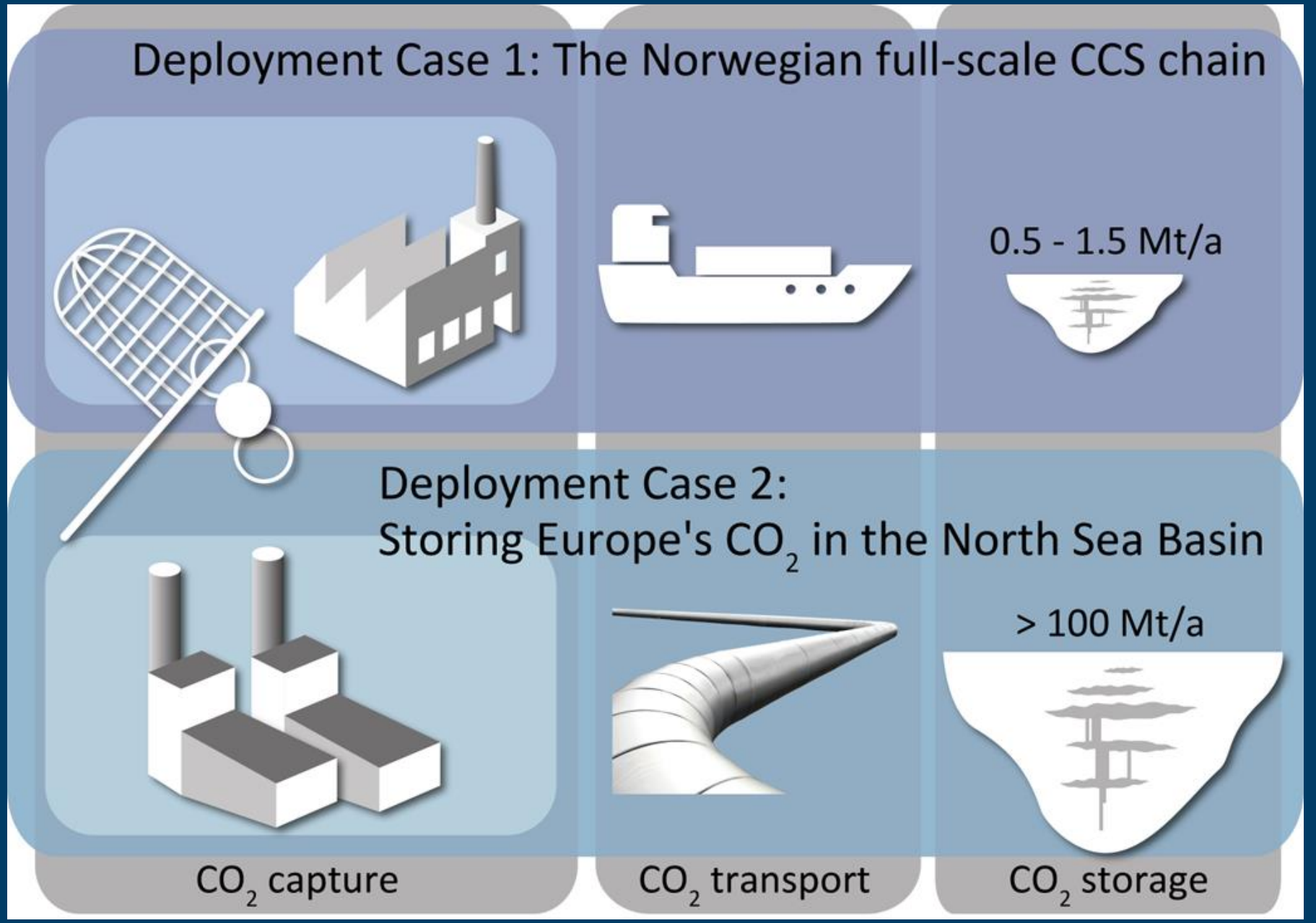
CO_2- FANGST, TRANSPORT OG LAGRING: EN STOR MULIGHET FOR NORGE OG KLIMAET VÅRT

2020-01-30 Mona J. Mølnvik, forskningssjef SINTEF Energi og direktør for FME NCCS

HVA ER CCS?


Deployment Case 1: The Norwegian full-scale CCS chain
0.5 - 1.5 Mt/a
Deployment Case 2:
Storing Europe's CO_2 in the North Sea Basin
> 100 Mt/a
CO_2 capture
CO_2 transport
CO_2 storage

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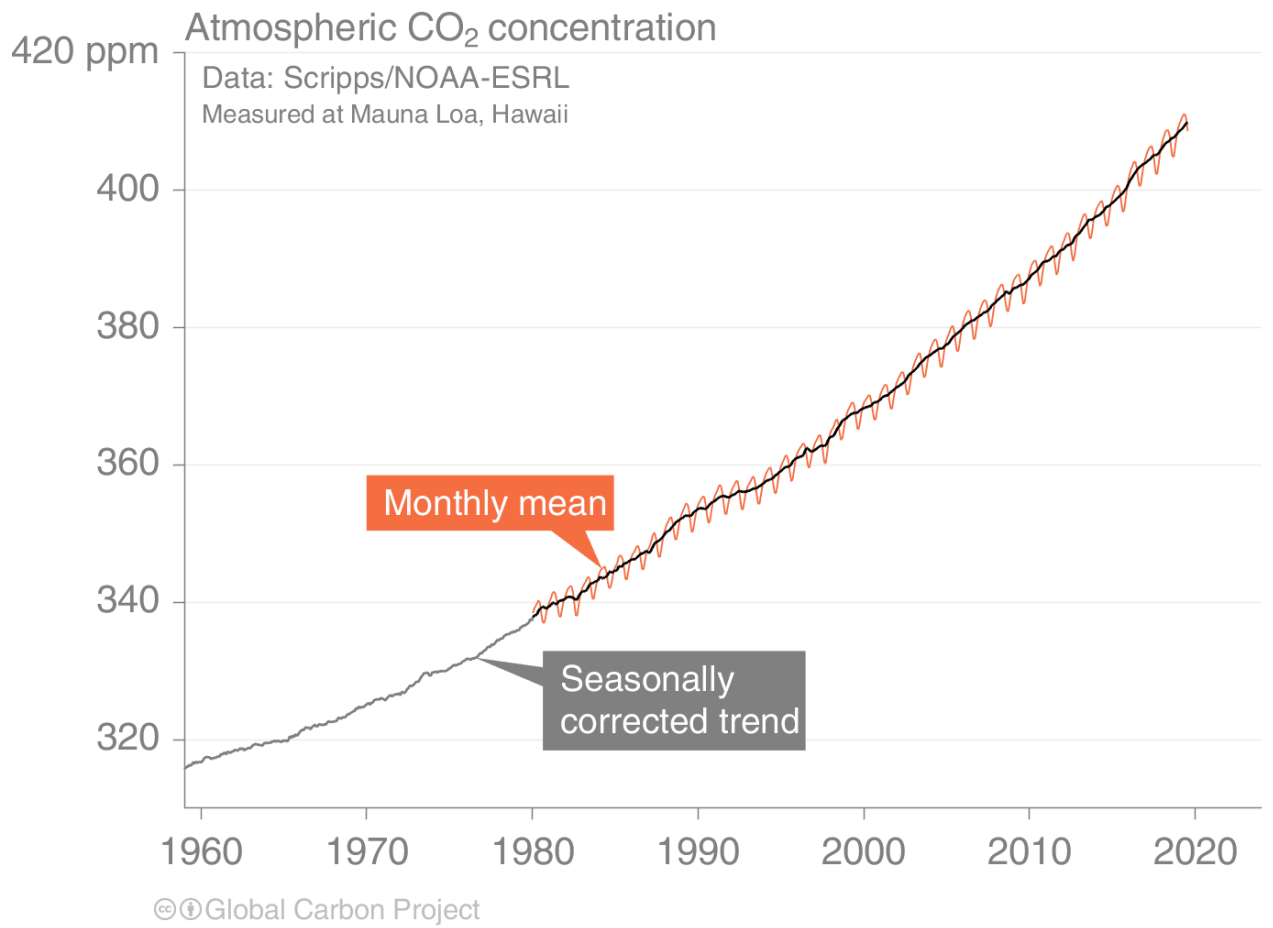
HVORFOR ER DETTE LURT?

Atmospheric concentration

The global CO_2 concentration increased from ~277ppm in 1750 to 407ppm in 2018 (up 46%)
2016 was the first full year with concentration above 400ppm



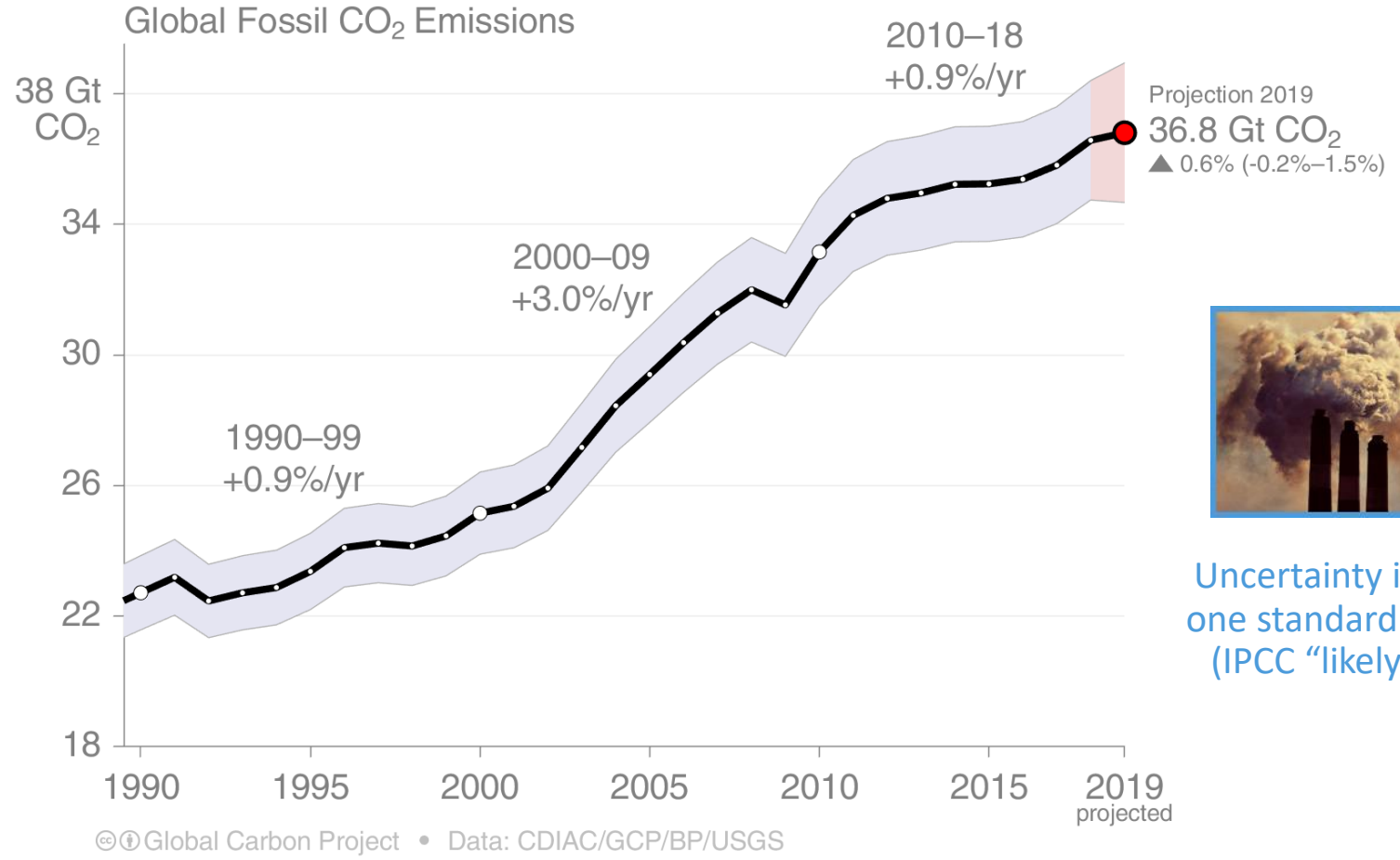
Globally averaged surface atmospheric CO_2 concentration. Data from: NOAA-ESRL after 1980;
the Scripps Institution of Oceanography before 1980 (harmonised to recent data by adding 0.542ppm)
Source: NOAA-ESRL; Scripps Institution of Oceanography; Friedlingstein et al 2019; Global Carbon Budget 2019

Global Fossil CO_2 Emissions

Global fossil CO_2 emissions: 36.6 ± 2 $GtCO_2$ in 2018, 61% over 1990

Projection for 2019: 36.8 ± 2 $GtCO_2$, 0.6% higher than 2018 (range -0.2% to 1.5%)

Fossil CO_2 emissions will likely be more than 4% higher in 2019 than the year of the Paris Agreement in 2015



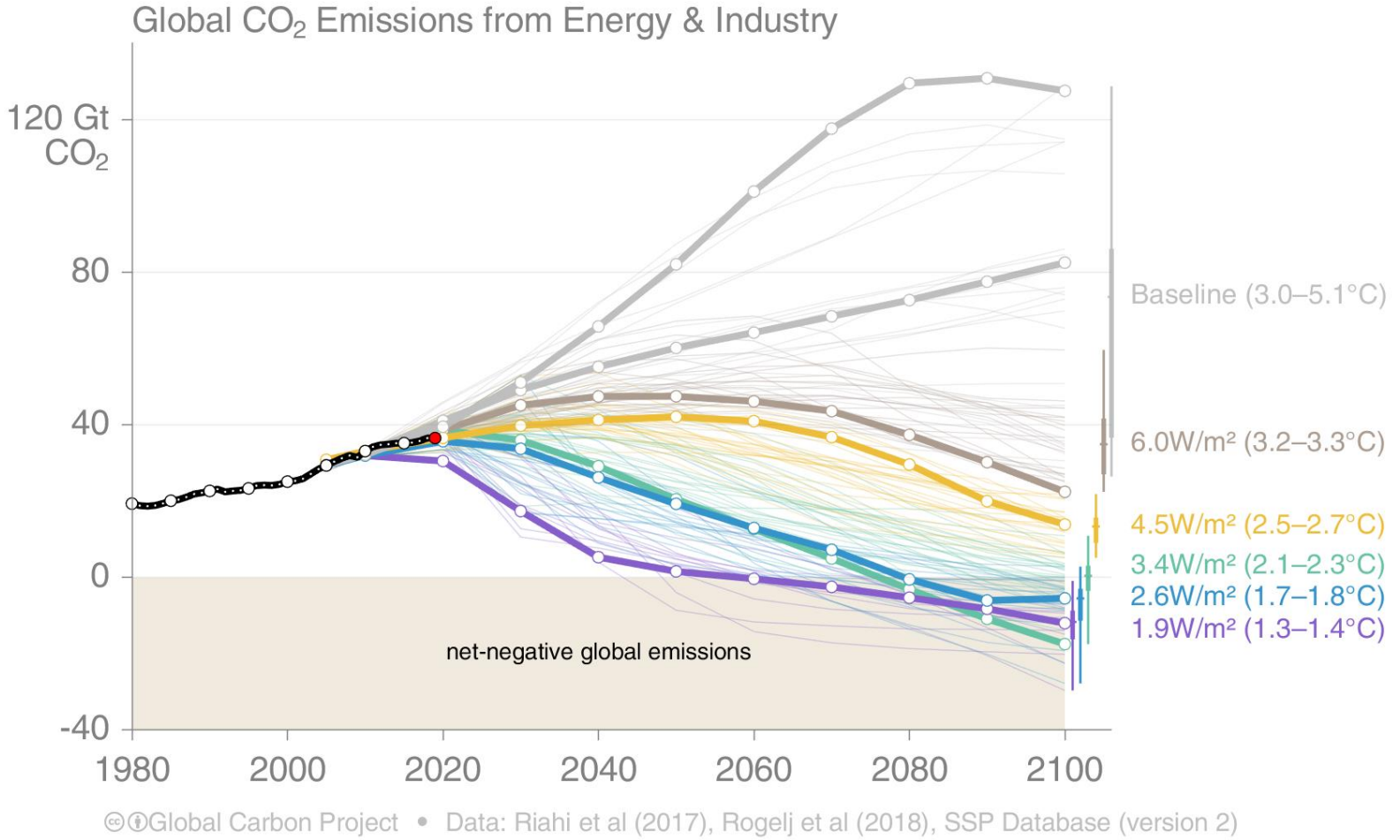
Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

The 2019 projection is based on preliminary data and modelling.

Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

Shared Socioeconomic Pathways (SSPs)

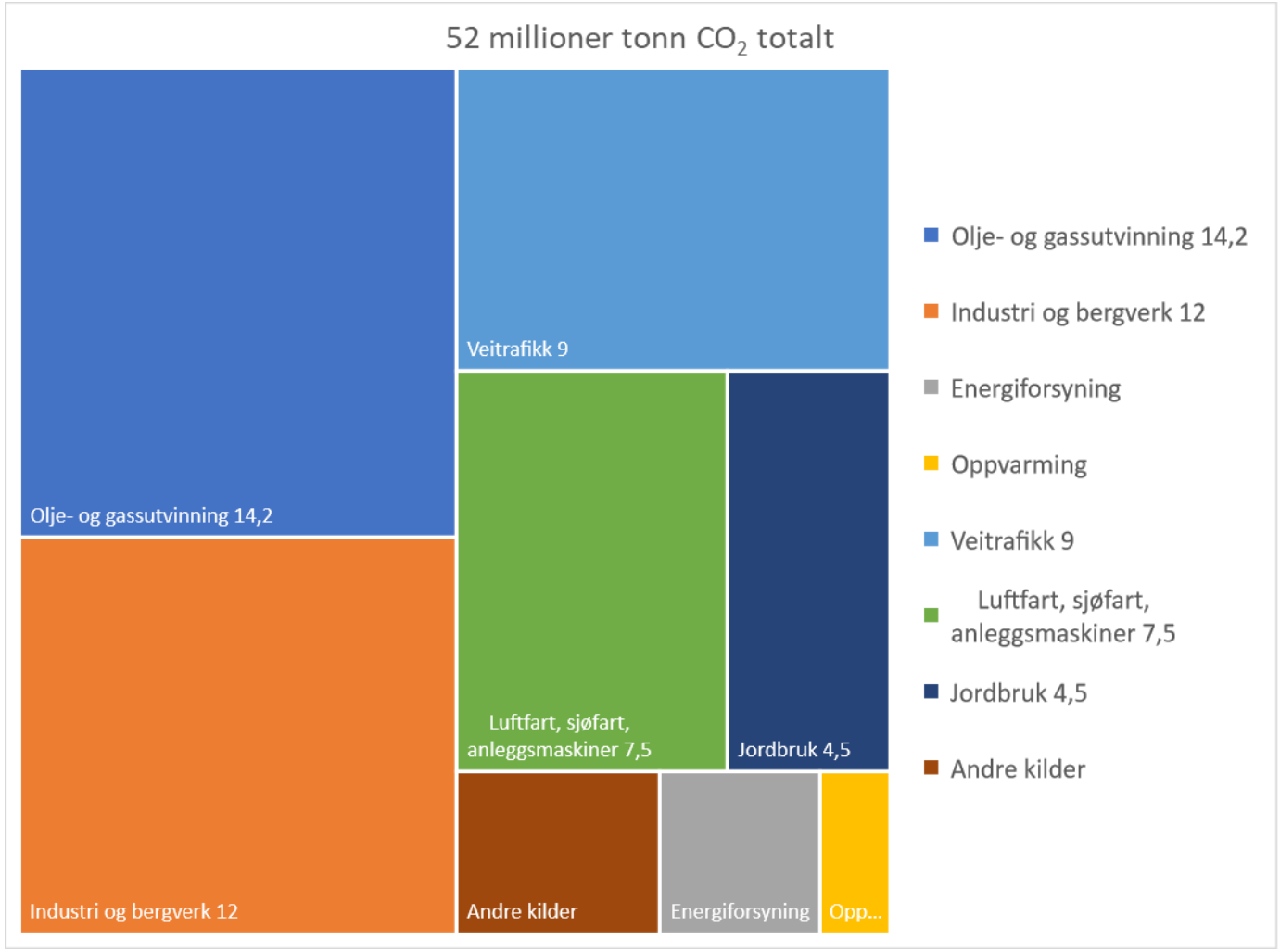
The SSPs lead to a broad range in baselines (grey), with more aggressive mitigation leading to lower temperature outcomes. The bold lines are scenarios that will be analysed in CMIP6 and the results assessed in the IPCC AR6 process.



This set of quantified SSPs are based on the output of six Integrated Assessment Models (AIM/CGE, GCAM, IMAGE, MESSAGE, REMIND, WITCH). Net emissions include those from land-use change and bioenergy with CCS.

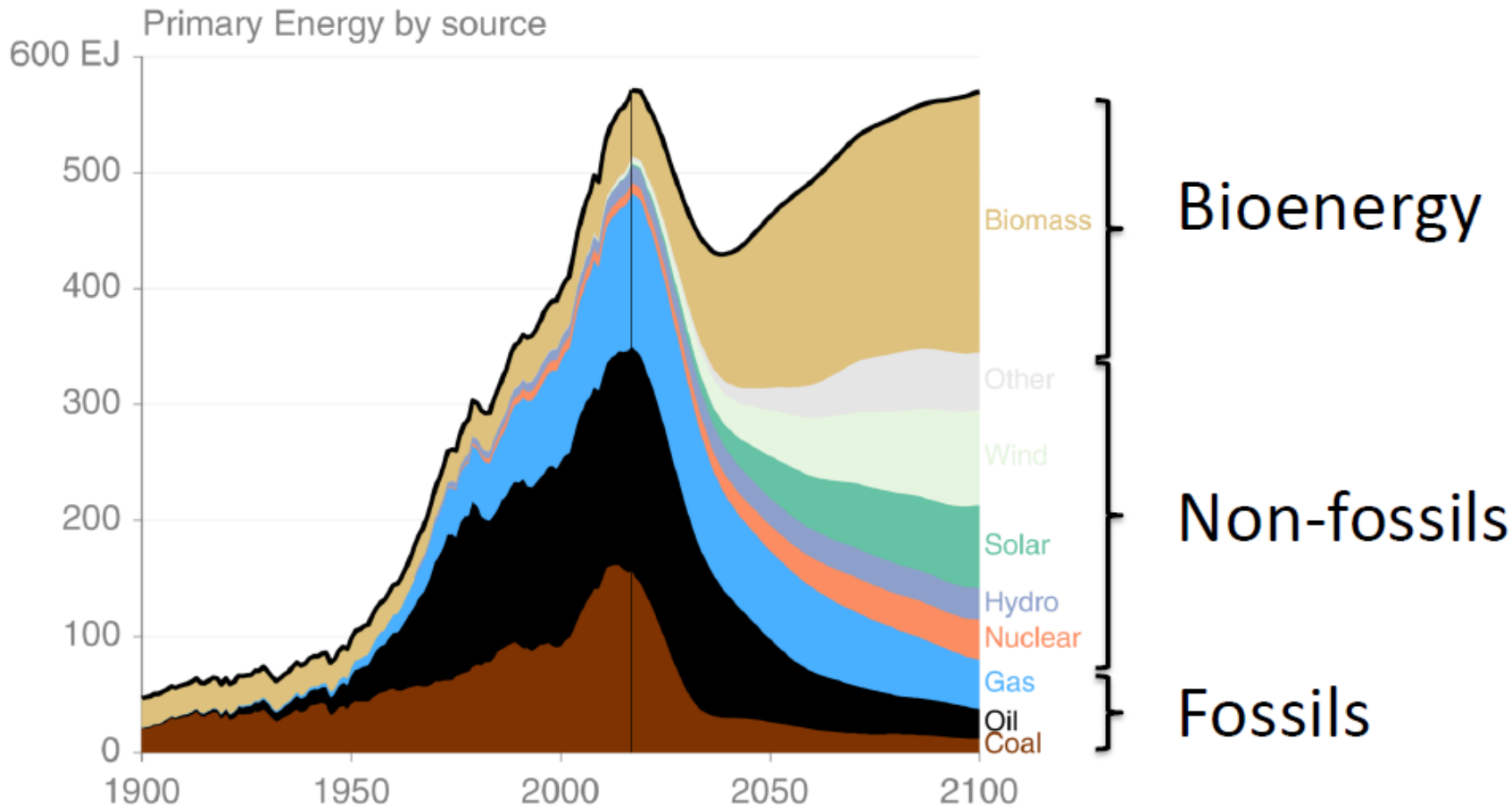
Source: Riahi et al. 2016; Rogelj et al. 2018; IIASA SSP Database; IAMC; Global Carbon Budget 2019

CO_2-utslipp i Norge i 2018



Energy system in a 1.5°C world

What are the “key characteristics” of 1.5°C? These are stylised, but based on average scenario outputs.

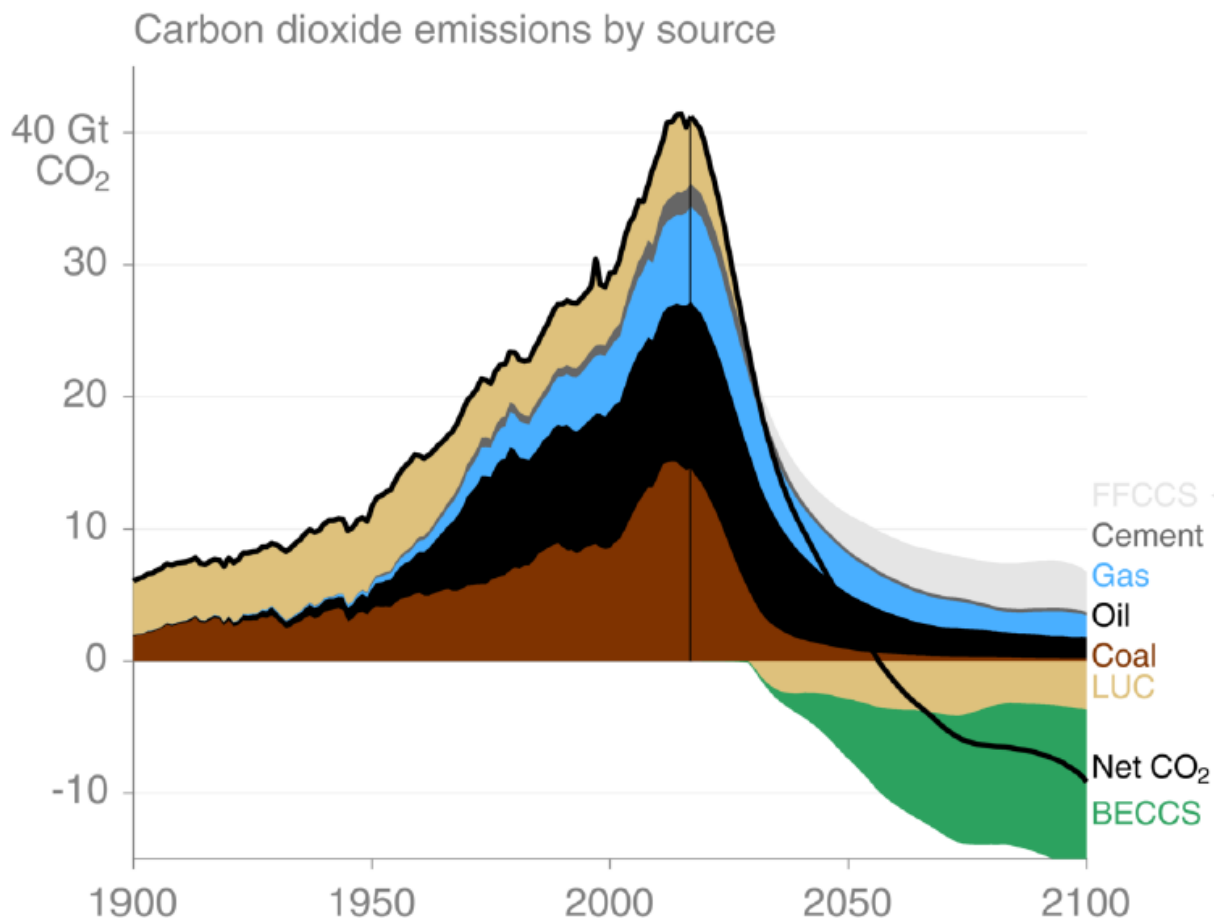


°CICERO

Data: Global Carbon Project (2019); IAMC 1.5°C Scenario Explorer (hosted by IIASA); own calculations

CO_2 Emissions in a 1.5°C world

What are the "key characteristics" of 1.5°C? These are stylised, but based on average scenario outputs.



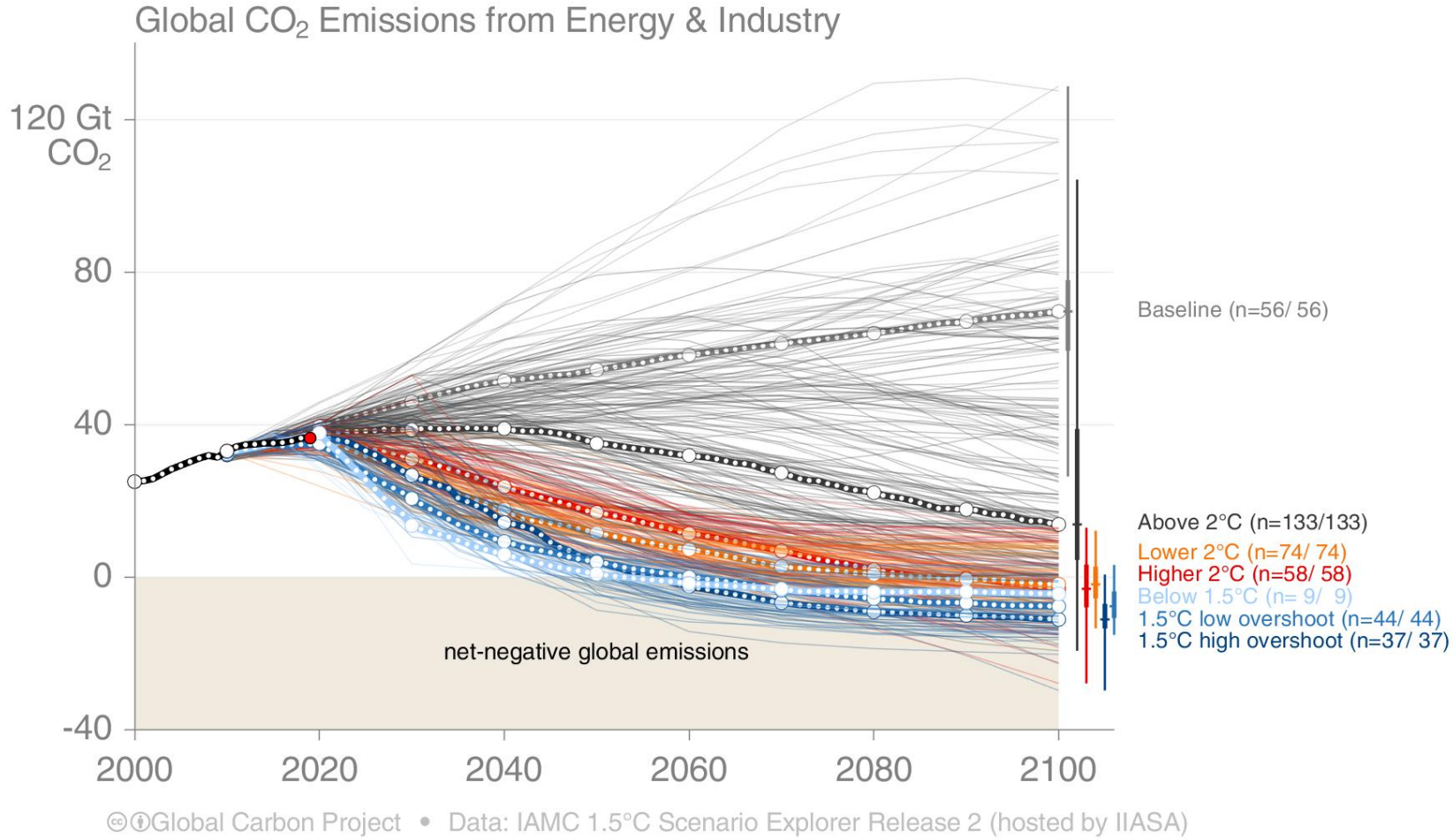
This is not an emission, but to give an idea of the scale of CCS

°CICERO

Data: Global Carbon Project (2019); IAMC 1.5°C Scenario Explorer (hosted by IIASA); own calculations

The IPCC Special Report on "Global Warming of 1.5°C"

The IPCC Special Report on "Global Warming of 1.5°C" presented new scenarios:
1.5°C scenarios generally require halving emissions by ~2030, net-zero by ~2050, and negative thereafter



Net emissions include those from bioenergy with carbon capture and storage (BECCS).
Source: Huppmann et al 2018; IAMC 1.5C Scenario Database; IPCC SR15; Global Carbon Budget 2019

IDEEN OM DET NORSKE FULLSKALA CCS PROSJEKTET

HVA FORSKER VI PÅ?

FME NCCS

Norwegian CCS Research Centre

NGI

SINTEF

TNO

BGS 1835

Industry
Product development and the application of research results

The universities
Strategic research and education

Research institutes
Multidisciplinary strategic research

NTNU

UiO : University of Oslo

RUHR UNIVERSITÄT BOCHUM

RUB

University of Zurich[UZH]

NOOS

Accelerating CCS deployment

NCCS

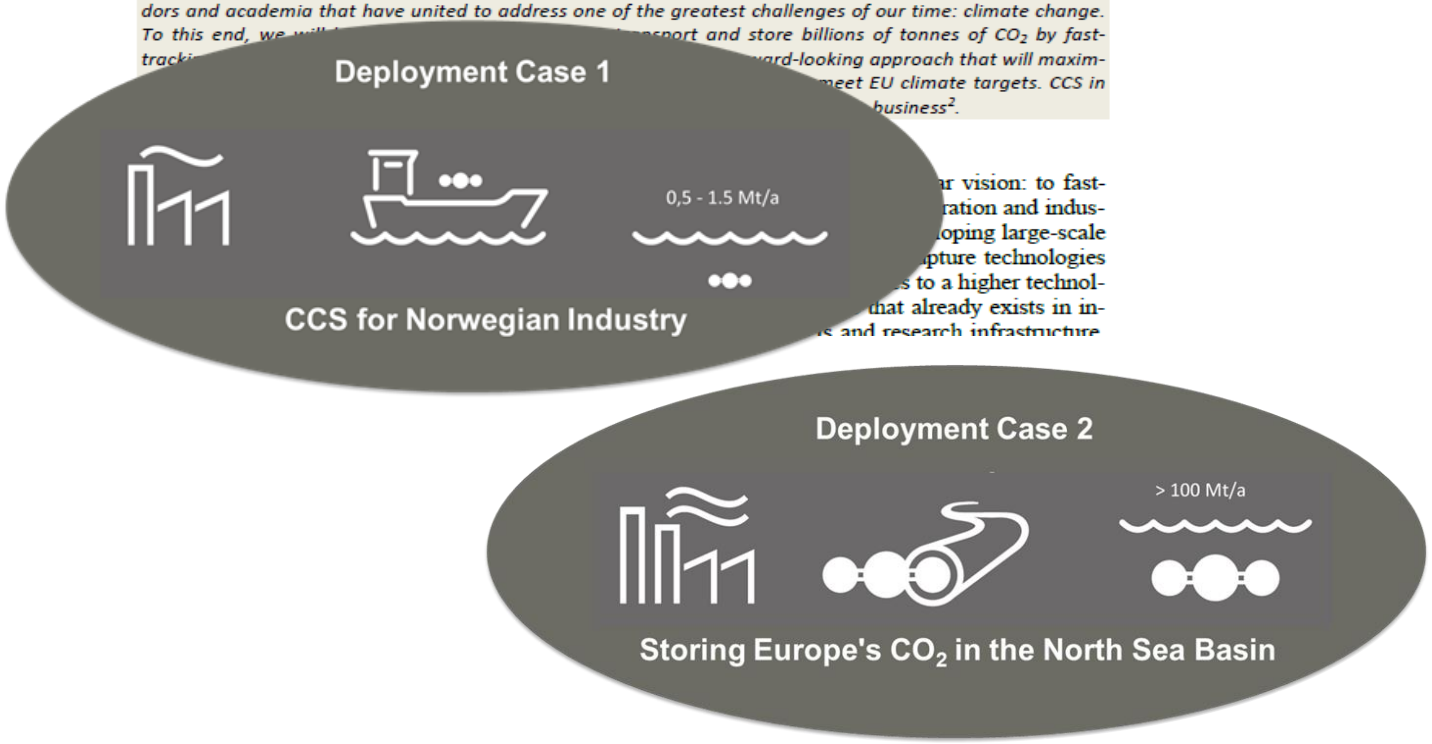
Norwegian CCS Research Centre – Industry-driven innovation for fast-track CCS deployment

Centre Director: *Dr Mona J. Mølnvik, SINTEF Energy Research (SINTEF ER)*

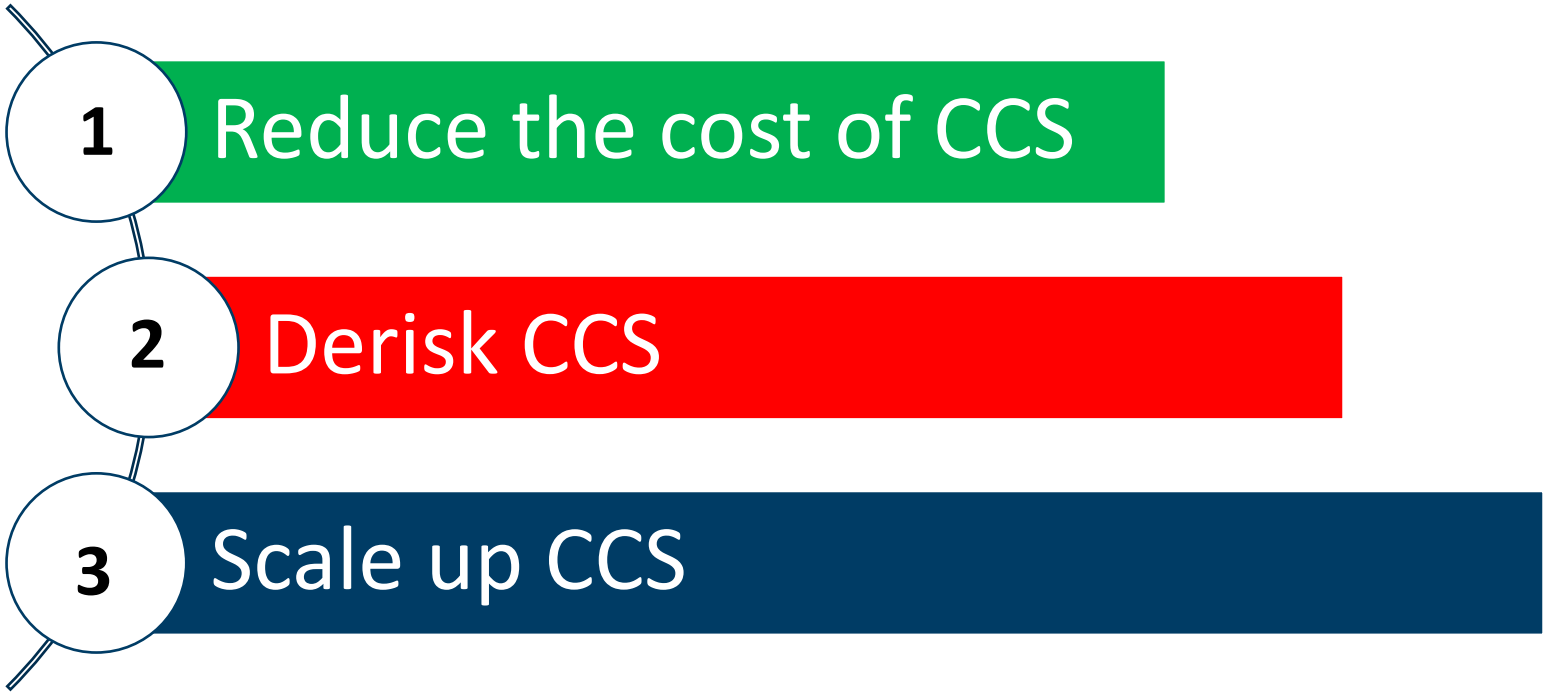
Call: *Centres for Environment-Friendly Energy Research (FME[1]), 2015-11-25*

NCCS is a world-class national and international multi-disciplinary CCS partnership between operators, vendors and academia that have united to address one of the greatest challenges of our time: climate change. To this end, we will [illegible] transport and store billions of tonnes of CO_2 by fast-track[illegible]ward-looking approach that will maximmeet EU climate targets. CCS in business[2].

r vision: to fast-ration and industoping large-scale pture technologies s to a higher technolthat already exists in in-s and research infrastructure



Overcoming barriers to CCS deployment



users

GASSCO

TOTAL

equinor

vår energi

Lundin Norway

research institutes

NGI

TNO

BGS 1835

NIST National Institute of Standards and Technology

SINTEF

Lawrence Livermore National Laboratory

university

NTNU

UiO : University of Oslo

RUHR UNIVERSITÄT BOCHUM

RUB

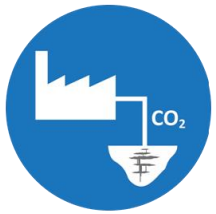
UNIS

MIT

TUM

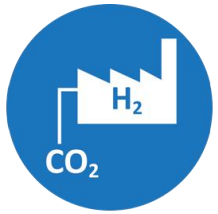
University of Zurich[UZH]

NCCS

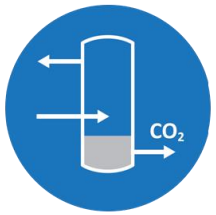


CO_2 value chain and legal aspects

Solvent technology – environmental issues

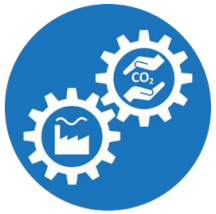


Low emission H_2 production



Conditioning through liquefaction

Gas turbines



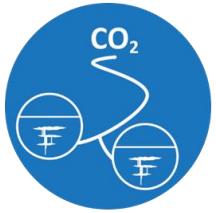
CO_2 capture process integration

CO_2 transport

Fiscal metering and thermodynamics

Structural derisking

CO_2 storage site containment



Reservoir management and EOR

Cost-efficient CO_2 monitoring technology

vendors

KROHNE

AkerSolutions

ANSALDO ENERGIA

emgs

CoorsTek

NORCEM HEIDELBERGCEMENT Group

LarvikShipping

OSLO KOMMUNE

QUAD GEOMETRICS

associated partners

ecosel

Norges Rederiforbund
Norwegian Shipowners' Association

Norsk olje&gass

U.S. DEPARTMENT OF ENERGY

UKCCS RESEARCH CENTRE

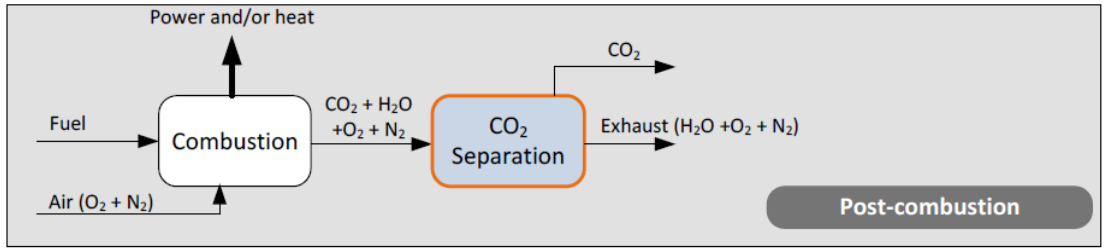
CEMCAP

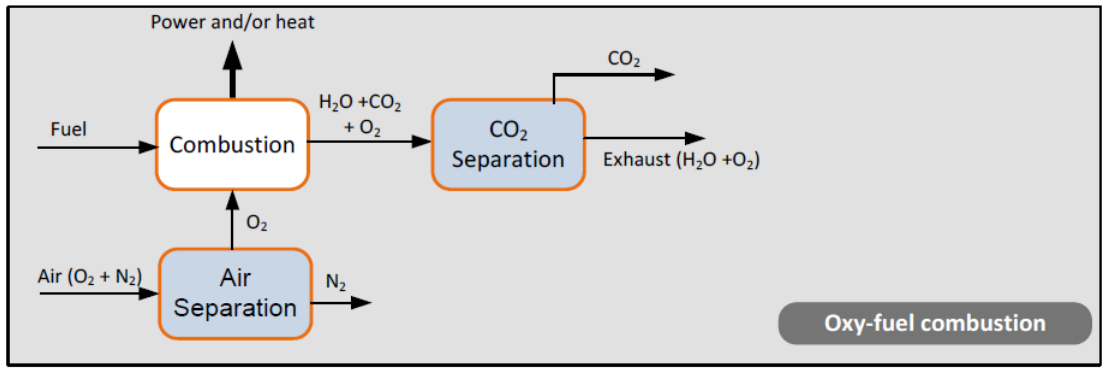
CO_2 CAPTURE FROM CEMENT PRODUCTION

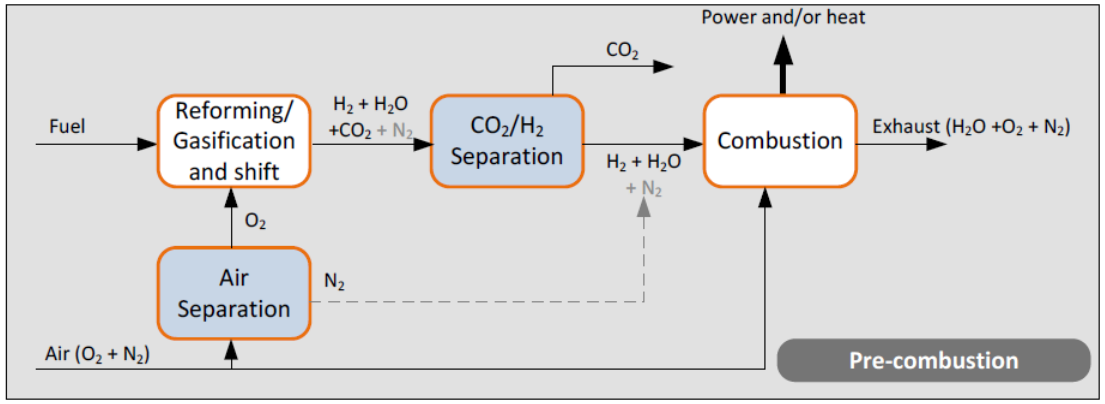
Kristin Jordal, SINTEF Energi

KL 2020-01-06

CO_2 capture – three technology groups







- Post-combustion capture: End-of-pipe capture, capture from exhaust gas
  - *Realtively* simple process modifications
  - Low CO_2 concentration -> high energy consumption for CO_2 separation
- Oxy-fuel combustion capture: Oxygen is separated from air before combustion
  - Recirculated CO_2 required for combustion temperature control
  - O_2 separation requires energy
- Pre-combustion capture: Fuel is converted to syngas, CO_2 is removed prior to combustion
  - O_2 and CO_2 separation require energy
  - Requires a low-NOx H_2 gas turbine

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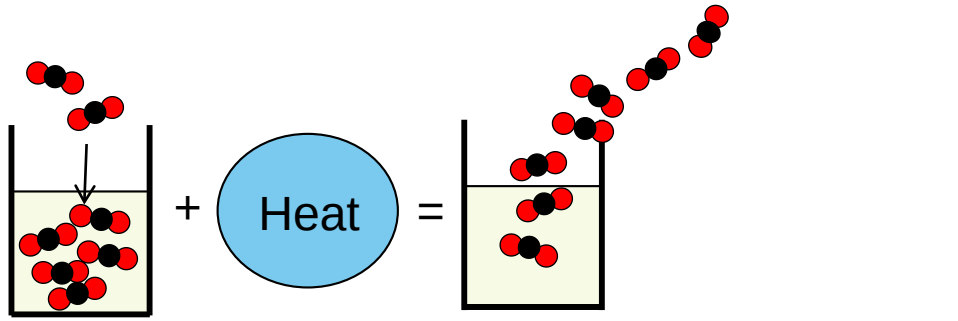
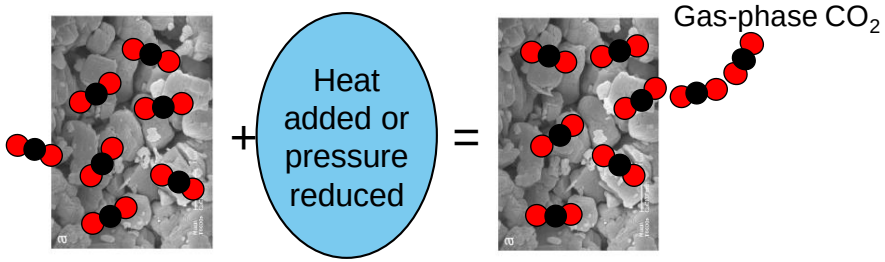
Four CO_2 separation principles

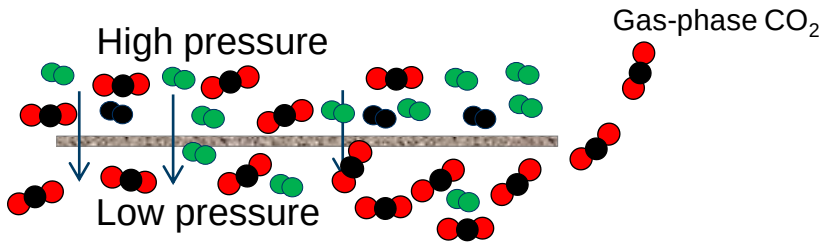
Liquid absorption/desorption



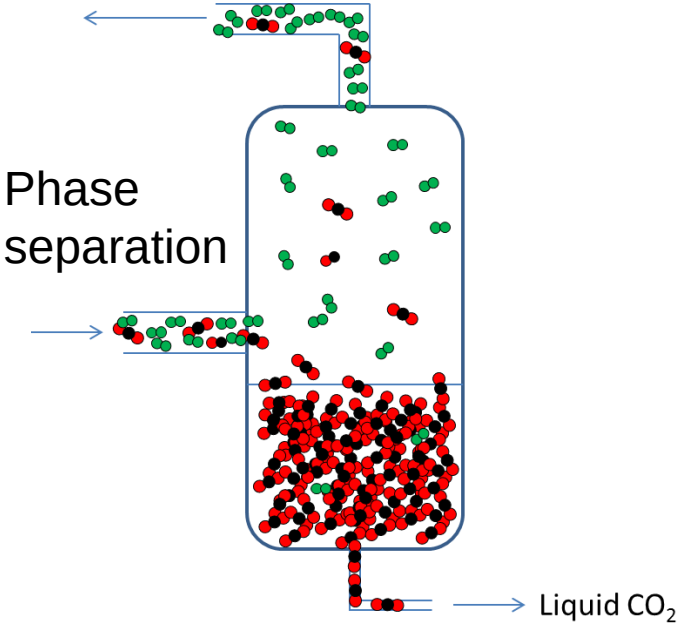
Solid adsorption/desorption



Membranes



Phase separation



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CO_2-transport

Mål

- Bedre lønnsomhet
- Riktig dimensjonering
- Bedre simuleringsmodeller
- Data validerer modellene

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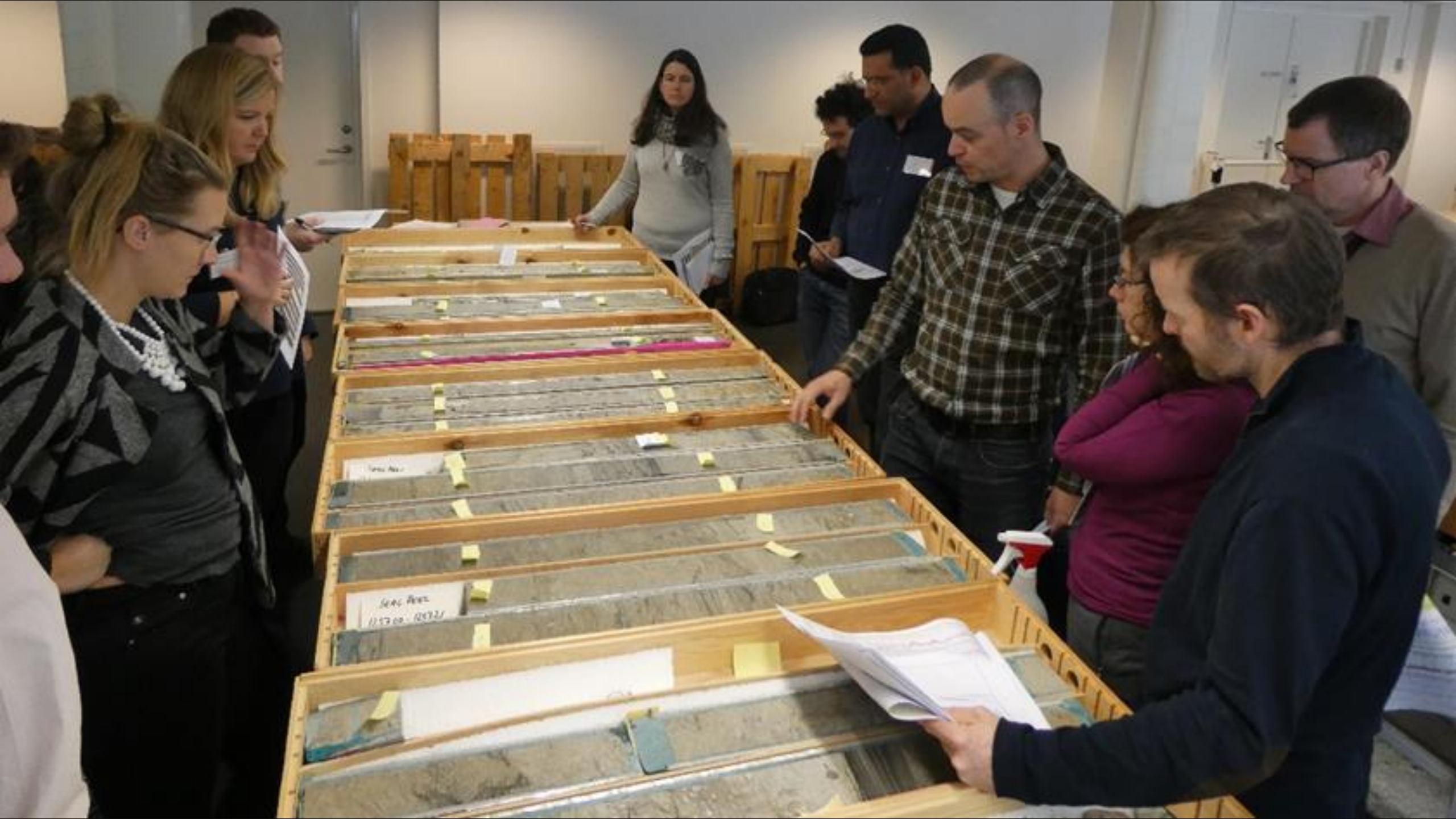
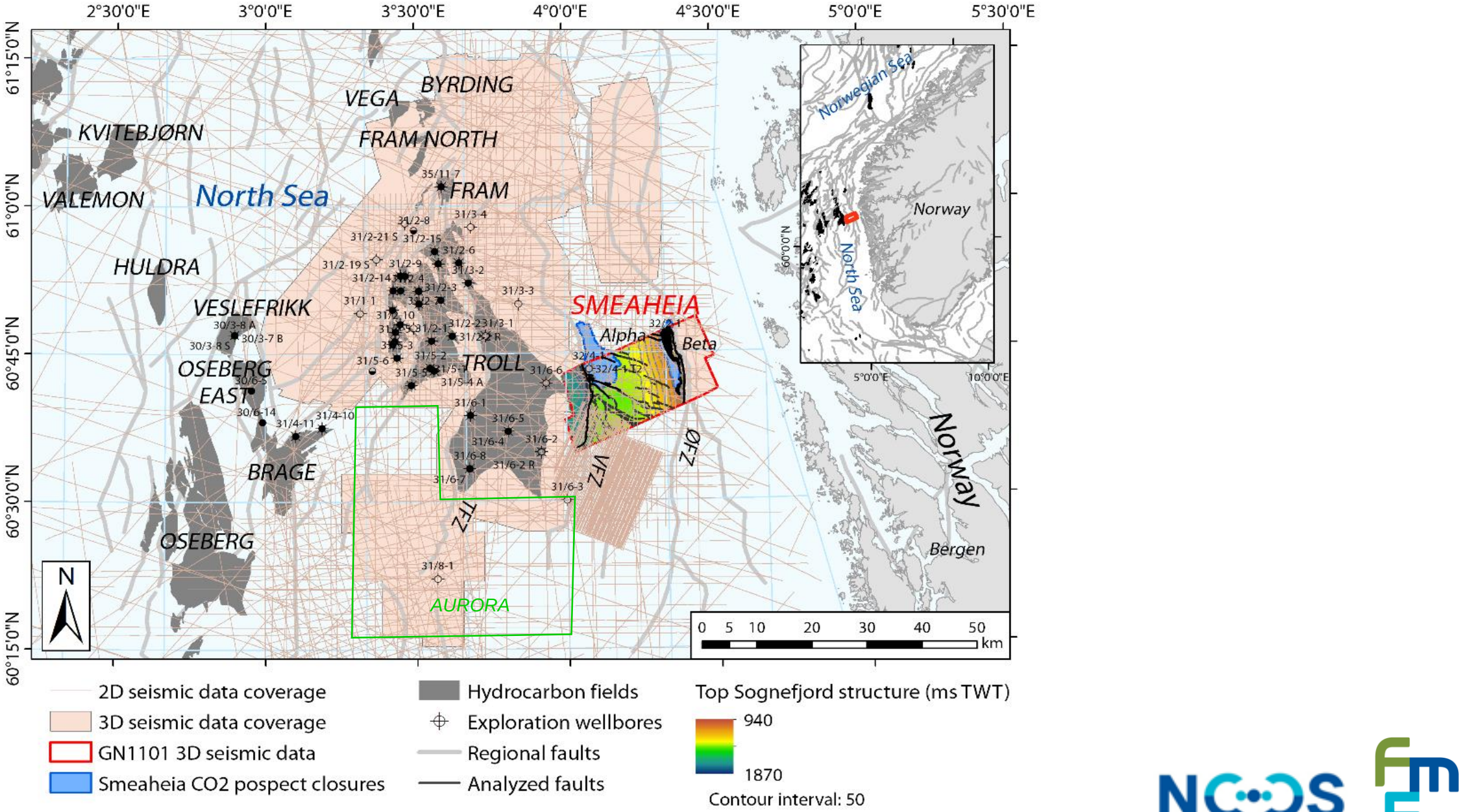
NCOS

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KVITEBJØRN
VALEMON
North Sea
HULDRA
VESLEFRIKK
OSEBERG
EAST
BRAGE
OSEBERG
VEGA
BYRDING
FRAM NORTH
FRAM
TROLL
SMEAHEIA
Alpha
Beta
AURORA
TFZ
VFZ
ØFZ
Norwegian Sea
Norway
North Sea
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Bergen
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km
2D seismic data coverage
3D seismic data coverage
GN1101 3D seismic data
Smeaheia CO2 pospect closures
Hydrocarbon fields
Exploration wellbores
Regional faults
Analyzed faults
Top Sognefjord structure (ms TWT)
940
1870
Contour interval: 50

In the public media


NCCS
NORWEGIAN CCS RESEARCH CENTRE
Industry-driven innovation for fast-track CCS deployment

HVORFOR ER JEG OPTIMIST?

I kategorien over 100 milliarder finner vi:

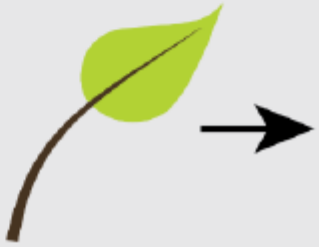
- Prosessindustri
- Karbonfangst og lagring
- Hydrogen
- Havvind
- Elektrifisering av transport
- Digitalisert leverandør- og forbruksvareindustri

I kategorien 10-100 milliarder:

- Mineraler og gruvedrift
- Batteriproduksjon
- Fornybar energi
- Solceller
- Elektriske overføringsnett

I tillegg kommer spennende ideer som ikke så lett lar seg verdifeste som:

- Bioenergi og biokull
- Utslippsfri utvinning av olje og gass



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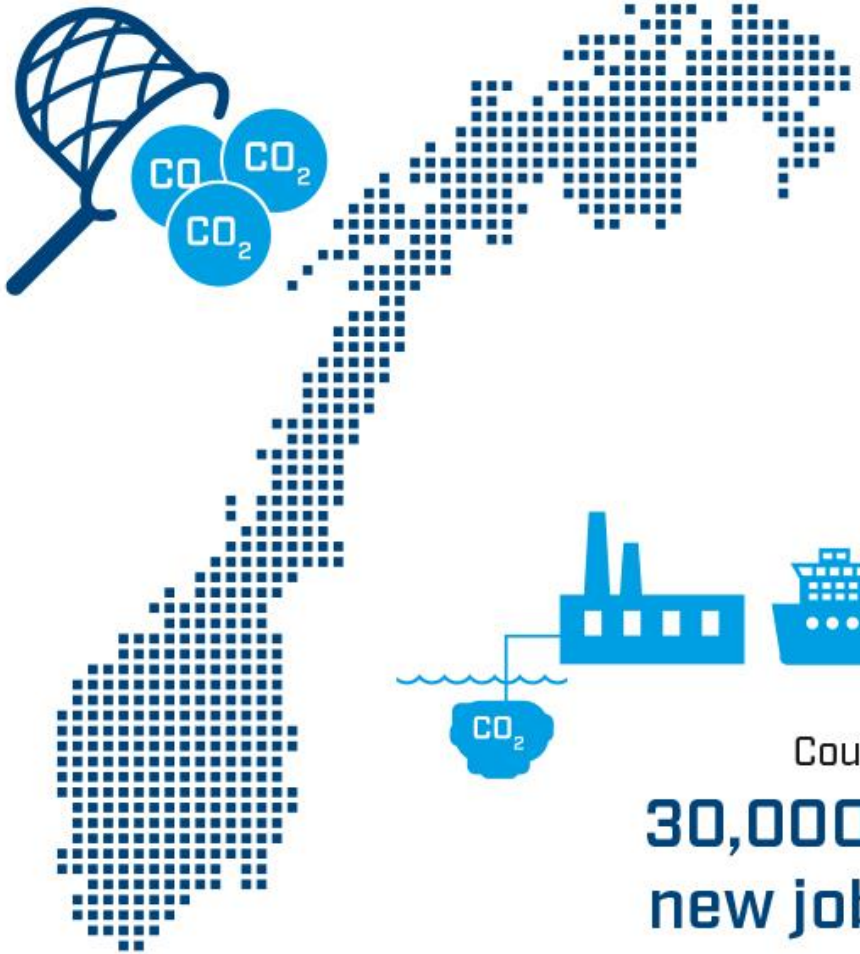
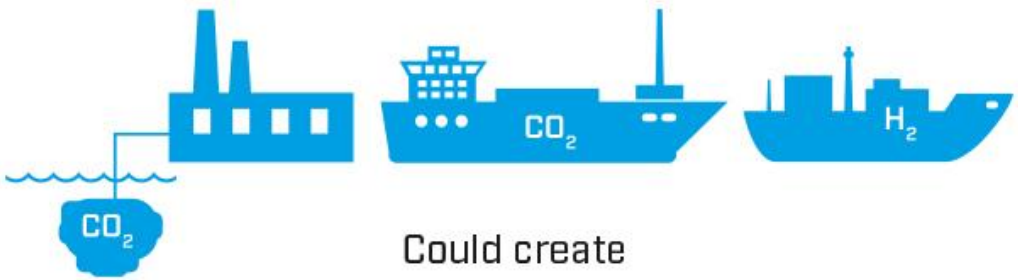


Carbon capture and storage investment in Norway

could strengthen the competitiveness of

80,000 – 90,000 jobs



Could create

30,000 – 40,000 new jobs in 2050

- 6,000 – 20,000 CCS-related jobs
- 25,000 – 35,000 jobs in natural gas hydrogen production, half of which would be new jobs

With **ripple effects**, could strengthen

160,000 – 200,000 jobs

and contribute to creating up to

70,000 new jobs

in 2050

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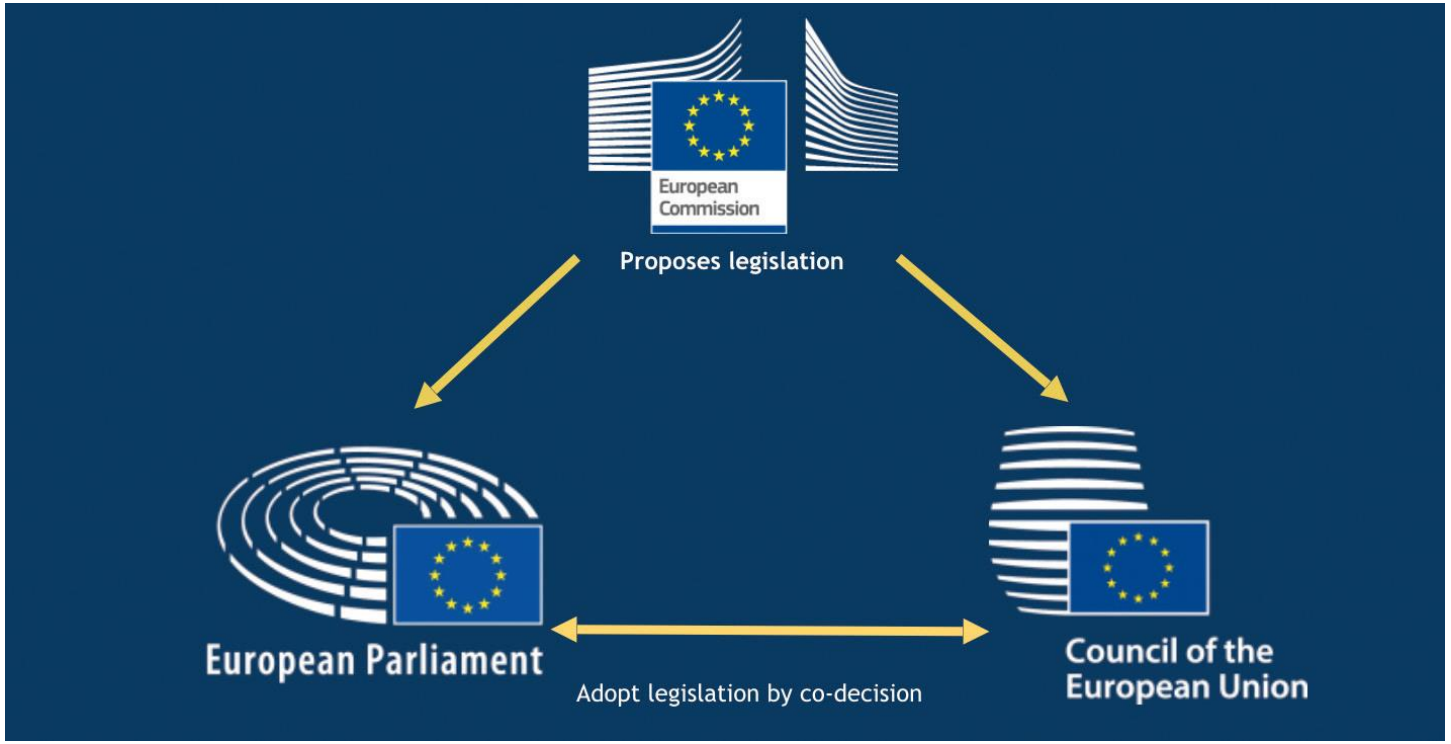
From the SINTEF report:
Industrielle muligheter og arbeidsplasser ved CO_2-håndtering i Norge

New leadership EU

Ursula von der Leyen (DE)
President elect - Commission



David Sassoli (IT)
President of the European Parliament

Charles Michel (BE)
President – European Council

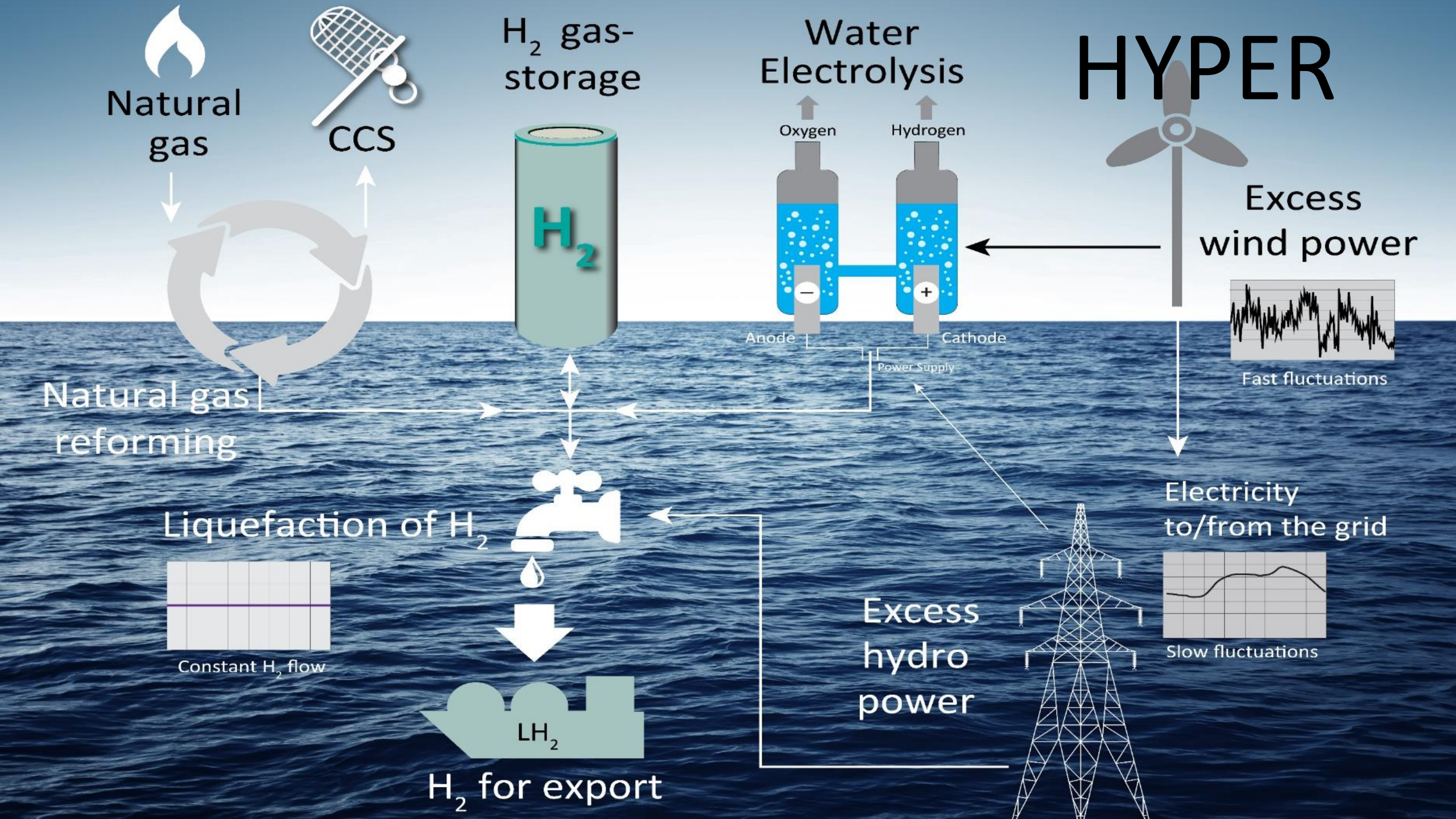
SINTEF

Ursula von der Leyen's Green Deal

"Protecting our planet and our shared environment is our generation's defining task," said von der Leyen, adding that the new EU commission's commitment is to become "the world's first climate-neutral continent".

https://euobserver.com/environment/145902

40 → 50-55% CO_2 emission cuts "just transision fund" "carbon border tax "


HYPER
Natural gas
CCS
H_2 gas-storage
Water Electrolysis
Oxygen
Hydrogen
Anode
Cathode
Power Supply
Excess wind power
Fast fluctuations
Natural gas reforming
Liquefaction of H_2
Constant H_2 flow
LH_2
H_2 for export
Excess hydro power
Electricity to/from the grid
Slow fluctuations

Teknologi for et bedre samfunn