



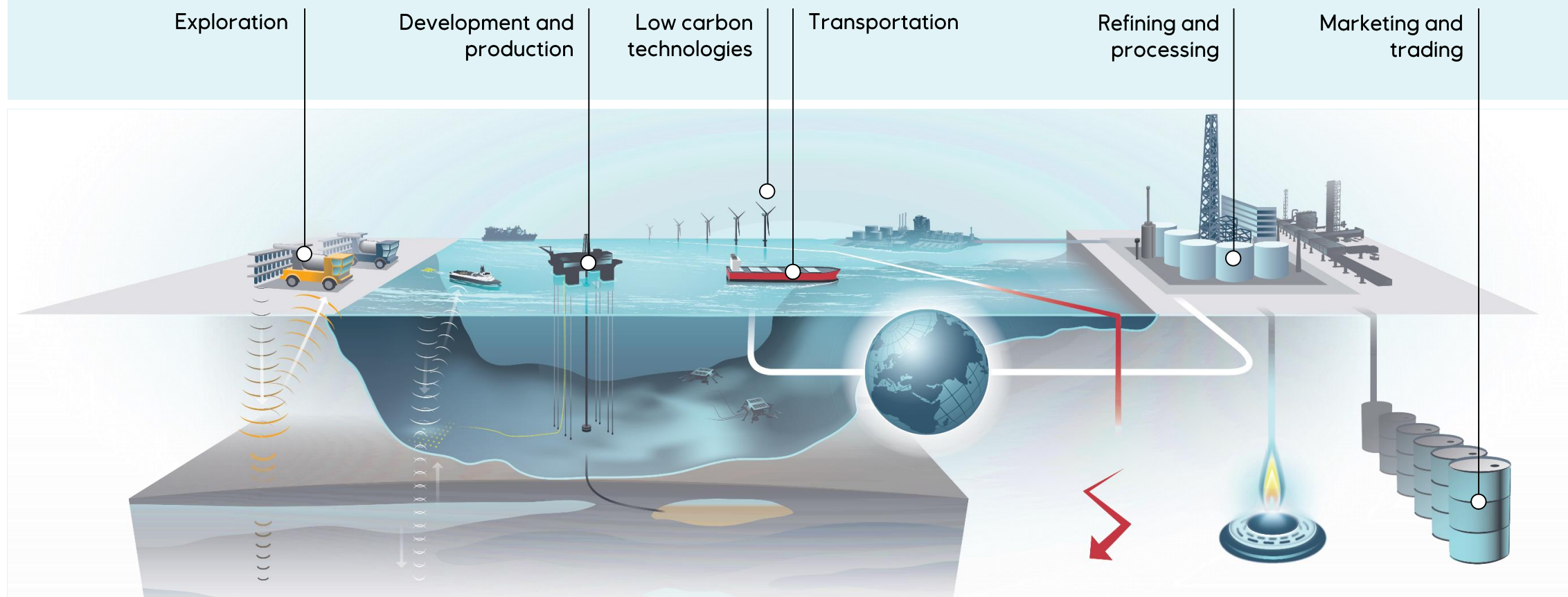
equinor

Shaping the future of energy

Lagring och affärsmöjligheter med CCS
Gasdagarna, Båstad, Sverige, 16 maj 2019

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Our value chain



Key figures



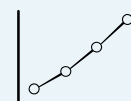
2.08 million

Barrels of oil equivalent per day in 2017



19 billion

Barrels of oil equivalent in resources



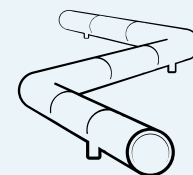
12.6 bn USD

Adjusted earnings as of Q4 2017



more than **35%**

of oil and gas equity production took place outside Norway in 2017



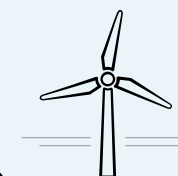
2nd

Second biggest gas supplier to Europe

Growing offshore wind business supplying more than

650 000

UK homes

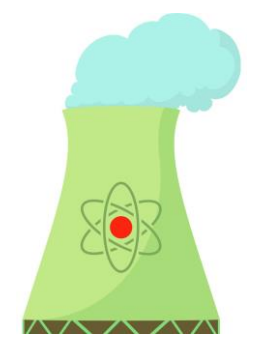
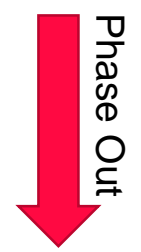


Demand for Clean and Flexible Power Expected to go up

Baseload



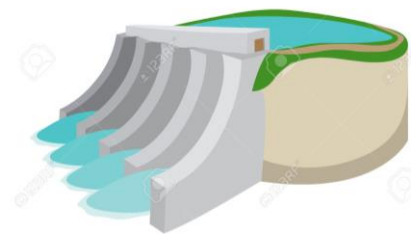
Coal



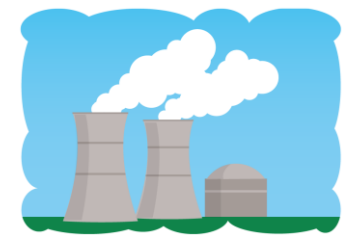
Nuclear



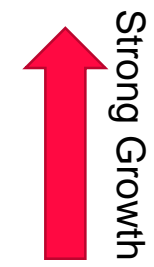
Flexible



Hydro



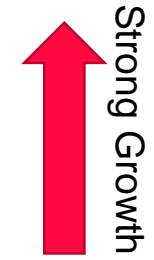
Gas -> Clean Hydrogen



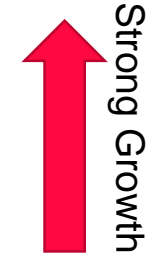
Intermittent



Wind



Solar

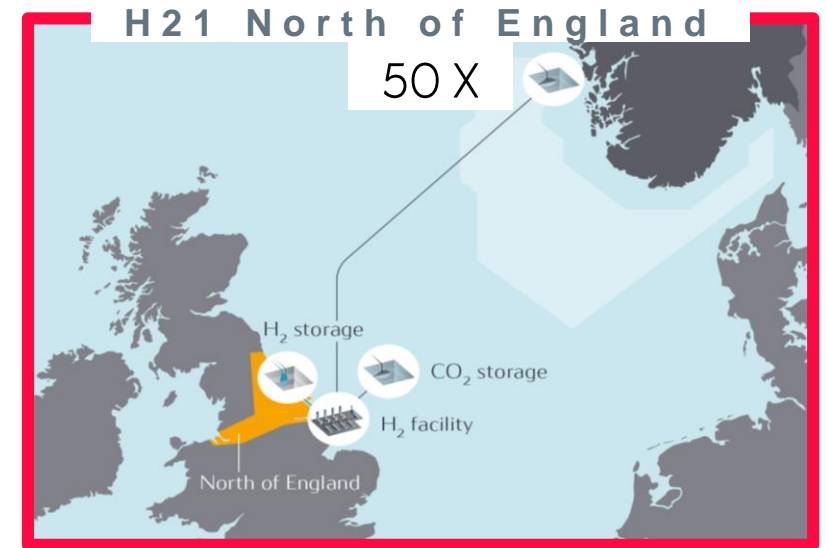


**Balance
Supply
&
Demand**

Understanding the Challenge

Natural Gas currently provides Europe with more than 1500 TWh of flexible energy.

What is 1500 TWh?



Vehicle

20 000 000 000 X



Battery park

11 600 000 X



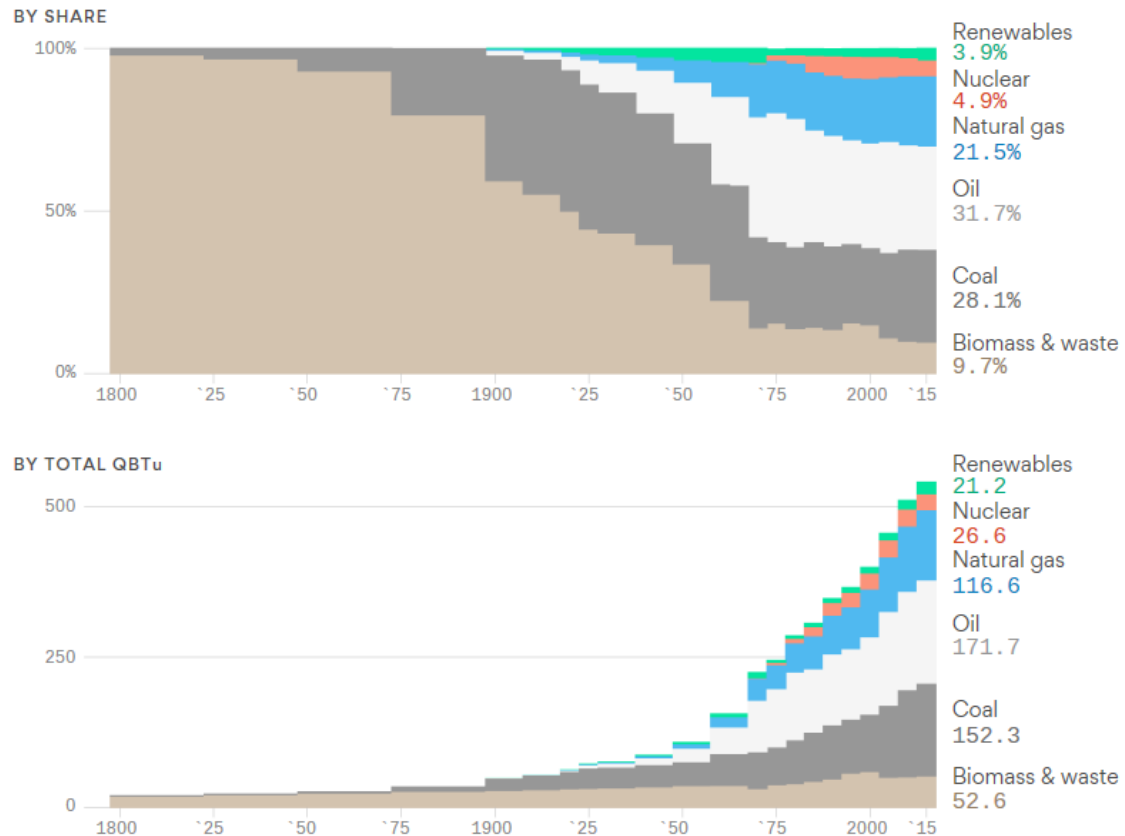
Hydro

200 X



Despite new technology, there has never been an energy transition in the past...

Global energy sources, 1800–2015



Note: 1800–1900 data shown at 25-year intervals, 1900–1920 & 1930–1970 data shown at 10-year intervals, and 1920–1930 & 1970–2015 data shown at 5-year intervals. Data: Arnulf Grubler (2008), International Energy Agency (2017). Reproduced from charts by Richard Newell and Daniel Raimi. Chart: Axios Visuals

- Shifts in primary energy supply has taken decades in the past
- ...but GROWTH in energy demand more than outweigh shift between supply sources
- To meet the 1.5 degree target, all energy use has to be carbon neutral by 2050!
- This cannot be solved by phasing in renewables only - it is currently a small fraction
- We need to use the entire toolbox to have the slightest chance of succeeding

Decarbonising Energy Systems



Easy ← complexity to decarbonise → Hard

Transport

Battery (mostly) plus Hydrogen for Heavy Duty

Hydrogen Fuel-Cell Trains

Liquid Hydrogen and Fuel-Cells for long haul Big Ships

Power

Large Battery Systems for Daily Swing (night-to-day)

Hydro-Power as Battery for Small Scale Intermittency

Hydrogen fired CCGTs Clean Back-Up Power for Large Scale Intermittency

Industry

Light Industry powered by Renewable

Heavy Industry powered by Hydrogen from Natural Gas + CCS

CCS for Industry without other Alternatives

Heat

Heat Pumps For Efficient Use of Electricity in Homes

Hydrogen for Efficient Transfer of Energy from Production to End-Users

Hydrogen for Large Scale Seasonal Storage

Natural Gas Reforming to Hydrogen with CCS

Combustion zone
 $CH_4 + 1.5 O_2 \rightarrow CO + 2H_2O$

Thermal and catalytic zones
 $CH_4 + H_2O \rightarrow CO + 3H_2$
 $CO + H_2O \rightarrow CO_2 + H_2$

Multiple technologies to address the challenge

Equinor- New Energy Solution business unit is a key vehicle



Build a profitable renewable business



Develop new low-carbon business opportunities for Equinor's core products

Enable CO₂ storage as an effective climate tool for a low carbon future

Northern Lights project: Developing an 'open source' service for transport and storage of European CO₂



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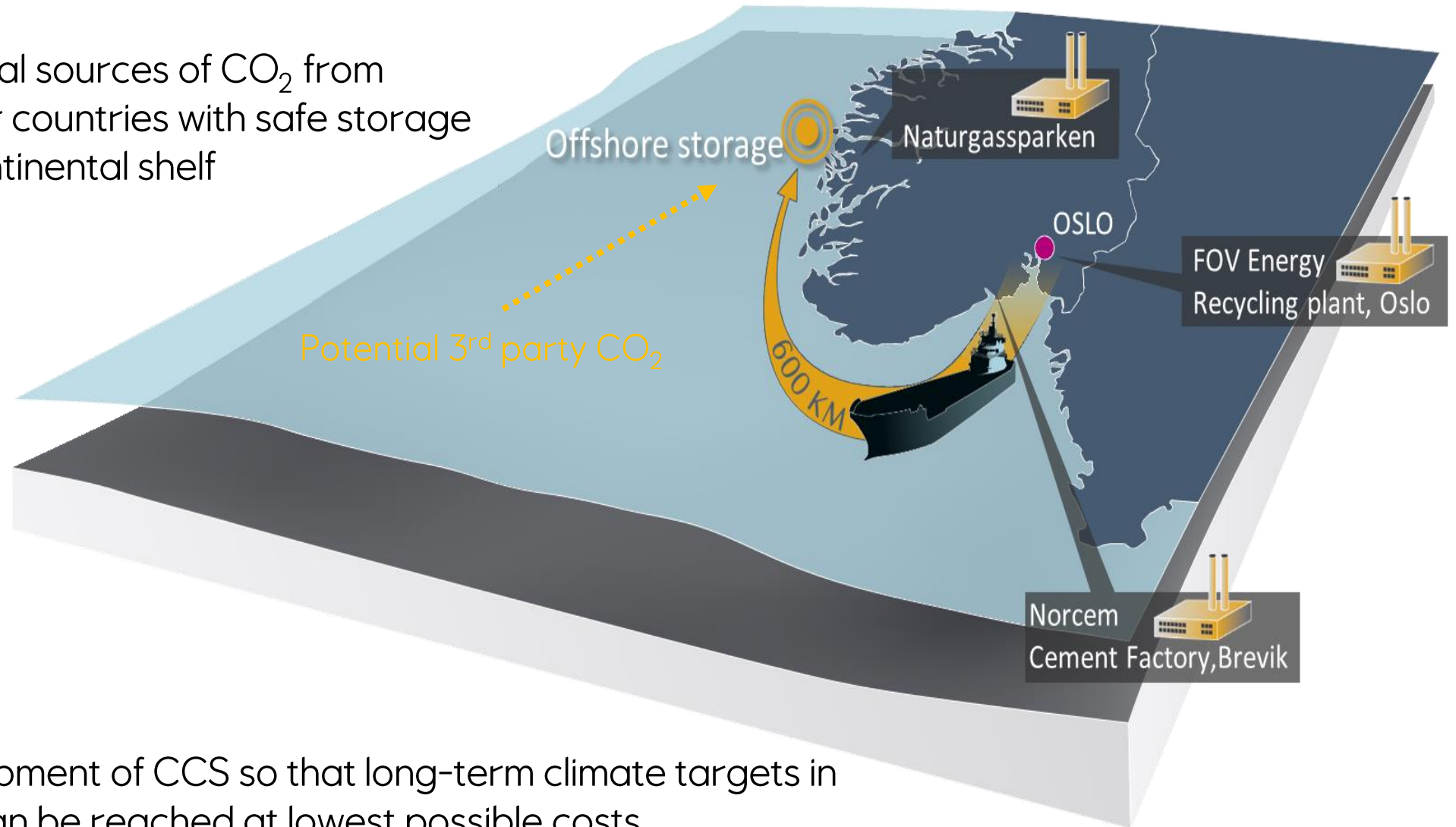


TOTAL

From words to action

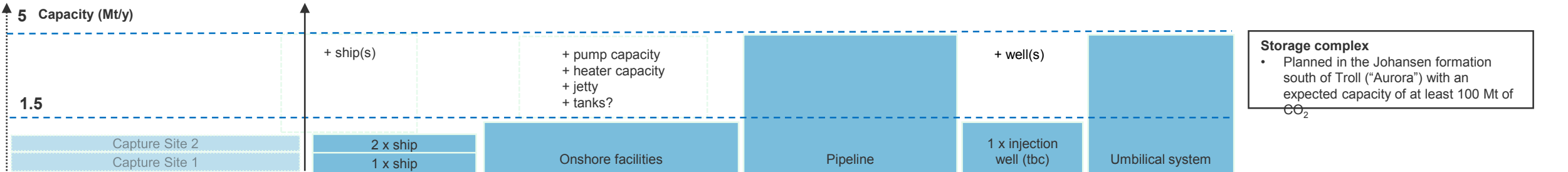
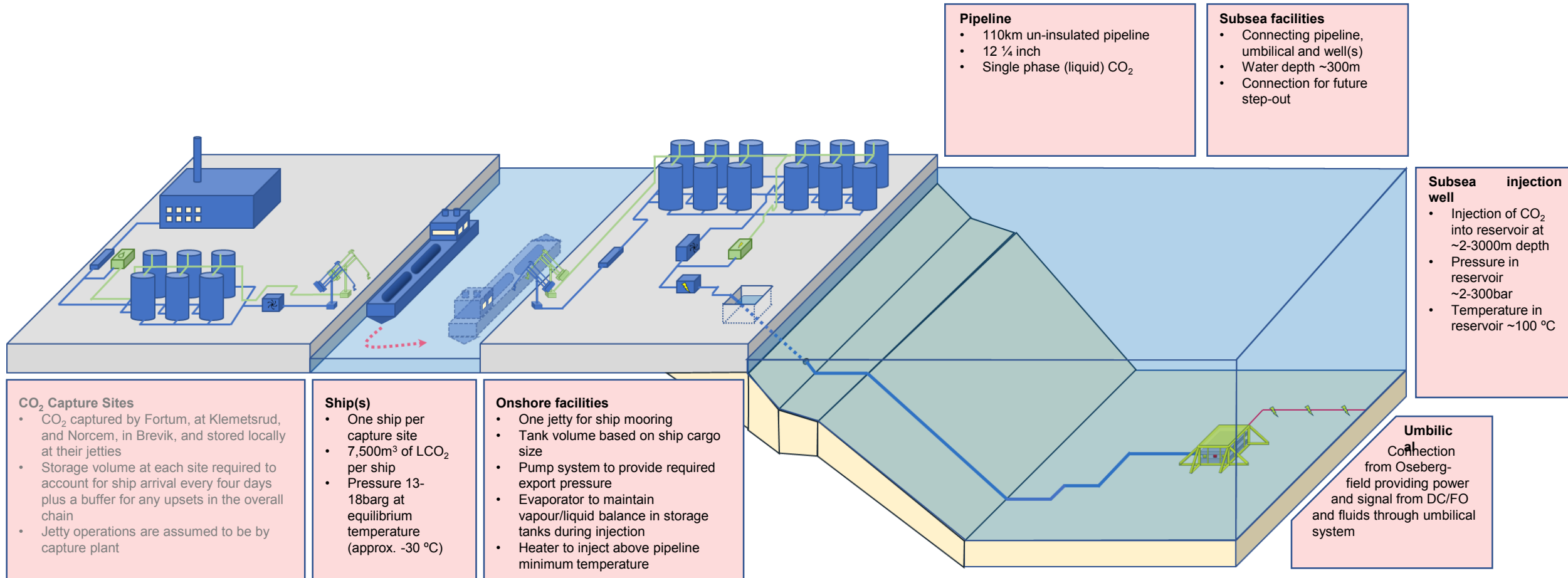
Norway full-scale CCS project

- Combines industrial sources of CO₂ from Norway and other countries with safe storage on Norwegian continental shelf



- Stimulates development of CCS so that long-term climate targets in Norway and EU can be reached at lowest possible costs

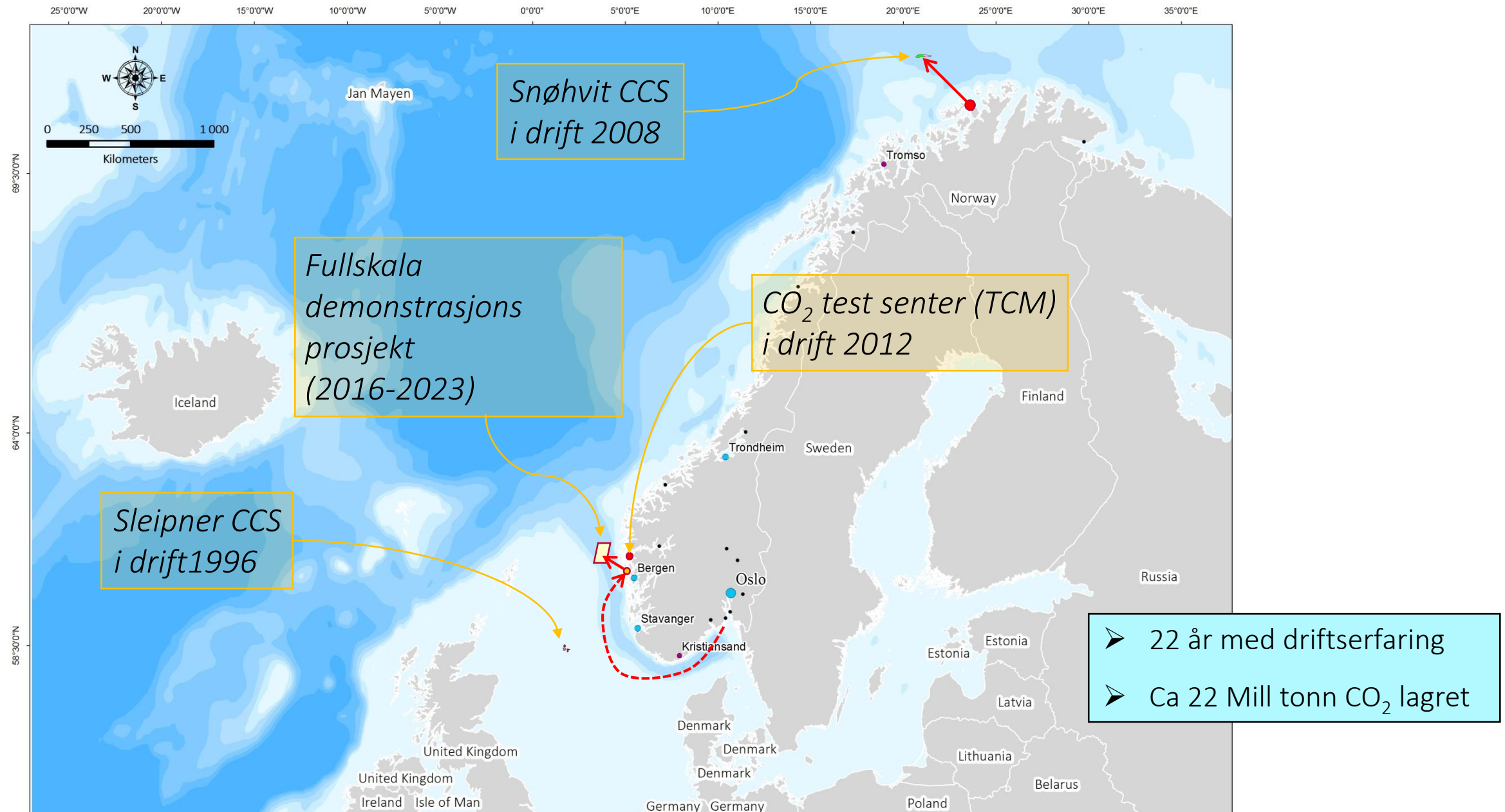
Concept overview



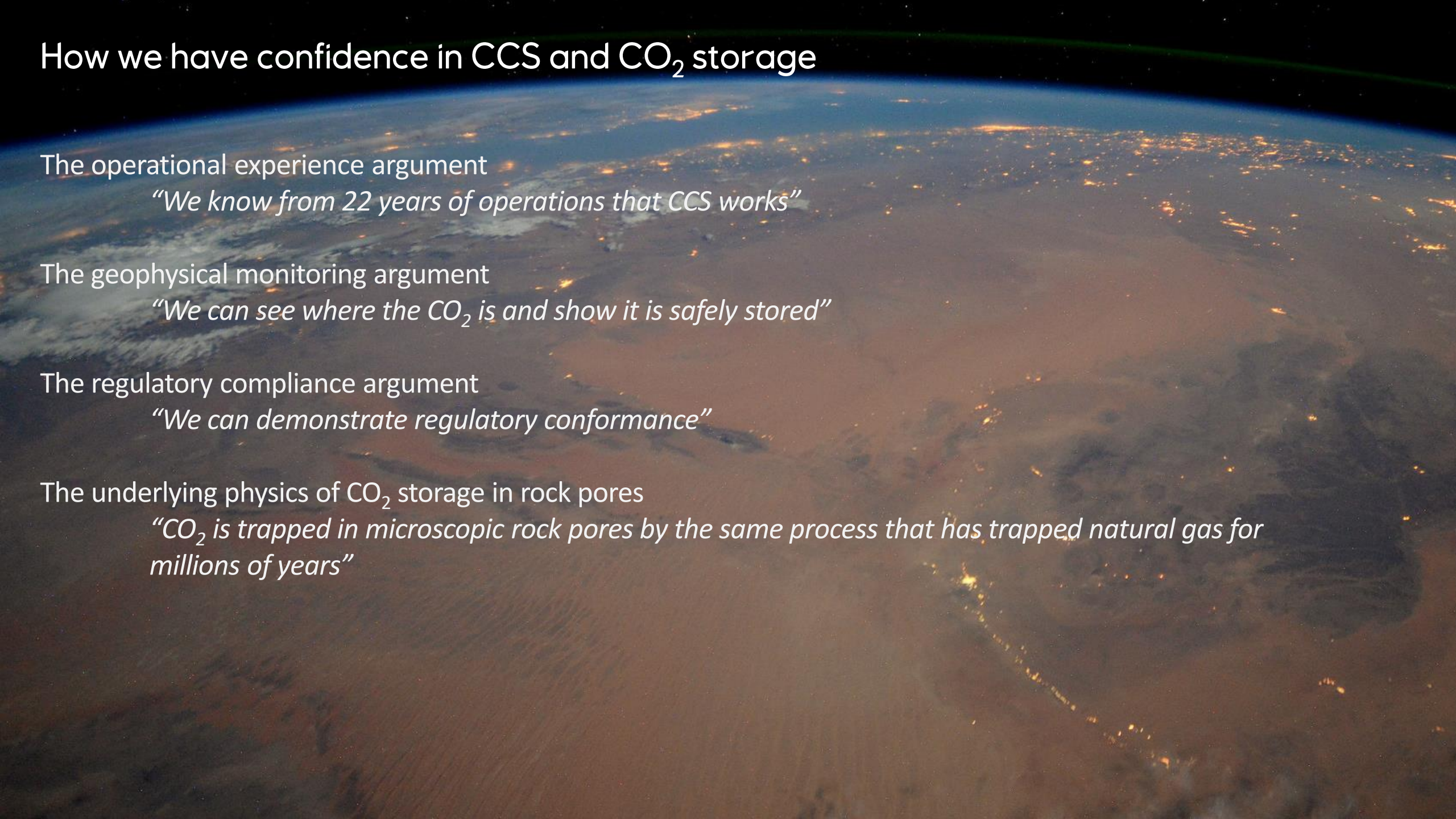
Visualisation of intermediate storage facility



CCS in Norway – 22 years of succesful industrial experience



How we have confidence in CCS and CO₂ storage



The operational experience argument

"We know from 22 years of operations that CCS works"

The geophysical monitoring argument

"We can see where the CO₂ is and show it is safely stored"

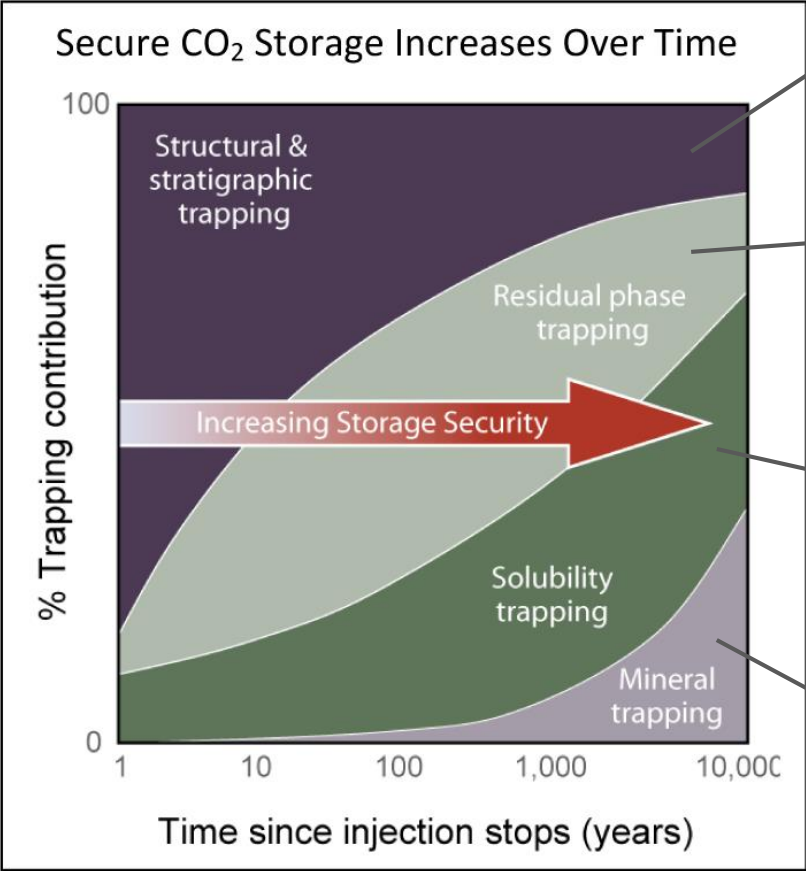
The regulatory compliance argument

"We can demonstrate regulatory conformance"

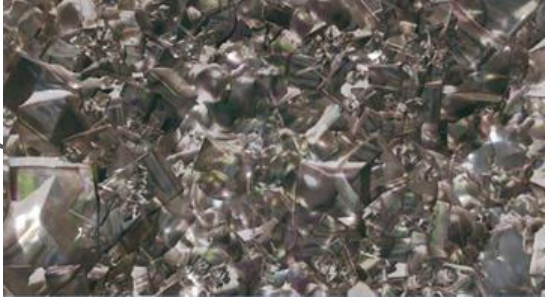
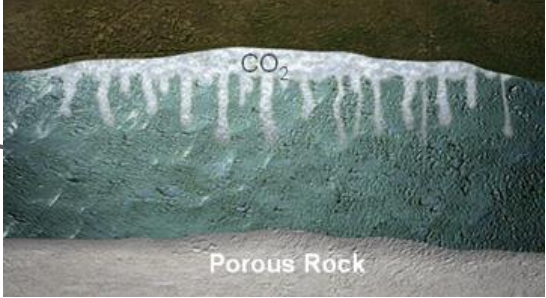
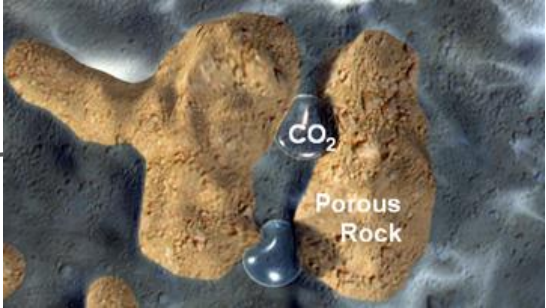
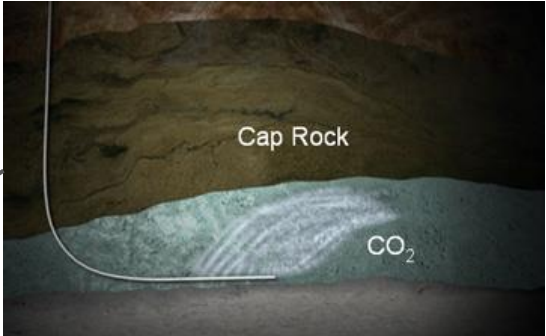
The underlying physics of CO₂ storage in rock pores

"CO₂ is trapped in microscopic rock pores by the same process that has trapped natural gas for millions of years"

Storage mechanisms – increasing safety over time



After IPCC (2005): Carbon Dioxide Capture and Storage



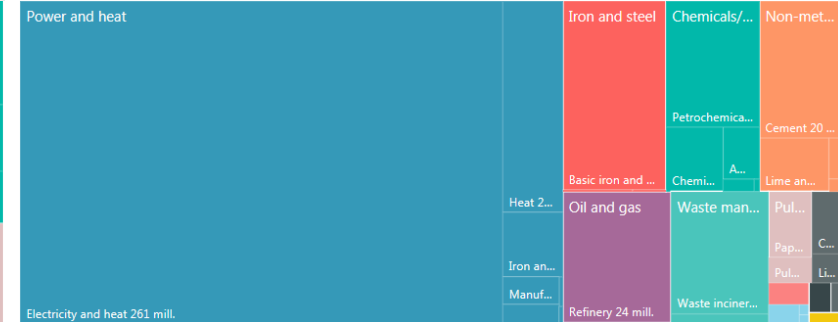
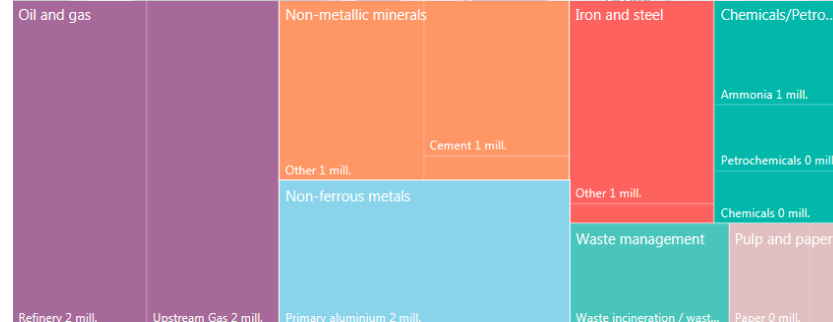
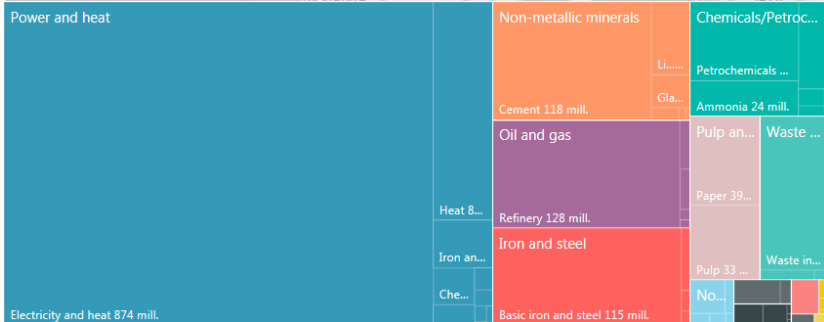
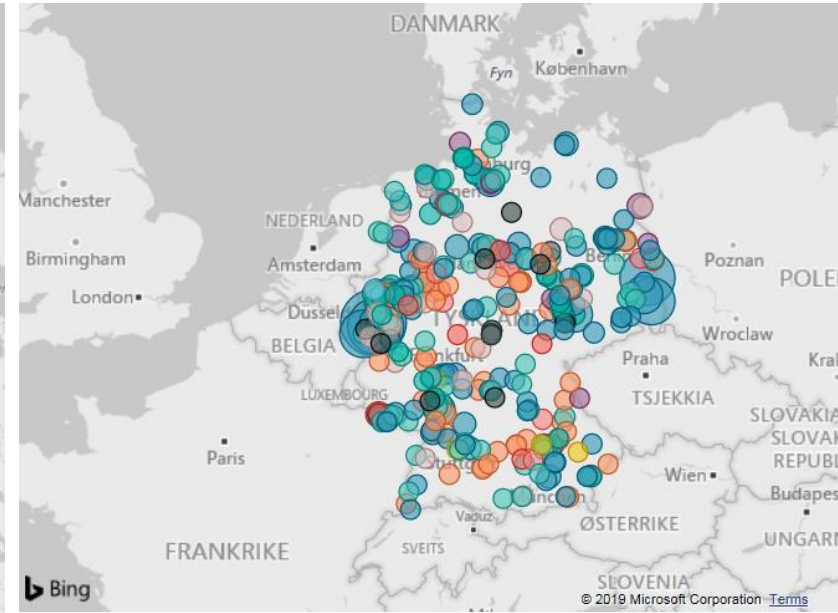
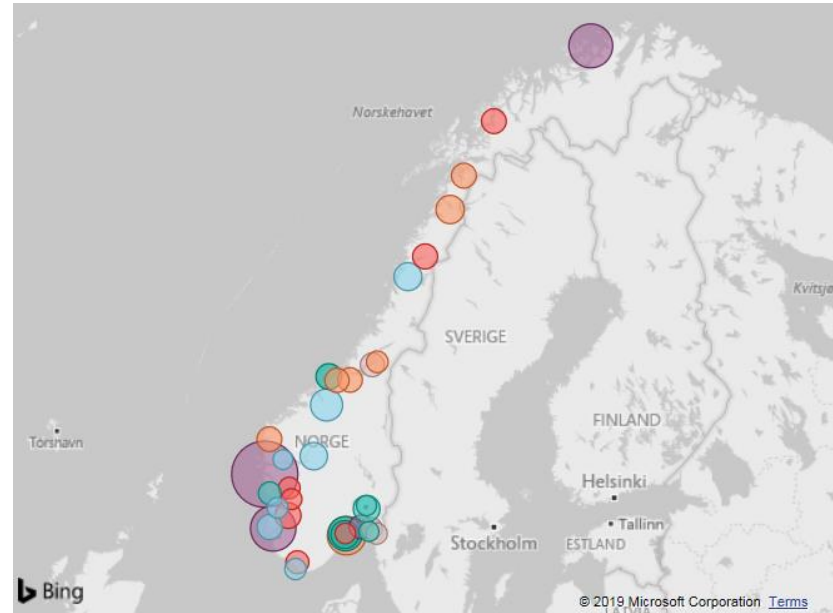
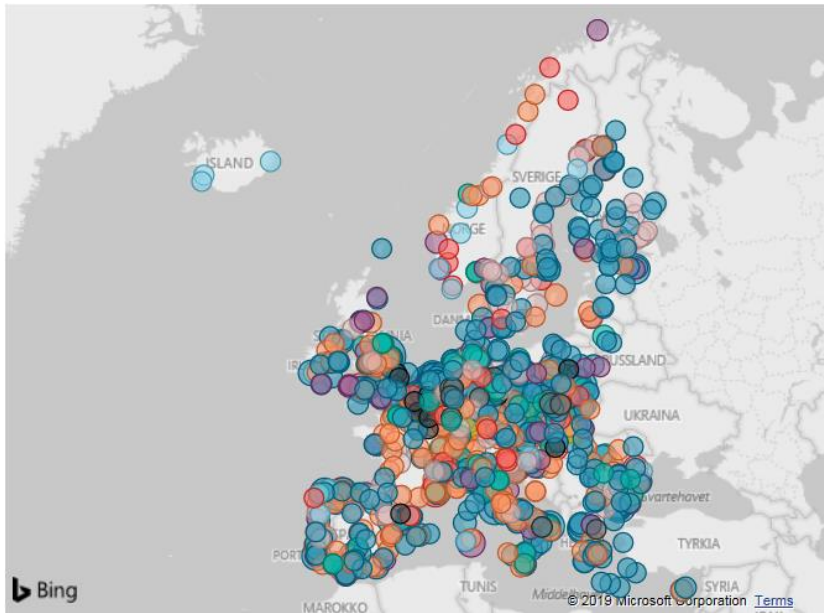
http://www.co2captureproject.org/co2_trapping.html

The European potential – understanding the scale

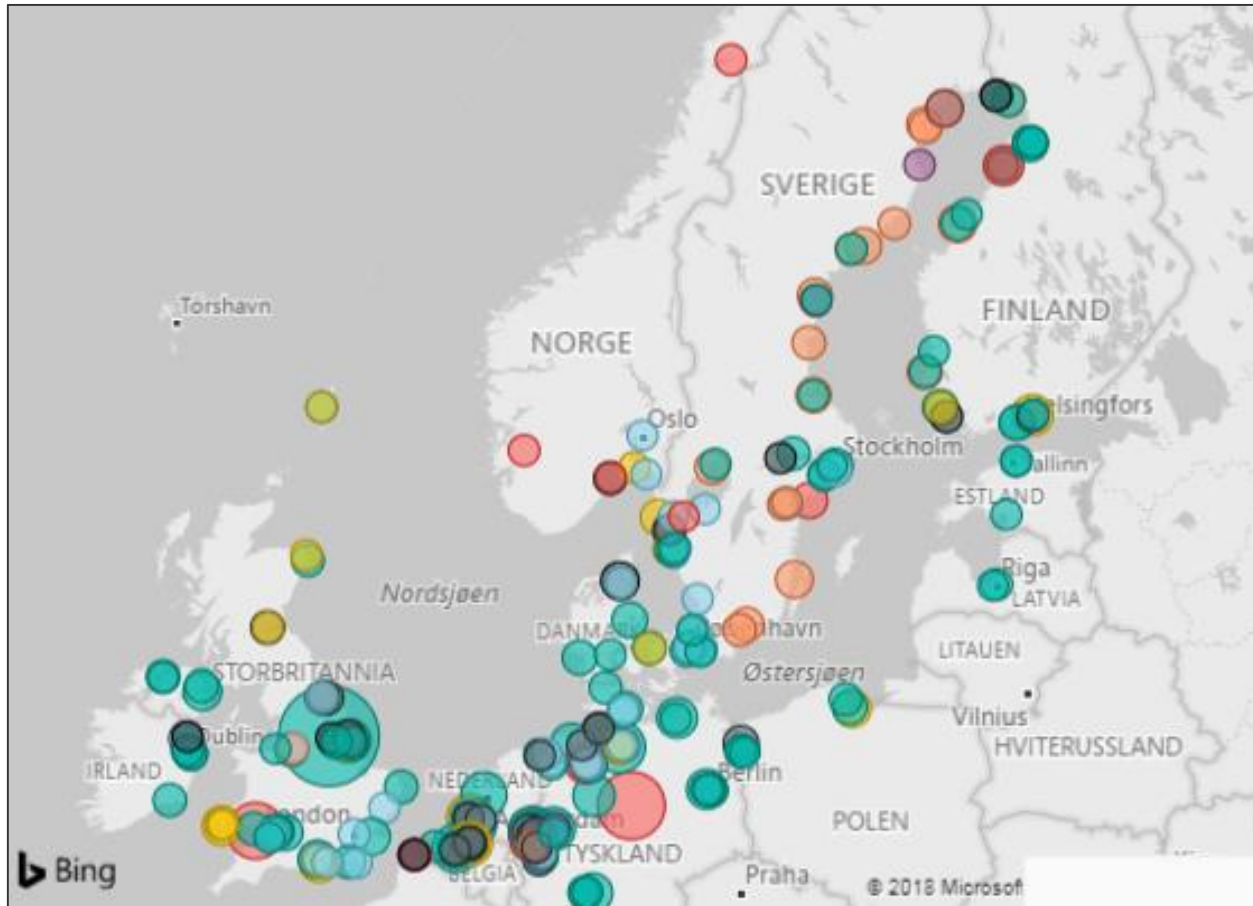
Europe
1994 facilities
1680 million tons of CO₂

Norway
35 facilities
13.6 million tons of CO₂

Germany
406 facilities
447 million tons of CO₂



Provides "open access " to CO₂ sources that want to start capturing

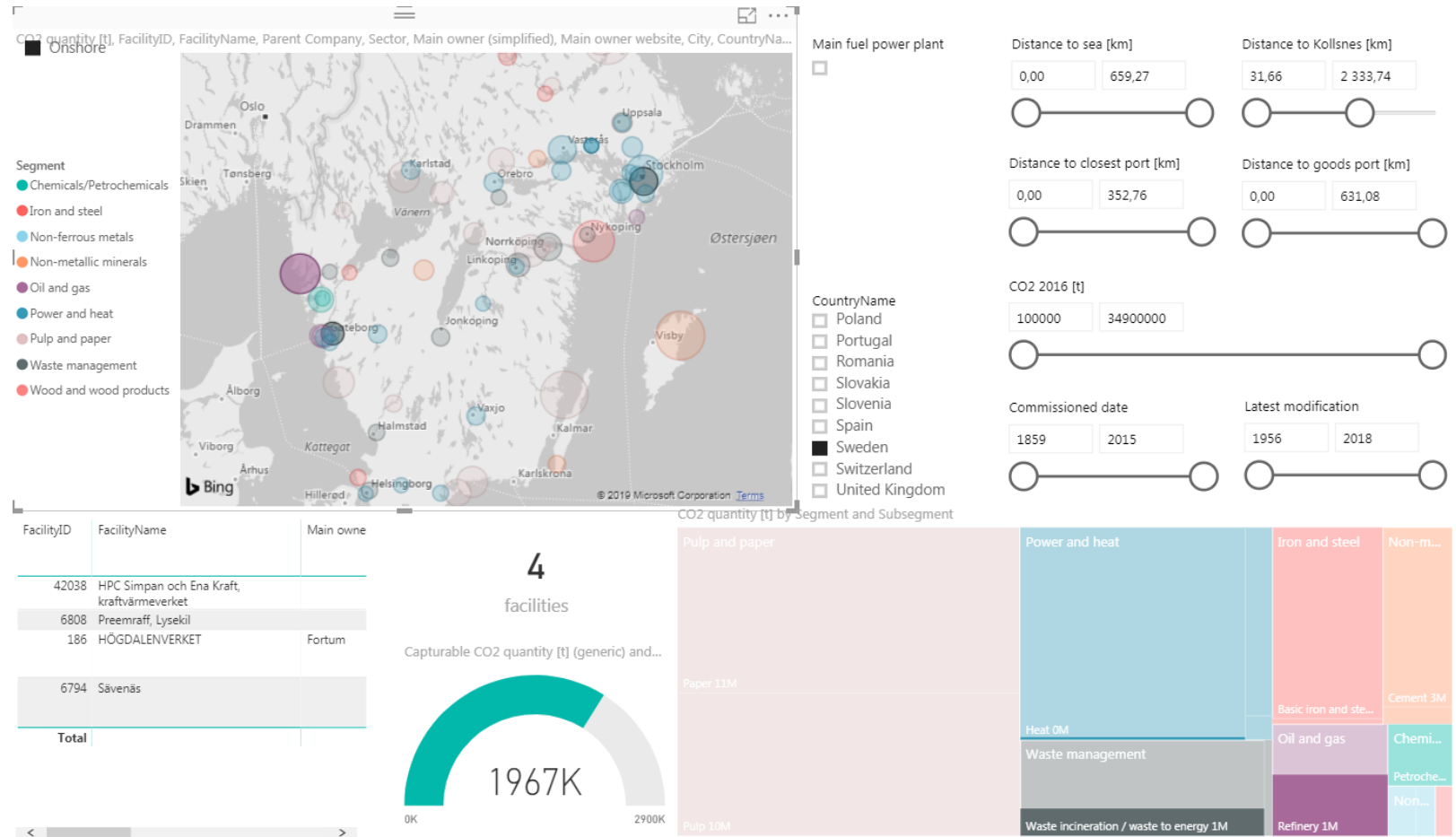


- Hydrogen from natural gas
- Waste incineration (60% biogenic)
- Cement
- Biomass and biofuels
- Steel
- Refining
- Other industry

In dialogue with 4 facilities in Sweden

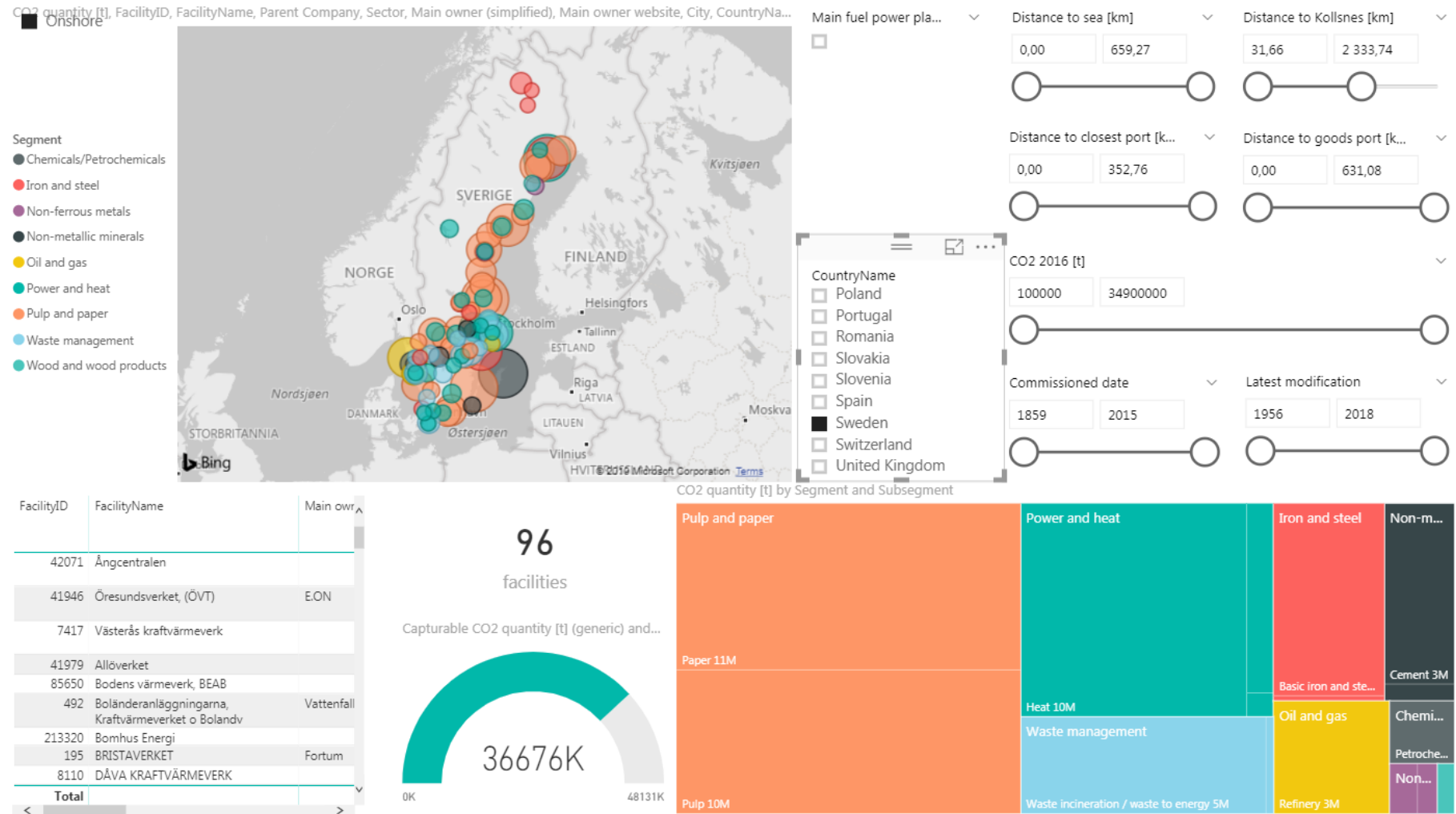
- Preem Lysekil & Gothenburg
- Stockholm Exergi
- Renova Gothenburg
- Plagazi Köping

- Estimated total of 2 MTPA capturable CO2
- Several other sites are well positioned



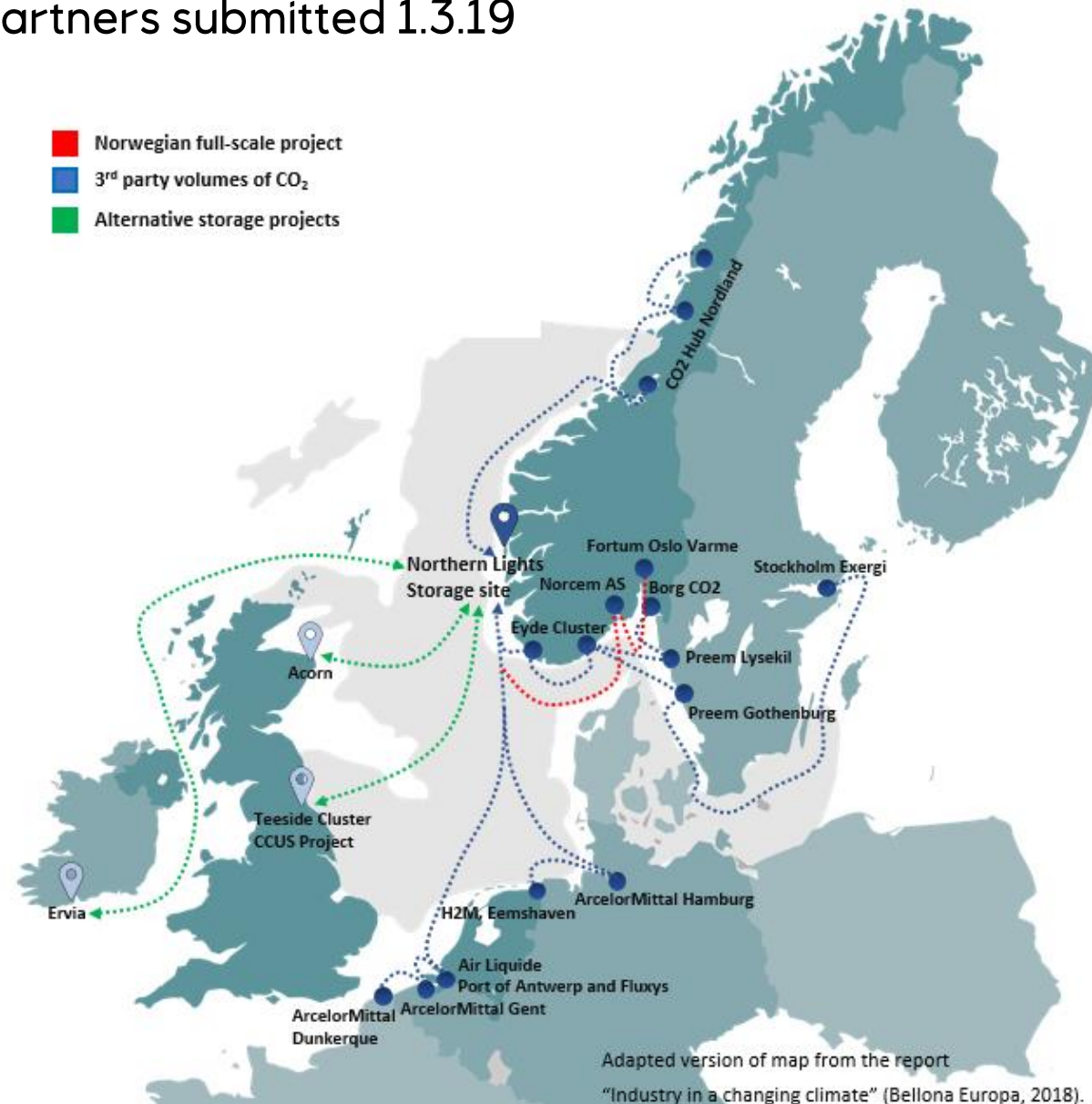
Swedish potential is large – Equinor and Northern Lights is ready!

- 96 facilities
- 48 MTPA of CO2
- Estimated 37 MTPA of capturable CO2
- Large amounts of bio-based CO2 emissions

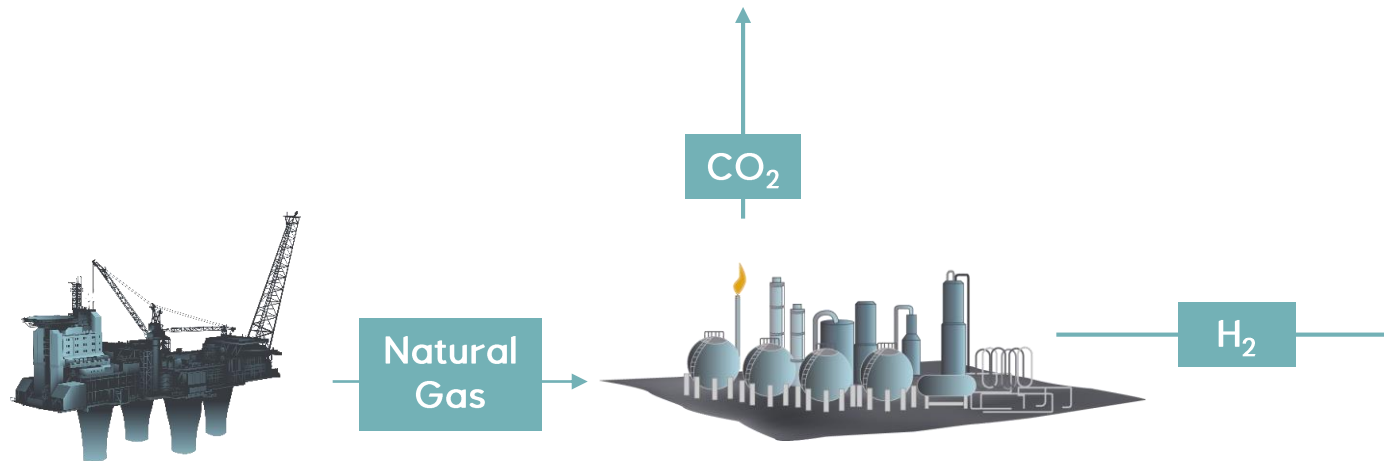
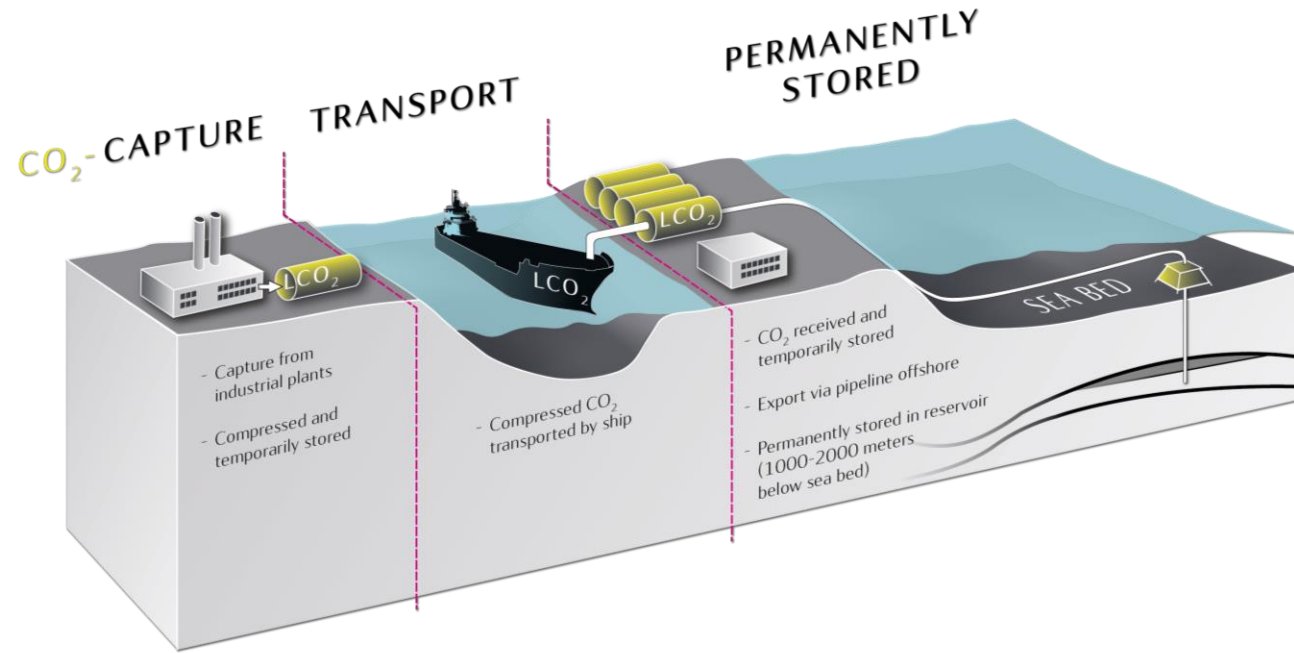


Beginning of a European network for CO2 removal

EU PCI application with 15 partners submitted 1.3.19



CCS as enabler for hydrogen production



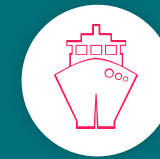
H₂
Clean Hydrogen



for power generation



for heat



for maritime transport

Equinor Hydrogen Portfolio

H2M - Magnum

- Energy: 8-12 TWh
- Utilise existing gas power plants
- Switch fuel from natural gas to clean H2
- Clean electricity
- Clean back-up for solar and wind
- Launch large-scale H2 economy
- **Partners: Nuon and Gasunie**



H21 North of England

- Energy: 75-85 TWh
- Domestic heating in UK
- Utilise existing gas network
- Synergies with industry/power generation
- Enables H2 to transport later
- **Partners: Northern Gas Network and Cadent**



New Projects

- Maritime transport – Norway
- Clean Hydrogen Pilot - Norway
- Ammonia to Power – Japan (6-7 TWh)
- Power and Industry – France with GRT Gaz
- Heat and power – Germany with OGE
- Hydrogen CCU – UK (80-90 TWh)
- Power and Industry – NL (12-20 TWh)



Key Messages



- Decarbonizing Europe towards 2050 is a major challenge.
- Renewable solutions are perfect for the carbon-light sectors.
- Heavy industry, heat and flexible power generation require large-scale solutions on which we need to start working today
- Hydrogen from natural gas with permanent offshore storage of CO2 offers:
 - **Low cost** – *Gas reforming is the most cost effective hydrogen pathway*
 - **Low technical risk** - *Proven technology in H2 production and CO2 storage*
 - **A clean value chain** – *The CO2 is returned to permanent offshore storage*
 - **Large scale** – *The industry has demonstrated a track-record of mega projects*
- Hydrogen from natural gas with CCS will establish a robust hydrogen infrastructure that green hydrogen can utilize

Gas is a cost efficient enabler

... to a carbon neutral energy system



Gas displacing more carbon intense fuels in transport, heating and power

Gas combination with renewables (gas and electricity)

Hydrogen and renewable electricity smartly integrated