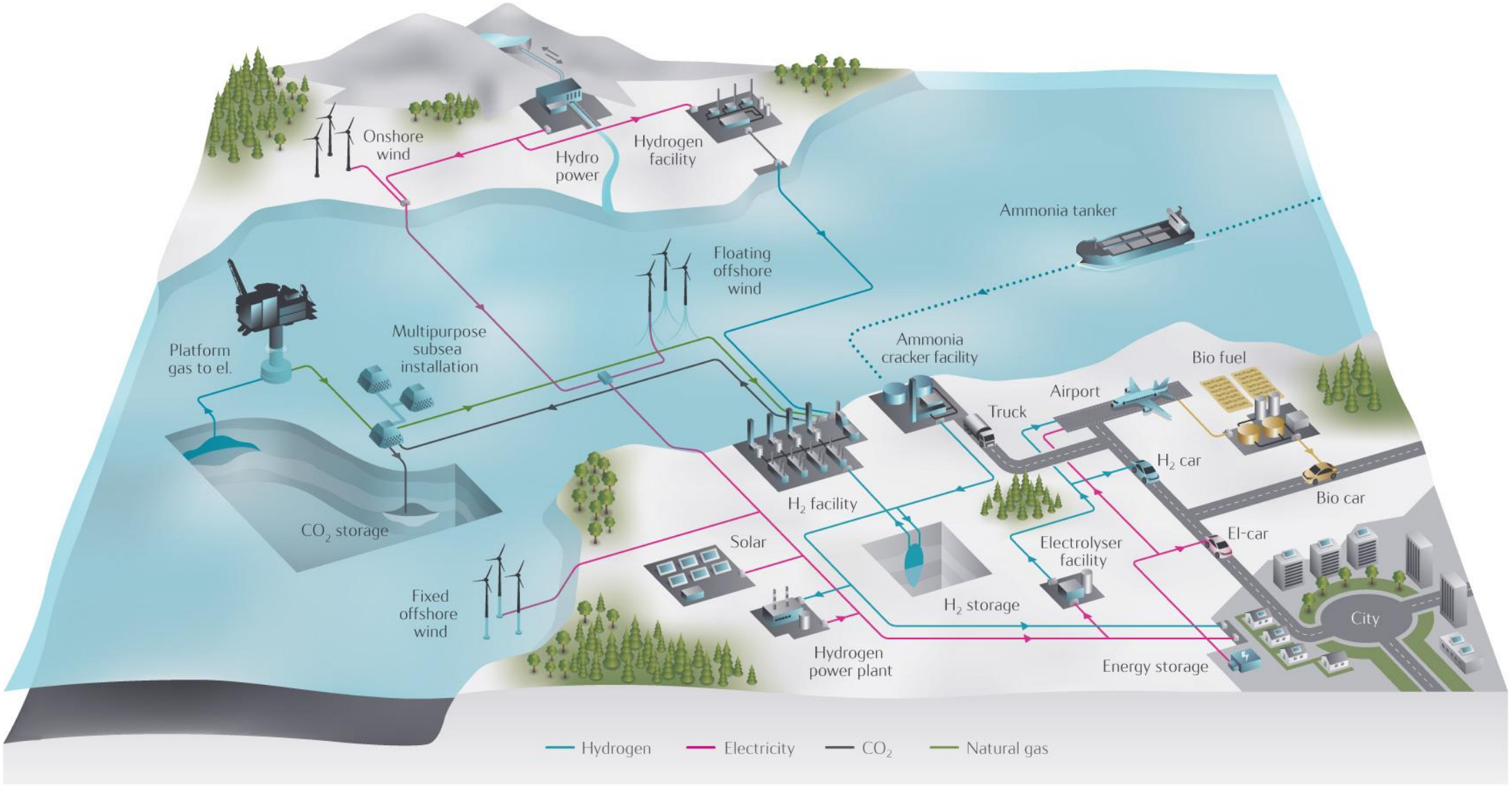
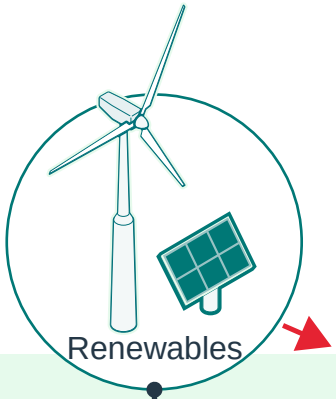
Low Carbon Solutions

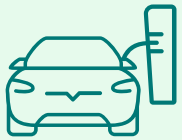
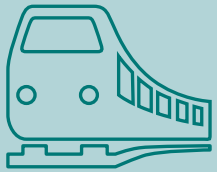
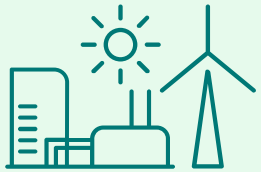
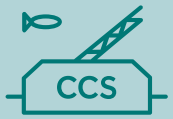
Steinar Eikaas – Equinor



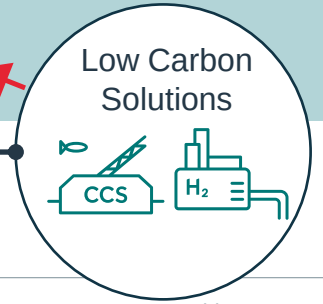
Decarbonising Energy Systems



Easy ⟵ Complexity to Decarbonize ⟶ Hard

	Easy		Complexity to Decarbonize		Hard
Transport		Light Vehicle Battery		Train Hydrogen		Shipping Hydrogen
Power		Daily storage Battery		Medium storage Hydro-Power		Back up for intermittent power Hydrogen
Industry		Light Industry Power		Heavy Industry NG + CCS Hydrogen		Heavy industry CCS
Heat		Heat Pumps Power		Heating Hydrogen		Long-term storage Hydrogen

Multiple technologies to address the challenge



CCS and Hydrogen Portfolio

CCS Post Combustion

2026

Net Zero Teesside

- Post-combustion CCS power generation
- CCS for industry

CO_2 T&S

2024

Northern Lights

- CCS for industry
- Transport of CO2 by ship
- Open/ flexible
- Phase 1 approved (1.5 Mt/y)
- Phase 2 (5 Mt/y) progressing

2026

Northern Endurance Partnership

- Pipeline transport
- Storage for Humber and Teesside

2026->

North Sea Basin

- General screening
- Future scale-up
- Saline formations and depleted reservoirs

Blue H2

2025

Hydrogen Norway

- Liquid hydrogen for maritime (green phase 1)
- Integration with existing onshore plants
- Barents Blue

2026

Zero Carbon Humber

- Hydrogen for industry
- Chemicals
- Synthetic fuels
- BECCS
- Hydrogen to power
- Blue Ammonia

2027/28

NW Europe

- Hydrogen for industry (steel)
- H2 Magnum
- Power/industry
- Flexible back-up for intermittent renewable
- Market based H2 approach

Green H2

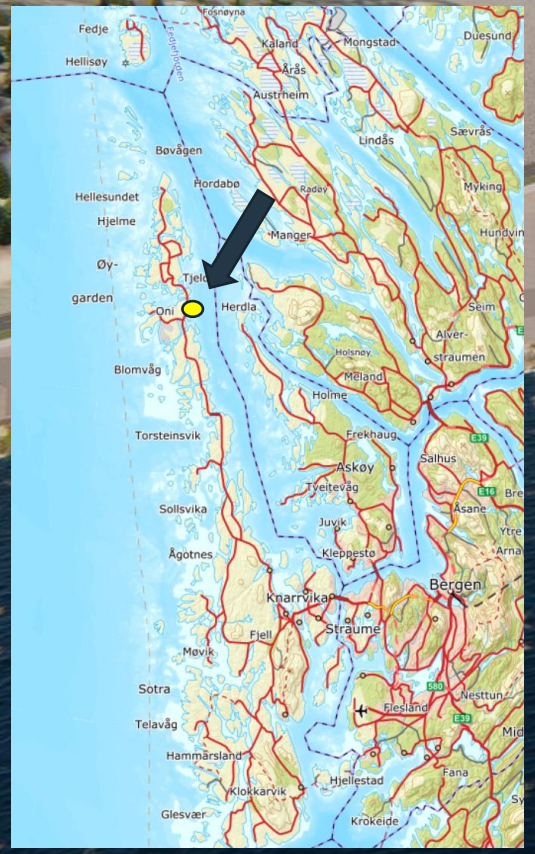
2027

NortH2

- H2 production from offshore (wind) renewable
- H2 for industry
- Back-up renewable intermittence

Projects are going to need a lot of CO2 storage!

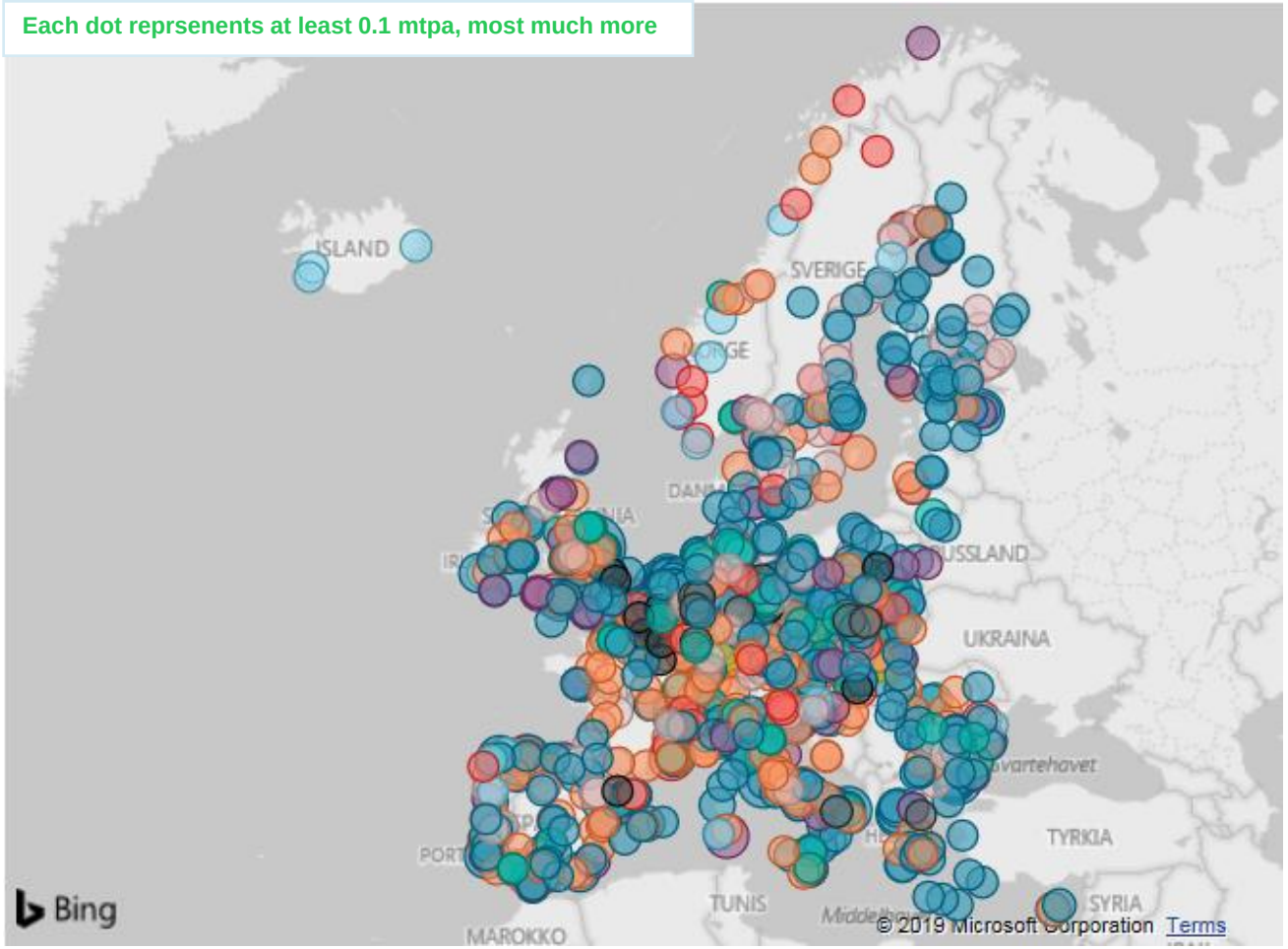
Northern Lights onshore facilities in Øygarden



Is there a business opportunity?

- There is no lack of CO2 in Europe
- The ship-based solution means access for CO_2 emitters across Europe

Each dot reprsenents at least 0.1 mtpa, most much more

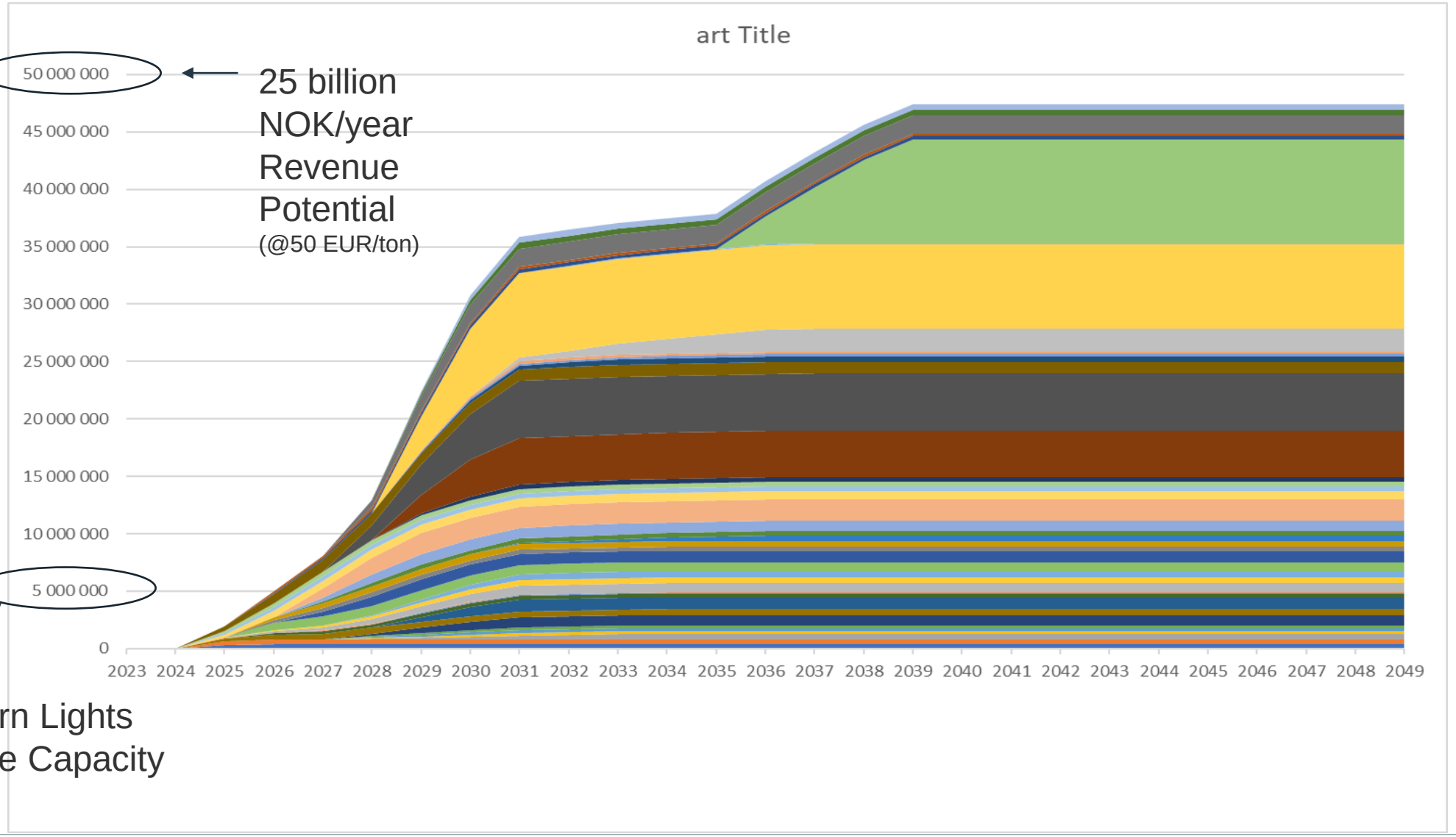


endrava CARBON LIMITS

Sectors with the largest potential

- Waste incineration / WtE
- Cement
- Biomass and biofuel
- Refineries
- Steel
- Natural gas
  - Hydrogen
  - Electricity

Ongoing dialogue with several potential customers in Europe



25 billion NOK/year Revenue Potential (@50 EUR/ton)

Northern Lights Pipeline Capacity

Project Aurora - HyShip/ Topeka

- Potentially Equinor's first hydrogen project
- Green Hydrogen upgraded to Liquid Hydrogen
- Operated by Air Liquide
- BKK and Equinor partners
- 6 tons per day (ie small)
- Equinor producer and buyer
- Shift cargo from land to sea
- IPCEI candidate
- FID by 2022

Air Liquide

Green H2

BKK

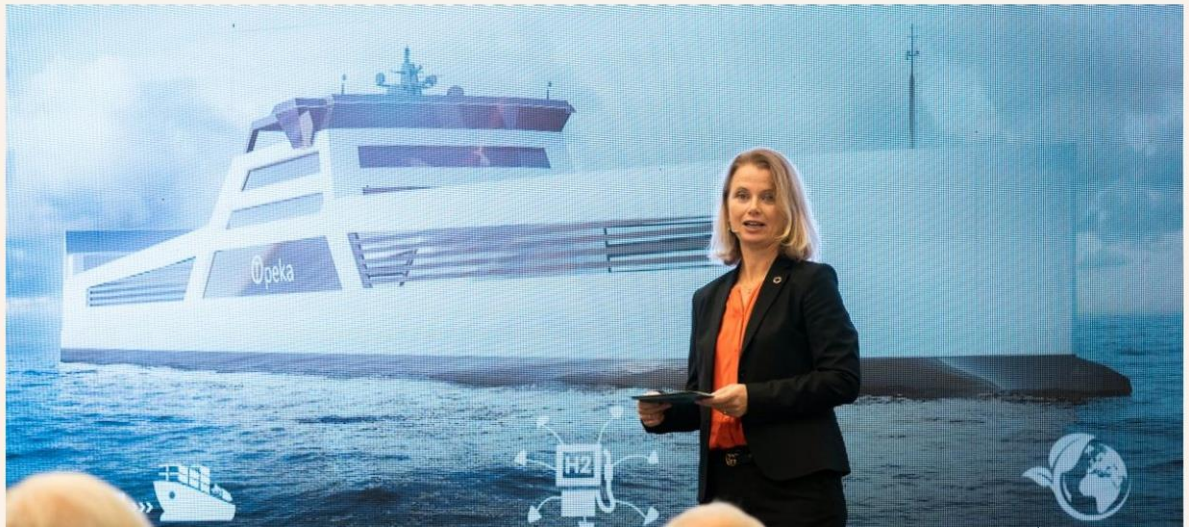
Liquid H2

equinor

E24! AKSJELIVE BØRS E24+ TIPS OSS

Skal bygge verdens første frakteskip drevet av hydrogen

Wilhelmsen-rederiet og partnerne har fått 80 millioner kroner i støtte fra EU for å realisere pionérprosjektet til havs.

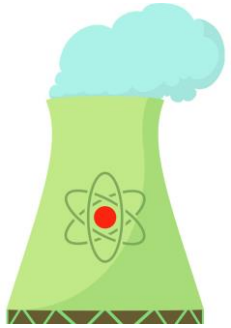


Demand for Clean and Flexible Power Expected to go up

Baseload

Coal

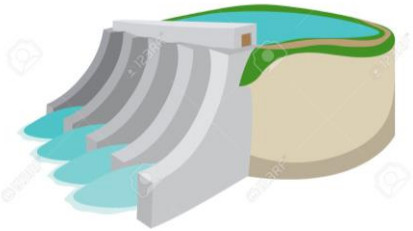
Phase Out



Nuclear

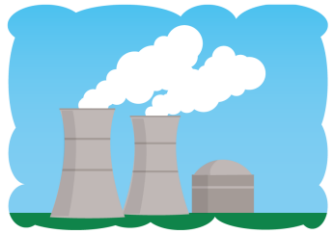
?

Flexible



Hydro

Limited Growth



Gas -> Clean Hydrogen

Strong Growth

Balance
Supply
&
Demand

Intermittent

Wind

Strong Growth

Solar

Strong Growth

Perfect fit of Offshore Wind and Hydrogen

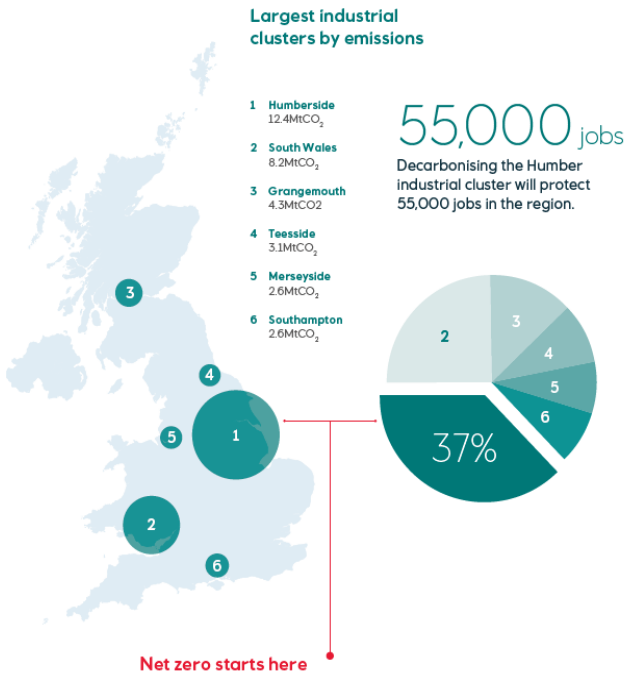
10 sec backup

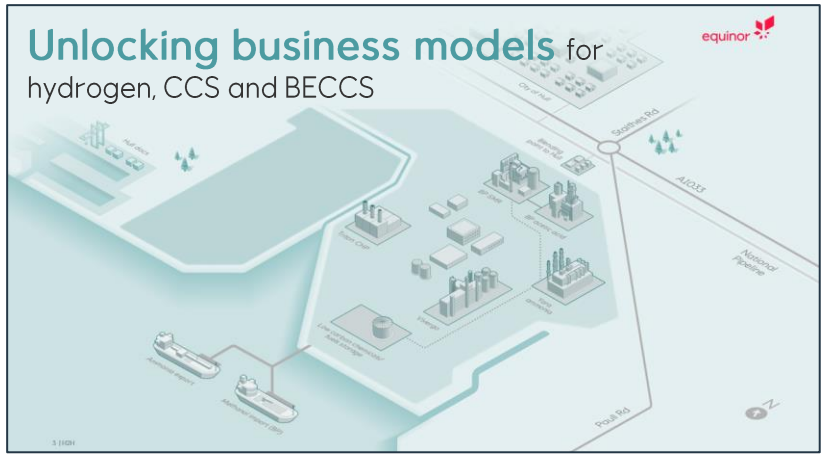
360 MW

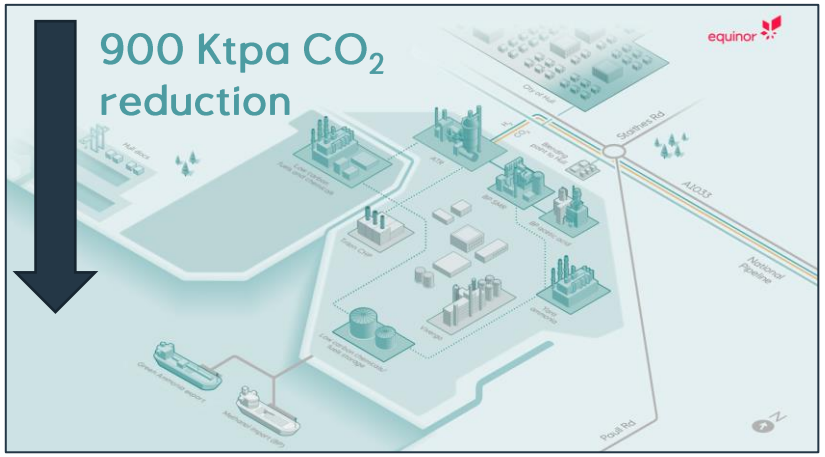
20.000 x 20ft (2,5 days backup)

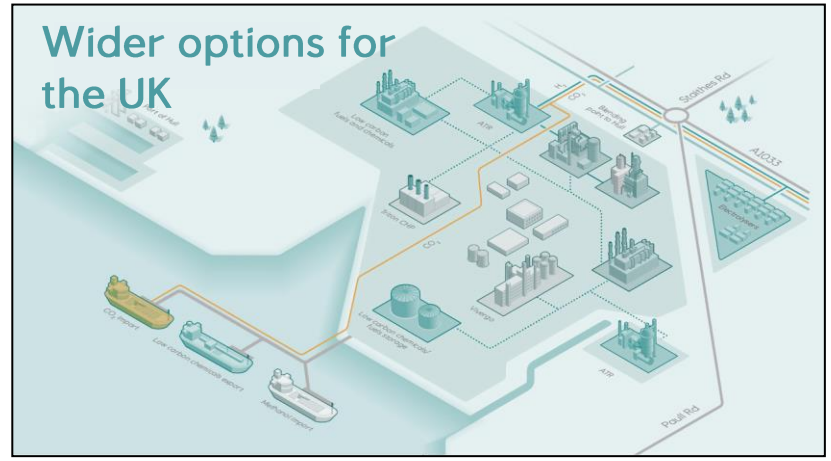
440 Mw Unlimited, Clean Backup

Zero Carbon Humber | H2H Saltend - A UK Lighthouse Project









Zero Carbon Humber | Decarbonisation of Industrial Clusters and Flexible Power

If the UK develops a world-leading hydrogen economy, the expansion of low carbon infrastructure could generate over 200,000 jobs and add £16 billion each year to the UK's economy.[1]

Expansion of hydrogen production and transmission system further west towards Drax and Ferrybridge.

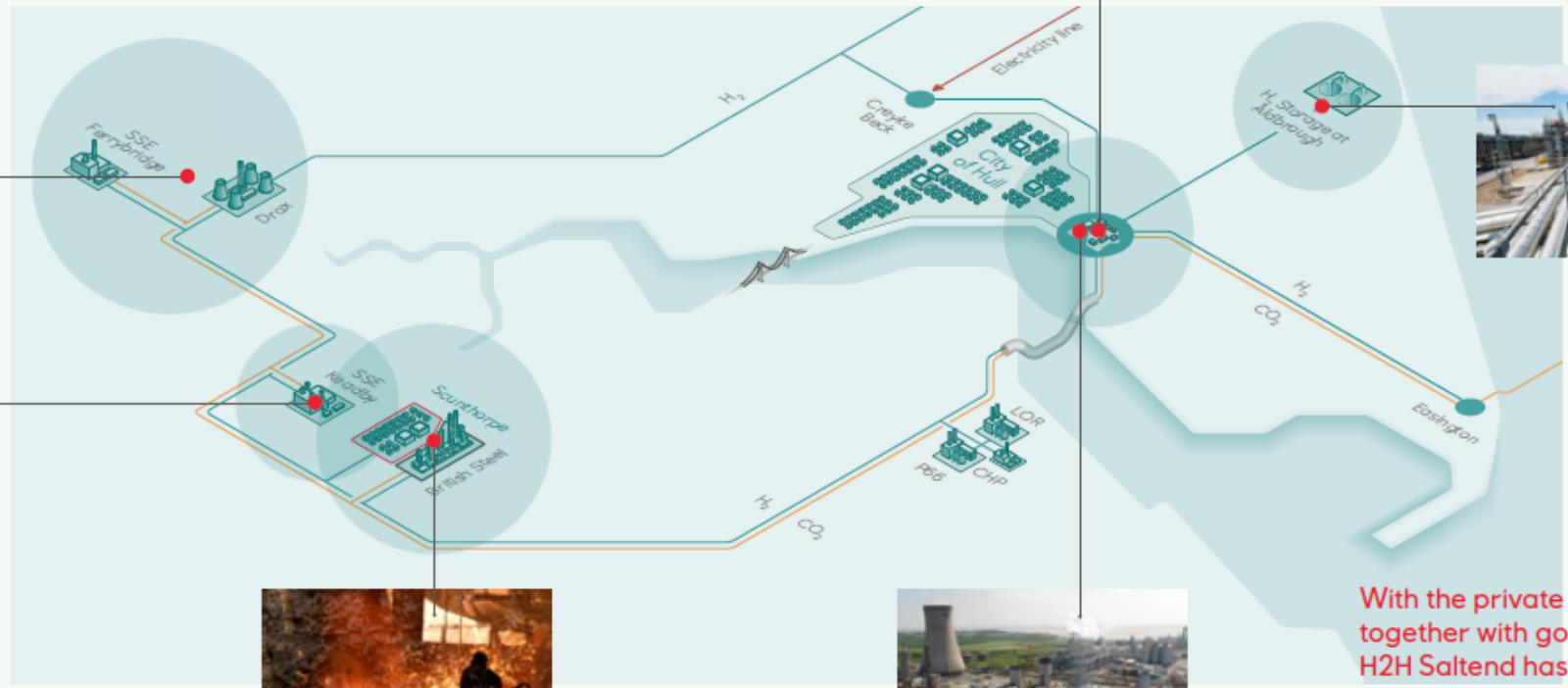
Transmission of hydrogen produced at Saltend will provide the option for decarbonisation at SSE Keadby Clean Power Hub.

1, 2 – Hy-Impact Series: A summary of four studies assessing the role of hydrogen in the UK net-zero transition

3 – H21 North of England report

Development of green hydrogen production at Saltend Chemicals Park through electrolysis.

H2H Saltend enables the decarbonisation of industry and power across the Humber region and can expand further to deliver low carbon energy in heat and transport too.



Potential to develop hydrogen storage at Aldbrough.

Hydrogen available to support decarbonisation of British Steel, one of only two steelworks in the UK.

Expansion of hydrogen production capacity at Saltend (fuel switch at Triton to 100% hydrogen).

With the private sector working together with government, H2H Saltend has the potential to deliver meaningful impact to the region, the UK, and the wider world.

Hydrogen to Steel ThyssenKrupp, Europe (video)

2018
The world premiere

The concept: CO_2 becomes raw materials. In September 2018, thyssenkrupp produced
ammonia from steel mill gases for the first time at its Carbon2Chem® technical cent
in Duisburg.

From 2019
The test

Thyssenkrupp will gradually replace pulverized coal in one blast furnace (BF) with hydrogen (H_2).

From 2020
The industrialization

The pilot system at the Duisburg steel plant will use steel mill gases to produce base chemicals.

From 2022
The introduction phase

Step by step, all three blast furnaces (BF) will be transitioned to H2 injection.

From 2024
The milestone

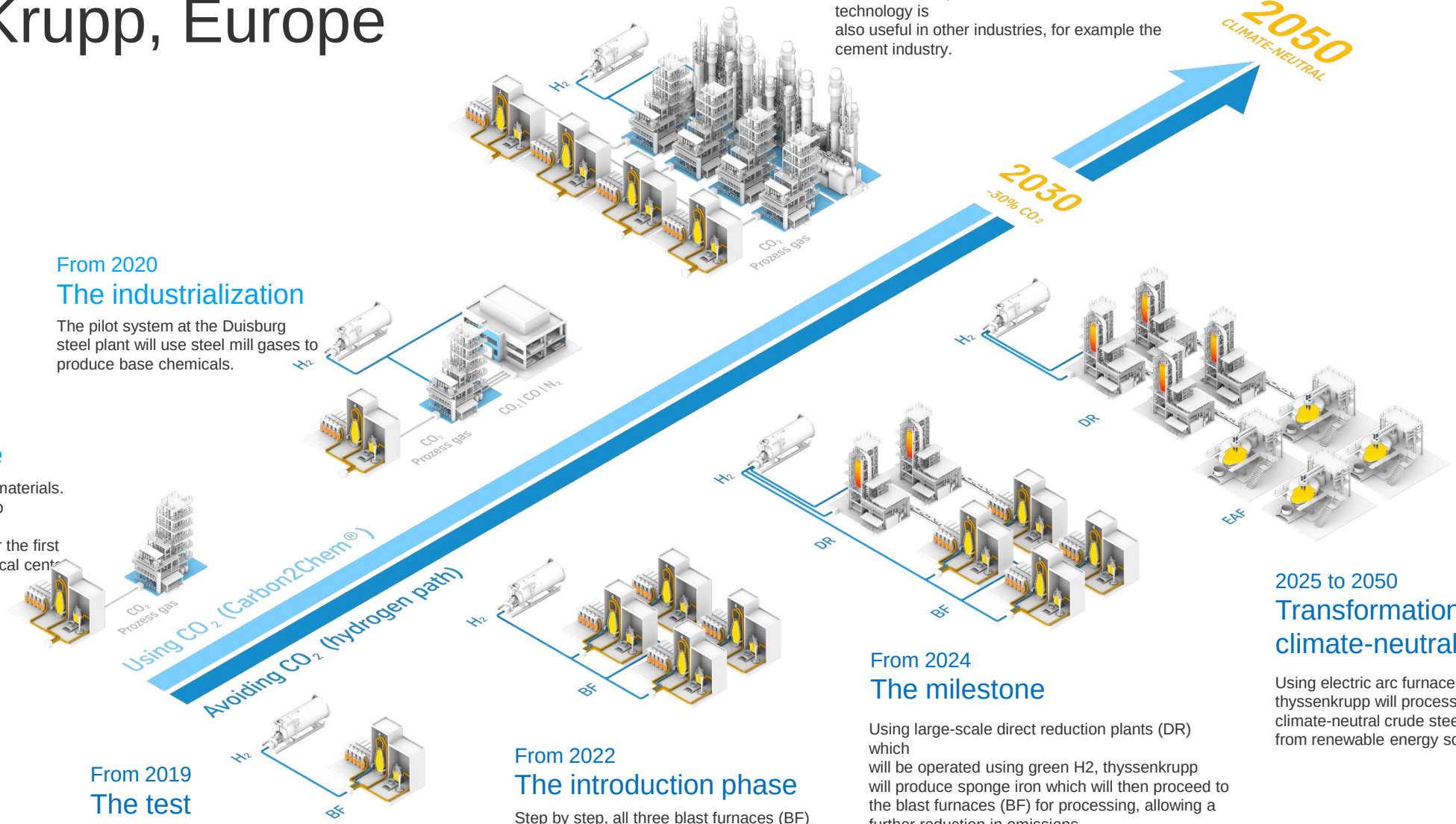
Using large-scale direct reduction plants (DR) which
will be operated using green H2, thyssenkrupp will produce sponge iron which will then proceed to the blast furnaces (BF) for processing, allowing a further reduction in emissions.

From 2025
The breakthrough

CO_2 will be used as a raw material in an industrial-scale plant. The Carbon2Chem® technology is
also useful in other industries, for example the cement industry.

2025 to 2050
Transformation into a climate-neutral steel mill

Using electric arc furnaces (EAF), thyssenkrupp will process sponge iron into climate-neutral crude steel using electricity from renewable energy sources.

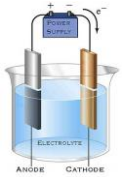
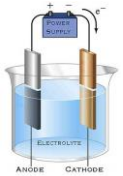


How it looks today – To become carbon neutral by 2050 by using hydrogen

Why Blue Hydrogen?

Europe (EU) currently consumes about 8000 TWh of Oil & Gas

How can half of that be converted to decarbonized Hydrogen?
(assuming all new renewable generation is channeled towards electrifying the other half)

REQUIREMENTS	Green Hydrogen	Blue Hydrogen
Energy Source	 x 150 New Plants ✗	Already Exists (Natural Gas) ✓
Hydrogen World-Class Units	 x 50.000 (10 MW units)	 x 500 (1 GW units)
vs.		
Existing Supply Chain *annual global deliveries*	 x 100 (10 MW units) ✗	 x 100 (1 GW units) SMR, ATR, LNG ✓

Large Scale CO_2 Storage

Can we manage to store the CO_2 from such a massive shift to Blue Hydrogen?

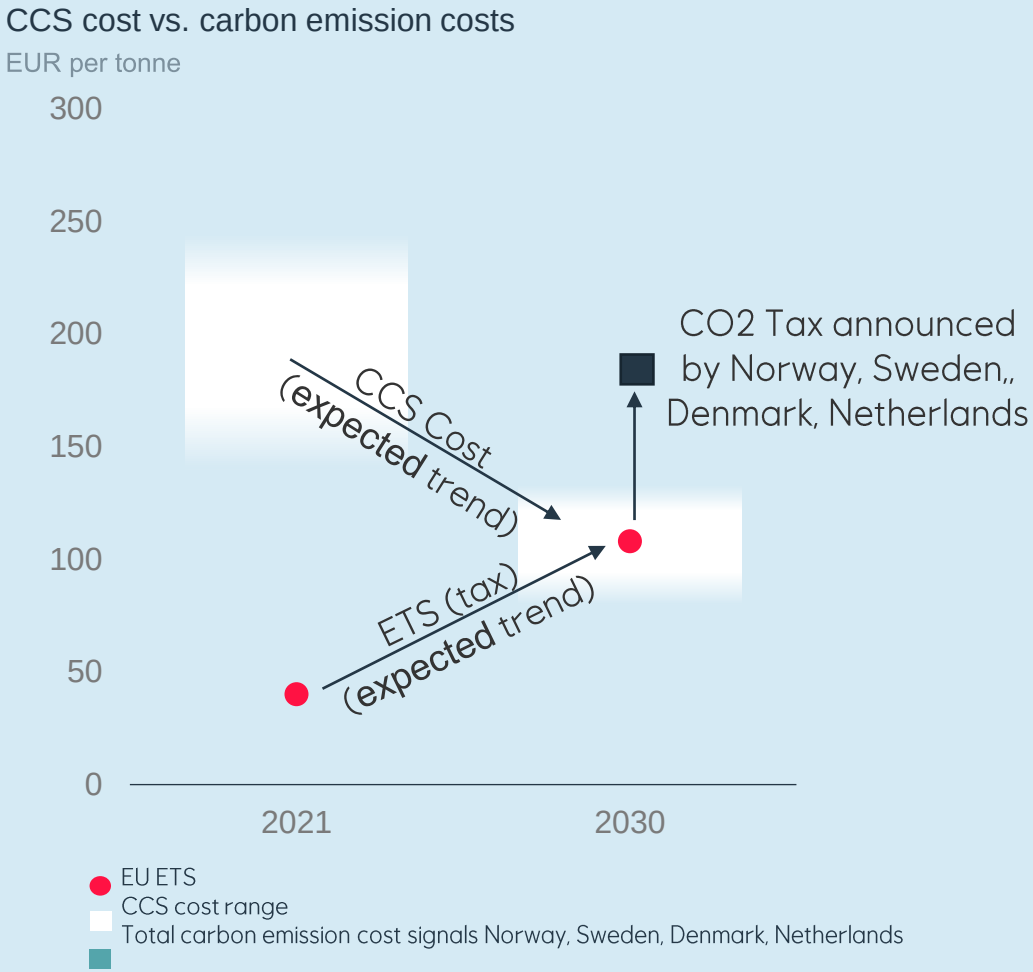
Converting 50% of EUs Oil & Gas to Blue Hydrogen yields 1000 Mill Tons/Yr of CO_2

REQUIREMENTS	Industrial Capability to Deliver
1000 Wells to store CO2 *1000 Million Tons per year*	200 Wells / year Drilled each year on the NCS (Exploration and Production wells) ✓
50 years of Operation *50 Giga Tons total Capacity*	Northern Lights is 5 Mill T/yr 200x Northern Lights needed! !

-> Massive Blue Hydrogen production requires significant maturation of CO2 storage capacity -> within reach, but step-up of activities required!

CCS: The Commercial Story

- First wave of CCS projects will need subsidies to be realized
  - They are essential and are paving the way for commerciality
- Expect commercial CCS projects (without subsidies) by the end of 2030
- Economy of scale is key



CCS cost: various sources including Equinor, Northern Lights and IEA.
EU ETS projections from BloombergNEF March 2021

Blue Hydrogen – What Will it Cost? …

Sector	Price Premium	Compared to …
Industry	+25%	Grey Hydrogen
Heat	+50%	Natural Gas
Power (on demand)	+100%	Natural Gas

… and What Will it Take?

- Industrial leadership to design credible anchor projects to show what it costs
- Political leadership to design a financial framework to absorb the costs initially
- An outlook for a market willing to pay for zero carbon products