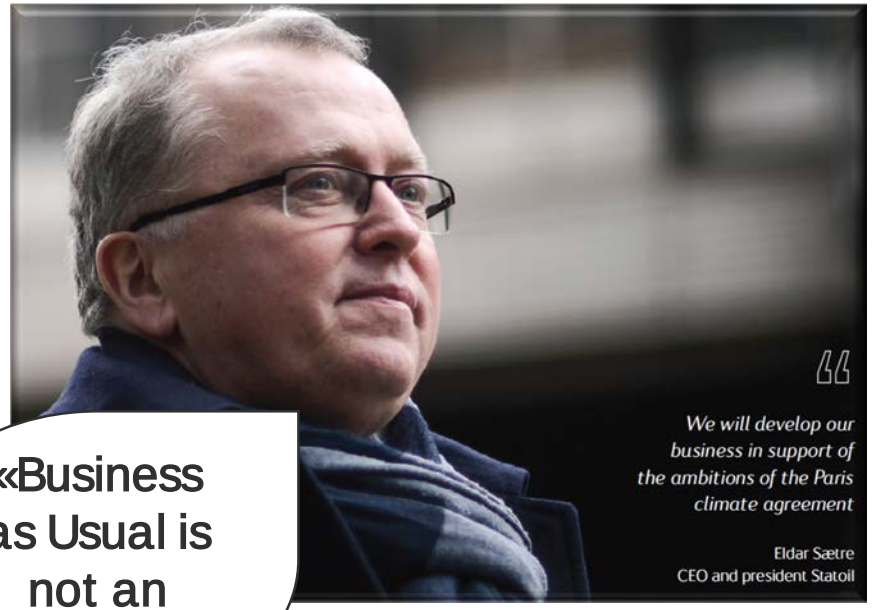


«Business as Usual is not an option»

LOWEMISSION

equinor

Hyper Seminar

Equinor – The role of hydrogen in de-carbonization

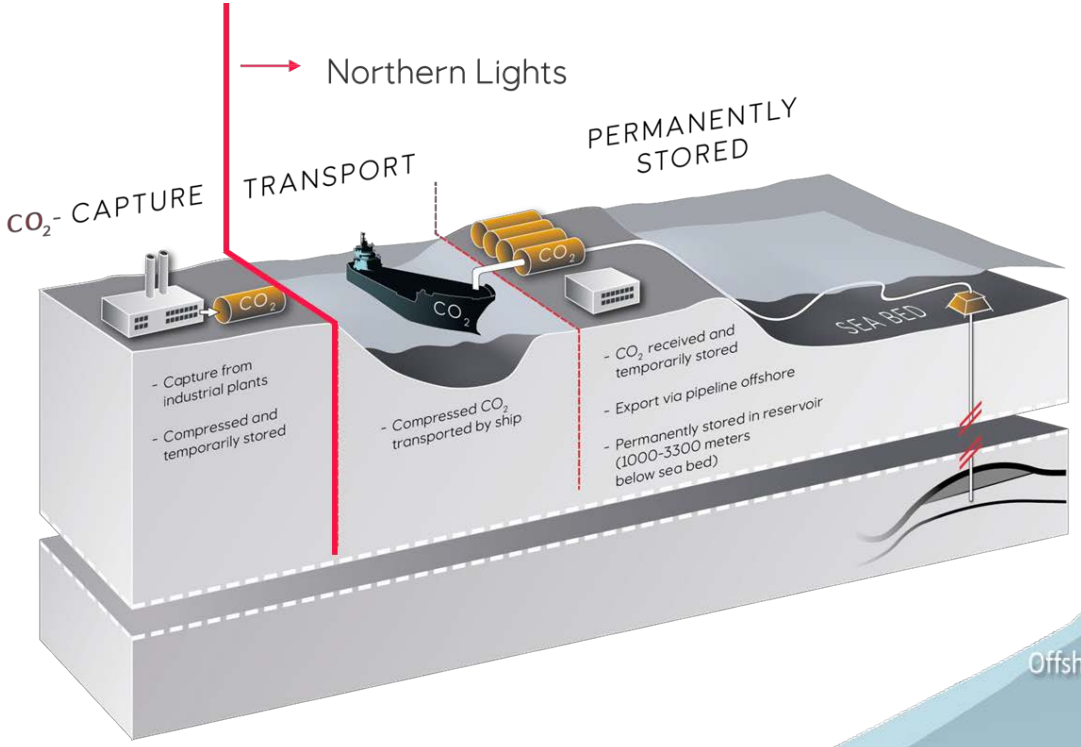
Hege Rognø

December 10th, 2019

Norwegian CCS project – enabling industrial decarbonization!

Objective

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

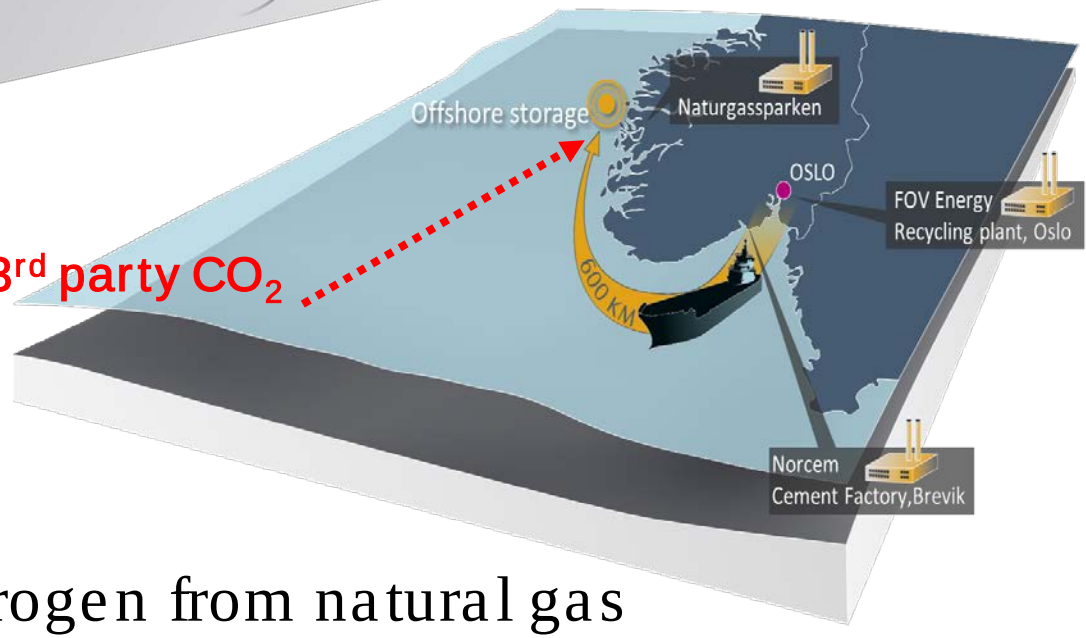


GASSNOVA

equinor TOTAL

First "open access infrastructure"

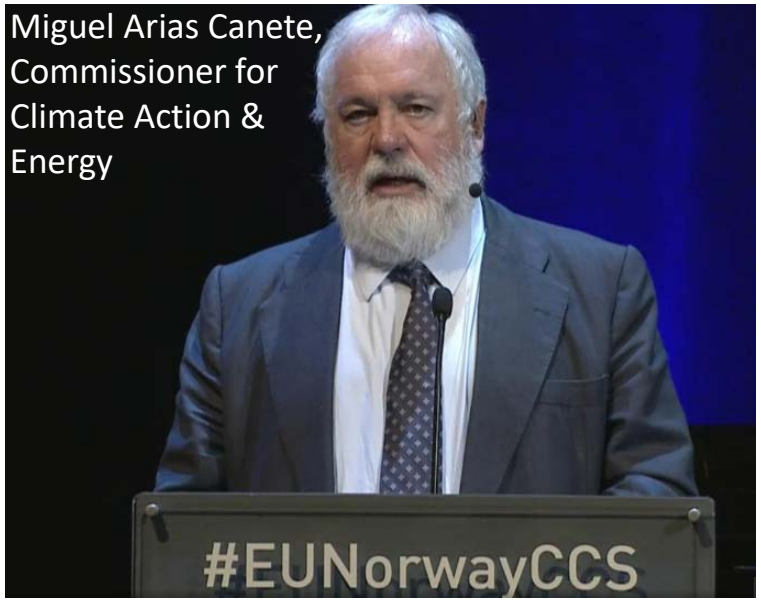
Combines industrial sources of CO_2 from Norway and other countries with safe storage on Norwegian continental shelf



Potential 3rd party CO_2

=> CCS will cater for production of clean hydrogen from natural gas

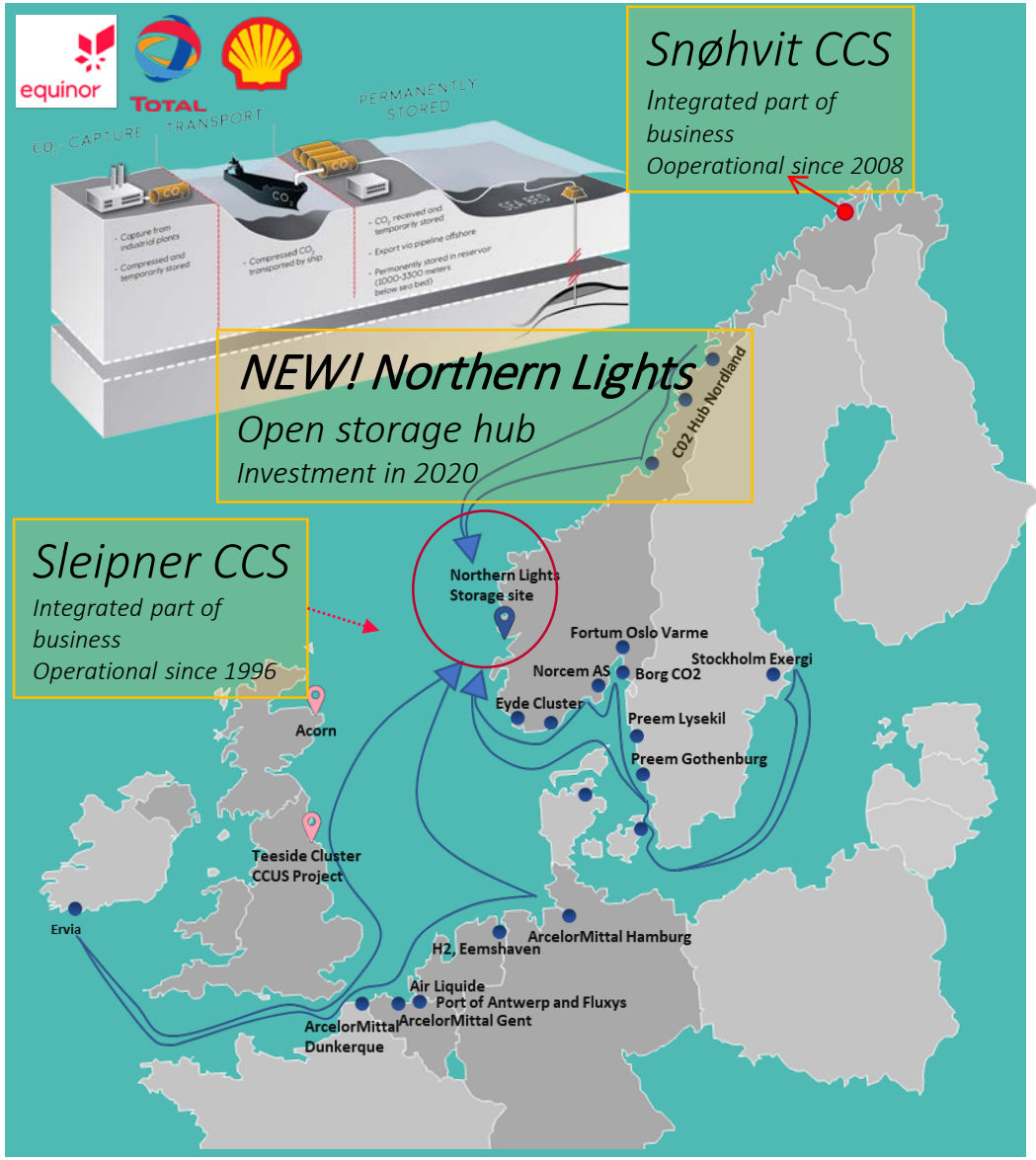
#EUNorway CCS



"CCS is an absolutely necessary part of the solution. Norway's leadership is needed. Northern Lights among the most promising flagships that we need …"

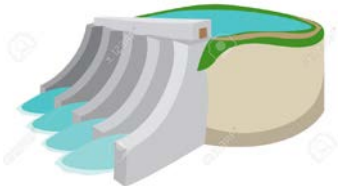
Seven MoU's signed

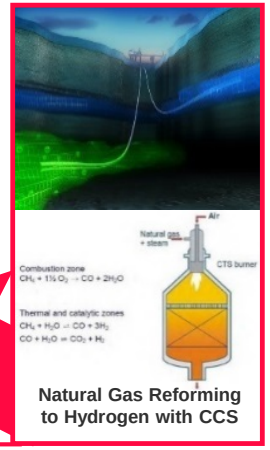
- Fortum Group; Finland
- Ervia, Ireland
- Air Liquide, Belgium
- Stockholm Exergi, Sweden
- ArcelorMittal, Luxembourg
- Preem, Sweden
- Heidelberg Group, Germany



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

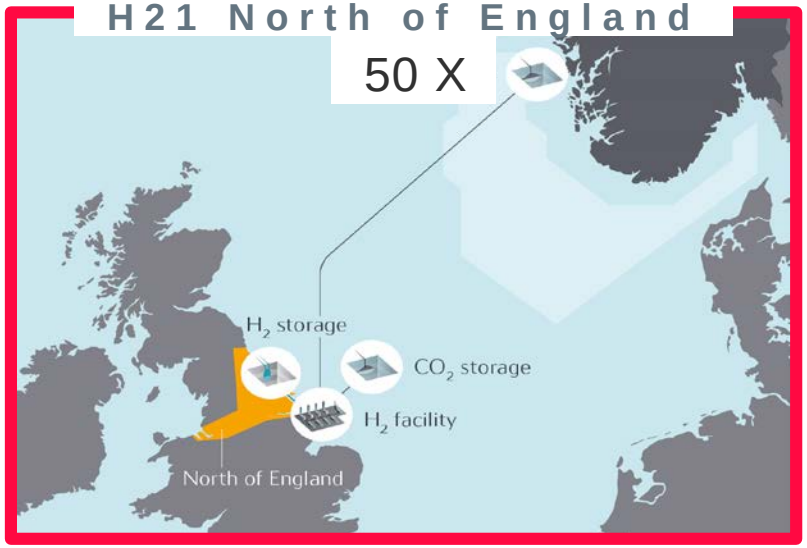


Multiple technologies to address the challenge

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

11600 000 X

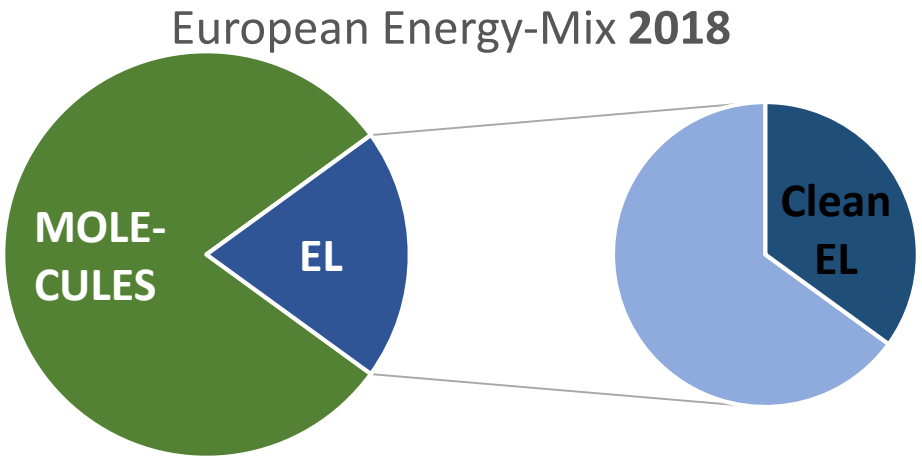
Hydro

200 X

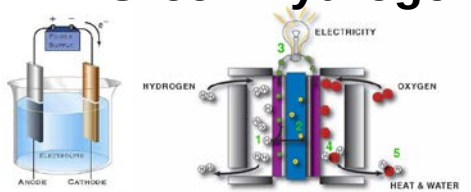
The Challenge and the Tool-Box

Cost Efficiency EL : MOL

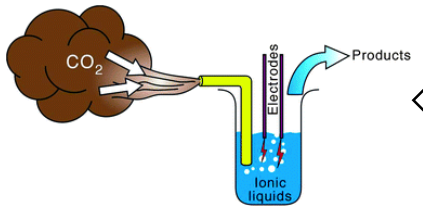
Energy Transport 1 : 10
Long Term Storage 1 : 100



Green Hydrogen and Power to X

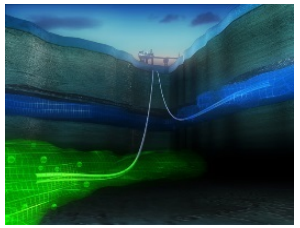


Electrolyser and Fuel Cell



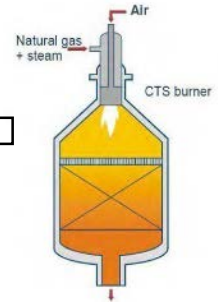
CCS

Hard-to-Decarbonize Industry



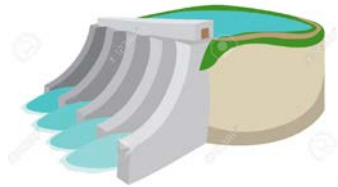
Permanent CO2 Storage (CCS)

Blue Hydrogen

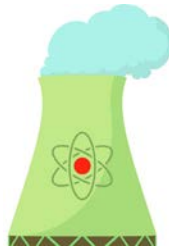


Gas Reformer w/CCS

Renewable EL



Zero Carbon EL



Nuclear

Hydrogen fired EL power

Improve Carbon Efficiency

Switch from Coal …

… to Natural Gas

Hydrogen in the gas narrative

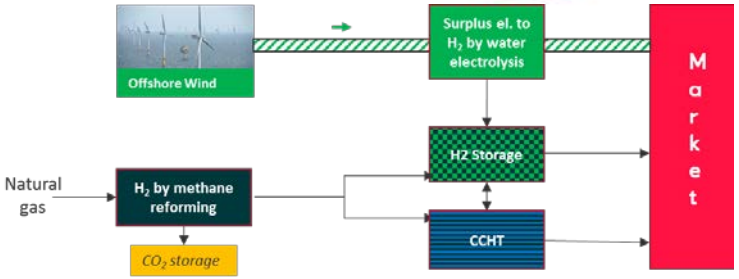
Various option and time line

Now	2020 – 2040	Towards 2050

2020 —(-20% CO_2)→ 2030 —(-40% CO_2)→ 2050 —(-95% CO_2)

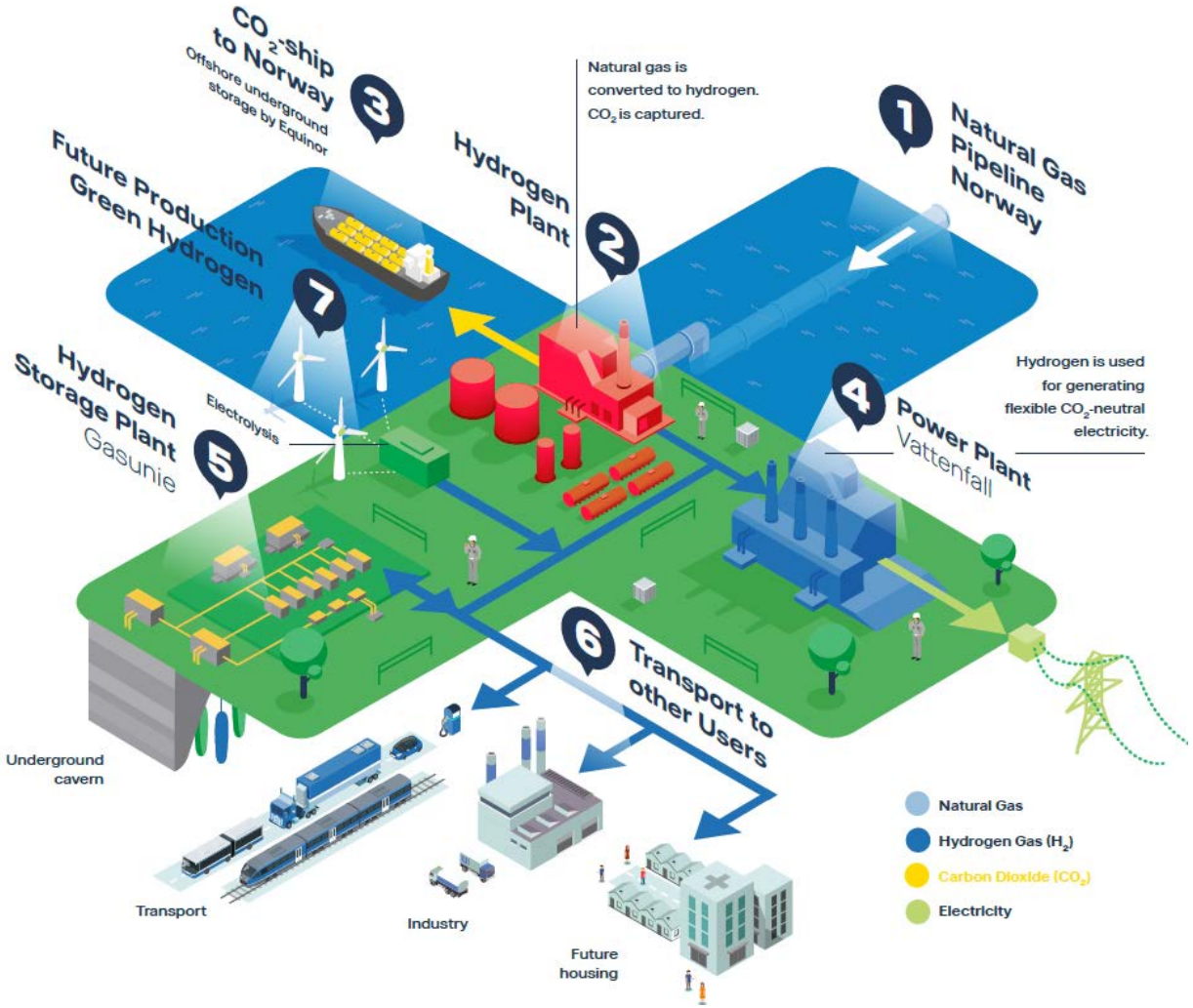
Natural gas → **New CCGTs, CHPs or OCs**

+



Phase 1: Nuclear and coal phase-out	Phase 2: Wind, solar and gas	Phase 3: Wind, solar and hydrogen
• Meets urgent baseload capacity needs on time	• Flexible capacity in to back-up intermittent sun and wind • H2 pilot projects and "H2 ready plants"	• Introducing hydrogen economy with zero emissions from power and industry segments

H2M – Magnum, Netherlands



- Energy: 8-12 TWh
- CO2 emissions reduction of 2 Mton/year
- Utilise existing gas power plants and gas infrastructure
- Switch fuel from natural gas to clean H2
- Clean, flexible electricity as back-up for solar and wind
- Launch large-scale H2 economy

- Partners: gasunie & NUON VATTENFALL

Perfect fit of Offshore Wind and Hydrogen

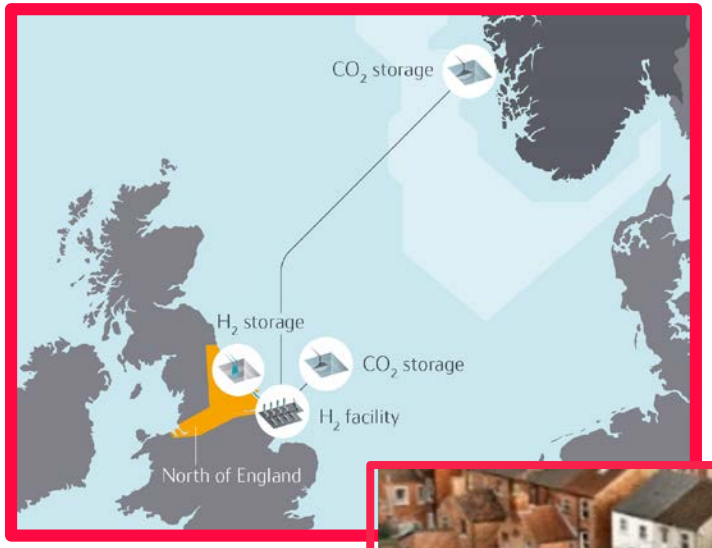
10 sec backup

360 MW

20.000 x 20ft (2,5 days backup)

440 Mw Unlimited, Clean Backup

H21 North of England



System approach to decarbonise residential heating and distributed gas

Energy: ~85 TWh (12.5% of UK population)

/ 12 GW hydrogen production

CO2 emissions reduction: 12,5 Mt CO2 pa

CO2 storage offshore UK / Norway

8 TWh (seasonal) hydrogen storage

CO2 footprint 14,5 g/KWh

Unlimited system coupling

CAPEX: £23 billion

H21 - What will it cost?

2035 Residential Prices

	2035 Residential Prices	CO2 Footprint
Electricity	£200/MWh (BEIS Projection)	50 g/KWh
Natural Gas	£50/MWh (BEIS Projection)	200 g/KWh
Hydrogen	£75/MWh (H21)	15 g/KWh (H21)

Roadmap towards a commercial large scale hydrogen value chain

From Technology Demonstration and Market Build to Large Scale Implementation

2023

Northern Light

CO_2 storage infrastructure

2024/25

H_2 Value Chain demos

Clean hydrogen value chain demonstration(s)

2024

Transport: Maritime Fuel

Hydrogen for marine propulsion

2024

Hydrogen (green) as REN Storage

Hydrogen as renewable energy storage

2027

Power: Magnum

Hydrogen for power generation with CCS

2028

Clean Steel

Hydrogen for industry (steel)

2029

Heat/Power/Industry: H21

Hydrogen to heat & power

2030+

Power/Industry: H_2 to Japan

Global hydrogen supply chain

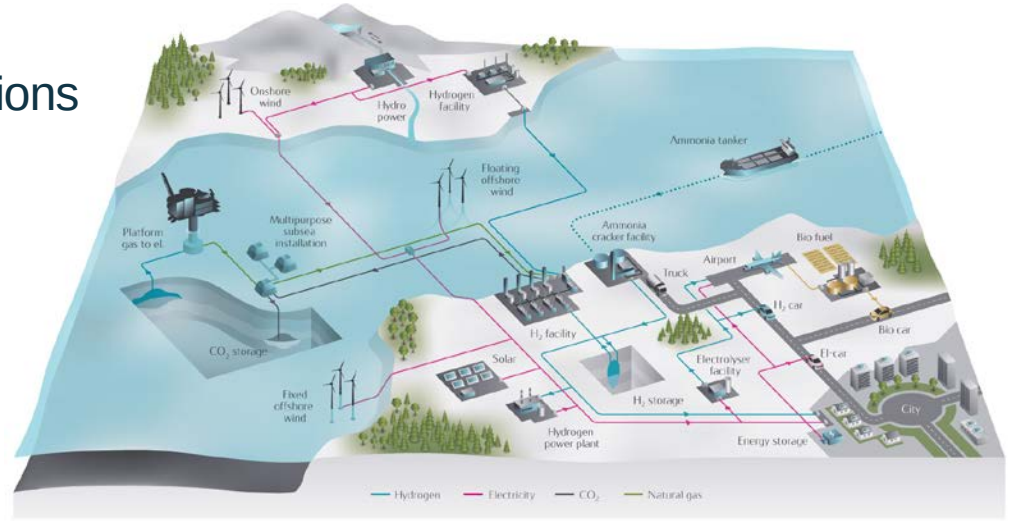
Large Scale Implementation

Market build

Value Chain Demonstration

Key Messages

- Global decarbonisation towards 2050 a major challenge
- Renewable solutions critical for the energy transition
- Heavy industry, heat- and flexible power require large-scale solutions such as clean H_2 from natural gas
- Clean H_2 from natural gas with CO_2 storage offers
  - Large scale, clean value chain
  - Flexible power
  - Relatively low cost and acceptable technical risk
- Public-private collaboration, firm policies and incentive structure necessary to realise the energy transition



=> Clean gas/hydrogen essential to the decarbonization of the energy system

Questions?