Ammonia (Hydrogen) Markets

Input to Session 6 of NH_3 Energy Implementation Conference

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OUR VISION

Shaping the future of energy

- Competitive at all times
- Transforming the oil and gas industry
- Providing energy for a low carbon future

Our approach - Clean (Blue) Hydrogen

- **Infrastructure Dimension**

- Build on the massive existing natural gas infrastructure
- Produce hydrogen at large scale from natural gas
- Capture the CO_2 in the process and send it to permanent offshore storage

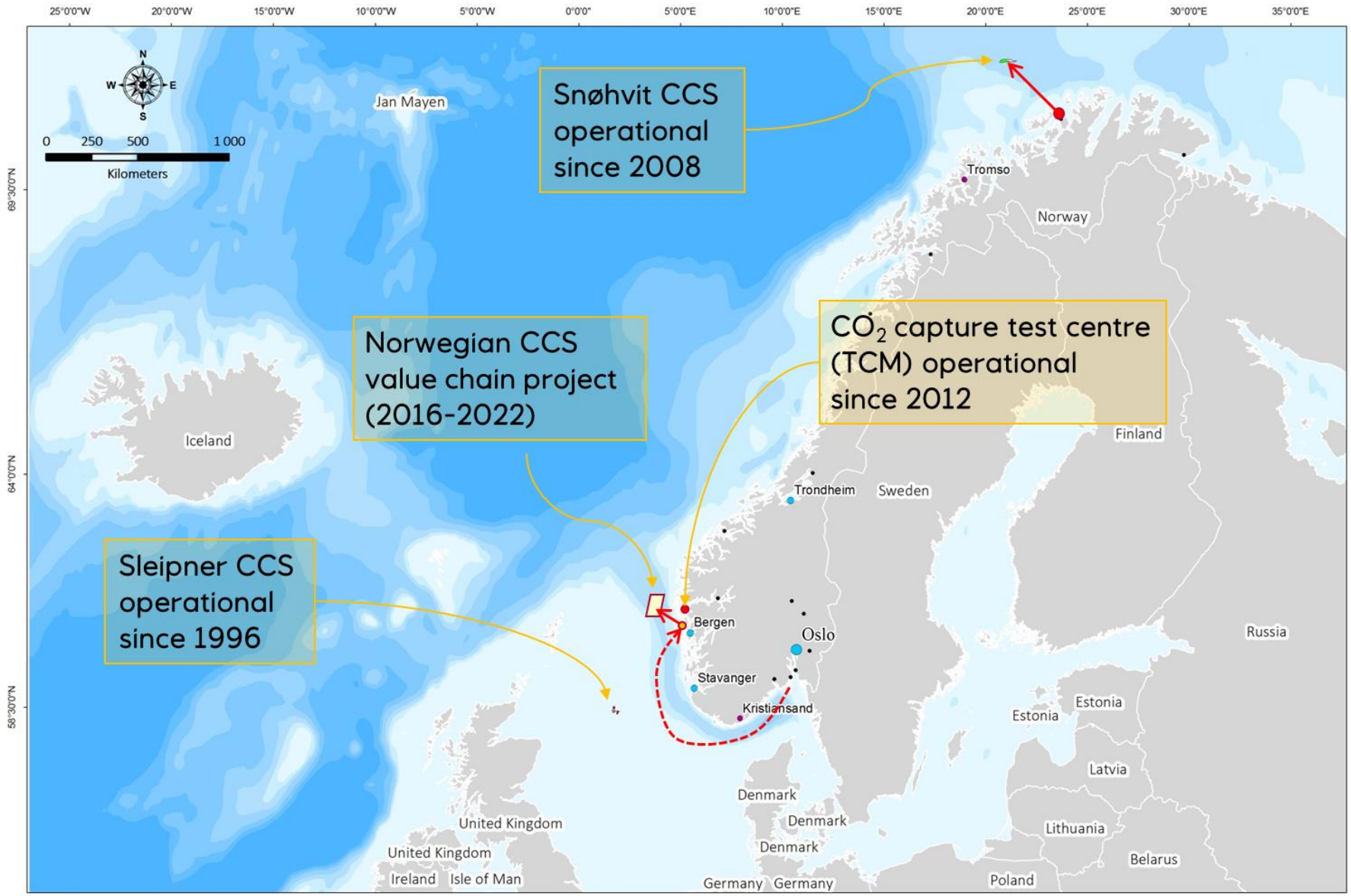
- **Commercial Dimension**

- Identify markets suitable for switching to hydrogen
- Partner with large customers who are pioneers in pursuing low carbon solutions
- Develop real, tangible and sizable projects
- Approach authorities to design suitable financial support solutions

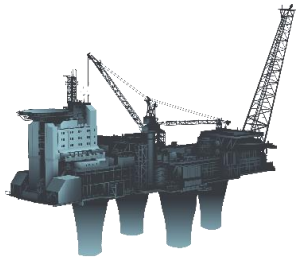
Hydrogen Council · Hydrogen Europe · NUON · gasunie · Northern Gas Networks · VIKING CRUISES · Open Grid Europe The Gas Wheel

Norway CCS: Building on experience

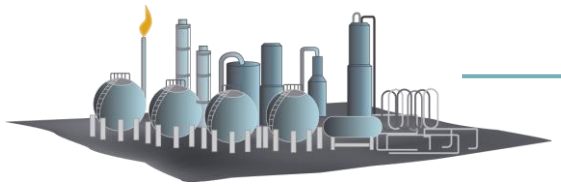
- 22 years of operations
- Building confidence in CCS
- > 22 Mt CO_2 stored
- New full-scale CCS project being developed



CCS as enabler for clean hydrogen



Natural Gas



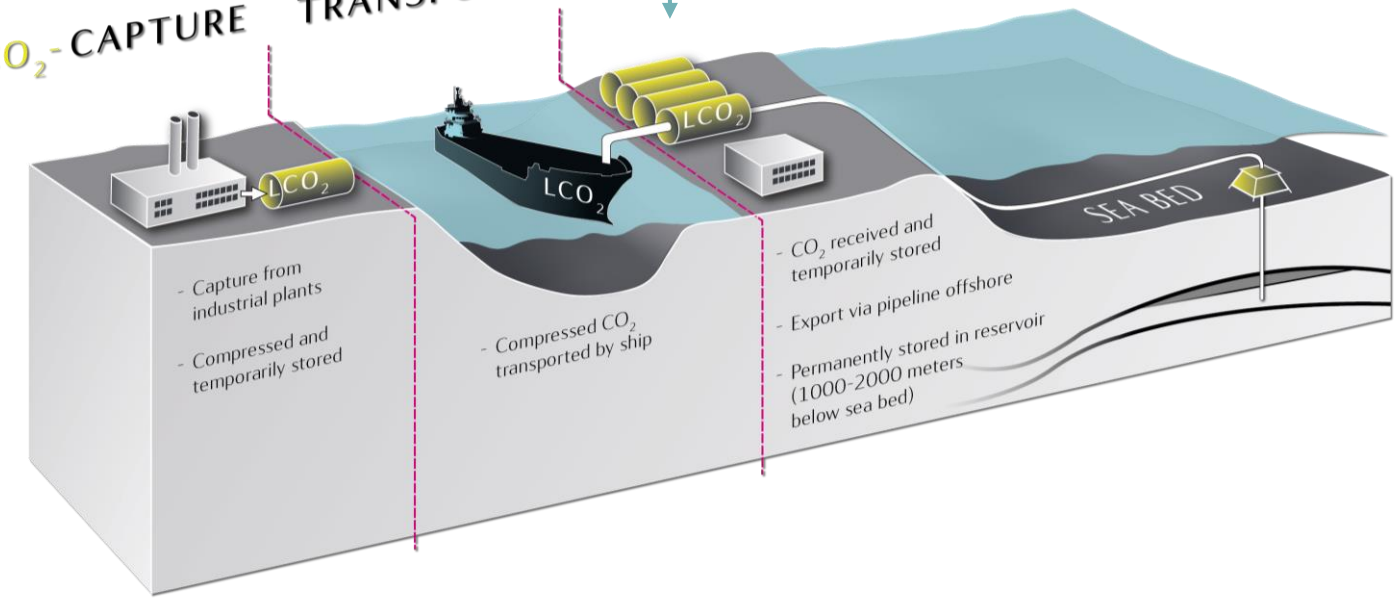
H_2

CO_2

PERMANENTLY STORED

CO_2 - CAPTURE

TRANSPORT



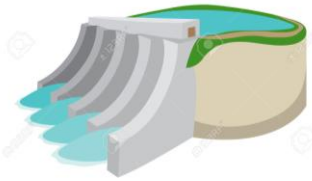
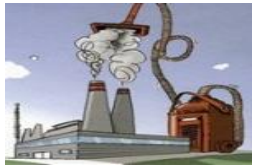
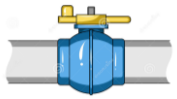
H_2

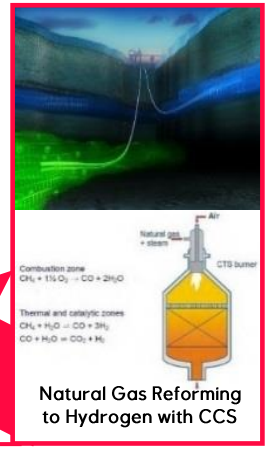
Clean Hydrogen

- for power generation
- for heat
- for maritime transport

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 Renewables	 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

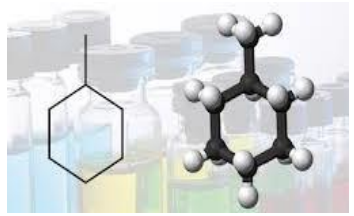
How to bring hydrogen ("decarbonized gas") to the users?

Choice depends on volume & distance

Liquefied H_2 at – 253°C

Ammonia liquid at -33°C

LOHC at ambient T



Liquid Organic Hydrogen Carriers

Compressed H_2 in gas pipeline

Compressed H_2 in containers

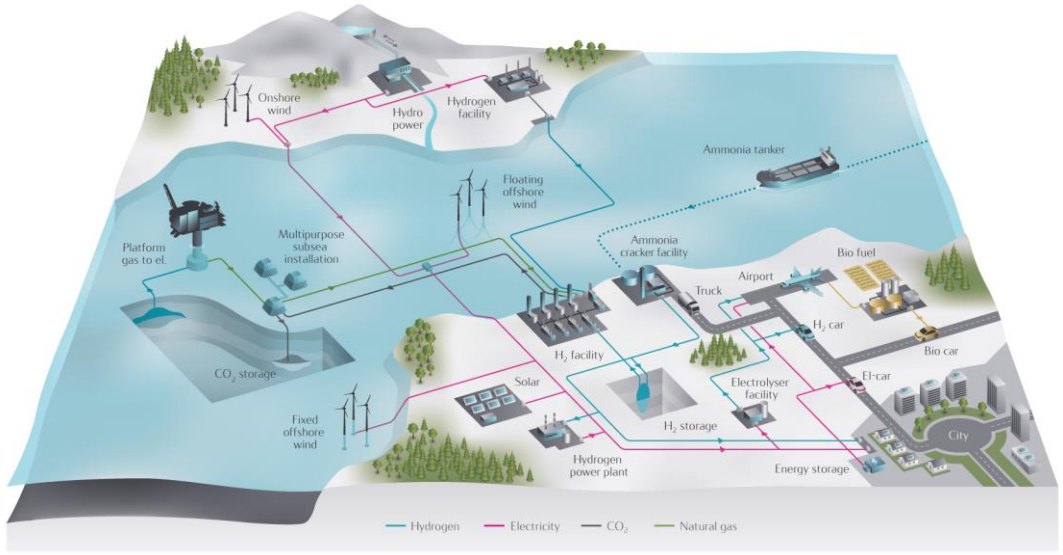
Key data for liquid energy carriers intended for marine transport:

	Liquefied H_2	Ammonia (NH_3)	LOHC* (MCH)	LNG (reference)
Boiling point, °C	-253	-33	101	-162
Volumetric energy content, MJ/m^3	8 600	12 700	5 600 *)	21 600
Volume ratio to LNG (equal energy basis)	2.5	1.7	3.8	1

*) "Based on Methylcyclohexane and theoretically extractable H_2"

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 hydrogen complementary to renewables => require incentives to be realised

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Equinor 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