Low Carbon Solutions

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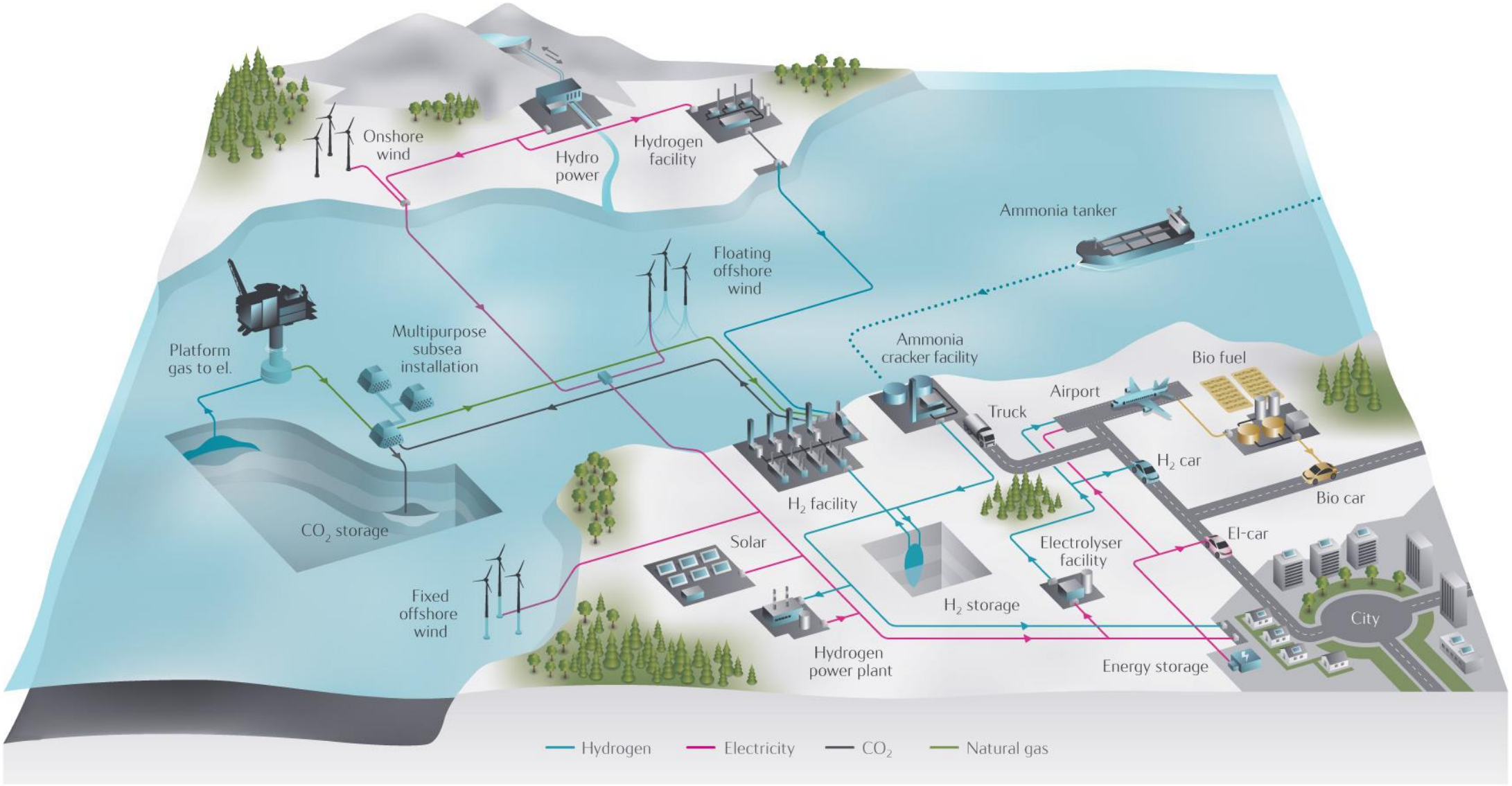
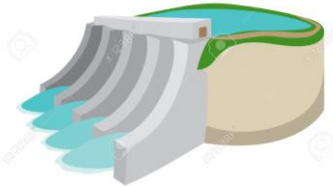
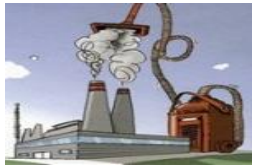
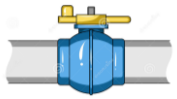
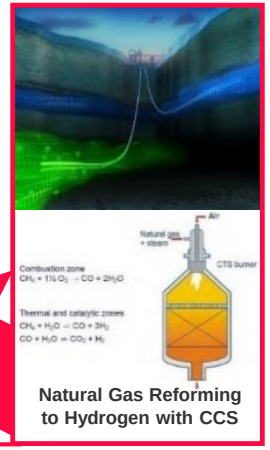


Decarbonising Energy Systems

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

Low Carbon Solutions Portfolio
- building markets for CCS and clean hydrogen

CCS

2023

Northern Lights

- CCS for industry
- Transport of CO2 by ship

Hydrogen

2025

HyDemo Norway

- Liquid hydrogen for maritime
- Distribution of hydrogen
- Integration with existing onshore plants

2026

Zero Carbon Humber

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

2027/28

Clean Steel

- Hydrogen for industry (steel)

2027/28

H2 Magnum

- Hydrogen to power
- Hydrogen for industry
- Flexible back-up for intermittent renewable

Post-combustion

2026

Net Zero Tesside

- Post-combustion CCS power generation
- CCS for industry
- BECCS
- Hydrogen production

It’s not a question of Blue or Green H2…

… it’s a question of timing and cost-effective roadmap to a zero-carbon energy system

Overall Objective

Deliver a zero-carbon energy system by 2050

Renewable electricity generation as an end-game for zero-carbon electrons and molecules (2050+)

Key Constraints

Intermittency of renewables

Energy storage (hydrogen vs electricity)

Industrial capacities and cost outlook

Optimal Roadmap

Energy efficiency favors electrification…

- … but also to use electricity as electrons directly as far as possible

Priority to Renewable as electricity generation, natural gas left with backup function

Develop a hydrogen network as carrier for large-scale energy storage

- Build on existing natural gas infrastructure to save costs
- Start with blue hydrogen to have sufficient momentum early
- Phase in green, intermittent hydrogen from curtailed low-cost renewable electricity
- Expand green hydrogen when the electron sector has been fully decarbonized
- Import green ammonia from global renewable energy hot-spots when the hydrogen market is established