Large Scale Hydrogen Solutions
Steinar Eikaas, Low Carbon Solutions
Decarbonising Energy Systems

**Transport**
- Battery EV
- Electrolyser + Fuel Cell Truck
- Fuel Cell Train
- Cruise Line + Liquid Hydrogen

**Power**
- Air Condition → Solar
- Grid battery
- Hydropower as battery
- Smart Cities
- Clean Back Up / Base Load

**Industry**
- Light Industry → Solar/Wind
- Heavy Industry → Hydrogen
- Post Combustion CCS

**Heat**
- Heat Pumps
- Solar Capture
- Short term storage
- Seasonal Swing
- Long term storage

Multiple technologies to address the challenge
CCS value chain as enabler for clean Hydrogen production

**Step 1**
Establish CCS infrastructure

**Step 2**
Utilize CCS infrastructure to produce clean hydrogen from natural gas and/or import CO2 from Europe
Statoil Hydrogen Portfolio

**Power Generation**
- Utilize existing gas power-plants
- Switch fuel from gas to hydrogen
- Clean baseload electricity
- Clean back-up for solar and wind
- Launch large-scale H2 economy
- Enables H2 to transport later

**Heat**
- Large energy sector in UK
- Difficult (and expensive) to de-carbonize with electricity
- Utilize existing gas network
- Synergies with industry/power gen
- Enables H2 to transport later

**Maritime**
- Battery solutions not available
- Compressed or Liquefied H2
- Utilize existing gas processing plants to provide low cost H2
- FC efficiency -> CO₂ reductions
- Centralize CO₂ emissions which provides CCS optionality

**Hydrogen**
- to Power Generation
- to Heat
- to Transport
Energy Storage Solutions

360 MW

+ 1 MWh Li-ion batteries

(Equivalent to 10-15 Tesla cars)
Perfect fit of Offshore Wind and Hydrogen

360 MW

440 Mw Unlimited, clean backup

20,000 x 20ft (2.5 days backup)

10 sec backup
UK Energy Consumptions – Huge Seasonal Variations

**UK Energy**
- Gas dominated – 800 TWh
- CO2 emission from gas = 160 MTPA
- Seasonal variations in heat only require 60-80 TWh storage/flexible supply

**Gas Power**
- 20-25 GW installed capacity
- Majority swing producers
- Increase with phase out of coal

**Norwegian Gas to UK**
- The UK «energy storage»
- 40% of Norwegian gas export
- Norwegian total gas export= 1100 TWh
H21 – Statoil Clean Hydrogen Concept Development

**Hydrogen Production and seasonal storage**
- Technology Evaluation
- Supplier and references
- Establish CAPEX estimates
- Efficiency and CO2 capture rate
- Risk evaluation
- Technology selection
- Ammonia storage and import

**CO2 Transport and Storage**
- Establish a transport and storage solution for 15 mtpa in 25 years
- Review potential for 75 mtpa in 50 years
- Mapping UK storage sites in SNS
- Detailed analysis of selected sites
- CO2 shipping and pipeline transport

**System Design**
- 1-10 GW facility design, CO2 transport and storage solution based on Statoil project execution model
- Operation and redundancy
- Project schedule and investment cost
- GVA and Environmental performance
- Economic assessment

SMR, ATR, Ammonia cracking and Electrolysis
Liquid Hydrogen from Tjeldbergodden

**Maritime**

- Traditional battery solutions not available (2-3 hours of range)
- Introduce Liquefied Hydrogen as battery (up to 30 days of range)
- Utilize TBO for low cost Hydrogen
- Fuel Cell efficiency $\rightarrow$ CO$_2$ reductions
- Centralize CO$_2$ $\rightarrow$ CCS optionality

**LIQUID HYDROGEN to Transport**

**New low-carbon solution for maritime transport**

- Cruise segment has clear benefits from zero emissions
- Fuel cost is small compared to operating the hotel
- Introduces interesting logistics solutions (new markets)

**Discussions with Viking Cruises**

- Two vessels initially, options for more
- Could materialise with FID in 2021, operational in 2024

**Growth opportunity for Tjeldbergodden**

- Utilise existing H2 reformer, build H2 liquefaction and storage
- Introduce CCS when critical scale is reached
- Potential for 50 cruise vessels (= no methanol)
Potential Hydrogen Infrastructure based on Liquid Hydrogen coming from sea

- Building hydrogen infrastructure is like laying a puzzle (start with the best pieces)
  - West Coast innovative maritime industry cluster
  - Existing natural gas reformer available
  - Large projects to secure long-term demand
  - Innovative solutions using proven technology

- Hydrogen infrastructure built from the sea
  - Liquid hydrogen transported on ships
  - Establish liquid hydrogen terminals in key cities
  - Enable both liquid and compressed hydrogen
  - Phase-in renewable hydrogen as a substitute source over time