CCS and Hydrogen Projects

Northern Lights - Decarbonising Industry
H21 North of England – Decarbonising Heat
H2M-Magnum – Decarbonising Electricity
Zero Carbon Humber – Decarbonising Industry
The Challenge and the Tool-Box

Clean
Reliable and Safe
Affordable

Cost Efficiency EL : MOL
Energy Transport 1 : 10
Long Term Storage 1 : 100

European Energy-Mix 2018

Green Hydrogen and Power to X
- Electrolyser and Fuel Cell
- CCS
- Blue Hydrogen
  - Permanent CO2 Storage (CCS)
  - Gas Reformer w/CCS

Renewable EL
- Nuclear

Zero Carbon EL
- Hydrogen fired EL power

Improve Carbon Efficiency
- Switch from Coal …
- … to Natural Gas
## Blue Hydrogen – What Will it Cost?

<table>
<thead>
<tr>
<th>Sector</th>
<th>Price Premium</th>
<th>Compared to …</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>+25%</td>
<td>Grey Hydrogen</td>
</tr>
<tr>
<td>Heat</td>
<td>+50%</td>
<td>Natural Gas</td>
</tr>
<tr>
<td>Power (on demand)</td>
<td>+100%</td>
<td>Natural Gas</td>
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</tbody>
</table>
A European “open source” network for CO2 removal

THE EUROPEAN CO₂ NETWORK

Source: Bellona Europe
Project status & future

• **Transport, intermediate storage, pipeline**
  FEED to be delivered Q3 2019

• **Storage**
  – Use permission Nr 001 given for “Aurora” south of Troll
  – Confirmation well to be drilled November 2019, subsea equipment is being built

• **Potential beyond anchor customers**
  In dialogue with 15 possible users in 8 European countries

• **Investment decisions**
  Planned for December 2020 (State budget)

• **Operational 2023**
  Then all emitters have a storage solution – start capture!
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 NoE supply concept

Greenfield Hydrogen Facility
- Location: Easington
- Capacity: 12 GW
- Configuration: Multi train, self-sufficient with power

Hydrogen Storage
- Location: Aldbrough
- Capacity: 8 TWh
- Configuration: 56 caverns at 300,000 m³

CO₂ Storage
- Location: Bundter
- Capacity: +600 Million @ 17 mtpa
- Configuration: Saline aquifers
## H21 - What will it cost?
### 2035 Residential Prices

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Price 2035 (BEIS Projection)</th>
<th>CO2 Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>£200/MWh</td>
<td>50 g/KWh</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>£50/MWh</td>
<td>200 g/KWh</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>£75/MWh (H21)</td>
<td>15 g/KWh (H21)</td>
</tr>
</tbody>
</table>
The next steps

<table>
<thead>
<tr>
<th>Year</th>
<th>Critical Safety Evidence</th>
<th>Strategic Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>BEIS Led: £25m ‘Hy4Heat’</td>
<td>H21 North of England (H21 NoE)</td>
</tr>
<tr>
<td>2020</td>
<td>GDN Led: £10.3m H21 NIC</td>
<td>H21 Strategic Modelling</td>
</tr>
<tr>
<td>2021</td>
<td>GDN led: £5m Field Trials (NOT YET FUNDED)</td>
<td>H21 Domestic &amp; Commercial Metering</td>
</tr>
<tr>
<td>2022</td>
<td>Live Trial (one winter)</td>
<td>The Critical Evidence Justifies the safety case for the live trial (NOT YET FUNDED).</td>
</tr>
<tr>
<td>2023</td>
<td>The Critical Evidence Justifies the safety case for the live trial (NOT YET FUNDED).</td>
<td>H21 NoE: £250m FEED Study (NOT YET FUNDED)</td>
</tr>
</tbody>
</table>

Earliest Policy Decision
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: &
Zero Carbon Humber

Our vision
CCS Projects
Northern Lights - Decarbonising industry
H21 North of England – Decarbonising heat
H2M-Magnum – Decarbonising electricity
Zero Carbon Humber - Decarbonising industry

Steinar Eikaas