Wind to Hydrogen in Southwest England

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Importance: Hydrogen powers the globe without carbon

Net Zero Commitment

2019

• Hydrogen Strategy

2021

• Net Zero Strategy: Build Back Greener

2022

Energy Security Strategy

2022

10 GW low carbon H₂

PM’s 10-point plan
For a green industrial revolution
5 GW low carbon H₂

H₂ development timeline in the UK
2021 Electricity Generation in the UK

<table>
<thead>
<tr>
<th>Year Q</th>
<th>Bioenergy</th>
<th>Offshore wind</th>
<th>Onshore wind</th>
<th>Solar PV</th>
<th>Hydro</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020 Q1</td>
<td>11.8%</td>
<td>14.8%</td>
<td>15.3%</td>
<td>2.5%</td>
<td>2.7%</td>
</tr>
<tr>
<td>2021 Q1</td>
<td>12.3%</td>
<td>11.8%</td>
<td>13.4%</td>
<td>2.1%</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

Percentage of total electricity generation
Fluctuation between production and consumption

![Graph showing fluctuations between production and consumption](image-url)
Let’s store it! Wind-to-H₂
Future Energy Scenario

(National grid ESO, 2020a, p. 15)
Case study: Southwest England
Case study: SW England

- Energy Source: Offshore wind
- Hydrogen Production: Electrolysis - (PEM electrolyser, Desalinator)
- Hydrogen Transport: New subsea pipeline
  - Existing natural gas transmission pipelines
  - New and retrofitted distribution pipelines
- Hydrogen Storage: Linepack in pipeline
- Application: Seasonal salt cavern (summer)
  - Heat homes in the Southwest
Case study: Wind to H₂ in Southwest Region
## H₂ production cost

<table>
<thead>
<tr>
<th>Production technology component</th>
<th>Capacity (MW) (C)</th>
<th>Electrical requirements</th>
<th>Capacity factor (%) (CF)</th>
<th>Cost (£/kW)</th>
<th>Emissions (construction, installation)</th>
<th>Water requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore wind turbine</td>
<td>20 (a)</td>
<td>-</td>
<td>60 (a)</td>
<td>1,000 (h)</td>
<td>4gCO₂eq/kWh in 2050 (c)</td>
<td>-</td>
</tr>
<tr>
<td>PEM Electrolyser</td>
<td>20 (4 X 5MW electrolyser units (d))</td>
<td>33.33kWh/kgH₂, with 79% efficiency = 42kWh</td>
<td>(Efficiency) ~79% (e)</td>
<td>370 (f) and (E2)</td>
<td>1.2gCO₂eq/kWh (i)</td>
<td>9L/kgH₂(b)</td>
</tr>
<tr>
<td>Desalination (SWRO)</td>
<td>-</td>
<td>0.027kwh/kg</td>
<td>-</td>
<td>£0.21/kW (f)</td>
<td>No isolated data of indirect emissions (g)</td>
<td>-</td>
</tr>
</tbody>
</table>
## Comparison with natural gas (2020 vs. 2050)

<table>
<thead>
<tr>
<th>Source</th>
<th>Emissions in 2020 (g/kWh)</th>
<th>Emissions in 2050 (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>183.6 (a)</td>
<td>183.6 (a)</td>
</tr>
<tr>
<td>H₂ from wind Southwest</td>
<td>12</td>
<td>5.2</td>
</tr>
<tr>
<td>% Reduction in emissions between natural gas and H₂ in 2050</td>
<td>-</td>
<td>97%</td>
</tr>
</tbody>
</table>

## Emissions compared with current natural gas use

<table>
<thead>
<tr>
<th>Source</th>
<th>Natural gas price (£/MWh)</th>
<th>H₂ price (this project) (£/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>16.4 (a)</td>
<td>62</td>
</tr>
<tr>
<td>2050</td>
<td>27 (b)</td>
<td>43</td>
</tr>
</tbody>
</table>
Conclusions

• The case study demonstrates that replacing natural gas with hydrogen in the Southwest, and nationwide, is feasible in terms of overall sustainability and emissions reductions, and would contribute to net-zero goals.

• It is clear that green hydrogen could be a successful heating solution for the Southwest.

• The conversion efficiency of high purity hydrogen from electrolyser need to be further improved in order to reduce the cost.

• The other scenarios need to be further analysed.

• A model for optimising both economics and feasibility is under development, with taking into account wind power output, electrolyser size, hydrogen amount, NPV, DPB etc.
Acknowledgement

Dr Shuya Zhong

Ms Rosie Rees
Onshore hydrogen production
Offshore hydrogen production

Offshore

Production and conditioning

Substation

DC Electricity

H₂ Compression

H₂ Liquefaction

NH₃ Conversion

LOHC Conversion

H₂ production platform

Transportation

Electricity

H₂ production

Pipeline

H₂ reconversion

Vessel

Import terminal

CH₂

Distribution

LH₂

Pathway 1

Pathway 2

Pathway 3

Pathway 4 a/b

Pathway 5 a/b