A syngas network for reducing industrial carbon footprint and energy use

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The basic proposition

There is a case for building syngas (or synthesis gas) networks as a means of contributing to the reduction of industrial carbon footprints.
What is syngas?

• To a chemist: $H_2 + CO$
• Usually also contains $CO_2$
• Often contains methane
• Contaminants: $H_2S$, COS, particulates, tars, nitrogen compounds
• Composition depends on feedstock, gasification conditions, choice of gasification technology, choice of oxidant, extent of clean-up
Outline of presentation

• Syngas from fossil fuels
• Syngas from sustainable sources
• Syngas for power, heat, fuels & chemical feedstocks/products
• CO₂ capture & storage?
• Pathways that reduce net energy footprint or CO₂ emissions
• The case for building a syngas network
• Syngas network development – the issues.
Syngas from fossil fuels

Eston Grange 850MW IGCC plant with CCS
Syngas from fossil fuels

<table>
<thead>
<tr>
<th>Composition</th>
<th>% v/v</th>
<th>Contaminants</th>
<th>g/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>61</td>
<td>Dust</td>
<td>Nil</td>
</tr>
<tr>
<td>Methane</td>
<td>25</td>
<td>Ammonia</td>
<td>0.1</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>5</td>
<td>Naphthalene</td>
<td>0.5</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>2</td>
<td>Benzole</td>
<td>4 – 15</td>
</tr>
<tr>
<td>Ethane</td>
<td>1</td>
<td>Hydrogen Sulphide</td>
<td>1 – 5</td>
</tr>
<tr>
<td>Ethylene</td>
<td>2</td>
<td>Hydrogen Cyanide</td>
<td>0.1 - 5</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UCG

Coke oven gas
Syngas from sustainable sources
Syngas from sustainable sources

Gussing plant, Austria
Syngas for power, heat, fuels & chemical feedstocks/products

- **Fischer-Tropsch synthesis**
  - Iron or cobalt catalyst
  - 200-350°C
  - 20-40bar
  - Heavy waxes for diesel, or light olefins for gasoline

- **Methanol synthesis**
  - Copper-zinc catalyst
  - 220-300°C
  - 50-100bar
  - Methanol

- **Mixed alcohols synthesis**
  - Alkali-FT or Alkali-methanol catalyst
  - 260-425°C
  - 30-300bar
  - Mixed alcohols: methanol, ethanol and higher alcohols

- **Syngas fermentation**
  - Biological: anaerobic microbes
  - 20-40°C
  - Atmospheric
  - Ethanol and/or other alcohols

How pure does syngas need to be?

<table>
<thead>
<tr>
<th></th>
<th>Raw syngas (mg/Nm³)</th>
<th>Engine (mg/Nm³)</th>
<th>Chemical synthesis (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur</td>
<td>750</td>
<td>50</td>
<td>0.1</td>
</tr>
<tr>
<td>Halides</td>
<td>15</td>
<td>15</td>
<td>0.1</td>
</tr>
<tr>
<td>Particulates</td>
<td>2500</td>
<td>15</td>
<td>0.001-0.01</td>
</tr>
</tbody>
</table>

CO\textsubscript{2} capture from syngas

\begin{eqnarray*}
\text{CO } + \text{H}_2\text{O} & \leftrightarrow \text{H}_2 + \text{CO}_2 \\
\end{eqnarray*}
# Technologies for CO$_2$ separation

<table>
<thead>
<tr>
<th>Chemical absorption</th>
<th>eg mono-ethanolamine</th>
<th>Developed in 1940s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical absorption</td>
<td>eg pressure swing absorption</td>
<td>Mature technology</td>
</tr>
<tr>
<td>Membranes</td>
<td>eg cellulose acetate, polydimethylsiloxane, polyvinyl alcohol</td>
<td>Compact, simple, low maintenance &amp; energy efficient. Working on selectivity, permeability &amp; cost.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Technology of choice today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very small</td>
<td>Membrane units</td>
</tr>
<tr>
<td>&lt;5 million scfd</td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>Amine and membrane units compete</td>
</tr>
<tr>
<td>5-40 million scfd</td>
<td></td>
</tr>
<tr>
<td>Medium/large</td>
<td>Amine units are cheaper</td>
</tr>
<tr>
<td>&gt;40 million scfd</td>
<td></td>
</tr>
</tbody>
</table>

CO$_2$ capture & storage?
Pathways that reduce net energy footprint or CO$_2$ emissions

• Where the original source of the syngas is sustainably grown biomass
• Where the original source of the syngas is waste oils, flare gases or other carbonaceous industrial wastes
• Where syngas is decarbonised and used for power generation or hydrogen displacement
• Where CO$_2$ is captured during syngas conversion (eg to ammonia)
• Where syngas is converted into long-life polymers
• Carbon-negative combinations?
The case for building a syngas network

• Carbon floor price is coming
• Energy-intensive industries in the UK are struggling to secure Government support (except possibly for the electricity-intensive industries)
• There are options for reducing energy footprint & CO₂ emissions using syngas
• Relevant plants are spatially distributed in regional clusters – so a network is needed
• The same concept applies to other process industry clusters around the world with the same or similar drivers.
Buffer storage

- Brine Reservoir
- Brine Heater
- Heat exchanger
- Condensate
- Steam
- Hydrogen in
- Hydrogen out
- 300 – 400m

F: Duplicated product flow meter
Not shown: Emergency shutdown system
Knockout pots
Filters
Syngas network development – the issues

- Sizing the network
- Timing its growth
- Determining ownership & access arrangements
- Planning & regulatory hurdles
- Wide range of “syngas” compositions.
Questions?

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