Integrating CO$_2$ into the value chain – the Role of Chemistry
The twin problems of fossil fuels

**Reserves (Current usage)**

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>12.1</td>
<td>4.8</td>
<td>50.3</td>
<td>19.24</td>
</tr>
<tr>
<td>India</td>
<td>4.2</td>
<td>1.5</td>
<td>8.5</td>
<td>17.5</td>
</tr>
<tr>
<td>USA</td>
<td>19.9</td>
<td>22.2</td>
<td>11.9</td>
<td>4.45</td>
</tr>
</tbody>
</table>

Fracked gas and shale oil?

Energy return on energy investment EROEI is low (12 – world economy could be destabilised at 10)

Global Warming and Climate Change

BP Statistical Review of World Energy 2014
Is Global Warming Real?

Are CO$_2$ levels rising?

> 20 % in 40 years mainly from burning fossil fuels
Are CO$_2$ levels and temperature related?

Analysis of ice cores in Greenland

CO$_2$ rises **follow** rises in temperature, so do not cause the rises in temperature.
Recent rises in CO$_2$ and temperature

Almost all scientists now believe that increased global warming is caused by the actions of mankind.

Temperature rise occurred after rise in CO$_2$ levels.
Can the problem also be the solution?

We need a new carbon source
We need to remove CO$_2$ from the atmosphere

Coal
Oil
Gas

Chemicals (<10 %)

hydrogen
gasoline
Gasoline from CO$_2$

**Problems**

**Distribution of CO$_2$**
- 400 ppm in atmosphere

**BUT**

**Source of hydrogen**
- Currently from fossil fuels

**BUT**

$\text{H}_2\text{O} \xrightarrow{\text{catalyst}} \text{H}_2 + \frac{1}{2} \text{O}_2$

12-14% CO$_2$

10-15% CO$_2$

10% efficiency
Water splitting


6.9 % efficiency
Conclusions

- CO\textsubscript{2} can make a significant contribution to chemicals production, reducing the carbon footprint.
- In the longer term CO\textsubscript{2} could contribute to reducing carbon emissions from fuels:
  - Need ways of collecting dilute CO\textsubscript{2}
  - Need a sustained and efficient way of producing hydrogen from water using sunlight.