Direct Air Capture promises near future business opportunities

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Direct Air Capture will have an important role to reach climate goals

1. Mitigate climate change
2. Immediate actions
3. Business potential
How to make Direct Air Capture profitable for future business?
Various factors affect CO$_2$ capture price

<table>
<thead>
<tr>
<th>Technology</th>
<th>Price distribution</th>
<th>Synergies of excess heat</th>
<th>Market potential</th>
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</thead>
</table>

DAC x Helen
Adsorbent technology captures CO$_2$

1. Air capture
2. CO$_2$ binds to adsorbent
3. Heat to release CO$_2$

CO$_2$ utilization or storage

Filtered air released

Graph adapted from Cbnsights
Picture from Climeworks
Moving towards 145 €/tCO₂ by 2030

\[ LCOD = \frac{capex \cdot crf + opexFix}{output_{DAC}} + opeX_{var} + cost_{electricity} + cost_{heat} + cost_{sorbent} \]

<table>
<thead>
<tr>
<th>Plant size</th>
<th>100000 tCO₂/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target year</td>
<td>2030</td>
</tr>
<tr>
<td>Electricity price</td>
<td>50 €/MWh</td>
</tr>
<tr>
<td>Heat price</td>
<td>20 €/MWh</td>
</tr>
<tr>
<td>Sorbent price</td>
<td>50 €/kg sorbent</td>
</tr>
</tbody>
</table>

Price estimation

145 €/tCO₂
Optimistic scenario results in extremely low price

- Reduced energy demand:
  - Optimistic: 1340 kWh/t CO₂
  - Base: 1725 kWh/t CO₂

- Much higher sorbent lifetime:
  - Optimistic: 30000 cycles
  - Base: 5000 cycles

- Reduced capex:
  - Optimistic: 18.9 M€
  - Base: 33.8 M€

**Price estimation**

<table>
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<tr>
<th>Scenario</th>
<th>Optimistic scenario</th>
<th>Base scenario</th>
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<tbody>
<tr>
<td>Price (€/tCO₂)</td>
<td>70 €/tCO₂</td>
<td>145 €/tCO₂</td>
</tr>
</tbody>
</table>

* VTT (2022)
**Fasihi (2019)
Adsorbent and heat dominate the price

LCOD Distribution - Base Scenario

- Heat: 30 €
- Adsorbent: 57 €
- Capex: 29 €
- Opex fixed: 14 €
- Opex var: 4 €

LCOD Distribution - Optimistic Scenario

- Heat: 24 €
- Adsorbent: 9 €
- Capex: 16 €
- Opex fixed: 8 €
- Opex var: 4 €
- Electricity: 9 €
Industrial excess heat is a good heat source for DAC

DAC requirement

Nuclear*

Steel mill**

Amount of heat (GWh/a)

DAC requirement

Nuclear

Steel mill

DAC x Helen

* Fortum, TVO
** Fasihi (2019)
DAC demand potential for industries

Potential for capacity demand (MtCO₂/year)

Relative climate benefits

- Cement
- Polymers
- Fuels

0-100 100-500 > 500

IEA 2019: Putting Carbon to Use
How to make Direct Air Capture profitable for future business?

- Low temperature technology has advantages
- Adsorbents need to become more feasible
- Industrial excess heat meets the requirements
- Synthetic fuels production most appealing