A look at incentive policies for BECCS

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Bio-CCS can provide ‘negative emissions’

- Bio-CCS has the potential to reduce atmospheric concentrations of CO₂
  - CO₂ sequestered from air as biomass grows is not returned to atmosphere
    - sustainability needs to be ensured
  - may well be needed for climate stabilisation, in particular looking beyond 2050

<table>
<thead>
<tr>
<th>Process</th>
<th>CCS</th>
<th>BECCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>sequestration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combustion</td>
<td>+1</td>
<td>+1</td>
</tr>
<tr>
<td>Storage</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>Lifecycle emissions</strong></td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

Note: Table only includes abstract values

Should be reflected as extra incentive
Large-scale *projects* moving ahead

- **Power (pre-combustion):**
  - Kemper, United States
  - TCEP, United States

- **Power (post-combustion):**
  - Boundary Dam, Canada
  - ROAD, Netherlands
  - Enid, United States, 1982
  - Decatur, United States
  - Port Arthur, United States

- **Iron and steel:**
  - Shute Creek, United States, 1986
  - Great Plains, (Weyburn), United States

- **Biofuels:**
  - Val Verde, United States, 1972
  - Sleipner, Norway, 1996

- **Refining:**
  - Shute Creek, United States, 1986
  - Enid, United States, 1982

- **Chemicals:**
  - Shute Creek, United States, 1986
  - Great Plains, (Weyburn), United States

- **Gas processing:**
  - Enid, United States, 1982
  - Sleipner, Norway, 1996

- **CO₂** captured and used for EOR:
  - Size = 1MtCO₂/yr captured

- **CO₂** used for storage without EOR:
  - Size = 1MtCO₂/yr captured

Source: IEA, GCCSI
Carbon Storage at an Ethanol Production Facility: Illinois Basin – Decatur Project (IBDP), Decatur, Illinois, USA

Operational Injection:
17 November 2011

• IBDP fully operational 24/7
• IBDP is the first 1 million tonne carbon capture and storage project from a biofuel facility in the US
• Injection through fall 2014
• Intensive post-injection monitoring under MGSC through fall 2017
• Cumulative Injection (10 June 2013): 504,900 tonnes

Source: Rob Finley, Midwest Geological Sequestration Consortium, University of Illinois, USA
The starting point: Economic characteristics of CCS technology will change with time
Markets failures produce outcomes that are not socially optimal

- Complementary Markets
- Externality
- Incomplete information
- Public good
# Market failure as rationale for intervention

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Example policies</th>
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</thead>
<tbody>
<tr>
<td><strong>Emissions externality</strong></td>
<td>Carbon tax or emissions trading scheme</td>
</tr>
<tr>
<td><em>Failure to internalise the cost of greenhouse gas emissions</em></td>
<td></td>
</tr>
<tr>
<td><strong>Public good</strong></td>
<td><em>Quantity</em>-based instruments: feed-in tariff, portfolio standards</td>
</tr>
<tr>
<td><em>Failure to appropriate returns generated by investments in innovation</em></td>
<td></td>
</tr>
<tr>
<td><strong>Risk and capital market failure</strong></td>
<td>Provision of debt/equity, grants, investment tax credits, insurance</td>
</tr>
<tr>
<td><em>Underprovision of private capital resulting from imperfect information</em></td>
<td></td>
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<tr>
<td><strong>Complementary markets</strong></td>
<td>Regulation</td>
</tr>
<tr>
<td>Undersupply due to dependency on complementary markets and coordination failure</td>
<td></td>
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</tbody>
</table>
The policy dilemma

- Change in the characteristics of CCS, and associated focus of incentive policy, creates a challenge for policy-making
  - on the one hand, want to be able to adapt and modify policy as technology changes or new information comes to light
  - on the other hand, the (perception of) changing policy may damage investment

Investor wants stability and predictability

Policy

Policy maker wants flexibility
Possible Gateways within a CCS Policy Framework

Incentive mechanisms are specific to deployment stage.
Decarbonising electricity generation from coal

Large-scale, commercial power generation

Cases analyzed:
- Coal without CCS (Coal)
- Coal with CCS (Coal-CCS)
- Bioenergy without CCS (Bioenergy)
- Bioenergy with CCS (Bioenergy-CCS)
- Coal co-fired with 30 % biomass with CCS (Coal-Cofired)
Instruments analyzed

- **CO₂ Emission Penalty** per tonne of CO₂ emitted (as used in CO₂ Cap and Trade Scheme or CO₂ Tax)
- **Feed-in-Tariff** per kWh produced using biomass and/or CCS

Additional BECCS-specific mechanisms:

- Bonus for negative emissions
- Feed-in-Tariff for using BECCS

Impact on net production cost analyzed
Costs and emission penalty

- CO₂ emission penalty for coal power emissions
- No feed-in-tariff
- No negative CO₂ emission bonus

Coal-CCS most attractive above ~60 €/t CO₂
No incentive for using Bioenergy-CCS
Costs and feed-in tariff

- CO₂ emission penalty for coal power emissions at 30 €/tonne
- Feed-in-tariff for using biomass
- Negative CO₂ emission bonus for BECCS (of same value as CO₂ emission penalty)

Bioenergy-CCS most attractive above ~2.8 €-ct/kWh
Strong incentive for using Bioenergy-CCS
### Summary of Results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CO₂ Emission Penalty</th>
<th>Feed-in-Tariff</th>
<th>Negative CO₂ Emission Bonus</th>
<th>Most economic low-CO₂ emission option</th>
<th>Inventive for using BECCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For coal</td>
<td>-</td>
<td>-</td>
<td>Coal-CCS above ~60 €/t&lt;sub&gt;CO₂&lt;/sub&gt;</td>
<td>✗</td>
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<tr>
<td>2</td>
<td>For coal</td>
<td>-</td>
<td>for BECCS</td>
<td>BECCS above ~40 €/t&lt;sub&gt;CO₂&lt;/sub&gt;</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>For CCS</td>
<td>-</td>
<td>Coal-CCS above ~2.5 €-ct/kWh</td>
<td>✗</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>For biomass</td>
<td>-</td>
<td>Bioenergy above ~60 €-ct/kWh</td>
<td>✗</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>For CCS and biomass</td>
<td></td>
<td>BECCS above ~6.5 €-ct/kWh</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>For coal (at 30 €/t&lt;sub&gt;CO₂&lt;/sub&gt;)</td>
<td>For biomass</td>
<td>For BECCS (at 30 €/t&lt;sub&gt;CO₂&lt;/sub&gt;)</td>
<td>BECCS above ~2.8 €-ct/kWh</td>
<td>✓</td>
</tr>
</tbody>
</table>
Conclusions

- Today, neither conventional CCS nor BECCS are competitive.
- A CO$_2$ emission penalty alone does stimulate conv. CCS but not BECCS.
- A feed-in-tariff for using CCS reduces costs of conventional CCS and BECCS, but conventional CCS always remains more attractive.
- A feed-in-tariff for using biomass reduces costs of conventional bioenergy and BECCS, but bioenergy without CCS always remains more attractive.
- A combined feed-in-tariff for CCS and biomass would incentivize using BECCS.
- An additional bonus for negative CO$_2$ emissions would effectively incentivize using BECCS (at comparably low €/t$_{CO2}$).
Thank you

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www.iea.org/ccs