Climate Accounts for various CCUS measures

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Agenda

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2. The inputs
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   II. Resource efficiency
3. Accounting for emissions reductions in the current EU legislation
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Types of Carbon Capture and Use
The CO2 molecule is transformed into a new compound by chemical transformation, breaking down with enzymes (photosynthesis) or a process where a catalyst is used.

Sources: Zheng et al. 2017
Types of CCU

Applications range from chemicals and fuels, to fertilisers and enhanced oil extraction.
“From fluffy pillows to concrete” (BBC, 2017)

Sources: Zheng et al. 2017
Types of CCU

Storage potential and comparison to CCS

From a climate perspective, the extent to which a CCU process can contribute towards climate change mitigation depends on the lifecycle of the product and whether and when the captured CO₂ is released into atmosphere. Treating all forms of CCU as de facto CO₂ abatement could have serious detrimental impacts on efforts to reduce emissions.

**Short term storage:** 10 years or less before release of utilised CO₂.

**Medium term storage:** 10 to 100 years before release of utilised CO₂.

**Long term or permanent storage:** CO₂ prevented from entering the atmosphere for a century or more.

The emerging markets for CO₂ use will only be able to address a small proportion of the emissions that will need to be abated to meet climate targets.
The inputs
Types of CCU

Carbon dioxide is a molecule of **low thermodynamic potential**.

".../ it is known that the activation of C-O bonds in CO$_2$ molecules is hindered by its nature from a thermodynamic and kinetic standpoint. The high chemical/electrochemical stability of CO$_2$ is a basic contradiction for conversion." Zheng et al. 2017

*used to calculate the maximum of reversible work that may be performed by a thermodynamic system at a constant temperature and pressure (isothermal, isobaric).
Chemicals and Fuels

1. Relevant ongoing legislative process – the Renewable Energy Directive

2. Headlines, research and support from member states such as Germany

The entrepreneurs turning carbon dioxide into fuels

The race is on to prove that CO2 can be taken from the air and recycled into profitable, carbon neutral fuels. But cost and investment obstacles remain.

Bosch: synthetic fuels can make combustion engines CO2-neutral

Taking the leap in June 2015, the three founded Opus 12 which aims to develop a device to capture carbon emissions from its source, and to create valuable products in the process – i.e. clean-burning fuels and chemicals.

Can clean synthetic diesel fuels succeed?

Some German industry officials have lately been touting 'e-fuels,' synthetic liquid fuels that can be burned in diesel engines, as an alternative to an all-electric automotive future. Is this workable - or mere PR?
Chemicals and Fuels


2. Headlines, research and support from member states such as Germany
**Methane production from syngas** goes back to more than 100 years of research and process development. (Ronsch et al. 2016)

*Source: Bocin-Dumitriu et al. 2013, Joint Research Centre*

<table>
<thead>
<tr>
<th>CO2 re-use technology</th>
<th>Uptake potential (Mt/y)</th>
<th>Research &amp; Industrial engagement</th>
<th>TRLs</th>
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<tbody>
<tr>
<td>Methanol production</td>
<td>&gt; 300</td>
<td>++ +</td>
<td>4-6</td>
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<tr>
<td>(Carbonate) Mineralisation</td>
<td>&gt; 300</td>
<td>++ +</td>
<td>3-6</td>
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<tr>
<td>Polymerisation</td>
<td>5 &lt; demand &lt; 30</td>
<td>++ +</td>
<td>8-9</td>
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<tr>
<td>Formic acid</td>
<td>&gt; 300</td>
<td>++ +</td>
<td>2-4</td>
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<tr>
<td>Urea</td>
<td>5 &lt; demand &lt; 30</td>
<td>++ +</td>
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<tr>
<td>Enhanced coal bed methane recovery</td>
<td>30 &lt; demand &lt; 300</td>
<td>+ . .</td>
<td>6</td>
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<tr>
<td>Enhanced geothermal systems</td>
<td>5 &lt; demand &lt; 30</td>
<td>+ + .</td>
<td>4</td>
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<tr>
<td>Algae cultivation</td>
<td>&gt; 300</td>
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<td>Concrete curing</td>
<td>30 &lt; demand &lt; 300</td>
<td>+ + .</td>
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<tr>
<td>Bauxite residue treatment</td>
<td>5 &lt; demand &lt; 30</td>
<td>+ + .</td>
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<tr>
<td>Fuels engineered micro-organism</td>
<td>&gt; 300</td>
<td>+ + .</td>
<td>2-4</td>
</tr>
<tr>
<td>CO2 injection to methanol synthesis</td>
<td>1 &lt; demand &lt; 5</td>
<td>+ . .</td>
<td>2-4</td>
</tr>
</tbody>
</table>

*Table 3. Overview of the most promising European CCU technological pathways and the DG JRC CO2 reuse shortlisted technologies showing the CO2 uptake potential (based on GCCS/I/Parsons & Brinckerhoff, 2011), the research and industrial engagement and the TRLs.*
“Methane production from syngas goes back to more than 100 years of research and process development.”
(Ronsch et al. 2016)
A simple assessment shows using CCU fuels to reach the target of 3% fuel mixing of EU road transport would require **164 TWh*.  

The amount of CO2 that can be converted to chemicals and materials is relatively small compared to the amount of anthropogenic CO2 emitted from fossil fuel combustion. (Song et al. 2012)
Scale – Emissions reductions

The low conversion efficiency of CCU paired with insufficient low carbon electricity can act as a multiplier of emissions intensity:

With current German grid electricity, the production results in fuel GHG emissions of >330 gCO₂/ MJ. (German Federal ministry for the environment, nature conservation, building and nuclear safety, 2018)

This is 3.5 times more CO₂ intensive than fossil diesel (94.1 gCO₂/ MJ)

Figure 4 | CCS versus CCU—a perspective for the period 2010 to 2050.

Source: Mac Dowell et al., 2018

* EU road transport 3305 TWh x 3% = 99 TWh of Power to liquid fuel. @ 60% conversion efficiency input electricity requirement = 164 TWh
This is all the electricity produced in Europe. It’s used for everything from lighting, air-conditioning, heating, industry etc.

If all passenger cars in Europe were electric, the increase in electricity is significant — but not world changing. It would amount to approximately 800 TWh.

Electrifying EU base industrial chemicals - 140% additional electricity!

Adding the production of synthetic fuels increases electricity demand beyond all reality.

CCU: Using CO2 to produce synthetic fuels

CCU: Using CO2 for the production of chemicals

~ 3,200 TWh

~ 7,600 TWh

~ 14,400 TWh

At what cost?

- Consultant reports on the commercial viability of CCU fuels rely on periods of oversupply and low wholesale prices in the electricity market.

- In addition, commercial operations of CCU fuels are expected to have high utilisation to recover sunk investment costs, estimates 5,000 to 6,000 operating hours a year are required for positive business case.

- The production of the CCU fuels is linked to the CO₂ producers operation.
Accounting for emissions reductions in the current EU legislation
What about the climate?

It’s complicated:

"The process of making such products involves some chemical voodoo."

German Environment Agency
Dr. Harry Lehmann, General Director of Division Environmental Planning and Sustainability Strategies
In comparison to CCS, CCU does not have significant emissions abatement potential.

The MeOH analysis shows CCU to be an inferior mitigation option compared to a system with CCS producing the same fuel without CO₂ utilization. The generalized analysis further reveals that the mitigation potential of CCU for fuels production is limited to 50% of the original emissions of the reference system without CCU. We further highlight that the main challenge to CCU cost reduction is not the CO₂-to-fuel conversion step but the production of required carbon-free electricity at very low cost.


Fig. 3  Total CO₂ avoided per kg of MeOH product as a function of the emission rate, ER (kg CO₂ per kW h) of the power grid elements replaced by the 9.82 kW h of carbon-free electricity available in the full CCS system in Fig. 2.
1 re-use of the CO₂ molecule means a maximum **50% emissions reduction** in ideal conditions.

The standard emissions reduction target for low-carbon fuels is 70% (target for 2021).

Source: Benedikt Stefansson, Director of Business Development - Carbon Recycling International
Robert Edwards, DG JRC, ISPRA, "Proposed principles for calculating emissions from RES fuels of non-biological origin and CCU fuels", presented during the official LCA workshop organised by the European Commission

The life cycle of the product

Available LCA studies (for example a recent JRC publication on “Methanol using captured CO2” [2]) refer to very narrow process boundaries, where CO2 and H2 are entering the boundaries. However, to assess the real mitigation potential of any CCU process it is essential to consider much wider system boundaries.

Source: Abanades et al. 2017, referring to Peres-Fortes et al. 2016

If you can use the industrial carbon dioxide, the only CO2 emissions attached to it are the purification, compression and transport – because otherwise it would be released to the atmosphere.

Classifying CO2 streams as unavoidable waste
Counting the CO₂

- From 1 January 2018 greenhouse gas emission saving vs petroleum alternatives shall be at least 60% for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017 (70% by 2021).

- Counting the CO₂ in and CO₂ out, CCU fuels with industrial CO₂ source does not come close even to the 60% minimum target for biofuels.

Source: Nils Rittenmeier and Thomas Froehlich, IFEU 2017

Ideal: CO₂ reduction of 40%

Realistic: CO₂ reduction of 25%
Double counting CO₂ reductions

- CCU can link emissions from one sector to another
- CO₂ captured in one sector can then be emitted in another
- Different CO₂ reduction policies can become entangled or short-circuited
- Danger of double counting – who gets the credit?
How to avoid buyers remorse?

A full life cycle assessment is needed. The calculation of the climate footprint of these products must account for:

1. **The source of CO2** (e.g. fossil CO2 coming from industry)
2. **The resources and inputs** (e.g. the electricity used for the production of H2)
3. **The final emissions at the end-of-life** stage of the product (e.g. final combustion of a fuel)

In addition to these elements vital to the GHG footprint, the knock on effects on other technologies should be considered. These products should not hinder the deployment of more efficient options.


https://doi.org/10.1016/j.apenergy.2015.07.067

When is CO$_2$ emitted counted as emitted?

In 2012 – Schaefer asked the German authorities, as this CO2 is not “emitted” may they be subtracted from ETS monitoring plan?

Precipitated Calcium Carbonate (PCC)

PCC is used in the Paper industry, healthcare, plastics

CO$_2$ used for the production of PCC is chemically bound in that stable product.
In 2017 ECJ = CCU CO$_2$ not emitted (in this case)

Press: “ECJ acknowledges that CCU is not subject to emissions trading.”; “Bombshell in the ETS”; “ECJ rewards innovation in the ETS”; SK’s lawyers more cautious, refer only to the lime industry

But: ECJ chose to invalidate provisions only for PCC; for all other examples CCU they stand – despite the arguably transferable reasoning

German emissions regulators will continue to apply rules in all other cases, for the time being

Art. 49(1), 2$^{nd}$ sentence and point 10(B) of Annex IV Monitoring Reg. “are invalid in so far as they systematically include […] CO$_2$ transferred to another installation for the production of [PCC] in the emissions of the lime combustion installation, regardless of whether or not that CO$_2$ is released into the atmosphere.”

Roundtable: Power to Liquids - Problem or Solution?
Do we have better ways to use renewable electricity for the same service?

- Electric vehicles (EVs) greatly outperform Internal Combustion Engine (ICE) cars using synthetic fossil fuels in the conversion of renewable electricity to kilometres.
  - Synthetic fossil fuel manufacture with captured industrial CO₂ is ~60% efficient. (Stefansson 2015)
  - ICE cars have an efficiency of 30%, but generally lower. Driving style and idling can reduce efficiency further. (EPA 2014)
  - Electric power transmission and distribution losses in EU-28 (% of output) is 6.5% in 2014. (Worldbank 2017)
  - EVs have an efficiency of 81%. (Samferdselsdepartementet 2017)