Converting a liability into an asset

THE GLOBAL CO₂ INITIATIVE

October 2016
The Global CO$_2$ Initiative (GCI) is building a new pathway for reducing carbon emissions. The novel approach converts CO$_2$ into useful products. GCI is comprised of two platforms: a non-profit to fund R&D (CO$_2$ Sciences), and a for-profit to fund commercial investments.
The Challenge

Annual CO₂ emissions have exceed 35 gigatons

- Approximately 1.9% annual increase
- Only 0.5% is currently captured and used

Mass equivalent:

1.1 billion garbage trucks

The effects of climate change are clearly evident:

- Global temperatures are rising – 2015 was the warmest year on record
- Sea levels have risen by over 80 millimeters since 1993
- Arctic land ice is being lost at 134 gigatons per year
- Arctic sea ice decreasing by 13% per decade

Source: Global Carbon Project, 2015 Carbon Budget
Introduction

CO₂-based products are one part of the solution

Decarbonization
Energy efficiency, clean renewable energy

Adaptation
Managing impacts of climate change

Capture and Storage
Long-term sequestration

Capture and Use
To create valuable CO₂-based products

Progress, but not fast enough
Increasingly necessary
Necessary but costly
Market-driven approach
Key Points

- A large number of products can be created using CO$_2$
- Separation and purification may be avoided in certain applications such as fermentation processes in the biofuels industry
- Some products are viable today; a roadmap for deployment is being developed by The Global CO$_2$ Initiative and is being funded by the Government of Japan and the RK Mellon Foundation
Introduction: Opportunities with some CO₂-based products

<table>
<thead>
<tr>
<th>CCU category</th>
<th>Technology / application</th>
<th>Potential abatement effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ to fuels</td>
<td>Algae cultivation</td>
<td>Displacement of fossil fuel and/or other GHG benefits</td>
</tr>
<tr>
<td></td>
<td>Renewable methanol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Formic acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Photo-catalysis</td>
<td></td>
</tr>
<tr>
<td>Enhanced commodity production</td>
<td>Enhanced geothermal systems with CO₂</td>
<td>Improved efficiency</td>
</tr>
<tr>
<td></td>
<td>Supercritical CO₂ power cycles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urea yield boosting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methanol yield boosting</td>
<td></td>
</tr>
<tr>
<td>Enhanced hydrocarbon production</td>
<td>Enhanced coal bed methane (ECBM)</td>
<td>Temporary storage</td>
</tr>
<tr>
<td></td>
<td>Enhanced gas recovery (EGR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enhanced oil recovery (EOR)</td>
<td></td>
</tr>
<tr>
<td>CO₂ mineralisation</td>
<td>Carbonate mineralisation</td>
<td>Permanent storage</td>
</tr>
<tr>
<td></td>
<td>Concrete curing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bauxite residue treatment</td>
<td></td>
</tr>
<tr>
<td>Chemicals production</td>
<td>Sodium bicarbonate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polymers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other chemical processes</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Ecofys and Carbon Counts, forthcoming
Introduction: Criteria for selecting technologies

We applied five key criteria, both economic and environmental to assess CO₂-based products:

<table>
<thead>
<tr>
<th>Environmental criteria</th>
<th>Economic criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ potential</td>
<td>Willingness to pay</td>
</tr>
<tr>
<td>Permanence of capture</td>
<td>Ease of implementation</td>
</tr>
<tr>
<td></td>
<td>Side effects and co-benefits</td>
</tr>
</tbody>
</table>

- **Total amount of CO₂ that could be captured (tenth of a GT), given technical capacity and market potential**
- **Length of time before the captured carbon is released back into the atmosphere as CO₂ (years)**
- **Based on the economics of the target market, unit cost/price point of CO₂ supply at which product is competitive for that use ($/tonne of CO₂)**
- **Key factors to consider when entering the market, e.g., regulatory and competitive barriers to entry, substitutability of product, distribution channels**
- **Benefits (e.g. energy security, reduced air pollution) and negative side effects (e.g., increased production of fossil fuels)**

Source: McKinsey and Company

Put differently,

1. **Carbon Negative:** Does the process lead to CO₂ reduction?
2. **Material:** Can the process be scaled? Are the markets material?
3. **Commercially viable:** Is the process competitive and commercially viable?
Making the case

In making the case for the CO₂-based products marketplace and for working with the Global CO₂ Initiative, we attempt to answer the following questions:

• **Does carbon capture and utilization work (CCU)?** Does it reduce emissions?
• Does it have a **significant environmental impact**?
• Is the **market opportunity** material?
• **Are CO₂-based products commercially viable?** What does a techno-economic feasibility study look like?
• Is **partnering** the right model to get engaged with CO₂-based products?
• Is the **Global CO₂ Initiative (GCI)** the right partner?
Making the case: 1. Does it work? Does it reduce emissions?

The GCI will focus on technologies that:

1. Destabilize the CO₂ molecule
2. Efficiently generate hydrogen
3. Reduce the cost of low carbon energy

Product made with carbon capture and conversion

Same product produced by conventional means

The carbon footprint of co-reactant 1 and co-reactant 2, the carbon footprint of the energy source, and the carbon footprint of the product are shown. The carbon footprint is negative if the end product has a net CO₂ reduction.
Making the case:

2. Do CO₂-based products have a significant environmental impact?
3. Is the market opportunity material?

Key Points

- We commissioned McKinsey and Company to conduct a comprehensive market assessment study on CO₂-based products.
  - Conclusion: By 2030, the environmental impact can be significant (10% of annual CO₂ emissions).
  - Conclusion: The market opportunity is massive - $800 billion to $1.1 trillion in annual revenues.

ANNUAL MARKET SIZE:
$800 billion - $1.1 trillion

ANNUAL CO₂ CONSUMPTION
4 gigatons per year

Source: CO₂-based products market analysis by McKinsey and Company and CO₂ Sciences, Inc.
Making the case: 4. Are CO₂-based products commercially viable?

The cost of carbon-free energy will approach 2 cents/kWh:

• A number of CO₂-based products and processes exist today and are at different degrees of maturity. However, many have not been commercially viable and could not compete with traditional products made the traditional way; mainly due to:
  • Low oil prices that lead to low cost chemicals, polymers and fuels
  • High cost of low carbon power
  • However, the low carbon power cost is going down significantly and we believe that this will accelerate the deployment of CO₂-based products
  • We believe that there are products that are commercially viable today
Making the case: 4. Are CO$_2$-based products commercially viable?

A convergence of government initiatives, private investors and markets.

- Reduction in cost and increase in deployment of low carbon power
- Environmental Impact Financial Returns
- Breakthrough Energy Coalition; a $2 billion commitment
- Paris, COP 21 meeting targets require carbon negative technologies
- Market traction: Commercial plants are being built in Europe and the U.S.
- Government Action: Mission Innovation Initiative - 16 of 20 countries are interested in funding CO$_2$-based products
Making the case: 4. Are CO$_2$-based products commercially viable?

**Market traction examples:**

**Skyonic** is commissioning the first commercial plant (83,000 ton/year) for making sodium carbonate and hydrochloric acid.

**Bayer (Covestro)** is building a 5,000 ton/year polyether-polycarbonate polyols plant. The product will have a 15-20% lower carbon footprint than a comparably made one today.

The UK’s **Carbon8 Systems** is operating a 50,000 ton/year aggregates plant where CO$_2$ is reacted with solid waste incinerators product (fly ash) to make carbonates.

Iceland’s **CRI (Carbon Recycling International)**: The 2012 industrial scale facility converts CO$_2$ to **methanol** was expanded to 4,000 ton/year in 2015. The plant uses Iceland’s mix of no-carbon power sources such as hydro, geothermal and wind
Making the case: 4. Are CO₂-based products commercially viable?

Techno-Economic Viability: Cement

- A new process for making cement that is cured with CO₂
- Does not assume a premium for being green.
- Has low capex for retrofitting
- Has lower overall cost
- The techno-economic feasibility was confirmed as the industry leader decided to invest in and test the technology
- Is expected to scale in the next 12-24 months
The approach: building partnerships with key stakeholders

- **Philanthropic investments** to fund research and development
- **Corporations**: Philanthropic and for profit investments to drive technology development and commercialization
- **NGOs**: Bring resources and mission-aligned support
- **Investors**: For profit investments to bring technologies to market scale
- **Governments**: Support early stage technologies. Provide policy/regulatory incentives
- **Foundations**: Support early stage technologies. Participate in **impact investing**
And accelerate innovation while building a market
Making the case: 6. Is The Global CO\textsubscript{2} Initiative the right partner?

The GCI is positioned to play a leading role in bringing CO\textsubscript{2}-based products to the market. It will serve a unique role as:

- **Trusted third party**
  - Facilitates and orchestrates interactions between all stakeholders on a global scale

- **Accelerator**
  - Identify and advance emerging technologies
  - Accelerate development of emerging technologies using a unique funding model (slide x)
  - Early and broad engagement of industry

- **Convener**
  - Big tent
  - Information and technology transfer
  - Collaboration with policy and regulatory bodies
  - The global source for CO\textsubscript{2}-based product innovation and markets
Our unique toolset
Grant making and investments are driven by in-depth, proprietary knowledge

Is this a worthwhile effort?
How do we find these opportunities?
How do we assess their carbon reduction potential?
How do we assess their commercial viability?
How do we make an impact at scale?

Market Assessment & Environmental Impact
Cognitive Computing
Life Cycle Analysis
Techno Economic Analysis
Roadmap for Implementation

Innovation at every step
An experienced and motivated team
Driven by a team of global scientific, technical, and business leaders

Deeply experienced Leadership team
World-class Advisory Board
Strong and devoted Board of Directors
A unique structure and two platform model

**R&D Platform**
- Early Stage R&D Support
- Appreciation & Value Creation

**Commercialization Platform**
- Late Stage Investments
- Various Funding Vehicles

**CO₂-based products**
- **Fund the best scientific minds** in discovery and development
- $100 million per year for 10 years
- Non-profit: CO₂ Sciences, Inc., 501(c)(3)
- $50+ million raised to date
- **Fund companies** to accelerate markets
- $ billions for investment funds, joint ventures and deals
- For-profit
- Various funding vehicles
Focused technology development and commercialization

Bold grant making and investment focus

- **CO₂ capture**
- **CO₂ transformation into CO₂-based products**
- **Hydrogen generation** (Hydrogen is sometimes needed to make products)
- **Low-carbon power sources** (generation and storage) Needed to make products
Commercial focus

Analysis of willingness to pay for CO\textsubscript{2} as an input feedstock

Source: Analysis by McKinsey and Company for CO\textsubscript{2} Sciences, Inc.
Implementing strategic actions will drive adoption of CO$_2$U

Status quo
- Concrete curing
- Methanol
- Polymers
- Aggregates
- Syngas
- Liquid fuels
- Formic acid
- Methane

Strategic actions implemented
- Concrete curing
- Methanol
- Polymers
- Aggregates
- Syngas
- Liquid fuels
- Formic acid
- Methane

Timeline for production in full scale
- 2015
- 2020
- 2025
- 2030
Conclusions

A number of factors are converging to accelerate the development and adoption of CO$_2$-based products

- COP21 created a great sense of urgency to act. Many realize that carbon negative technologies are essential to attaining the goals set in Paris.

- Significant reduction in the cost of low carbon power

- Market traction as manifested by the building and commissioning of several commercial CO$_2$-based product plants in Europe and the U.S.

- Major government initiatives (such as Mission Innovation) specify CO$_2$-based products as one of the most important pathways to reducing carbon emissions
Conclusions

Making the case:

1. **Do CO₂-based products work? Do they reduce emissions?**
   There are a number of processes that can lead to reduction in overall CO₂ emissions. Careful consideration should be given to the footprint of co-reactants and source of energy.

2. **Do CO₂-based products have a significant environmental impact?**
   CO₂-based products can account for an annual 10% reduction in carbon emissions by 2030.

3. **Is the market opportunity material?**
   CO₂-based products can lead to developing an annual $1 trillion industry by 2030.

4. **Are CO₂-based products commercially viable? What does techno-economic feasibility look like?**
   Some products can be commercially viable in the short term. Others are far from it. Therefore, a roadmap for deploying CO₂-based products is needed. We expect to have such a roadmap completed before the end of the year.

5. **Is partnership the right model for getting engaged in CO₂-based products?**
   The level of complexity, the stage of development, and the amount of funding required necessitates creating partnerships from different stakeholders - governments, corporations, investors and foundations.

6. **Is The Global CO₂ Initiative the right partner?**
   The Global CO₂ Initiative can play the role of a trusted third party. It has the right structure and business model to address the challenges of the emerging CO₂-based products industry. GCI has access to first tier talent and tools to ensure success.
Financial returns and climate impact

Realizing the power of a market-based solution