THE GLOBAL CO_2 INITIATIVE

Converting a liability into an asset

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.

Construction materials

Industrial gas & fluids

Agriculture & food

Plastics

The Challenge

Annual CO_2 emissions have exceed 35 gigatons

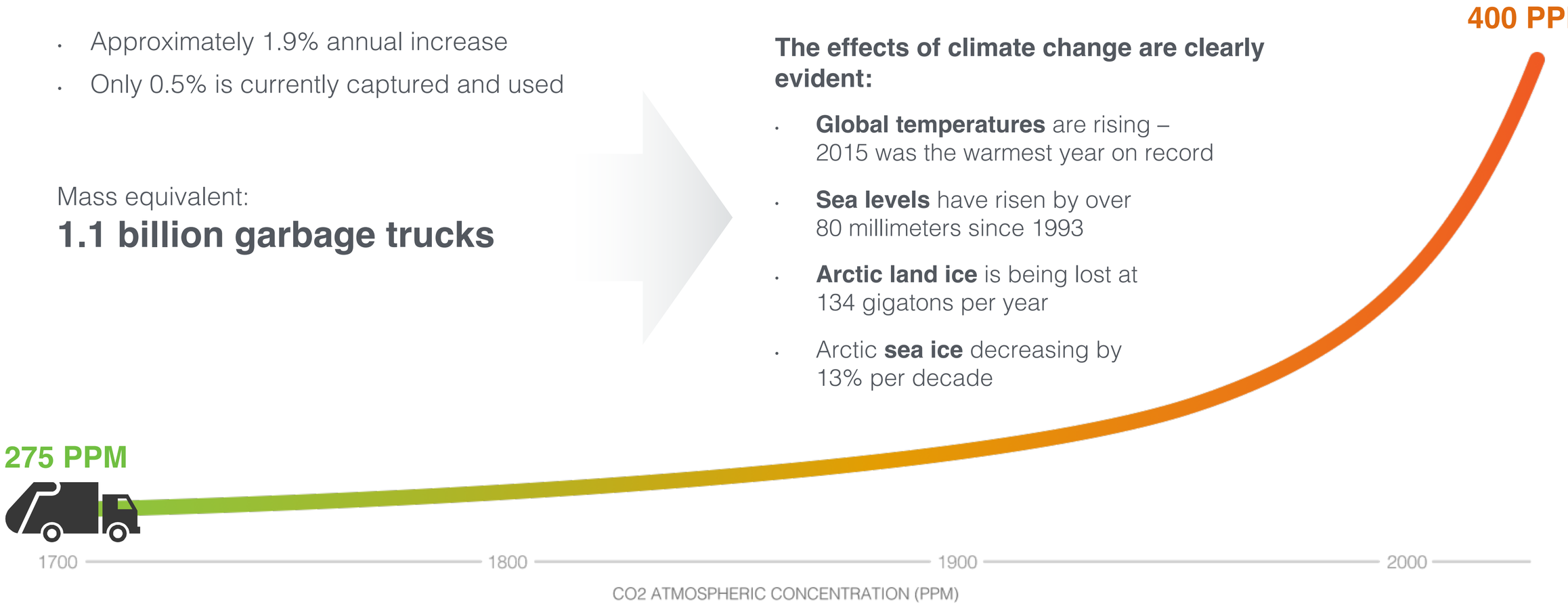
- Approximately 1.9% annual increase
- Only 0.5% is currently captured and used

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

CO_2-based products are one part of the solution

Decarbonization
Energy efficiency, clean renewable energy

Progress, but not fast enough

Adaptation
Managing impacts of climate change

Increasingly necessary

Capture and Storage
Long-term sequestration

Necessary but costly

Capture and Use
To create valuable CO_2-based products

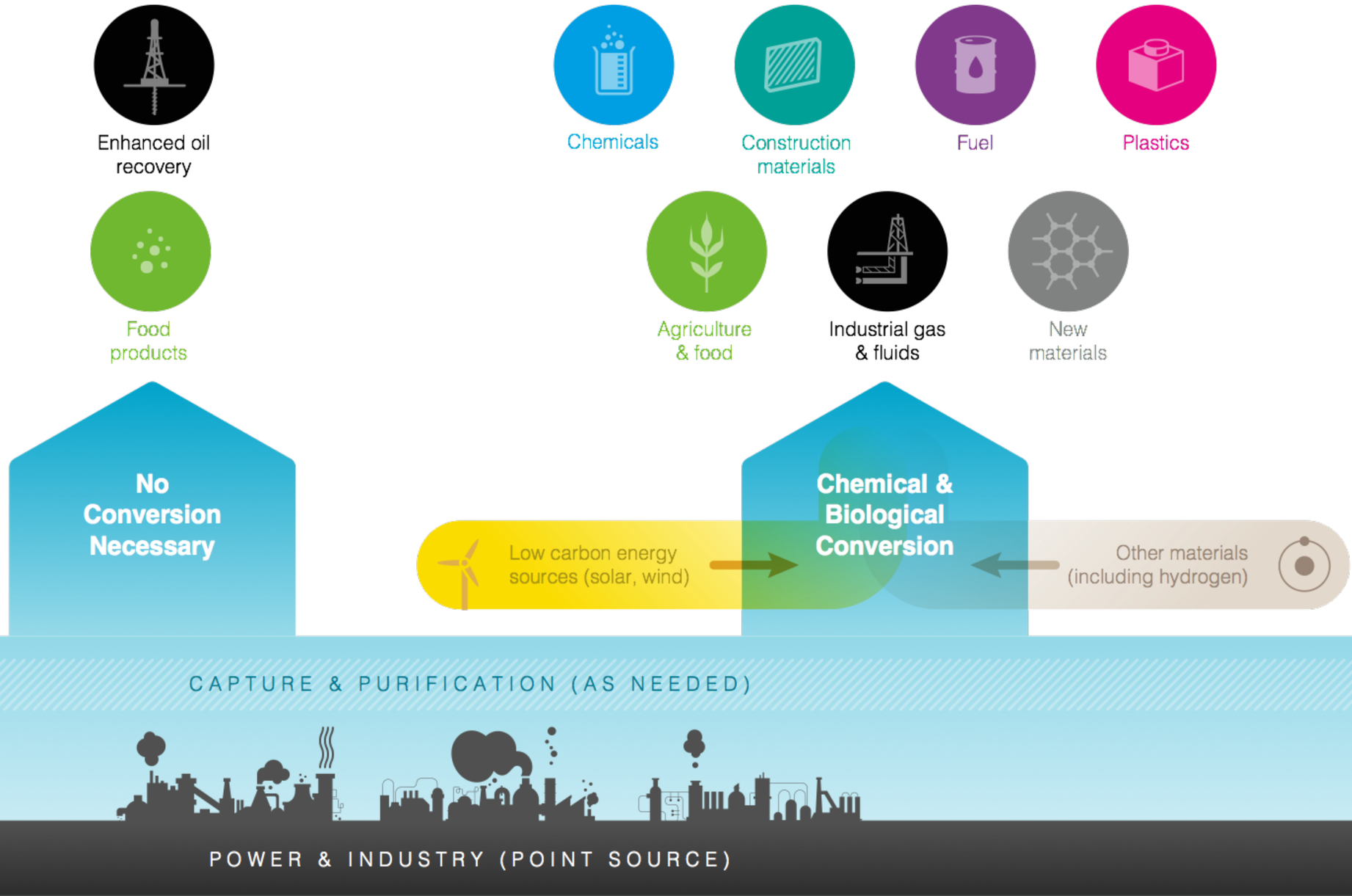
THE GLOBAL CO_2 INITIATIVE

Market-driven approach

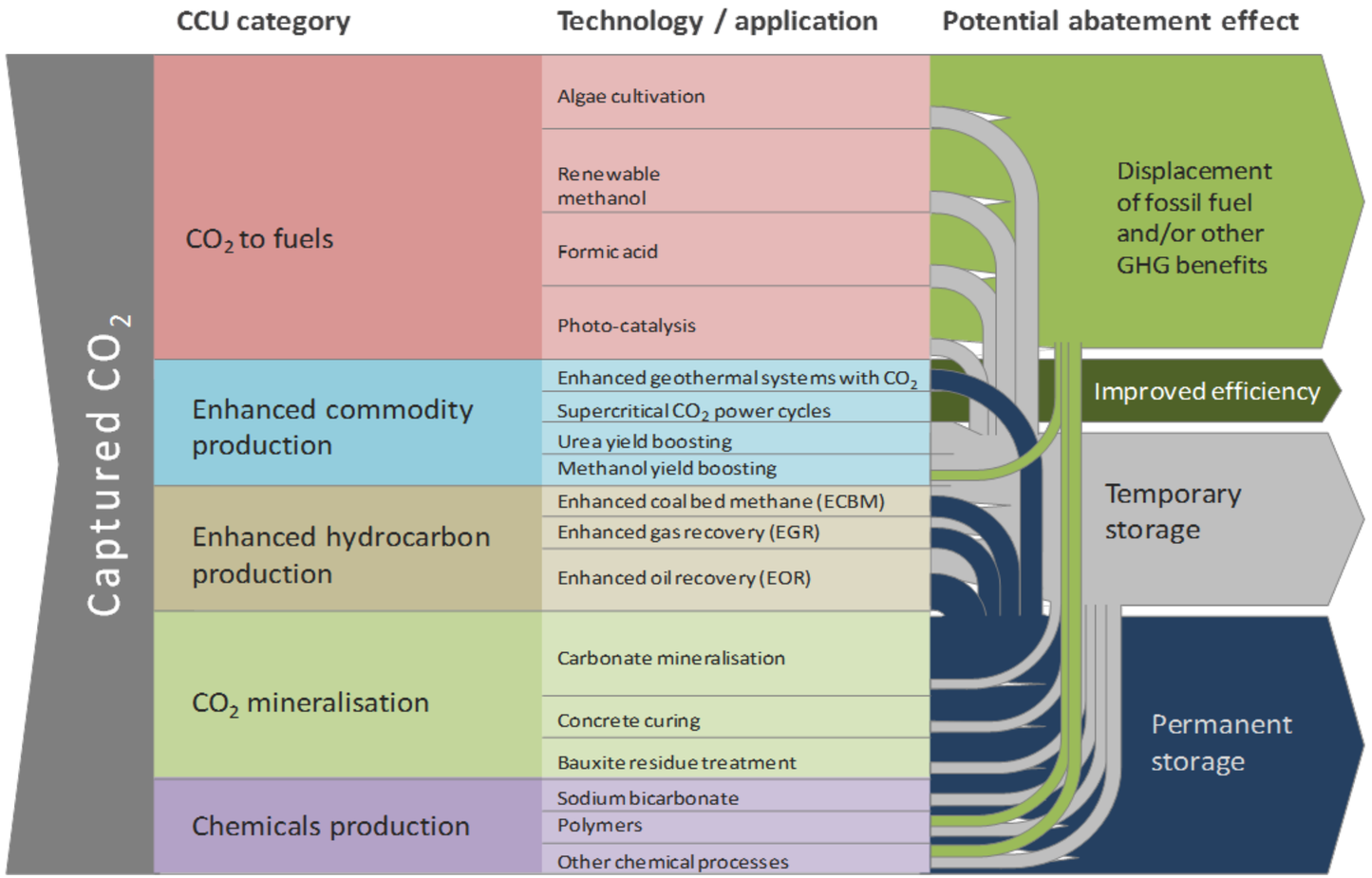
Key Points

- 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

CO_2-based products



Introduction: Opportunities with some CO_2-based products



MARKET SIZE	TECHNOLOGY READINESS	WILLINGNESSTO PAY
Large	2-4	Low
Medium	6-9	Low
Small	4-5	Low
Large	4-5	Med
Large	8-9	Med
Large	6-8	Med
Medium	3-5	High

Source: Adapted from Ecofys and Carbon Counts, *forthcoming*

Introduction: Criteria for selecting technologies

We applied five key criteria, both economic and environmental to assess CO_2-based products:

Environmental criteria	**CO_2 potential**	▪ Total amount of CO_2 that could be captured (tenths of a GT), given technical capacity and market potential
	Permanence of capture	▪ Length of time before the captured carbon is released back into the atmosphere as CO2 (years)
Economic criteria	**Willingness to pay**	▪ Based on the economics of the target market, unit cost/price point of CO_2 supply at which product is competitive for that use ($/tonne of CO_2)
	Ease of implementation	▪ Key factors to consider when entering the market, e.g., regulatory and competitive barriers to entry, substitutability of product, distribution channels
	Side effects and co-benefits	▪ 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,

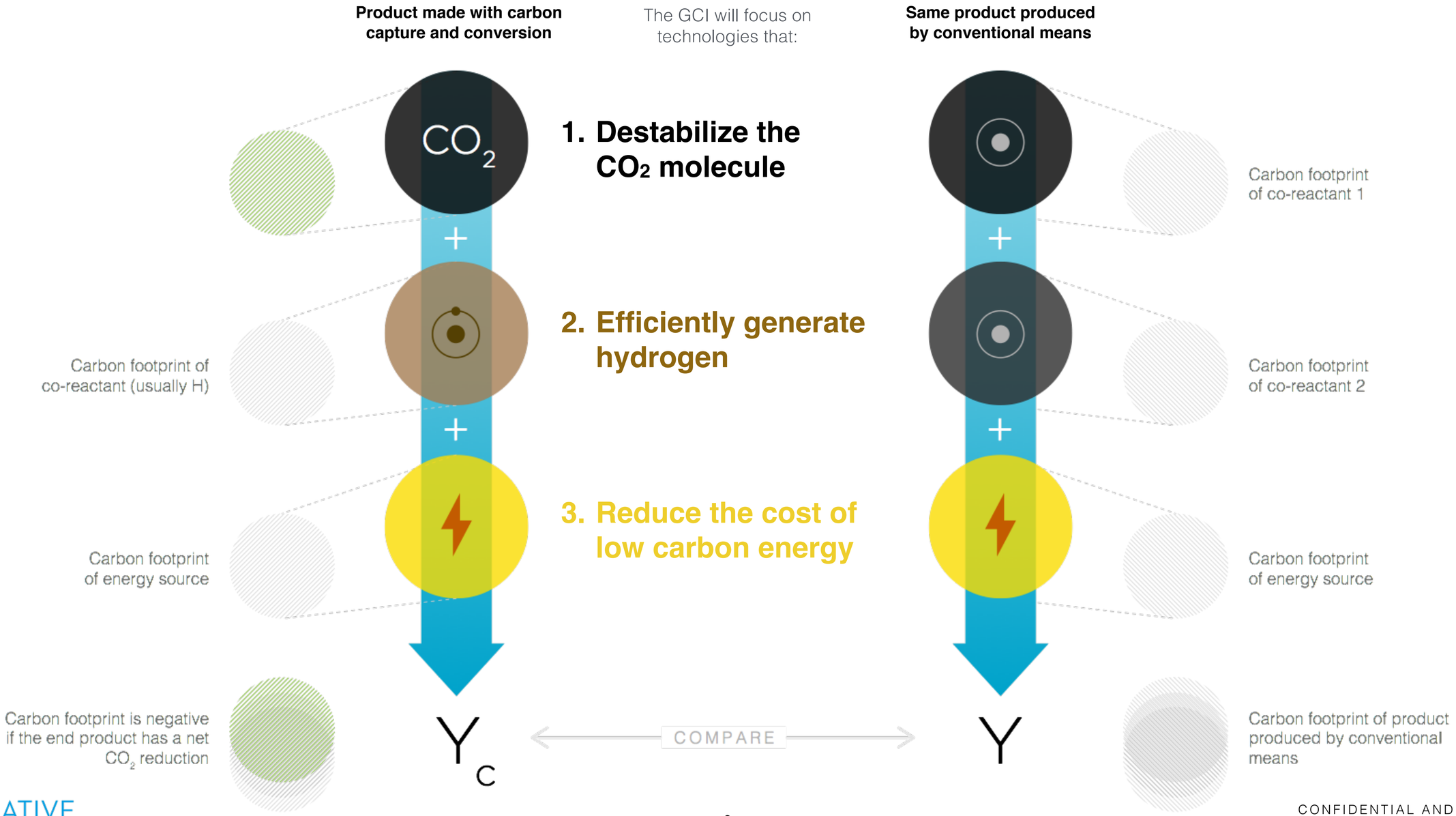
1. **Carbon Negative:** Does the process lead to CO_2 reduction?
2. **Material:** Can the process be scaled? Are the markets material?
3. **Commercially viable:** Is the process competitive and commercially viable?

Making the case

In making the case for the CO_2-based products marketplace and for working with the Global CO_2 Initiative, we attempt to answer the following questions:

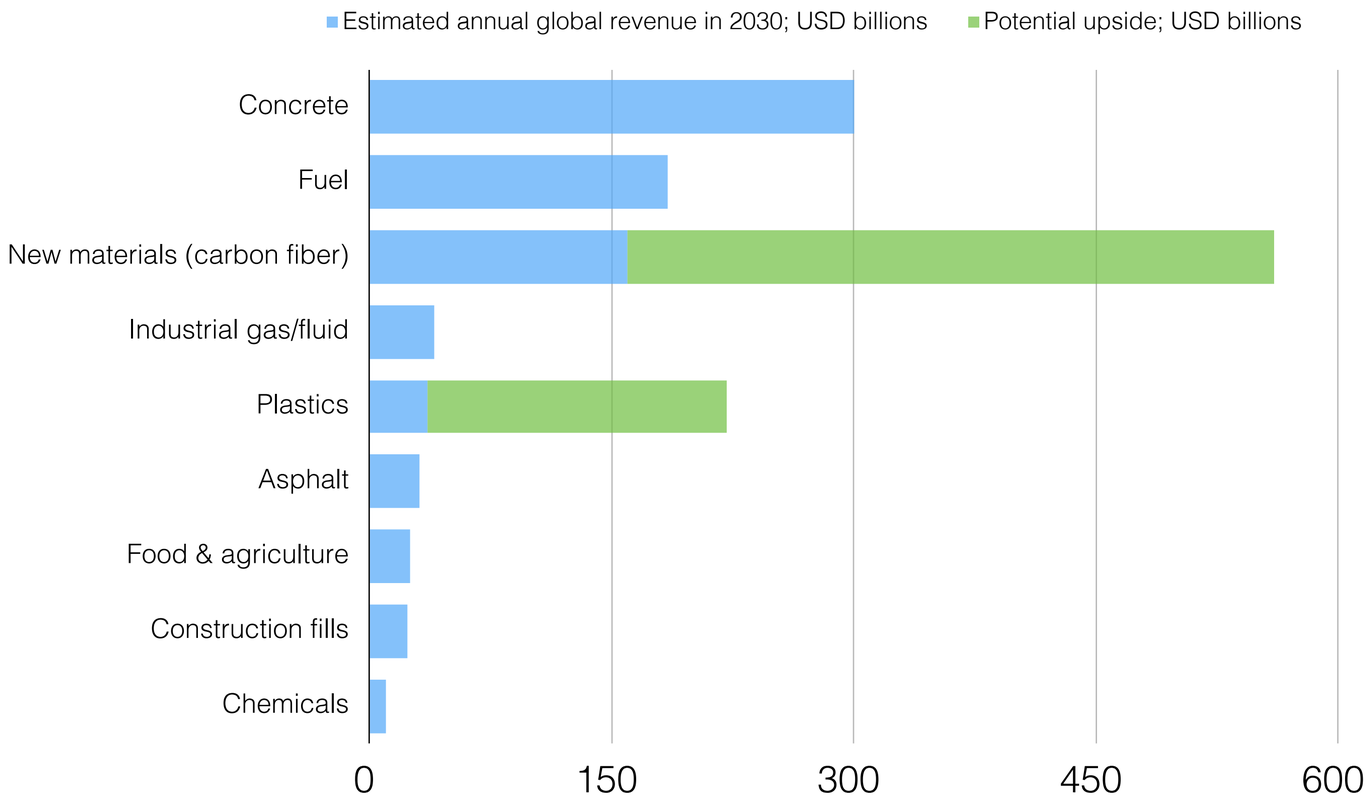
- **Does carbon capture and utilization work (CCU)**? Does it reduce emissions?
- Does it have a **significant environmental impact**?
- Is the **market opportunity** material?
- **Are CO_2-based products commercially viable**? What does a techno-economic feasibility study look like?
- Is **partnering** the right model to get engaged with CO_2-based products?
- Is the **Global CO_2 Initiative (GCI) the right partner?**

Making the case: 1. Does it work? Does it reduce emissions?



Making the case:

2. Do CO_2-based products have a significant environmental impact?
3. Is the market opportunity material?



Source: CO_2-based products market analysis by McKinsey and Company and CO_2 Sciences, Inc.

Key Points

- We commissioned **McKinsey and Company** to conduct a comprehensive market assessment study on CO_2-based products
- **Conclusion:** By 2030, the environmental impact can be significant (10% of annual CO_2 emissions)
- **Conclusion:** The market opportunity is massive - $800 billion to $1.1 trillion in annual revenues

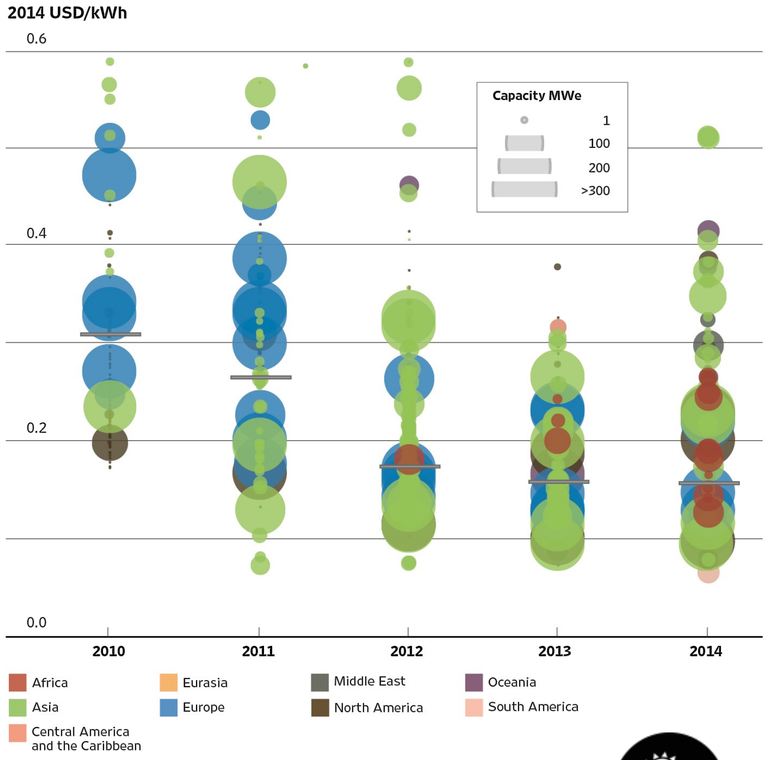
ANNUAL MARKET SIZE:
$800 billion - $1.1trillion

ANNUAL CO_2 CONSUMPTION
4 gigatons per year

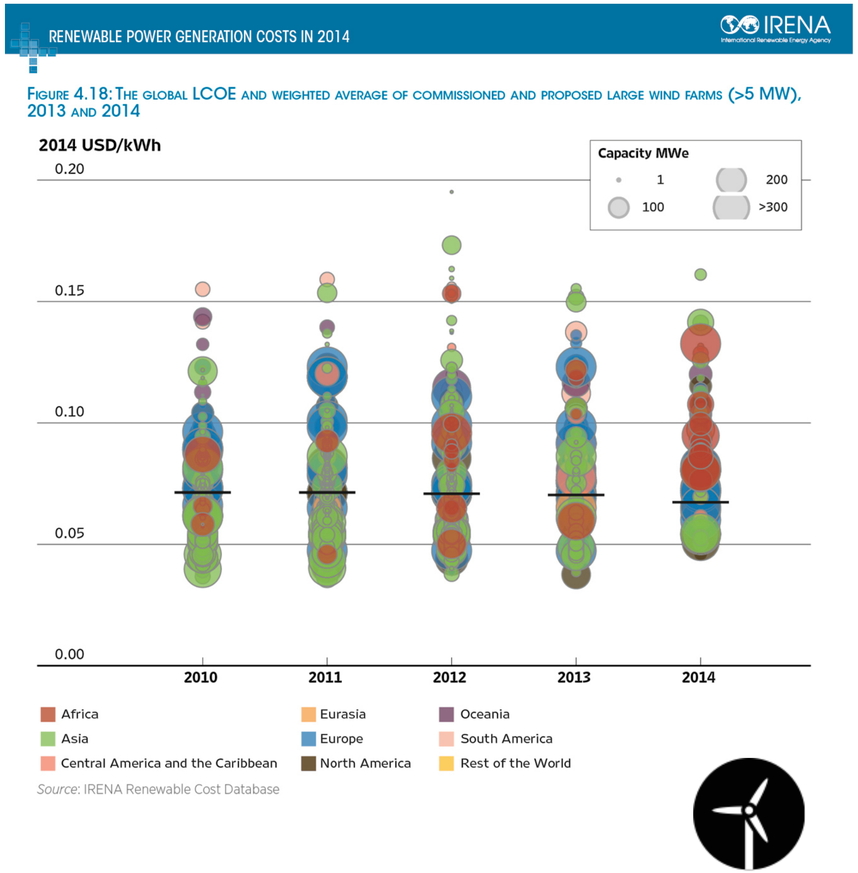
Making the case: 4. Are CO_2-based products commercially viable?

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

FIGURE 5.18: LEVELISED COST OF ELECTRICITY OF RESIDENTIAL SOLAR PHOTOVOLTAIC SYSTEMS BY COUNTRY, 2010 TO 2014



Source: IRENA Renewable Cost Database and Photon Consulting, 2014.

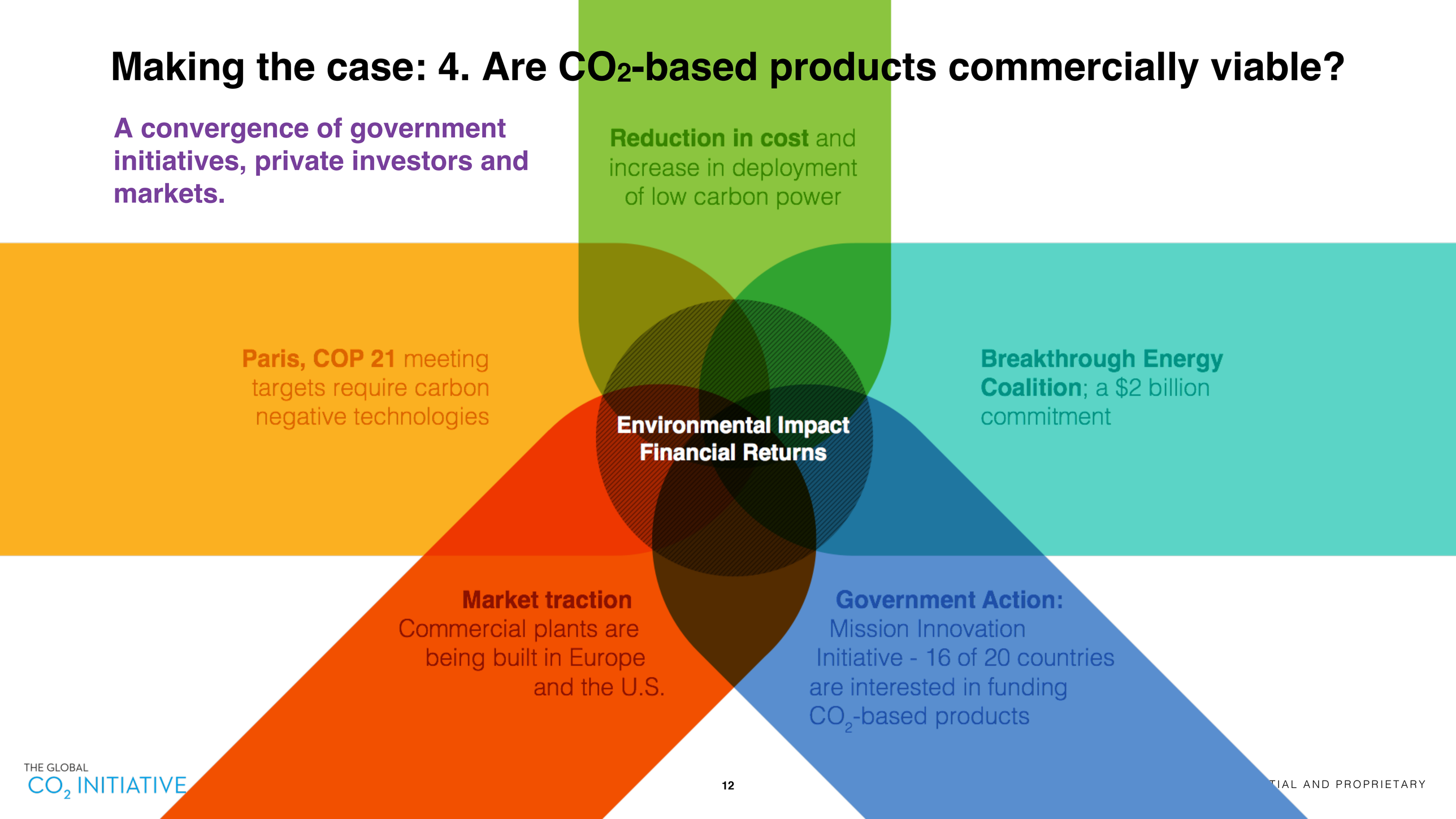


Source: IRENA Renewable Cost Database

- A number of CO_2-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 CO_2-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.



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**.

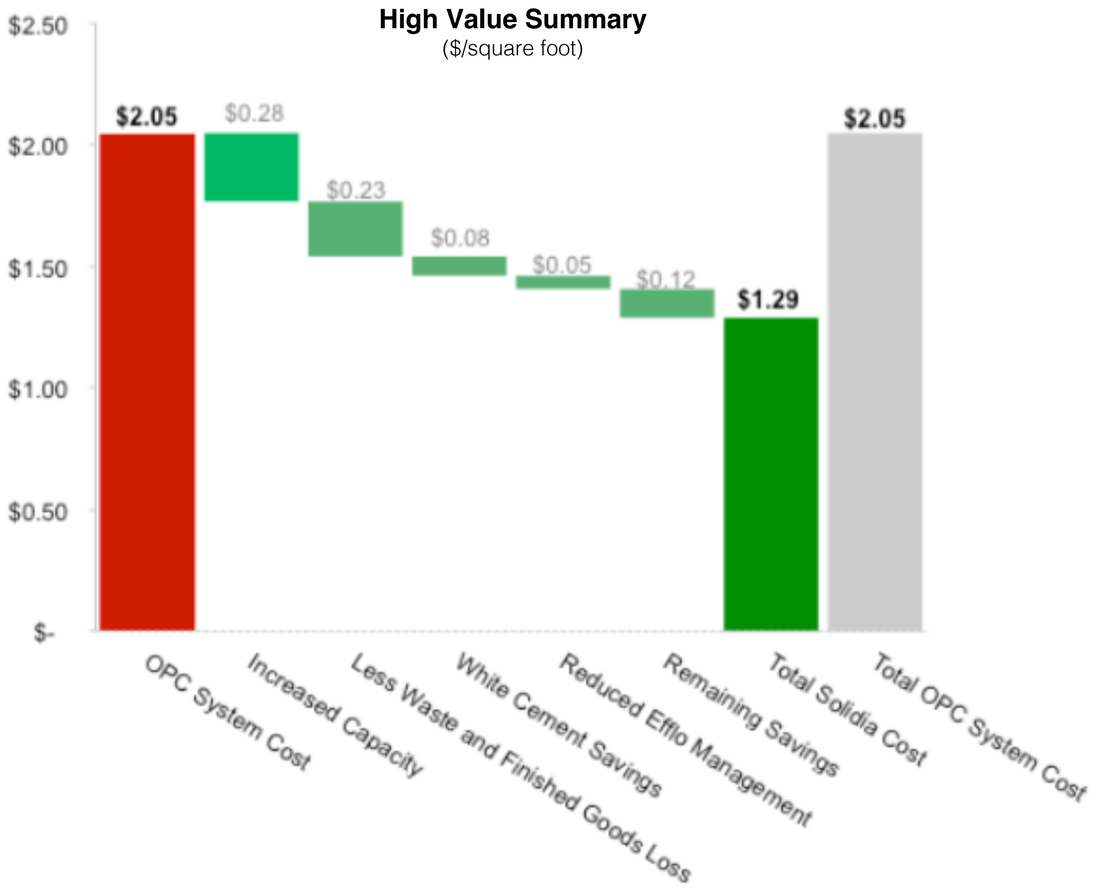
Bayer (Covestro) is building a 5,000 ton/year **polyether-polycarbonate polyols** plant. The product will have a 15-20% lower carbon footprint than a comparably made one today.

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 coverts 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

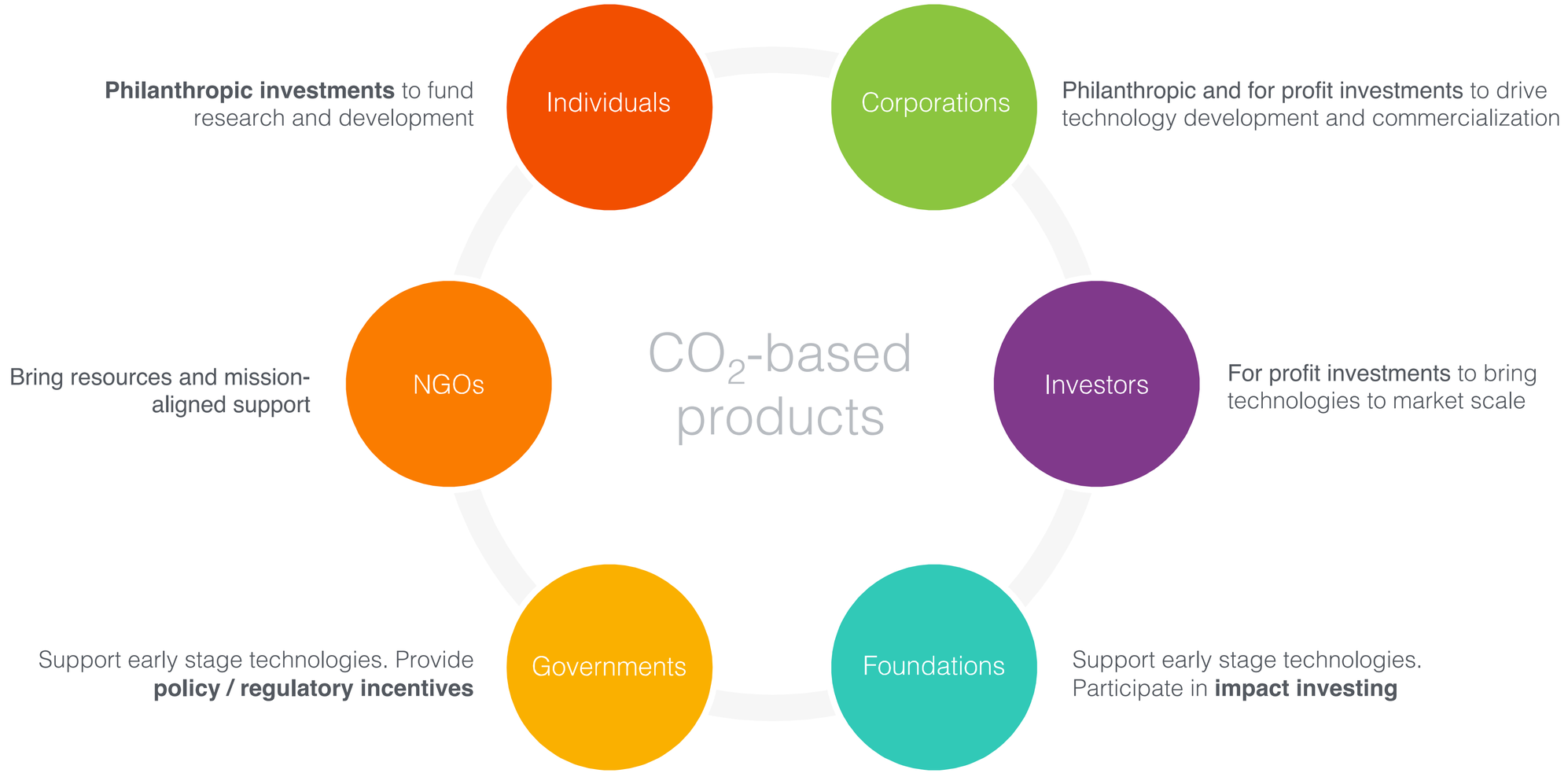
Making the case: 4. Are CO_2-based products commercially viable?

Techno-Economic Viability: Cement



- A new process for making cement that is cured with CO_2
- 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



And accelerate innovation while building a market

CO_2-based products

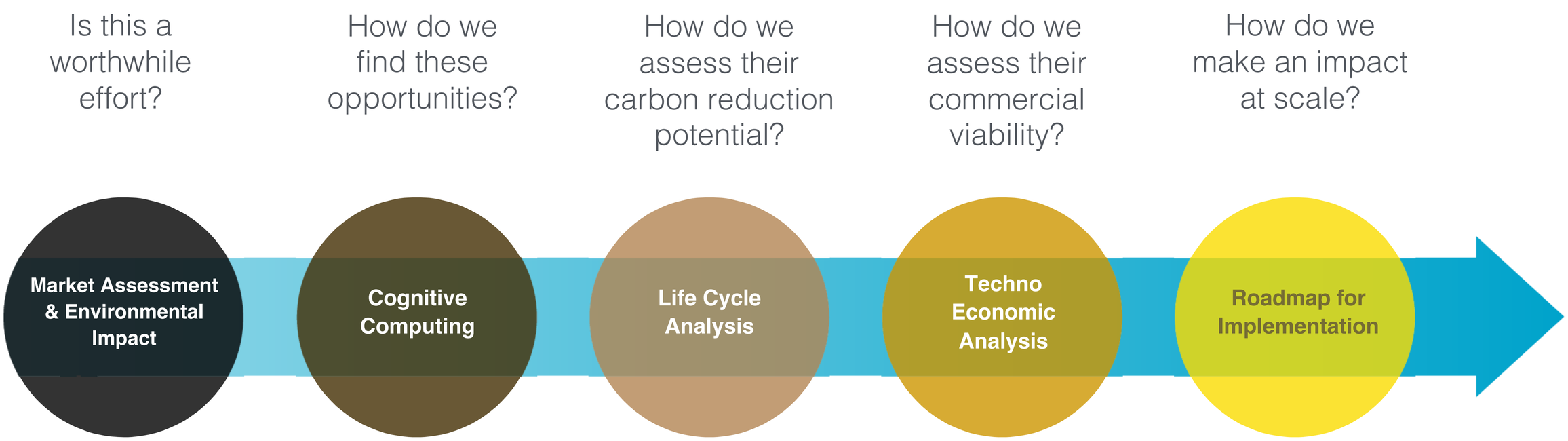
Making the case: 6. Is The Global CO_2 Initiative the right partner?

The GCI is positioned to play a leading role in bringing CO_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_2-based product innovation and markets

Our unique toolset

Grant making and investments are driven by in-depth, proprietary knowledge

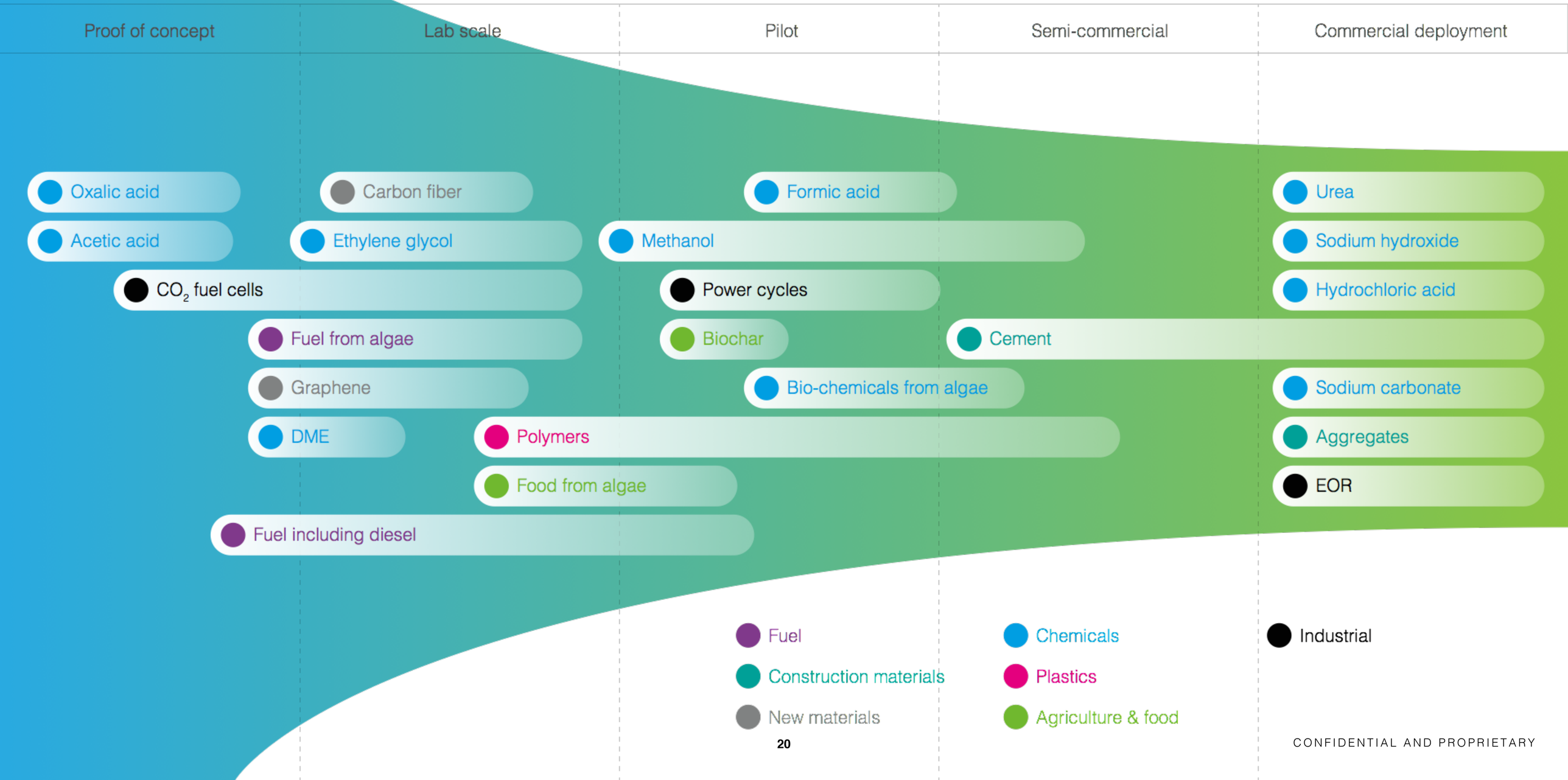


Innovation at every step

An experienced and motivated team

Driven by a team of global scientific, technical, and business leaders

CO_2-based product technology readiness



A unique structure and two platform model

Focused technology development and commercialization

Bold grant making and investment focus

CO_2 capture

CO_2 transformation into CO_2 –based products

Hydrogen generation

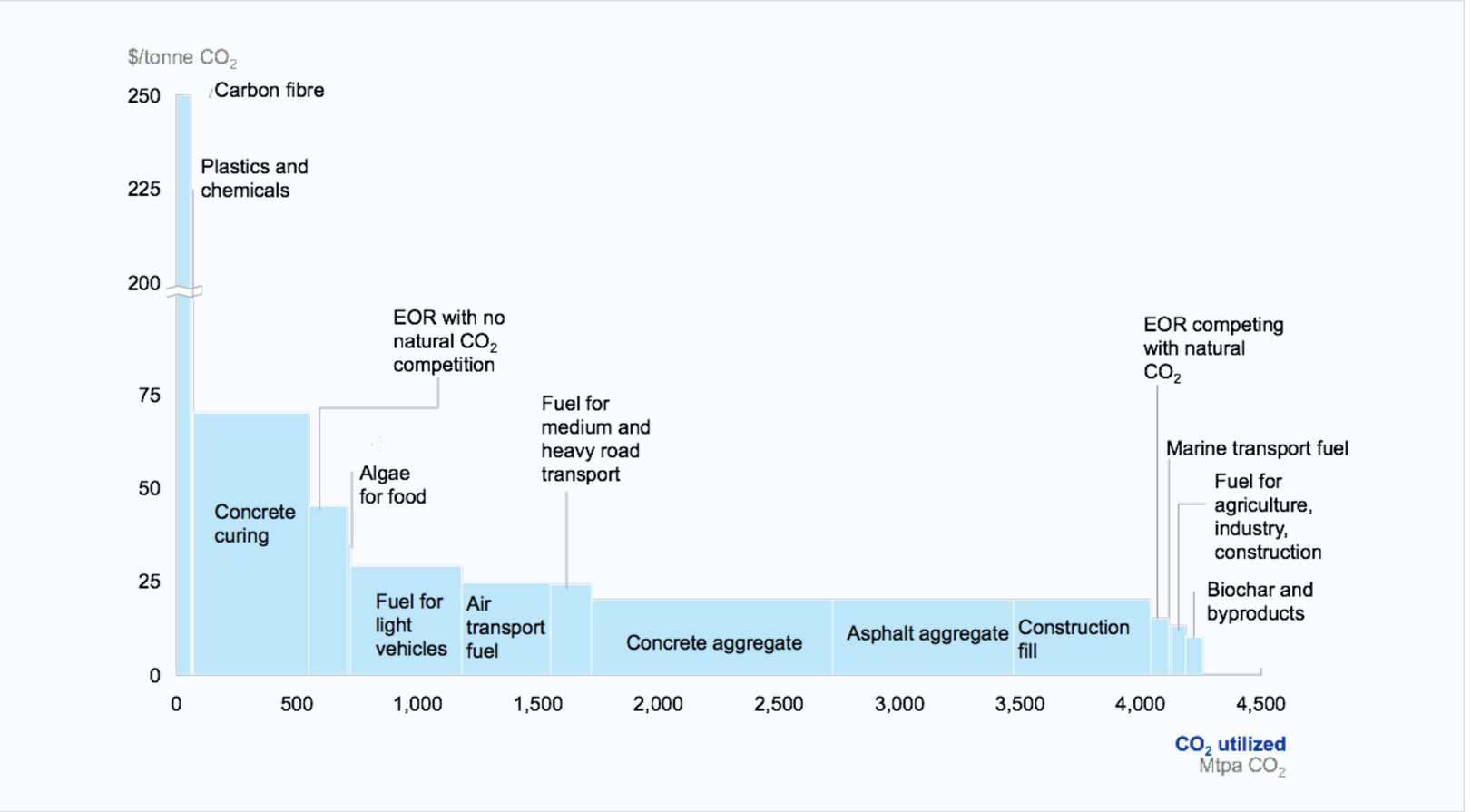
(Hydrogen is sometimes needed to make products)

Low-carbon power sources (generation and storage)

Needed to make products

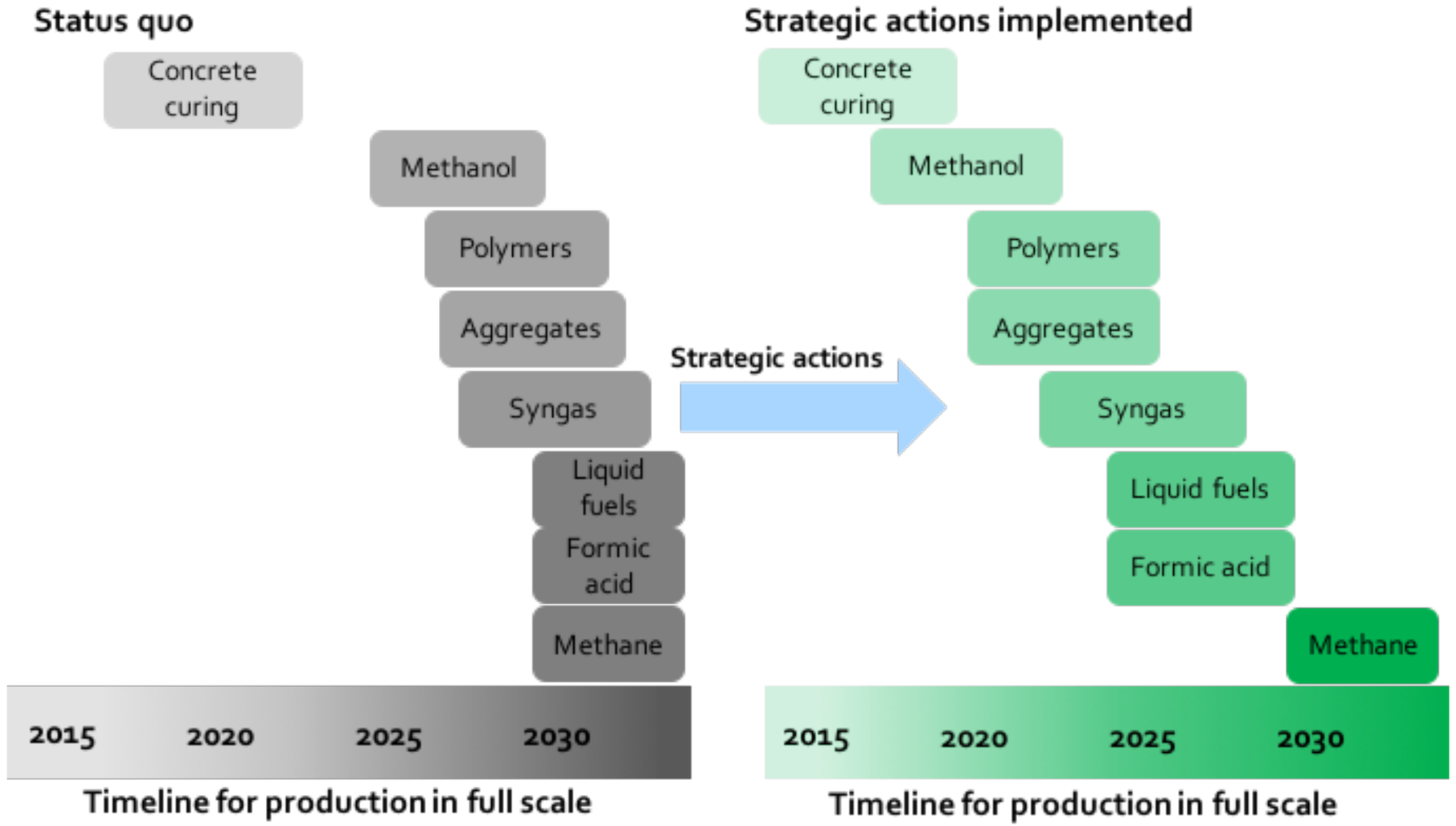
Commercial focus

Analysis of willingness to pay for CO_2 as an input feedstock



Source: Analysis by McKinsey and Company for CO_2 Sciences, Inc.

Implementing strategic actions will drive adoption of CO_2U



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 CO_2-based products work? Do they reduce emissions?**
   There are a number of processes that can lead to reduction in overall CO_2 emissions. Careful consideration should be given to the footprint of co-reactants and source of energy.

2. **Do CO_2-based products have a significant environmental impact?**
   CO_2-based products can account for an annual 10% reduction in carbon emissions by 2030.

3. **Is the market opportunity material?**
   CO_2-based products can lead to developing an annual $1 trillion industry by 2030.

4. **Are CO_2-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 CO_2-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 CO_2-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 CO_2 Initiative the right partner?**
   The Global CO_2 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 CO_2-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