

CO₂ Upgrading Strategy in Petrochemical Industry

Chemical Strategic Report Prospectus

July 2023

S&P Global
Commodity Insights



Contents



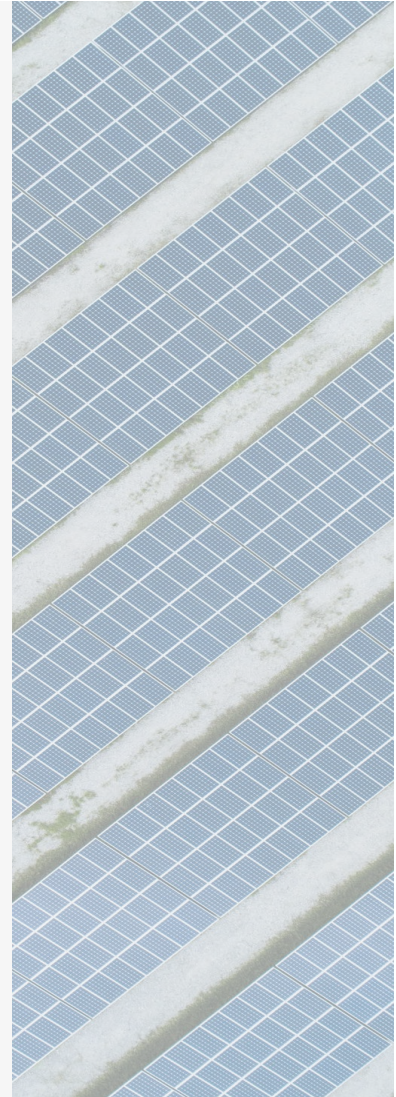
1. Why this report and why now?

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Emerging Opportunities for CO₂ Utilization as part of a Wider CCUS Strategy for Petrochemical Industry



- Sustainability was a key initiative within the petrochemicals and allied industries.
- Legislation is moving to more aggressive carbon reduction measures to encourage industry decarbonization in response to climate change targets.
- Within the petrochemicals' industry, sustainability-focused legislation is driving initiatives in carbon capture, utilization and storage (CCUS).
- Companies worldwide are facing challenges in CO₂ reduction throughout their supply chains as they seek to make their manufacturing operations more sustainable.
- Following a short overview of global CO₂ markets, SPGCI will provide potential initiatives in CO₂ use, ranging from new approaches for well-established commodities to emerging specialties, as well as potential longer-term opportunities in early-stage development.
- This report will provide options possible for CO₂ valorization covering opportunities involving both organic and inorganic chemistry, with an emphasis on market opportunity, technology maturity as well as potential volumes of CO₂ converted.
- An overview of the possible options for CO₂ utilization in petrochemical industry is covered in this report. The scope focuses on market attractiveness and technical feasibility in the first instance.
- SPGCI is well-positioned to collaborate and explore key issues facing petrochemical producers, including site-specific initiatives, together with approaches to finding solutions and sustainability strategies, as well as their cost/benefit impact.

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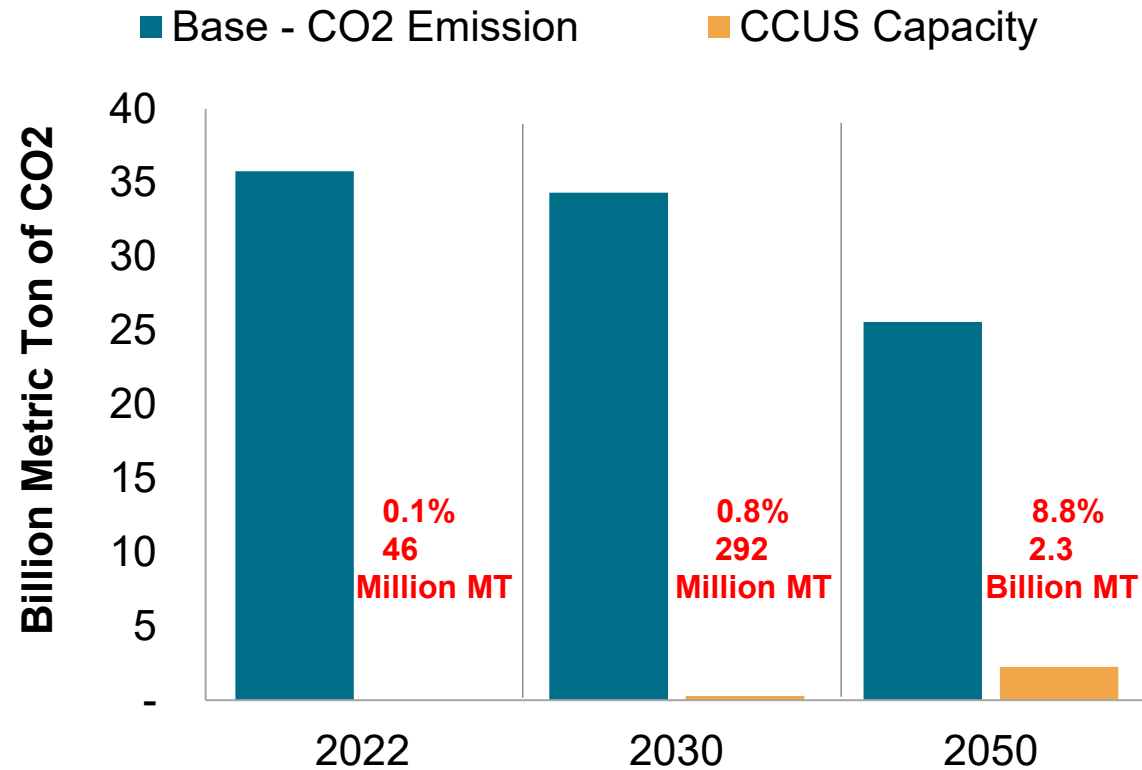
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CCUS is a key technology needed to decarbonize 'hard-to-abate' sectors such as petrochemicals and cement industries

Future Growth Drivers of CCUS will be Depleted Geological Storage and Oil/Gas Reservoir as well as Utilization

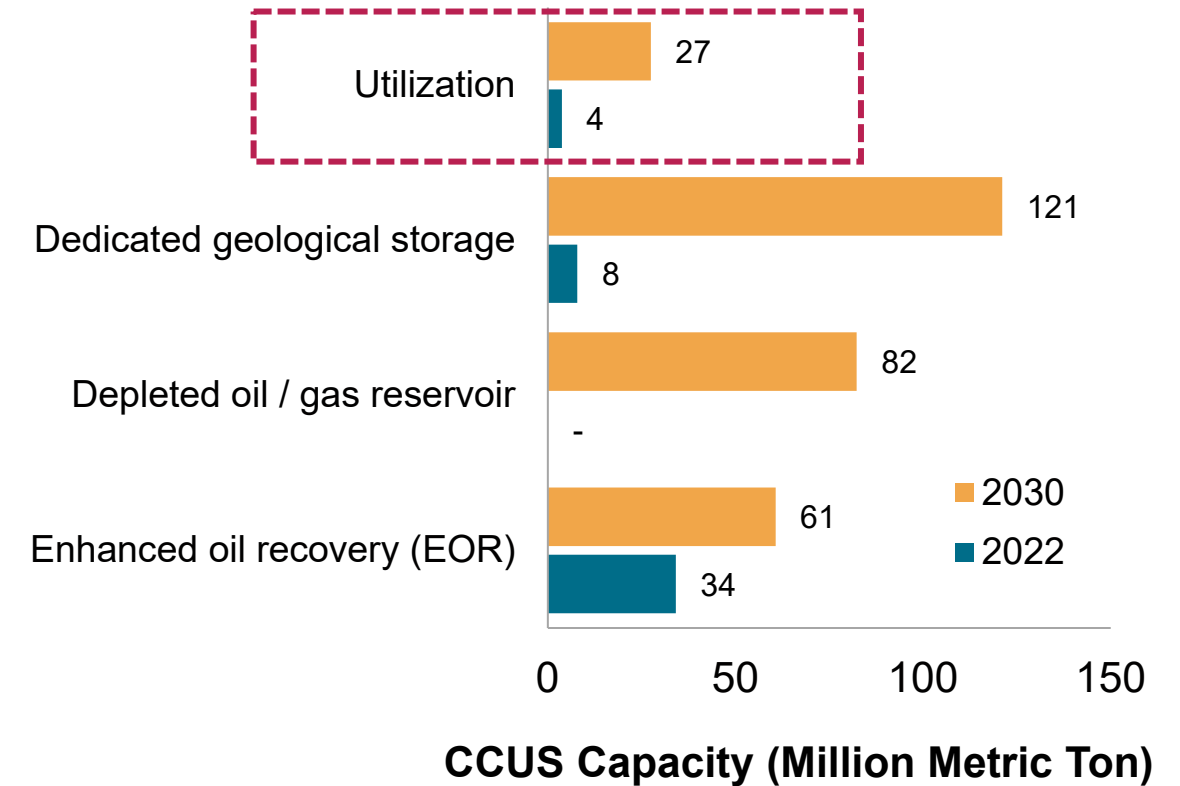
Global Energy-Related CO2 Emission and CCUS



Source: S&P Global Commodity Insights

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CCUS Capacity Break Down by End Use



Source: S&P Global Commodity Insights

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Criteria and scoring for initial screening

Market Attractiveness	
Global market size and growth	<ul style="list-style-type: none"> • Bigger the market and higher market growth, the better opportunity for low-carbon footprint product to substitute the conventional product • This criteria is suitable for long-term outlook. It demonstrates the highest market volume that low-carbon product can be consumed.
Market potential for low-carbon product	<ul style="list-style-type: none"> • How important is sustainability in particular product? • Will sustainable product enable a premium? • This is an important criteria for short-term deployment. Not all end use sectors can absorb the current high premium of low-carbon products over products from conventional route.
Environment sustainability impact	<ul style="list-style-type: none"> • What are GHG emission reduction potential and other aspects (e.g., VOC and harmful emissions, energy consumption intensity, indirect beneficiaries)?
Technology Feasibility	
Technology accessibility	<ul style="list-style-type: none"> • Is technology commercially available or available via JV only?
Technological maturity	<ul style="list-style-type: none"> • Is technology well-established or still at developmental stage? • Technology accessibility and maturity are the most important criteria. Product with commercial license and mature technology helps reducing the risk of the operation to a certain level.
CO ₂ uptake potential	<ul style="list-style-type: none"> • Does product consume reasonable amount of CO₂? • Products with large CO₂ consumption factor and large plant scale can maximize CO₂ consumption from your asset

26 Potential CO₂ Valorization Opportunities are Covered in this Report

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Alcohols

1. Methanol (MeOH)
2. n-Butanol (BuOH)
3. Ethanol (EtOH)

Foods and Fuels

1. Fuels (gasoline, diesel, jet fuel/kerosene, methanol, ethanol) (Fuel)
2. Algae (ALG)
3. Animal protein (AniP)

Acids

1. Lactic acid (LAC)
2. Succinic acid (SA)
3. Acetic acid (AA)
4. Glycolic acid (GA)
5. Salicylic acid (SAL)
6. Formic acid (FA)

Organic Carbonates

1. Ethylene carbonate (EC)
2. Propylene carbonate (PC)
3. Polypropylene carbonate polyols (PCP)
4. Diphenyl carbonate (DPC)

Inorganics

1. Sodium bicarbonate (Baking soda) (BakS)
2. Calcium carbonate (CaC)
3. Cement mineralization (CM)
4. Carbon monoxide (CO)

Intermediates and Others

1. Biochar (BioC)
2. Olefins (Ole)
3. Aromatics (Aro)
4. Urea (UREA)
5. Diamonds (Dia)
6. Carbon black (CB)

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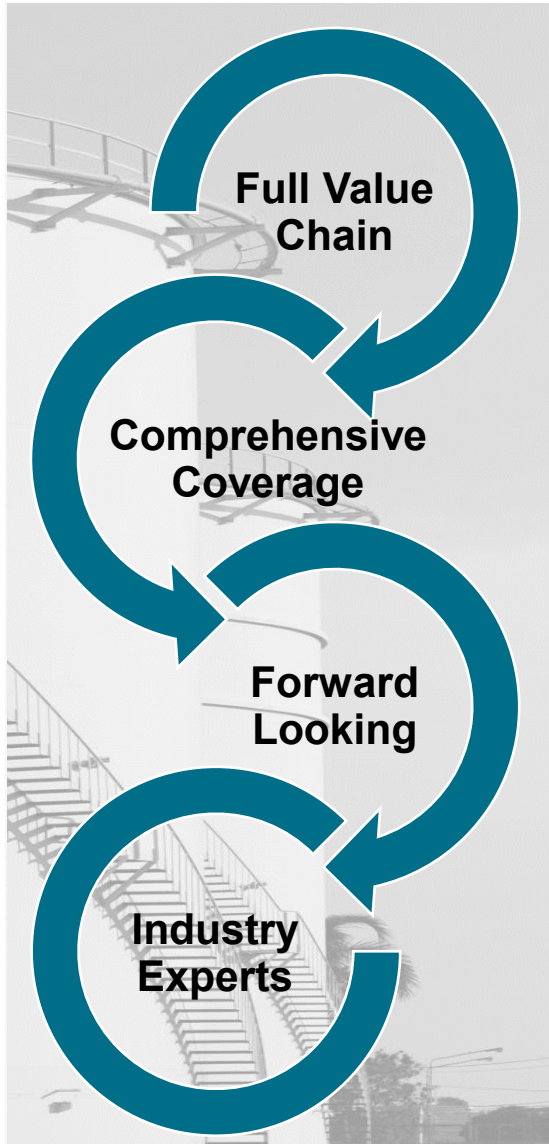
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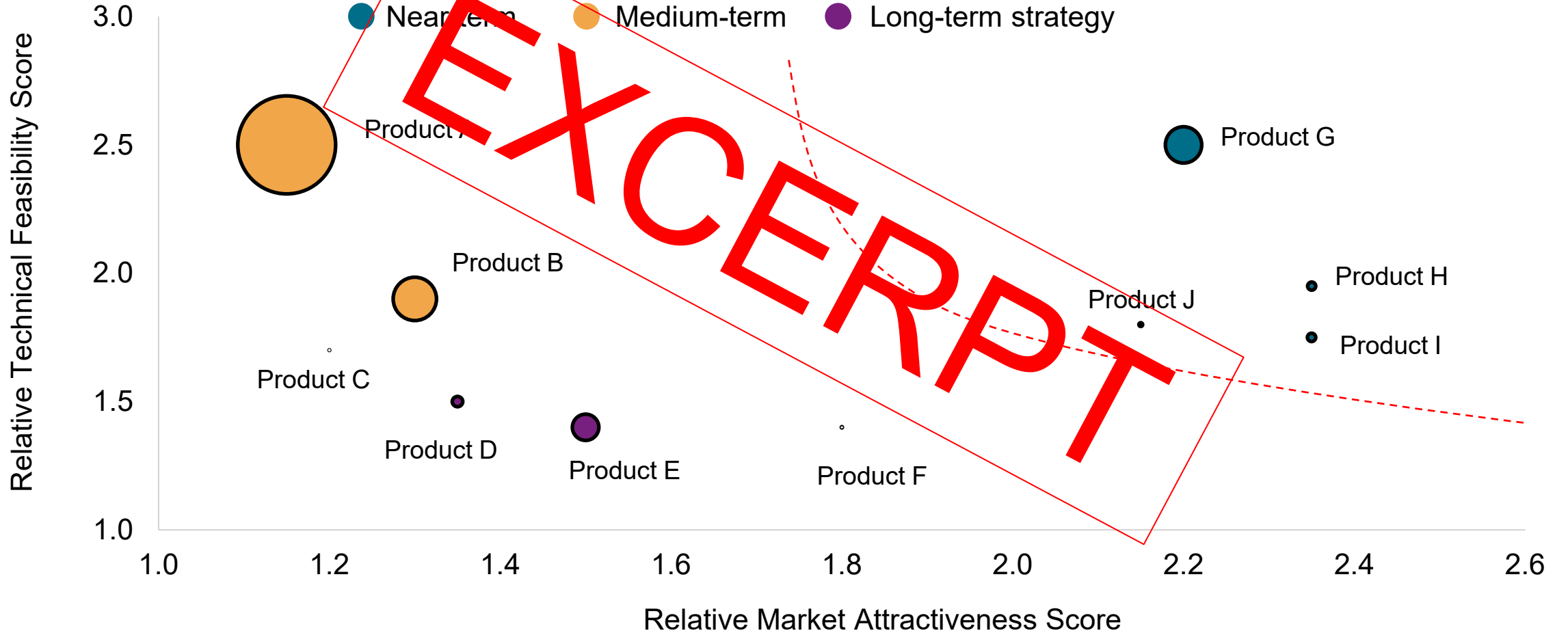
Chemicals consulting brings a comprehensive report on **CO₂ Upgrading Strategy in Petchem Industry** based on its experience from actual projects and wider S&P Global expertise



- This report will provide options possible for CO₂ sequestration, ranging from new approaches for well-established commodities to emerging specialties, as well as ambitious products with infancy stage of development.
- The report covers opportunities involving both organic and inorganic chemistry, with an emphasis on market opportunity, technology maturity as well as potential volumes of CO₂ converted.
- The opportunities reviewed in this report will stimulate interest for companies to solve their own CO₂ emission challenges and to develop their roadmap for sustainability strategy. The report serves all purposes whether the intention is to consume large amount of CO₂, to produce low-carbon product with high margin and readily market end uses, or to leverage existing assets and networks.
- SPGCI is already working with companies worldwide on carbon footprint reduction, including the implementation of CCS/CCSU approaches including site-specific initiatives. SPGCI can provide support from a commercial and technical perspective, throughout any project development process.

CO2 upgrading opportunities screening

Bubble size: CO₂ uptake potential



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4. Potential CO₂ Valorization Opportunities

Product profile for 26 potential CO₂ derivatives

5. Product Ranking

Market attractiveness considers 3 criteria: (1) global demand, (2) market potential for low-carbon product, (3) sustainability impact

Technical feasibility considers 3 criteria: (1) technology accessibility, (2) technology maturity, (3) CO₂ uptake potential

6. Summary and CO₂ Upgrading Strategy

Screening summary of all 26 CO₂ product initiatives

Identify CO₂ opportunities for on short-term implementation as well as longer term sustainable business roadmap

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