The following slides outlines amendments to data and analysis to the original report delivered in May 2022

Global CO_2 Initiative identified an error in the starting data point used for the forecast of CO_2-to-methane pathway, which impacted subsequent analysis related to the pathway. The following slides includes amendments and updated analysis for the following:

- Methane 2020 market volume (tonne) and 2050 market volume (tonne)

- Global methane market value (US$ billion)

- Cumulative methane CO_2 utilization (Gt CO_2)

In addition, a supplemental Excel with updated data and analysis is provided along with this MS PowerPoint.

Lux Research

Lux Research estimated a starting market volume in 2020 and projected growth to 2050 to establish the total addressable market

Market	2020 market volume (tonne)	Market growth rate (CAGR %)	2050 market volume (tonne)	Sources and comments
Formic acid	780,000 tonne	2%	1.4 million tonne	2020 market volume based on values reported by Perez-Fortes et al. (2016) Growth rate is based on a triangulation of values reported by Perez-Fortes et al. (2016) and Lux Research's interviews with Dioxide Materials and Coval Energy that range between 1% to 3.8%
Animal feed	337 million tonne	6%	1.9 billion tonne	2020 market volume based on reported values by Fraanje et al. (2020) on 90% of soybean production used for animal feed Growth rate based on triangulation of values reported by the Food and Agriculture Organization as it relates to demand in fish and livestock products
Methane	2.8 billion tonne	3%	7.0 billion tonne	2020 market volume based on values reported by the International Energy Agency Growth rate based on triangulation of annual growth rate between 2010 to 2019 reported by the International Energy Agency; excludes 2020 due to the impact of COVID-19 on natural gas production
Jet fuel	305 million tonne	8%	3.1 billion tonne	2020 market volume based on values reported by the International Civil Aviation Organization Growth rate based on triangulation of values reported by the International Civil Aviation Organization, the International Air Transport Association, the International Energy Agency, Shell Sky Scenario, and ExxonMobil Outlook for Energy; growth rates range from 5% to 24% through 2050; assumes growth will likely be between the low and medium scenarios of the reported values
Polyurethane	24 million tonne	3%	58 million tonne	2020 market volume based on values reported by Statista Growth rate based on annual increase in demand towards 2025 of 27.9 million tonnes reported by Statista

Lux Research estimated starting product price in 2020 to project the cost tipping point between incumbent and CCU end products

Market	Incumbent 2020 price (US$/tonne)	Incumbent price change (%/year)	CCU end product 2020 price (US$/tonne)	Sources and comments
Methane	US$198	3.5% increase/year	$US1,700	2020 incumbent price based on triangulation of reported values by The World Bank and the U.S. Energy Information Administration of approximately US$4/mmBTU; incumbent price increase based on projections for Europe and the U.S. based on changes reported by The World Bank CCU end product price based on values reported by Becker et al. (2019)
Jet fuel	US$450	3% increase/year	US$2,250	2020 incumbent price based on January 2021 spot price reported by the International Aviation Transport Authority; incumbent price increase based on annual historical price changes reported by the International Aviation Transport Authority, though jet fuel prices are directly tied to oil prices and long-term forecasts remain challenging CCU end product price based on triangulation of values reported by the International Council on Clean Transportation and corroborated with Lux Research's correspondence with Sunfire, Climeworks, and Infra Technology
Polyurethanes	US$3,200	0.5% increase/year	US$4,160	2020 incumbent price based on triangulation of values reported for TPU resin price by Plastic News and Plastic Price; incumbent price increase assumed at 0.5% increase/year due to the commodity nature, though price remains susceptible to isocyanate availability, but was not considered for the scope of this study CCU end product price based on Lux Research's correspondence with CO_2-derived polyurethane producers citing an average 10% premium over fossil fuel-based polyurethane

CO_2-derived methane reaches cost tipping point by 2038 but witnesses limited adoption as market size reaches US$217 billion
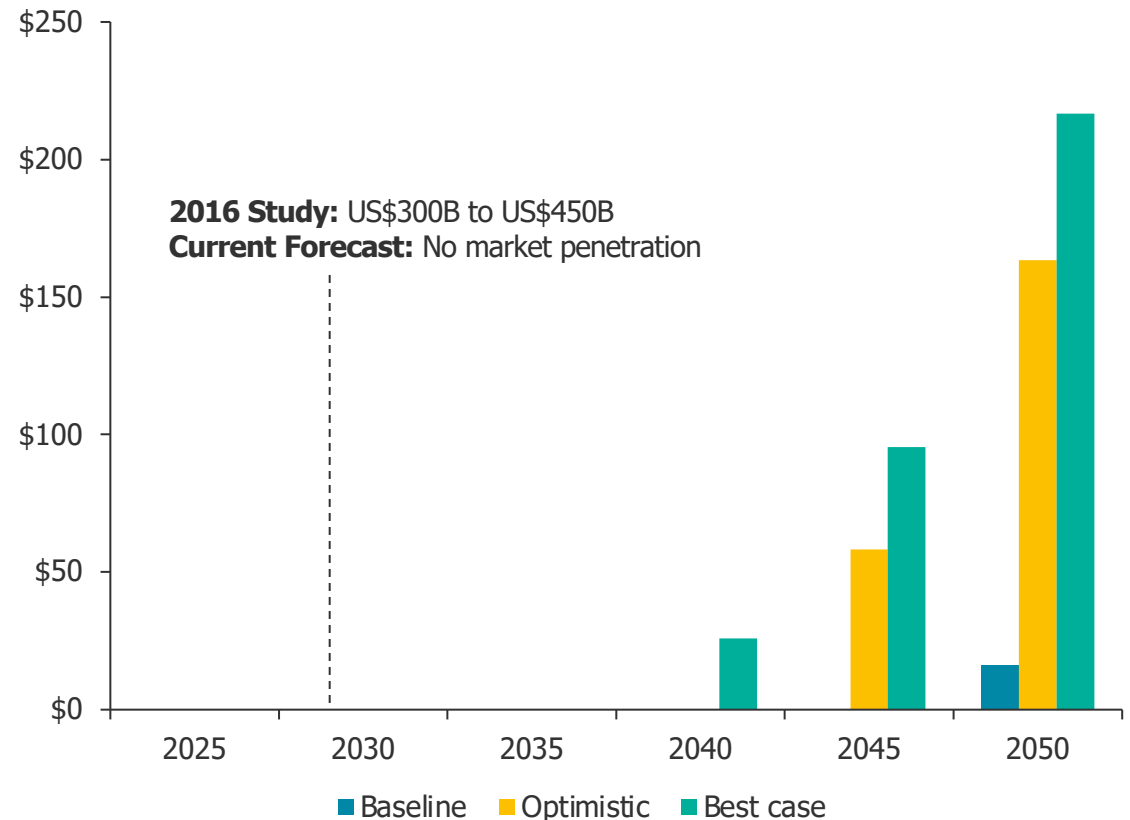
MARKET POTENTIAL

- The global methane market is expected to grow to US$3.8 trillion by 2050 with a CAGR of 3% driven by large shift away from coal in emerging economies.
- **Baseline.** Cost tipping point occurs in 2050 with an immediate uptake of CO_2-derived methane to reach a market size of US$16 billion.
- **Optimistic.** Cost tipping point occurs in 2041 with a CAGR of 38% through 2050 to reach a market size of US$163 billion.
- **Best case.** Cost tipping point occurs in 2038 with a CAGR of 32% through 2050 to reach a market size of US$217 billion.

MARKET DRIVERS

- Cost reduction via technology advancements and access to low-cost green hydrogen and renewable electricity remains key to improving CO_2-derived methane's economics
- Carbon pricing plays an instrumental role in the acceleration of the timeline for cost parity. In the best case scenario, cost parity is never achieved without the introduction of carbon pricing
- Faces stiff competition from alternative technologies, such as renewable natural gas, which is already commercially available and gaining market traction in markets such as the U.S. and Europe

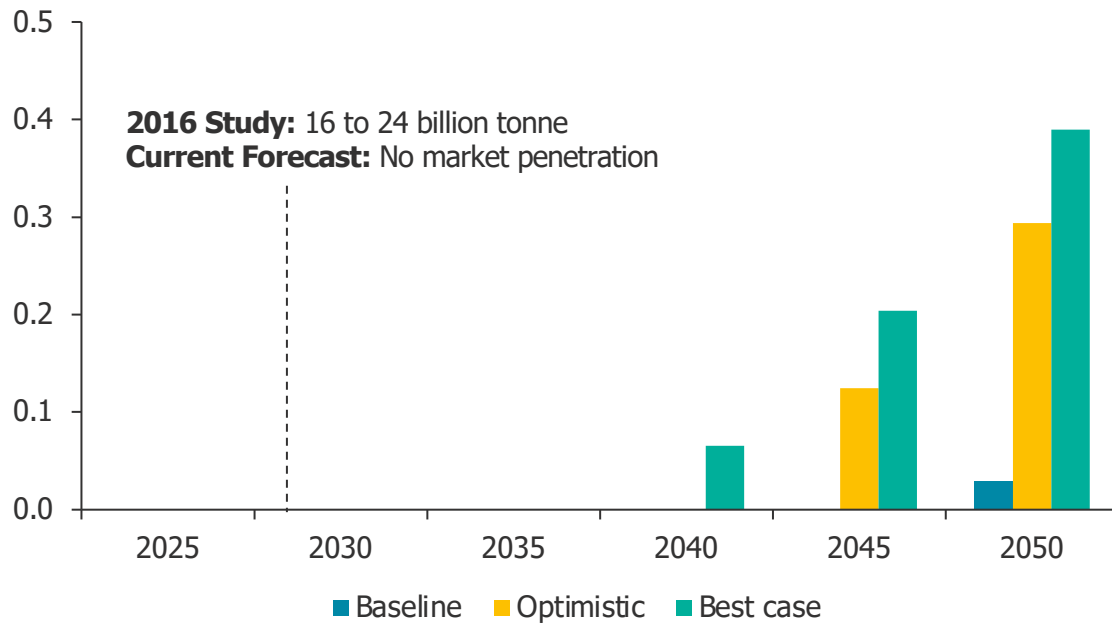**Global Methane Market Value**
US$ billion

2016 Study: US$300B to US$450B
Current Forecast: No market penetration

Legend: ■ Baseline ■ Optimistic ■ Best case

Lux Research

Large global methane market results in 0.4 Gt of CO_2 utilization potential despite only 6% market penetration by 2050

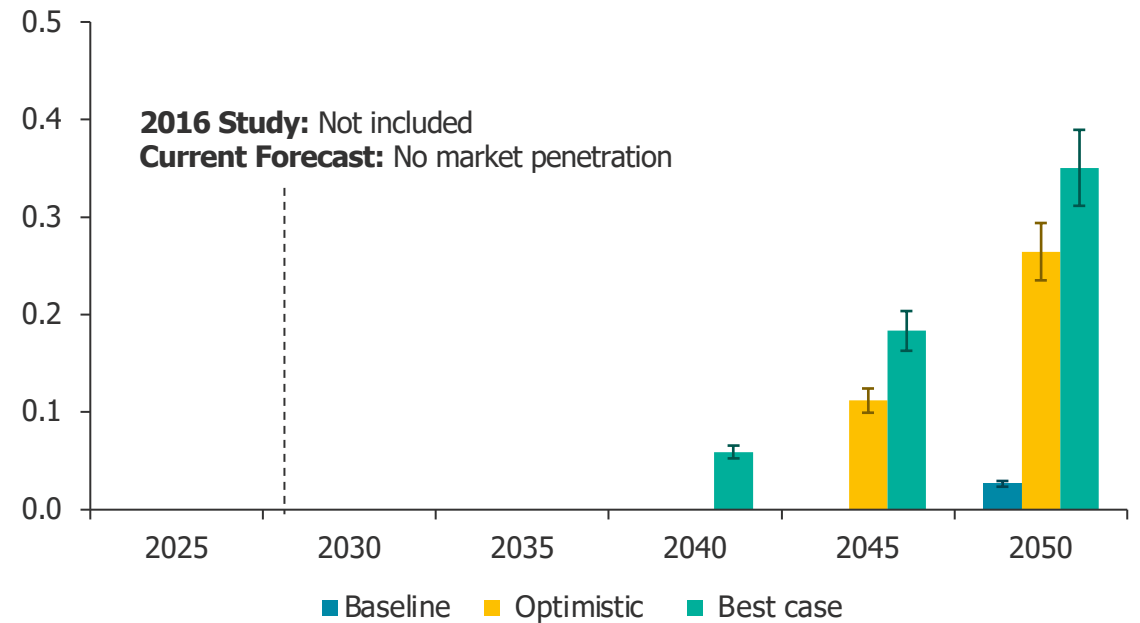**Global Methane Market Volume**
Annual billion tonne

2016 Study: 16 to 24 billion tonne
Current Forecast: No market penetration

- Baseline
- Optimistic
- Best case

Global Methane CO_2 Emissions Utilization Potential
Annual Gt of CO_2

2016 Study: Not included
Current Forecast: No market penetration

- Baseline
- Optimistic
- Best case

Error bars reflect the range of CO_2 utilization in the low CO_2 uptake scenario of 0.8 tCO_2/tonne of methane and high CO_2 uptake scenario of 1 tCO_2/tonne of methane.
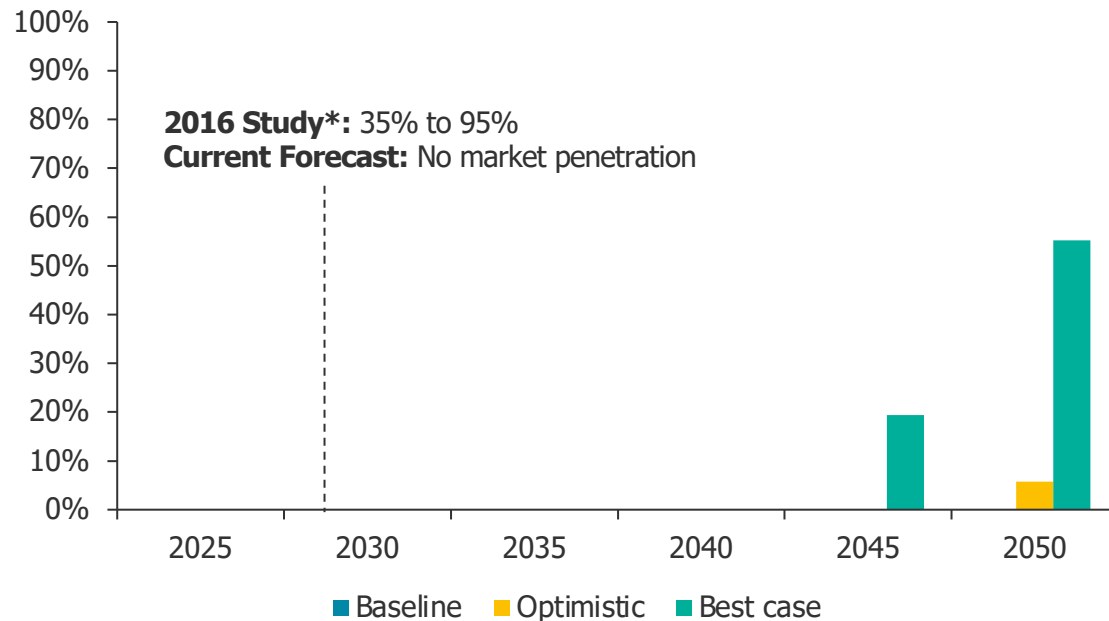
LUX TAKE

Despite low market penetration rates of CO_2-derived methane, the outlook remains promising in the long-term. While economics and competing technologies will deter widespread adoption, the large addressable market for natural gas results in both promising economic and CO_2 utilization potential.

Lux Research

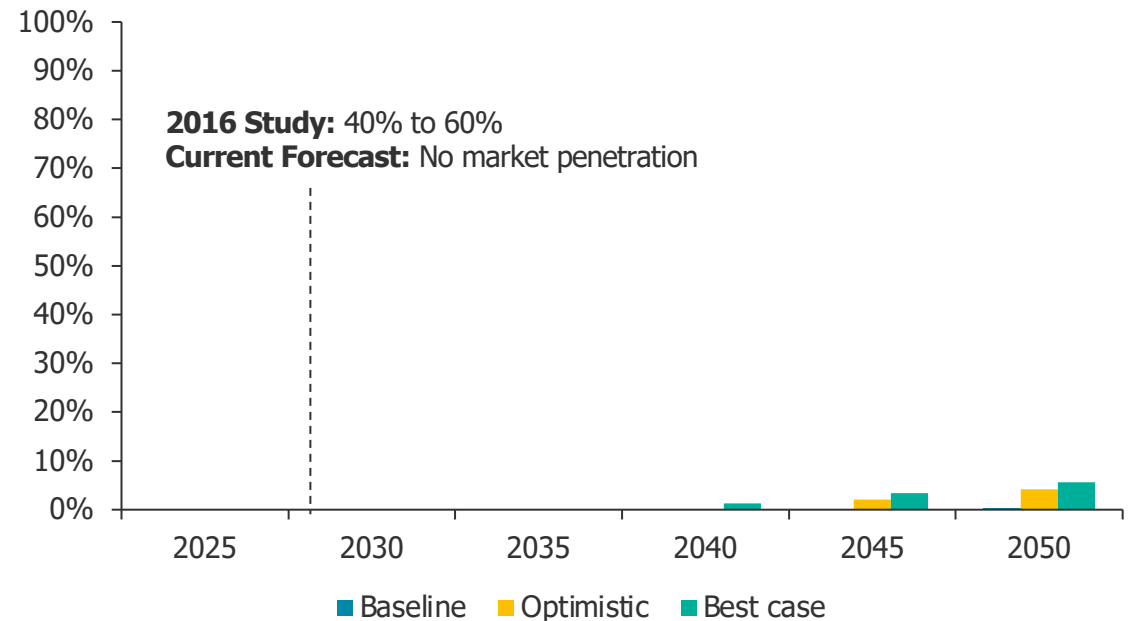# Projected market penetration of CO_2-based jet fuel and CO_2-based methane for three adoption scenarios

Global Jet Fuel Market Penetration
% penetration rate (*2016 study includes all liquid fuels)

2016 Study*: 35% to 95%
Current Forecast: No market penetration

■ Baseline　■ Optimistic　■ Best case

Global Methane Market Penetration
% penetration rate

2016 Study: 40% to 60%
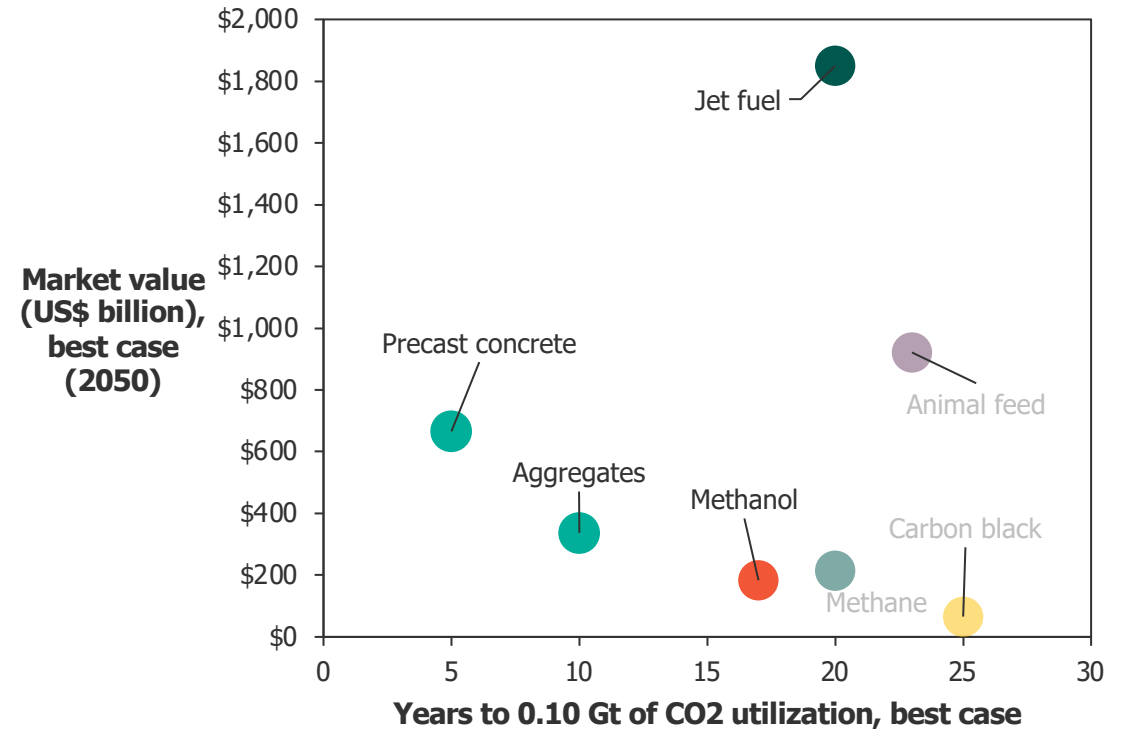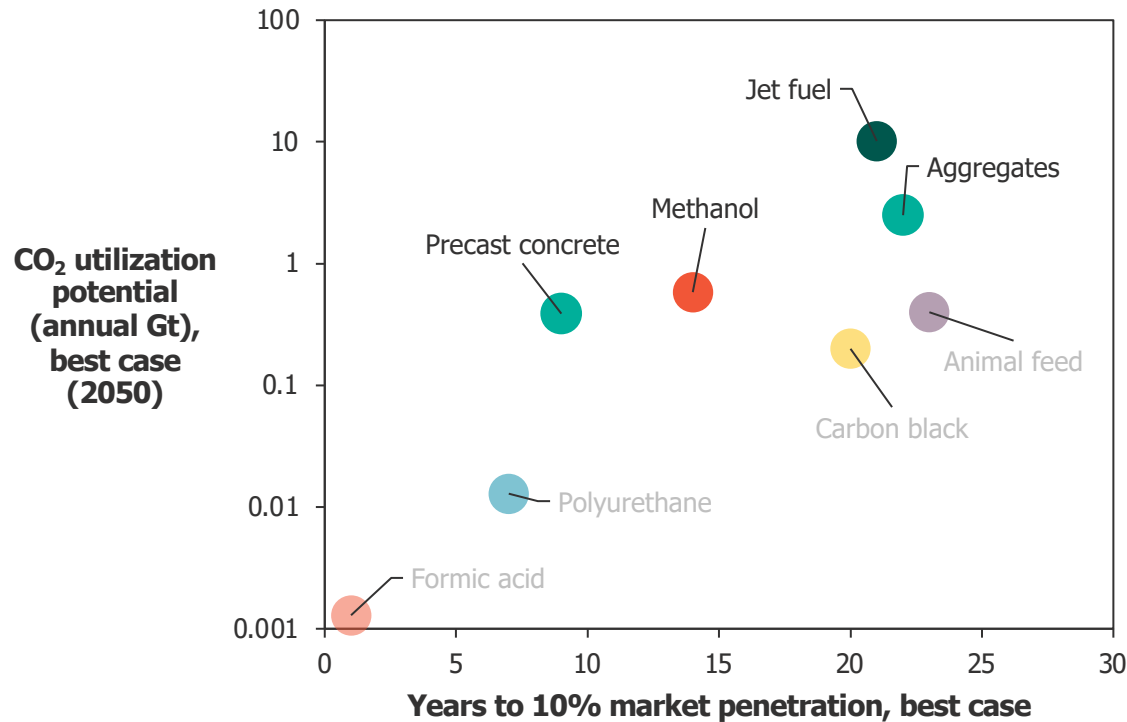**Current Forecast:** No market penetration

■ Baseline　■ Optimistic　■ Best case

The overall market is the native incumbent market, and the penetration rate is defined as the potential replacement of incumbent product with CO_2-derived products based on the baseline, optimistic, and best case scenario. Projected market volume of jet fuel is 3.1 billion MT by 2050 based on a 305 million MT market volume in 2020 and an estimated CAGR of 8%. Projected market volume of methane is 7.0 billion MT by 2050 based on a 2.8 billion MT market volume in 2020 and an estimated CAGR of 3%.

Lux Research

Lux Research analyzed best case scenario key metrics to identify high potential CCU end product opportunities in Track 1 and Track 2

Based on the findings from the CCU end product assessment, Lux Research analyzed key metrics including potential market value (US$ billion), annual CO_2 utilization potential (Gt CO2), technology maturity, and years until market penetration to identify priority opportunities for assessment in Track 1 and Track end products. **Lux Research and Global CO_2 Initiative identified aggregates and precast concrete (Track 1) and jet fuel and methanol (Track 2) that offer the best opportunities for immediate government and private sector support.**


CO_2 utilization potential (annual Gt), best case (2050)

Jet fuel · Aggregates · Methanol · Precast concrete · Animal feed · Carbon black · Polyurethane · Formic acid

Years to 10% market penetration, best case

Market value (US$ billion), best case (2050)

Jet fuel · Precast concrete · Aggregates · Methanol · Animal feed · Carbon black · Methane

Years to 0.10 Gt of CO2 utilization, best case

Legend: ● Building materials ● Carbon additives ● Polymers ● Chemicals ● Food ● Fuels

Note: CCU end products not present in the above figures failed to reach 10% market penetration or utilize 0.1 Gt of CO2 in the best case scenario.

Lux Research

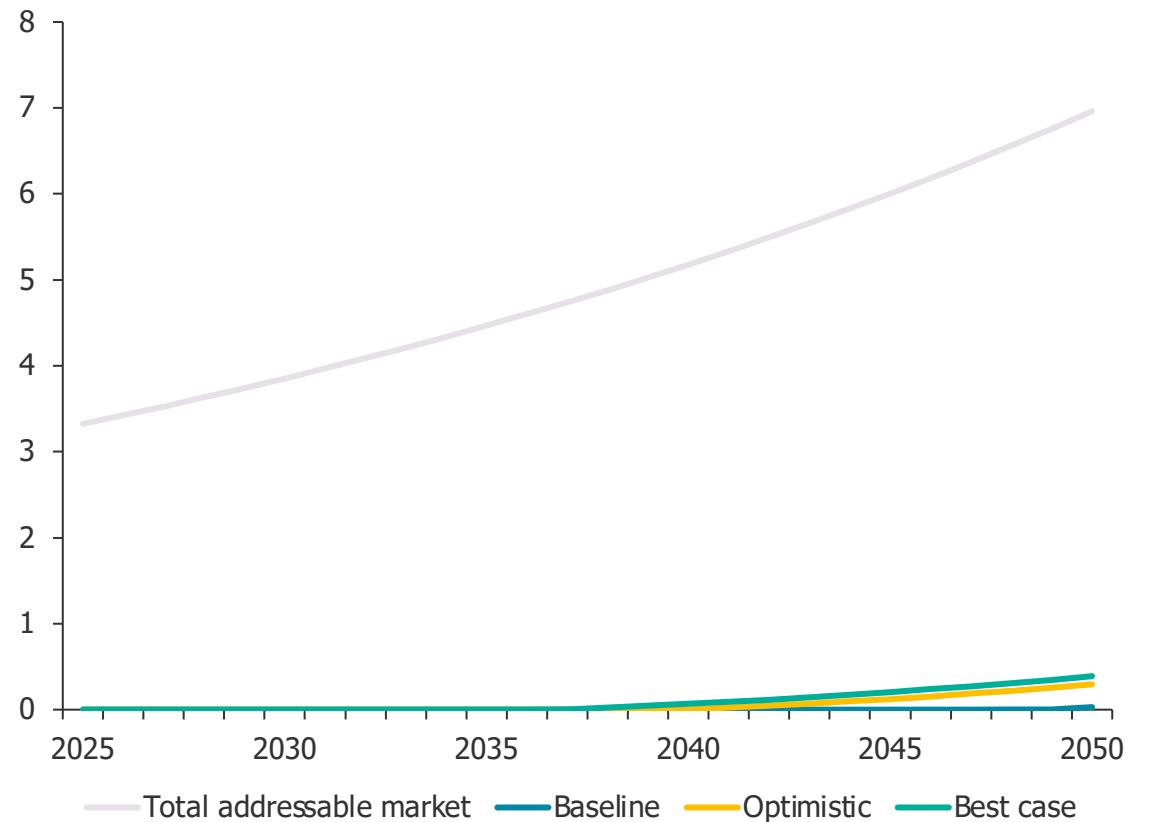# Total addressable market value and market volume for methane with three adoption scenarios

Global Methane Market Value
US$ billion (including incumbent)
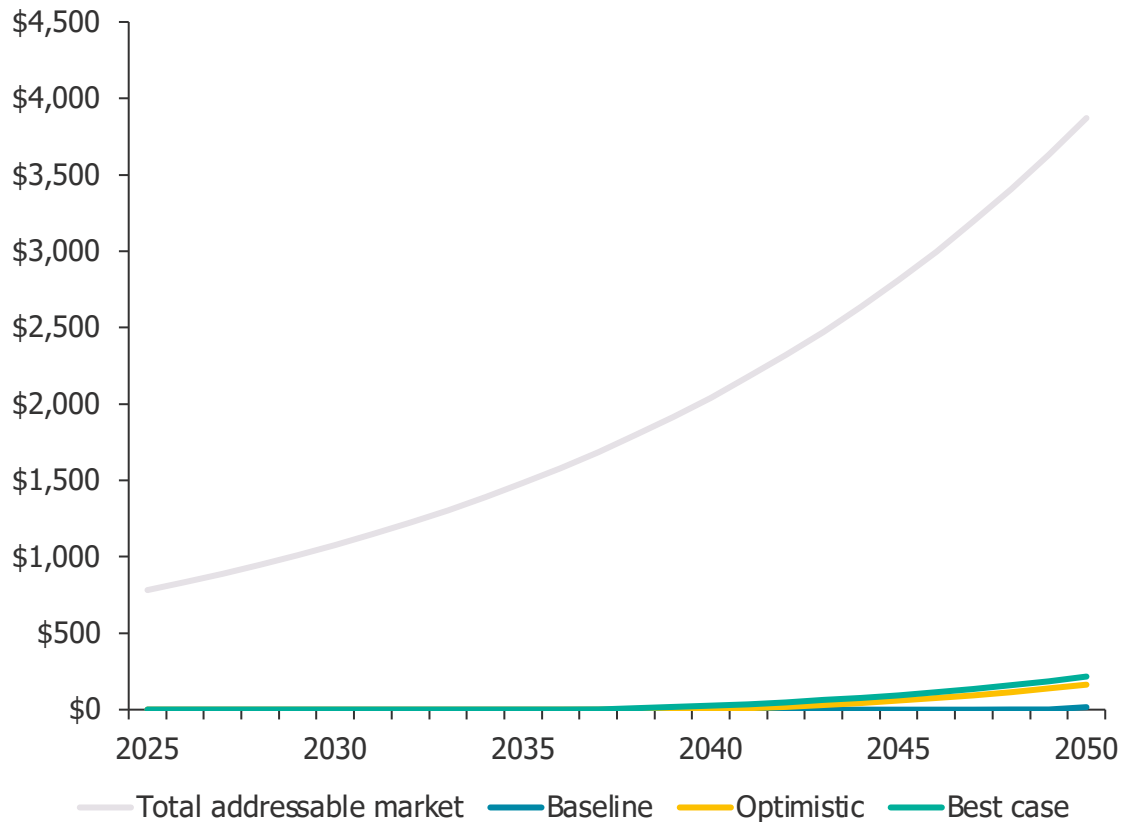
Global Methane Market Volume
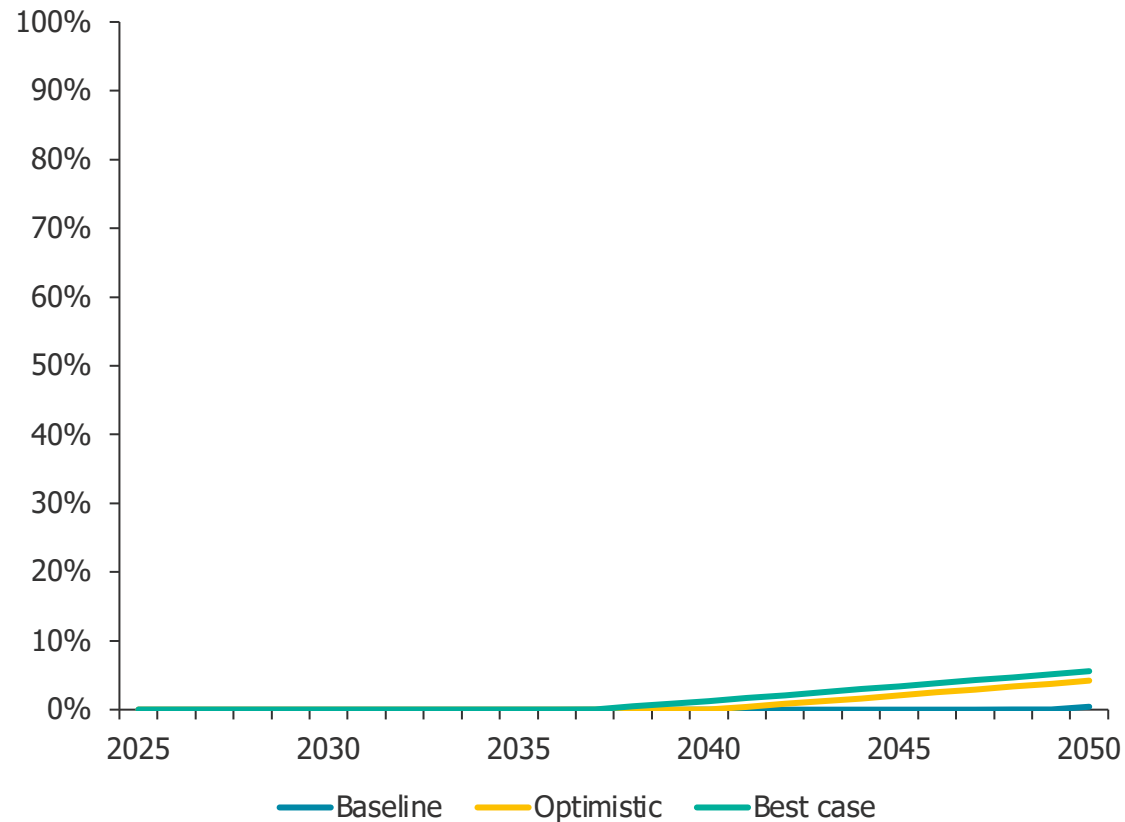Annual billion tonne (including incumbent)

Legend: Total addressable market — Baseline — Optimistic — Best case

Lux Research

Market penetration and cumulative CO_2 utilization for methane for three adoption scenarios

Global Methane Market Penetration
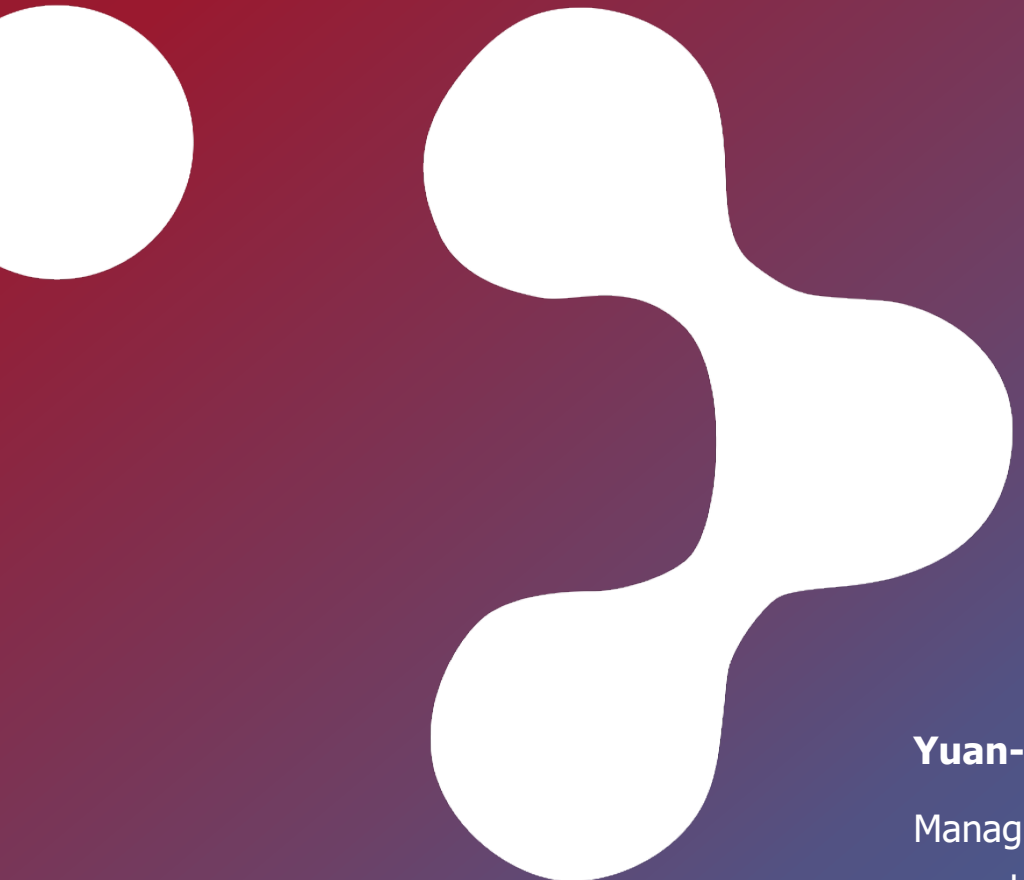% penetration rate

Cumulative Methane CO_2 Utilization
Gt CO_2

Lux Research

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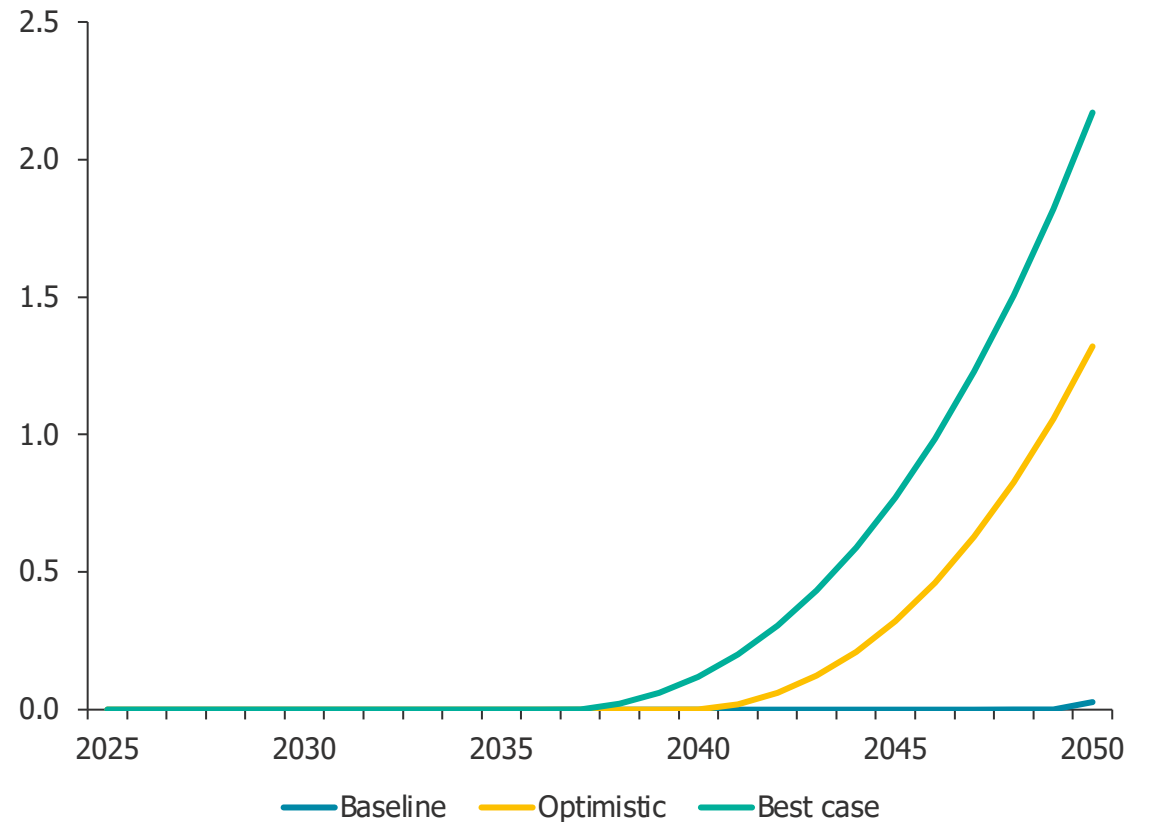
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