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Global and China's CCUS Technology Industry

Independent Market Research

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Scope

The project scope is defined as follows:

Research Period	• Historical Year: 2020-2024 • Base Year: 2024 • Forecast Year: 2025E-2029E
Research Coverage and Methodology	• China Market • Include both primary research and secondary research.
Service Scope and Assumptions	• Global and China CCUS Technology Industry. • Frost & Sullivan's projection on the size of each of the related markets is based on the assumption that (i) the overall global social, economic, and political environment is expected to maintain a stable trend over the next decade; (ii) during the forecast period, related key industry drivers are likely to continue driving growth in China, and global market; and (iii) there are no extreme force major event or industry regulations by which the market situation may be affected either dramatically or fundamentally.

Agenda

1. Overview of Global and China's CCUS Technology Industry

2. The Application of Synthetic Biology Technology in CCUS Technology Industry

3. Competitive Landscape of Global Synthetic Biology Technology CCUS Industry

4. Overview of The Steel and Ferroalloy Industry

Overview of Global and China's CCUS Technology Industry

Introduction to the CCUS Industry

Definition of CCUS

Definition

- CCUS (Carbon Capture, Utilization, and Storage) refers to the process of capturing carbon emissions from industrial processes, energy use, or the atmosphere, for direct utilization, conversion or injection into geological formations to achieve carbon reduction.

Carbon Capture

- Carbon capture refers to the use of technologies such as absorption, adsorption, membrane separation, and synthetic biotechnology to enable the separation of carbon emissions from industrial emissions or ambient air.

Carbon Utilization

- Carbon utilization refers to the process of converting captured carbon emissions into economically viable, value-added products, such as those used in industrial applications.

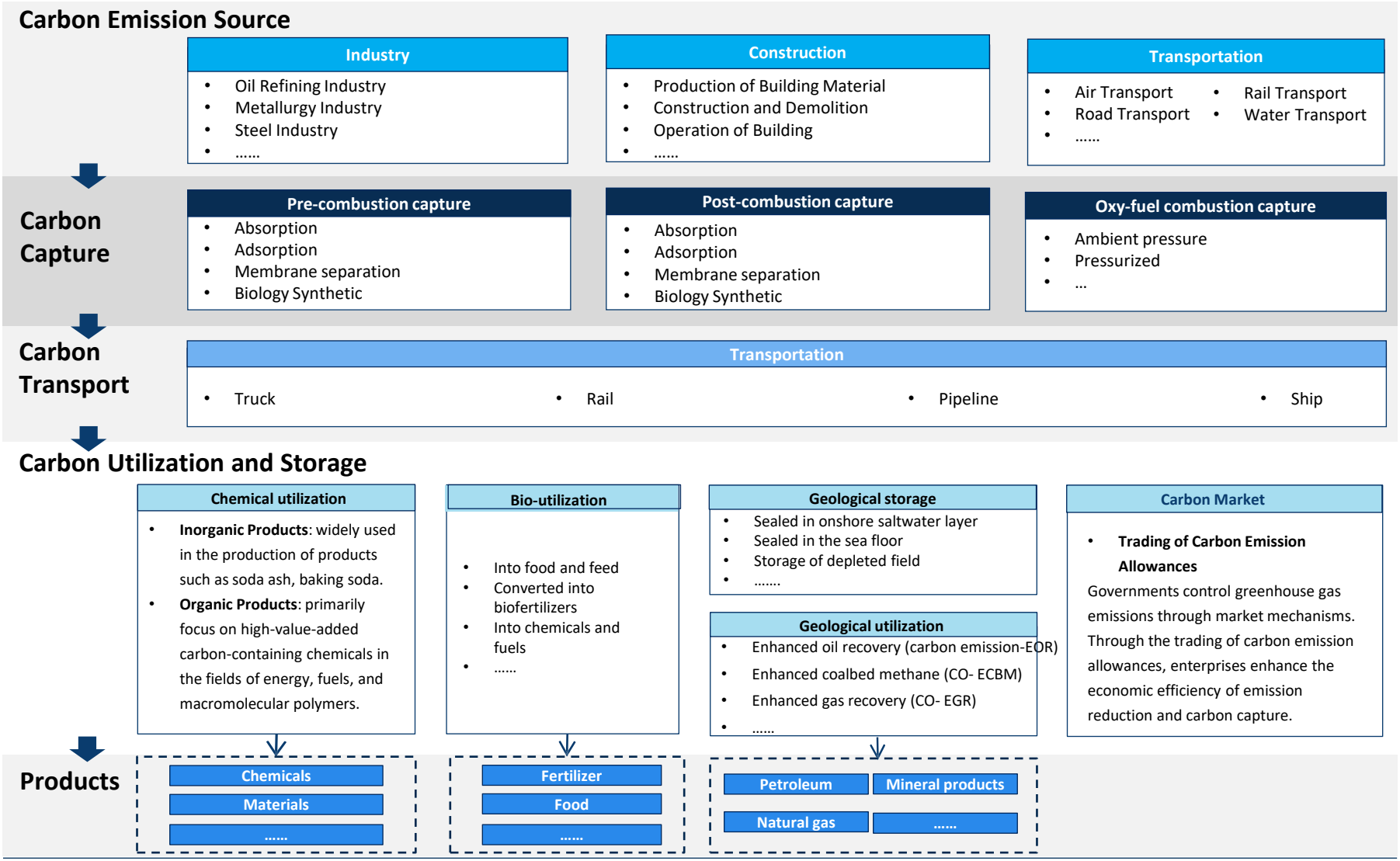
Carbon Storage

- Carbon storage is the proactive process of capturing carbon emissions from the atmosphere and transferring them to long-term storage reservoirs.

Source: Frost & Sullivan

Overview of Global and China's CCUS Technology Industry

Illustration of CCUS Industry Segments



Source: Frost & Sullivan

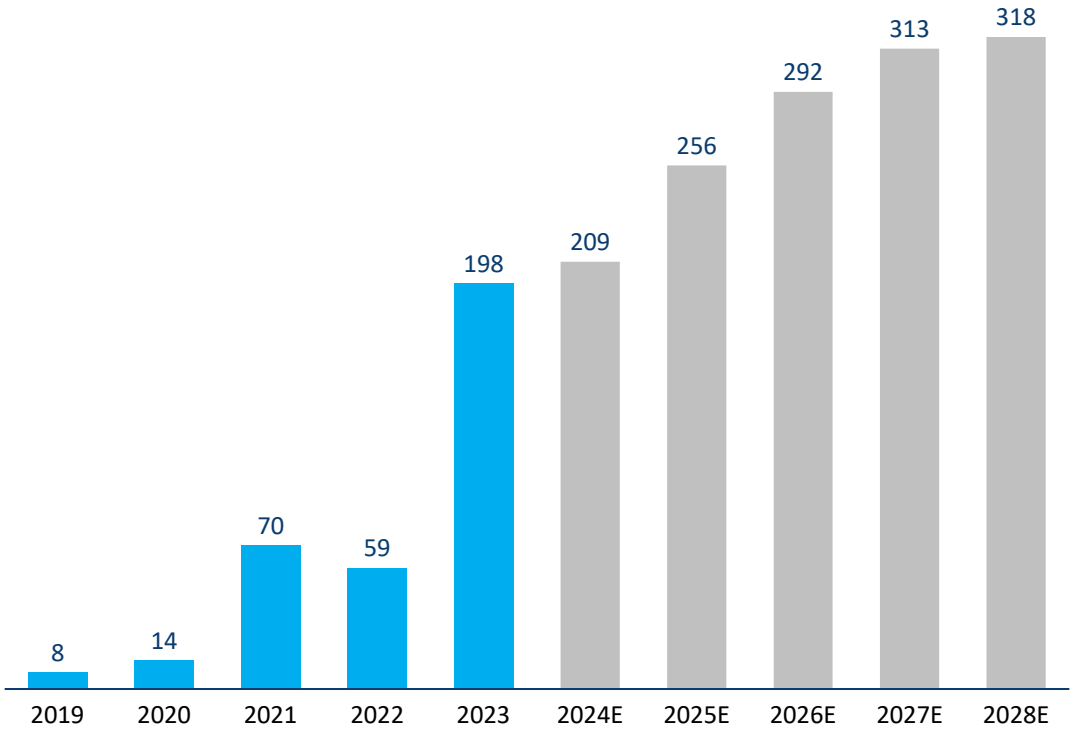
Overview of CCUS Technology Industry

Market Size of Global CCUS Technology Industry

Market Size of Global CCUS Technology Industry, by Incremental Number of Projects

Units, 2019-2028E

	2019-2023	2023-2028E
CAGR	123.0%	10.0%



Note: Facilities involve those in early development, advanced development, in construction and in operation.

Key Findings

- Since 2019, the number of global CCUS projects has shown a remarkable growth trend. In 2019, 8 new CCUS projects were added globally, injecting new vitality into the development of this field. Subsequently, the number of projects has been on the rise continuously. By 2023, the total number of global CCUS projects has increased to 198, fully demonstrating the strong development momentum of this industry.
- The number of global CCUS projects is expected to continue to increase in the future. According to relevant forecasts, the number of newly added global CCUS projects will reach 318 by 2028. With the increasing emphasis on carbon reduction by various countries, the introduction of a series of favorable policies, as well as continuous technological breakthroughs and gradual cost reduction, all will provide strong support for the further development of CCUS projects.

Source: Frost & Sullivan

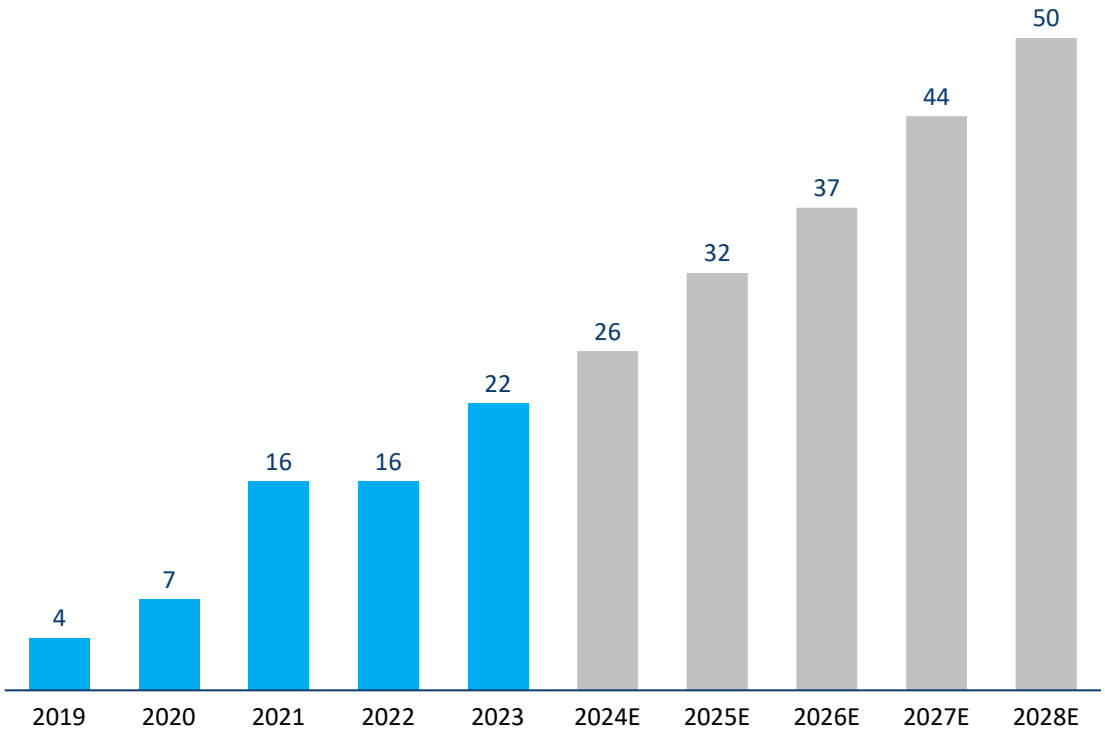
Overview of CCUS Technology Industry

Market Size of China's CCUS Technology Industry

Market Size of China's CCUS Technology Industry, by Incremental Number of Projects

Units, 2019-2028E

	2019-2023	2023-2028E
CAGR	53.1%	17.8%



Note: Facilities involve those in early development, advanced development, in construction and in operation.

Key Findings

- In China, the development of CCUS projects has been remarkable. In 2019, 4 new CCUS projects were added. In recent years, the number of new projects has continued to increase. By 2023, the number of new projects had risen to 22. This growth is mainly attributed to the strong support from the Chinese government, which has introduced a series of policies to encourage the development of low-carbon technologies, with CCUS being seen as a key technology for achieving carbon neutrality. Additionally, as the awareness of enterprises of environmental protection continues to rise, more and more companies are willing to invest in CCUS projects to reduce carbon emissions. The number of CCUS projects in China is projected to maintain a robust growth in the future. Concurrently, the investment amount per project is also on the rise. These trends are set to drive the vigorous development of the CCUS industry in the years to come.

Source: Frost & Sullivan

Overview of Global and China's CCUS Technology Industry

Market Driver of Global and China's CCUS Technology Industry (1/2)

Favorable Policies

- Driven by various favorable policies and regulations worldwide, global CCUS technology has flourished. In China, the "dual carbon" goals have created significant opportunities, positioning CCUS as a key pillar for achieving carbon neutrality. For instance, China's 2024-2025 Energy Conservation and Carbon Reduction Action Plan (2024-2025年節能降碳行動方案) sets targets, including achieving energy savings equivalent to 50 million tons of standard coal and reducing CO2 emissions by approximately 130 million tons annually in key sectors by 2024 and 2025.

Acceleration of Industry Development by Emerging CCUS Technologies

- Traditional CCUS technologies, such as absorption and adsorption methods, are relatively mature. However, the emergence of new CCUS technologies, represented by synthetic biotechnology, has brought new opportunities for development in the CCUS field. By integrating carbon capture and carbon utilization, synthetic biotechnology has accelerated the conversion efficiency of carbon emissions, as well as expanded utilization scenarios, driving the commercialization process of the CCUS industry.

Source: Frost & Sullivan

Overview of Global and China's CCUS Technology Industry

Market Driver of Global and China's CCUS Technology Industry (2/2)

Accelerated Transition of Technology towards Industrialization Capability

- industrial applications, encompassing equipment design, process optimization, and commercial deployment. These capabilities drive the transition from experimental to practical solutions, enabling widespread CCUS adoption. Strain selection and iteration, key to synthetic biotechnology, improve microorganism stability and productivity in fermentation, enhancing industrial suitability. Advanced industrialization design expands production, lowers costs, and boosts CCUS competitiveness in large-scale applications.

Development of the Carbon Trading Market

- The carbon capture segment of CCUS enables companies to reduce carbon emissions, thus obtaining more carbon emission allowances for trading and actively participating in the carbon market. By the end of 2023, the total volume of carbon emission allowances traded in China's national carbon market reached 440 million tons, with a total transaction value of RMB24.9 billion. By the end of 2028, China's carbon emission allowance trading volume is expected to exceed 3 billion tons, with a total transaction value expected to surpass RMB300 billion. China's carbon trading price increased from RMB42.8 per ton in 2021 to RMB103.2 per ton in October 2024 and is expected to increase to RMB145.0 per ton in 2028.

Source: Frost & Sullivan

Overview of Global and China's CCUS Technology Industry

Favorable Policies/Regulations Regarding Global CCUS Industry

Release Date	Issuing Authority	Policies	Main Contents
Oct. 2024	**European Union** European Commission	The Net-Zero Industry Act	By 2030, EU domestic manufacturing capacity in key net-zero technology fields should meet 40% of EU demand. For carbon capture and storage, the act mandates that the EU's geological carbon storage capacity should reach 50 million tons per year by 2030.
August 2022	**United States** U.S. Government	Inflation Reduction Act ("IRA")	The IRA provides significant updates to the 45Q tax credit, incentivizing carbon capture and storage. For industrial and power generation facilities storing carbon in deep saline formations, the 45Q credit increases from USD50/ton to USD85/ton. For industrial and power generation facilities utilizing carbon capture, the credit rises from USD35/ton to USD60/ton. These incentives are available for up to 12 years after the carbon capture equipment becomes operational.

Source: Frost & Sullivan

Overview The Application of Synthetic Biology Technology in CCUS Technology Industry

Release Date	Issuing Authority	Policies	Main Contents
January 2025	General Office of the State Council	Opinions on Promoting the High-quality Development of Refined Oil Circulation (關於推動成品油流通高質量發展的意見)	Local governments at all levels shall: coordinate the supervision, investigation and punishment of violations of laws and regulations regarding the distribution of refined oil products, and it is strictly forbidden to sell vehicle fuels with gasoline or diesel as the main ingredients in the names of 'new energy' and 'alternative energy' that do not comply with national policies and regulations. The government will investigate and deal with serious acts such as substandard oil product quality, illegal blending of refined oil, and sale of non-standard oil products as engine fuel to refined oil retailers or engine fuel users.
December 2023	National Development and Reform Commission (NDRC) and other relevant departments	Guideline Catalog for Industrial Restructuring (2024 Edition) (產業結構調整指導目錄(2024年版))	The catalog classifies CCUS technologies for coal-fired power generation units, as well as carbon capture, purification, utilization, and storage technologies for furnace flue gas emissions, as encouraged technologies to promote industrial upgrading and low-carbon transformation.
December 2021	Ministry of Industry and Information Technology (MIIT), Ministry of Science and Technology (MOST), Ministry of Natural Resources (MNR)	"14th Five-Year Plan" for the Development of Raw Material Industries (“十四五”原材料工業發展規劃)	The plan aims to promote a range of advanced technologies, including low-carbon technologies such as bio-fermentation of industrial carbon monoxide tail gas for ethanol production, to facilitate the green and high-quality development of raw material industries.
November 2021	Ministry of Industry and Information Technology (MIIT)	14th Five-Year Plan for Industrial Green Development (“十四五”工業綠色發展規劃)	The plan emphasizes strengthening industrial foundational research and advancing the deployment of frontier technologies, including innovative approaches such as carbon monoxide fermentation for ethanol production. These initiatives aim to drive low-carbon transformation in industrial processes, enhance resource efficiency, and foster breakthroughs in green manufacturing technologies.

Source: Frost & Sullivan

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The Application of Synthetic Biology Technology in CCUS Technology Industry

Cost Analysis of Each Technical Route(1/2)

Comparison of Mainstream Technology Paths for Ethanol Production in China

- In the carbon capture and utilization (CCU) industry, there are four main methods, namely absorption, adsorption, membrane separation and synthetic biotechnology.
- The first three methods focus on carbon capture, but they often face practical issues such as limited utilization pathways or restricted usage scenarios after capture. For example, the captured gas is used for enhanced oil recovery, underground storage, or converted into carbonates through mineralization for sale.
- Compared to the first three methods, synthetic biotechnology can achieve an integrated layout from carbon capture to carbon utilization, converting industrial off-gas directly into high-value-added products with diverse applications, such as ethanol and microbial protein. Additionally, the cost of carbon capture using synthetic biotechnology is lower, saving more than RMB200 per ton.
- The different production technologies generally do not affect the selling price of fuel ethanol, which remains stable within a certain price range.

	Industrial Off-Gas Synthetic Ethanol	Grain Ethanol	Coal-based Ethanol	Cassava Ethanol
Type of Raw Material	Carbon-containing industrial off-gas	Grain crops represented by corn	Fossil fuels represented by coalbased syngas	Non-grain crops represented by cassava
Production Cost(1)	4,800-5,900 RMB/Ton	6,800-7,000 RMB/Ton	3,600-4,500 RMB/Ton	6,800-7,500 RMB/Ton
Market Share in Fuel Ethanol Production	3.33% in 2023 and projected to be 3.38% in 2024	79.05% in 2023 and projected to be 78.26% in 2024	N/A(2)	17.62% in 2023 and projected to be 18.36% in 2024
Market Sales Price	Around RMB 5,500- 6,500	Around RMB 5,500-6,500	N/A(2)	Around RMB 5,500- 6,500
RSB/ISCC	Available (the Company's ethanol products have already obtained such)	Relatively difficult to be obtained	Unavailable	Relatively difficult to be obtained
Product Accessibility and Scalability	Fuel ethanol, SAF (China, the EU and the US)(3), green polyethylene and other chemicals sectors	Fuel ethanol, SAF (the US)(3), edible ethanol and other chemical sectors	Chemical sector, not allowed to enter into the fuel ethanol market	Fuel ethanol, SAF (the US)(3), edible ethanol and other chemical sectors
National Policy(4)	Non-grain raw materials, encourage development	Strictly control the increase of grain-based fuel ethanol	Preventing and combating entry into the fuel ethanol market	Non-grain raw materials, encourage development

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Cost Analysis of Each Technical Route(2/2)

	Industrial Off-Gas Synthetic Ethanol	Grain Ethanol	Coal-based Ethanol	Cassava Ethanol
Advantages	Environmentally friendly raw material, can obtain low-carbon and sustainable certification; low production cost	Highly mature traditional production process	Large individual scale	Producing ethanol from non-grain crops avoids occupying food resources
Disadvantages	Susceptible to upstream gas supply	High production cost Reliance on food resources	Consumes fossil energy, not allowed in the fuel ethanol market, unable to obtain low-carbon and sustainable certification	Raw materials depend on Imports Reliance on land resources

Note:
(1) The production cost range is the average annual cost of each method in China from 2021 to 2024. The production cost takes into account the raw material cost and processing cost. The production cost of grain ethanol deducts the economic value of the by-product.

(2) Due to government policies restricting coal-based ethanol from entering the fuel ethanol market, there are no statistics available on the use of coal-derived ethanol in fuel ethanol.

(3) The eligibility of raw materials for SAF production is determined based on the material list of the ISCC EU, ISCC Plus, ISCC CORSIA, etc.

(4) For further details, please refer to "Regulatory Overview — Regulations on Clean Production and Renewable Energy" of this prospectus.

The Application of Synthetic Biology Technology in CCUS Technology Industry

Key Technologies for Achieving the Carbon Peaking and Carbon Neutrality Goals	• In 2020, China explicitly committed to enhancing its national contribution to carbon peaking and carbon neutrality goals by implementing more robust policies and measures. Synthetic biotechnology is a key technology for carbon capture, supporting energy transformation and playing a vital role in reaching the "dual carbon" goals.
Upgrade and Transformation of CCS to CCUS	• CCS has faced challenges in commercialization due to technological limitations and economic viability. Synthetic biotechnology is changing this by optimizing fermentation strains to produce high-value products, advancing CCS to CCUS. This accelerates carbon neutrality goals and fosters a green, low-carbon economy.
Addressing Resource Constraints and Global Regional Development Imbalances	• Unlike traditional ethanol production methods reliant on food-based fermentation, synthetic biotechnology leverages COX compounds from industrial off-gases as raw materials to produce high-value products. This innovative approach not only reduces production costs and enhances energy efficiency but also minimizes dependence on food resources. In addition, microorganisms modified through synthetic biotechnology can utilize nontraditional raw materials, such as industrial off-gases, to produce microbial proteins. This innovation breaks the spatial and temporal limitations of traditional protein synthesis, effectively conserving food resources and arable land. It also significantly alleviates the pressure of regional imbalances in food supply and demand, providing strong support for sustainable development.
Development of ESG	• Taking China as an example, synthetic biotechnology promotes ESG development in China's manufacturing sector, reduces the carbon footprint of Chinese products throughout their lifecycle, and drives the growth of a low-carbon economy. This not only enhances the sustainable use of resources but also fosters the formation of green industrial chains, fueling a virtuous cycle of green investment and technological innovation.

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Favorable Policies and Regulations Promoting Technologies(1/3)

Policies	Issuance Date	Issuing Authority	Main Content
National Biofuel Ethanol Industry Overall Layout Plan (全國生物燃料乙醇產業總體布局方案)	2018.09	National Development and Reform Commission and others	The Hebei Shoulang 45,000 tons/year fuel ethanol project of the company has been included as a pilot demonstration project.
"14th Five-Year Plan" for Bioeconomic Development ("十四五"生物經濟發展規劃)	2021.12	National Development and Reform Commission	Conducting research and development of new biomass energy technologies and fostering them, promoting the integration of biofuels and bio-based chemicals. Actively advancing the substitution and application of advanced biofuels in key sectors such as municipal and transportation industries, and promoting the transition of fossil energy to green, low-carbon, renewable energy.
"14th Five-Year Plan" for Raw Materials Industry Development ("十四五"原材料工業發展規劃)	2021.12	Ministry of Industry and Information Technology, Ministry of Science and Technology, Ministry of Natural Resources	Promoting a batch of advanced technologies (including carbon monoxide industrial off-gas fermentation for ethanol and other low-carbon technologies).
Resource Comprehensive Utilization Corporate Income Tax Incentive Directory (2021 Edition) (資源綜合利用企業所得稅優惠目錄(2021版))	2021.12	Ministry of Finance, State Taxation Administration, National Development and Reform Commission (NDRC), Ministry of Ecology and Environment	Coke oven gas, converter gas, and biomass syngas for producing denatured fuel ethanol (purity: 99.5%), ethanol clostridium protein/microbial protein (crude protein: 80%).
Resource Comprehensive Utilization Products and Services VAT Incentive Directory (2022 Edition) (資源綜合利用產品和勞務增值稅優惠目錄(2022版))	2021.12	Ministry of Finance, State Taxation Administration	Converter gas, blast furnace gas, chemical off-gas, biomass syngas, and garbage gasification syngas for fuel ethanol production.

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Favorable Policies and Regulations Promoting Technologies(2/3)

Policies	Issuance Date	Issuing Authority	Main Content
New Products Directory for Feed and Feed Additives (飼料和飼料添加劑新產品目錄)	2021.12	Ministry of Agriculture and Rural Affairs	According to the Feed and Feed Additives Management Regulations and New Feed and New Feed Additives Management Methods, the application for ethanol clostridium protein from Beijing Shoulang Biotechnology Co., Ltd. Has been approved as a new feed; applicable to fish.
Steel Industry Energy Saving and Carbon Reduction Upgrade Implementation Guide (鋼鐵行業節能降碳改造升級實施指南)	2022.02	National Development and Reform Commission (NDRC)	Gradually promoting the use of metallurgical industry off-gas for fuel ethanol and feed protein production technology, realizing carbon dioxide capture and utilization.
Announcement No. 692 of the Ministry of Agriculture and Rural Affairs of the People's Republic of China (中華人民共和國農業農村部公告第692號)	2023.07	Ministry of Agriculture and Rural Affairs	Expanding the scope of feed material ethanol clostridium protein for piglets and poultry.
Notice regarding Preventing Coal-based Ethanol from Entering Biomass Fuel Ethanol Market and Further Regulating Market Order (關於防止煤制乙醇進入生物燃料乙醇市場進一步規範市場秩序的通知)	2023.10	Comprehensive Department of the National Energy Administration Notice	Specifically and vigorously crack down on the flow of coal-based ethanol into the biomass fuel ethanol market
Green and Low-Carbon Transformation Industry Guidance Directory (2024 Edition) (綠色低碳轉型產業指導目錄(2024年版))	2024.02	National Development and Reform Commission (NDRC) and others	Energy recovery and raw material utilization of waste gases such as coke oven gas, blast furnace gas, converter gas, and high-sulfur natural gas for fuel ethanol production.

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Favorable Policies and Regulations Promoting Technologies(3/3)

Policies	Issuance Date	Issuing Authority	Main Content
Green and Low-Carbon Advanced Technology Demonstration Project List (First Batch) (綠色低碳先進技術示範項目清單(第一批))	2024.03	National Development and Reform Commission (NDRC)	Shougang Langze Hebei Shoulang CO_2-containing industrial off-gas biological synthesis anhydrous ethanol project successfully selected.
National Industrial and Information Technology Field Energy Saving and Carbon Reduction Technology and Equipment Recommended Directory (2024 Edition) (國家工業和信息化領域節能降碳技術裝備推薦目錄(2024年版))	2024.04	Ministry of Industry and Information Technology	The Steel Industry Off-gas Fermentation to Ethanol Technology has been included in the National Industrial and Information Technology Field Energy Conservation and Carbon Reduction Technology and Equipment Recommendation Directory.
Green Technology Promotion Directory (2024 Edition) (綠色技術推廣目錄(2024年版))	2024.12	National Development and Reform Commission (NDRC) and 7 other departments	The company's technology has been selected as a demonstration case.
Notice on Announcing the First Batch of New-round Key "Little Giant" Enterprises Receiving High-Quality Development Subsidy Fund Support (關於對新一輪第一批重點"小巨人"企業高質量發展獎補資金支持項目進行公告的通知)	2024.12	Beijing Municipal Bureau of Economy and Information Technology	Selected as a key "Little Giant" enterprise in the first batch of the new round
National Catalogue of Low-Carbon Technologies (Fifth Batch) (國家重點推廣的低碳技術目錄(第五批))	2025.01	Ministry of Ecology and Environment and five other ministries	Hebei Shoulang's bio-fermentation technology for ethanol production from steel industry off-gas was included in the catalogue.
Opinions on Promoting the Development of High Quality Refined Oil Products (關於推動成品油流通高質量發展的意見)	2025.01	General Office of the State Council	Local governments at all levels shall coordinate the supervision, investigation and punishment of violations of laws and regulations regarding the distribution of refined oil products, and it is strictly forbidden to sell vehicle fuels with gasoline or diesel as the main ingredients in the names of "new energy" and "alternative energy" that do not comply with national policies and regulations. The government will investigate and deal with serious acts such as substandard oil product quality, illegal blending of refined oil, and sale of non-standard oil products as engine fuel to refined oil retailers or engine fuel users.

Source: Frost & Sullivan

Overview of Global and China's CCUS Technology Industry

Introduction to the Fuel Ethanol

Definition of Fuel Ethanol

Definition

- Fuel ethanol, a clean and renewable biofuel, reduces reliance on non-renewable energy sources like petroleum, with significantly lower emissions (105-150 g CO2e/MJ) compared to petroleum fuel (190-250 g CO2e/MJ). Boasting a high-octane number (109) for superior anti-knock performance, it also enhances the complete combustion efficiency of gasoline, minimizing atmospheric pollution.

Source: Frost & Sullivan

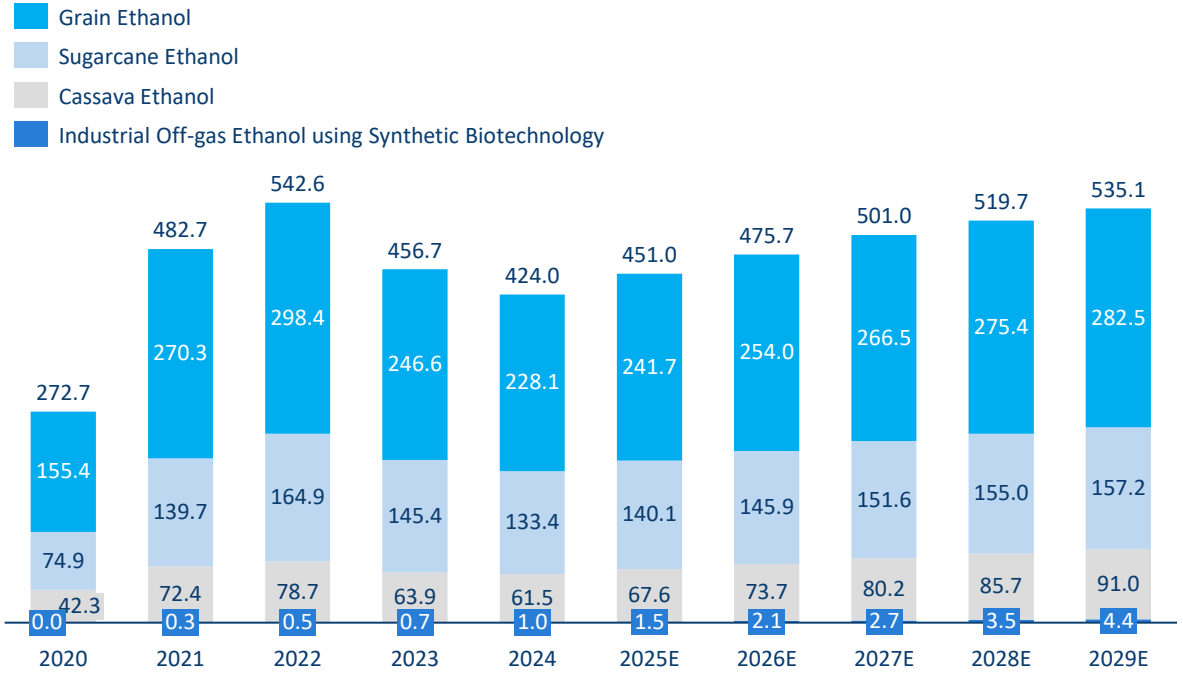
The Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Global Fuel Ethanol

Production Value of Global Fuel Ethanol

Billion RMB, 2020-2029E

CAGR	2020-2024 CAGR	2024-2029E CAGR
Grain Ethanol	10.1%	4.4%
Sugarcane Ethanol	15.5%	3.3%
Cassava Ethanol	9.8%	8.2%
Industrial Off-gas Ethanol using Synthetic Biotechnology	132.4%	34.4%



Key Findings

- Globally, the market value of fuel ethanol increased from RMB272.7 billion in 2020 to RMB424.0 billion in 2024, with a compound annual growth rate (CAGR) of 11.7%. In 2024,the global fuel ethanol production was 92.93 million tons. The United States accounted for approximately 53% to 55%, whilst Brazil accounted for about 30% and the European Union for around 5%. Among them, the United States and Brazil are the two largest producers globally. The United States primarily adopts the corn method, while Brazil primarily adopts the sugarcane method. In 2024, 54% of the global fuel ethanol market value came from the corn method, 32% from the sugarcane method, and 15% from the cassava method and others. With the continuous expansion of downstream demand and the strengthening of environmental policies, it is expected that by 2029, the global fuel ethanol production value will reach RMB535.1 billion, with a CAGR of 4.8% from 2024 to 2029.

Source: Frost & Sullivan

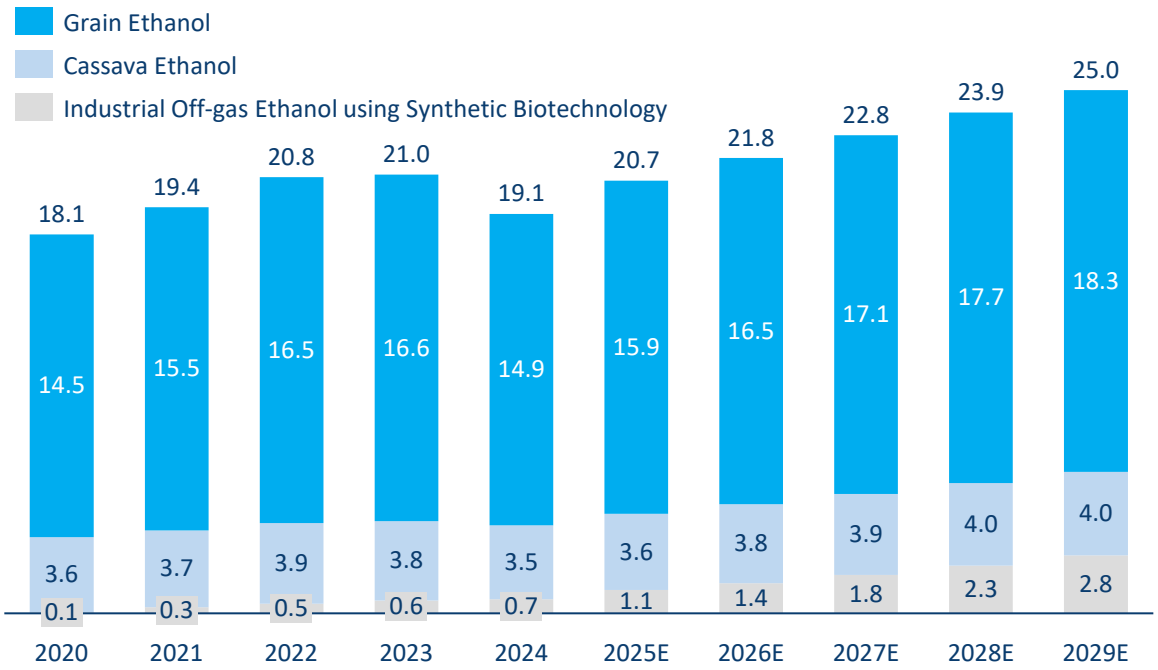
The Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of China's Fuel Ethanol

Production Value of China's Fuel Ethanol

Billion RMB, 2020-2029E

CAGR	2020-2024 CAGR	2024-2029E CAGR
Total	1.3%	5.5%
Grain Ethanol	0.7%	4.2%
Cassava Ethanol	-0.4%	2.5%
Industrial Off-gas Ethanol using Synthetic Biotechnology	89.9%	32.6%



Key Findings

- In China, the market value of China's fuel ethanol was RMB19.1 billion in 2024, with the corn method being the mainstream method. It is expected that by 2029, the market value of fuel ethanol will reach RMB25.0 billion, with a compound annual growth rate (CAGR) of 5.5%.

Source: Frost & Sullivan

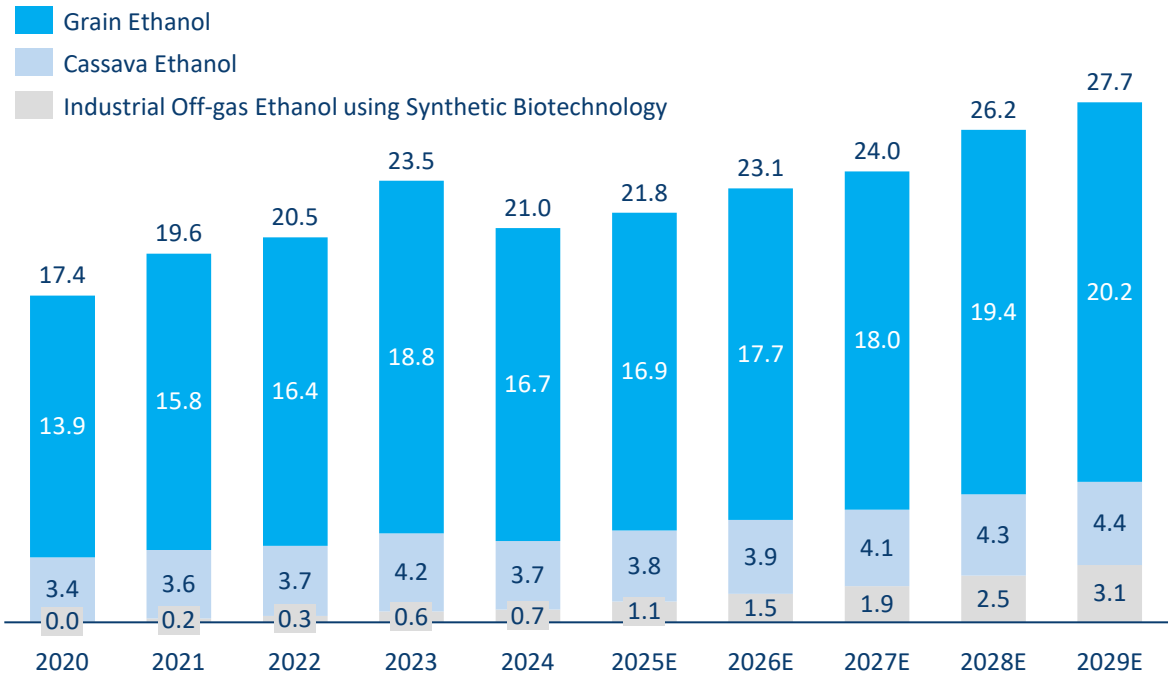
The Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of China's Fuel Ethanol

Sales Value of China's Fuel Ethanol

Billion RMB, 2020-2029E

CAGR	2020-2024 CAGR	2024-2029E CAGR
Total	3.8%	5.7%
Grain Ethanol	3.6%	3.9%
Cassava Ethanol	1.4%	3.8%
Industrial Off-gas Ethanol using Synthetic Biotechnology	71.6%	35.3%



Key Findings

- In China, the sales value of fuel ethanol increased from RMB17.4 billion in 2020 to RMB21.0 billion in 2024 with a CAGR of 3.8%, primarily driven by corn-based production methods. The market is expected to reach around RMB27.7 billion by 2029, with a CAGR of 5.7%.

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

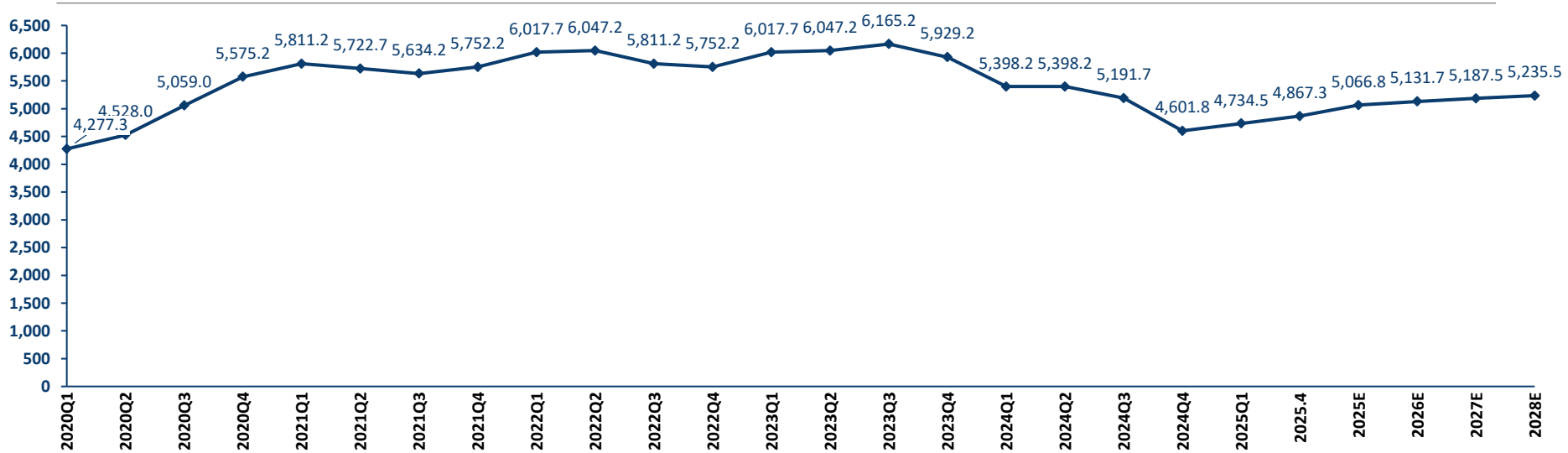
Market Price of Fuel Ethanol in China

Key Findings

- From 2020, the COVID-19 pandemic disrupted supply chains and pushed prices into an upward trend. Despite certain monthly fluctuations during this period, prices continued to rise and eventually reached a record quarterly high of RMB6,047.2 per ton in the second quarter of 2022. From 2022 to the end of 2023, the quarterly price of fuel ethanol in China exhibited a general downward trend, primarily due to the market impact of low-cost coal-based ethanol. From the end of 2023, regulatory measures were gradually introduced in China to restrict the entry of coal-based ethanol into the fuel ethanol market. As there was a lag between policy implementation and market response, prices continued to decline throughout 2024. Since 2025, fuel ethanol prices have shown a relatively clear upward trend, reaching RMB4,734.5 per ton in the first quarter and remaining at RMB4,867.3 per ton in April 2025. In the future, as environmental protection policies become more stringent and the demand for sustainable aviation fuel and green polyethylene continues to grow, the demand for fuel ethanol as a feedstock is expected to increase steadily, driving prices upward. It is projected that by 2028, the overall price will reach RMB5,235.5 per ton.

China Fuel Ethanol Price (RMB/ton)

2020-2028E



Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Market Drivers for Industrial off-gas Synthetic Biotechnology Ethanol Use

Market Drivers

Reducing Dependence on Food, Land and Water Resources	• With population growth and an increasing demand for food, food resources have become increasingly scarce. The production of industrial off-gas synthetic biotechnology ethanol avoids the risk of exacerbating food shortages due to energy production. Such production has a positive impact on protecting farmland and achieving sustainable development, while also helping to reduce the consumption of water resources.
Transforming the Global Energy Structure	• The depletion of traditional fossil fuels and environmental pollution issues have prompted people to seek clean and renewable energy alternatives. As a renewable and low-carbon energy option, the use of industrial off-gas synthetic biotechnology ethanol will help reduce dependence on fossil fuels, promote the diversification of energy structure, and drive the green transformation of the global energy system..

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Market Entry Barriers/Threats and Challenges of Fuel Ethanol

Market Entry Barriers

Reducing Dependence on Food, Land and Water Resources	• High market entry threshold. In 2013, the State Council issued the Catalogue of Investment Projects Approved by the Government (2013 Edition) (Guo Fa [2013] No. 47) (政府核准的投資項目目錄(2013年本)(國發[2013]47號)), stipulating that denatured fuel ethanol projects are to be approved by provincial governments, and this practice has continued to date. According to the Opinions of the Central Committee of the Communist Party of China and the State Council on Doing a Good Job in Promoting Rural Revitalization in 2022 (中共中央國務院關於做好2022年全面推進鄉村振興重點工作的意見), the processing of fuel ethanol using corn as raw material is strictly controlled, thus limiting the production paths of traditional bioethanol. At the end of 2023, the General Office of the National Energy Administration issued the Notice on Preventing Coal-based Ethanol from Entering the Biofuel Ethanol Market and Further Regulating Market Order (Guo Neng Zong Tong Ke Ji [2023] No. 124) (關於防止煤制乙醇進入生物燃料乙醇市場進一步規範市場秩序的通知(國能綜通科技[2023]124號)), cracking down on the inflow of coal-based ethanol into the biofuel ethanol market.
Advanced non-grain ethanol technology requirements	• With stricter restrictions on the raw materials for the production of fuel ethanol, new entrants need to adopt more advanced production technologies, such as converting non-grain raw materials, agricultural and forestry waste, or industrial off-gas into fuel ethanol. This requires significant investment in R&D, technological innovation and technical training, which cannot be achieved in a short time.
High initial investment	• The construction of fuel ethanol production facilities requires substantial capital investment. New entrants must have sufficient financial strength to support the construction of large-scale production facilities and ensure they can meet the ongoing funding needs during operation.

Threats and Challenges

- Fuel ethanol is primarily used in the automotive fuel sector. With the increase in the number of new energy vehicles, gasoline consumption may face the risk of decline, leading to weakened market demand for fuel ethanol.

Source: Frost & Sullivan

The Application of Synthetic Biology Technology in CCUS Technology Industry

Favorable Policies and Regulations Promoting Non-grain-based Ethanol in China

- The PRC government has been actively promoting non-grain-based ethanol. The table below outlines the main government policies implemented after 2017 promoting the usage of non-grain-based ethanol

Release Date	Policies	Main Contents
2021	The 14th Five-Year Plan for Bioeconomy Development (“十四五”生物經濟發展規劃)	Developing new biomass energy technologies, promoting their growth, and advancing the integrated development of biofuels and biotechnology
2022	The 14th Five-Year Plan for Modern Energy System Development (“十四五”現代能源體系規劃)	Aiming to enhance the overall benefits of fuel ethanol while adhering to the principle of not competing with food crops for land or grain resources, and promoting the development of non-grain biofuels such as bio-aviation kerosene
2022	2022 Rural Revitalization Priorities (關於做好2022年全面推進鄉村振興重點工作的意見)	Strictly controlling the processing of fuel ethanol using corn as a raw material
2024	2024-2025 Energy Conservation & Carbon Reduction Action Plan (2024—2025年節能降碳行動方案)	Regulating petroleum consumption and promoting the adoption of advanced biobased liquid fuels and sustainable aviation fuels.
2025	2025 Energy Sector Work Guidelines (2025年能源工作指導意見)	Expanding emerging energy industries and business models, promoting the development of renewable hydrogen and sustainable fuel industries, advance research, technological breakthroughs, and industrial pilot projects for green liquid Fuels

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Introduction to Sustainable Aviation Fuel

Definition

- Sustainable Aviation Fuel (SAF) is an alternative fuel designed to replace conventional aviation fuel. It is typically produced from renewable biomass materials or other sustainable resources, such as waste oils, agricultural and forestry residues, synthetic hydrogen, and captured COx.
- According to Frost & Sullivan and International Air Transport Association (IATA), SAF is expected to account for 65% of the aviation industry's carbon reduction target in 2050, playing a critical role in mitigating greenhouse gas emissions in the sector. Additionally, SAF can lower the emissions of other pollutants such as soot, sulfur oxides (SOx) and ultrafine particulate matter, thereby minimizing the pollutants' negative impact on the climate.

Production Method	Advantage	Disadvantage	Commercialization Progress
HEFA (Hydro-processed Esters and Fatty Acids)	• The technology has matured and is well-developed. • The yield is the highest among all methods.	• Raw Material Limitations: The raw materials include plant oils, animal fats, waste oils, and algae. These sources are limited, difficult to collect and store, and require strict temperature control during transportation. Ensuring a stable supply is challenging, which results in high raw material costs.	This technology pathway is mature, with most SAF production relying on HEFA.
FT (Fischer-Tropsch)	• This method allows the use of diverse feedstock, such as city waste, biomass, and captured carbon.	• The yield is relatively low. • The technology has certain barriers, requiring specific catalysts and separation techniques.	In the early stages of commercialization.
ATJ (Alcohol-to-Jet)	• Flexible feedstock can be used, as this method utilizes ethanol derived from various sources such as corn, sugarcane, and cellulose, which can adapt to different regional conditions.	• The yield is relatively low.	In the early stages of commercialization
PTL (Power-to-Liquid)	• This method has a high emission reduction potential. • It demonstrates strong adaptability by utilizing renewable electricity sources such as solar and wind, combined with carbon capture technology.	• High costs are a major limitation, as expensive carbon capture and water electrolysis technologies hinder short-term feasibility.	Laboratory stage

Source: Frost & Sullivan

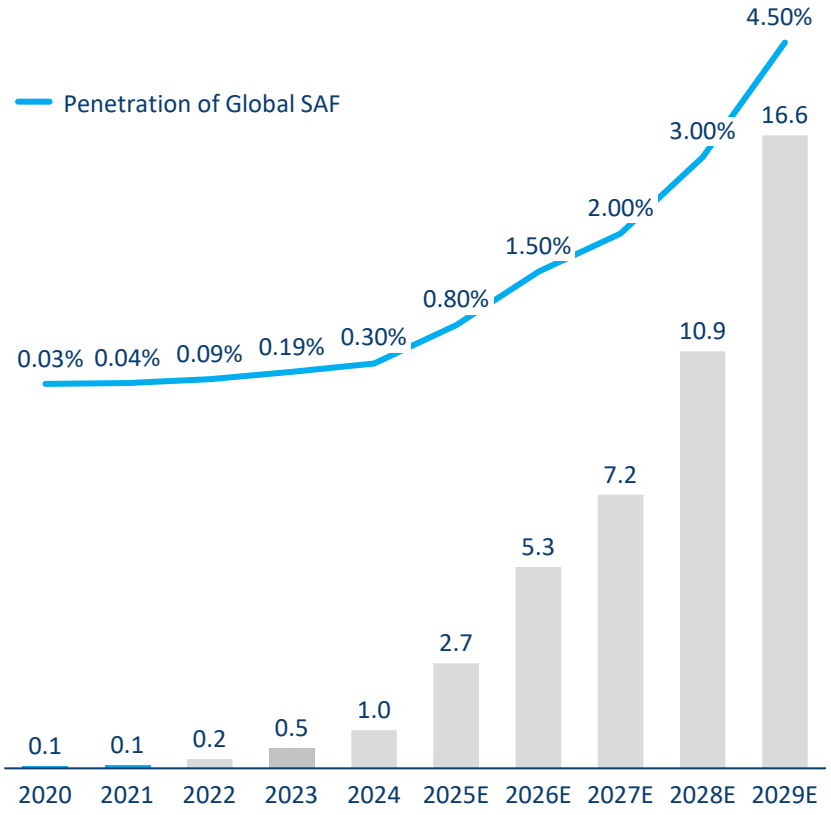
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Global SAF

Consumption Volume of Global SAF

Million Tons, 2020-2029E

	2020-2024 CAGR	2024-2029E CAGR
CAGR	111.5%	75.3%



Key Findings

- Globally, in terms of consumption, the EU has issued mandatory regulations for the useof SAF, and both the US and China have quantitative policy guidelines: 1)The EU. The ReFuelEU initiative, approved by the European Parliament in October 2023, mandates that at least 2% of aviation fuel used by 2025 must be SAF, increasing to 6% by 2030, 20% by 2035, 34% by 2040, 42% by 2045, and 70% by 205; 2)The US. The SAF Grand Challenge aims to achieve domestic SAF production of 3 billion gallons (9 million tons) by 2030 and 35 billion gallons (over 100 million tons) by 2050, with 100% of aviation fuel being SAF; 3) China. The "14th Five-Year Plan" for Green Development in Civil Aviation ("十四五"民航綠色發展專項規劃) specifies that during the "14th Five-Year Plan" period, the consumption of bio-jet fuel should reach 50,000 tons, with an annual consumption of 20,000 tons by 2025. On September 18, 2024, the National Development and Reform Commission (NDRC) and the Civil Aviation Administration of China (CAAC) launched a SAF application pilot. As part of this initiative, 12 flights from Beijing Daxing, Chengdu Shuangliu, Zhengzhou Xinzheng, and Ningbo Lishe airports by Air China, China Eastern Airlines, and China Southern Airlines were fueled with SAF. It is expected that the number of participating units will gradually increase throughout 2025. With the gradual implementation of policies, the demand and the size of the market for the consumption for SAF will steadily grow.
- Against the backdrop of carbon neutrality, various industries are implementing carbon reduction measures. As a major source of carbon emissions in the transportation sector, the aviation industry is moving towards green transformation, with the adoption of SAF becoming a primary carbon reduction pathway. Currently, the SAF market is still in its early stages. Global SAF consumption increased from 50,000 tons in 2020 to 1,000,000 tons in 2024, with a CAGR of 111.5%. Driven by national policies, the SAF market is expected to achieve rapid growth in the future. Globally, the EU's ReFuelEU aviation initiative mandates that at least 2% of aviation fuel must come from SAF by 2025, increasing to 6% by 2030 and 20% by 2035. In the U.S., the SAF Grand Challenge Roadmap aims to achieve a domestic production target of 3 billion gallons (9 million tons) of SAF by 2030. Global SAF consumption is expected to continue to grow, reaching 16.6 million tons by 2029, with a CAGR of 75.3% from 2024 to 2029.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of China's SAF

Key Findings

- In China, the SAF consumption was approximately 10,000 tons in 2024. The "14th Five-Year Plan" for Green Development in Civil Aviation ("十四五" 民航綠色發展專項規劃) aims to achieve a cumulative consumption of 50,000 tons of SAF during the 14th Five-Year Plan period. Encouraged by policies, China's SAF consumption is expected to continue to grow, reaching 702.6 thousand tons by 2029, with a CAGR of 134.1% from 2024 to 2029.
- The SAF market in China is expected to hold significant growth potential, due to the following reasons: **1)**In terms of demand, China's SAF consumption in 2024 is expected to grow rapidly compared to 2023. The Civil Aviation Administration of China (CAAC) officially launched a SAF application pilot program in 2024. The first phase, from September to December 2024, requires twelve flights operated by Air China, China Eastern Airlines, and China Southern Airlines departing from Beijing Daxing, Chengdu Shuangliu, Zhengzhou Xinzheng, and Ningbo Lishe airports to be fueled with SAF. The second phase, starting from March 19, 2025, requires all domestic flights departing from Beijing Daxing, Chengdu Shuangliu, Zhengzhou Xinzheng, and Ningbo Lishe airports to be regularly fueled with a 1% SAF blend. It is expected that the third phase of the pilot program will be expanded large-scale to provincial capital airports nationwide in the third quarter of 2025; **2)** In terms of supply, the number of SAF manufacturers approved by the CAAC has been increasing since 2024. In March 2025, Zhejiang Jiaao Enprotech Stock Co Ltd received an airworthiness certificate from CAAC, signifying that its bio-jet fuel products meet Chinese civil aviation airworthiness requirements and can be sold domestically; **3)**From a policy perspective, on October 18, 2024, six key ministries and commissions — including the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MIIT), the Ministry of Housing and Urban-Rural Development (MOHURD), the Ministry of Transport, the National Energy Administration (NEA), and the National Data Administration — jointly issued the "Guiding Opinions on Vigorously Promoting Renewable Energy Substitution". The document emphasizes on the following points: ①developing green fuels such as biogas, biodiesel, and bio-jet fuel according to local conditions; ② actively and orderly advancing renewable hydrogen production; and ③promoting the application of sustainable aviation fuel, and supporting qualified regions to conduct pilot operations of biodiesel, bio-jet fuel, biogas, and green hydrogen, ammonia and methanol in shipping and aviation; **4)**From December 2024, China will cancel export tax rebates for used cooking oil (UCO), encouraging more UCO to be diverted toward domestic SAF production. As a result, the application of marine biodiesel and bio-jet fuel is expected to expand further.

Source: Frost & Sullivan

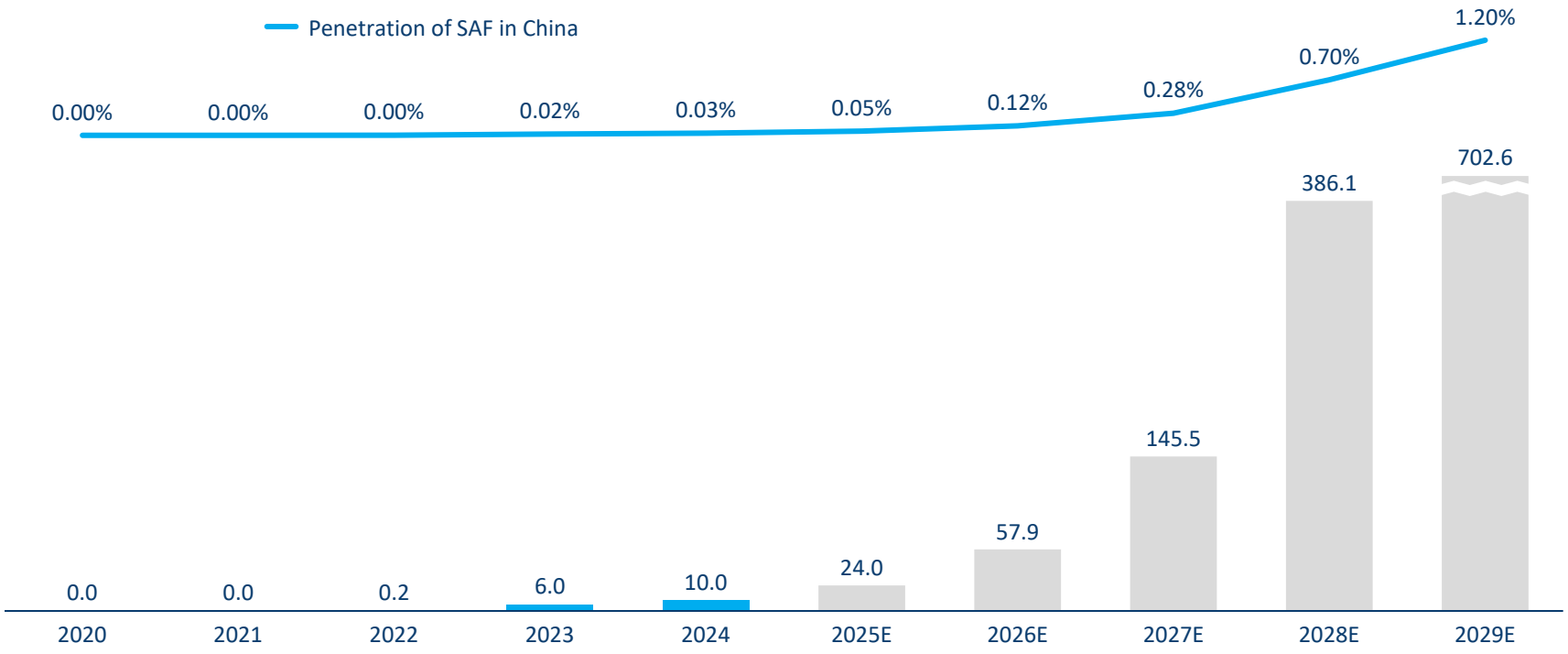
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of China's SAF

Consumption Volume of China's SAF

Thousand Tons, 2020-2029E

	2020-2024 CAGR	2024-2029E CAGR
CAGR	/	134.1%



Source: Frost & Sullivan

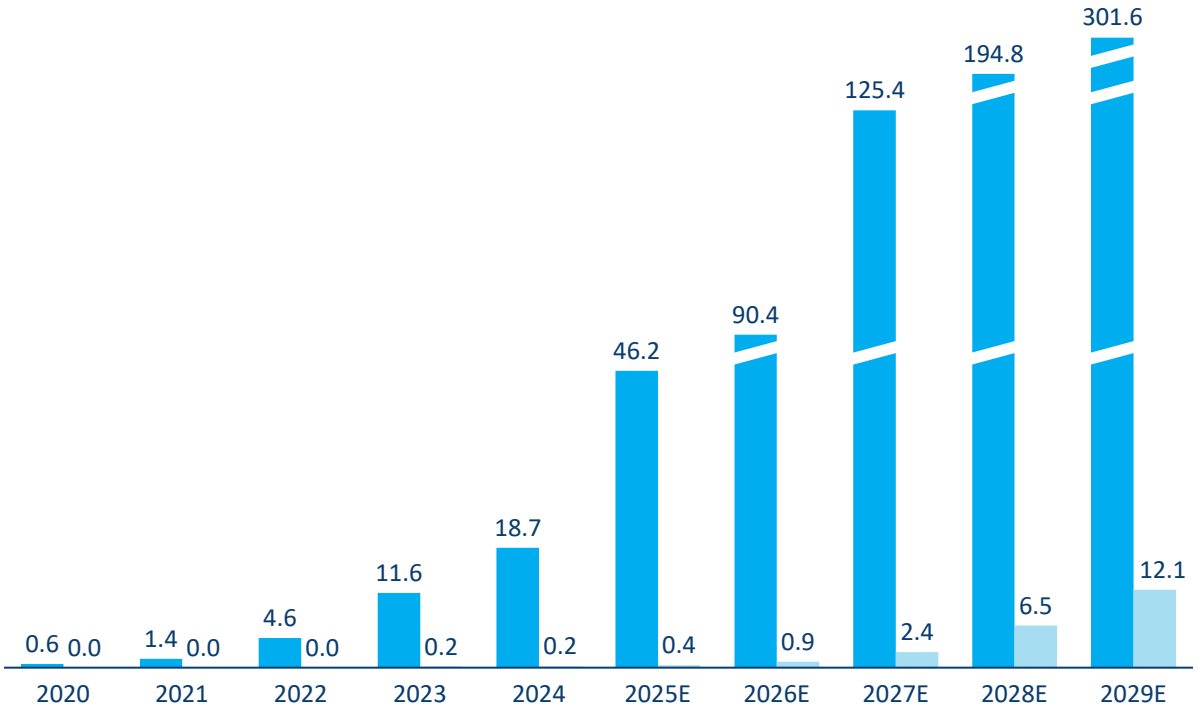
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Global/China's SAF

Consumption Value of Global and Chinese SAF

Billion RMB, 2020-2029E

	2020-2024 CAGR	2024-2029E CAGR
Global	140.4%	74.4%
China	/	130.2%



Key Findings

- Driven by policy incentives, SAF consumption is expected to grow steadily, expanding the market. The global SAF consumption market size grew from RMB560 million in 2020 to RMB18.7 billion in 2024, with a CAGR of 140.4%. The global SAF consumption market size is expected to continue growing, reaching RMB301.7 billion by 2029, with a CAGR of 74.4% from 2024 to 2029.
- China's SAF consumption market size grew from RMB4.7 million in 2022 to RMB187.7 million in 2024. China's SAF consumption market size is expected to continue growing, reaching RMB12.1 billion by 2029, with a CAGR of 130.2%.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Driver of SAF

Market Driver (1/2)

Carbon Emission Reduction Goals

- The aviation sector is a critical area for global carbon emission reduction. SAF can significantly reduce the carbon footprint of aviation in light of the stringent carbon reduction targets set by many countries and aviation organizations.
- For example, IATA targets to reach net-zero carbon emissions by 2050, and have urged member airlines to prioritize SAF and reduce their reliance on fossil fuels.

Technological Advancements and Cost Reduction

- Innovations in catalytic cracking, hydrogenation and synthetic biotechnology have enhanced the efficiency and costeffectiveness of SAF production, with waste oil derived SAF already proving stable in use by some airlines. As production technologies such as HEFA, ATJ, and FT pathways mature, costs continue to decline. Simultaneously, growing market demand and scaling production enable manufacturers to spread fixed costs and boost capacity, further reducing unit costs. Government policies and investments also play a pivotal role in supporting technological R&D and industrialization, accelerating SAF's commercial viability and market acceptance.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Driver of SAF

Market Driver (2/2)

Policy Support	• Government policies play an essential role in supporting the development of the SAF industry. Governmental policies play an essential role in supporting the development of the SAF industry. In 2022, China's NDRC and CAAC released the 14th Five-Year Plan for Green Development of Civil Aviation ("十四五" 民航綠色發展專項規劃), aiming to accelerate SAF research and development and promote its application. The plan supports the establishment of SAF production bases, with a target of reaching annual consumption of over 20,000 tons by 2025 and a cumulative total of 50,000 tons during the 14th Five-Year Plan period to promote SAF research and development and commercialization. As part of the ReFuelEU initiative, approved by the European Parliament in October 2023, fuel suppliers are required to use a mandatory SAF quota, starting with 2% by 2025, reaching 6% by 2030, 20% by 2035, 34% by 2040, 42% by 2045, and 70% by 2050.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Entry Barriers/Threats and Challenges

Market Entry Barriers	
Qualification Barriers	• Internationally, certification standards for aviation fuel (such as ASTM-D7566) must be met, with strict requirements for chemical composition, combustion performance, cold resistance, stability, and compatibility with traditional aviation kerosene to ensure flight safety. In China, a bio-jet fuel airworthiness certificate from the Civil Aviation Administration of China is required to be obtained. Additionally, the raw materials used for SAF production must meet green sustainability requirements in different countries and regions.
Raw Materials and Technical Barriers	• Internationally, certification standards for aviation fuel (such as ASTM-D7566) must be met, with strict requirements for chemical composition, combustion performance, cold resistance, stability, and compatibility with traditional aviation kerosene to ensure flight safety. In China, a bio-jet fuel airworthiness certificate from the Civil Aviation Administration of China is required to be obtained. Additionally, the raw materials used for SAF production must meet green sustainability requirements in different countries and regions.
Capital Barriers	• Internationally, certification standards for aviation fuel (such as ASTM-D7566) must be met, with strict requirements for chemical composition, combustion performance, cold resistance, stability, and compatibility with traditional aviation kerosene to ensure flight safety. In China, a bio-jet fuel airworthiness certificate from the Civil Aviation Administration of China is required to be obtained. Additionally, the raw materials used for SAF production must meet green sustainability requirements in different countries and regions.

Threats and Challenges of the SAF Market

- Currently, the production cost of SAF is much higher than that of traditional fossil aviation fuel. The main reasons include complex technology processes, large equipment investments and high raw material costs. Due to the lack of economies of scale, SAF companies face significant pressure in commercial promotion.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Introduction of PE

- Polyethylene (PE) is widely used in the production of plastic bags, plastic films, containers, bottles, and food packaging bags.
- Green polyethylene refers to polyethylene produced using non-traditional fossil fuels (such as coal or oil) as raw materials, with a production process that offers significant environmental advantages. Green polyethylene is one of the key materials in achieving a low-carbon economy and sustainable development.
- Green polyethylene has a significantly lower carbon footprint compared to traditional polyethylene, making it a key choice for many industries pursuing sustainable transformation. In particular, in sectors such as packaging, consumer goods, and automotive, brands and manufacturers are increasingly adopting green materials to comply with environmental regulations, meet emission reduction targets, and cater to consumer preferences for eco-friendly products, thereby driving the continued expansion of the green polyethylene market.

Source: Frost & Sullivan

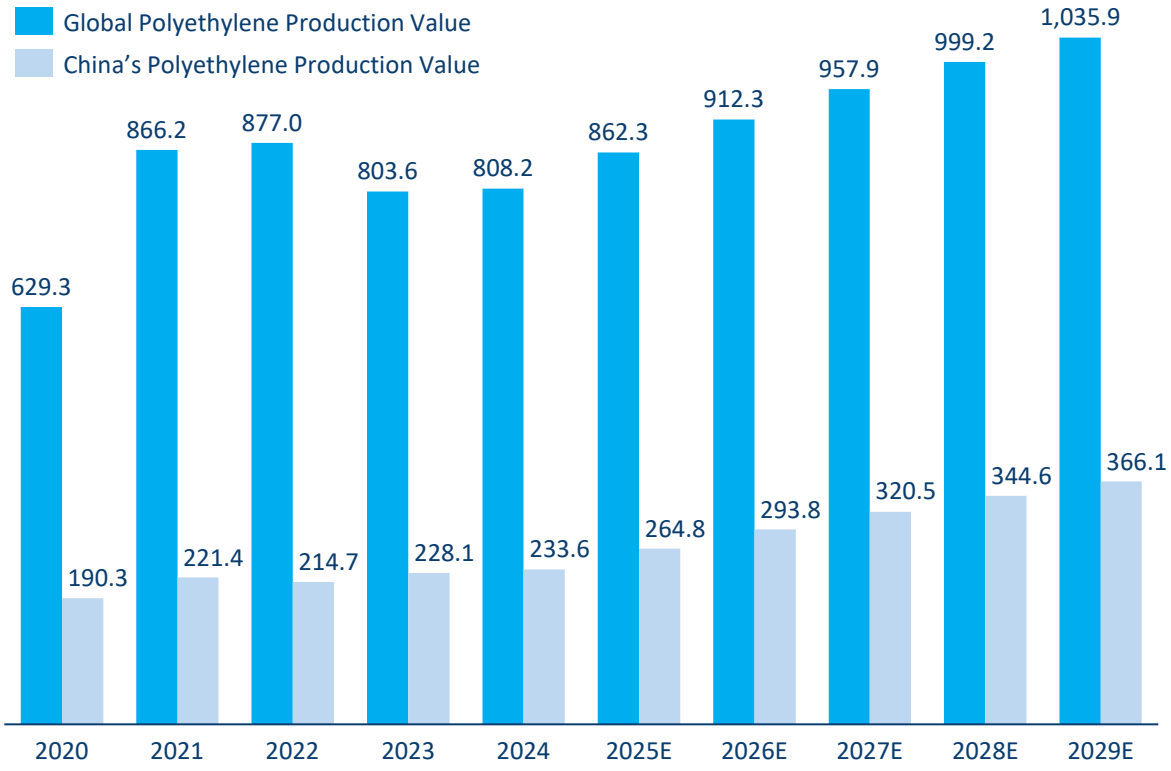
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Global Polyethylene

Global and Chinese Polyethylene Production Value

Billion RMB, 2020-2029E

	2020-2024 CAGR	2024-2029E CAGR
Global	6.5%	5.1%
China	5.3%	9.4%



Key Findings

- The market size of global polyethylene production value grew from RMB629.3 billion in 2020 to RMB808.2 billion in 2024, with a CAGR of 6.5%. With the advancement of urbanization and industrialization in emerging economies such as Asia and Africa, the demand for plastic packaging and building materials has increased significantly. It is estimated that in 2029, the market size of global polyethylene production value will reach RMB1,035.9 billion, with a CAGR of 5.1% from 2024 to 2029.
- The market size of polyethylene production value in China increased from RMB190.3 billion in 2020 to RMB233.6 billion in 2024, with a CAGR of 5.3%. This growth was mainly driven by the continued growth of market demand and the increasing demand for alternative materials such as metal glass. With the recovery of the downstream industries, the packaging industry has grown steadily, driving the recovery of polyethylene production and prices. It is expected that China's market size of polyethylene production value will continue to grow in the future, reaching RMB366.1 billion in 2029, with a CAGR of 9.4% from 2024 to 2029.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Driver of PE

Market Drivers of Green Polyethylene

Growth in Downstream Demand for Green Polyethylene	• Green polyethylene has a significantly lower carbon footprint compared to traditional polyethylene, making it a key choice for many industries pursuing sustainable transformation. In particular, in sectors such as packaging, consumer goods, and automotive, brands and manufacturers are increasingly adopting green materials to comply with environmental regulations, meet emission reduction targets, and cater to consumer preferences for eco-friendly products, thereby driving the continued expansion of the green polyethylene market.
Technological Innovation in Green Ethanol	• Technological advancements have not only improved the production efficiency and resource utilization of green ethanol, but also ensured a more stable and reliable supply, providing a solid foundation for the large-scale application of green polyethylene. These technological breakthroughs have also strengthened the competitiveness of green polyethylene, encouraging more companies to adopt it as a low-carbon material solution to meet sustainability objectives.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Entry Barriers/Threats and Challenges of Green Polyethylene

Market Entry Barriers

Raw Material Barriers

- The raw materials for producing green polyethylene are primarily biomass resources such as sugars, starch, lignocellulose and industrial off-gas. The stability, cost-effectiveness and sustainability of these raw materials are crucial for the commercial application of green polyethylene products.

Capital Barriers

- The green polyethylene industry is capital-intensive, involving processes such as dehydration, polymerization and separation, requiring the construction of large chemical installations with high upfront capital investment.

Threats and Challenges of the Green Polyethylene Market

- Currently, the production cost of green polyethylene is higher than that of traditional polyethylene due to the high cost of raw materials.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Microbial Proteins

Comparison of Advantages and Disadvantages of Feed Protein Raw Materials in China

Microbial protein provides more advantages by reducing dependence on food resources and offering superior nutritional value. Their production avoids reliance on food crops and reducing dependence on imported soybeans. This approach conserves arable land, improves the self-sufficiency of the feed industry. Moreover, microbial protein is highly nutritious, with generally over 80% protein content, surpassing traditional sources like soybean meal. It is rich in essential amino acids such as lysine and tryptophan, along with vitamins and minerals, making it an excellent and sustainable protein source.

	Fish Meal	Soybean Meal	Cotton Meal	Microbial Protein
Price[1] (RNB/Ton)	11,000-15,000	3,200-4,600	3,400-4,100	6,800-8,500
Crude Protein Content[2]	About 60%	About 40%	About 40%	Generally over 80%
Advantages	High crude protein content Balanced amino acid composition High digestibility Rich in essential and functional amino acids	Wide range of downstream applications	The raw materials are easily available and is a substitute for soybean meal	Using industrial off-gas as raw material is environmentally friendly Reduces dependence on food resources Conserves arable land Raw materials are easily accessible High crude protein content Balanced amino acid composition Rich in essential and functional amino acids High digestion and absorption rate; has the effect of improving animal intestinal function
Disadvantages	Limited marine resources Fishing policy restrictions Dependence on imports Prone to rancidity Uneven quality	Dependence on imports Low digestion and absorption	Unbalanced amino acid composition Low digestion and absorption	With high technical barriers, only a few companies have achieved large-scale production

1. The price range is the average annual selling price from 2021 to 2024; 2. Crude protein content is an important indicator for measuring the nutritional value of feed protein. Generally, the higher the crude protein content, the more amino acids it provides, resulting in higher nutritional value and promoting the growth and development of animals.

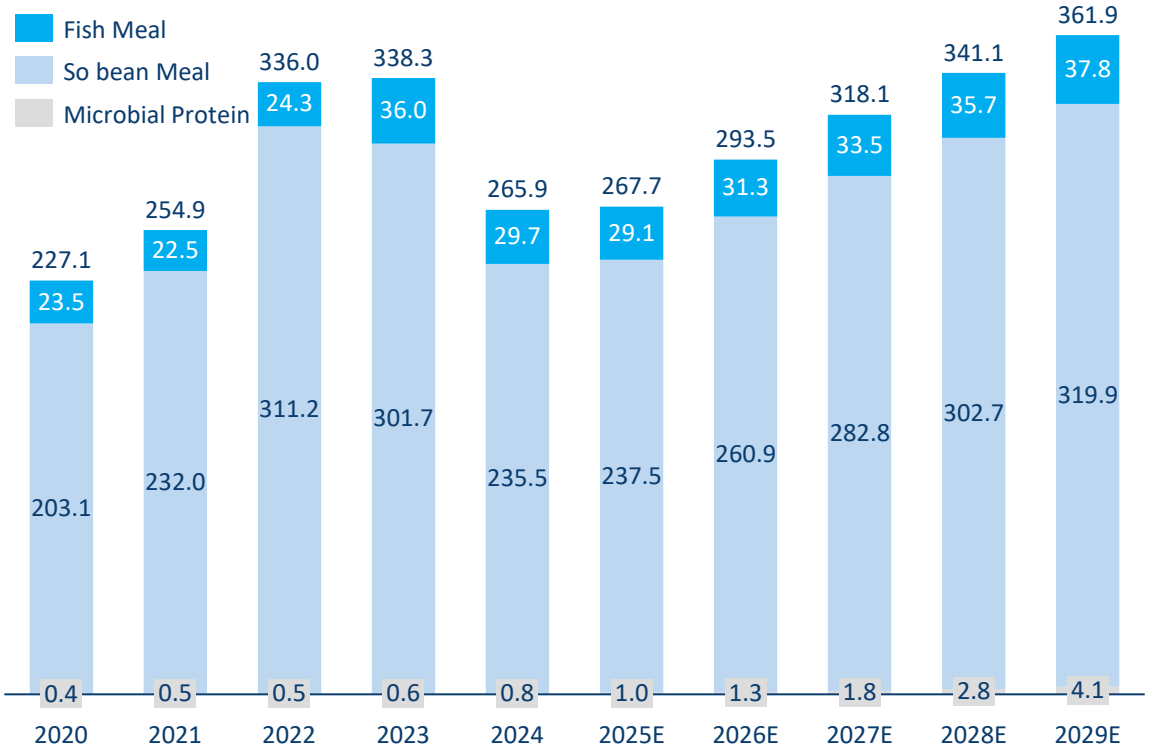
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of China's Feed Protein Raw Materials

Consumption Value of China's Feed Protein

Billion RMB, 2020-2029E

	2020-2024 CAGR	2024-2029E CAGR
Fish Meal	6.0%	4.9%
Soybean Meal	3.8%	6.3%
Microbial Protein	14.3%	40.8%



Key Findings

- The market size of China's feed protein raw materials increased from RMB227.1 billion in 2020 to RMB266.0 billion in 2024, with a compound annual growth rate (CAGR) of 4.0%. This growth is mainly due to the increasing awareness of high-quality feed formulations in the livestock industry and the continuous demand for high-quality protein raw materials. In 2024, the market showed a downturn due to the continuous decline in fish meal and soybean meal prices. However, with the application of alternative protein technologies and the growth in downstream demand, the market size of China's feed protein raw materials is expected to continue expanding, reaching RMB361.9 billion by 2029, with a CAGR of 6.4% from 2024 to 2029. Among them, the microbial protein market is expected to achieve a CAGR of 40.8% from 2024 to 2029, significantly higher than the overall growth rate of the feed protein market.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Driver of Microbial Protein

Market Driver (1/2)

Increased Demand for Reducing Dependence on Food Resources

- The production process of microbial protein can address the limitations of finite land resources and is more resilient to natural disasters and extreme weather conditions, thereby providing strong support for reducing dependence on food resources. With significantly higher production efficiency than traditional agriculture, it utilizes limited resources more effectively, offering a sustainable solution to the food crisis. As a partial substitute for traditional food, microbial protein helps alleviate global food shortages, promotes the green transformation of agriculture, and provides healthier, more environmentally friendly food options.

Increased Demand for High-Quality Protein by Feed Companies

- With the rapid development of the livestock industry and the growing consumer demand for high-quality animal products, feed companies are experiencing a significant increase in the demand for high-quality proteins. High-quality protein offers better digestibility, nutritional value, and feed conversion rates, which help shorten breeding cycles, reduce breeding costs, and improve economic returns. Microbial protein production technology can produce complete proteins or proteins with specific nutritional value, precisely meeting the diverse needs of animal growth and health maintenance, thereby further driving the robust growth of the feed protein raw materials market.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Market Entry Barriers/Threats and Challenges

Market Entry Barriers

Market Qualification Barriers	• According to the Regulations on the Administration of Feed and Feed Additives (飼料和飼料添加劑管理條例), application must be made to the Ministry of Agriculture and Rural Affairs and be approved by the National Feed Review Committee before production of new feed and feed additives can be entered into. For example, the Company's microbial protein product took nearly six years from R&D to certification.
Technical Barriers	• The production process of microbial feed protein is complex, requiring precise control over raw material pretreatment, fermentation, protein extraction and separation. Products also require extensive animal testing in order for their effectiveness and safety to be verified. Additionally, the industry demands high stability and safety standards for product quality, necessitating the establishment of comprehensive quality inspection systems to ensure product quality during production, storage, and transportation.

Threats and Challenges of the SAF Market

- The prices of feed protein raw materials in China (such as soybeans and fish meal) are significantly influenced by factors like international market supply and demand, weather changes, geopolitical events and exchange rate fluctuations.

Source: Frost & Sullivan

Application of Synthetic Biology Technology in CCUS Technology Industry

Favorable Policies and Regulations Encouraging the Development of Alternative Protein

Favorable Policies and Regulations Encouraging the Development of Alternative Protein

- In March 2022, the PRC government publicly announced the policies in relation to developing biotechnology and bio-industries, and deriving energy and protein from plants, animals and microorganisms.

- On May 10, 2022, the National Development and Reform Commission issued the 14th Five-Year Plan for the Development of Bioeconomy (“十四五”生物經濟發展規劃), which explicitly mentioned developing synthetic biotechnology, exploring and developing new foods such as artificial protein, realizing the iterative upgrading of food industrialization, and reducing the environmental resource pressure brought by traditional breeding industry.

- On April 12, 2023, the General Office of the Ministry of Agriculture and Rural Affairs issued a notice on the issuance of the Three-Year Action Plan for Reducing and Substituting Soybean Meal for Feed (飼用豆粕減量替代三年行動方案), pointing out the implementation of the pilot actions for exploration and utilization of new protein feed resources, supporting the expansion of the application scope of Clostridium ethanol protein to pigs, chickens, and other livestock, poultry, and aquaculture animals, expediting the approval process for microbial protein produced through fermentation of other single-carbon gases, increase the production scale of microbial protein raw materials, promoting their application. Organize pilot projects for the feed utilization of leftover food from dining tables and fur animal carcasses, and supporting pilot projects for the feed utilization of new protein resources such as hydrolyzed composite amino acids derived from livestock carcasses. This action plan proposes that the proportion of soybean meal usage should continue to decline. On the premise of ensuring that the production efficiency of livestock and poultry remains stable, China will strive to reduce the proportion of soybean meal in feed by more than 0.5 percentage points each year, and by 2025, the proportion of soybean meal in feed will drop from 14.5% in 2022 to below 13%.

Source: Frost & Sullivan

Agenda

1. Overview of Global and China's CCUS Technology Industry
2. The Application of Synthetic Biology Technology in CCUS Technology Industry
3. Competitive Landscape of Global Synthetic Biology Technology CCUS Industry
4. Overview of The Steel and Ferroalloy Industry

Competitive Landscape

Overview

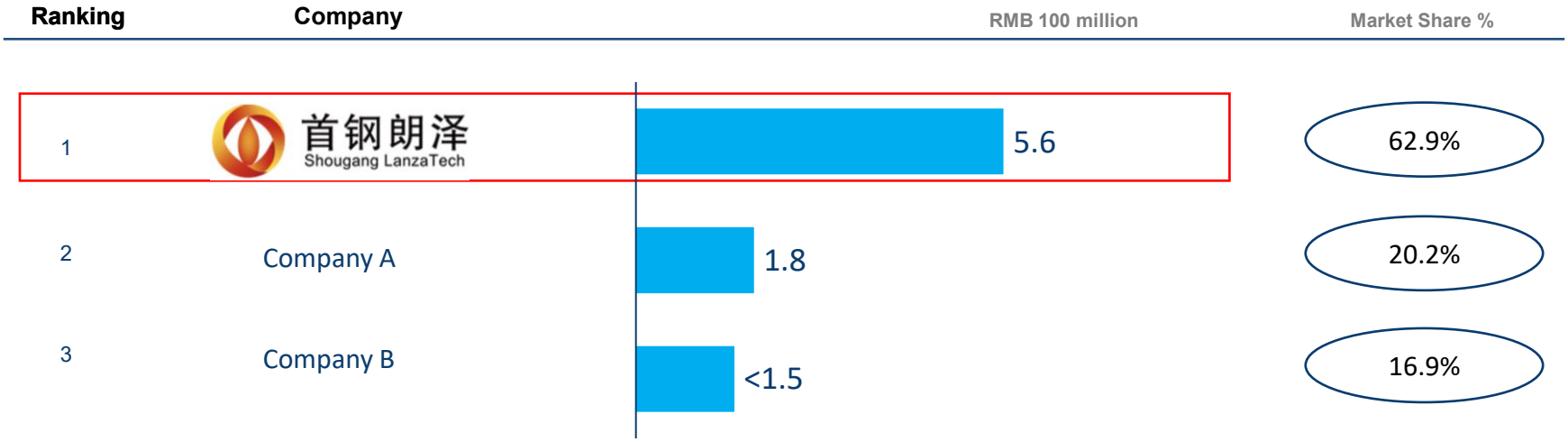
The CCUS industry is in its early stages of development, with relatively few players in the market. There are three main business models among these players, namely (i) technology service-oriented companies, (ii) product-oriented companies, and (iii) energy giants with in-house CCUS facilities. Technology service-oriented companies focus on providing carbon capture and utilization equipment as well as technical training to project owners and generate revenue by charging technical service fees to these owners. Product-oriented companies either own carbon sources or can access low-cost carbon sources and use their proprietary technologies to capture and utilize carbon sources, generating profits through high concentration carbon emission products or converted products. Energy giants with in-house CCUS facilities establish CCUS plants to capture carbon emission for their internal projects and their primary objective is not to generate profit but to meet the carbon emission standards of the group.

Source: Frost & Sullivan

Competitive Landscape

Ranking of Global CCUS Players with Biological Fermentation as the Core Technology, by Revenue

Ranking of Global CCUS Players with Synthetic Biotechnology as the Core Technology, by Revenue, 2024



In terms of revenue in 2024, the company is the largest company in the global CCUS industry utilizing synthetic biotechnology.

- *Company A: A private biotechnology company founded in 2018, specializing in microbial technology. Company A focuses on developing sustainable solutions to convert carbon emission into valuable bio-based products and operates through a joint venture subsidiary focused on production.*
- *Company B: A private biotechnology company founded in 2022, specializing in sustainable chemical production. Company B leverages synthetic biotechnology and carbon recycling technology to convert carbon emission into high-value chemicals and fuels and operates through a joint venture subsidiary focused on production.*

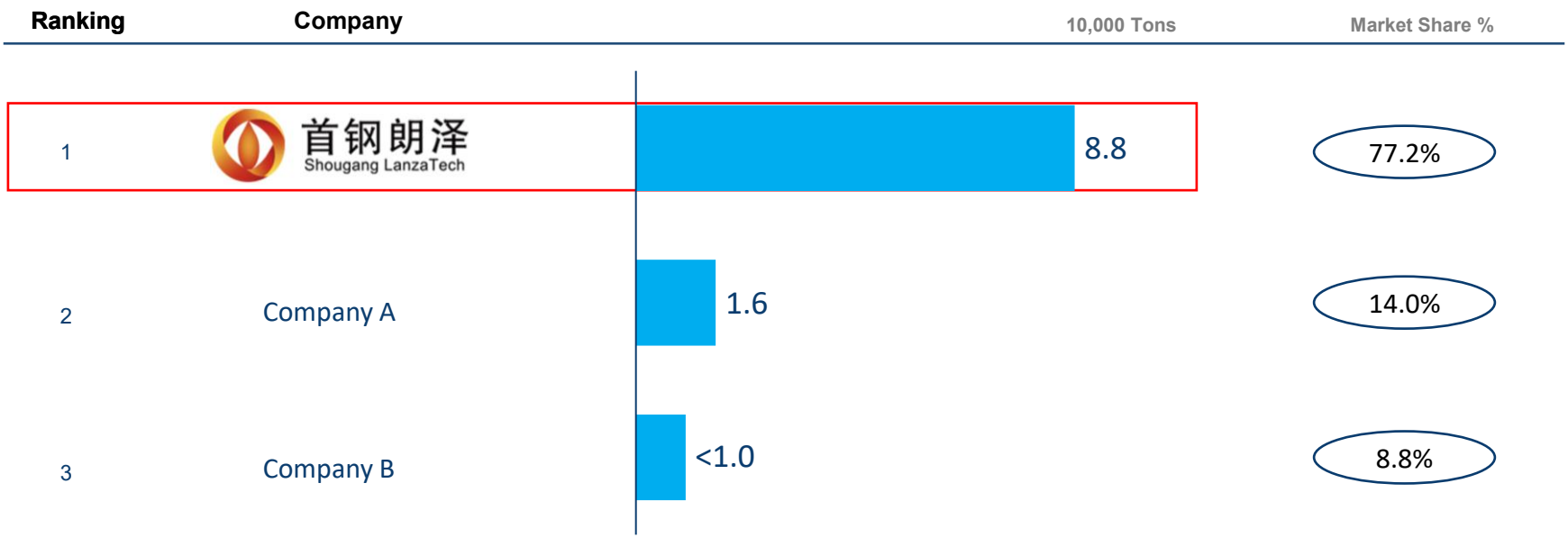
Note: Only companies that focus on synthetic biotechnology as the core technology pathway, possess proprietary technology, and have the ability to carry out industrial-scale production are considered.

Source: Frost & Sullivan

Competitive Landscape

Ranking of Global CCUS Players with Biological Fermentation as the Core Technology, by Production capacity

Ranking of Global CCUS Players Synthetic Biotechnology as the Core Technology, by Production Volume of Ethanol, 2024



- In terms of the production volume for ethanol, the company is the largest CCUS company in 2024 with biological fermentation as the core technology.

Note: Only companies that focus on synthetic biotechnology as the core technology pathway, possess proprietary technology, and have the ability to carry out industrial-scale production are considered.

Source: Frost & Sullivan

Competitive Landscape

Global CCUS Players with Biological Fermentation as the Core Technology, by Product Portfolio

Ranking of CCUS Players with Synthetic Biotechnology as the Core Technology, by product portfolio, 2024

Ranking	Company	Ethanol	Microbial Protein
1	首钢朗泽 Shougang LanzaTech	✓	✓
2	Company A	✓	
3	Company B	✓	

- In terms of product portfolio, the Company is the first company in the CCUS industry utilizing synthetic biotechnology that has been validated to achieve both commercialization and scalability of the production of low-carbon products.

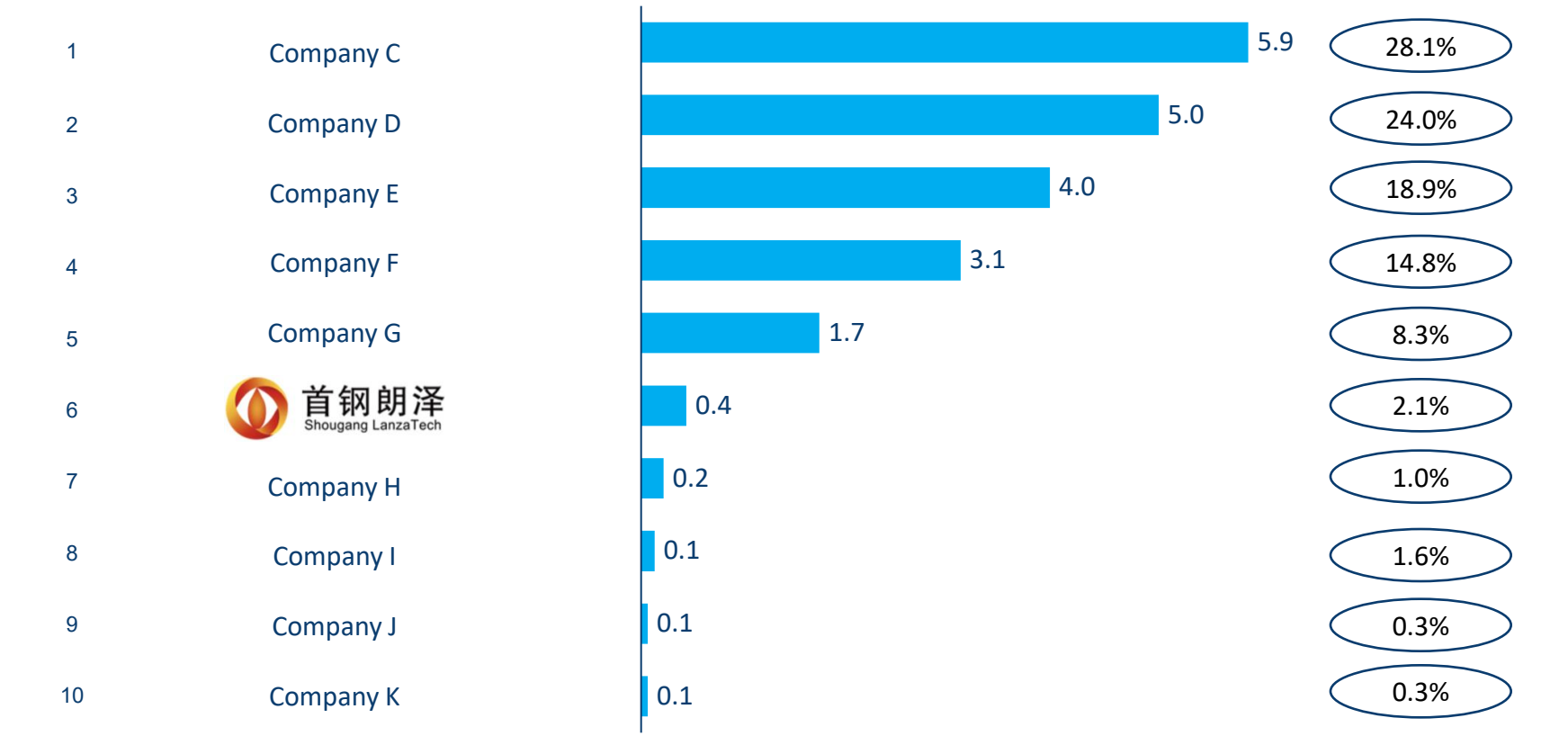
Note: Only companies that focus on synthetic biotechnology as the core technology pathway, possess proprietary technology, and have the ability to carry out industrial-scale production are considered.
In the global CCUS industry, low-carbon products produced and sold by companies utilizing synthetic biotechnology primarily refer to ethanol and microbial protein, excluding low-output by-products from the production process.

Source: Frost & Sullivan

Competitive Landscape

Ranking of Fuel Ethanol Players in China Market, by Revenue

Ranking of Fuel Ethanol Players in China Market, by Revenue of Fuel Ethanol, 2024



- In terms of revenue of fuel ethanol in 2024, the Company ranks among the top six in the Chinese market and is the only enterprise using industrial off-gas as the raw material for its production technology

FROST & SULLIVAN 沙利文

Source: Frost & Sullivan

Competitive Landscape

Ranking of Fuel Ethanol Players in China Market, by Revenue

Introduction of Fuel Ethanol Players in China Market (1/2)

- *Company C: Established in 1998, its main product is fuel ethanol, primarily used for ethanol gasoline preparation. The company actively promotes a raw material diversification strategy, building fuel ethanol production lines mainly based on corn, with flexible use of cassava and non-edible rice and wheat. It has established and continuously optimized a pilot line for cellulosic fuel ethanol, with technical reserves for non-grain biomass ethanol production. The company's products are sold both domestically and overseas. In 2023, the company's fuel ethanol production was approximately 1 million tons.*

- *Company D: Established in 2017 as a wholly-owned subsidiary of State Development & Investment Corporation, it focuses on investment and operation in the bioenergy and biochemical fields. Its main products include fuel ethanol and related by-products. The company uses various raw materials, including corn and cellulose, and its products mainly supply the domestic market. Its business model covers investment, construction, and operation of biomass energy projects.*

- *Company E: Established in 2017, Company E produces edible alcohol, medicinal ethanol, denatured fuel ethanol, premium anhydrous ethanol, new energy battery electrolyte ethanol, DDGS high-protein feed, corn germ oil, and carbon dioxide. The company uses deep processing technology for corn, and its products mainly supply the domestic market.*

- *Company F: Established in 2003, its main products are fuel ethanol and DDGS feed. The company uses corn as the main raw material and adopts deep processing technology for corn. Its products mainly supply the northeastern region, and its business model includes the production and sales of fuel ethanol and its by-products.*

- *Company G: Established in 2017, its main products include fuel ethanol, edible alcohol, and DDGS feed. The company uses deep processing technology for corn, and its products mainly supply Heilongjiang and surrounding areas. Its business model covers production and sales.*

- *Company H: Established in 1997, it is one of China's earliest alcohol production enterprises. Its main products include fuel ethanol, edible alcohol, and DDGS feed. The company uses corn and tubers as the main raw materials and adopts deep processing technology for corn. Its products are sold nationwide, and its business model covers production and sales.*

Source: Frost & Sullivan

Competitive Landscape

Ranking of Fuel Ethanol Players in China Market, by Revenue

Introduction of Fuel Ethanol Players in China Market (2/2)

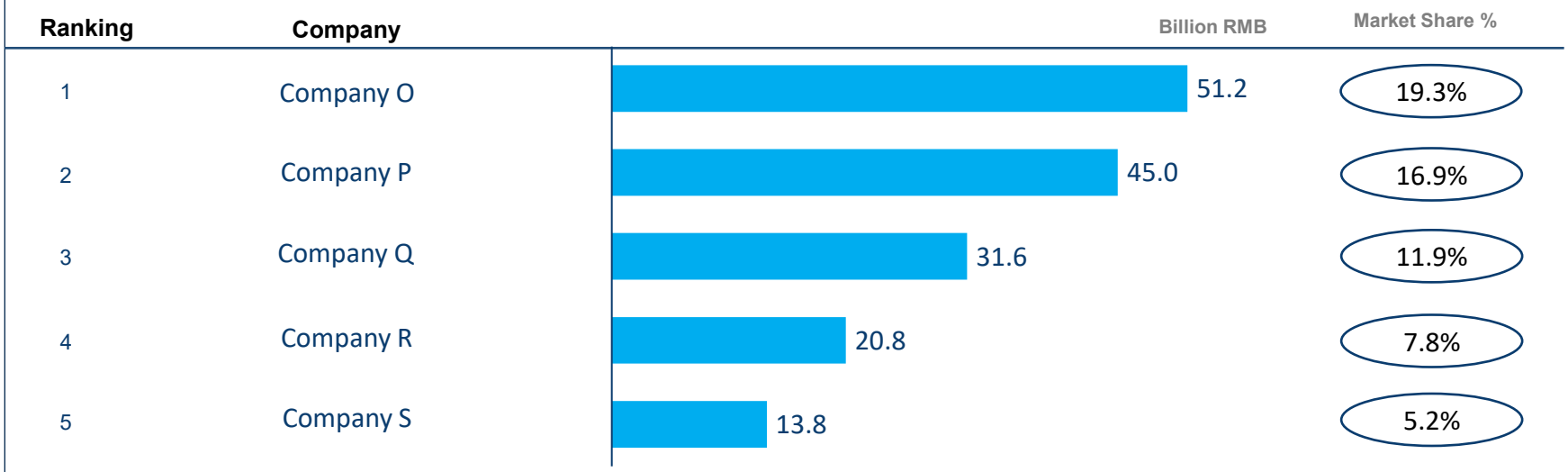
- *Company I: Established in 2011, its main products include fuel ethanol, edible alcohol, and DDGS feed. The company uses corn as the main raw material and adopts deep processing technology for corn. Its products mainly supply the northeastern region, and its business model includes production and sales.*
- *Company J: Established in 2005, its main product is fuel ethanol. The company uses cassava as the main raw material and adopts deep processing technology for cassava. Its products mainly supply the eastern region, and its business model covers production and sales.*
- *Company K: Established in 2007, located in Haimen, Nantong, Jiangsu Province. Its main products include n-butanol, acetone, fuel ethanol, anhydrous ethanol, food-grade and industrial-grade carbon dioxide, etc. The company uses deep processing technology for corn, and its products mainly supply the eastern region. Its business model covers production and sales.*

Source: Frost & Sullivan

Competitive Landscape

Ranking of Animal Feed Protein Players in China Market, by Sales Value

Ranking of Animal Feed Protein Players in China Market, by Sales Value, 2024



- *Company O: A centrally administered state-owned enterprise founded in 1949, primarily engaged in major agricultural commodities such as grain, oil, sugar, cotton, meat, and dairy, with additional operations in food, finance, and real estate.*
- *Company P: A Sino-foreign joint venture with crushing plants across China, involved in soybean procurement, processing, and sales of oil and meal, and is a key player in the national soybean meal supply chain.*
- *Company Q: A state-controlled enterprise established in 2002, focused on soybean processing and integrated with international trade and capital operations.*
- *Company R: Founded in 1995, this company specializes in soybean import and processing, with production bases in Shandong and Guangdong and a trading center in Shanghai.*
- *Company S: A privately owned enterprise established in 1998, operating modern soybean crushing and refining facilities in South China, serving as a major regional supplier of soybean oil and meal.*

Source: Frost & Sullivan

Agenda

1. Overview of Global and China's CCUS Technology Industry

2. The Application of Synthetic Biology Technology in CCUS Technology Industry

3. Competitive Landscape of Global Synthetic Biology Technology CCUS Industry

4. Overview of The Steel and Ferroalloy Industry

Overview of The Steel and Ferroalloy Industry

Introduction and Market Size

- The iron and steel industry is an important pillar industry of the national economy, playing a key strategic role in ensuring national economic security, advancing manufacturing upgrades and supporting infrastructure development. As a fundamental material of modern industry, steel is widely used in core sectors such as construction, machinery manufacturing, automotive, shipbuilding and aerospace, serving as a cornerstone for industrialization and modernization. However, the industry is also one of the sectors with the highest carbon emission. In the face of global climate change and China's "dual carbon" goals, it is essential to promote energy conservation and emission reduction, optimize off-gas treatment technologies and enhance energy efficiency, in order to facilitate the industry's high-quality development, support the nation's green economic transformation and actively contribute to global carbon neutrality initiatives.

- Ferroalloy are alloy materials composed of iron and one or more elements, such as manganese, silicon, chromium, molybdenum, vanadium, and titanium. They are widely used in the steel smelting process to improve the mechanical properties, chemical characteristics and corrosion resistance of steel, thereby meeting the demands of various applications. As a high-energy-consuming and high-carbon-emission industry, the iron alloy sector also faces the need for a green and low-carbon transition. Driven by the upgrading of the steel industry, the advancement of high-end manufacturing, the development of new materials and the "dual carbon" goals, the iron alloy industry will continue to promote green transformation and technological innovation to achieve long-term sustainable development.

Market Size of the Chinese Steel Market

Steel production increased from 1,324.9 million tons in 2020 to 1,399.7 million tons in 2024, representing a compound annual growth rate (CAGR) of 1.4% from 2020 to 2024. Looking ahead, with the steady growth of downstream manufacturing industries, steel production is expected to reach 1,646.8 million tons by 2029.

Market Size of the Chinese Ferroalloy Market

In 2024, China's ferroalloy production reached 36.24 million tons. Ferroalloys are essential raw materials for steel production. With continued growth in infrastructure and manufacturing investment, the production of ferroalloys is expected to increase to 39.31 million tons by 2029, representing a CAGR of 1.6%.

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Market River of Steel and Ferroalloy

Market Driver (1/3)

Growth in fixed investment in manufacturing industry

- Steel, as one of the basic raw materials for manufacturing, is widely used in various sectors, including machinery, automotive, shipbuilding, and home appliances. In fixed investment in manufacturing industry, sectors like railway, shipbuilding, and aerospace equipment have experienced rapid growth. Additionally, the strong demand for ships in the international market has supported the steel and ferroalloy market. Furthermore, the State Council's Action Plan for Promoting Large-Scale Equipment Upgrades and Consumer Goods Replacement (推動大規模設備更新和消費品以舊換新行動方案) aims to advance equipment updates and digital transformation in key industries such as steel, non-ferrous metals, petrochemicals, chemicals, building materials, power, machinery, aerospace, shipbuilding, textiles, and electronics, while phasing out energy-intensive equipment. The demand for replacement and upgrades will also drive an increase in the demand for steel and ferroalloy. In addition, the real estate and automotive markets are the main drivers of growth in the steel and ferroalloy markets. In the real estate market, during the "14th Five-Year Plan" period, 40 key cities across the country initially planned to add 6.5 million units (rooms) of guaranteed rental housing, which has driven the growth in demand for steel and ferroalloys. In the automotive industry, according to statistics from the China Association of Automobile Manufacturers, China's vehicle sales have continued to grow, with sales volumes of 26.8 million, 30.0 million and 31.4 million vehicles in 2022, 2023, and 2024 respectively. Since vehicle manufacturing requires steel and ferroalloys, the continuous growth in vehicle sales will continue to promote the growth in sales of steel and ferroalloys.

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Market River of Steel and Ferroalloy

Market Driver (2/3)

Huge demand for infrastructure construction

- Iron alloys are primarily used in steel production as deoxidizers, desulfurizers and alloying additives, so the development of the steel industry directly determines the market demand for iron alloys. Currently, the largest demand for steel is driven by infrastructure construction, including large-scale projects such as highways, railways, bridges and ports. In recent years, the PRC government has focused on promoting new urban infrastructure development. In December 2024, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council released the Opinions on Promoting New Urban Infrastructure Construction to Build Resilient Cities (關於推進新型城市基礎設施建設打造韌性城市的意見), which advocates the implementation of intelligent urban infrastructure construction and renovation. Urban renovation will generate demand for steel, thereby promoting the development of the iron alloy industry.

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Market River of Steel and Ferroalloy

Market Driver (3/3)

Policy guidance for the industry's transition to high-quality capacity structure

- In recent years, national policies have focused on strengthening the regulation of steel production capacity. In the 2024-2025 Energy Conservation and Carbon Reduction Action Plan (2024-2025年節能降碳行動方案), the State Council proposed strict implementation of steel capacity replacement, prohibiting the addition of new steel production capacity under the guise of mechanical processing, casting, or iron alloys, and preventing the resurgence of illegal "ground steel" capacity. In 2024, the control of crude steel production will continue. For regions that have fallen behind in meeting energy conservation and carbon reduction targets during the first three years of the 14th Five-Year Plan, new steel production capacity will not be allowed in the last two years of the plan. New and expanded steelmaking projects must meet energy efficiency benchmarks and environmental performance grade A standards. These measures aim to avoid intense market competition after reaching the peak of crude steel production, while quality control helps prevent resource waste and directs resources toward high-value added capacity, supporting the long-term high-quality development of the industry. In addition, driven by the "dual carbon" strategic goals, China's steel industry is also facing the imminent requirement to accelerate its low-carbon transformation. In September 2024, the Ministry of Ecology and Environment released the National Carbon Emission Trading Market Coverage for the Steel Industry Work Plan (Draft for Comments) (全國碳排放權交易市場覆蓋鋼鐵行業工作方案(徵求意見稿)), which includes steel units with annual emissions of 26,000 tons of carbon dioxide equivalent into the carbon trading system. Against this backdrop, the Company's industrial off-gas fermentation technology for producing ethanol and protein demonstrates multiple strategic values.

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Challenges of the Steel and Ferroalloy Industry

Dependence on imported raw materials weakens bargaining power

- China's steel production heavily relies on imported raw materials, particularly iron ore, with over 70% of the iron ore supply being imported. Additionally, the reliance on alloy raw materials such as manganese, chromium and nickel is also high. In the context of high global inflation, steel industry raw material prices face premium risks. As the industry cannot shift its costs abroad, companies within the industry will face certain profit challenges.

Pressure from environmental policies and regulatory requirements

- Environmental regulations in various countries are becoming increasingly strict, imposing higher standards on emissions of waste gases, wastewater and slag, as well as energy consumption in steel and ferroalloy enterprises. Companies are experiencing increased expenditures on compliance costs such as equipment upgrades, operational cost maintenance, and energy structure adjustments. To comply with these regulations, enterprises must upgrade waste treatment facilities, conduct regular equipment maintenance, and transition to clean energy, all of which require significant capital investment. Furthermore, companies need to establish a robust environmental management system, define the environmental responsibilities of each department and employee, develop detailed environmental management policies and operating procedures, and continuously monitor pollutant emissions. Regular public disclosure of environmental data is required to ensure the effective operation of the environmental management system. This not only demands considerable human and material resources from enterprises, increasing management costs but also subjects their environmental practices to stricter social oversight.

Market Price Fluctuation Risks

- The prices of steel and ferroalloy are influenced by multiple factors, including raw material prices, market supply and demand, and macroeconomic policies. Steel prices are particularly sensitive to fluctuations in raw material prices. Iron ore, coking coal, and other key materials for steel production often experience significant price fluctuations in the international market. For example, changes in international geopolitical conditions or adjustments in mining supply strategies can trigger sharp short-term price changes in iron ore. Frequent and large price fluctuations make it difficult for companies to accurately plan production and sales, increasing operational risks and compressing profit margins.

Source: Frost & Sullivan

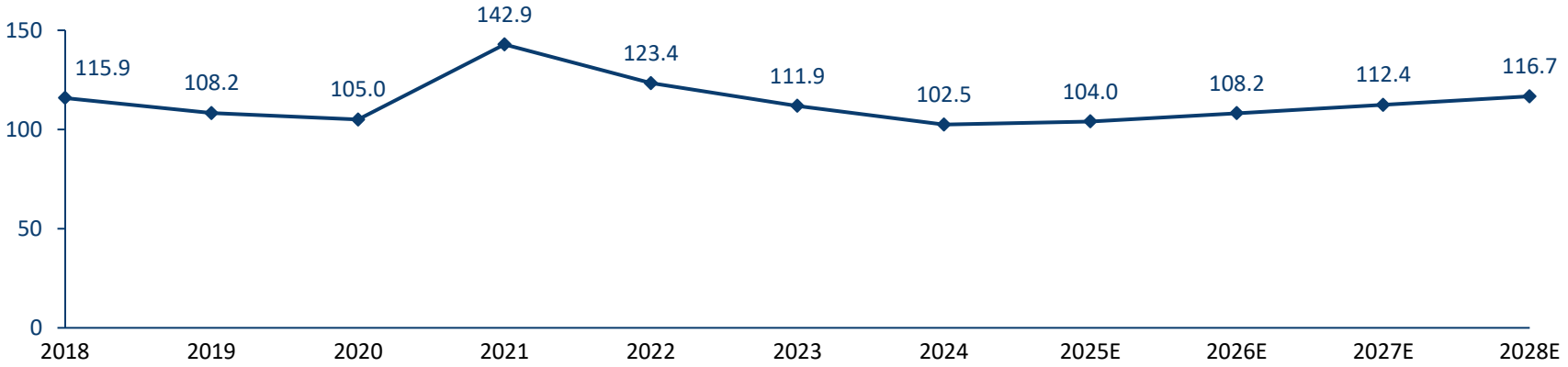
Overview of The Steel and Ferroalloy Industry

China Steel Price

China Steel Price Index (CSPI)

2018-2028E

	2018-2024	2024-2028E
CAGR	-2.0%	3.3%



Key Findings

- Under the influence of national economic stimulus policies and other factors, both domestic and international demand surged, while supply chains faced certain disruptions. This led to a shortage of steel supply and a significant price increase, with the comprehensive steel price index rising to 142.9. However, as downstream production weakened and steel demand declined, coupled with international trade friction limiting steel exports, prices faced downward pressure and decreased. By 2024, the China Steel Price Index is approximately 102.5. In the medium term, steel prices are anticipated to recover. Since the fourth quarter of 2024, steel prices have shown a trend of rebounding from the bottom, mainly due to the incremental policies in macro — control, which have driven the increased demand for steel. In the long run, it is expected that steel prices will continue to grow.

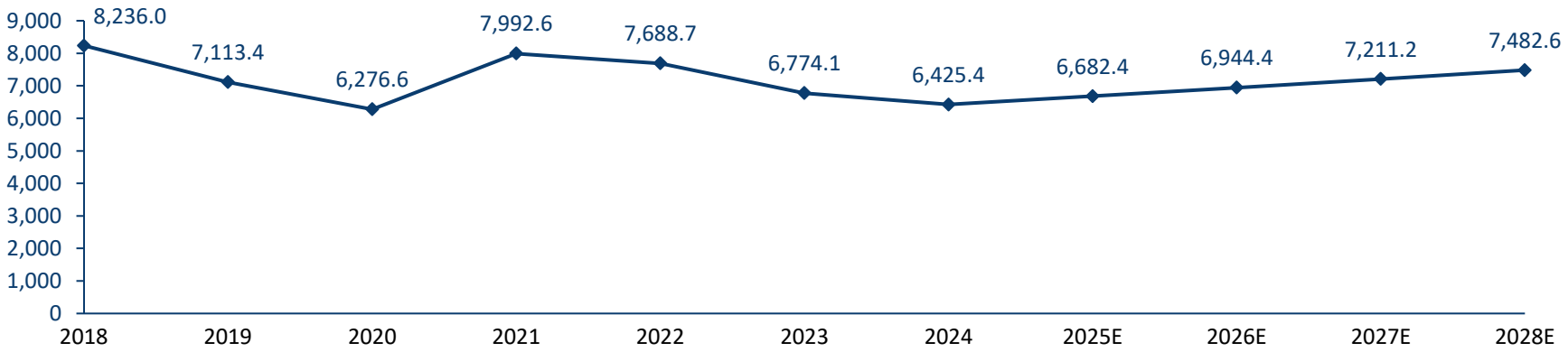
Overview of The Steel and Ferroalloy Industry

China Ferroalloy Spot Price

Price of Silicon Manganese Alloy

RMB/ton, 2018-2028E

	2018-2024	2024-2028E
CAGR	-4.1%	3.9%



Key Findings

- Due to the fact that the downstream demand for silicon manganese alloy mainly comes from steel mills, the price of silicon manganese alloy is closely related to steel prices. In 2019, the spot price of silicon manganese alloy in China was RMB7,113.4 per ton. During the pandemic in 2020, the demand dropped due to factory shutdowns, and the price fell to RMB6,276.7 per ton. In 2021, with the implementation of recovery policies and a rebound in demand, the price of silicon manganese alloy increased. In 2024, the spot price of silicon manganese alloy is RMB6,425.4 per ton (with the spot price of the silicon manganese alloy being at the lowest point in seven years other than in the COVID-19 pandemic). With the stable growth of the global economy and the expansion of demand in emerging markets, the market demand for silicon manganese alloy is expected to continue to grow, thus pushing up the price.

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

The Reason for the Weakened Downstream Demand for Steel and Ferroalloy since 2021

Downturn in the real estate industry

- Because of the recent real estate regulatory policies in the PRC, the growth rate of real estate investment has experienced a significant decline. According to the data from the National Bureau of Statistics, the growth rates of the national real estate development investment from 2021 to 2024 were 4.4%, -10.0%, -9.6% and -10.6% respectively. Although there have been some optimizations in real estate policies since 2022, the effects have not been significant. The confidence in the real estate market has continued to decline, resulting in fewer new construction projects and slower construction progress, which has severely dragged down the demand for steel and ferroalloy.

Slowdown in infrastructure investment

- In recent years, the structural slowdown in China's infrastructure investment has led to a weakening demand for steel and ferroalloy. As the traditional infrastructure becomes saturated, the investment focus has shifted to filling gaps and upgrading existing infrastructure. Coupled with the strict control of the debt of local governments, the Chinese government has implemented the principle of "precision investment, "directing funds towards new infrastructure such as 5G and data centers, as well as supporting facilities for urban agglomerations, which has caused the growth rate of traditional infrastructure to decline.

Challenges in manufacturing development

- Global trade frictions and pandemic disruptions have severely impacted the manufacturing sector. Export uncertainties have significantly reduced orders, forcing many export-focused manufacturers to cut production. Raw material price volatility and soaring costs further compress profit margins, prompting some firms to decrease output or revamp product lines, thus curbing the consumption of steel and ferroalloy. Nonetheless, the automotive and shipping industries present an encouraging opportunity as the production of automobile in China in 2024 rose 3.7% year-on-year, while the completions of shipbuilding grew 13.8%, both of which increase the demand for steel and ferroalloy..

Source: Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Weekly Steel Price Index

Key Findings

- For the steel market, in 2024, China's weekly steel price index showed an overall downward trend. Specifically, the highest steel price index was 113.6 in January 2024. The lowest steel price index was 91.3 in September 2024, which rose slightly to 103.9 in October 2024. After that, prices continued to decline until April 2025. However, price is not an absolute indicator of recovery in the performance of an industry. Considering that the price of coke, a raw material for steel, is on a downward trend, steel companies still retain a certain level of profitability in steelmaking. In addition, several policies were progressively implemented by the Chinese government in April 2025, such as the "ultra-long-term special government bonds" and the "equipment renewal re-lending tool," which provide strong stimulus to the demand side of the steel industry. Coupled with rising temperatures and the rapid rollout of infrastructure projects, the demand of steel is recovering quickly. Additionally, the demand of steel from the manufacturing sector remains resilient, and the second round of the automobile "trade-in" policy has entered its implementation phase. These factors are expected to drive a rebound in steel prices.

Note: China's steel price index system includes a comprehensive index, two sub-indexes (long steel index, plate index), as well as indexes and prices of eight major steel varieties.

Source: China Iron & Steel Association, Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

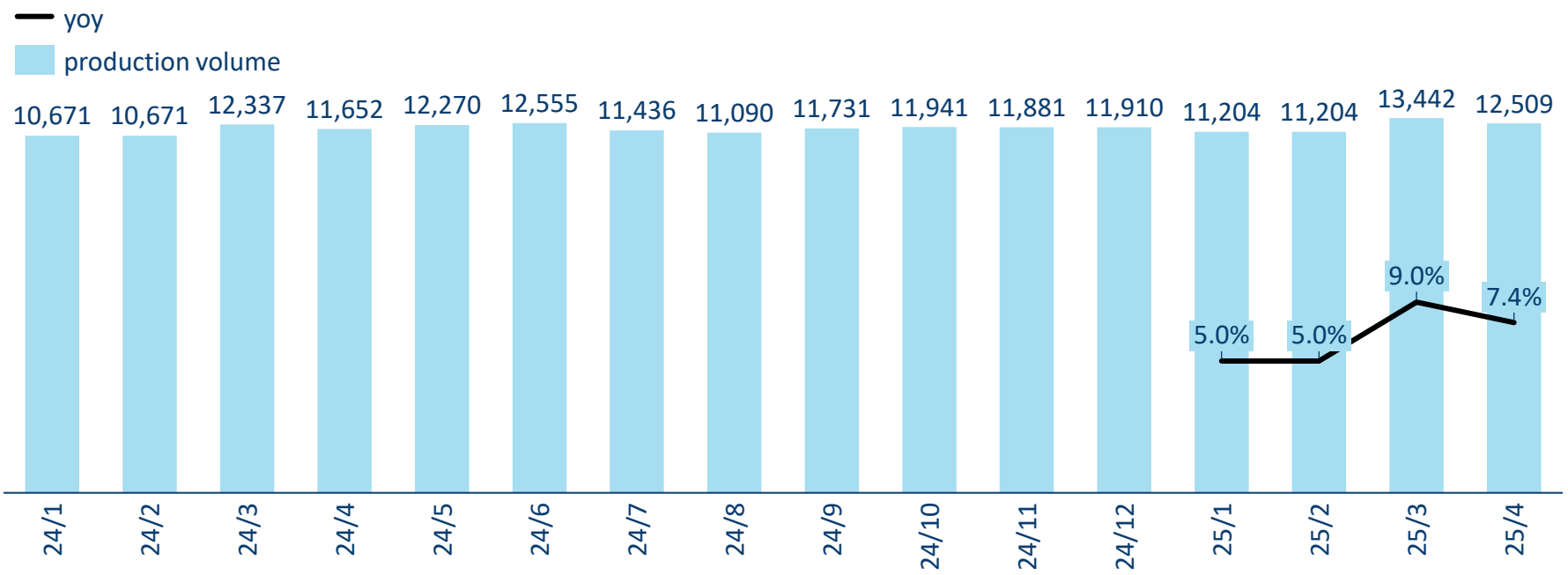
Monthly Production Volume of Steel

Key Finding:

- In addition to price, production volume is also an important indicator of the steel industry's prosperity. Compared to price, the growth in output has a more direct relationship with the supply of industrial exhaust gas. Compared to 2024, steel production in 2025 shows a clear upward trend. From January to April 2025, steel output increased by 5.0%, 5.0%, 9.0%, and 7.4% year-on-year, respectively, indicating that steel enterprises are carrying out production activities in an orderly manner.

China's monthly production volume of steel

10,000 Tons, %, 2024/01 – 2025/04



Note: China's steel price index system includes a comprehensive index, two sub-indexes (long steel index, plate index), as well as indexes and prices of eight major steel varieties..

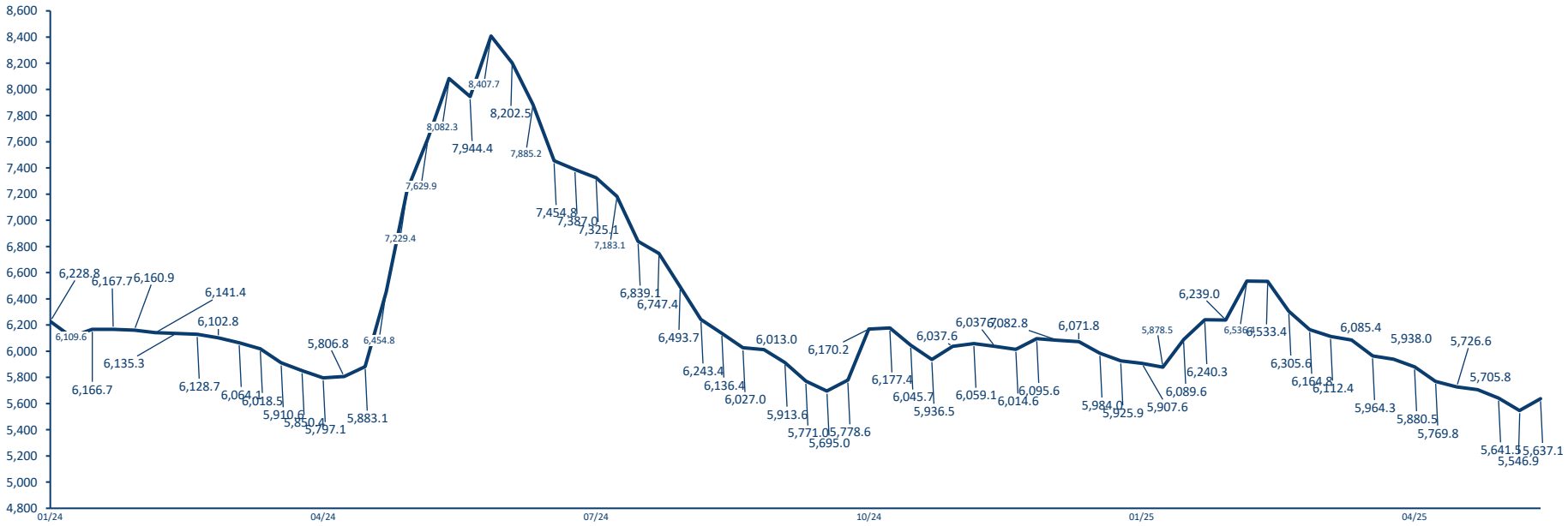
Source: China Iron & Steel Association, Frost & Sullivan

Overview of The Steel and Ferroalloy Industry

Weekly Price of Silicon Manganese

China's Weekly Price of Silicon Manganese

RMB/ton, 2024/01 – 2025/05



Key Findings

- In 2024, the weekly prices of silicon manganese alloy in China showed an overall downward trend. Specifically, the weekly average price of silicon manganese alloy in China rose to RMB8407.7 per ton in June 2024, but continued to decline thereafter. Since the beginning of 2025, the price of silicon manganese alloy has experienced some fluctuations and has remained at around RMB5,600 per ton. As silicon manganese alloy is an upstream raw material in the steel industry, the anticipated recovery of the steel sector is expected to drive an increase in demand for silicon manganese alloy, thereby supporting a rebound in its price.

Note: China's steel price index system includes a comprehensive index, two sub-indexes (long steel index, plate index), as well as indexes and prices of eight major steel varieties.

Source: China Iron & Steel Association, Frost & Sullivan

Overview of CCUS Technology Industry

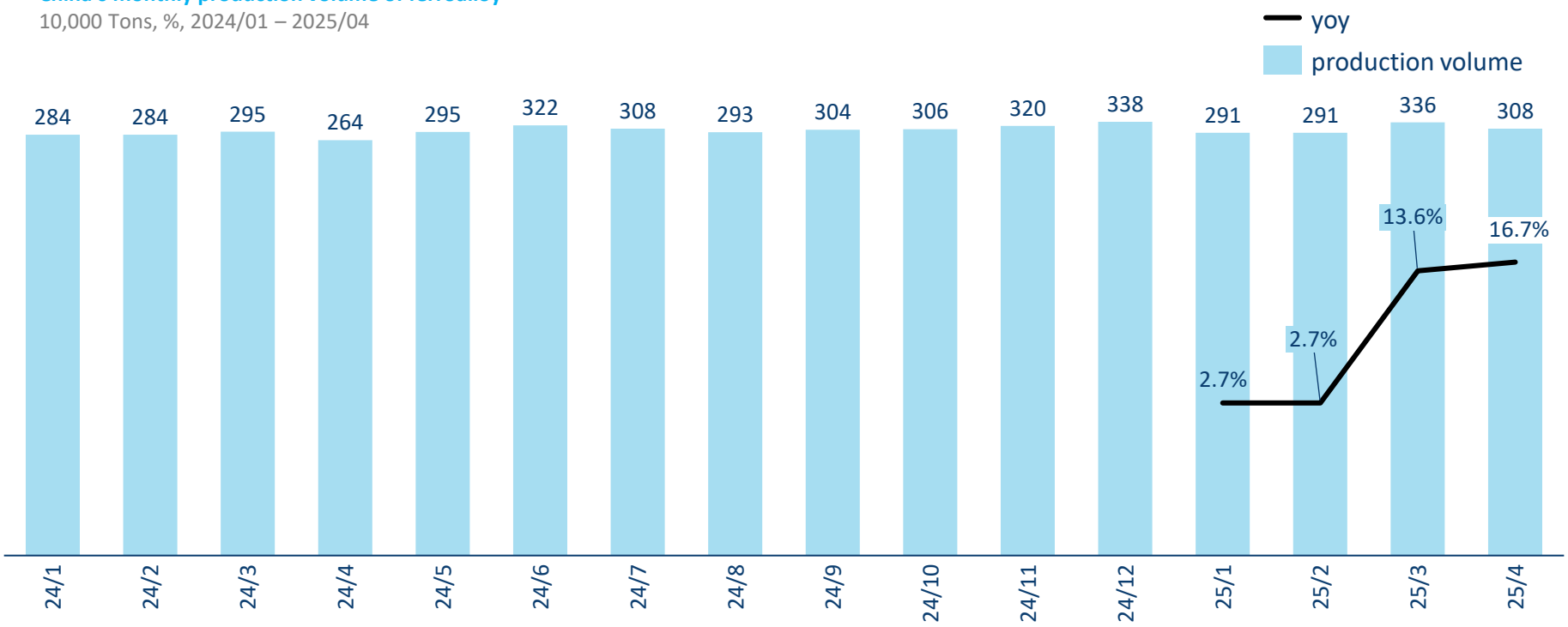
Monthly production volume of ferroalloy

Key Finding:

- In addition to price, production volume is also an important indicator of the ferroalloy industry's prosperity. Compared to price, the growth in output has a more direct relationship with the supply of industrial off gas. Compared to 2024, production volume of ferroalloy in 2025 shows a clear upward trend. From January to April 2025, ferroalloy output increased by 2.7%, 2.7%, 13.6%, 16.7% year-on-year, respectively, indicating that ferroalloy enterprises are carrying out production activities in an orderly manner.

China's monthly production volume of ferroalloy

10,000 Tons, %, 2024/01 – 2025/04



Note: Note: Since the National Bureau of Statistics began releasing monthly ferroalloy production data for the current year starting in March, the production figures for January and February of each year are calculated by dividing the cumulative production as of February by two.

Source: China Iron & Steel Association, Frost & Sullivan

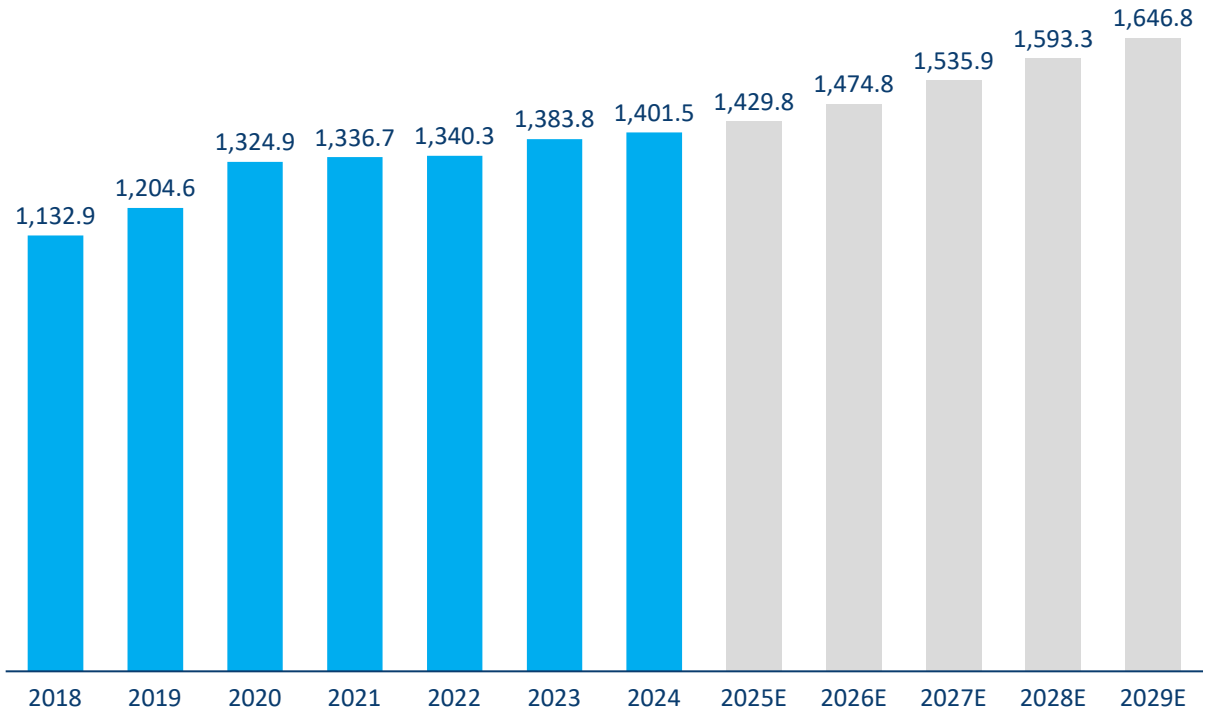
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Steel

Annual Production Volume of Steel

Million Tons, 2018-2029E

	2018-2024	2024-2029E
CAGR	3.6%	3.3%



Key Findings

- The annual production volume of steel has increase from 1,132.9 million tons in 2018 to 1,401.5 million tons in 2024 , with a CAGR of 3.6%.
- Although the demand for steel in the real estate industry may fluctuate, there is still significant demand for infrastructure construction in China. it is expected that by 2029, the annual production volume of steel will reach 1,646.8 million tons, with a CAGR of approximately 3.3% from 2024 to 2029.

Source: Frost & Sullivan

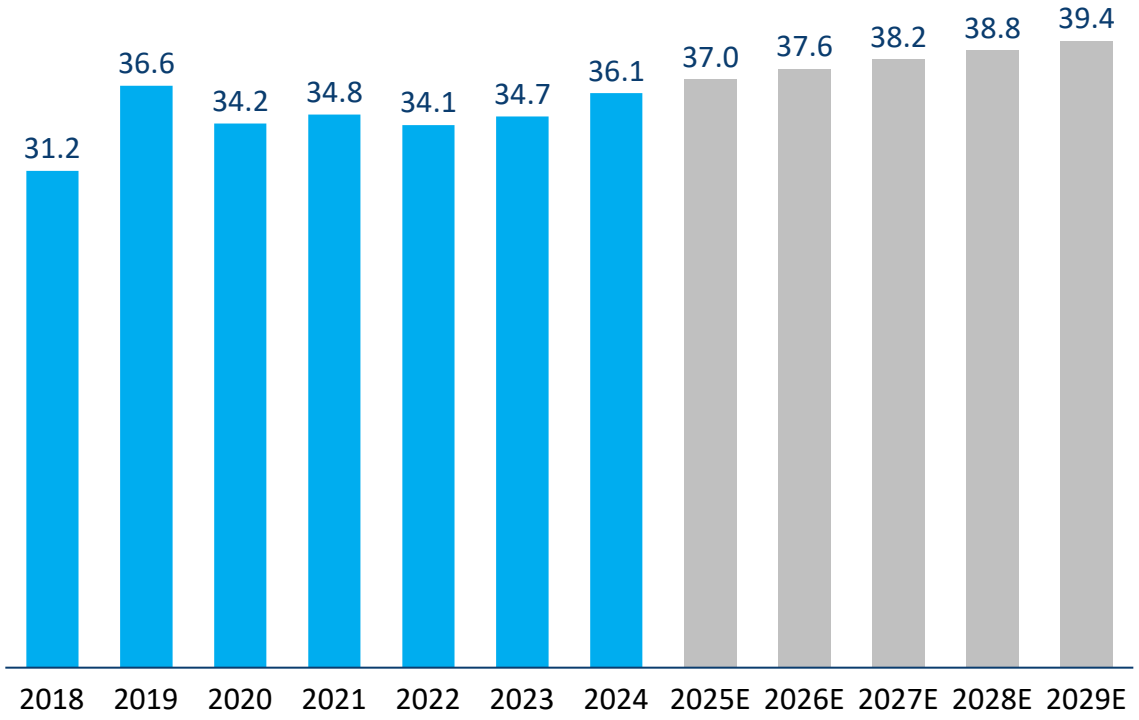
Application of Synthetic Biology Technology in CCUS Technology Industry

Market Size of Ferroalloys

Annual Production Volume of Ferroalloys

Million Tons, 2018-2029E

	2018-2024	2024-2029E
CAGR	2.4%	1.7%



Key Findings

- With the rise of new energy, high-end manufacturing and other fields, the application scenarios of ferroalloys have gradually expanded to high-performance material fields such as aerospace, new energy vehicles, and electronic equipment. The annual production volume of ferroalloys has increase from 31.2 million tons in 2018 to 36.1 million tons in 2024, with a CAGR of 2.4%.
- The recovery of the global economy has driven the of demand for steel and its raw materials, leading to a rebound in the market price of ferroalloys and boosting the prosperity of the entire industrial chain. Annual production volume of ferroalloys is expected to continue to grow, reaching 39.4 million tons by 2029, with a CAGR of 1.7% from 2024 to 2029.

Source: Frost & Sullivan

Appendix

- The Company is the first company in the CCUS industry utilizing synthetic biotechnology that has been validated to achieve both commercialization and scalability of the production of low-carbon products.
- The Company completed the world's first set of industrial devices for producing ethanol and microbial protein through bio-fermentation processes by utilizing the carbon-containing industrial off-gas generated by steel and ferroalloy mills.
- The Company's microbial protein is China's first novel feed protein raw material.
- The Company has established the world's first large-scale industrial fermentation facility for steel industrial off-gases.
- In 2022, the Shoulang Jiyuan project was launched in Ningxia Province, creating the world's first industrial fermentation facility for ferroalloy mill off-gas.
- The annual investment in the global CCUS industry is expected to increase from USD12.6 billion in 2023 to USD76.8 billion in 2028 and is expected to grow at a CAGR of 43.5% during this same period. As the country with the largest carbon emissions, the annual investment in China's CCUS industry is expected to increase from RMB21.6 billion in 2023 to RMB99.3 billion in 2028 and is expected to grow at a CAGR of 35.7% during this same period.
- The industrial off-gas required for a CCUS biosynthesis production facility is usually provided by one industrial off-gas supplier.
- It is a common industry practice for production enterprises to establish production facilities near key raw material suppliers. This approach facilitates cost-efficient operations and logistical convenience while fostering mutual reliance and benefits between the production enterprises and their suppliers.
- Aside from the impact of the pandemic in 2020, 2024 marked the lowest point of China's ferroalloy industry's sale prices of silicon manganese alloy in the past seven years

Source: Frost & Sullivan

Appendix

- 2024 marked a sharp decline in fuel ethanol prices, which was caused by the entry into the market by a large amount of low-cost coal-based ethanol.
- According to Frost & Sullivan, the price of fuel ethanol in China is expected to increase approximately by 4.1% in 2025 and is expected to further increase by 1.3% in 2026.
- steel plants are restricted from decreasing the CO concentration in their industrial off-gas below certain levels due to production safety requirements.
- Commercialization: The process where relevant products, after obtaining industry qualifications, enter the market for sale, have stable sales channels and scale, and generate revenue. “commercialization” is a term widely adopted and recognized in the industry.
- Industrial scale: The attribute whereby a technology is successfully transformed from laboratory research and small-scale testing stages to commercialization and large-scale production, and that the annual ethanol production is equal to or greater than 10,000 tons. “industrial scale” is a term widely adopted and recognized in the industry.
- Large-scale: The attribute whereby the annual ethanol production is equal to or greater than 10,000 tons. “large-scale” is a term widely adopted and recognized in the industry.
- Low-carbon: The attribute whereby, when compared to similar products or products with the same function, the carbon emission data from raw material acquisition to finished production of the product meets the low-carbon evaluation criteria for such product and has obtained certifications from international organizations such as ISCC. “low-carbon” is a term widely adopted and recognized in the industry.
- The annual jet fuel consumption of China was 33.9 million tons in 2023, and is expected to reach 48.3 million tons in 2026.

Source: Frost & Sullivan

Appendix

- Scalability: The commercialization of ethanol and protein products obtained through CCUS and synthetic biotechnology, with single unit production exceeding ten thousand tons, and the engineering capability as demonstrated by the presence of at least two production bases indicating mature technology as well as successfully replicated production experience. “scalability” is a term widely adopted and recognized in the industry.

- The sales volume of fuel-powered vehicles in China reached 14.7 million units in 2024 which accounted for approximately 53% of the total sales of passenger vehicles and that the stock of fuel-powered vehicles is expected to remain above 200 million units over the next five years.

- The fuel ethanol industry in China has a CR5 exceeding 50%, indicating a high level of market concentration. Despite the fact that new entrants may face challenges from leading players due to the high market concentration, there is low-price competition within the fuel ethanol industry itself which intensifies competition amongst the competitors. On the other hand, the feed protein industry is highly fragmented. There is a large number of sizable market players for fish meal and soybean meal, being the mainstream raw materials for feed protein. Such industry participants compete for market shares through channel development and brand differentiation.

- Comparing with other technological pathways, synthetic biotechnology offers advantages in supporting ESG development and accelerating the transition from CCS to CCUS.

- The Company had invented China’s first large-scale gas-liquid-solid continuous bioreactor capable of supporting production at a scale of tens of thousands of tons.

- Compared with producing ethanol from grains, producing ethanol from industrial off-gas through synthetic biotechnology has the advantages of reducing dependence on food resources and conserving arable land.

- The company was the only company in China capable of producing feed protein on an industrial scale by utilizing industrial off-gas.

Source: Frost & Sullivan

Appendix

- HEFA, as the most mature technical pathway of SAF production, primarily relies on waste grease from kitchens as raw materials. These raw materials are limited, difficult to collect and store, and require strict temperature control during transportation, which poses challenges to ensure a stable supply and results in high raw material costs. Leveraging the abundant industrial off-gas resources in China, the ATJ technical pathway ensures a more stable and sustainable supply of raw materials for SAF production.

- The average prices of soybean meal per ton were approximately RMB3,630, RMB4,600, RMB4,350, and RMB3,430 for the years ended December 31, 2021, 2022 and 2023 and the six months ended June 30, 2024 respectively.

- The company's royalty and sublicense fees and associated licensing arrangements align with industry norms.

- Such customer concentration is common in the industrial gas and energy sectors due to the scale of operations and investment required.

- All of our production facilities obtain industrial off-gas through pipelines connected to nearby suppliers who produce industrial off-gas, which is in line with common practice for CCUS biosynthetic production facilities. The industrial off-gas required for a CCUS biosynthesis production facility is usually provided by one industrial off-gas supplier.

- Silicon manganese alloy is expected to gradually recover in 2025 and 2026.

- it is not uncommon that a customer is also a supplier where both parties operate in the same production zone and no alternative companies are available.

- The sale prices of silicon manganese alloy of China's ferroalloy industry is expected to rebound from the industry bottom in 2024 and will gradually recover in 2025 and 2026.

Source: Frost & Sullivan

Appendix

- Leading international companies in the cosmetics, fast-moving consumer goods, and fashion sectors have announced commitments to utilize 100% recycled or bio-based plastics in their product packaging by 2030 and are at the forefront of adopting environmentally friendly packaging materials.
- an increasing number of downstream customers are willing to pay a premium for green products, for example, SAF commands a premium of approximately 290% compared to conventional aviation kerosene globally.
- The company exported approximately 5,700 tons of ethanol overseas, with an average selling price of around RMB7,200 per ton. Such price is about 20% higher than the average international ethanol price.
- The company's current insurance coverage in relation to our business as mentioned above is in line with relevant industry practice in the PRC.
- The company has also confirmed that the continuous and stable supply of energy medium and off-gas is the foundation of the strain cultivation, and it is consistent with industry practice for the Company to enter into industrial off-gas and energy medium supply agreements with a term exceeding or equal to 10 years.
- It is industry practice for companies to jointly establish subsidiaries with companies supplying industrial off-gas in the CCUS industry utilizing synthetic biotechnology.
- It is a common industry practice for production enterprises to establish production facilities near key raw material suppliers.
- It is a common industry practice to suspend production during the asset restructuring of industrial enterprises.

Source: Frost & Sullivan

Thanks !

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