Kaolin and Its Deep Processing Products Industry Market Research

Project 9566

Frost & Sullivan

2025

Agenda

Scope

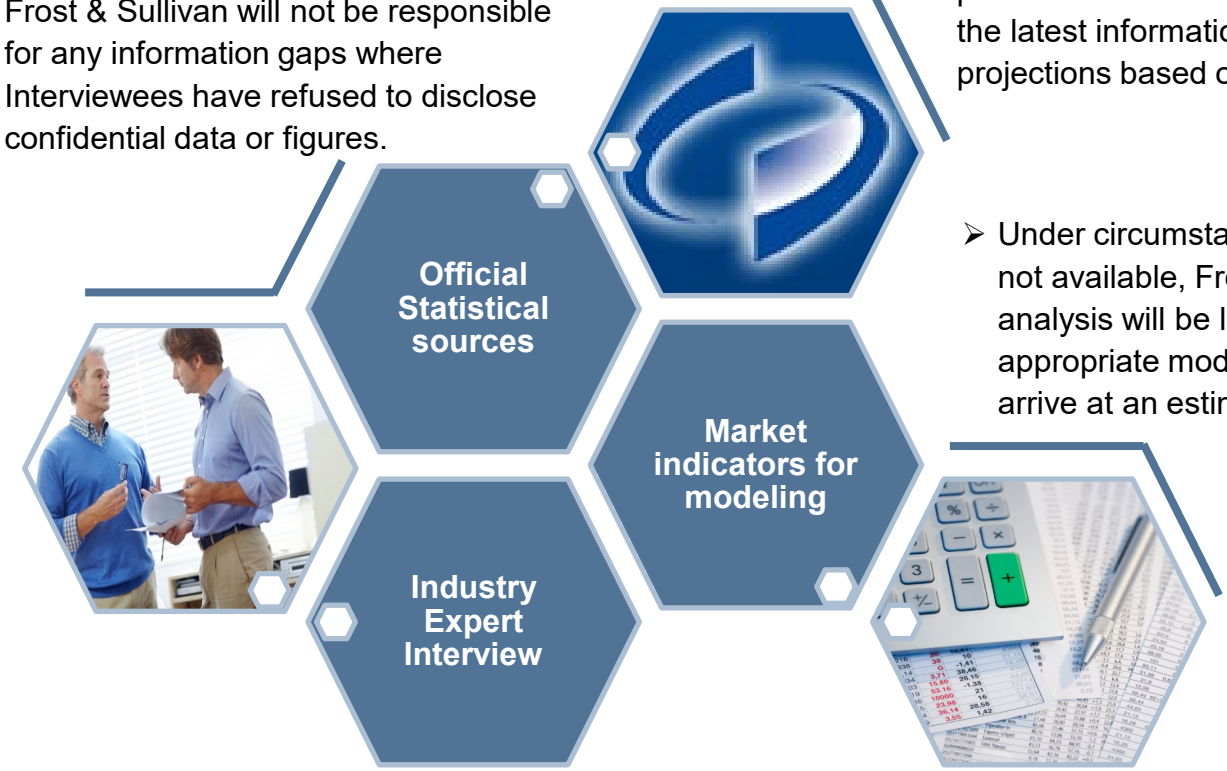
- **The project scope is defined as follows:**

Research Period	• **Historical Year: 2020-2024** • **Base Year: 2024** • **Forecast Year: 2025-2029**
Geographic Scope	• **China**
Industry Scope	• **Kaolin Resources Market** • **Precision Casting Mullite Products Market** • **Refractory Mullite Products Market** • **Ceramic Fiber Market**

Limitations

Source of Information

- Interviews with industry experts and competitors will be conducted on a best-effort basis to collect information in aiding in-depth analysis for this report.
- Frost & Sullivan will not be responsible for any information gaps where Interviewees have refused to disclose confidential data or figures.
- The study took 2024 as the base year and 2025-2029 as the forecast period. However, as the point of this study being 2024, some of the figures of 2023 may not be available at the moment from public statistical sources. Frost & Sullivan will use the latest information available (e.g. 2022) or make projections based on historical trends.



- Under circumstances where information is not available, Frost & Sullivan in-house analysis will be leveraged using appropriate models and indicators to arrive at an estimate.
- Source of information will be stated in the right hand corner at the bottom on each slide for easy reference.

Agenda

Overview of China Kaolin Resources Market
Basic Definition of Kaolin

- Kaolin is a non-metallic clay and claystone primarily composed of minerals from the kaolinite family. It is also called dolomite due to its white and delicate appearance. Kaolin is known as one of the four major non-metallic minerals, alongside mica, quartz and calcium carbonate.
- The main components of kaolin are silica and alumina, along with oxides of potassium, sodium, calcium, magnesium, iron and titanium. Pure kaolin is a mineral in white, fine size and soft texture. It possesses excellent physical and chemical properties, including good plasticity and high refractoriness.

Typical Chemical Composition of Kaolin

Compound	Composition(wt.%)
Aluminum Oxide	20.34
Calcium Oxide	2.29
Ferric Oxide	1.35
Potassium Oxide	2.02
Magnesium Oxide	1.99
Silicon Dioxide	58.02
Titanium Dioxide	2.05

Compound	Composition(wt.%)
Manganese Oxide	0.01
Sodium Oxide	0.13
Potassium Oxide	0.17
Sulfur Trioxide	0.23
Phosphorus Pentoxide	0.45
Loss-on-Ignition	10.95

Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

Overview of China Kaolin Resources Market

Performance Characteristics and Advantages of Kaolin

Whiteness and Brightness	• The whiteness of kaolin is an important specification, usually appearing as white or nearly white. The better quality demonstrates higher whiteness. • The whiteness is divided into natural whiteness and calcined whiteness, the latter being particularly critical for related industries such as ceramics, paper and coatings.
Particle Size Distribution	• The common particle size of kaolin is around 0.2-5μm, and the fine particle size enables the improved plasticity and dry strength.
Plasticity	• The plasticity of kaolin is a key characteristic in *ceramic forming,* assessed through the plasticity index and plasticity metrics. Plasticity is categorized into four levels; *the higher index and metrics lead to better forming performance.*
Refractory	• Kaolin has excellent refractory properties, with a calcination temperature above 1700 °C. Therefore, it demonstrates remarkable thermal stability and resistance to chemical corrosion at high temperatures.
Chemical Stability	• Kaolin exhibits high stability in most acidic and alkaline environments. It is resistant to corrosion by acids and bases, thus maintaining long-term stability.
Adsorption	• Kaolin shows outstanding adsorption properties by virtue of its excellent specific surface area, porous structure and enhanced performance through chemical modification. • It is widely used in areas such as wastewater treatment, air purification, catalyst carriers, petrochemical processes, and pharmaceutical adsorbents.

Source: Public information, Frost & Sullivan

Overview of China Kaolin resources Market

Kaolin Application Development History

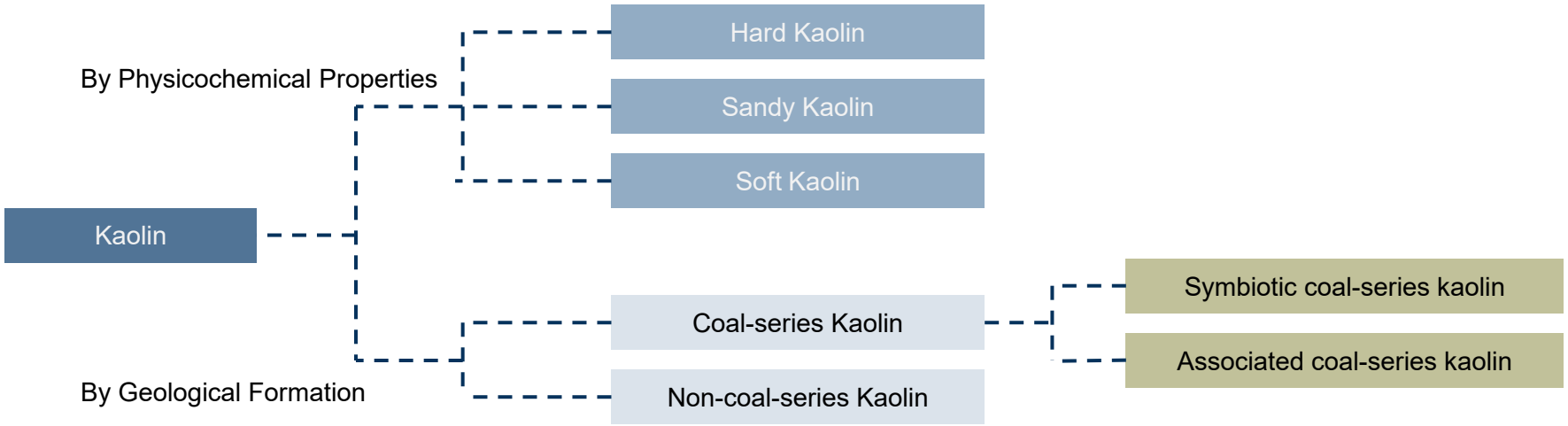
■ Before 1990s	■ 1990s~ 2010s	■ 2010s ~ Today
Application in the early stage	**Diversification of products**	**Comprehensive use of resource**
• As early as 1990s, with the development of industrial technology, kaolin began to be widely used in paper, ceramics, rubber and other industrial fields, and gradually formed a large-scale production. • China has successfully developed coal-based calcined kaolin products and started to apply them to refractory products, fine casting moulds, reinforcing fillers for rubber and nylon materials, adsorbents and so on. • As a first-generation technology, the production capacity is small, with an annual output of about 1,000 tonnes.	• The global demand for kaolin is growing rapidly, especially in developed countries. Kaolin is widely used in various new materials and high-tech products. • The coal-based calcined kaolin products have developed from primary processing to finishing, and with the birth of the second generation technology, the scale of the production line has been gradually expanded. • After the birth of the second generation technology, the scale of the production line is gradually expanding, and the application fields of coal-based calcined kaolin products are also gradually expanding, in addition to the basic industry, it is beginning to expand to the field of paint, paper, plastics, rubber, chemical industry, pharmaceuticals, environmental protection, and high-end refractory materials.	• The kaolin industry has entered an era of modernised mass production. Advanced mining technology, fine processing techniques and the implementation of environmental and safety norms have led to a significant improvement in product quality. • The third-generation technology of coal-based calcined kaolin was born, and the production capacity was further expanded, with an annual output of 50,000 to 200,000 tonnes. The product technology has become more mature, beneficial for expanding more applications, especially in high-end fields such as precision casting, refractory materials and military industry. The comprehensive use of resources and circular economy has become the direction of development of kaolin industry.

Source: Public information, Frost & Sullivan

Overview of China Kaolin resources Market
Classification of Kaolin (1/6)

- Kaolin ores can be generally classified into hard kaolin, soft kaolin and sandy kaolin based on their physicochemical properties. Based on the geological formation, kaolin can be categorized into coal-series kaolin and non-coal-series kaolin. Within the coal-series kaolin category, there are further subdivisions into symbiotic coal-series kaolin and associated coal-series kaolin.
- Symbiotic coal-series kaolin, which is found alongside with other minerals, requires separation and purification processes before deep-processed due to its variable mineral composition and the separation difficulties. Associated coal-series kaolin coal and other minerals are independent as they are deposited independently within the same ore bed. After mining, kaolin is classified by type and specification and can proceed directly to deep-processed procedure without the need for additional purification.

Classification of Kaolin



Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

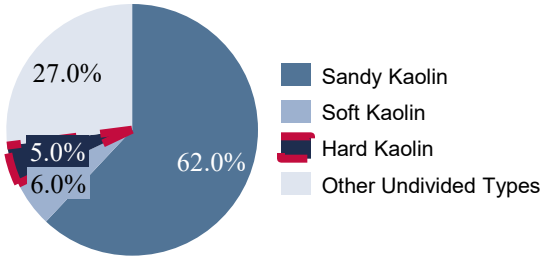
Overview of China Kaolin resources Market

Classification of Kaolin (2/6)

Kaolin Classification by Physicochemical Properties

Classification	Hard Kaolin*	Sandy Kaolin	Soft Kaolin
Features	• Hard (Mohs hardness 3~4) • No plasticity • Plasticity only after crushing and fine grinding	• Soft soil • General plasticity • High plasticity after sand removal • Sand content ≥50%	• Soft soil • Commonly high plasticity • Sand content <50%
Example of Application	• Refractories • Precision casting • Paper • Coatings	• Ceramics • Paper • Coatings	• Paper • Chemical catalysts
Mine Distribution	• **Huaibei, Anhui** • Datong, Shanxi • Jungar, Inner Mongolia.	• Longyan, Fujian • Maoming, Guangdong • Hepu, Guangxi	• Suzhou, Jiangsu • Beihai, Guangxi

Distribution of China Kaolin Ore Resources by Texture



- The types of kaolin ore in China, based on texture, are predominantly sandy kaolin with more than 60% of the total reserves. Soft kaolin and hard kaolin share approximately 6% and 5% of the total reserves, respectively. Other unspecified types of kaolin account for around 27% of the total reserves.

Note: Due to limited geological exploration, complex composition that complicates categorization, and transitional mineral characteristics, some kaolin deposits cannot yet be definitively classified into specific kaolin types.

Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

Overview of China Kaolin resources Market
Classification of Kaolin (3/6)

- According to the paper "Mineralization Characteristics and Resource Potential Assessment of Kaolin Deposits in China" jointly published by the Chinese Academy of Geological Sciences and the Ministry of Natural Resources. Kaolin ores can be generally classified into hard kaolin, soft kaolin and sandy kaolin based on their physicochemical properties. Among them, sandy kaolin accounts for the largest proportion of total reserves, exceeding 60%, while hard kaolin represents the smallest share, at approximately 5%. Within the hard kaolin category, unlike the deposits in Shanxi and Inner Mongolia which are primarily symbiotic coal-series kaolin resources, the hard coal-series kaolin held by Anhui Jinyan is of the associated type and can be directly processed, making it a scarce and valuable resource. Geological reserve data for such kaolin types is published exclusively by national authorities, and no further quantitative disclosures are currently available; related assessments are primarily based on qualitative research. Based on the geological formation, kaolin can be categorized into coal-series kaolin and non-coal-series kaolin. Within the coal-series kaolin category, there are further subdivisions into symbiotic coal-series kaolin and associated coal-series kaolin. Symbiotic coal-series kaolin, which is found alongside with other minerals, requires separation and purification processes before deep-processed due to its variable mineral composition and the separation difficulties. Associated coal-series kaolin coal and other minerals are independent as they are deposited independently within the same ore bed. After mining, kaolin is classified by type and specification and can proceed directly to deep-processed procedure without the need for additional purification.

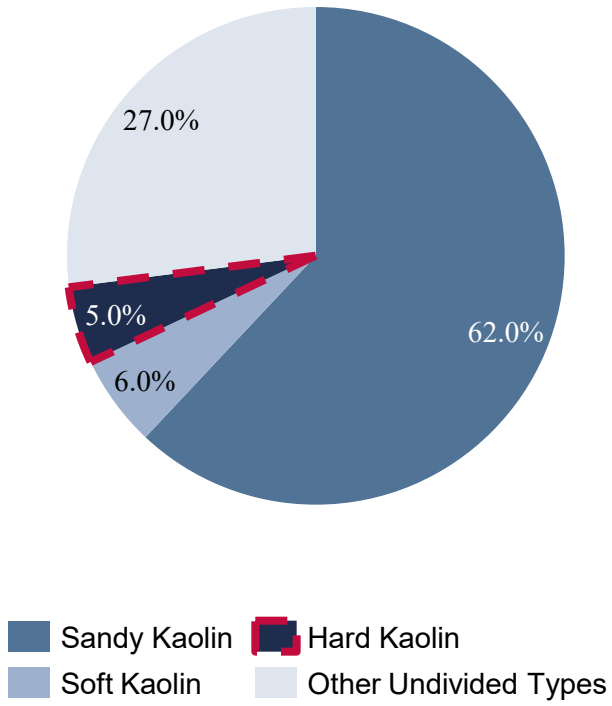
- The quality of kaolin ore is classified by the concentrations of Al_2O_3, Fe_2O_3 and TiO_2 in terms of chemical compositions. According to the Appendix E.1 of DZ/T 0206-2002 "Specifications for Kaolinite, Bentonite, Refractory-Clay Mineral Exploration" (《高嶺土、膨潤土、耐火黏土礦地質勘查規範》), the industrial standard weight percent of Al_2O_3 should be higher than 30%, weight percent of Fe_2O_3 plus TiO_2 should be less than 2%, besides TiO_2 should be less than 0.6%. There is no industry standard to specify the weight of SiO_2 in kaolin ore. The Company's kaolin ore consists of 38.1% Al_2O_3, 1.5% Fe_2O_3 plus TiO_2 and 0.5% TiO_2 in weight. All specifications are better than industrial standard, indicating the kaolin ore in deposits has a high effective content of Al_2O_3, less impurities, and relatively high refractoriness.

Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

Overview of China Kaolin resources Market

Classification of Kaolin (4/6)

Distribution of China Kaolin Ore Resources by Texture



- The types of kaolin ore in China, based on texture, kaolin ores can be classified into hard kaolin, soft kaolin and sandy kaolin. In terms of reserves in 2022, sandy kaolin is the dominant type, accounting for over 60% of the total reserves. Soft kaolin and hard kaolin account for approximately 6% and 5% of the total reserves respectively, while other unspecified types of kaolin account for about 27% of the total reserves. Therefore, hard kaolin resources are the scarcest. The kaolin of the company belongs to hard coal-series kaolin. Coal-series kaolin exhibits specific physical and chemical properties, including high purity, high chemical stability, and high refractoriness. Within the limited reserve of coal-series kaolin, there are further subdivisions into symbiotic coal-series kaolin and associated coal-series kaolin. Upon extraction, associated coal-series kaolin can be proceed directly to deep process without requiring further purification. It can achieve lower production costs. As a high-quality kaolin resource, associated coal-series kaolin has certain unique characteristics and differs from most of the symbiotic coal-series kaolin resources in Shanxi and Inner Mongolia deposits.

Note: Due to limited geological exploration, complex composition that complicates categorization, and transitional mineral characteristics, some kaolin deposits cannot yet be definitively classified into specific kaolin types.

Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

Overview of China Kaolin resources Market

Classification of Kaolin (5/6)

Kaolin Classification by Geological Formation

Classification	Non-coal-series Kaolin	Coal-series kaolin*
Mineral Features	• Formed by weathering of feldspar or other silicate minerals • Varies depending on the source	• Contains carbonaceous matter • Low iron and titanium content • High whiteness after calcination • Good dispensability • Fine particle size
Example of Application	• Ceramics • Paper • Coatings • Catalyst carriers	• Precision casting • Paper • Rubber • Refractories
Mine Distribution	• Guangxi • Jiangxi • Fujian • Hunan	• **Anhui** • Shanxi • Shaanxi • Inner Mongolia

Symbiotic coal series

- Symbiotic coal-series kaolin, which is found alongside with other minerals, requires separation and purification processes before deep-processed due to its variable mineral composition and the separation difficulties.

Associated coal series

- Associated coal-series kaolin coal and other minerals are independent as they are deposited independently within the same ore bed. After mining, kaolin is classified by type and specification and can proceed directly to deep-processed procedure without the need for additional purification.

Source: Chinese Academy of Geological Sciences, China Geological Survey, Frost & Sullivan

Overview of China Kaolin resources Market
Classification of Kaolin (6/6)

Kaolin Classification by Geological Formation

- New materials refer to those materials that have emerged or are currently in development, and possess superior properties and special functions that traditional materials do not have. There is no clear boundary between new materials and traditional materials. New materials can be developed based on traditional materials through significant improvements in composition, structure, design, and process to enhance material performance or introduce new properties through modifications. Anhui Jinyan's deep- processed kaolin products are derived from advanced processes such as calcination from traditional kaolin minerals, substantially optimizing their structure, with improved whiteness, adsorption capacity and insulation as well as new functionalities, which are aligned with the definition of new materials.

- Deep-processed kaolin materials are widely used in high-end manufacturing, where precision casting mullite is widely used in industries such as automotive, aerospace, medical, and general machinery, while refractory mullite is widely used in high-temperature manufacturing sectors. In addition, deep-processed kaolin is also utilized in premium applications such as specialty ceramics, molecular sieves, cosmetic-grade fillers, and pharmaceutical carriers/excipients. Such wide applications in high-end manufacturing demonstrate kaolin to be classified as a new material.

Source: General Office of the State Council,, Frost & Sullivan

Overview of China Kaolin Resources Market
Kaolin Mining Methods

- There are two main methods for kaolin ore mining: underground mining and open-pit mining. Different mining techniques are used based on the specific characteristics.

	Underground Mining Methods	*Open-pit Mining Methods*
Mining Processes	• Underground kaolin mining techniques: mine development, ore preparation, cutting, and extraction. • Underground depth-dependent economy.	• Open-pit kaolin mining techniques: blasting, excavation, loading, and transportation. • For surface and shallow mineral deposits, with typically wide mining areas.
Equipment Costs	• Equipment required: tunnel excavation equipment, ventilation, and drainage systems.	• Simple equipment required: excavators, trucks, and drills. • Short distances of ground surface ore transportation.
Suitability	• Deep underground deposit mining.	• Ground and shallow surface deposit mining.
Environmental Impacts	• Less impact on ground surface ecosystems.	• Significant damage to ground surface ecosystems, with high restoration costs.

Underground Mining Methods Strengths

- Compared to open-pit mining, underground mining maximizes the use of deeper kaolin deposits, causes less damage to the surface environment, and can prevent potential geological hazards such as slope instability associated with open-pit mining.

Source: Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

Traditional Applications of Kaolin

Ceramics	• The source of alumina and silica components in ceramic green body. Good plasticity, fine particle sizes and low calcination temperatures enable ceramics improved mechanical strength, whiteness, good looking and ease of manufacturing. The ceramics is broadly used in construction, sanitary, daily goods, etc.
Precision casting	• Precision casting mold prepared by mullite demonstrates high volume density, low thermal expansion and deformation, and high surface smoothness that is attractive for fabricating high-precision and irregular parts used in aerospace, vessel, automotive, military and more industries. Kaolin is the unclaimed precursor of mullite.
Refractory	• The refractories made of kaolin can bear force without deformation at high temperatures (> 1730 oC). Kaolin refractory bricks are manufactured via calcination with desired shapes. The other advanced type is lightweight aluminosilicate cotton manufactured by blowing molten kaolin.
Paper	• Kaolin is one of the excellent fillers of paper products. The gloss and mechanical properties are enhanced by its fine particle size and flake shape. The unique porous structure of kaolin absorbs the inks efficiently making the paper easy to write. The impurities of kaolin used in paper industry are generally controlled to low levels for uniform color.
Coating	• Kaolin is widely used in powder, water-borne, high solid content coatings due to good flowability, dispersion, and chemical stability. Kaolin also benefits coatings with optimized viscosity, leveling performance, good gloss and longer storage time. The high ionic exchange volume enables strengthened hyperchromicity.
Rubber & plastics	• Modified rubbers and plastics consist of a certain amount of fillers to improve mechanical performance, processing capability and reduce cost. The calcined kaolin can be well wetted by polyolefin materials in high loading rates. It significantly improves mechanical properties of EPDM rubbers for cables and thermal insulation of polyethylene or polypropylene film for agricultural greenhouses.

Source: Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

Emerging Applications of Kaolin

Environmental protection	• Kaolin with natural two-dimensional layer structure and porous structure is an effective absorbers for metal separation. Kaolin shows high tendency of heavy metal capture in polluted gas and water for purification. Reversibly, it is good for recycling useful metals such as extraction of lithium in bittern. Moreover, the aluminosilicate absorbers made of kaolin can separate deteriorated oils.
Renewable energy	• Kaolin modified by alkyl alcohols, acids or esters is a useful organic/kaolin hybrid phase change materials. They provide excellent thermal capacity and storage to maintain heat for building and construction, air-conditioner systems, concentrated solar power stations to save a huge amount of heat dissipation.
Advanced materials	• Mesoporous materials have broad applications in chemical processing, absorption, carriers of medicine, etc. Kaolin with porous structural is a natural mesoporous materials. With further calcination and modification, Kaolin can be easily made for molecular sieves and silicate mesoporous materials due to containing similar chemical components. The applications of Kaolin are also extended to nano-materials, glass fibers, etc.
Cosmetics	• Soft kaolin is popular in cosmetic industry. The high absorption rate of Kaolin can clean out the grease and sweat on the skin, Kaolin also demonstrate other functions like lubricity, viscosity control and smoothness that improve both uniformity and texture of cosmetic goods.
Biology and medicine	• Ferro-oxide/kaolin composite is developed as a new hemostatic material. Kaolin acting as a coagulant does not release heat and toxic substances during coagulation. Kaolin is also a good carrier and controlled release agent of medicine for its high specific surface area and porosity, to improve effect of medicine and depress by effects.

Source: Public information, Frost & Sullivan

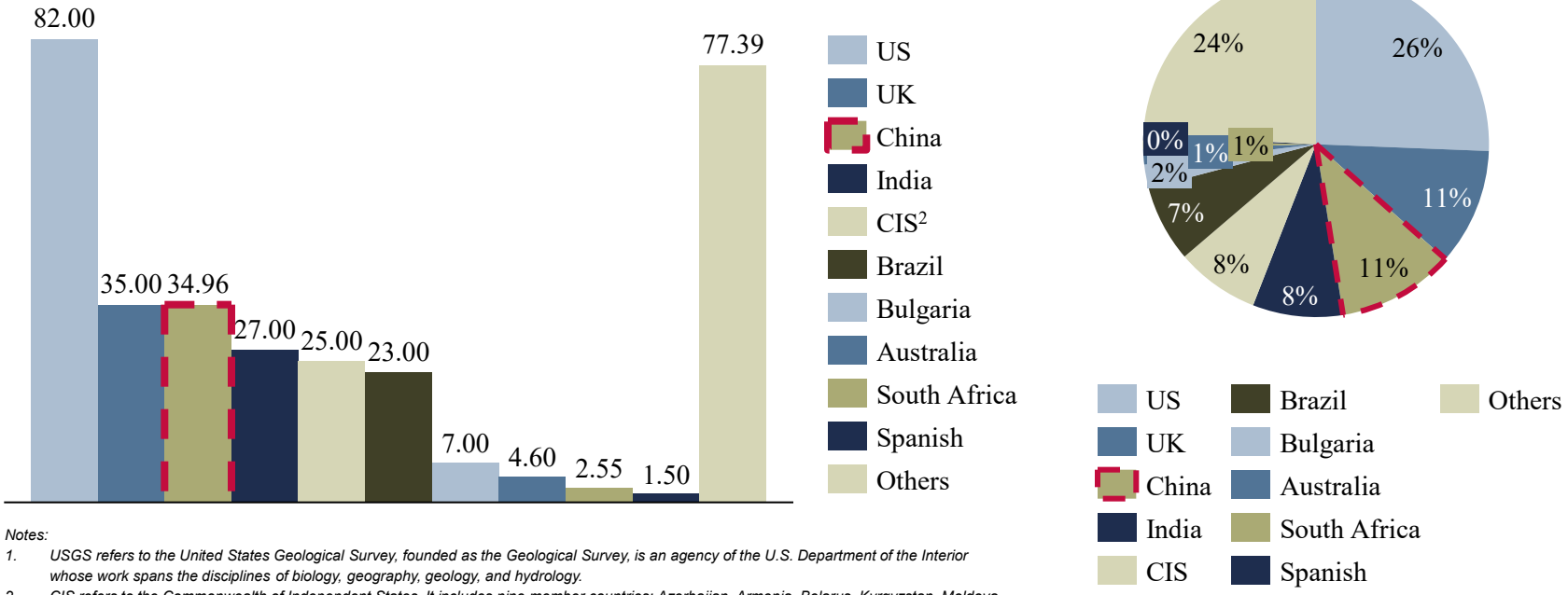
Overview of China Kaolin Resources Market

Global kaolin Reserves

- According to the USGS[1], the global proven reserves of kaolin are approximately 32 billion tonnes. These reserves are mainly distributed in the United States, the United Kingdom, China, India and other regions.
- The United States ranks first with reserves of 8.2 billion tonnes, while China holds nearly 3.5 billion tonnes of kaolin reserves, positioning it as one of the foremost countries globally in terms of kaolin reserves.

Global Major Countries Kaolin Reserves

Unit: 100 Million Tonnes



Notes:

1. *USGS refers to the United States Geological Survey, founded as the Geological Survey, is an agency of the U.S. Department of the Interior whose work spans the disciplines of biology, geography, geology, and hydrology.*
2. *CIS refers to the Commonwealth of Independent States. It includes nine member countries: Azerbaijan, Armenia, Belarus, Kyrgyzstan, Moldova, Kazakhstan, Russia, Uzbekistan, and Tajikistan.*

Source: USGS

Overview of China Kaolin Resources Market

China Kaolin Reserves by Province

Region	Province	Market Share, by Reserves
North China	Inner Mongolia	1.15%
	Total	1.15%
Northeast China	Liaoning	0.01%
	Jilin	0.28%
	Heilongjiang	0.76%
	Total	1.05%
East China	Jiangxi	30.44%
	Fujian	4.8%
	Jiangsu	0.16%
	Zhejiang	1.05%
	Anhui	**1.46%**
	Total	37.91%
South Central China	Hunan	1.4%
	Guangdong	6.07%
	Guangxi	49.53%
	Total	57.59%
Southwestern China	Sichuan	0.62%
	Guizhou	0.03%
	Yunnan	1%
	Total	1.65%
Northwestern China	Shanxi	0.17%
	Xinjiang	0.01%
	Total	0.18%

- China's kaolin resources are widely distributed across whole nation. However, the resources are predominantly concentrated. The south central region of China holds the largest kaolin mineral reserves, with Guangxi Province holding 49.5% of the country's total reserves. This is followed by Jiangxi Province, Guangdong Province and Fujian Province. In the ranking of kaolin reserves in China by province, Anhui Province ranks fifth, accounting for 1.46% of the total reserves.

- Judging from the ore quality, most of China's kaolin ores are ceramic clays (Sandy Kaolin). The content (grade) of Aluminum Oxide is generally about 20%, which is only suitable for producing products such as ceramics and bricks. The high-grade kaolin is mainly concentrated in areas such as Huaibei, Anhui Province and Inner Mongolia. The ore type is hard kaolinite rock, which can be used in the fields of refractory materials or precision casting.

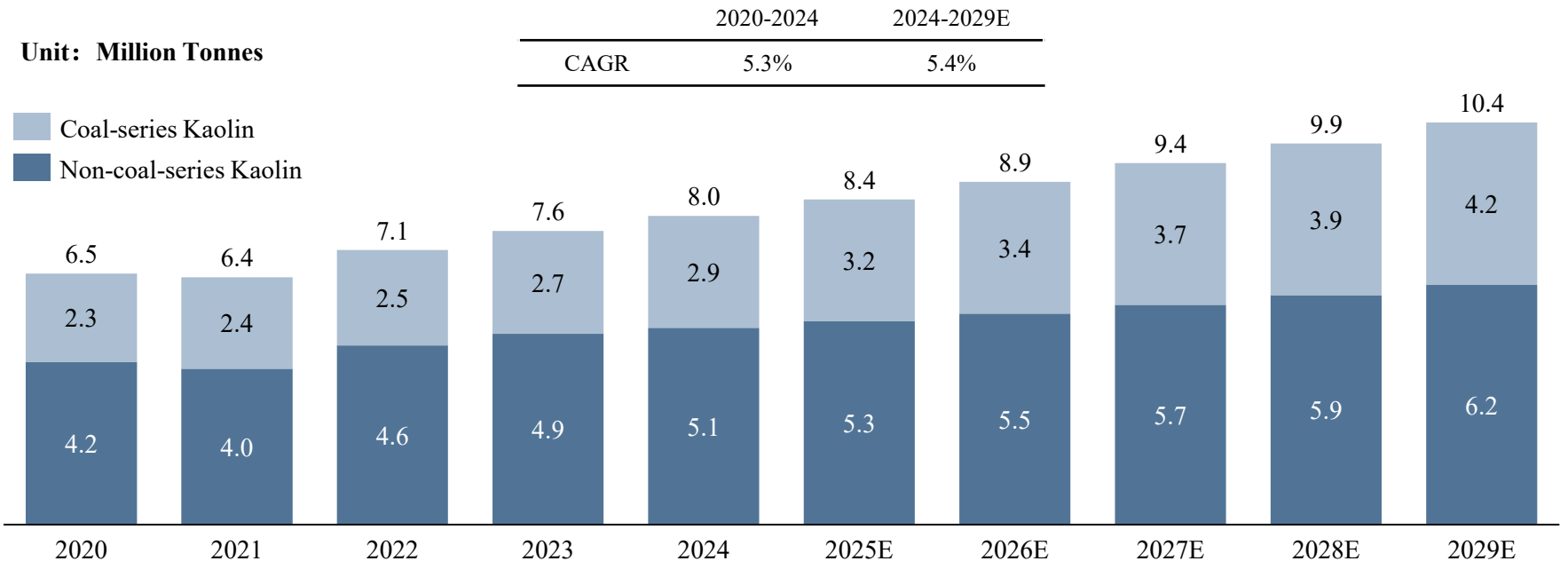
Source: Ministry of Natural Resources, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

China kaolin Production Volume

- The production volume of kaolin in China is experiencing steady growth, driven by technological innovations, supportive policies and the expansion of global trade. China's kaolin production showed a growth trend from 2020 to 2024, with particularly strong increases in 2022 and 2024. In 2021, with the release of the "14th Five —Year Plan for Industrial Green Development" during China's "14th Five — Year Plan" period, the tightening of environmental law enforcement led to an increase in enterprise environmental compliance costs and a slight decline in kaolin production volume. The production volume is expected to reach 10.4 million tonnes in 2029, representing a CAGR of 5.4% from 2024 to 2029. Due to the ever-increasing application of kaolin in both the high-end sectors of traditional fields and in emerging fields, the production volume of raw kaolin in China will continuously increase.

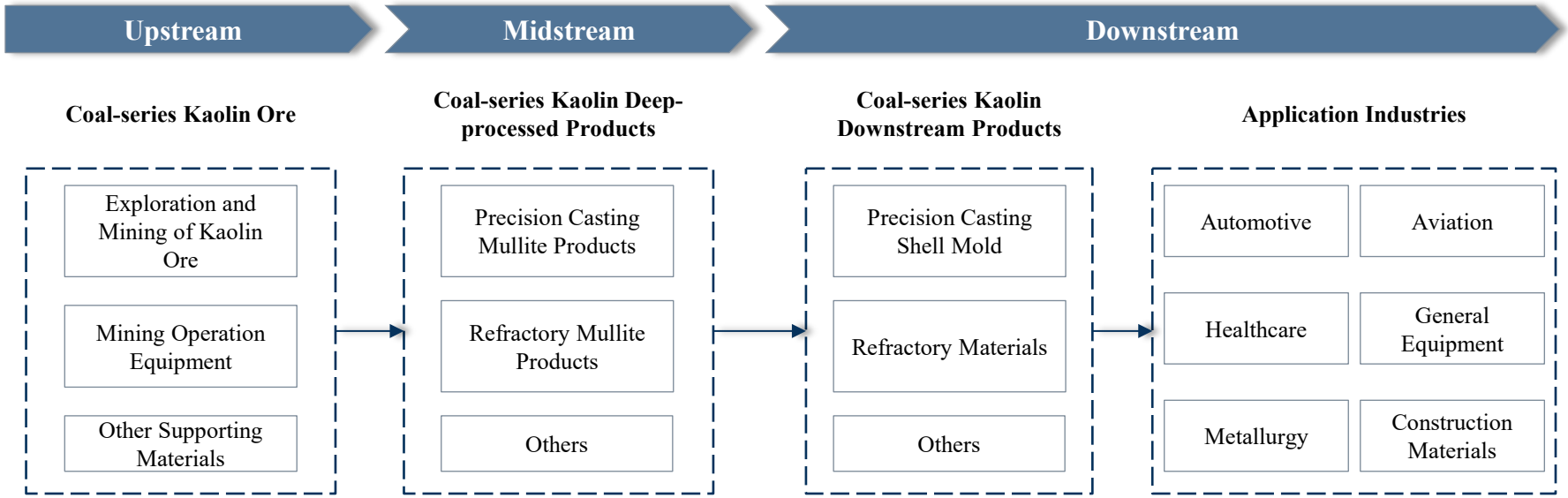
China Kaolin Production Volume，2020-2029E



Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

Kaolin Industry Chain



- The upstream segment mainly includes mining and initial processing of the kaolin ore. After kaolin mining operations are completed, the kaolin ore undergoes initial processing and is converted into raw coke and raw powder. Midstream participants are kaolin processed products manufacturers who use calcination processes to process these products into precision casting mullite products and refractory mullite products, and other materials for sale to downstream customers. Midstream kaolin deep-processed manufacturers without their own mineral resources typically need to procure raw coke and raw powder or coal by-product ores from resource-owning enterprises as raw material sources for further deep-processed. Manufacturers with kaolin mining resources possess a resource advantage, enabling them to acquire high-quality raw materials at lower costs. Sales models of midstream kaolin deep-processed manufacturers include sales to end customers and sales to traders. Due to the broad and fragmented downstream customer base, kaolin deep-processed manufacturers typically rely on traders to more effectively meet the diverse application needs and market demands of various downstream industries. It covers a wide range of downstream industry chains, mainly involving broad application fields, including automotive, aviation, healthcare, general equipment, metallurgy, construction materials, and others.

Source: Expert Interview, Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

China Kaolin Deep-processed Technology

- Select proper purification methods for different kaolin ore purities and target qualities. A systematical purification process commonly combines at least three steps.
- Grinding, calcination and post-modification are considered for specifications of down-streaming applications, in terms of powder sizes, porosity, whiteness, assay, surface wetness, etc.

Purification

Gravity separation: roughly separate gangue impurities including light organics, carbon and heavy iron, titanium, manganese. Separate different particle size or mesh of kaolin powder. Cost-effective and achieve moderate quality.

Magnetic separation: remove magnetic impurities mainly for reducing content of iron compounds. Highly rely on equipment capability.

Floatation: reverse floatation of iron, titanium and carbon from kaolin mineral. Use various chemicals for floatation and suitable for cost driven kaolin products with tolerance of a few impurities.

Leaching: use some certain chemical reagents (hydrochloric acid, sulfuric acid, microbes, redox reagents) to selectively remove impurities. Simplified process and high purification efficiency.

Grinding

Dry milling: use physical force to decrease particle size of kaolin. Easy processing and cost-effective

Wet milling: kaolin ground in aqueous or solvent environment to prepare highly distributed particle sizes. But the chemical components of kaolin may change.

Peeling: use chemicals or physical force to break the hydrogen bonding between kaolin layer structure and fabricate ultrathin two-dimensional powder. Peeling is time-consuming process but can produce high-quality products for paper, cosmetic and medicine applications.

Sizing: differentiate particle sizes through gravity separation, floatation, filtering, meshing, those physical sizing methods.

Calcination

~ 700 ºC: fabricate metakaolin with high surface activity. Broadly used for absorber manufacturing.

~ 850 ºC: increase porosity (oil absorption value) and electrical insulation. Mainly for kaolin reinforced rubber and plastics.

~ 1000 ºC: remove carbon impurities for high whiteness and further increase porosity that meet high quality requirements from paper and coating applications.

> 1300 ºC: phase change to mullite with improved stability and mechanical performance, essential for ceramic and refractory industries.

Post-Modification

Chemical modification: use acid or base reagents to adjust ratio of aluminum and silicon in kaolin. Further impact specific surface area and surface activity.

Polymerized hydroxyl iron modification: ion exchange of aluminum in kaolin by iron. Improve absorption rate through increasing surface hydroxyl sites.

Coupling agent modification: kaolin surface coated by silanes or titanates can improve its solubility in organic polymers. Enable rubber and plastics outstanding physical properties and low cost.

Source: Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

China Kaolin Deep-processed Common Methods

- Deep-processed kaolin products are generally categorized into two processes: washing and calcination. Washed kaolin merely undergoes physical treatment without change the properties of the kaolin ore, mainly applied for non-coal-series kaolin. Washed kaolin is the optimal raw material for ceramic production. In contrast, high-temperature calcination for carbon removal and whitening is a typical processing method for purifying coal-series kaolin ore. Calcined type is mainly utilized in fields such as refractory materials, precision casting and coatings.

	Washed Kaolin	*Calcined Kaolin*
Process	• Through a physical cleaning process • Involves blunging, slurrying, sieving, grinding, centrifuging, classifying, chemically and possibly magnetically treating, concentrating, and drying	• Through a chemical cleaning process • Involves heating kaolin to high temperatures in a kiln, typically ranging from 600° C to 1,000° C.
Whiteness	• Limited increase in whiteness	• Increase after heat treatment
Properties	• The raw soil of washed kaolin has bonding properties • Can be used directly as a binder for refractory materials.	• Imparts mechanical strength • No volume expansion or contraction
Example of Application	• Ceramics, pharmaceuticals, food additives and other fields.	• Refractories, precision casting, coatings, plastics, and other fields.

Source: Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

Coal-series Kaolin Calcining Equipment Analysis

- In current kaolin calcination processes, shaft kilns are the most commonly used type, while only a few companies use rotary kilns, which offer potential advantages in kaolin calcination such as high-temperature stability, high production efficiency, improved kaolin quality, energy-saving and environmentally friendly.

	Rotary Kiln Calcination	***Shaft Kiln Calcination***
Calcination Processes	• Pre-processed kaolin ore enters from the kiln tail. • Material rolls along the kiln circumference and moves axially for decomposition and calcination. • Produced clinker exits through the kiln head into a cooler. • Fuel is sprayed into the kiln from the head to tail, for convective heat exchange with the material.	• Top to down kaolin ore feeding in kiln. • Ore passes through the middle high-temperature section around 1300 °C for calcination. • Preheating above the middle section and cooling below the middle section. • The entire process takes approximately 96 hours.
Calcination Features	• High processing capacity. • Uniform and rapid material reactions. • Minimize the impact of sintering. • Ensure high product quality with less contamination.	• Allows flexible temperature adjustments. • Relatively low initial investment and operational costs. • Broadly adopted by small- to middle-scale enterprises or start-up production.
Main Products	• Ultrafine Calcined Kaolin, precision casting products, etc.	• Common grade calcined kaolin, unshaped refractory aggregate, etc.

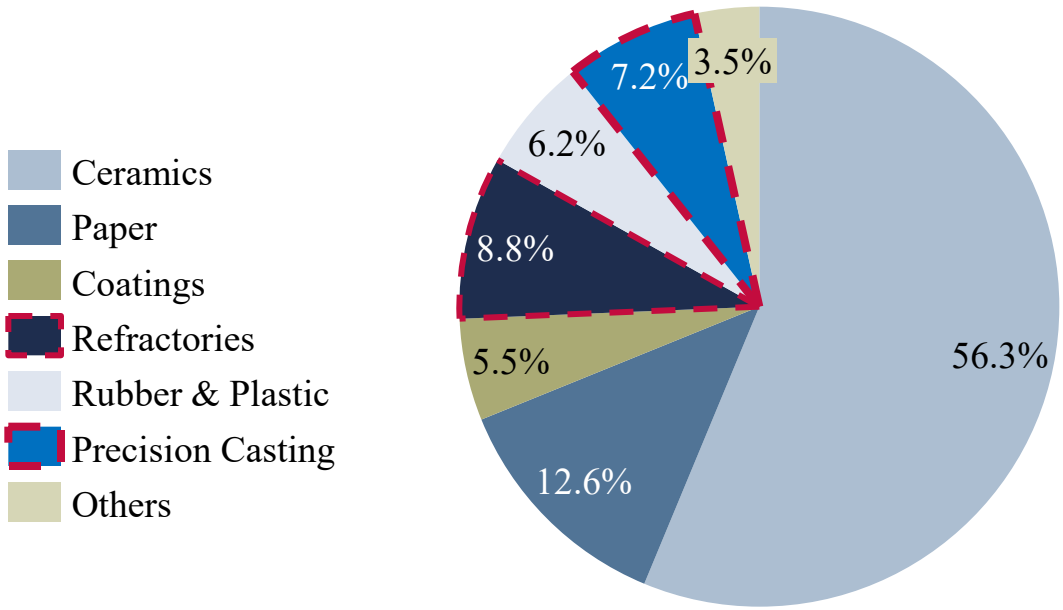
Source: Public information, Frost & Sullivan

Overview of China Kaolin Resources Market

China Kaolin End Applications Distribution Analysis

- In 2024, the major end application for kaolin in China was the ceramics industry, accounting for 56.3% of the total market. With its strong plasticity and refractoriness, kaolin dominates in high-end ceramics and building ceramics. Kaolin's usage in the paper industry represents 12.6%, where it is primarily used to enhance the brightness, gloss, and surface quality of paper while also assisting in reduce the amount of pulp required. The coatings and refractory materials sectors account for 5.5% and 8.8% respectively. Calcined kaolin is extensively used in refractory materials to improve high-temperature stability and resistance to chemical corrosion. The precision casting occupied 7.2%, with kaolin being an ideal material in this high-precision field due to its excellent refractory properties and fine particle size.

China Kaolin End Applications Distribution, 2024

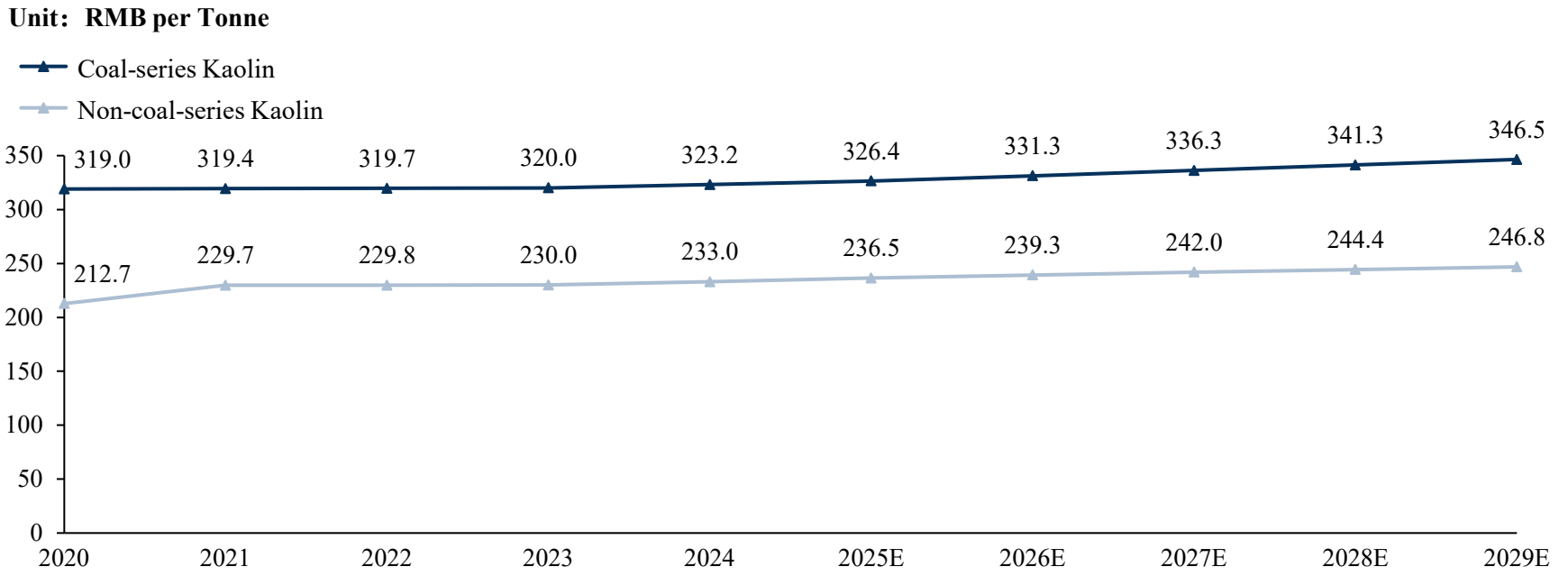


Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market
Average Price of Kaolin Ore Analysis

- As the scarcity of high-grade, non-renewable kaolin resources increases, along with the implementation of stricter environmental policies and rising extraction and production costs, the price of kaolin ore has been steadily rising year by year. From 2020 to 2024, the price of coal-series kaolin ore has shown a relatively stable trend. It started at RMB319.0 per tonne in 2020 and is projected to reach RMB346.5 in 2029. The prices of coal-series and non-coal-series kaolin ore are varied based on certain specifications and quality.

Average Price of Kaolin Ore (2020-2029E)



Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

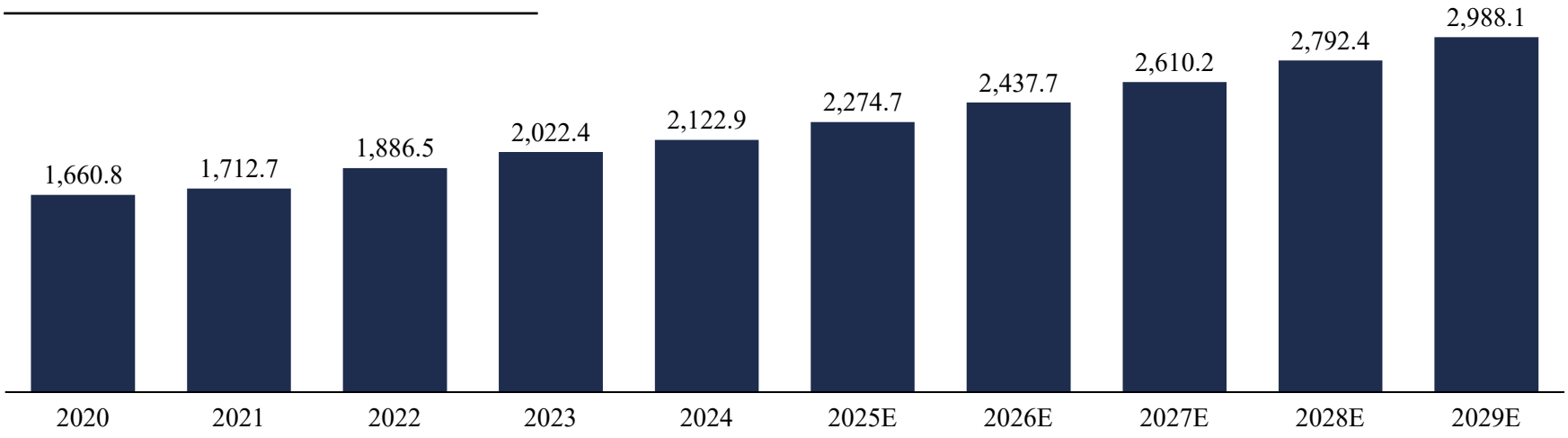
China Kaolin Market Size

- In China, the kaolin market increased from RMB1,660.8 million in 2020 to RMB2,122.9 million in 2024. It is to reach RMB2,988.1 million with a CAGR of 7.1% by 2029.
- The expansion of downstream industries, particularly the increasing demand for high-performance materials in China's manufacturing sector, will drive further growth in the kaolin market. Kaolin also holds innovative applications in the fields of refractory materials, eco-friendly materials, and functional materials. The chart below shows the market size of China's kaolin industry during the indicated period.

China Kaolin Market Size, Measured by Ore

Unit: Million RMB

	2020-2024	2024-2029E
CAGR	6.9%	7.1%



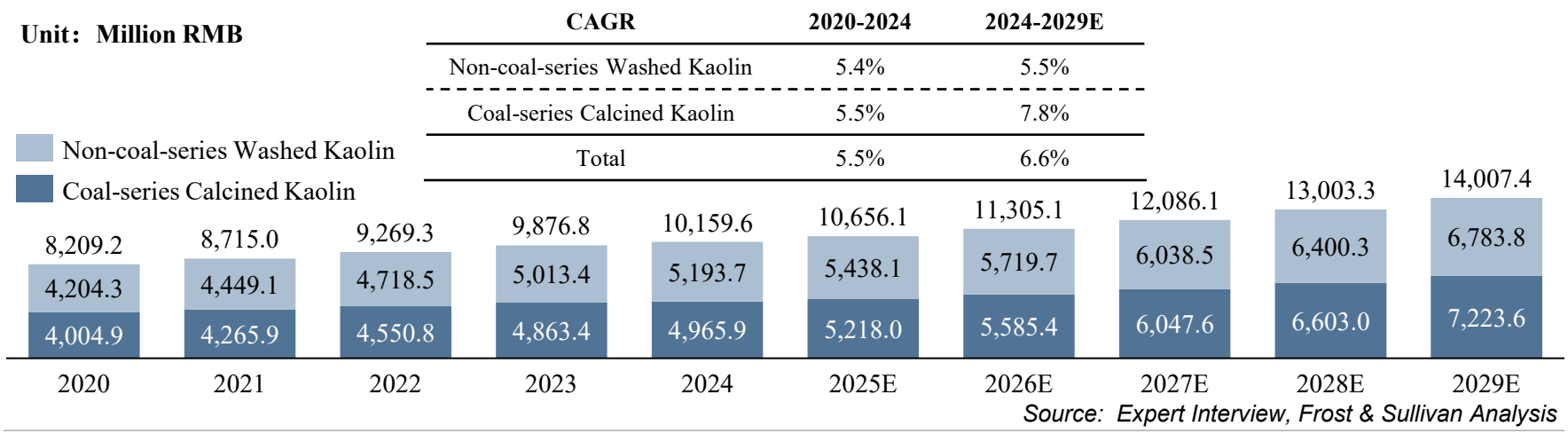
Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

China Kaolin Deep-processed Products Market Size

- Due to the diverse range of deep-processed kaolin products and their extensive downstream applications, the market for these products is experiencing stable growth. According to Frost & Sullivan, the market for kaolin deep-processed products increased from RMB8,209.2 million in 2020 to RMB10,159.6 million in 2024. It is expected to reach RMB14,007.4 million, with a CAGR of 6.6% by 2029. Within the category of non-coal-series washed kaolin products, the market increased from RMB4,204.3 million in 2020 to RMB5,193.7 million in 2024, with a CAGR of 5.4%. This segment is expected to reach RMB6,783.8 million in 2029, representing a CAGR of 5.5% from 2024 to 2029. The coal-series calcined kaolin products market in China increased from RMB4,004.9 million in 2020 to RMB4,965.9 million in 2024, representing a CAGR of 5.5%, and is expected to reach RMB7,223.6 million in 2029, representing a CAGR of 7.8% from 2024 to 2029. In the future, with the growth of high-end manufacturing, the demand for high-performance materials is expected to increase, raising requirements for the physical and chemical properties of deep-processed kaolin products, such as high whiteness, refractoriness and fineness. This trend will drive the market demand for deep-processed kaolin products. Additionally, continuous progress has been made in the deep processed technologies of kaolin. For instance, the application of techniques such as ultra-fine pulverization, surface modification and calcination has improved the performance of kaolin, enabled kaolin to be widely applied in more fields, increased the added value of the products and further driving market growth.

China Kaolin Market Size, Measured by Deep-processed Products

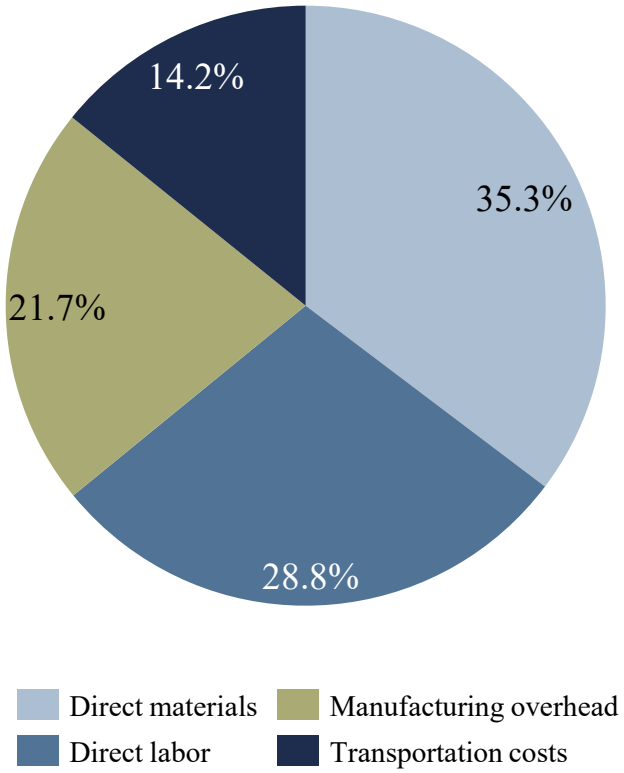


Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

China Kaolin Product Cost Analysis

Major Cost Structure of China Coal-Series Kaolin Ore, 2024



Notes: The cost of coal-series kaolin ore in China is mainly composed of four parts: direct materials, direct labor, manufacturing expenses and transportation expenses. Direct materials mainly include mineral and auxiliary materials consumed in the production process. Direct labor refers to labor costs such as wages, subsidies, bonuses and social security directly attributable to production workers. Manufacturing expenses mainly include depreciation and amortization, equipment rental fees, electricity fees, natural gas fees, salaries of production management personnel. Transportation expenses are the transportation fees borne in the actual sales process.

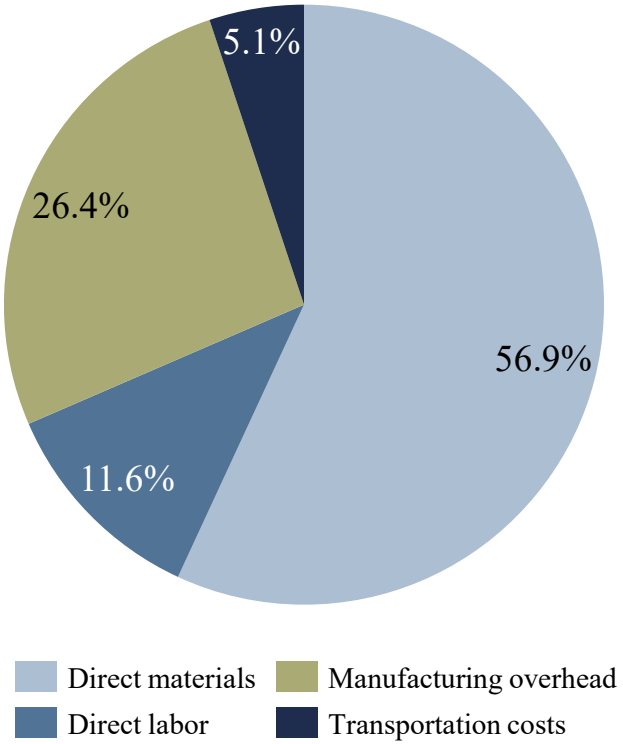
- In 2024, based on the cost structure of China coal-series kaolin raw ore, direct materials were 35.3%, direct labor occupied 28.8%, while manufacturing overhead and transportation costs accounted for approximately 21.7% and 14.2%.
- Direct materials are one of the major costs in the mining process of coal-series kaolin. A large amount of materials and equipment are used in kaolin raw ore extraction, such as explosives, mechanical equipment consumables, and drilling equipment.
- In labor-intensive kaolin mines, labor expenses are relatively high. With the continuous improvement of automation, labor costs will decrease in the future.
- Timely maintenance and upgrading of equipment are crucial in kaolin mining, therefore the depreciation cost of equipment accounts for a large portion of the manufacturing overhead.
- The geographical location of kaolin mines impacts the proportion of transportation costs.

Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

China Kaolin Product Cost Analysis

Main Cost Components of China Coal-Series Kaolin Deep Processing Product, 2024



- In 2024, based on the cost structure of China coal-series kaolin deep processing product, direct materials were 56.9%, manufacturing overhead occupied 26.4%, while direct labor and transportation costs accounted for approximately 11.6% and 5.1%.
- The direct material costs include the raw ore used for the deep processing of coal-series kaolin products, accompanied with various chemical agents and additives. In particular, in the production of calcined kaolin, high-quality kaolin ore is one of the major cost components. Therefore, direct material costs account for the largest proportion.
- Manufacturing overhead, as the second largest cost for deep processed coal-series kaolin products, continues to rise due to energy-intensive steps such as calcination and ultrafine processing.
- With the improvement in production automation, the proportion of direct labor costs for deep processed coal-series kaolin products accounts for a relatively small proportion.

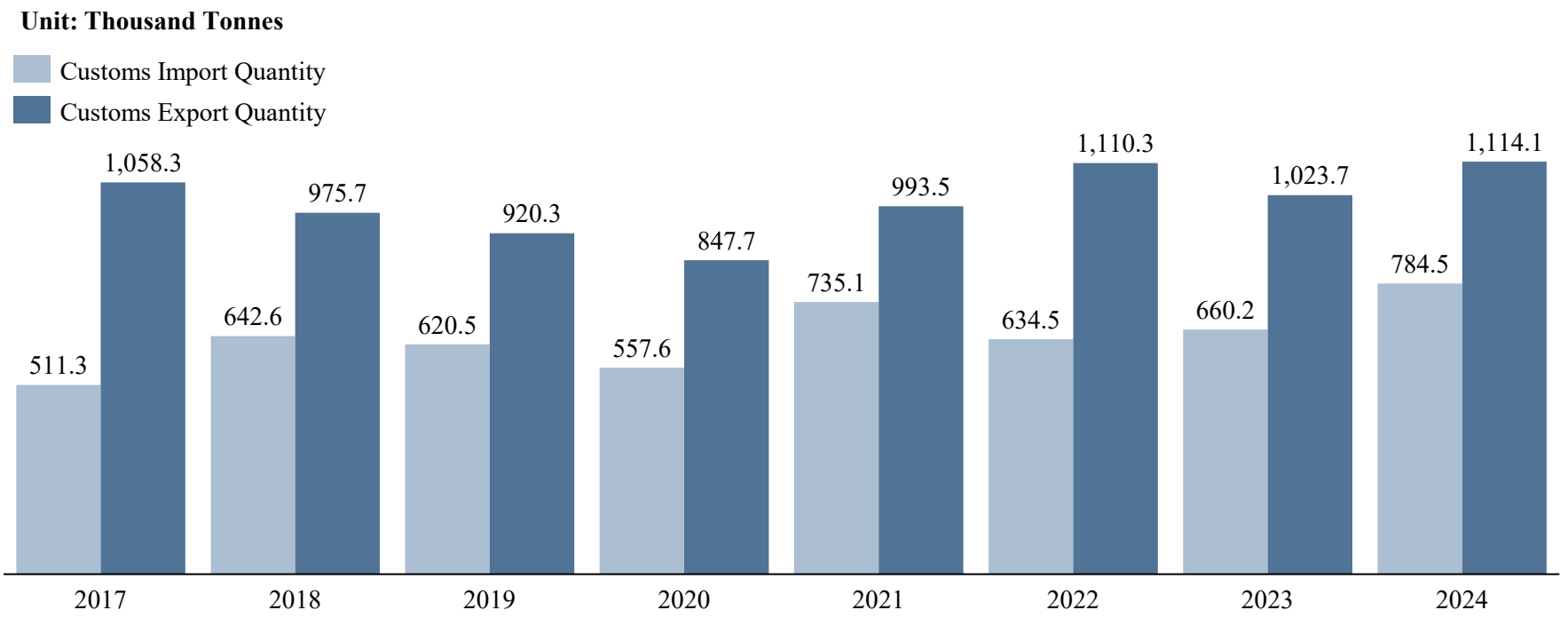
Source: Expert Interview, Frost & Sullivan Analysis

Overview of China Kaolin Resources Market

China Kaolin Market Import and Export Analysis

- China's kaolin imports increased from 511.3 thousand tonnes in 2017 to 784.5 thousand tonnes in 2024. Despite slight fluctuations occurred in 2020 and 2022, China's kaolin imports showed an overall upward trend over the eight-year period. This trend reflects the increased demand for kaolin in the Chinese market. Although the overall export volume has shown some fluctuations, China’s abundant kaolin resources mean that its export volume exceeds its import volume.

China Kaolin Market Import and Export Volume，2017-2024



Source: General Administration of Customs , Frost & Sullivan Analysis

Overview of China Kaolin Resources Market
Entry Barriers to Kaolin Market

The high-tech barriers of deep-processed of kaolin

China's kaolin resources have complex geological origins, and the production process for coal-series kaolin products involves multiple stages such as calcination, crushing, air blowing and screening, each with significant variability. This requires companies not only to master deep-processed technologies for kaolin but also to continuously optimize and innovate their production processes to ensure consistent product quality. As a result, the high technical demands serve as a barrier for new entrants in the industry, limiting access for companies with insufficient technical expertise.

Strict environmental protection requirements

In 2024, the government issued regulations related to the mining industry. Notably, the Ministry of Natural Resources and other relevant departments released the "Notice on Further Strengthening the Construction of Green Mines"(《關於進一步加強綠色礦山建設的通知》) and the "Notice on Fully Implementing Green Exploration in the New Round of Strategic Prospecting Breakthrough Actions"(《關於在新一輪找礦突破戰略行動中全面實施綠色勘查的通知》). These policies aim to achieve the coordinated development of mining and ecological environmental protection by enhancing mine environmental construction, resource development and utilization, ecological protection, enterprise management, and cultural development. Companies are required to adopt green production methods, improve processes and use eco-friendly materials to minimize environmental impact and improve resource utilization efficiency. The investment in environmentally friendly technologies also creates a barrier to new entrants.

The capital required for large-scale production

Coal-series kaolin processing requires substantial investment in equipment, facilities, raw material procurement and operations. The industry exhibits economies of scale, where larger companies can gain a competitive advantage by increasing capacity, reducing marginal costs and lowering product prices. The expanding application fields and increasing diversity in customer demands require companies to enhance their supply capabilities. For new entrants, the initial investment is substantial and large production capacity is difficult to establish in the short term.

The Scarcity of High-Grade Kaolin Resources

High-quality kaolin resources are relatively scarce in China's kaolin mineral reserves. There are significant differences among production enterprises regarding resource grade, scale, and mining conditions. These disparities result in considerable price variations for kaolin of different grades. Low-grade kaolin will incur higher costs in the mining and processing procedure, thus increasing the burden of enterprise operations. Therefore, possessing reserves of high-quality kaolin has become a key factor for enhancing a company's competitiveness.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Kaolin Market Growth Drivers and Future Market Forecasts

Policy Support and Guidance Highlighted

In recent years, China has successively introduced policies such as the Industrial Structure Adjustment Guidance Catalog (2024 Edition))(《產業結構調整指導目錄（2024年本）》) , the Catalog of Industries Encouraging Foreign Investment（《鼓勵外商投資產業目錄》）, and the 14th Five-Year Development Plan and 2035 Vision for the Non-Metallic Mineral Industry（《非金屬礦行業「十四五」發展規劃及2035年遠景目標》）. These policies explicitly support the comprehensive development and utilization of non-metallic minerals and strongly promote the progress and development of related downstream industries, including precision casting and refractory materials. Additionally, the Three-Year Action Plan for Promoting High-Quality Development of the Non-Metallic Mineral Industry (2023-2025) （《推動非金屬礦工業高質量發展三年行動計劃(2023-2025年)》） outlines that by 2025, the scale and economic benefits of the non-metallic mineral industry will continue to grow, with a targeted total industry output value of RMB1.2 trillion. The plan also emphasizes accelerating R&D in key areas, including projects related to kaolin and other non-metallic minerals.

Increasing demand for high-end and deep-processed kaolin product

As increasing demand of high-performance materials in downstream fields such as precision casting, renewable energy and new materials, the kaolin industry is expected to gradually shift from traditional low-value-added products to high-end deep-processed products. Calcined kaolin, known for its high whiteness, low iron content, and excellent thermal and physical properties, is anticipated to become a key focus for industry development. Its applications are expected to expand further in precision casting, renewable energy (such as building phase change thermal storage materials and solar energy thermal storage materials), and advanced materials.

Improved standardization of kaolin processing industry

In the past, the kaolin processing industry faced low resource utilization rates and lacked orderly development due to inadequate regulations and weak corporate compliance awareness. In recent years, policy guidance and technological advancements have promoted higher standardization. In 2024, the implementation of national standards such as the Method for Determining Dispersion Performance of Water Treatment Agents — Part 1: Dispersed Kaolin Method（《水處理劑分散性能測定方法第1部分：分散高嶺土法》） and the “Three Rates” Indicator Requirements for Mineral Resources — Part 13: Clay Minerals（《礦產資源「三率」指標要求第13部分：黏土類礦產》） provided unified quality control and performance testing standards for kaolin processing enterprises. These efforts comprehensively enhanced the industry’s standardization, enabling kaolin processing manufactures to steadily progress toward high-quality development.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Kaolin Market Growth Drivers and Future Market Forecasts

The Industrial Structure Adjustment Guidance Catalogue (2024 Edition) (《產業結構調整指導目錄(2024年本)》) proposes encouraging green technology innovation and the development of environmentally friendly industries, promoting energy conservation, carbon reduction, and green transformation in key sectors, while firmly curbing the blind expansion of high-energy-consuming, high-emission, and low-level projects. This policy promotes the elimination of enterprises in the kaolin processing industry that are energy-intensive, heavily polluting, and low in added value. It guides enterprises toward orderly competition and encourages investment in energy-saving equipment and intelligent upgrades. The Company has actively invested in environmental protection and sustainable development, thereby gaining greater growth potential and market competitiveness under this policy.

The Catalogue of Industries for Encouraging Foreign Investment (《鼓勵外商投資產業目錄》) emphasizes support for foreign investment in green environmental protection, new materials, and related fields. These policy orientations provide development opportunities for the non-metallic mineral industry, especially for enterprises that prioritise environmental protection and technological innovation. The Company's investment in green mining and energy efficiency within the non-metallic minerals sector not only enhances our access to policy support but also strengthen our competitive edge in the market. The government promotes foreign investment improves the overall business environment for the entire sector. This includes strengthening infrastructure, promoting industry-wide technological exchanges, and setting higher-standard industry norms. For domestic company, these improvements mean better access to resources and a more stable market environment. However, the strict standards set for foreign-invested enterprises will gradually become the norm for the whole industry. By proactively meeting more standardized guidelines, domestic company, including the Company, can not only gain more recognition from the government but also establish itself as a high-quality enterprise in the market, thereby driving long-term business growth.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Kaolin Market Growth Drivers and Future Market Forecasts

- The 14th Five-Year Development Plan and 2035 Vision for the Non-metallic Mineral Industry (《非金屬礦行業「十四五」發展規劃及2035年遠景目標》) notes that during the 13th Five-Year Plan period, China's non-metallic mineral mining and processing industry experienced rapid growth in both deep processing output and value, accelerated industrial cluster development, increased concentration, and continuous structural optimization. On one hand, the policy clearly encourages extending non-metallic mineral products into deep processing and higher value-added segments, signalling the government's strong support for downstream demand expansion. For companies processing high-quality hard coal-series kaolin, this presents greater market opportunities in the automotive, healthcare and aviation, contributing to increased product sales and output value. On the other hand, the policy promotes improved industry concentration and structural optimization, which facilitates the formation of an orderly competitive landscape. As low-efficiency and fragmented enterprises are phased out, the Company with stronger technical capabilities, standardized management, and integrated resource advantages are likely to achieve steady development and long-term growth under policy guidance.

- The Three-Year Action Plan for Promoting High-Quality Development of the Nonmetallic Mineral Industry (2023-2025) (《推動非金屬礦工業高質量發展三年行動計劃 (2023-2025年)》) sets the goal of continuously improving the scale and economic efficiency of the non-metallic mineral industry, aiming for total output value to reach RMB1.2 trillion by 2025. This policy helps direct resources and supportive measures toward specific sub-sectors. Kaolin, as a representative non-metallic mineral especially hard coal-series kaolin, has been included in the scope of policy support due to its wide applicability in industries such as automotive, aerospace, and medical. This inclusion not only enhances the likelihood of favourable resource allocation but also facilitates the accelerated implementation of the Company's projects.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Development Trend Analysis of Kaolin Industry

The accelerated advancement of kaolin deep-processed technology

As kaolin processing technology continues to advance, its applications are expanding. Deep-processed techniques for kaolin, including calcination, iron removal, grinding and blending, are improving the physical and chemical properties of the product. The improvements in whiteness, fineness and plasticity contribute to higher product quality and stability.

Promotion of smart and automated production

With the widespread adoption of smart manufacturing technologies, kaolin production is expected to gradually become more automated and intelligent. By introducing advanced mining equipment, automated production lines and intelligent management systems, companies can improve production efficiency, reduce costs and optimize resource utilization. Additionally, smart production can reduce manual intervention, enhancing product stability and consistency.

Technological change driven by strengthening environmental awareness

In 2020, China announced its “dual carbon goals” to reach carbon peaking by 2030 and carbon neutrality by 2060, thereby enhancing society’s focus on environmental protection and sustainability. With stricter environmental regulations, the coal-series kaolin industry is undergoing technological transformation in mining and deep-processed. Companies are progressively adopting cleaner production technologies while actively exploring pathways for resource recycling.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Kaolin Industry Policy and Regulation（1/2）

Industrial Policy	Issued Department	Issued Time	Key Information
Anhui Province '14th Five-Year Plan' non-coal mine development plan (draft) 《安徽省“十四五”非煤矿山发展规划（征求意见稿）》	Anhui Provincial Department of Economy and Information Technology 安徽省经济和信息化厅	2024.05	Grow the industrial bases of iron-based, copper-based, cement, building materials and chemical industry, improve the level of deep processing and utilisation of silicon-based, fluorite and other resources, and push forward the applied research and industrial chain extension of mineral salts, calcite, bumpstone, metallurgical dolomite, kaolin, gypsum and other featured mineral resources, so as to enhance the driving force of the industry.
Technical Specification for Land Reclamation and Ecological Restoration of Coal Mines 《煤矿土地复垦与生态修复技术规范》	Ministry of Natural resources 自然资源部	2024.04	Coal gangue elimination should be prioritized to the comprehensive use of more industrial value-added methods. It can be used for backfilling or land reclamation If it really cannot be utilised. The standard came into effect on the 1st of this month.
List of Policies for Promoting High-Quality Industrial Development by Advancing Stability through Stabilisation 《坚持稳中求进以进促稳推动产业高质量发展政策清单》	Ministry of Industry and Information Technology 工业和信息化部	2024.03	Clearly support the comprehensive utilisation of industrial solid waste resources. For the projects with comprehensive use of new industrial solid waste resources of more than 10,000 tonnes/year and using advanced technology for high-end, green, and recycling industrial solid waste and renewable resources, support 10 yuan of subsidies to the comprehensive use of 1 tonne.
Special Management for Investment in Energy Conservation and Carbon Reduction within the Central Budget 《节能降碳中央预算内投资专项管理办法》	National Development and Reform Commission 国家发展改革委	2024.03	The purpose of the policy is to optimise investment within the central budget, promote the participation of social capital in energy conservation and carbon reduction, and support carbon-neutral technologies and energy-saving projects in the industry, so as to achieve the goal of carbon peaking and carbon neutrality.
Guidance Catalogue for Industrial Restructuring (2024 Edition) 《产业结构调整指导目录（2024年本）》	National Development and Reform Commission 国家发展改革委	2023.12	In 'III. Coal', '4. Coal clean and efficient development and utilisation technology: processing and comprehensive utilisation of coal co-associated resources belonging to the category encouraged by the nation.
Three-Year Action Plan to Promote High-Quality Development of the Non-metallic Mining Industry (2023-2025) 《推动非金属矿工业高质量发展三年行动计划（2023-2025年）》	China Non-Metallic Minerals Industry Association 中国非金属矿工业协会	2023.10	By 2025, the industrial scale and economic benefits of the non-metallic mining industry will continue to improve, with the total output value of the industry striving for 1.2 trillion yuan. We will build a new mode of high-quality development of the non-metallic mining industry with obvious scale efficiency, reasonable industrial structure, strong scientific and technological drive, leap in independent innovation capability, high level of greening, safe and reliable resources, increasingly prominent quality and brand benefits, and strong support for the development of the national economy and society. Initially, a system of high-quality development of the non-metallic mining industry that meets the requirements of China socialist modernisation will be built.
Catalogue of Industries Encouraging Foreign Investment 《鼓励外商投资产业目录》	National Development and Reform Commission 国家发展改革委	2022.10	Non-metallic mineral products industry: production of long-life energy-saving and environmentally friendly (non-chromated) refractory materials for kilns for cement, electronic glass, ceramics, microporous carbon bricks, etc.; Shanxi Province: comprehensive utilisation, refinement and application of non-metallic minerals (bauxite, manzanite, refractory clay, perlite) (except for exploration and mining); Anhui Province, Chongqing City, Qinghai Province: production of long-life energy-saving and environmentally friendly refractory materials.
Non-metallic Mining Industry Development Plan for the 14th Five-Year Plan and Vision 2035 《非金属矿行业“十四五”发展规划及2035年远景目标》	China Non-Metallic Minerals Industry Association 中国非金属矿工业协会	2021.12	By 2035, China will achieve socialist modernisation and become a powerhouse in the non-metallic mining industry. The scale and efficiency of the industry will be remarkable, and its development will be comprehensive and coordinated. The industry will be green, low-carbon, digital and intelligent, with a sound standardisation system and outstanding quality brands, becoming an important pillar of the national economy.

Source: Frost & Sullivan

Overview of China Kaolin Resources Market

Kaolin Industry Policy and Regulation（2/2）

Industrial Policy	Issued Department	Issued Time	Key Information
Foundry industry '14th Five-Year' Development Plan 《铸造行业“十四五”发展规划》	China Foundry Association 中国铸造协会	2021.05	Strengthen the key common casting technology research and application, including investment casting materials: fast-drying silica sol, high-quality zircon sand and other refractory materials, high-quality filler wax, stearic acid-free low-temperature moulding materials, special coating additives, ceramic cores, capacitor stones.
Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Vision 2035 《中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要》	The National People Congress 全国人大	2021.03	Clearly raise: will promote electronic glass and other advanced metal and inorganic non-metallic materials to make breakthroughs; improve the level of mineral resources development and protection, the development of green mining, the construction of green mines; tailings and co-associated minerals, coal gangue, fly ash, construction waste and other key to carry out the comprehensive utilization of 100 bulk solid waste demonstration.
Provisions for Geological Environmental Protection in Mines 《矿山地质环境保护规定》	Ministry of Natural Resources 自然资源部	2019.07	Protecting the geological environment of mines, reducing the damage to the geological environment of mines caused by mineral resources exploration and mining activities, protecting people's lives and property safety, and promoting the rational development and use of mineral resources and the coordinated development of the economy, society, resources and the environment.
Guidelines for the Development of Key Common Industrial Technologies (2017) 《产业关键共性技术发展指南（2017年）》	Ministry of Industry and Information Technology 工业和信息化部	2017.10	In 'Key Technology for Materialisation and Efficient Utilisation of Typical Non-metallic Tailings Resources' of '(IV) Comprehensive Utilisation of Resources' sets out 'Technology for Efficient Separation and Extraction of Minerals from Typical Non-metallic Tailings, such as Graphite and Kaolin'.
Guidance Catalogue of Key Products and Services for Strategic Emerging Industries (2016 Edition) 《战略性新兴产业重点产品和服务指导目录》（2016年版）	National Development and Reform Commission 国家发展改革委	2017.01	Comprehensive utilisation of mineral resources: comprehensive utilisation and deep processing of non-metallic minerals, including kaolin, bauxite and other co-associated non-metallic mineral resources. Phosphate mine acidic wastewater recycling, phosphorus mine associated fluorine iodine resource recovery, lithium extraction from carbonate-type lithium-rich brine, scalar graphite multi-stage grinding multi-stage sorting, low-grade fluorite and associated minerals beneficiation and other advanced technologies and equipment.
Measures for the Administration of Registration of Mineral Resources Exploration Blocks 《矿产资源勘查区块登记管理办法》	Ministry of Land and Resources 国土资源部	2014.07	The measure is intended to strengthen the management of mineral resources exploration, protect the lawful rights and interests of prospectors, maintain the order of mineral resources exploration and promote the development of the mining industry.
Safety Production Licence Regulations 《安全生产许可证条例》	Ministry of Land and Resources 国土资源部	2014.07	Strictly regulating the conditions for safe production, further strengthening the supervision and management of production safety, and preventing and reducing production safety accidents. In accordance with the relevant provisions of the Work Safety Law of the People's Republic of China, these regulations are formulated.
Requirements for the 'Three Rates' of Indicators for the Rational Exploitation and Utilisation of Kaolin Mineral Resources (for Trial Implementation) 《高岭土矿产资源合理开发利用“三率”指标要求（试行）》	Ministry of Land and Resources 国土资源部	2012.12	The 'three rates' for the rational development and utilisation of kaolin mineral resources are kaolin mining recovery rate, ore dressing recovery rate and comprehensive utilisation rate, which are the main indicators for evaluating the effectiveness of kaolin mining enterprises in the development and utilisation of kaolin mineral resources.

Source: Frost & Sullivan

Agenda

Overview of the Precision Casting Mullite Products Market
Definition of Casting

- **Casting** is a manufacturing process in which a liquid material, typically metal or alloy, is poured into a pre-shaped mold and allowed to cool and solidify into the desired shape. This process is fundamental for producing complex components and is widely used across industries such as automotive, aviation, medical devices and general machinery.

Procedure of Casting

Mold Making

- A mold is created using sand, metal, or other materials, designed in the shape of the final product.

Melting

- The metal or material is heated beyond its melting point to turn it into a liquid state.

Pouring

- The molten material is poured into the mold, filling the cavity.

Solidification

- The material cools and hardens, taking the shape of the mold.

Mold Removal

- After cooling, the solidified part is removed from the mold.

Finishing

- The cast part may undergo post-processing steps such as trimming, surface finishing, heat treatment, or machining to meet final specifications.

Source: Public information, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

Casting Classification and Comparison of Features

- **Precision casting** is a type of casting technology, where a wax pattern is coated with a refractory material to form a shell mold. The wax is subsequently melted out, allowing molten metal to be poured into the cavity, thereby producing highly detailed and accurate metal parts.

Mold Type	Process Type	Features
Expandable Mold Casting	Sand Casting	Uses a sand-based mold to create metal parts, suitable for complex shapes and large components
	Shell Molding	A variant of sand casting where the mold is a thin shell made of sand and resin, providing better surface finish and dimensional accuracy
	Vacuum Molding	A process where a vacuum is applied to form the mold, allowing for detailed and precise parts
	Expanded Polystyrene	Also known as Lost-Foam Casting, uses a foam pattern that evaporates when molten metal is poured, creating complex shapes
	Precision Casting	Also called Investment Casting or Lost-Wax Casting, it uses a wax model that is melted away to form high-precision, intricate parts
	Plaster Mold Casting	Uses plaster of Paris as the mold material, offering fine surface finishes and accurate details for non-ferrous metals
	Ceramic Mold Casting	A high-temperature method using ceramic molds, ideal for intricate shapes and high melting-point metals
Permanent Mold Casting	Permanent Mold Casting	Uses reusable metal molds to produce consistent, high-volume parts with good mechanical properties
	Variations of Permanent Mold Casting	Modifications of the basic permanent mold process, including different mold treatments or techniques for special properties
	Die Casting	A high-pressure process where molten metal is injected into a metal mold, creating high-quality, repeatable parts
	Centrifugal Casting	Uses a rotating mold to produce hollow cylindrical parts, with high material density and structural integrity

Source: Public information, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

Definition of Mullite Materials for Precision Casting

- **Kaolin mullite** is one of the main deep-processed products of coal-series kaolin. During the calcination process, kaolin will undergo a series of physical and chemical changes. In the high-temperature stage, dehydration and decomposition reactions will occur. Subsequently, the alumina and silica in kaolin will react, resulting in the formation of the mullite crystal phase and the transformation into mullite.
- **Mullite Materials for Precision Casting** are refractory materials composed primarily of mullite ($3Al_2O_3 \cdot 2SiO_2$), used in the precision casting process. With excellent high-temperature resistance, low thermal expansion, and thermal shock resistance, mullite materials create molds that ensure strength and stability at high temperatures. They help produce high-quality castings by minimizing defects like deformation and cracks, making them ideal for manufacturing complex, high-precision components.

High-Temperature Resistance

Mullite materials can withstand temperatures exceeding 1800° C, which is critical for high-temperature casting processes. Their thermal stability ensures the mold retains its strength and shape during the casting of molten metals, preventing deformation and ensuring high-quality castings.

Thermal Shock Resistance

Mullite materials exhibit excellent resistance to thermal shock, meaning they can endure rapid temperature fluctuations without cracking or losing integrity. This property is vital during the cooling and heating cycles of the casting process, reducing the risk of damage to the molds and improving the overall yield of quality castings.

Low Thermal Expansion

The low thermal expansion coefficient of mullite materials minimizes the risk of cracking or warping during heating and cooling. This stability helps maintain the precision and integrity of the casting mold, especially when producing intricate designs, where dimensional accuracy is crucial.

Chemical Stability

Mullite is highly resistant to chemical reactions, even in the presence of molten metals and corrosive gases at high temperatures. This resistance protects the mold from erosion or degradation, ensuring that it maintains its structure and provides a long service life.

Wear Resistance

Due to its dense microstructure, mullite materials possess excellent wear resistance, meaning they can endure the mechanical stresses involved in casting operations. This property reduces the need for frequent mold replacements, contributing to cost savings and efficiency in the casting process.

Source: Public information, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

The Application of Precision Casting Kaolin Mullite Products

- In precision casting, kaolin mullite products are used for the precision casting shell mold due to their refractory properties. These properties allow the shell mold to endure high temperatures during pouring and solidification processes. Additionally, the stability of mullite helps maintain the cavity's shape and dimensions, which is significant for manufacturing high-quality and defect-free precision casting parts. Such characteristics render mullite materials important in automotive, shipbuilding, medical devices, aviation and energy industries. Most of precision casting mullite products are made by calcining coal-series kaolin.
- Mullite materials are crucial in precision casting due to their exceptional resistance to high temperatures, thermal shock, and chemical stability. They ensure mold stability during extreme operations, reducing dimensional changes and improving casting quality. This results in fewer defects and longer mold lifespans, making them vital in industries like automotive, shipbuilding, medical, aviation, energy and military, where precision and durability are key.

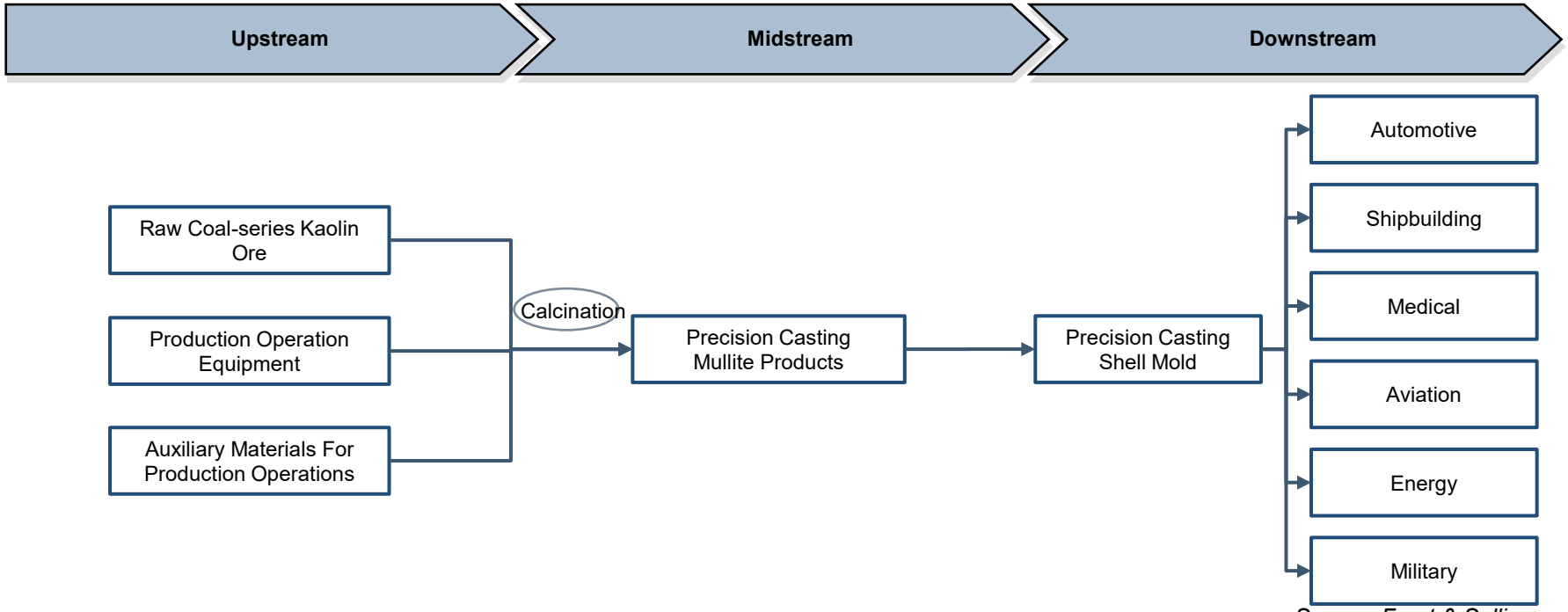
Category	Application
Automotive Industry	In the casting of high-performance engine components, mullite's contribution lies in providing dimensional accuracy and thermal shock resistance, which results in fewer defects and lower maintenance costs for critical automotive parts
Shipbuilding Industry	Mullite materials in precision casting is mainly applied in the manufacture of high-performance parts such as ship engine cylinder blocks and gearbox housings. Mullite material can ensure that the structure of parts is not damaged under such high temperature conditions, maintain the shape and performance
Medical Implants	Mullite is crucial in casting high-precise, biocompatible components, such as artificial joints, dental implants, etc., where both precise dimensions and smooth surfaces are vital for the success rate of surgeries and the quality of life of patients
Aviation Industry	Mullite is used in precision casting for precision turbine blades and engine components, where both temperature resistance and structural stability are critical for performance in flight-critical parts. This ensures long-term durability under high-stress conditions
Energy and Power Generation	Mullite is applied in the casting of parts for gas turbine blades and hot-end components in power plants. It enhances the lifespan of these components by providing thermal and chemical stability, which are vital in high-temperature energy environments
Defense Applications	Precision components, such as titanium alloy for fans, aviation compressors, missile parts, etc., are cast using mullite-based molds in precision casting, offering resistance to high temperatures and corrosion, which is essential for reliability in defense systems

Source: Frost & Sullivan, Malli Minerals International, Investment Casting Institute

Overview of the Precision Casting Mullite Products Market

Industry Chain Analysis of Precision Casting Mullite Products

- The upstream of the mullite materials for precision casting industry mainly consists of three categories: raw coal-series kaolin ore, production operation equipment, and production operation auxiliary materials.
- The midstream of the mullite materials for precision casting industry is the mullite product for precision casting, which includes precision casting mullite sand and precision casting mullite powder. Mullite is processed into specific particle sizes for use in precision casting shells from the back layer to the surface layer.
- The downstream of the mullite materials for precision casting industry is precision casting shell mold. Precision casting is not limited by alloy materials. Cast iron, cast steel, high-temperature alloys, as well as aluminum alloys, copper alloys, magnesium alloys, titanium alloys, and so on can all be produced by precision casting.

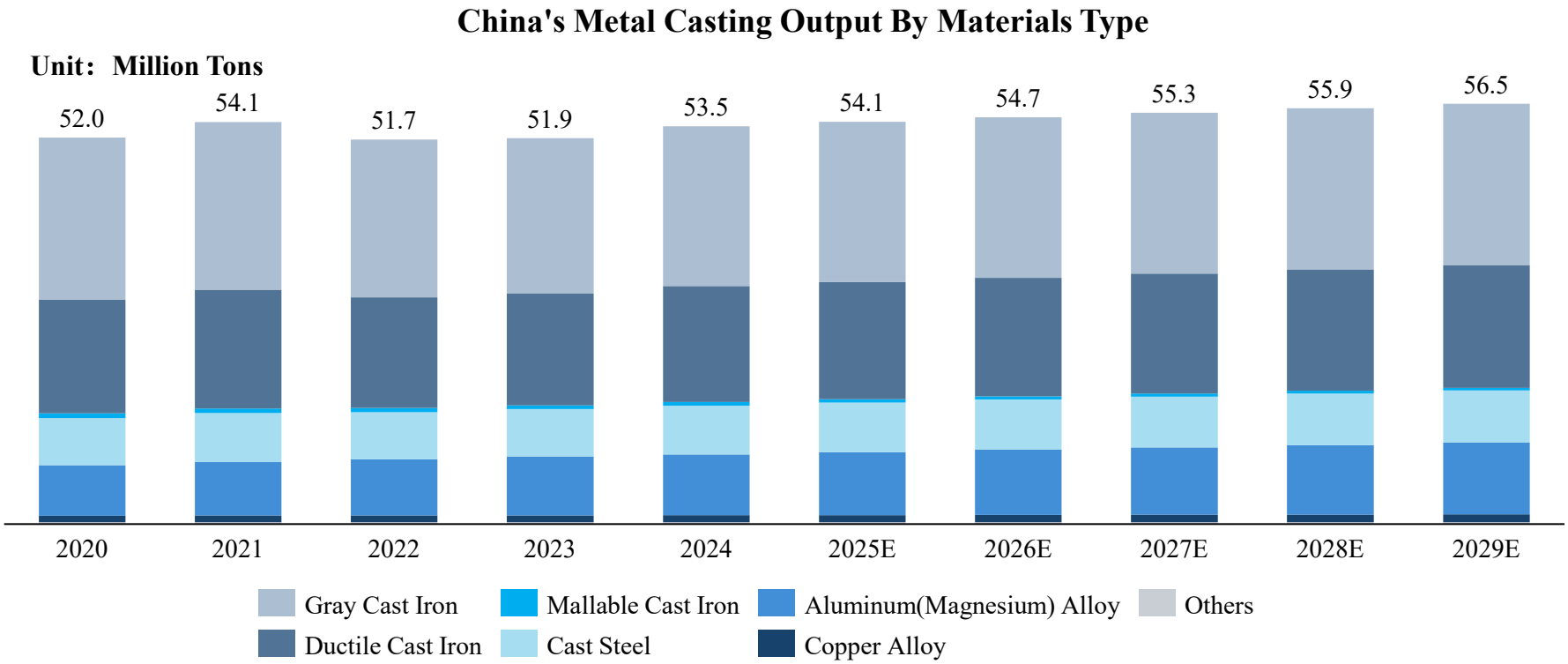


Source: Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

China's Metal Casting Output By Materials Type, 2020-2029E

- In 2024, the total output of various materials types of castings in China was 51.9 million tons, with a slight increase of 3.5% year-on-year, basically the same as the previous year.
- In 2024, the output proportion of gray iron castings was 40.2%, with a slight decrease of 0.1%. The proportion of ductile iron castings was 29.1%, showing a slight increase of 0.1%. The output proportion of steel castings remained at 12.3%, almost the same as that in 2023. Driven by the auto lightweight development and the rapid growth of new energy vehicles, the output proportion of aluminum (magnesium) alloy castings rose from 15.2% in 2023 to 15.3%.



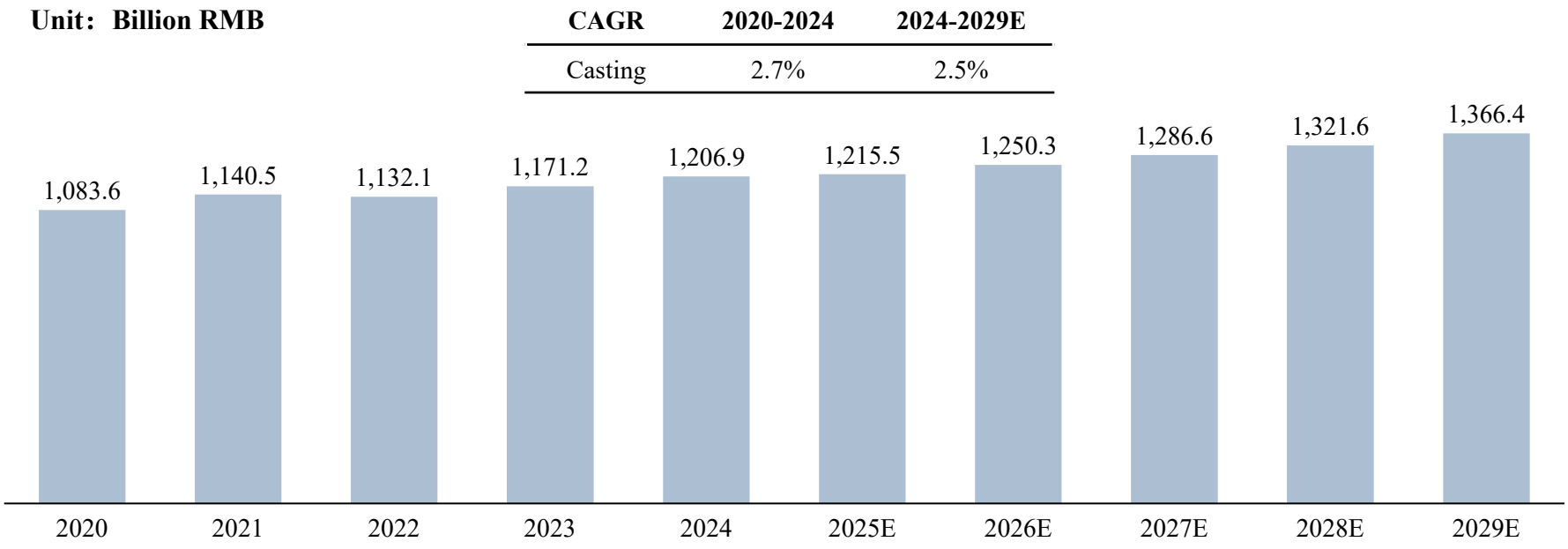
Source: China Foundry Association, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

China's Metal Casting Market Size, 2020-2029E

- From 2020 to 2024, the market size of China's metal casting experienced a slight increase. In 2020, it was RMB1,083.6 billion, and by 2024, it reached RMB1,206.9 billion, with a CAGR of 2.7% during this period. The continuously expanding automotive industry in China serves as a key factor. The development of the automotive industry offers a broad demand space for the metal casting market. It is expected to reach RMB1,366.4 billion in 2028, with a CAGR of 2.5% from 2024 to 2029, indicating that although the growth rate has slowed down, it remains stable. The rising trend of adopting advanced materials and technologies in the metal casting process, along with the development of innovative alloys and techniques that enhance the efficiency and performance of cast metal products, are acting as significant growth-inducing factors.

China's Metal Casting Market Size, by Sale Revenue of Castings



Source: China Foundry Association, Frost & Sullivan

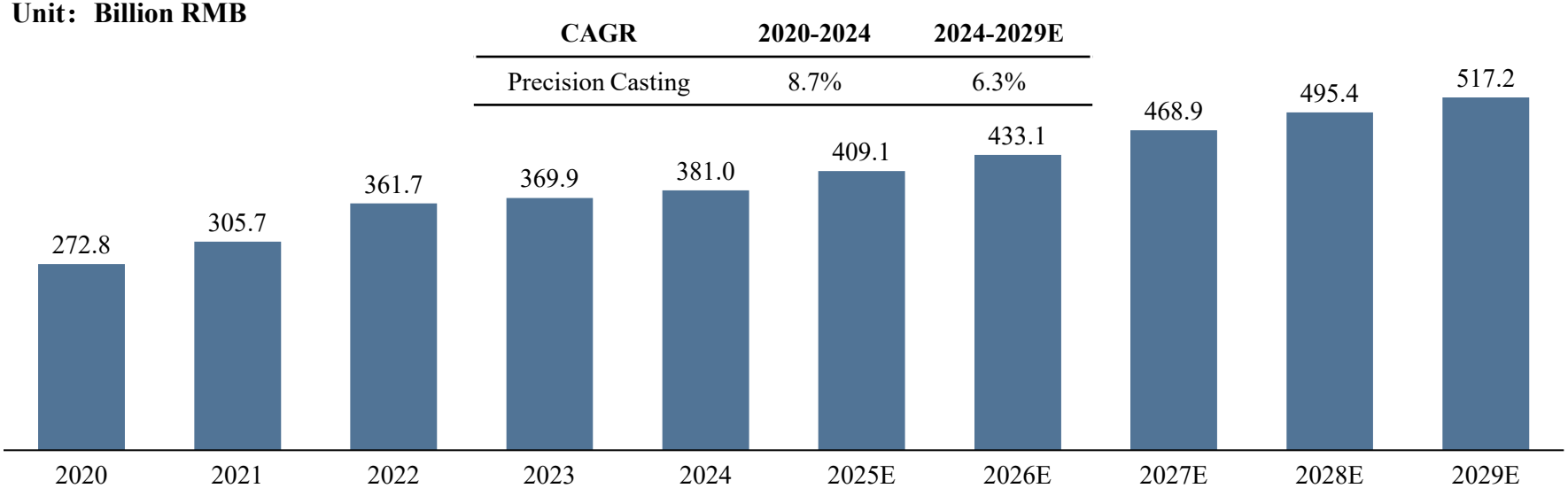
Overview of the Precision Casting Mullite Products Market

China's Precision Casting Market Size, 2020-2029E

- Precision casting is widely applied in industries like automotive, aviation, medical equipment, etc., which demand high-precision and high-performance parts. In the automotive industry, its upgrade, especially the pursuit of lightweight and high-performance solutions, boosts the demand for precision-cast components. China's automotive production is projected to grow from 31.3 million units in 2024 to 35.5 million in 2029, driving market expansion. The aviation field also shows strong demand, as IATA forecasts China will require about 8,000 new passenger aircraft over the next two decades, and the development of C919 and UAM projects drives the demand for high-performance parts. In the medical sector, rising demand for high-end equipment, like artificial joints and pacemaker casings, serves as a driving force for market growth. In 2024, China's medical device market was RMB1,090 billion, with precision casting related high-end equipment accounting for 10%, expected to reach 160.9 billion in 2029, with a CAGR of 8.1%. Looking forward, the automotive, aviation, and medical industries will drive China's precision casting market growth in the coming years. It is expected to have a CAGR of 6.3% during 2024-2029.

China's Precision Casting Market Size, by Sale Revenue of Castings

Unit: Billion RMB

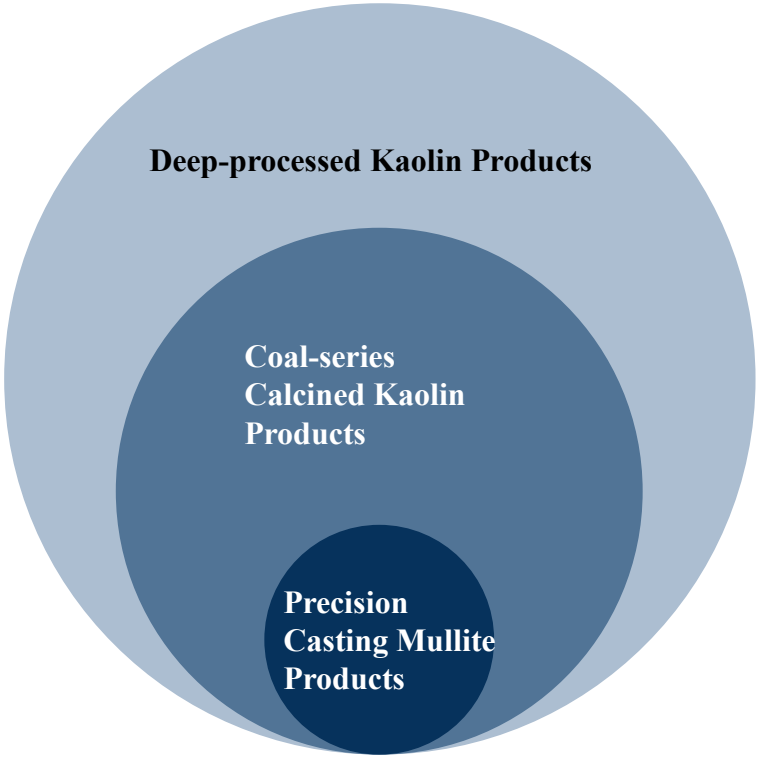


Source: China Foundry Association, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

China's Precision Casting Mullite Products Market Size, 2020-2029E

- In 2024, the market size of precision casting mullite products in China reached RMB925.0 million. In the same year, the market size of deep-processed kaolin products in China was RMB10,159.6 million. The market for precision casting mullite products accounted for approximately 9.6% of the deep-processed kaolin products market in China, making it a non-negligible market segment. Moreover, precision casting mullite products are made by calcining coal-series kaolin. In 2024, the market size of coal-series calcined kaolin products in China was RMB4,965.9 million, and precision casting mullite products accounted for 19.6% of it, being an important part of coal-series calcined kaolin products.



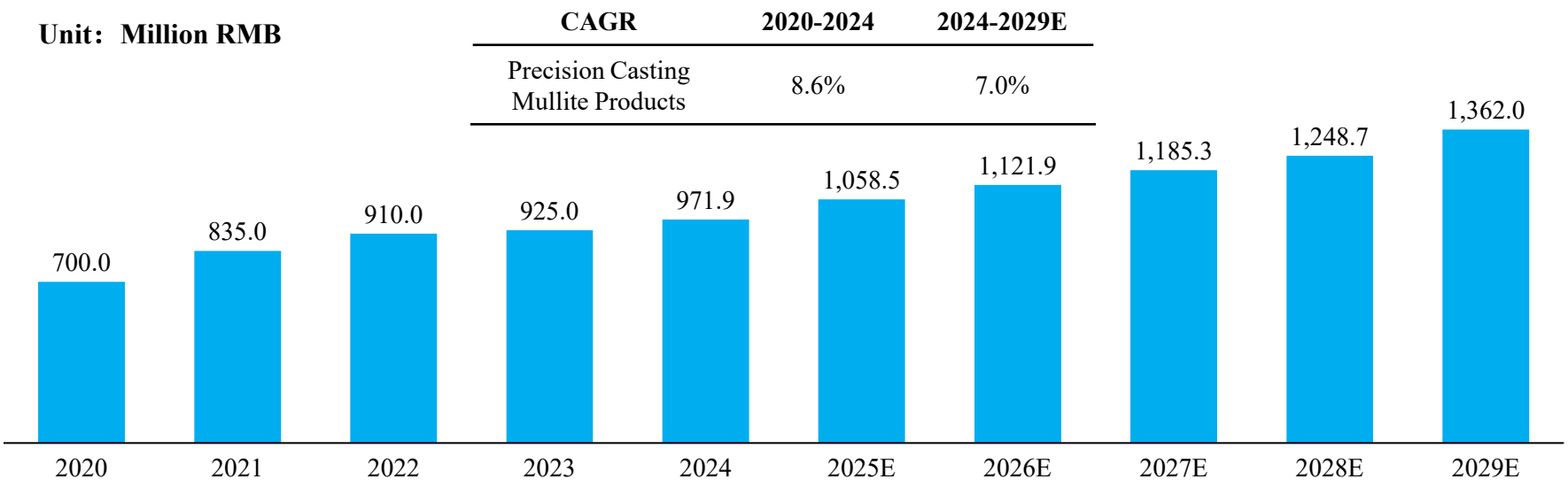
Market Segment	Market Size in China (million RMB)		CAGR (2024-2029E)
	2024	2029E	
Deep-processed Kaolin Products	10,159.6	14,007.4	6.6%
Coal-series Calcined Kaolin Products	4,965.9	7,223.8	7.8%
Precision Casting Mullite Products	971.9	1,362.0	7.0%

Overview of the Precision Casting Mullite Products Market

China's Precision Casting Mullite Products Market Size, 2020-2029E

- In 2024, China's precision casting mullite products market size was valued at RMB971.9 million. Among them, over 95% of the mullite products for precision casting on the market are derived from kaolin, only very few products are made from bauxite and synthetic mullite. Due to its low cost, mature technology, and stable performance, the calcined kaolin process is currently the mainstream method for preparing mullite products for precision casting. Mullite, with high-temperature stability and excellent corrosion resistance, endows castings in precision casting with a compact dimensional structure and a fine surface. It is thus widely used in manufacturing precision components and machine parts across industries, spurring the growth of the precision casting mullite products market. As the complexity, dimensional accuracy, and surface quality of castings keep increasing, the demand for mullite in precision casting will rise rapidly, at a pace faster than that of the precision casting market. The market is expected to grow to RMB1,362.0 million by 2029, exhibiting a CAGR of 7.0% during the forecast period.

China's Precision Casting Mullite Products Market Size, by Sale Revenue of Mullite Products



Source: Expert interviews, Frost & Sullivan

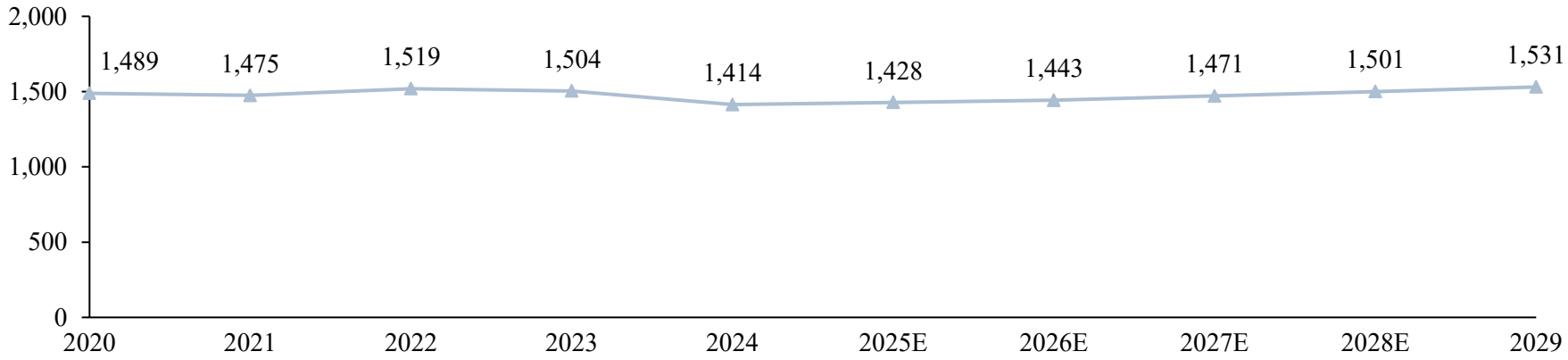
Overview of the Precision Casting Mullite Products Market

Average Price (Tax-excluded) of Precision Casting Kaolin Mullite Products in China, 2020-2029E

- The average tax-excluded price of China's precision casting kaolin mullite products (RMB/tonne) experienced slight fluctuations but remained relatively stable from 2020 to 2024, reaching 1,504 RMB/tonne in 2023. Due to the intensifying market competition, the average price of precision casting kaolin mullite products declines slightly by 6% compared to 2023, reaching 1,414 RMB/tonne in 2024. This is mainly attributed to the competitive strategy of price-cutting sales adopted by several leading enterprises in the market to expand their market share. However, considering the stability of the raw material cost, that is, the price of kaolin ore, the price decline of kaolin mullite for precision casting is only applicable in the short term. In the long run, development of the precision casting industry may lead to a continuous increase in demand for kaolin mullite, especially for high-performance and high-quality products, thereby driving the price upward. The price increase of coal-series kaolin ore due to policy changes, geological issues or environmental factors, may raise the production cost of precision casting mullite products, thereby potentially driving its price upward. The price is predicted to rise slightly annually from 2025 to 2029, with an expected price of 1,531 RMB/tonne in 2029. However, the price fluctuation of precision casting mullite products is also influenced by factors such as policies and regulations, market competition, as well as production processing costs.

Average Price (Tax-excluded) of Precision Casting Kaolin Mullite Products in China

Unit: RMB/Tonne



Source: Expert interviews, Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

Market Drivers of Precision Casting Mullite Products Market

Growing demand fueled by industry development

The development of automotive, medical, aviation and energy industries drive the precision casting mullite products market. For example, in the automotive industry, there is a significant demand for lightweight and high-performance precision-cast components. The medical industry relies on precision-cast biocompatible parts. In aviation and energy, there is an increasing need for high-performance heat-resistant components. Kaolin mullite materials, possessing excellent thermal stability, low thermal expansion and wear resistance, are essential for fabricating precision-cast parts that can endure high stress and harsh environments without deterioration or distortion, thereby fueling market growth.

New opportunities created by technological integration

Technological innovation has created new opportunities for mullite materials in precision casting. A noteworthy development is the combination of 3D printing and precision casting. 3D-printed wax patterns can be directly used in casting, increasing design flexibility and enabling the production of complex shapes. This integration reduces production time and accelerates product launch. As a result, the demand for high-quality mullite materials has risen as they are suitable for this new production method and ensure product quality and performance.

Source: Frost & Sullivan

Overview of the Precision Casting Mullite Products Market
Market Drivers of Precision Casting Mullite Products Market

The rapid development of complex precision castings

In the process of the vigorous development of modern industry, the structures of castings such as automobile and aviation components are evolving towards increasing complexity. Castings with complex structures usually have a significantly enlarged surface area, and this characteristic directly leads to a rapid increase in the amount of kaolin mullite used in their casting shells. Moreover, such castings with complex structures also put forward more stringent requirements for dimensional accuracy and surface quality. As the application range of these high-precision castings expands, the demand for precision casting mullite products is bound to increase significantly, presenting a notable growth opportunity.

The Advantages of Mullite under strict environmental requirements

In modern industrial progress, environmental considerations are increasingly significant, granting mullite materials particular benefits in the precision casting market. Stringent global environmental regulations lead manufacturers to emphasize the environmental features of materials. Kaolin mullite materials can withstand chemical reactions from environmental substances during precision casting with chemical emissions or corrosive exposures, averting harmful by-products and performance decline. This reduces on wastes associated with material damage or reactions. As a result, kaolin mullite is an attractive option for precision casting enterprises seeking cost reduction and sustainable growth.

Source: Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

Market Trends of Precision Casting Mullite Products Market

Accelerated Internationalization and Global Layout

On the one hand, the growing demand for high-performance ceramic fibers in overseas markets, especially driven by the advancement of industrialization in emerging economies, provides incremental space for Chinese enterprises. On the other hand, with the advancement of the Belt and Road Initiative, relying on cost advantages and technological accumulation, leading domestic enterprises are accelerating their efforts to explore the international market and participate in the division of labor in the global industrial chain. The penetration rate of Chinese ceramic fibers in markets such as Southeast Asia and the Middle East has increased, and the proportion of exports is expected to grow significantly.

Industry Integration and Concentration Enhancement

The intensification of market competition has spurred the reshuffling of the industry. Low-end production capacity is being gradually phased out, and standardized state-owned enterprises are expanding their market share through large-scale production and technological advantages. Enterprises with technological accumulation and control over the supply of upstream raw materials are expected to integrate resources through mergers and acquisitions. In the future, enterprises with technological, financial, and channel advantages will dominate the market, giving rise to a competitive landscape where the strong keep getting stronger.

Source: Frost & Sullivan

Overview of the Precision Casting Mullite Products Market

Overview of Policies in the Precision Casting Industry

Policy	Issue time	Department	Main contents
Guiding Opinions on Promoting High-Quality Development of the Steel Industry（《关于促进钢铁工业高质量发展的指导意见》）	2022.2	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Ecology and Environment（工业和信息化部、国家发展和改革委员会、生态环境部）	Strictly increase control over steel production capacity. New steel projects are strictly prohibited, and a stringent review of energy consumption, environmental impact, and project approvals is mandated. The policy does not allow expansion of new production capacity for industries such as machinery, foundry, and casting.
14th Five-Year Plan for Green Development of the Foundry Industry（《铸造行业绿色发展“十四五”规划》）	2021.5	China Foundry Association（中国铸造协会）	Targets key areas like automotive parts, energy and power conversion equipment, rail transportation equipment, and others. These are listed as key areas for foundry industry green development during the "14th Five-Year Plan," with a focus on creating green development model factories and fostering low-carbon, environmentally friendly foundry practices.
Green Foundry Industry Access Conditions“ (T/CFA0310021-2019 Group Standard)（《绿色铸造行业准入条件（T/CFA 0310021 - 2019）团体标准》）	2019.9	China Foundry Association（中国铸造协会）	Focused on improving the overall conditions in the foundry industry, including environmental regulations, equipment, product quality, energy consumption, environmental protection, worker health, and resource management, aiming to establish a sustainable and green foundry industry.
Notice on the Three-Year Action Plan to Win the Blue-Sky Defense Battle（《关于打赢蓝天保卫战三年行动计划的通知》）	2018.7	State Council（国务院）	Strengthens control over winter production for heavily polluting industries like foundry, smelting, and casting. Instructs regional governments to formulate targeted implementation plans for reducing air pollution and improving energy efficiency, with a focus on green development.
Guiding Opinions on Promoting High-Quality Development of the Foundry and Forging Industry（《关于推动铸造和锻压行业高质量发展的指导意见》）	2023.4	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Ecology and Environment（工业和信息化部、国家发展和改革委员会、生态环境部）	Focuses on promoting high-end projects, standardizing industry management, and accelerating green development. The policy encourages digital transformation, green production methods, and strict supervision over new projects. It also aims to enhance industry innovation and improve the environmental management system for sustainable development.
Guiding Opinions on Accelerating the Green Development of the Manufacturing Industry（《关于加快推动制造业绿色化发展的指导意见》）	2024.2	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Finance, Ministry of Ecology and Environment, People's Bank of China, State - owned Assets Supervision and Administration Commission of the State Council, State Administration for Market Regulation（工业和信息化部 国家发展改革委 财政部 生态环境部 中国人民银行 国务院国资委 市场监管总局）	Relying on the industrial foundation reconstruction project and the major - technology - and - equipment research project, we will orderly promote research on key basic materials, basic specialized components, and disruptive technologies closely related to green and low - carbon transformation, and accelerate breakthroughs in a number of landmark major equipment such as green power equipment, rail transit, and construction machinery.

Agenda

Overview of the Refractory Mullite Products Market

Definition of Refractory Materials

- **Refractory materials** are materials that are resistant to high temperatures, capable of withstanding extreme heat without melting, breaking down, or losing their strength. They are typically used in furnaces, kilns, reactors and other high-temperature industrial applications, providing essential thermal insulation and structural stability. Refractory materials are essential in industries such as metallurgy, construction materials and chemical industry, where they protect equipment from heat and thermal shock.

The Features and Applications of Refractory Material

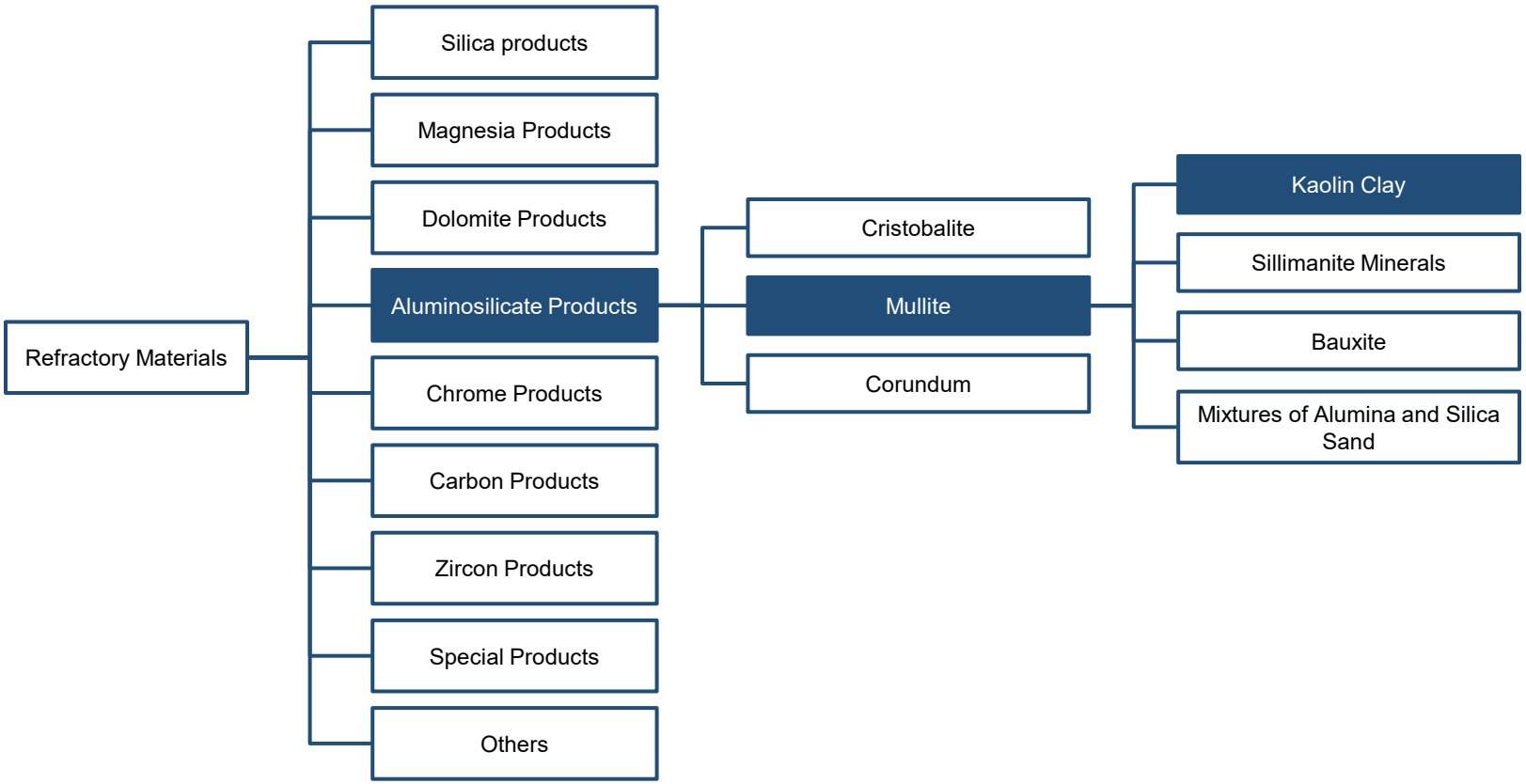
Features	Application
 High Thermal Resistance	Refractory materials are designed to withstand extreme temperatures, often exceeding 1,000° C. This makes them essential for use in furnaces, kilns, reactors, and other high-temperature equipment. Their ability to maintain structural integrity under such conditions is critical for industrial processes like steelmaking, glass production, and cement manufacturing.
 Mechanical Strength	These materials can bear heavy loads and resist mechanical stress at elevated temperatures. This mechanical strength ensures that refractory linings in industrial furnaces and reactors do not deform or collapse under the weight of materials or equipment, maintaining the structural stability of the system.
 Thermal Shock Resistance	Refractories are designed to handle rapid temperature fluctuations without cracking or breaking apart. This property is crucial in applications where materials are heated and cooled repeatedly, such as in batch-processing furnaces or during the quenching phase in metalworking.
 Chemical Stability	Refractory materials must resist corrosion and chemical reactions that can occur at high temperatures. They often encounter gases, molten metals, and slags that can erode or weaken materials. High chemical stability ensures that refractory linings do not degrade quickly, extending the life of the equipment.
 Wear and Abrasion Resistance	In certain industrial processes, refractories are subjected to physical abrasion from the movement of materials, such as molten metals, powders, or gases.

Source: Public information, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Classification of Refractory Materials（1/2）

- Refractory materials are high - temperature - resistant structural materials made from processing natural ores like bauxite, silica, magnesite, and dolomite. Besides, refractory materials from industrial and artificially synthesized raw materials are increasing. Those used in smelting pure metals, special alloys, and manufacturing oxides and refractory compounds in high - temperature technology have developed greatly, forming a large and complex refractory material system with different compositions, preparation processes, structural characteristics, and service properties.



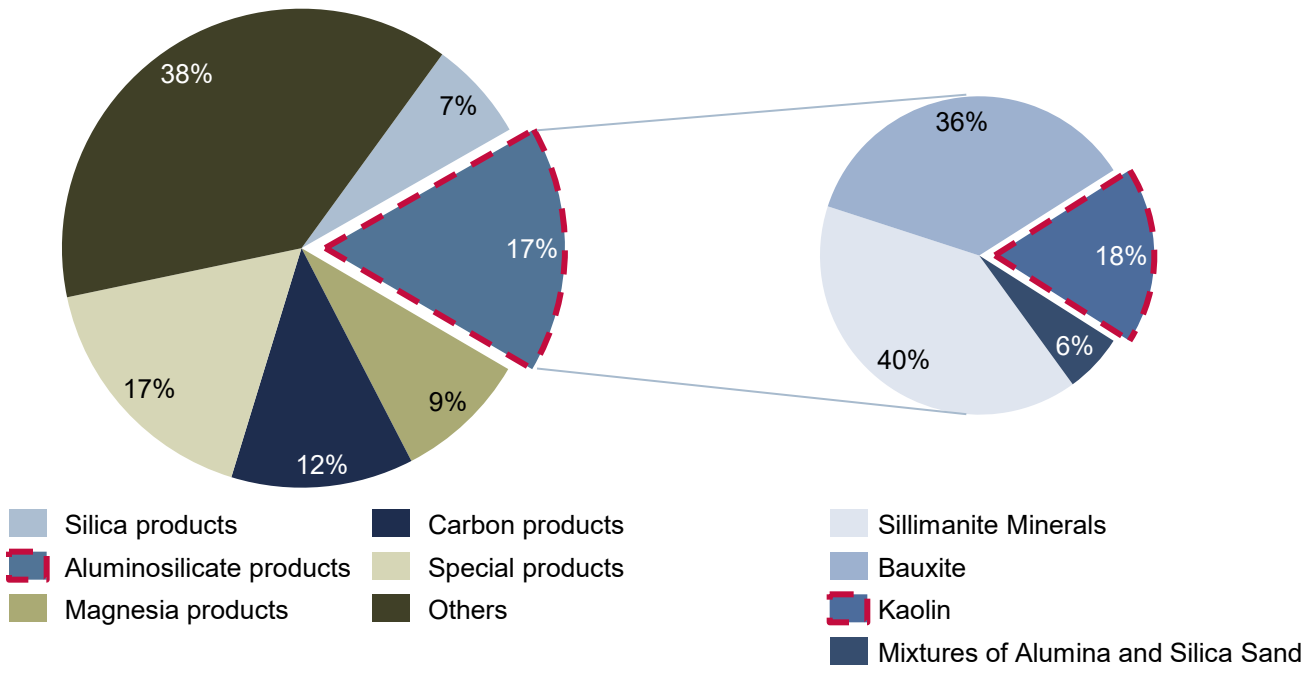
Source: Frost & Sullivan, Intelligence Research Group

Overview of the Refractory Mullite Products Market

Classification of Refractory Materials（2/2）

- Refractory materials are categorized into several classifications, including silica, aluminosilicate, magnesia and dolomite products. Aluminosilicate products consist of cristobalite, mullite and corundum. The mullite products for refractory material can be calcined from coal-series kaolin, or processed from sillimanite, bauxite, as well as mixtures of alumina and silica sand.
- The Aluminosilicate refractories are materials which are increasingly demanded and whose manufacturing involves necessarily the synthesis of mullite. They have the attributes of being relatively inexpensive compared to other bricks (special carbon refractories, zircon, zirconia, fused-cast refractory).

Composition of Classification and Raw Materials of Refractory Materials



Source: Frost & Sullivan, Intelligence Research Group

Overview of the Refractory Mullite Products Market

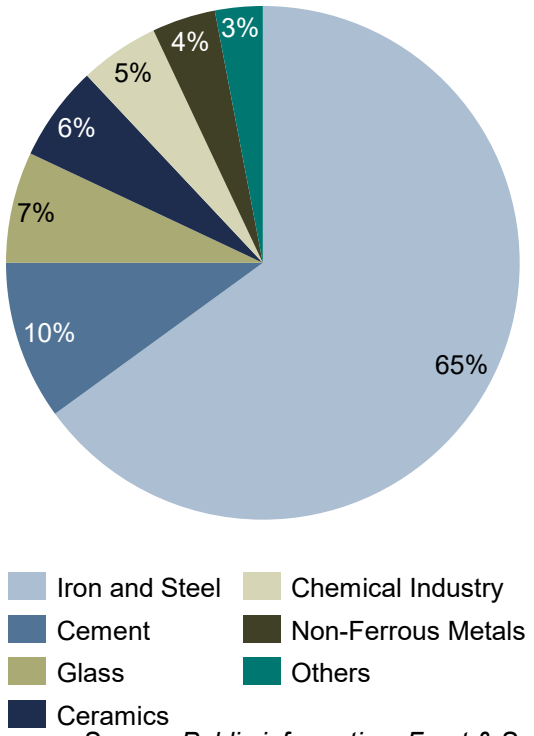
Downstream Applications Distribution of Refractory Materials

- The downstream industries of refractory materials are high-temperature industries, mainly including iron and steel, building materials, non-ferrous metals, chemical industry, environmental protection, military industry and other fields. Refractory materials are mainly used as lining structural materials, high-temperature resistant elements and component materials for high-temperature equipment to ensure the normal operation of operations in high-temperature environments. Refractory materials are an important guarantee for all production links involving high-temperature environments..

Downstream Applications of Refractory Materials

Downstream	Description
Iron and Steel	Refractory materials are primarily used in the iron and steel industry for applications like furnaces, kilns, and other high-temperature equipment.
Cement	In the cement industry, refractory materials are used in kilns and preheaters to withstand the extreme heat during production processes.
Glass	The glass industry utilizes refractory materials in furnaces and regenerators to resist high temperatures and corrosive materials.
Ceramics	Refractory products are used in ceramic production for kiln furniture, stoppers, and linings in high-temperature furnaces.
Chemical Industry	Refractory materials are applied in reactors and other high-temperature equipment in the chemical sector.
Non-Ferrous Metals	The non-ferrous metals industry uses refractory materials in furnaces for smelting metals like aluminum, copper, and others
Others	This category includes miscellaneous applications of refractory materials across various industries.

Composition of Downstream Applications of Refractory Materials



Source: Public information, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Definition of Refractory Kaolin Mullite Products

- Kaolin-based refractory mullite materials are high-temperature resistant materials that combine kaolin, a naturally occurring clay mineral, with mullite ($3Al_2O_3 \cdot 2SiO_2$), a crystalline compound known for its outstanding thermal and structural properties. These materials are specifically engineered to withstand extremely high temperatures, making them suitable for use in harsh industrial environments.
- Kaolin mullite materials for refractory materials, serving as lining structural materials and high - temperature - resistant element and component materials for high - temperature equipment, are significant for ensuring the smooth operation of high - temperature industries, improving product quality, developing new varieties, achieving high - efficiency production, and energy - saving and emission - reduction.
- As a refractory material, kaolin mullite is used to prepare mullite refractory bricks, mullite refractory aggregates or mullite refractory castables. Most of the mullite refractory materials are used to make the front chamber of high-temperature furnaces and can also be used as the lining of various kilns. In the metallurgical industry, mullite refractory materials are mainly used to make hot blast stove bricks and kiln furniture bricks. In addition, due to the good airtightness and corrosion resistance of mullite materials, mullite materials can also be applied to heat-resistant materials such as crucibles, thermocouple tubes and protective tubes.

Source: Public information, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Advantages and Applicable Scenarios of Refractory Kaolin Mullite Products

- Kaolin mullite materials offer distinct advantages over other refractory materials, including higher thermal stability, excellent thermal shock resistance, and strong chemical resistance. These properties make them ideal for high-temperature applications, such as kilns, steelmaking, and petrochemical reactors, where other materials would degrade or fail. Despite their higher cost, mullite materials provide superior performance and durability, ensuring long-term efficiency in demanding environments.

Advantages Compare to Other Materials

A Higher Thermal Stability

Mullite materials can withstand extreme temperatures, often exceeding 1800° C, without degrading. This makes them highly suitable for industries that require long-term performance in high-heat environments, such as steel, glass, and ceramics production.

B Excellent Thermal Shock Resistance

Kaolin-based mullite has superior thermal shock resistance compared to other refractory materials. This means it can handle rapid temperature fluctuations without cracking, which is essential for high-temperature processes where sudden changes are common.

C Chemical Resistance

Kaolin-based mullite refractories are highly resistant to corrosive substances such as molten metals, slags, and gases, which makes them suitable for environments where chemical attack is a concern.

D Performance vs. Cost

While kaolin-based mullite materials may be more expensive than lower-end refractory options, they offer superior performance (e.g., higher temperature resistance, better thermal shock resistance). This performance often justifies the higher initial cost, especially in industries where equipment durability and long-term efficiency are crucial.

Applicable Scenarios only for Mullite Materials

A High-Temperature Furnaces and Kilns (Ceramics and Glass)

Mullite's thermal stability and corrosion resistance make it essential for lining kilns and furnaces, where other materials would degrade due to heat and chemical exposure.

B Steel and Metallurgical (Tundish and Ladles)

Mullite is key in steelmaking, resisting both heat and chemical attacks from molten metals, ensuring long-lasting performance in tundish and ladle linings.

C Petrochemical Industry (Cracking Units and Reactors)

Mullite's chemical resistance and thermal shock resistance are unmatched in reactors and catalytic crackers, where other materials would quickly fail.

D Aerospace (Thermal Barriers)

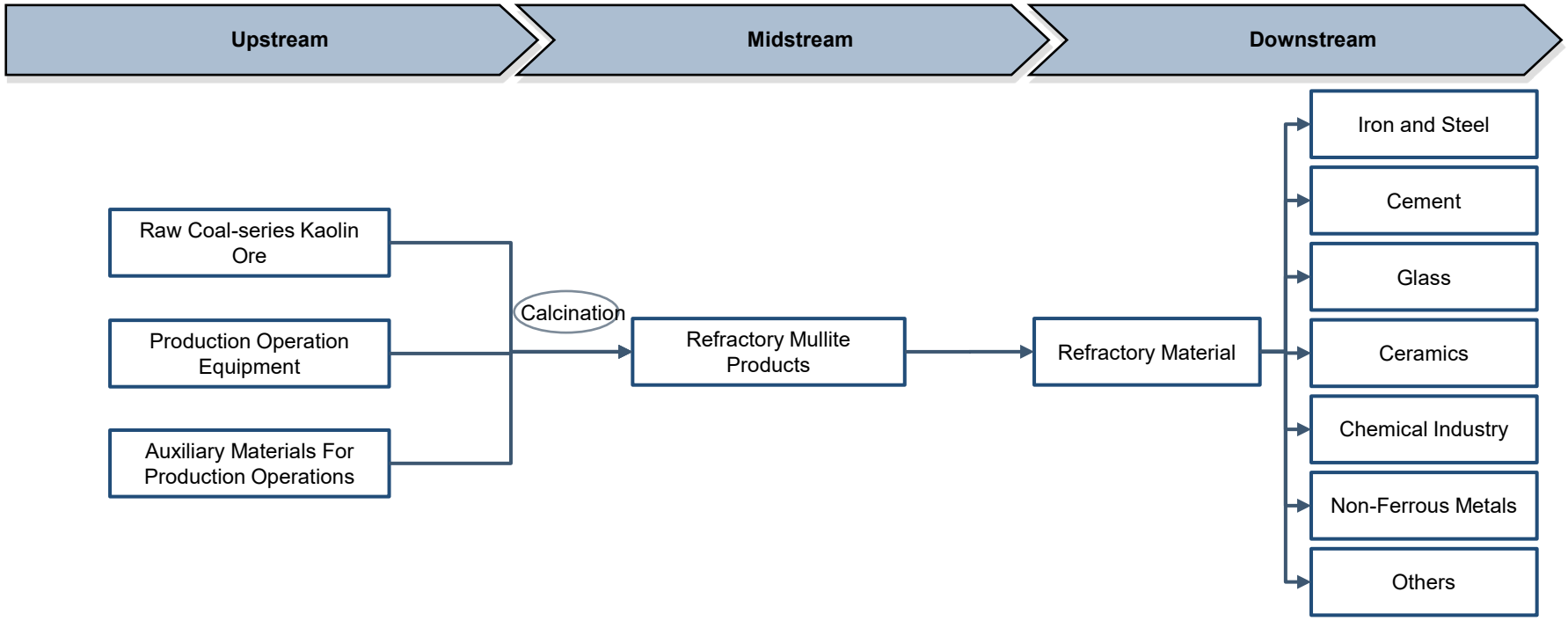
Mullite is used in thermal barrier coatings for engines, withstanding extreme temperatures and mechanical stress, where other materials fall short.

Source: Public information, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Industry Chain Analysis of Refractory Mullite Products

- The upstream of the mullite materials for refractory material industry mainly consists of three categories: raw coal-series kaolin ore, production operation equipment, and production operation auxiliary materials.
- The midstream of the mullite materials for refractory material industry is the refractory mullite products, which includes mullite granular for refractory material and mullite block for refractory material.
- The downstream of the mullite materials for refractory material industry is aluminosilicate refractory material. Mullite material for refractory is a kind of refractory castable material which is stirred with high-quality porous mullite aggregate as raw material and added with fine powder and additives. Mullite material for refractory is widely used in high-temperature equipment in industries such as metallurgy, glass, and ceramics. It is applied in structures such as hot blast furnace bricks, kiln furniture bricks, and the tops of glass kilns.



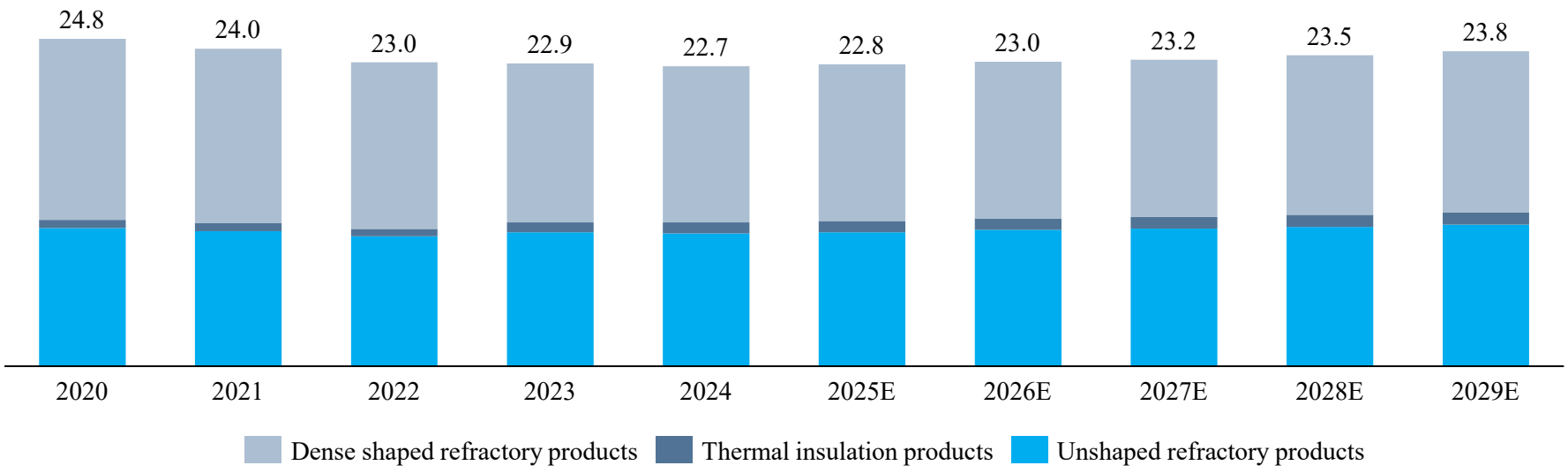
Source: Frost & Sullivan

Overview of the Refractory Mullite Products Market

China's Refractory Materials Output By Products Types, 2020-2029E

- In 2024, China's refractory material production was 22.7 million tons, a slight decrease of 0.96% year-on-year, indicating that the industry is generally stable. Among them, the production of dense shaped refractory products was 11.8 million tons, a decrease of 1.96% year-on-year; the production of thermal insulation refractory products was 837.7 thousand tons, a significant increase of 11.17% year-on-year; the production of unshaped refractory products was 10.1 million tons, an slight decrease of 0.68% year-on-year. Different types of refractory products showed significant differences in performance in 2024, with the production of thermal insulation refractory products increasing prominently.

China's Refractory Materials Output By Products Types



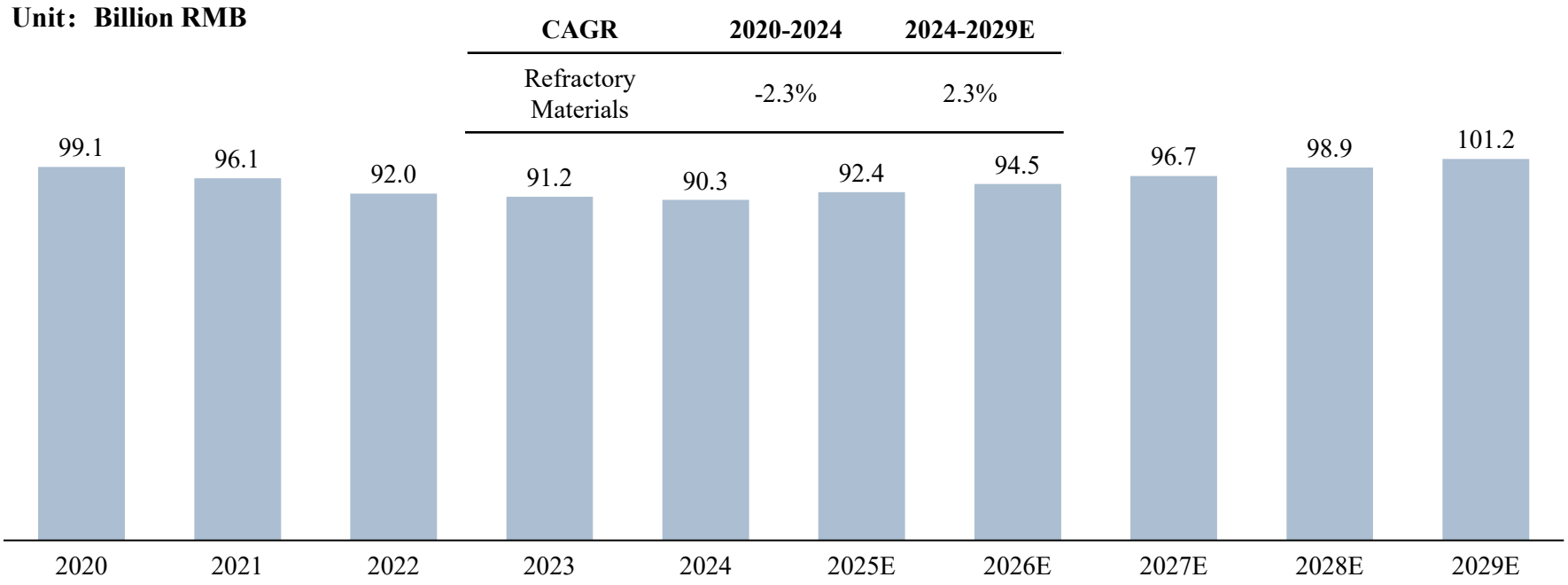
Source: The Association of China Refractories Industry, Frost & Sullivan

Overview of the Refractory Mullite Products Market

China's Refractory Materials Market Size, 2020-2029E

- China’s refractory materials market size fluctuated from RMB99.1 billion to RMB90.3 billion from 2020 to 2024. The market was generally stable but slightly decreased due to downward trend in some sectors such as cement and steel. The market is expected to expand slightly in the coming years due to the increased demand from high-temperature industries, the progress in refractory and insulation technology, energy-saving and environmental protection policies, and the optimization of raw material resources. The market size in 2029 is projected to increase to RMB101.2 billion with a CAGR of 2.3% from 2024 to 2029.

China's Refractory Materials Market Size, by Sale Revenue of Refractory Materials



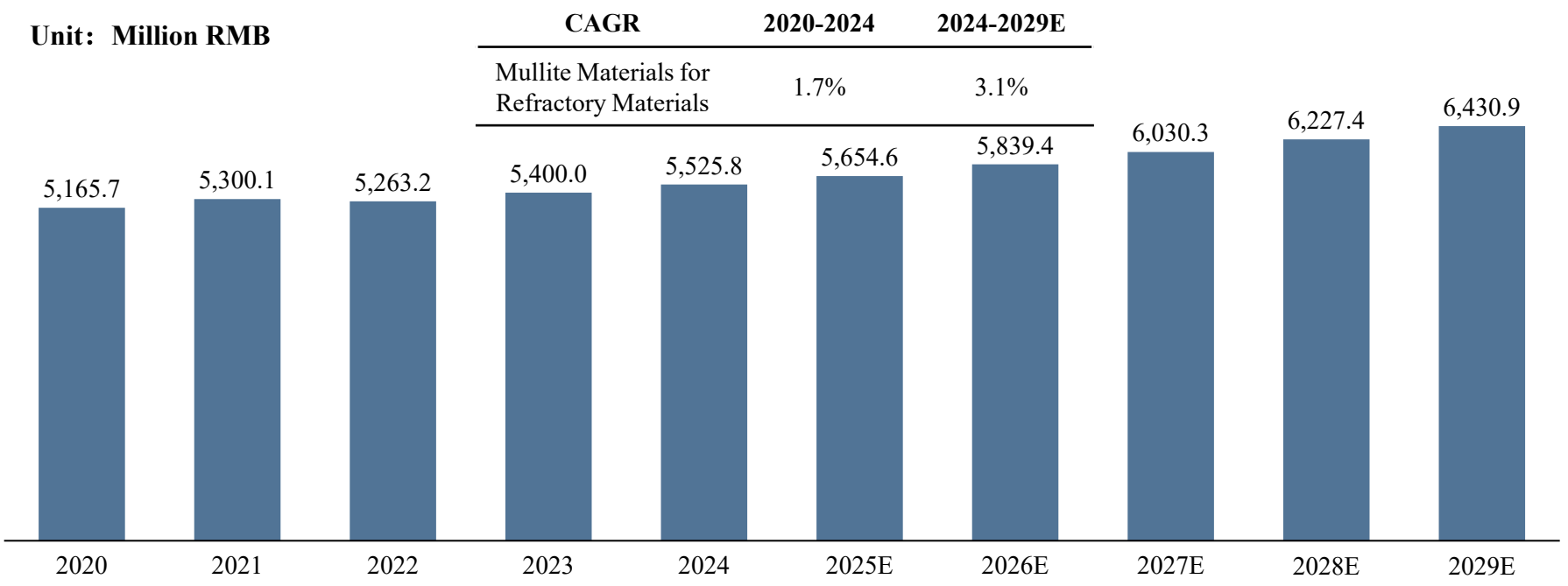
Source: The Association of China Refractories Industry, Frost & Sullivan

Overview of the Refractory Mullite Products Market

China's Refractory Mullite Products Market Size, 2020-2029E

- From 2020 to 2024, China's market size of refractory mullite products increased from RMB5,165.7 million to RMB5,525.8 million with a CAGR of 1.7%. Among them, the market size of refractory kaolin mullite in China was approximately RMB884.1 million in 2024. Due to outstanding performance advantages, expanded application fields and technological progress and innovation, the refractory mullite products market witnesses growth. It is expected that the market size to grow to RMB6,430.9 million in 2029, with a CAGR of 3.1% from 2024 to 2029.

China's Refractory Mullite Products Market Size, by Sale Revenue of Mullite Products



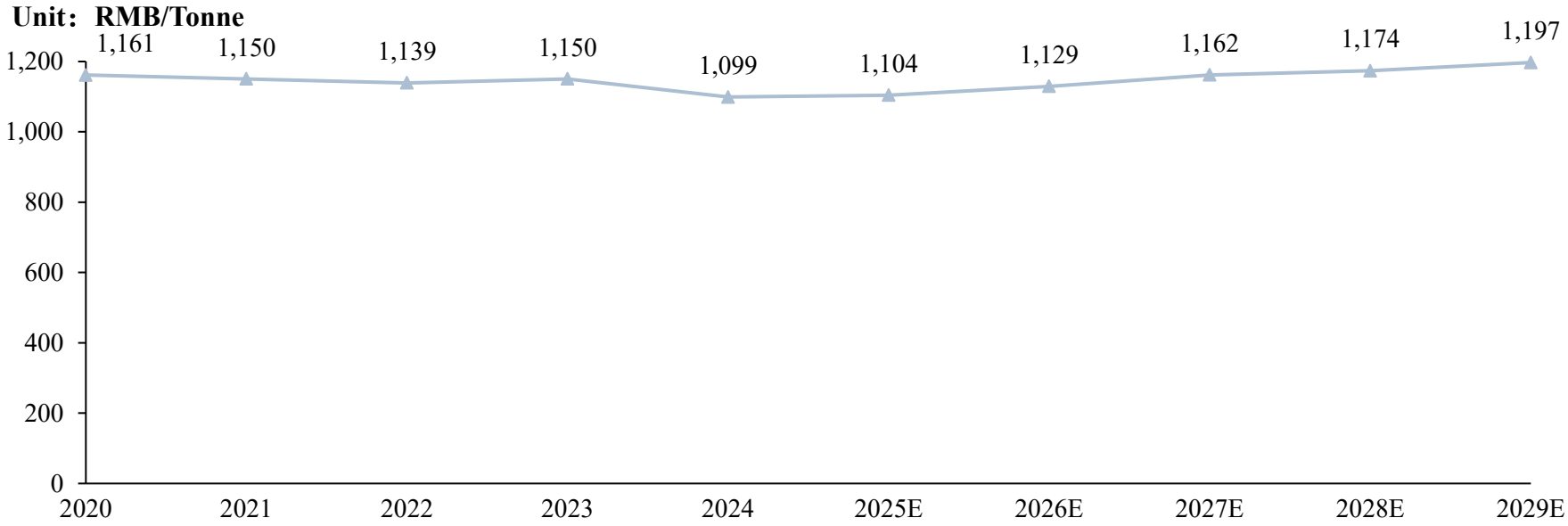
Source: Expert interviews, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Average Price (Tax-excluded) of Refractory Kaolin Mullite Products in China, 2020-2029E

- Among the refractory mullite products, the average tax-excluded price of refractory kaolin mullite products in China has experienced slight fluctuations in recent years. In 2024, the average price was 1,099 RMB/tonne. With the continuous development of high-temperature industries such as steel, cement and glass, the demand for refractory materials is expected to increase steadily. Kaolin mullite is widely used in these industries due to its excellent fire-resistance, thermal-shock resistance and low thermal-expansion coefficient, which will support its price. Meanwhile, The price hike of coal-series kaolin ore, a crucial raw material for refractory kaolin mullite products, may increase the production cost of kaolin mullite and pushes up its price to a certain extent. It is predicted that the price of this material will show an overall upward trend from 2024 to 2028, reaching 1,197 RMB/tonne by 2029. However, the price of refractory kaolin mullite products is also affected by other factors like policies and regulations, market competition and production process costs.

Average Price (Tax-excluded) of Refractory Kaolin Mullite Products in China



Source: Expert interviews, Frost & Sullivan

Overview of the Refractory Mullite Products Market

Market Drivers of Refractory Mullite Products Market

Steady Growth Driven by High-Temperature Industries

The demand for refractory mullite products is experiencing a consistent upward trend. High-temperature industries rely on the distinctive properties of refractory mullite products to maintain uninterrupted production. Due to its remarkable thermal stability, corrosion resistance and chemical resistance, kaolin mullite has become the preferred option for high-temperature applications in steel, glass and ceramic industries. The steadily developing industrial activities, along with the expansion of downstream applications, drive the demand for refractory mullite products.

Performance and Cost Optimization promoted by Calcination Technology

Technological progress play a crucial role in driving the refractory mullite products market. Specifically, advancements in calcination technology and the development of composite high-temperature refractory materials significantly impact refractory mullite products. These innovations enhance the high-temperature and anti-corrosion performance of kaolin mullite, increase production efficiency and improve cost-effectiveness in large-scale applications, thus boosting its market competitiveness and promoting its wide use.

Strict Regulations and Resource Utilization Jointly Promote Market Development

Environmental protection is a major market driver for refractory mullite products. Stricter regulations and increased environmental awareness are encouraging industries to adopt sustainable production practices. Kaolin mullite products are favored for their eco-friendliness. A key trend involves associated coal-series kaolin or mining by-products to manufacture high-performance mullite materials, which reduces costs and environmental impact thereby supporting sustainable development.

Source: Frost & Sullivan

Overview of the Refractory Mullite Products Market

Market Trends of Refractory Mullite Products Market

Technological Innovation

Technological advancements have been achieved in the field of refractory mullite products. The continuous innovation of production technologies, especially the improvements in calcination techniques and manufacturing processes, has improved the quality, performance, strength and thermal stability of kaolin mullite. These enhancements enable kaolin mullite to meet the requirements of more demanding application scenarios and have a greater cost-effectiveness advantage, thereby further expanding its application range in the industrial field.

Sustainability in Focus

Sustainability is the core concern in the refractory mullite products market. Due to strict environmental regulations, industries are inclined towards products with minimal environmental impact. Refractory kaolin mullite products are widely favored as they meet performance and sustainability standards. Additionally, the trend of recycling and reusing kaolin and other raw materials in refractory production is obvious, aligning with the global circular economy and sustainable resource management trend.

Source: Frost & Sullivan

Overview of the Refractory Mullite Products Market

Overview of Policies in the Refractory Material Industry

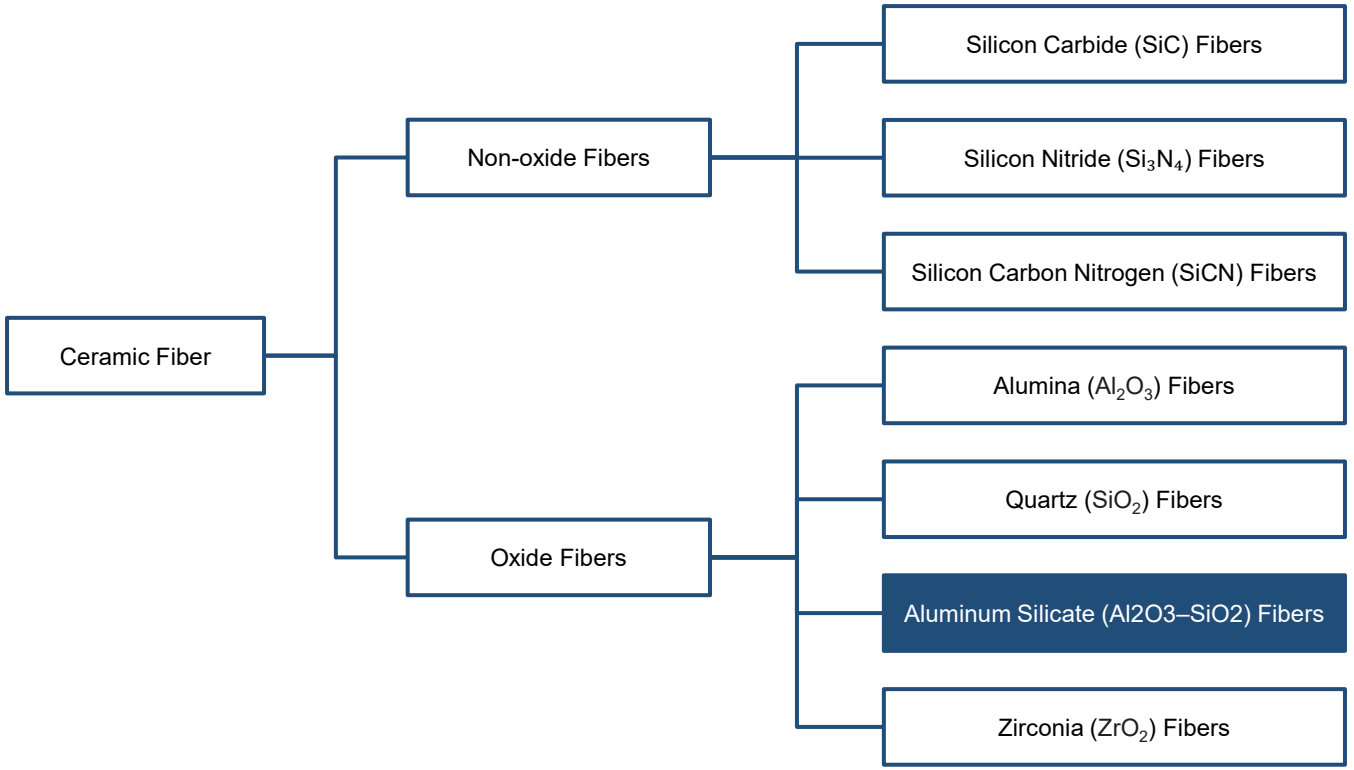
Policy	Issue time	Department	Main contents
Implementation Plan for High-Quality Development of Green Building Materials Industry（《绿色建材产业高质量发展实施方案》）	2023.12	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Ecology and Environment, Ministry of Housing and Urban-Rural Development, Ministry of Agriculture and Rural Affairs, Ministry of Commerce, People's Bank of China, State Administration for Market Regulation, China Financial Regulatory Administration, National Radio and Television Administration（工业和信息化部 国家发展改革委 生态环境部 住房城乡建设部 农业农村部 商务部 中国人民银行 市场监管总局 金融监管总局 广电总局）	Accelerate the cultivation of green building materials industrial clusters. Encourage regions with conditions to develop green building materials clusters with distinctive features in combination with local resource endowments and market demands, and build green industrial chains and supply chains. Support all regions to promote the construction of new industrialization industrial demonstration bases mainly composed of green building materials.
Guiding Opinions on Accelerating the Transformation and Upgrading of Traditional Manufacturing Industries（《关于加快传统制造业转型升级的指导意见》）	2023.1	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Education, Ministry of Finance, People's Bank of China, State Taxation Administration, China Financial Regulatory Administration, China Securities Regulatory Commission（工业和信息化部 国家发展改革委 教育部 财政部 中国人民银行 税务总局 金融监管总局 中国证监会）	Actively promote the resource recycling production model, vigorously develop the comprehensive utilization industry for recycling and processing of waste steel and non-ferrous metals, and promote the high-value recycling of renewable resources. Promote the coupled development of industries such as petrochemicals, iron and steel, non-ferrous metals, building materials, and electricity.
Guiding Opinions on Promoting High-Quality Development of the Iron and Steel Industry（《关于促进钢铁工业高质量发展的指导意见》）	2022.1	Ministry of Industry and Information Technology, National Development and Reform Commission, Ministry of Ecology and Environment（工业和 信息化部、发展改革委、生态环境部）	Encourages industries like steel, non-ferrous metals, and electric furnaces to adopt advanced refractory materials to reduce energy consumption and increase the utilization rate of waste heat by 20% by 2030.
14th Five-Year Plan for Raw Materials Development（《"十四五"原材料工业发展规划》）	2021.12	Ministry of Industry and Information Technology（工业和信息化部）	Promotes the application of advanced refractory materials in industries like steel, cement, glass, and ceramics to enhance sustainability and technological innovation.
Notice on Printing and Distributing the Action Plan for Carbon Peaking by 2030《关于印发2030年前碳达峰行动方素的通知》	2021.10	The State Council （国务院）	During the "14th Five-Year Plan" period, significant progress has been made in adjusting and optimizing the industrial structure and energy structure. The energy utilization efficiency of key industries has been greatly improved. The growth of coal consumption has been strictly controlled. The construction of a new power system has been accelerated. New progress has been made in the research, development and promotion of green and low-carbon technologies. Green production and lifestyle have been widely promoted. The policy system conducive to green, low-carbon and circular development has been further improved.

Agenda

Overview of the Ceramic Fiber Market
Definition and Classification of Ceramic Fiber

- **Ceramic fiber** is a kind of fibrous lightweight refractory material. It is renowned for its light weight, high temperature resistance, good thermal stability, low thermal conductivity, low specific heat capacity, and resistance to mechanical vibration. It is widely applied in industries such as machinery, metallurgy, chemical engineering, petroleum, ceramics, glass, and electronics.

The Classification of Ceramic Fiber



Source: Science Direct, Frost & Sullivan

Overview of the Ceramic Fiber Market

Performance Features of Ceramic Fiber

The Performance Features of Ceramic Fiber

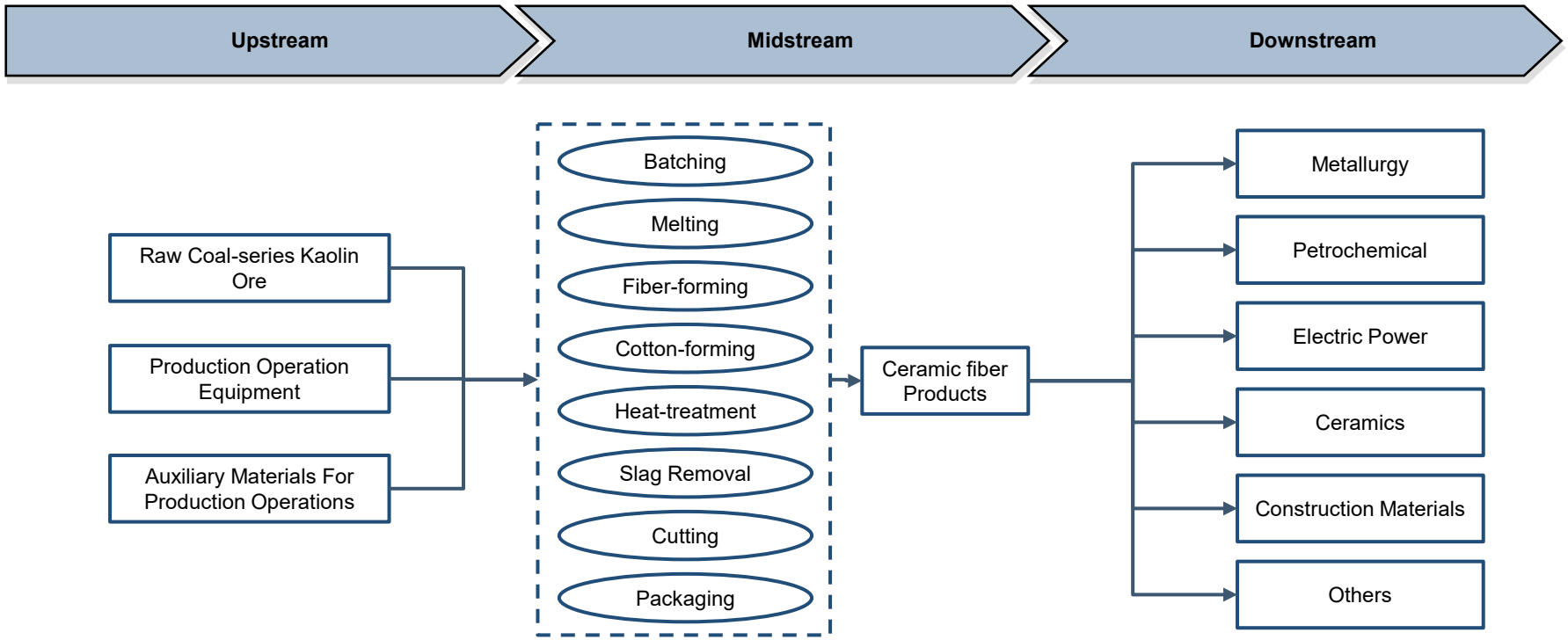
Performance Features	Specific Descriptions
Low Bulk Density	It is more than 75% lighter than lightweight thermal - insulating furnace linings and 90% - 95% lighter than lightweight castable furnace linings, reducing the load on the steel structure of the furnace body and extending the service life of the furnace body.
Low Heat Capacity	It is only about 1/10 of that of lightweight heat - resistant and castable linings. During reciprocating operations, it absorbs less heat and heats up faster, reducing energy consumption.
Low Thermal Conductivity	At different average temperatures, the thermal conductivity is much lower than that of lightweight clay bricks, etc., with remarkable heat - insulation effects.
Simple Construction	No expansion joints need to be set, and construction techniques have little impact on the heat - insulation effect.
Excellent Thermal Shock and Mechanical Vibration Resistance	It has excellent resistance to temperature fluctuations and mechanical vibrations. The folded module furnace lining is not easy to be damaged during heating and cooling.
No Need for Furnace Drying	It can be put into use immediately after construction without a furnace - drying procedure.
Good Sound - Insulation Performance	It can reduce high - frequency noise, and its sound - insulation ability is better than that of common sound - insulation materials.
High Thermal Sensitivity	It has good thermal sensitivity and is suitable for the automatic control of industrial furnaces.
Stable Chemical Properties	It is a neutral - to - slightly acidic material. Except for reactions with strong acids and alkalis, it is not eroded by weak acids and alkalis, etc., and does not infiltrate with aluminum and copper.
Wide Application Range	The service temperature is 600 - 1600℃. There are various forms, meeting the requirements of different industrial furnaces and construction.

Source: Frost & Sullivan

Overview of the Ceramic Fiber Market

Industry Chain Analysis of Ceramic Fiber Products

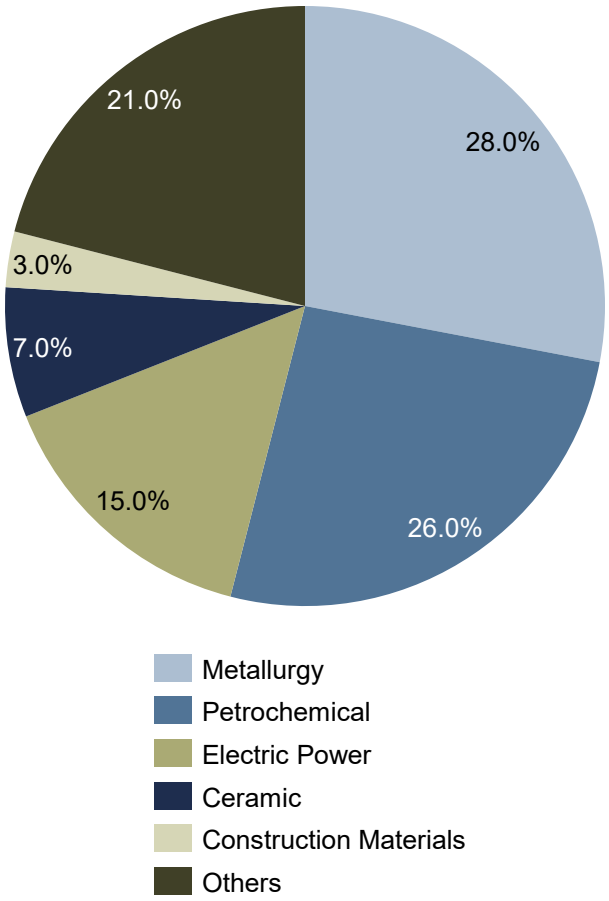
- The upstream of the ceramic fiber products mainly consists of three categories: raw coal-series kaolin ore, production operation equipment, and production operation auxiliary materials.
- The midstream of the ceramic fiber products is the ceramic fiber products production, which includes Processes such as batching, melting, fiber - forming, cotton - forming, heat - treatment, slag removal, cutting, and packaging.
- The downstream of the ceramic fiber products is the downstream application. Ceramic fiber products are widely used in high-temperature industries such as metallurgy, petrochemical, and ceramics. Ceramic fiber products come in various shapes, including blankets, boards, modules, papers, cloths and tubes, etc.



Source: Frost & Sullivan

Overview of the Ceramic Fiber Market
Downstream Applications of Ceramic Fibers in China

The proportion of Downstream Applications of Ceramic Fibers in China



Introduction to the Application Scenarios of Ceramic Fibers

- Metallurgy: Lining material for blast/reheating/annealing furnaces. High-temp resistance and insulation reduce heat loss (enhance efficiency/lifespan).
- Petrochemical: Insulation for cracking/hydrofining/hydrogen furnaces. Lightweight structure reduces load and construction time.
- Electric Power: Insulation boards for transformers/reactors. Low thermal conductivity ensures stable operation. Flue/duct casings improve energy efficiency.
- Ceramic: Kiln walls/doors in shuttle/tunnel kilns. Thermal-shock resistance ensures even temperatures (reduce energy loss). Kiln car/door linings enhance safety.
- Construction Materials: Fire doors/curtains/wall insulation (slow fire spread). Lightweight boards for roofs/partitions (support energy-saving goals).
- Others:
  - Aerospace: Thermal protection systems.
  - Automotive: Exhaust heat shields; brake linings.
  - New Energy: Nuclear insulation; battery high-temp protection.

Source: Frost & Sullivan

Overview of the Ceramic Fiber Market

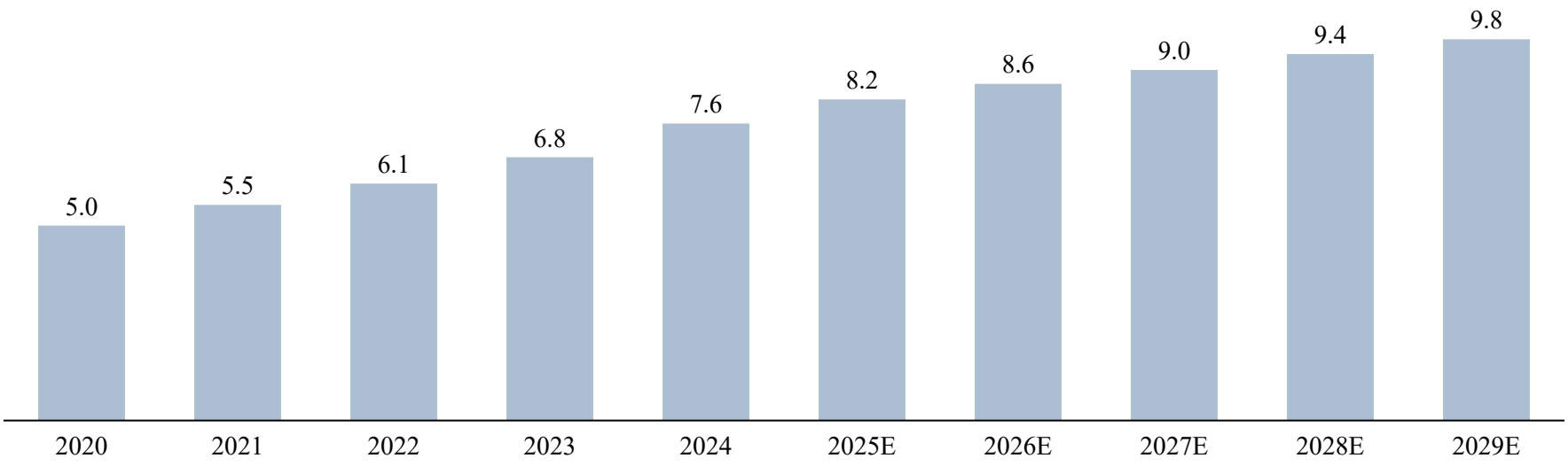
China's Ceramic Fiber Market Size, 2020-2029E

- Over the past five years, China's ceramic fiber market has grown steadily. Driven by the "dual control" energy policy, the lightweight needs of new - energy vehicles, and emerging applications in aerospace, concentrated solar power, etc., the market size reached RMB7.6 billion in 2024, with a 2020 - 2024 CAGR of 11.1%. In the next five years, with the deepening of energy - saving policies, ceramic fiber, due to its good fire - resistance and heat - insulation properties, will expand its replacement of low - grade refractory materials. Meanwhile, technological upgrades will increase the share of high - end products, further growing the market. It is expected to reach RMB9.8 billion in 2029, with a GAGR of 5.1%.

China's Ceramic Fiber Market Size, by Sale Revenue of Ceramic Fiber

Unit: Billion RMB

CAGR	2020-2024	2024-2029E
Ceramic Fiber	11.1%	5.1%



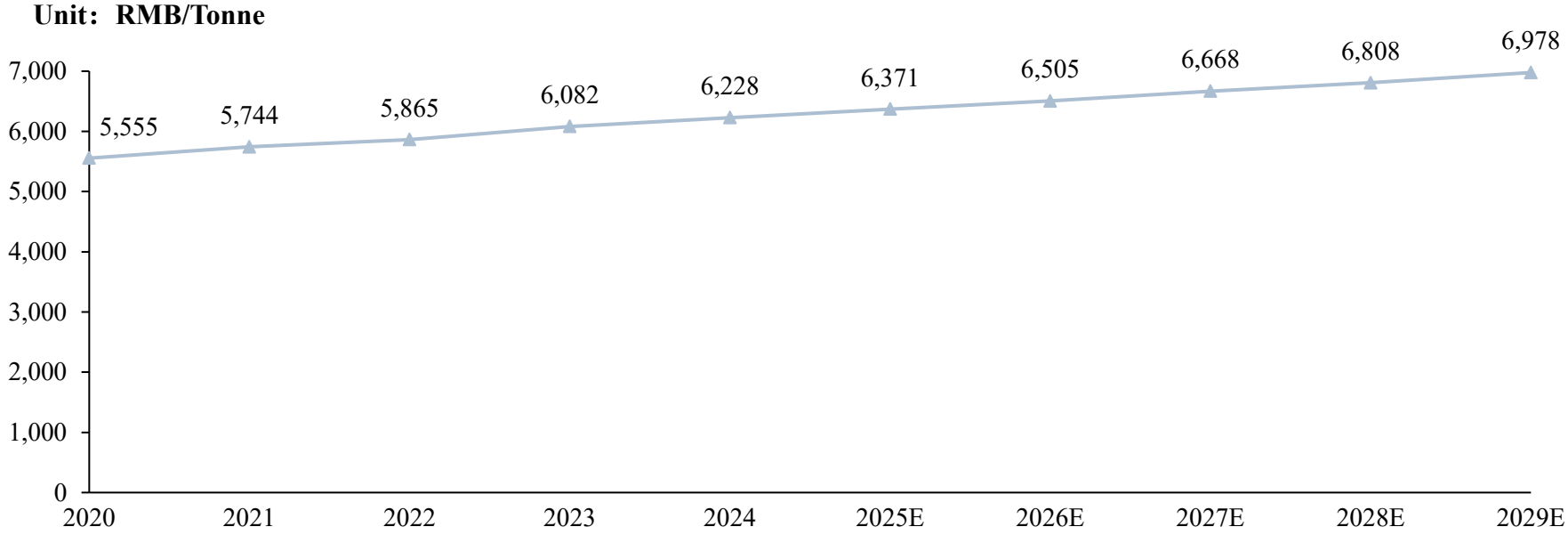
Source: Frost & Sullivan

Overview of the Ceramic Fiber Market

China's Ceramic Fiber Market Size, 2019-2028E

- Due to the difference in its aluminum content, ceramic fiber can be adapted to working environments within different temperature ranges from 800 ℃ to 1600 ℃. In terms of price, its tax-exclusive price fluctuates within a wide range, varying from several thousand yuan per ton to over ten thousand yuan per ton. In 2024, the average tax-exclusive price of ceramic fiber was 6,228 RMB/tonne. At the same time, ceramic fiber products also show a trend of developing towards high-end. In the selection of raw materials for high-end ceramic fiber products, the usage amount of aluminum oxide will be increased. In recent years, the market price of aluminum oxide materials has been on the rise, which undoubtedly promotes the increase in the production cost of ceramic fiber and, in turn, causes the average price of ceramic fiber to rise. It is expected that in the future, with the acceleration of the high-end process of products, the cost and price of ceramic fiber will further increase. It will reach 6,978 yuan per ton by 2029. However, the price of ceramic fiber is also affected by other factors such as policies and regulations, market competition, and production process costs.

Average Price (Tax-excluded) of Ceramic Fiber in China



Source: Expert interviews, Frost & Sullivan

Overview of the Ceramic Fiber Market
Market Drivers of the Ceramic Fiber Market

Policy-oriented Energy-saving Transformation

The implementation of China's "dual carbon" goals and the "dual control" policy on energy consumption has prompted industrial enterprises to accelerate the adoption of high-efficiency energy-saving materials. Due to its excellent thermal insulation performance, ceramic fiber can significantly reduce the heat energy losses of industrial furnaces, pipelines and other equipment. In recent years, through policies such as the "Action Plan for Industrial Energy Efficiency Improvement", the government has explicitly required high-energy-consuming industries to promote the substitution of traditional refractory bricks with ceramic fiber, further stimulating market demand.

Industrial Upgrading and Expansion of Emerging Application Scenarios

As traditional manufacturing upgrades to high - end and intelligent, demand for heat - resistant, lightweight materials surges. Equipment renewal and process improvement in metallurgy, petrochemicals, and power boost ceramic fiber application in high - temp insulation and equipment protection. Meanwhile, booming building fire prevention, new energy vehicles, and concentrated solar power drive new ceramic fiber demands. Material property requirements in these sectors push the industry towards diversification and customization.

Technological Innovation and High-end Breakthroughs

The industry continuously breaks through the bottlenecks of material performance through technological research and development. For example, it develops fiber products with higher temperature resistance and stronger corrosion resistance, as well as biodegradable and safe fibers. Technological upgrades not only broaden the application of ceramic fibers in high-end fields such as aerospace and new energy, but also enhance the overall added value of the industry.

Source: Frost & Sullivan

Overview of the Ceramic Fiber Market

Market Trends of the Ceramic Fiber Market

Technological Innovation

Technological advancements have been achieved in the field of refractory mullite products. The continuous innovation of production technologies, especially the improvements in calcination techniques and manufacturing processes, has improved the quality, performance, strength and thermal stability of kaolin mullite. These enhancements enable kaolin mullite to meet the requirements of more demanding application scenarios and have a greater cost-effectiveness advantage, thereby further expanding its application range in the industrial field.

Sustainability in Focus

Sustainability is the core concern in the refractory mullite products market. Due to strict environmental regulations, industries are inclined towards products with minimal environmental impact. Refractory kaolin mullite products are widely favored as they meet performance and sustainability standards. Additionally, the trend of recycling and reusing kaolin and other raw materials in refractory production is obvious, aligning with the global circular economy and sustainable resource management trend.

Source: Frost & Sullivan

Overview of the Ceramic Fiber Market

Overview of Policies in the Ceramic Fiber Industry

Policy	Issue time	Department	Main contents
Decision of the Central Committee of the Communist Party of China on Further Comprehensively Deepening Reforms and Promoting Chinese - style Modernization（《中共中央关于进一步全面深化改革推进中国式现代化的决定》）	2024.7	The Third Plenary Session of the 20th Central Committee（二十届三中全会）	Improve the green and low - carbon development mechanism, establish a new mechanism for the comprehensive transformation of dual - control of energy consumption to dual - control of carbon emissions, build relevant systems and institutions, and actively and steadily promote carbon peaking and carbon neutrality
2024 - 2025 Energy Conservation and Carbon Reduction Action Plan（《2024—2025 年节能降碳行动方案》）	2024.5	The State Council （国务院）	Deploy 10 actions and 27 tasks such as reducing and replacing fossil energy consumption and increasing non-fossil energy consumption.
Action Plan for Promoting Large - scale Equipment Updating and Trade - in of Consumer Goods（《关于促进钢铁工业高质量发展的指导意见》）	2024.3	The State Council （国务院）	Implement equipment renewal actions, promote equipment renewal and transformation in key industries, promote equipment renewal and technological transformation in the direction of energy conservation and carbon reduction, promote advanced energy conservation and energy use equipment, and implement energy conservation and carbon reduction transformation
Opinions on Accelerating the Establishment of a Product Carbon Footprint Management System, National Green and Low - carbon Advanced Technology Achievement Catalog, etc.（《关于加快建立产品碳足迹管理体系的意见》《国家绿色低碳先进技术成果目录》等）	2024.1	Ministries and commissions such as the Ministry of Industry and Information Technology, the National Development and Reform Commission, and the Ministry of Science and Technology（工业和信息化部、国家发展改革委、科技部等部委等）	Improve the green manufacturing and service system, promote industrial green development, contribute to carbon peaking and carbon neutrality, and organize and carry out work related to energy conservation and carbon reduction.
Guiding Opinions on Accelerating the Transformation and Upgrading of Traditional Manufacturing Industries（《关于加快传统制造业转型升级的指导意见》）	2023.12	Eight departments including the Ministry of Industry and Information Technology（工信部等八部门）	By 2027, enhance the high-end, intelligent, green, and integrated development level of China's traditional manufacturing industry, and consolidate and enhance its position and competitiveness in the global industrial division of labor.
National Standard of “Energy Consumption Quota per Unit Product of Aluminosilicate Fiber and Its Products” (GB40877 - 2021)（《硅酸铝纤维及制品单位产品能源消耗限额》（GB40877 - 2021）国家标准）	2022.11	State Administration for Market Regulation（国家市场监督管理总局）	Promote the optimized development of production technology in the ceramic fiber industry and phase out backward production capacity.

Source: Frost & Sullivan

Agenda

Overview of China Kaolin Resources Market

Ranking of Coal-series Calcined Kaolin Company by the Revenue for Kaolin Products in 2024

- In 2024, the market size for kaolin deep-processed products in China reached RMB10,159.6 million. The market size for coal-series calcined kaolin products accounted for RMB4,965.9 million, representing 48.9% of the overall market. In terms of revenue of coal-series calcined kaolin companies in 2024, the top five participating companies in the market had a combined market share of 50.8%. Among them, Anhui Jinyan ranked 5th with a market share of 5.4 %. The following table presents the ranking of China's coal-series calcined kaolin companies, as measured by the revenue of kaolin products in 2024.

Ranking of Coal-series Calcined Kaolin Companies, by Sales Revenue, 2024

Ranking	Company	Revenue (million RMB)	Market Share
1	Shanxi Bright Kaolin Technology Co., Ltd（A） 山西金宇科林科技有限公司	970	19.5%
2	Shanxi Hengyuan Kaolin Co., Ltd（B） 山西恒源高岭土有限公司	500	10.1%
3	Inner Mongolia Super New Material Co., Ltd（C） 内蒙古超牌新材料股份有限公司	496	10.0%
4	Inner Mongolia Sanxin Kaolin Co., Ltd（D） 内蒙古三鑫高岭土有限责任公司	290	5.8%
5	Anhui Jinyan Kaolin New Materials Co.,Ltd 安徽金岩高岭土新材料股份有限公司	267	5.4%
	Top five in total	2523.0	50.8%

Source: Expert interviews, Frost & Sullivan

Overview of Competitive Landscape of Kaolin Market

Ranking of Manufacturers of Precision Casting Mullite Products, by revenue of Precision Casting Mullite Products in 2024

- In 2024, the market size of precision casting mullite products in China reached RMB971.9 million. In terms of revenue of precision casting mullite products in 2024, the top five participating companies in the market had a combined market share of 48.6%. Among them, Anhui Jinyan ranked 1st with the market share of 19.1%.The following table presents the ranking of manufacturers of precision casting mullite products , as measured by revenue of precision casting mullite products in 2024.

Ranking of Manufacturers of Precision Casting Mullite Products, by revenue of Precision Casting Mullite Products, 2024

Ranking	Company	Revenue (million RMB)	Market Share
1	Anhui Jinyan Kaolin New Materials Co.,Ltd 安徽金岩高岭土新材料股份有限公司	186	19.1%
2	Shandong Minghua New Material Technology Co., Ltd.（E） 山东明华新材料科技有限公司	105	10.8%
3	Wanglu Branch of Shandong Refractories Group Co., Ltd. （F） 山东耐材集团有限公司王铝分公司	98	10.1%
4	Shanxi Super Calcined Kaolin Co., Ltd. （G） 山西超牌煅烧高岭土有限公司	53	5.5%
5	Yidu Chuxiong Kaolin Co., Ltd. （H） 宜都市楚雄高岭土有限责任公司	30	3.1%
	Top five in total	472	48.6%

Source: Expert interviews, Frost & Sullivan

Overview of Competitive Landscape of Kaolin Market

Ranking of Manufacturers of Refractory Mullite Products, by revenue of Refractory Mullite Products in 2024

- The market size of refractory mullite products in China reached RMB5,525.8 million in 2024. In terms of revenue of refractory mullite products in 2024, the top three participating manufacturer in the market, namely manufacturers I, J and K, have a combined market share of 9.2%. Our Company's market share in the refractory mullite products market is 0.94%. The market is relatively fragmented, with a majority of players being small to medium-sized enterprises. The following table presents the top three manufacturers of refractory mullite products, as measured by revenue of refractory mullite products in 2024.

Ranking of Manufacturers of Refractory Mullite Products, by revenue of Refractory Mullite Products, 2024

Ranking	Company	Revenue (million RMB)	Market Share
1	Shanxi Yangquan Rulaishan Metallurgy Industry Co.,Ltd.（I） 阳泉市如来山冶金工业有限公司	180	3.3%
2	Meng Sheng New Materials Co.,Ltd.（J） 准格尔旗蒙盛新材料有限责任公司	175	3.2%
3	Jiangsu Jingxin New Materials Co., Ltd.（K） 江苏晶鑫新材料股份有限公司	152	2.8%
	Top three in total	507	9.2%

Source: Expert interviews, Frost & Sullivan

Overview of Competitive Landscape of Kaolin Market

Introduction To Enterprises In The Market Competitive Landscape

Company	Introduction
Shanxi Bright Kaolin Technology Co., Ltd 山西金宇科林科技有限公司	Shanxi Bright Kaolin Technology Co., Ltd, established in 2007 and located in Shanxi Province, is a company specializing in the development, production, and sales of calcined kaolin products. Its products are primarily applied in the fields of paper, coatings, and rubber.
Shanxi Hengyuan Kaolin Co., Ltd 山西恒源高岭土有限公司	Shanxi Hengyuan Kaolin Co., Ltd, established in 2002 and located in Shanxi Province, is a company specializing in the production of calcined kaolin products. Its products are applied in the fields of paper, coatings, ceramics, and refractory materials.
Inner Mongolia Super New Material Co., Ltd 内蒙古超牌新材料股份有限公司	Inner Mongolia Super New Material Co., Ltd, established in 2012 and located in Inner Mongolia Autonomous Region, specializes in the research, development, and production of ultrafine calcined kaolin and calcined kaolin products. These products are widely used in coatings, paper, plastics and rubber, ceramics, and refractory materials.
Inner Mongolia Sanxin Kaolin Co., Ltd 内蒙古三鑫高岭土有限责任公司	Inner Mongolia Sanxin Kaolin Co., Ltd, established in 2009 and located in Inner Mongolia Autonomous Region, specializes in producing ultrafine, high-whiteness calcined kaolin products. Its products are widely used in paper, coatings, wires and cables, plastics, rubber, and ceramics.
Yidu Chuxiong Kaolin Co., Ltd. 宜都市楚雄高岭土有限责任公司	Yidu Chuxiong Kaolin Co., Ltd. was founded in 2004 and is located in Hubei Province. Its main products include mullite sand, mullite powder, kaolin suitable for precision casting, and calcined kaolin, etc. The products are mainly applied in precision casting industries.
Shandong Minghua New Material Technology Co., Ltd. 山东明华新材料科技有限公司	Shandong Minghua New Material Technology Co., Ltd., was founded in 2021, and is located in Shandong Province. Its principal business lies in the special refractory materials. The products are widely used in the precision casting of various alloys.

Source: Company website, Frost & Sullivan

Overview of Competitive Landscape of Kaolin Market

Introduction To Enterprises In The Market Competitive Landscape

Company	Introduction
Wanglu Branch of Shandong Refractories Group Co., Ltd. 山东耐材集团有限公司王铝分公司	Wanglu Branch of Shandong Refractories Group Co., Ltd. was established in 1958. It is located in Shandong Province. It is mainly engaged in the production, processing and sales of refractory — related products. The company's products are widely used in high-temperature manufacturing industries such as metallurgy and building materials.
Shanxi Super Calcined Kaolin Co., Ltd. 山西超牌煅烧高岭土有限公司	Shanxi Super Calcined Kaolin Co., Ltd., established in 2017, is located in Shanxi Province. The company mainly produces kaolin products through calcination. The company's products are widely used in industries such as ceramics, glass fiber, precision casting, calcining saggers for lithium battery materials and refractory materials.
Shanxi Yangquan Rulaishan Metallurgy Industry Co.,Ltd. 阳泉市如来山冶金工业有限公司	Shanxi Yangquan Rulaishan Metallurgy Industry Co.,Ltd. established in 1999 and located in Shanxi Province, is a company focused on the refractory materials sector. It primarily engages in the production and sales of high-performance refractory materials such as mullite, with products widely used in metallurgy, building materials, and chemical industries.
Meng Sheng New Materials Co.,Ltd. 准格尔旗蒙盛新材料有限责任公司	Meng Sheng New Materials Co.,Ltd. established in 2003 and located in Inner Mongolia Autonomous Region, is an enterprise that utilizes local mineral resources to process kaolin and produce mullite for refractory use. Its products are mainly applied in the steel and construction materials industries.
江苏晶鑫新材料股份有限公司	Jiangsu Jingxin New Materials Co., Ltd. established in 2005 and located in Jiangsu Province, is a company specializing in the research, production, and sales of high-purity, high-temperature synthetic refractory raw materials. Its main products include sintered mullite, sintered alumina, and magnesia-alumina spinel, which are widely used in industries such as steel, cement, glass, ceramics, and petrochemicals.

Source: Company website, Frost & Sullivan

Agenda

Appendix

- According to the national standard "Kaolin and Its Test Methods" (GB/T 14563-2020), The mass fraction of aluminum oxide (Al_2O_3) and silicon dioxide (SiO_2) are as follows:

Physicochemical Performance Requirements			
	Main Applications	Content of Aluminum Oxide (Mass Fraction) / %	Content of Silicon Dioxide (Mass Fraction) / %
Industry Standards	Enamel Industry	≥36	-
	Paper Industry	≥42	≤54
	Rubber Industry	≥42	≤55
	Ceramic Industry	≥42	-
	Coating Industry	≥42	≤55

Source: The State Administration for Market Regulation, Frost & Sullivan

Appendix

- Compared with other mullite sand/powder products for precision casting on the market, Anhui Jinyan's products have a higher content of Al_2O_3 and thus possess higher refractoriness. They also have a lower content of other impurities and better thermochemical stability. The shell molds prepared with them are of high strength and good collapsibility.

	Grade	Chemical Composition %							Physical Properties			
				Other components content				Burn reduction ≤	Main crystal phase			Refractoriness °C≥
		Al_2O_3	SiO_2	Fe_2O_3	CaO+MgO	K_2O+Na_2O	TiO_2		Mullite	Cristobalite	glass phase	
Industry standard	I	41.0~51.0	47.0~55.0	1.2	0.6	0.4	0.7	0.3	55~65	10~20	Remainder	1790
	II	41.0~51.0	47.0~55.0	1.5	0.7	0.5	0.8	0.3	55~60	10~20	Remainder	1770
	III	41.0~51.0	47.0~55.0	2	0.8	0.6	0.9	0.3	50~55	10~20	Remainder	1750
Anhui Jinyan Kaolin New Materials Co.,Ltd	-	**49.81**	**47.57**	**0.84**	**0.32**	**0.27**	**0.67**	\	**50-60**	**10~20**	**Remainder**	**1790**
Yidu Chuxiong Kaolin Co., Ltd.	-	42~47	50~53	0.8	0.7	0.5	1.2	0.25	56~65	-	-	1750
Shandong Minghua New Material Technology Co., Ltd.	-	44~46	51~54	0.8	0.3	-	1.4		55~60	-	-	1790
Shanxi Super Calcined Kaolin Co., Ltd	-	45±1	53±1	0.8	0.5	0.5	1.5	0.3	55~58	-	-	1790

Source: Frost & Sullivan

Appendix

- The Shuoli Kaolin Mine, situated in Shuoli Town, Duji District, Huaibei City, Anhui Province, has a 17.9955 - square - kilometer mining area. Located in the East China hinterland at the intersection of Jiangsu, Shandong, Henan, and Anhui provinces, adjacent to the Yangtze River Delta city cluster, it enjoys a well - developed transportation network. Connected to Huaibei City by Anhui Provincial Highway S101 and other paved roads, and reaching multiple provinces via G30 and G3 expressways, with the ability to ship products from Jiangsu and Shandong to Guangdong by sea, this network eases product transportation to Huaibei and its surroundings.

Source: Frost & Sullivan