From Regional Mismatch to Coordinated Optimization: Interpreting the Development of China's Anode Industry in 2024

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Abstract

In 2024, China's prebaked anode industry reached a total production capacity of 30.366 million tonnes and an output of 23.102 million tonnes, with a capacity utilization rate of approximately 76 %. High-efficiency capacity accounts for more than 40 %, signalling a shift from expansion to efficiency-driven development. Regionally, Shandong has a high concentration of capacity and strong export capability, whereas Yunnan and Inner Mongolia face tight supply due to the clustering of aluminum smelters, forming a clear regional mismatch. At the enterprise level, a "strong-get-stronger" pattern emerges as leading companies leverage scale and market advantages to maintain dominance, while inefficient and idle capacities continue to exit. Meanwhile, anode exports surged to a record 2.166 million tonnes in 2024, increasing reliance on international markets and driving globalization of the industry. Looking ahead, the industry will continue to evolve toward high-quality development through enhanced efficiency, structural optimization, and coordinated growth.

Keywords: Prebaked anode, Capacity distribution, Regional supply-demand mismatch, Export growth, Efficiency transition.

1. Background and Current Status

Prebaked anode is a key raw material in primary aluminum production, with about 450 kg of anode consumed per tonne of aluminum [1]. As China's electrolytic aluminum capacity gradually shifts westward, the anode industry has been marked by continued capacity expansion alongside regional supply-demand mismatches. Eastern provinces such as Shandong and Henan have highly concentrated anode capacity, leading to oversupply in some areas; whereas resource-rich regions like Yunnan and Inner Mongolia have relatively lagging supporting capacity and require significant inter-provincial transfers. In addition, international markets are increasingly reliant on high-quality anodes, and China's anode exports have sustained growth, becoming an important channel to absorb excess domestic capacity.

This paper focuses on the supply-demand landscape, efficiency structure, and export dynamics of China's anode industry in 2024. Based on field research, industry statistics, and analysis of enterprise samples, it systematically reviews the current state of the industry, summarizes the evolution of efficiency patterns, and forecasts future development trends, providing a reference for policy-making and corporate strategy.

2. Industry Development Trends under Supply-Demand Linkage

The prebaked anode value chain mainly comprises three segments: raw material supply, anode manufacturing, and aluminum electrolysis consumption. In recent years, the growth of China's

electrolytic aluminum capacity has gradually slowed, limiting the potential increase in anode demand, and overall industry demand has stabilized. However, domestic anode capacity continues to expand, with excess capacity arising in certain regions and pronounced regional supply-demand mismatches. Meanwhile, growing demand in the international aluminum market has driven foreign smelters to increase imports of Chinese anodes, and the export market has gradually become an important outlet to absorb surplus domestic capacity.

Consequently, a new supply-demand dynamic has emerged in the prebaked anode industry, characterized by *"steady domestic demand, easing regional mismatch, and continuously growing international demand."* This interplay is guiding the industry from a phase of scale expansion toward structural optimization, as shown in Figure 1.

Figure 1. Distribution of prebaked anode production capacity by province in mainland China, in 2024 (million tonnes)

3. Regional Capacity Distribution and Enterprise Efficiency Differences

3.1 Significance and Application of the Capacity Utilization Rate Indicator

Capacity utilization is an important metric for evaluating efficiency in the prebaked anode industry, as it comprehensively reflects a company's production level, economic performance, and market supply-demand status. A high-capacity utilization rate indicates that equipment is being used efficiently, spreading fixed costs over more output and thus lowering unit production costs; whereas a low utilization rate implies idle capacity and difficulties in profitability.

Moreover, differences in capacity utilization highlight market conditions and competitiveness: companies with high utilization typically possess technological, scale, or market advantages that allow them to lead in the competition, while those with persistently low utilization face the risk of being eliminated. Therefore, capacity utilization not only directly reflects an enterprise's operational efficiency but also reveals the industry's supply-demand structure and the direction of optimization, making it a critical foundation for analyzing efficiency disparities within the industry.

3.2 Criteria for Enterprise Efficiency Classification

As shown in Table 1, to accurately analyze efficiency differences among anode producers, a systematic statistical analysis of 2024 industry data was conducted. Using cluster analysis on the number of enterprises, capacity scale, and operating status, three efficiency categories were defined: high-efficiency (> 90 %), medium-efficiency (62–90 %), and low-efficiency (< 62 %).

Table 1. 2024 Capacity utilization rate distribution by province in China.

Province	Capacity (Mt)	High-efficiency (> 90 %)	Medium-efficiency (62–90 %)	Low-efficiency (< 62 %)	Shutdown
Shandong	9.15	60 %	16 %	18 %	6 %
Xinjiang	3.55	54 %	12 %	34 %	0 %
Henan	3.45	18 %	41 %	16 %	24 %
Inner Mongolia	2.16	32 %	68 %	0 %	0 %
Yunnan	1.7	100 %	0 %	0 %	0 %
Gansu	1.66	50 %	26 %	18 %	6 %
Guangxi	1.43	37 %	49 %	14 %	0 %
Qinghai	1.17	27 %	59 %	0 %	14 %
Liaoning	1.04	0 %	52 %	48 %	0 %
Guizhou	0.68	0 %	88 %	12 %	0 %
Ningxia	0.66	27 %	73 %	0 %	0 %
Others	3.73	29 %	34 %	17 %	20 %
Total	30.37	44 %	31 %	17 %	8 %

Specifically, the 90 % threshold for high-efficiency capacity was determined based on typical industry operating experience and indicates nearly full-capacity operation; the 62 % cutoff between medium and low efficiency was derived from cluster analysis of the 2024 capacity utilization distribution. As shown in Figure 3, a distinct gap in utilization appears around 62 %: companies above 62 % utilization operate under normal conditions, whereas those below 62 % exhibit significantly reduced utilization, with substantial capacity idle or nearly shut down. Thus, adopting 62 % as the medium/low efficiency boundary effectively differentiates enterprises at varying efficiency levels and helps reveal the internal structure of capacity utilization. This classification approach provides a robust data support and analytical basis for subsequent analysis of regional structure and industry efficiency.

3.3 Analysis of Nationwide Capacity Efficiency Structure

According to the above classification criteria, as shown in Figure 2, China's anode capacity in 2024 exhibits a "high concentration, high efficiency" profile.

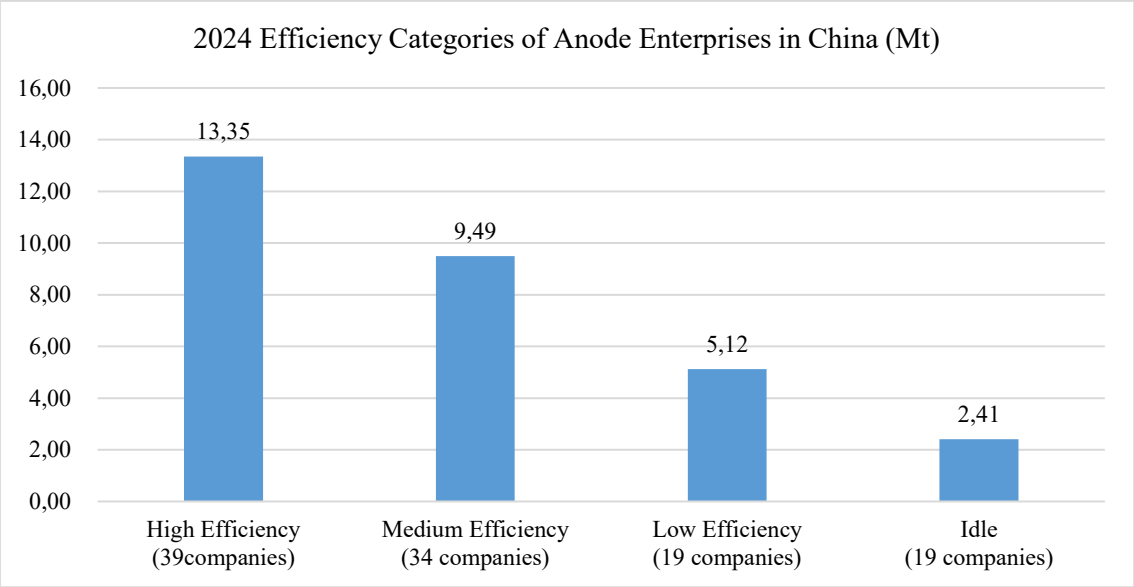

Figure 2. 2024 capacity utilization rate distribution of China's prebaked anode industry by efficiency category.

The specific breakdown is as follows:

- **High-efficiency capacity:** 39 enterprises with a combined capacity of 13.35 Mt, accounting for 44 % of the national total.
- **Medium-efficiency capacity:** 34 enterprises, combined capacity 9.491 Mt, about 31 % of the total.
- **Low-efficiency and idle capacity:** 38 enterprises (including 19 completely idle), combined capacity 7.53 Mt, about 24.8 % of the total, of which idle (shut-down) capacity is 2.41 Mt.

Structurally, the share of high-efficiency capacity has risen markedly – nearly 40 % of enterprises are running at above 90 % utilization, demonstrating the competitiveness of leading firms. Medium-efficiency capacity provides stable supply and serves as the backbone in their regions. Although low-efficiency and idle producers are large in number (over one-third of enterprises), they are generally small in scale and contribute relatively little. In total, the medium- and high-efficiency capacity accounts for over 75 % of supply, which constitutes the main effective supply in the market and reflects a trend of survival of the fittest and efficiency-driven evolution in the industry.

3.4 Regional Efficiency Differences and Supply-Demand Imbalance

As shown in Table 2, there are significant regional efficiency disparities in China's anode industry in 2024, generally reflecting a pattern of "higher efficiency in the West, mixed performance in the East/Central." Western regions (e.g. Yunnan, Ningxia, Qinghai) mostly host captive anode plants paired with local smelters, resulting in strong in-province demand absorption and average utilization rates near full capacity—significantly above the national average. In contrast, parts of the Central and Eastern regions have excess capacity and lower efficiency. Typical regional examples are as follows:

- **Shandong (East):** 2024 anode capacity 9.15 Mt, output 7.515 Mt, utilization 82 %. It is the country's largest anode production base and exporter. Although Shandong's electrolytic aluminum output (7.368 Mt [2]) corresponds to only 3.316 Mt of local anode demand (plus ~1.636 Mt for export), Shandong's concentration of raw materials, technology, and leading firms gives it a strong external supply capability. It is the only province with a supply

surplus over 4 Mt, and its high-efficiency capacity underpins the national redistribution of anodes.

- **Henan (Central):** Anode capacity 3.45 Mt, output 1.760 Mt, utilization only 51 %. Local anode demand is under 1 Mt [2], yet supply still exceeds demand, and 7 enterprises remained idle all year. Structural excess capacity and low utilization are prominent, making Henan a relatively low-efficiency region.
- **Yunnan (West):** Anode capacity 1.70 Mt, output 1.690 Mt, utilization as high as 99 %. Provincial electrolytic aluminum output is 5.47 Mt [2], corresponding to an anode demand of 2.462 Mt, far above local anode capacity. Yunnan is thus a net importer of anodes from other regions. A high anode-self-sufficiency rate (due to paired anode plants) ensures local factories operate at full capacity, making Yunnan a model high-efficiency province.

Table 2. 2024 anode production capacity, output, and utilization rate by province

Province	Capacity (Mt)	Output (Mt)	Utilization (%)
Shandong	9.15	7.52	82.13 %
Xinjiang	3.55	2.77	78.09 %
Henan	3.45	1.76	51.05 %
Inner Mongolia	2.16	1.89	87.70 %
Yunnan	1.70	1.69	99.24 %
Gansu	1.66	1.28	76.78 %
Guangxi	1.43	1.25	87.48 %
Qinghai	1.17	0.81	68.96 %
Liaoning	1.04	0.59	56.72 %
Guizhou	0.68	0.56	82.07 %
Ningxia	0.66	0.60	91.32 %
Others	3.73	2.40	64.30 %
Total	30.37	23.10	76.08 %

Overall, the anode industry's regional structure can be summarized as "high supporting capacity and efficiency in the West, and more oversupply and shutdowns in parts of the East/Central." Going forward, optimizing the geographic layout and improving regional supply-demand alignment will be key to enhancing overall industry efficiency.

3.5 Relationship between Enterprise Size and Capacity Utilization

As shown in Figure 3, examining the relationship between enterprise capacity scale and utilization in 2024 reveals a clear structural divergence: larger enterprises tend to have higher capacity utilization, exemplifying a "strong get stronger" characteristic of the industry [3]. In particular:

- **Large enterprises dominate high-efficiency capacity.** Most anode producers with annual capacity above 0.5 Mt are either captive plants of aluminum groups or independent industry leaders, and their utilization rates are generally above 90 %. For example, companies like Chinalco, Xinfa, and Sunstone operate anode bases in Shandong, Yunnan, Ningxia, etc., all at high load – some even above design capacity. Thanks to stable orders, integrated operations, and raw material bargaining advantages, these firms exhibit strong resilience through market cycles.
- **Small and medium enterprises are concentrated in the low-efficiency range.** Independent anode plants with annual capacity below 0.2 Mt are under significant pressure, and most operate below 62 % utilization, with quite a few completely idle. In 2024, 19 companies did not operate at all, with an average capacity of only ~0.127 Mt.

Lacking stable customers, bargaining power, and risk resistance, these enterprises have become prime targets for capacity exit.

- **Industry resources are rapidly concentrating toward advantaged firms.** Data show that high-efficiency capacity accounts for ~44 % of national capacity, mainly in about 40 large and mid-sized enterprises; whereas low-efficiency and idle enterprises number 38 (roughly one-third of producers) but together constitute less than one-quarter of capacity. The bulk of supply is thus provided by more efficient large players, indicating a continued tilt of resources toward industry leaders.

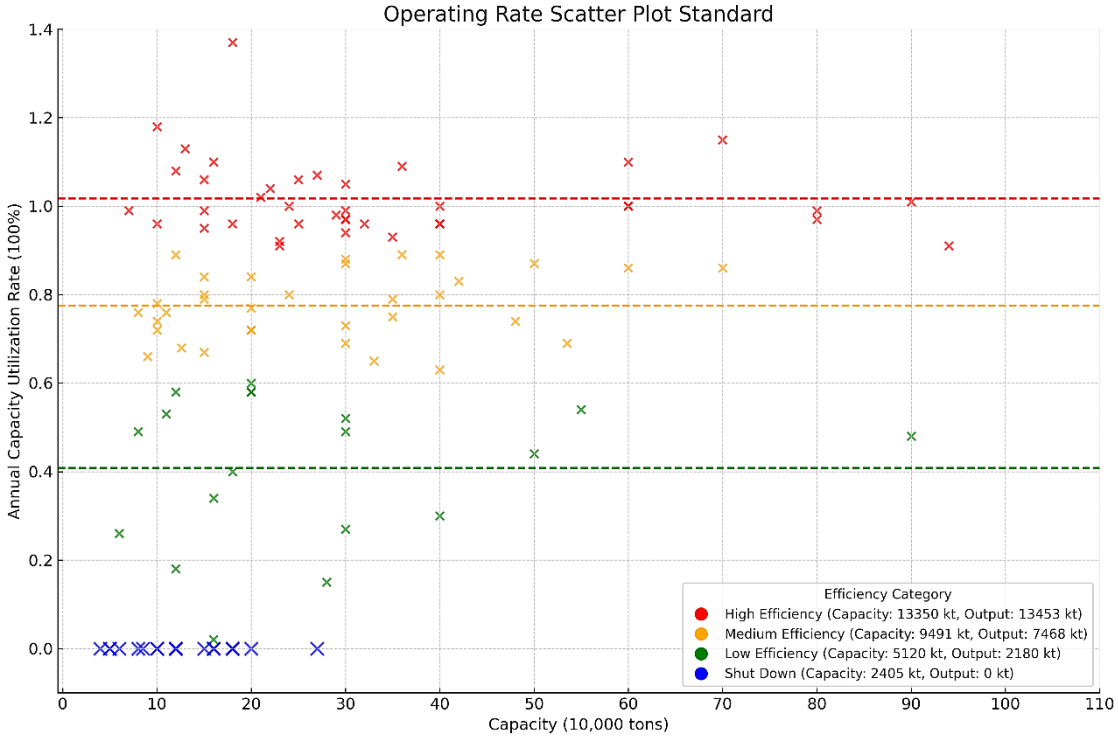

Figure 3. Scatter plot of capacity utilization vs. plant size for Chinese prebaked anode producers (2024).

In summary, the anode industry is undergoing dual transformations driven by both scale and efficiency: large enterprises are expanding market share through economies of scale and coordinated integration, while small enterprises face pressure to exit. In the future, effective supply is expected to concentrate further, and the overall baseline of capacity utilization should steadily rise.

4. Export Landscape and International Market

4.1 Growth of China's Anode Exports

As shown in Table 3, China is the world's largest exporter of prebaked anodes, with export volumes reaching 2.166 Mt in 2024, a year-on-year increase of 19.3 % and a new record. Export fluctuations closely mirror international demand. In 2023, China's anode exports had dipped to 1.815 Mt due to the restart of overseas anode plants, but in 2024, recovering demand from new aluminum capacity abroad drove a sharp rebound in exports. Leading companies secured sales through long-term contracts, effectively mitigating the impact of market volatility on profitability.

Table 3. 2024 anode output, domestic demand, exports, and regional balance in major Chinese provinces.

Province	Output (Mt)	Domestic Demand (Mt)	Exports (Mt)	Regional Balance (Mt)
Shandong	7.52	3.32	1.64	2.56
Xinjiang	2.77	2.80	0.00	–0.026
Inner Mongolia	1.89	2.99	0.00	–1.095
Yunnan	1.69	2.46	0.00	–0.775
Gansu	1.28	1.37	0.00	–0.097
Qinghai	0.81	1.29	0.00	–0.479
Guangxi	1.25	1.31	0.00	–0.062
Henan	1.76	0.88	0.02	0.87
Guizhou	0.56	0.76	0.00	–0.198
Others	3.59	2.39	0.51	0.68
Total	23.10	19.56	2.17	1.38

4.2 Changes in Major Export Markets

As shown in Table 4, China's anode export markets have become increasingly diversified in recent years. In 2024, the top three destination countries were Malaysia (0.5499 Mt, 25 % of total), Canada (0.2661 Mt, 12 %), and Norway (0.2427 Mt, 11 %). Malaysia's imports rose sharply due to new domestic smelting capacity coming online; Canada and Norway have long relied on China for high-quality anodes. Meanwhile, emerging markets are rapidly increasing their imports, especially Indonesia with a newly added million-tonne-class smelter project that is highly dependent on Chinese anodes.

Table 4. Chinese prebaked anode export volumes and shares by country, 2023–2024.

Country/Region	2024 Export (kt)	2024 Share (%)	2023 Export (kt)	2023 Share (%)
Malaysia	549.9	25 %	538.4	30 %
Canada	266.1	12 %	283.2	16 %
Norway	242.7	11 %	221.4	12 %
United Arab Emirates	240.4	11 %	104.2	6 %
Russia	216.7	10 %	179.6	10 %
Indonesia	192.3	9 %	96.5	5 %
Iceland	120.2	6 %	121.6	7 %
Oman	66.3	3 %	0	0 %
South Korea	53.4	2 %	0.6	0 %
Bahrain	52.5	2 %	26.9	1 %
Others	165.2	8 %	242.7	13 %
Total	2 165.8	100 %	1 815.2	100 %

Chinese companies are gradually shifting from solely exporting products to exporting capacity and services. For example, Sunstone Development will jointly build a plant with Emirates Global Aluminum (EGA), pioneering a new model of overseas production and achieving deep integration abroad. In addition, through long-term contracts, dedicated supply for key customers, and

differentiated market strategies, companies have further increased their penetration in overseas markets.

5. Results and Discussion

5.1 Slower Capacity Expansion, More Optimized Layout

The deployment of new anode capacity is becoming increasingly rational, focusing on areas with superior resource endowments and concentrated demand. For example, western regions like Yunnan and Gansu have accelerated project implementation, while traditional production hubs such as Shandong are concentrating on structural upgrades and technological renovations. Overall, the pace of capacity expansion has slowed and the industry layout is becoming more optimized.

5.2 Regional Mismatch Eases; Self-Sufficiency Expected to Improve

The westward shift of aluminum smelting capacity has exacerbated regional anode supply-demand imbalances. In 2024, Shandong's anode output exceeded in-province demand by about 4.2 Mt, while Yunnan and Inner Mongolia faced anode supply gaps of approximately 0.77 Mt and 1.1 Mt, respectively. With new supporting anode projects being commissioned, local supply-demand alignment is set to improve, and the pressure of cross-province transport will gradually decrease.

5.3 Export Growth Remains Sustainable, Capacity Gradually Spilling Over

In 2024, China's anode exports surpassed 2 Mt, providing a new avenue to effectively release excess domestic capacity. Dependence on markets in the Middle East and Southeast Asia continues to deepen. Chinese anode producers are accelerating their overseas footprint—including building plants abroad and forming long-term partnerships—to drive exports to a more advanced stage.

5.4 Leading Enterprises' Agglomeration Effect Strengthens, Concentration Increases

High-efficiency producers continue to run at high utilization; in Yunnan and Ningxia, many projects are operating near full capacity, while a wave of shutdowns of small plants is ongoing. Leading enterprises are leveraging synergies and scale advantages to further expand market share, resulting in a steady increase in industry concentration.

5.5 Coordination and Efficiency as Future Themes

The industry is undergoing a transition from an "incremental era" to an "optimization era." With capacity expansion slowing, companies are placing greater emphasis on coordinated development with downstream aluminum smelters, high-quality operations, and efficiency improvement – shifting the growth model from resource-driven to profit-driven.

6. Conclusions and Possible Further Work

By 2024, China's anode industry had formed a landscape dominated by high-efficiency leading enterprises, with exports and captive supply developing in tandem. As aluminum capacity continues to cluster in the western regions, local anode supporting capacity has rapidly strengthened; in the eastern regions, the focus has shifted from expansion to high-quality operations, with initial results in structural optimization. Industry resource allocation is concentrating faster towards dominant players, the proportion of high-efficiency capacity is steadily increasing, and overall capacity utilization is moving into a more rational range. The

ongoing expansion of export markets has not only helped absorb surplus capacity but also propelled Chinese anode companies onto the global stage, opening a new chapter of capacity internationalization. Meanwhile, leading enterprises are further solidifying their market position through coordinated strategies and scale advantages, driving a steady rise in industry consolidation.

Looking ahead, the anode industry will continue to progress in the direction of "efficiency orientation, structural optimization, and coordinated development", achieving a transition from scale expansion to quality enhancement and entering a more stable, efficient, and internationalized stage of development.

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