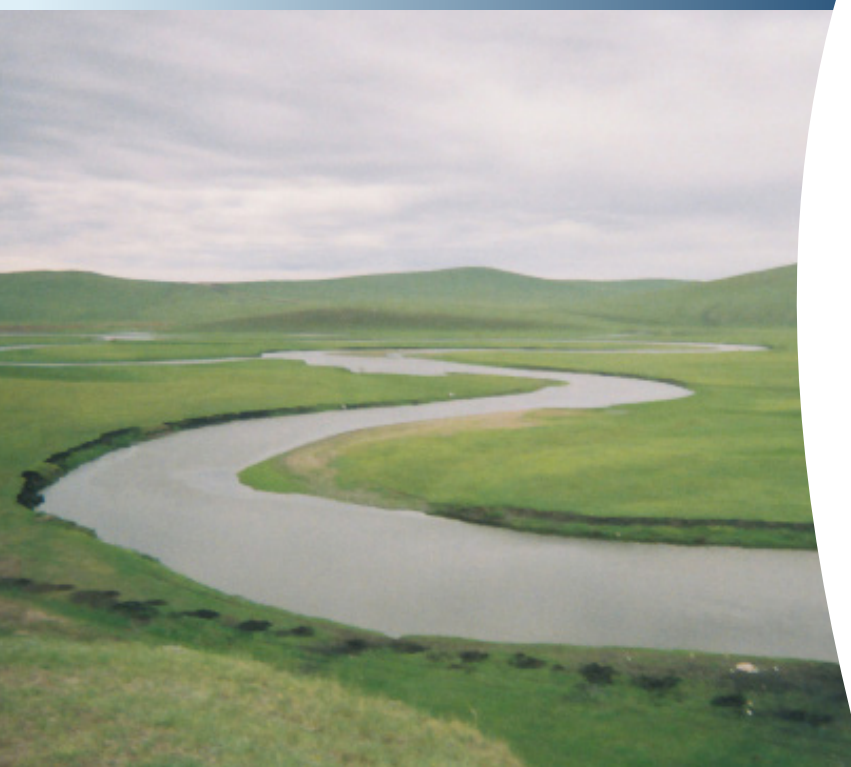


THE IMPACT OF CHINA'S ETS ON INNER MONGOLIA'S ALUMINIUM INDUSTRY:

A Deep Dive into Inner Mongolia, One of China's
Top Three Aluminium-Producing Provinces

September 2025



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INTRODUCTION

Aluminium production is one of China's most energy and greenhouse gas (GHG) emission-intensive industrial processes contributing to 5% of the country's total GHG emissions.¹ As a material of clean-energy technologies which contributes to more than 10% of China's economic growth in 2024, mitigation efforts in the aluminium sector are critical for China to achieve its dual carbon goals. Under the irreversible trend of ETS application in this industry, especially after the latest inclusion of the sector into the ETS system, regional characteristics such as local grid power sources, power consumption structure of smelters, smelter technology and policies require region specific attention. This in-depth research looks into the current status of the aluminium industry's GHG mitigation efforts in Inner Mongolia, analyses the carbon cost under China's ETS scheme across different scenarios, and outlines targeted policy recommendations that can pave the way for more sustainable aluminium production.

INNER MONGOLIA OVERVIEW

Inner Mongolia, the third largest aluminium producing province in China emitted 82 Mt CO₂e in 2021 through smelting processes, accounting for 19% of the country's total aluminium smelting related emissions. Captive coal power plants supply approximately 77% of the electricity consumed by Inner Mongolia's aluminium smelters. This reliance on coal is a major driver of the sector's emissions. Over half of these captive plants still rely on subcritical technology, which is significantly more polluting than alternative technologies. Despite the environmental impact, most of these plants are relatively young with remaining operational lives of 20–30 years compared to an average 35 years lifetime, posing a long-term challenge for decarbonising Inner Mongolia's aluminium industry.

Inner Mongolia is rich in renewable resources, especially wind power. The province is rapidly expanding its renewable capacity and by mid-2024, wind and solar power made up over 45% of total installed capacity. Policies are also sending signals encouraging companies in Inner Mongolia to build captive renewable power plants so that captive coal power plants only need to supply the remaining electricity demand.² Whilst new additions of captive coal power plants are now tightly regulated (in principle new projects will not be permitted) coal remains the dominant power source in grids, leaving Inner Mongolia among the provinces with the highest grid carbon intensities.³

1 <https://www.weforum.org/stories/2022/07/decarbonizing-china-aluminium-technology/>

2 <https://www.als.gov.cn/attach/0/17343c0575734e8f91134bf429eea839.pdf>

3 https://www.gov.cn/zhengce/content/202312/content_6919000.htm

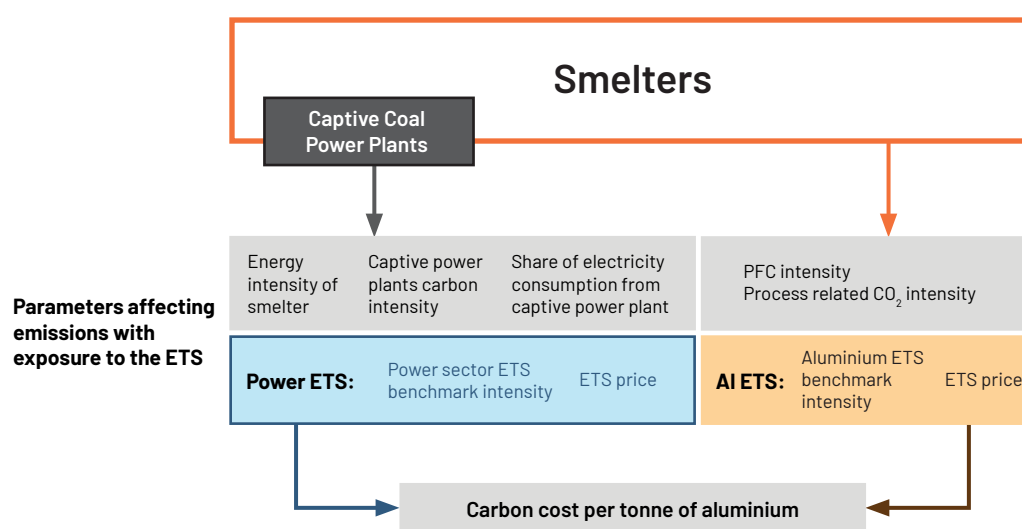
GREEN ALUMINIUM

Life cycle analysis finds that the emission intensity of one tonne of primary aluminium produced in China is about 14.8 tCO₂e/ t Al.⁴ Currently, there is no unified definition of what green aluminium is globally. Standards today are different in terms of emissions threshold, emissions scope and boundaries.⁵ In China, the China Nonferrous Metals Industry Association and the Nonferrous Metals Society of China define green aluminium as aluminium produced with no more than 30% non-green electricity. They further distinguish ultra-green aluminium as aluminium made entirely from 100% green electricity or 100% scrap.⁶

MODEL METHODOLOGY

The carbon cost simulation model is designed to replicate the China ETS market and to understand its impact on the aluminium industry in Inner Mongolia. This data-intensive model covers all 12 Inner Mongolian smelters and 39 captive coal power units. The final carbon cost results of the model are expressed in RMB per tonne of aluminium (RMB/t Al).

Figure 1. Structure of the Carbon Cost Model



When evaluating the carbon cost for primary aluminium production, this model is restricted to the smelting process only. Upstream processes, alumina refining where bauxite ores are refined into alumina that is pure enough for the smelting process, is not studied due to sample insufficiency.⁷ Inner Mongolia is not

4 Peng, T., Ou, X., Yan, X., & Wang, G. (2019). Life-cycle Analysis of Energy Consumption and GHG Emissions of Aluminium Production in China. *Energy Procedia*, 158, 3937–3943.

<https://doi.org/https://doi.org/10.1016/j.egypro.2019.01.849>

5 <https://international-aluminium.org/landing/low-carbon-aluminium-factsheet/>

6 <http://cgmc.cn/upload/1/cms/content/editor/1739519808146.pdf>

7 https://transitionasia.org/wp-content/uploads/2025/01/TA_Aluminium_Explainer_012025.pdf

a bauxite ore rich province and currently has only 3 refineries in operation. Domestically, bauxite reserves are concentrated in the provinces of Shanxi, Henan, Guangxi and Guizhou.⁸

In this study, three scenarios have been modeled:

- The **Current Policy Trajectory scenario**, is designed to provide a sense of prevailing direction of smelters' carbon cost based on current policies such as the power sector ETS and renewables replacement policy. Only direct emissions of electricity from captive coal power plants are considered aligning with the current ETS regulation.
- The **Enhanced ETS Impact scenario** explores the carbon cost under higher ETS prices (Accelerated ETS sub-scenario) and stricter ETS regulation (Zero Benchmark sub-scenario) using Current Policy Trajectory scenario as its foundation.
- The **Aluminium ETS Compliance scenario**, explores the carbon cost that aluminium smelters will be subject to. Emissions cover direct GHG emissions from smelters including Perfluorocarbons (PFCs), namely CF₄ and C₂F₆, due to anode effects and process-related CO₂ emissions due to pre-baked carbon anode consumption.

Captive power plants are subjected to the China ETS market as it applies to all thermal power plants emitting more than 26,000 tCO₂ per annum. The two main variable factors impacting the final carbon costs are the 1. ETS market price and 2. the carbon intensity of power plants. Under China's ETS rules, carbon intensity benchmarks are set according to technology type, for example, separate benchmarks apply to ultra-supercritical and subcritical coal-fired power plants. Only plants with emissions intensity above the relevant benchmark are required to purchase allowances, and even then, they only need to cover the portion of emissions that exceeds the benchmark.

Simplified power sector ETS carbon cost calculation

(Real emission intensity (tCO₂/kWh) - emission intensity benchmark (tCO₂/kWh)) x ETS market price

Whilst the details of how the aluminium ETS is to be implemented are yet to be published, the model assumes cost logic based on paying the difference between actual and benchmark emissions.

Importantly, smelters can also use electricity from grids. However, the carbon cost from grid electricity is subjected to power generators instead of consumers, these indirect emissions have not been included in the scope of this study.

MODEL RESULTS—SUMMARY

In the Current Policy Trajectory scenario, the average carbon cost for smelters in Inner Mongolia is projected to rise from approximately 120 RMB/t Al in 2021 to 400 RMB/t Al by 2030, driven by increasing ETS price and tightening standards. This is the equivalent to 2% of the average 2025 aluminium ingot price. The Current Policy Trajectory also records already-built and planned captive renewable power plants till 2030. By 2030, smelters that invest in on-site renewable power generation will reduce their carbon cost by an average of

⁸ <https://transitionasia.org/wp-content/uploads/2025/06/TA-The-Chinese-Aluminium-Sector-2025N.pdf>

around 90 RMB/t Al compared with those smelters that do not. Whilst this is encouraging, significantly more renewables are needed to drive a meaningful shift away from coal-dominated captive power in the province.

Separately, the model also assesses the impact of technological advancement. The best available technology (BAT) used in the model are the largest 600kA prebaked electrolytic cells owned by Weiqiao (Shandong) in China, and is one of the most energy-efficient smelters today. If smelters are replaced by BAT, we forecast a maximum carbon cost saving of 10 RMB/t Al. This assumes energy intensity is reduced from 13.6 MWh/t Al to 12.6 MWh/t Al while all other variables are uniformly fixed at 2021 levels. Smelters in Inner Mongolia have relatively big sizes and are efficient. This leaves limited room for further improvement, and even with full adoption of BAT, the resulting carbon cost reduction is low and insufficient to drive a fundamental shift in decarbonisation.

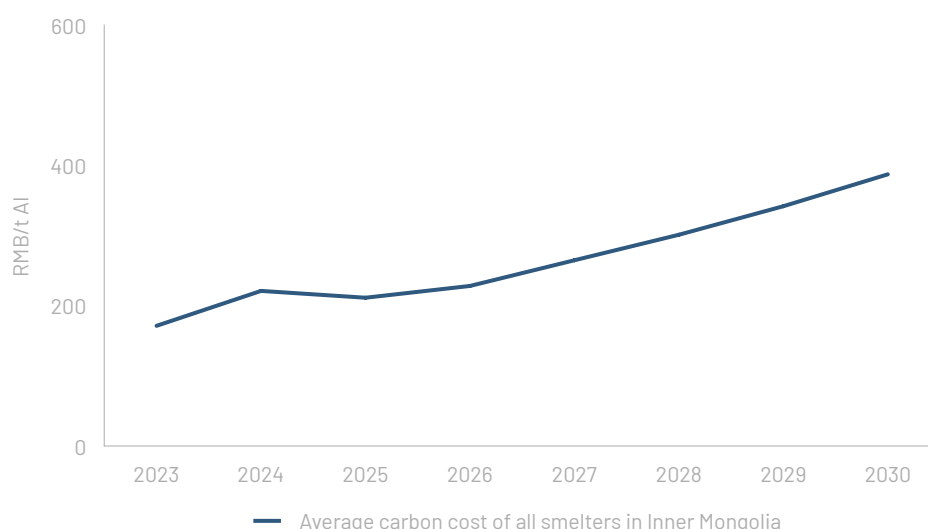
Among the variables assessed, the most significant impact comes from the introduction of full carbon cost coverage under the power sector ETS (zero benchmark scenario), which could increase carbon costs to over 1,500 RMB/t Al by 2030. The accelerated ETS scenario (a rapid escalation in ETS prices—136 RMB higher in 2030 than the 2024 peak) brings subsequent substantial cost increases, raising the carbon cost to 620 RMB/t Al.

In comparison, the newly announced aluminium sector ETS adds only minimal costs under our aluminium ETS compliance scenario. Referencing the EU ETS's benchmark change in phase 3 and phase 4, the aluminium ETS will only cost companies around 8 RMB/t Al by 2030. This is largely due to limited scope coverage as only process related direct CO₂ and PFC emissions are covered while other large emissions sources from indirect electricity use or from alumina refining are not included. Even in a full-cost scenario when benchmark intensities phase out, average carbon costs related to the aluminium ETS would only reach 250 RMB/t Al by 2030, far lower than the impact of the power sector ETS.

CURRENT POLICY TRAJECTORY SCENARIO

The current policy trajectory scenario is designed to reflect the most realistic outlook. Forecasts are based on current policies, technology advancement and historical market data.

Figure 2. Average Carbon Cost in Inner Mongolia under Current Policy Trajectory, 2023–30



Source: TA Analysis

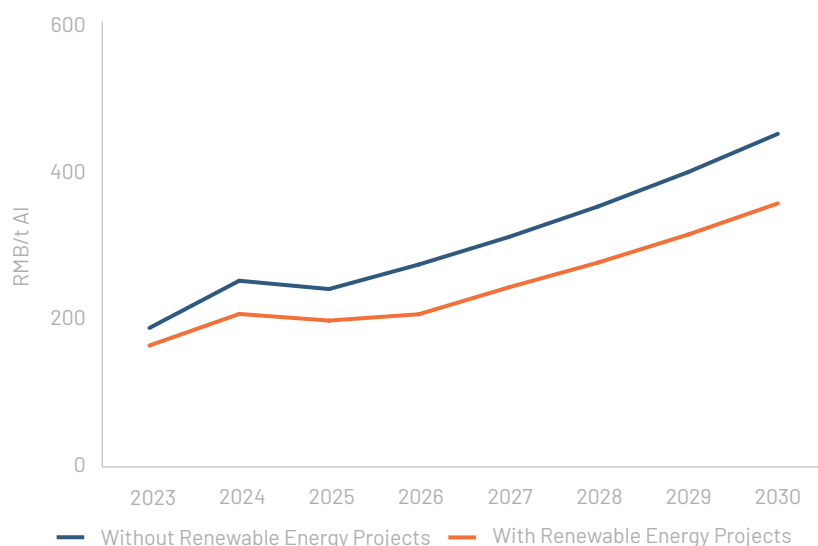
The average carbon cost for aluminium smelters in Inner Mongolia is set to rise steadily under our current policy trajectory scenario, reaching around 400 RMB/t Al by 2030. Combined efforts from ETS price increase and more stringent ETS benchmark intensities are the main drivers behind the carbon cost increase.

In Inner Mongolia, all the captive coal power plants recorded by our model have carbon intensity higher than the power sector ETS benchmark. Assuming this is a common case for most aluminium companies and to better visualise the impact, Aluminium Corporation of China ("Chinalco") is taken as an example thanks to its data transparency. The average aluminium ingot price in China for the first half of 2025 fluctuated around 20,000 RMB per tonne making the current maximum carbon cost approximately 2% of the aluminium ingot price. For Chinalco this 2% of aluminium ingot price can lead to 2.3% decrease in ROCE. Chinalco's 2023 return on capital employed (ROCE) is around 15% with 15 billion operating income and 99 billion capital employed. Chinalco's production of electrolytic aluminium is 6.8 million tonnes in 2023. Adding a maximum extra 400 RMB/t Al carbon cost to the ROCE formula, therefore results in a 2.3% decrease in ROCE and 18% decrease in operating profit.

MAXIMISING RENEWABLES IN INNER MONGOLIA TO REDUCE ETS EXPOSURE

In 2023, the Inner Mongolian government officially released the renewable energy replacement policy (RES policy) encouraging companies to replace the electricity generated by captive coal power plants with renewable power plants.⁹ Electricity generated from these renewables must be consumed onsite and is not allowed to connect to public grids. In the current policy trajectory scenario, required coal capacity needed by smelters after the planned captive solar and wind capacity were installed has been calculated. Assuming renewable generation hours remain at 2023 levels, additional solar and wind capacity will partly displace the coal capacity that would otherwise be required. This, in turn, lowers the share of electricity consumed from captive power plants and reduces the associated carbon costs.¹⁰

Figure 3. Average Carbon Cost: Smelters With vs. Without Renewable Projects, 2023–30



Source: TA Analysis

⁹ <https://www.nmxc.gov.cn/nmxc/qwqk/xxgk/zfxqkml/tzqg/2023112110034988685/2023112110024197118.pdf>

¹⁰ <https://m.bjx.com.cn/mnews/20240222/1362244.shtml>

In the Current Policy Trajectory scenario, smelters equipped with renewables projects are set to pay a carbon cost of up to 356 RMB per tonnes of aluminium produced in 2030 while those smelters without need to pay an additional carbon cost of around 90 RMB/t Al, totalling 450 RMB/t Al. Importantly, the ascending trendline in the figure indicates that aluminium smelters with currently planned renewable energy projects build-out does not do enough to offset costs arising from ETS regulations.

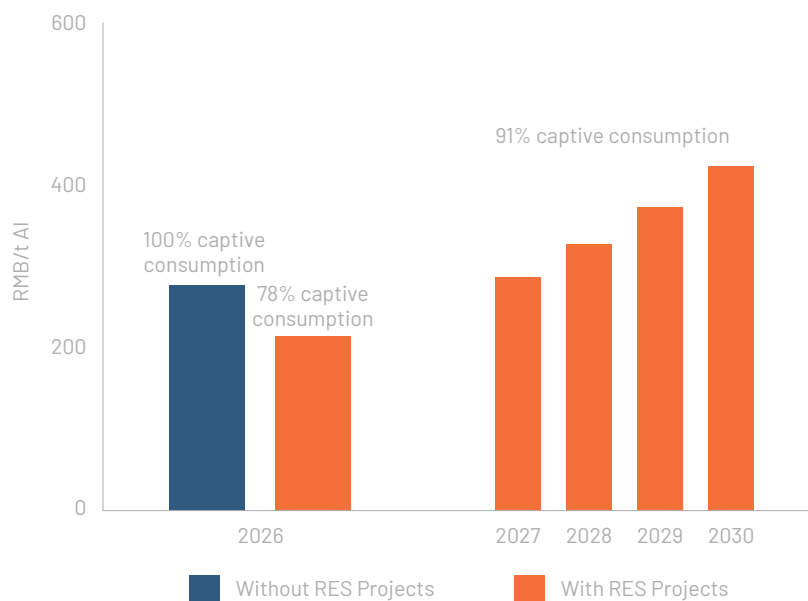
By 2025, aluminium companies in Inner Mongolia will have installed around 400 MW solar and wind capacity respectively. By 2030, this number amounts to 2,220 MW for wind power plants and 940 MW for solar power plants which are included into this model for projection and attributed to correspondent smelters. The largest project collected in the model is the 1 GW Wind capacity and 200 MW solar capacity together with 2h 240MW battery storage owned by Chinalco Baotou Aluminium. However, the battery storage capacity is not sufficient to store unused renewable electricity during daytime and discharge at nighttime. To fully replace the captive coal power plants, not only companies in the region need to build more captive renewable plants, but as they are currently unable to connect to the grid, also equip sufficient energy storage to enhance the utilisation of renewable electricity generated. Additionally, efforts can focus on further decarbonising grid electricity and expanding grid infrastructure, enabling smelters to either purchase cleaner-than-coal electricity from the grid or source renewable electricity via dedicated grid connections to renewable power plants.

UNDERSTANDING SMELTER-LEVEL DYNAMICS: THE CASE OF SMELTER A

Decarbonisation is rarely a linear process. While provincial averages provide a useful overview, they can obscure the specific dynamics of individual smelters. For example, Smelter A is set to complete a major renewable energy buildout by 2026, adding 300 MW of solar and 350 MW of wind capacity to support its existing 700 MW of captive coal power. This shift is expected to reduce the share of electricity from coal by 22% and lower its carbon cost by 30%, amounting to a savings of 62 RMB per tonne of aluminium.

Based on historical plans, Smelter A will also start three new coal-fired units in 2027, raising its captive coal share from 78% back up to around 90%, effectively reversing prior gains in decarbonising its power source. It is not clear whether these coal-fired units are still planned or have received approval, but if these new coal units were avoided, the smelter could save as much as 100 RMB/t Al by 2030, under the current policy trajectory scenario.

Figure 4. Carbon Cost of Smelter A in Current Policy Trajectory, 2026–30

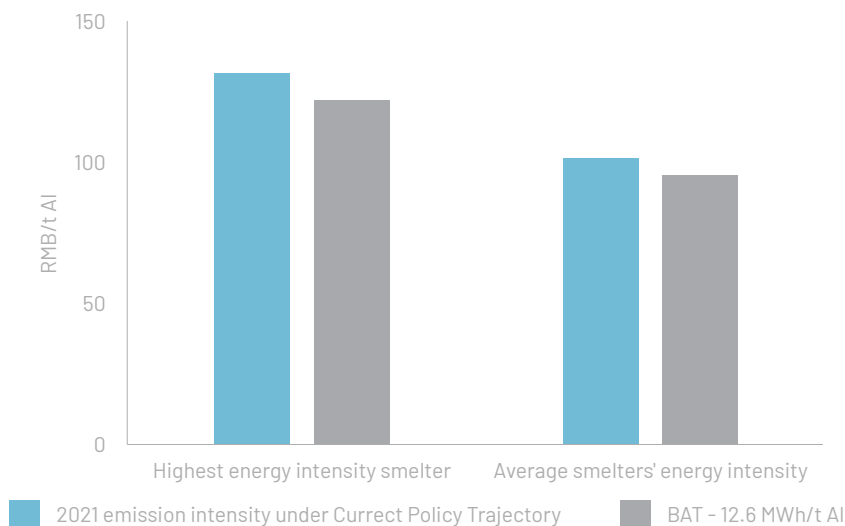


Source: TA analysis

LIMITED IMPACT OF TECHNOLOGICAL IMPROVEMENTS ON CARBON COSTS

Aluminium companies are likely to involve larger smelters with higher amperage which can improve current efficiency and reduce energy intensity. The most advanced technology today is the 600+kA cell owned by Weiqiao (Shandong) Group with an energy intensity of 12.6 MWh/t Al.

Figure 5. Carbon Cost Reduction Potential from Energy Intensity Improvements in Inner Mongolia



Source: TA Analysis

To assess the potential impact of the BAT on reducing carbon cost in Inner Mongolia, we model a scenario where the energy intensity of all 12 smelters in 2021 base year is uniformly set to 12.6 MWh/t Al. The resulting carbon costs are then compared with those under the actual energy and emissions intensity levels. The analysis shows that technological improvement could reduce carbon costs up to 10 RMB/t Al with an average saving of 6 RMB/t Al across the province. However, given that the current energy intensity ranges from 13.6 MWh/t Al to 12.7 MWh/t Al, the scope for further improvement through efficiency gains alone remains limited.

Since there have been no announcements of smelters reconstruction in Inner Mongolia, the region is unlikely to see emission reductions from new technologies by 2030. Retrofitting smelters with mitigation technology which helps with thermal balance inside the cell or electrode retrofit, can also reduce emissions, though only marginally. Technologies that are expected to be commercially ready by 2030 in China can only save less than 1 KWh/kg Al.¹¹ As a result, they are not considered in this paper. Similarly, since inert anodes are not expected to be commercially applied until after 2030, they have been excluded from our analysis.

THE ENHANCED ETS IMPACT SCENARIO— THE IMPACT OF THE POWER SECTOR ETS CHANGES ON THE CARBON COST OF ALUMINIUM

The enhanced ETS impact scenario explores how aluminium smelters' carbon costs could evolve under a more stringent and ambitious emissions trading framework. Building on the base case, this scenario introduces two key stress tests:

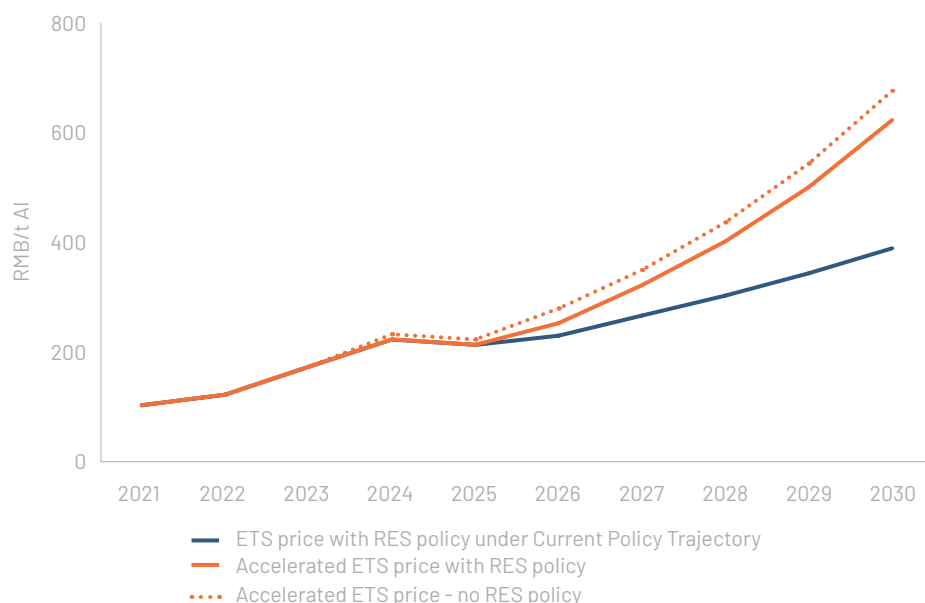
1. The *accelerated ETS sub-scenario* models the impact of a significantly higher ETS price trajectory, referencing historical trends from the EU ETS Phase 3, where free allowances decline sharply.
2. The *zero benchmark sub-scenario* simulates the effect of an aggressive tightening of benchmark intensity, with allocation benchmarks set to zero starting in 2026.

Together, these sub-scenarios test the financial exposure of smelters under stronger climate policy, highlighting the risks for coal-reliant operations and the potential savings for early movers toward renewable energy adoption.

¹¹ Tan, C., Yu, X., Li, D., Lei, T., Hao, Q., & Guan, D. (2025). Different technology packages for aluminium smelters worldwide to deliver the 1.5° C target. *Nature Climate Change*, 1-8.

THE ACCELERATED ETS SUB-SCENARIO

Figure 6. Average Carbon Cost in Accelerated ETS Sub-scenario, 2021–30



Source: TA Analysis

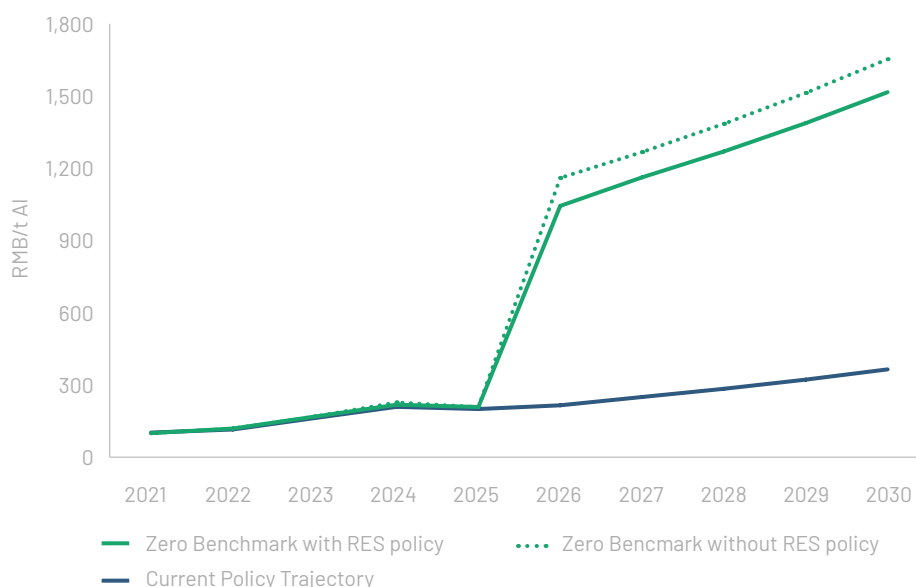
Carbon costs are set to increase over the year until 2030 under both the current policy scenario and the accelerated ETS scenario. Being very sensitive to ETS price, if carbon prices increased to 242 RMB/t CO₂, carbon costs for aluminium smelters could become higher than 600 RMB/t Al by 2030, almost 3% of the current aluminium ingot price. In comparison with the current policy scenario result, this means adding another over 200 RMB/t Al by 2030—a tripling from today's level.

An additional analysis was performed to understand how much carbon costs vary under current renewables deployment under a higher carbon price scenario. Over time, Inner Mongolian aluminium smelters' current rate of renewables build-out reduces carbon costs but the impact is limited. By 2030, planned projects are set to save around 50 RMB per tonne of aluminium produced under higher ETS price scenarios.

THE ZERO BENCHMARK SUB-SCENARIO

China's ETS benchmark carbon intensity for regular coal-fired units has inched down year by year from an average 0.93 tCO₂/MWh in 2019 to 0.8 tCO₂/MWh in 2024. The current policy trajectory captures the historical decrease and assumes a similar rate for the future. In the zero benchmark scenario, benchmark intensities are eliminated, offering a clearer view of the full carbon costs associated with aluminium smelting under complete emissions coverage. Simply, companies participating in the ETS market need to pay for all the CO₂ emitted instead of the part above benchmark intensity starting from 2026.

Figure 7. Average Carbon Cost in Zero Benchmark Sub-scenario, 2021–30



Source: TA Analysis

This scenario has the highest impact on carbon cost as it raises the cost to over 1,500 RMB per tonne of aluminium produced by 2030. Cushioning back carbon cost growth only marginally, the impact of current renewables projects built-out is not amplified under zero benchmark assumption. Planned renewable energy projects only help to save 8% of carbon cost equalling to 137 RMB per tonne of aluminium produced.

Reflecting on experiences from China regional ETS market pilots and EU ETS, the gradual phase out of free allowances could be expected in the future. Whilst no clear signals have been given from the Chinese government in the near term to remove benchmarks, long term aspirations are understood to exclude benchmarking from the ETS.

ALUMINIUM ETS COMPLIANCE

China's ETS was announced officially this March to cover the steel, cement and aluminium sectors. In its first-year of implementation, allowances will be based on verified actual carbon emissions from 2024. Companies will not be required to pay carbon cost during the compliance period, which runs through the end of 2025. In the following two years, allocation will follow a carbon emission intensity control approach.

Like the power sector ETS scheme, indirect emissions are excluded. Only on-site direct GHG emissions from aluminium smelter itself, such as CO₂, CF₄ and C₂F₆, are considered for the aluminium sector ETS. There is no further official notice on how the intensity control approach might be implemented. Following the cost logic of the power sector ETS, this model assumes two intensity benchmarks, the PFC intensity (t CO₂e/Al) and process-related CO₂ emission (t CO₂/Al).

Due to data insufficiency, this model referenced the default number from NDRC's guiding document on calculating aluminium smelting's GHG emissions. The starting benchmark as the sum of PFC intensity and process-related CO₂ emissions is set at 1.648 t CO₂/Al. For the 2030 projection, EU phase 3 and phase 4 benchmarks are referenced to achieve a gradual decrease benchmark in our model until 2030.

Electricity consumption, being the most emissions-intensive component, is excluded from the scope; therefore, the impact of the Aluminium ETS is expected to be negligible. By 2030, the carbon cost is estimated at only 8 RMB/t Aluminium. Even in the extreme case when full carbon cost is considered, i.e. companies need to pay for all CO₂ and PFCs emission, the carbon cost would rise to approximately 250 RMB/t Al, still significantly lower than the impact of the power sector ETS.

RECOMMENDATIONS

1. STRENGTHEN ETS DESIGN TO DRIVE DECARBONISATION

To fully decarbonise the aluminium industry in Inner Mongolia, a more stringent ETS regulation targeting both the power sector and aluminium sector is required. The power sector ETS will continue to have the most material effect on the aluminium sector's decarbonisation trajectory, and as the most mature ETS scheme, should be prioritised for development. This should be done through mechanisms such as gradually phased-out benchmarks and reducing the supply of carbon credits to a level that sufficiently raises carbon prices. If effective enough, carbon costs will increase to the point that it cannot be overlooked in companies financial statements.

2. SUPPORT RENEWABLE ELECTRICITY ADOPTION THROUGH POLICY AND INFRASTRUCTURE

Policies to encourage higher renewable electricity consumption in the sector is another factor that is essential. The current planning of captive renewable power plants built-out is not sufficient to fully replace coal power and to de-risk effects from potential future ETS market evolution. Decarbonising the aluminium sector hinges increasingly on access to reliable, low-carbon electricity. To support this transition, policies need to focus on three specific areas. First, local governments should set mandatory targets for renewable electricity consumption for the aluminium sector to drive demand for clean power. Second, infrastructure expansion, particularly on grid transmission and distribution, is essential. Improved transmission and distribution capacity and flexible grid technology should allow for smelters to directly access electricity from renewable electricity plants connected to the grid, in addition to benefiting from renewable energy projects built on site or with direct connections. Third, Inner Mongolian policy makers should continue to decarbonise the electricity grid and make full use of the exceptional wind and solar natural resources it enjoys. Supplementing renewables electricity using grid electricity can ease the cost burden of more expensive energy storage solutions on aluminium companies as it allows for greater flexibility and reduces the emissions related to aluminium smelters exposure to the grid.

3. COMPANIES SHOULD BE PREPARED FOR RISING CARBON COSTS

Aluminium companies should stay alert for policy changes and prepare for increasing carbon costs related to

the ETS. For smelters that have easy access and enough land for renewable energy, more renewable projects need to be built such that coal power plants can increasingly act as back-up power. Meanwhile, investing in sufficient energy storage is also important as it enhances system flexibility such that renewable resources can be fully utilised. For smelters that do not have those conditions, aluminium companies should explore options to, and encourage policy makers to facilitate access to, on-grid renewable electricity.

APPENDIX 1: SCENARIOS' DESIGN AND ASSUMPTIONS

ASSUMPTIONS IN CURRENT POLICY TRAJECTORY:

ETS price	Increases over time at a historical rate
ETS benchmark intensity	Benchmark intensity becomes more stringent over time based on historical rate
Power plants carbon intensity change	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030
Share of electricity consumption from captive power plants	Adjusted in line with existing and announced renewables electricity replacement policy.
Smelters' energy intensity	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030

ASSUMPTIONS IN ENHANCED ETS IMPACT SCENARIO:

ACCELERATED ETS SCENARIO

ETS price*	Increasing at a higher rate, referencing the price change in EU ETS phase 3, when free allowance decreases from 80% to 30%.
ETS benchmark intensity	Benchmark intensity becomes more stringent over time based on historical rate
Power plants carbon intensity change	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030
Share of electricity consumption from captive power plants	Adjusted in line with existing and announced renewables electricity replacement policy.
Smelters' energy intensity	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030

ZERO BENCHMARK SCENARIO

ETS price	Increases over time at a historical rate
ETS benchmark intensity	ETS benchmark set to zero starting 2026.
Power plants carbon intensity change	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030
Share of electricity consumption from captive power plants	Adjusted in line with existing and announced renewables electricity replacement policy.
Smelters' energy intensity	Remain constant as no retirements, reconstruction or important retrofits plans are found till 2030

ALUMINIUM ETS COMPLIANCE SCENARIO

ETS price	Increases over time at a historical rate
ETS benchmark intensity (PFC&processed CO ₂)	Based on the EU ETS aluminium benchmark from Phase 3 to Phase 4
Process-related PFCs emissions	Equal to benchmark
Process related CO₂ emissions	Equal to benchmark

*Variables in **bold** are changed variables in respective scenarios compared to the Current Policy Trajectory.

