Appendix B: Narrative scenarios for China

Scenarios for the global steel transition

s-curve economics

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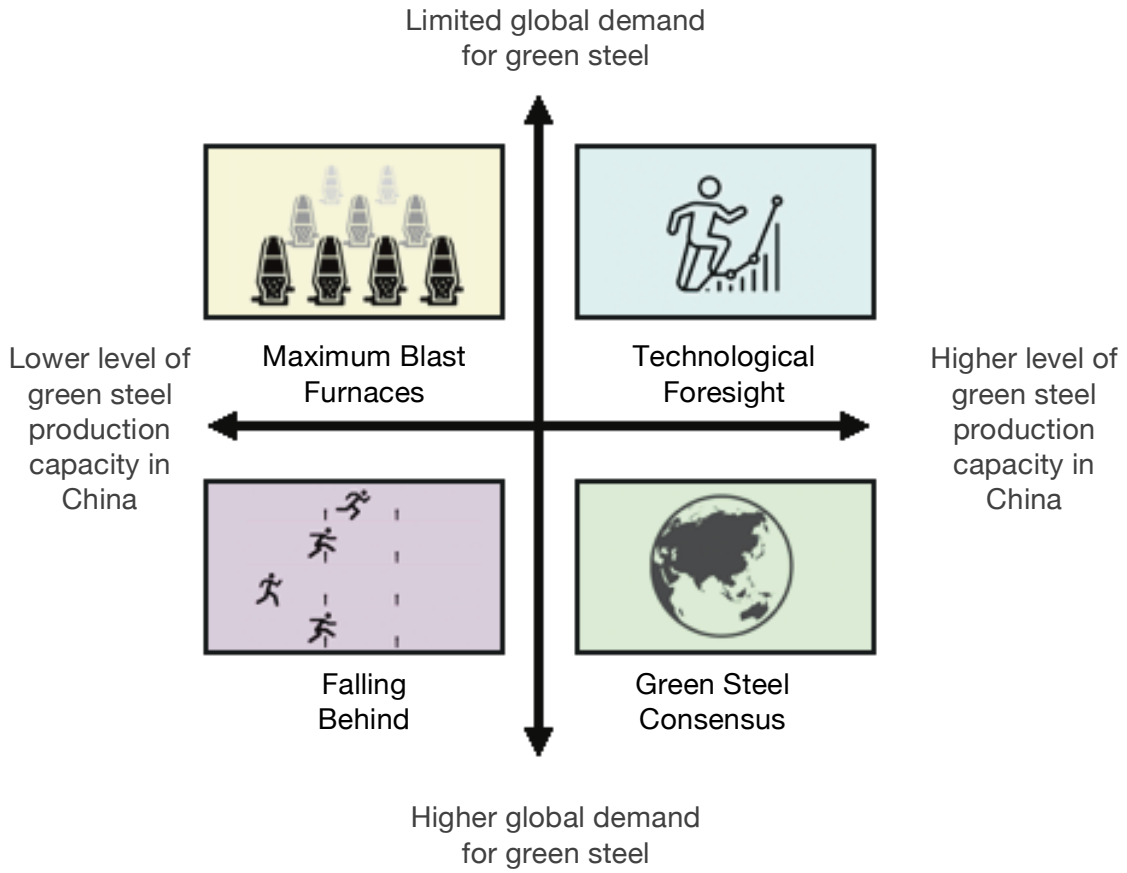


Technological Foresight

Technological Foresight describes a future where global demand for low carbon steel is limited and green steel production in China is high.

The global effort to decarbonise energy-intensive industries has gained little momentum over the last decade. Political instability and economic uncertainty mean that many governments and industries are risk averse. Investment has fallen and planning is reactive.

There are exceptions. Some countries – including China - remain focussed on developing leadership in clean technologies. The pace of change is slower than was anticipated in the 2020s but they continue to press ahead.

The view from 2035

As China enters the Year of the Pig, the leaders of its steel companies are optimistic, but their optimism is tinged with frustration. As they mark the end of the New Year holiday, they feel that China has secured its future as the undisputed global leader in steel production. That it has done so is a testament to the wisdom and foresight of those leaders who decided a decade ago that China's future was best served not by waiting for global markets to demand green steel, but by acting in anticipation.

Their frustration is due to the fact that global demand for green steel remains low for now. That is not a threat to China's producers: they are able to serve the domestic market and prepared to wait until the current turbulence in foreign markets has settled down. But they have not yet been able to reap the rewards that they feel they are due, from years of patient development of new technologies, bold investments in new plants, and difficult structural change.

A challenging decade

The last ten years have not been easy for the global economy. The disruptive forces that were clearly visible at the start of 2025 – extreme weather events, energy shocks, debt overhang and rising job losses due to the adoption of AI – accelerated through the mid 2020s and left many countries struggling to respond. It quickly became clear that these were global challenges beyond the control of any individual nation state acting alone.

Instead of agreeing a way forward together, the advanced economies turned inwards to relieve domestic pressures. Some believed this to be a sub-optimal approach but were unable to secure the political leverage they needed to make difficult long term changes. Others believed that putting their own needs first was the only way to secure future prosperity.

Whatever the causes, the effects were the same: investor confidence hit an all-time low, growth stalled and national economic planning and policy making became increasingly short termist. Protectionism spread, with increasing disregard for international trade rules.

The developed economies were in firefighting mode and no-one, it seemed, had the vision or appetite to invest in the long term. Industrial transformation and green infrastructure development simply fell off the public agenda.

Preparing for the future

China was not immune to the economic headwinds, and suffered from slow growth as domestic demand faltered and its exports faced increasing barriers. While managing the short-term pressures, the government continued to invest strategically (if carefully) in new technologies, seeing this as the best way to secure long-term growth.

Green steel was high on China's agenda. Its ambition was to build on its industrial capabilities and market dominance and establish itself in pole position for the shift to green steel. It took a measured approach, building capacity steadily; both to ensure it remained on track to achieve its Dual Carbon Goal and to minimise the social cost of switching some capacity away from Blast Furnace-Basic Oxygen Furnace (BF-BOF) production.

The first stage of investment focussed on three key building blocks: developing large-scale hydrogen production capacity in strategically located industrial zones, expanding the national fleet of Electric Arc Furnaces (EAFs) supported by improved scrap collection, and establishing the

first wave of hydrogen direct reduced iron steel plants in key steel-producing provinces.

Learning from past successes in solar photovoltaics and electric vehicles, these efforts were underpinned by state-directed investment, preferential financing for near-zero emission primary steel technologies and coordinated infrastructure development to ensure alignment between clean energy supply, industrial demand and logistics. Long-term subsidy contracts, awarded through a reverse auction process, enabled the hydrogen DRI plants to compete on a level playing field with BF-BOF and scrap-EAF plants. The cost of these contracts was funded by a small charge on all steel consumption, so that the policy was revenue-neutral from the government's perspective.

There was considerable optimism in Beijing about the path ahead.

The rocky road

China had fully expected that global demand for green steel would be weak for some time, but it was nevertheless surprised how flat the market remained through the late 20s and into the 30s.

This was partly due to continuing risk aversion in the developed economies. While many countries operated carbon pricing mechanisms, they did so at relatively low levels that were sufficient to drive a shift towards more recycling but not sufficient to enable the deployment of any clean primary steel production.

The bigger challenge was the sustained global overcapacity that caused other countries to raise trade barriers to protect their domestic industries - resulting in a reduction of Chinese exports of conventional steel. Struggling to find international buyers, China could only sell into the slowing domestic market. The industry contracted, causing closures and job losses that were particularly difficult for industrial communities in the regions.

It was a challenging time politically but Beijing maintained its investment in green steel production, convinced of its long term strategic importance.

Vindication?

The last few years have provided what optimists see as a vindication of Beijing's approach. Strong urban growth and infrastructure development in India, Southeast Asia and across the Global South has grown to mop up significant overcapacity. China is selectively introducing green steel into the mix of its exports, especially in Europe and parts of East Asia where standards are at last tightening up.

The transition still has a long way to go. China has built a modest stock of green primary steel production capacity that accounts for just over a tenth of its total production, while scrap recycling has risen to 20% and BF-BOF production remains high at close to 70%. Globally, the pace of change remains uncertain.

China's competitors, many of whom have spent the past decade wrestling with short term challenges, have lost sight of how well it plays the long game. When they raise their heads again – as they surely will – and resume their internal discussions on how to transition to near-zero emission carbon steel production, they will find that China has built its platform already. And that it is ready to launch.

Green Steel Consensus

Green Steel Consensus describes a future where demand for low carbon steel is high and green steel production in China is high.

The global transition to low carbon steel has moved ahead at pace. Governments in first-mover countries have implemented mandatory green public procurement policies and green steel subsidies. This, together with growing green iron production in countries with abundant renewable energy has prompted other countries to follow to protect their long-term competitiveness.

China has secured competitive advantage in the global green steel market by investing strongly in clean power and in green hydrogen production.

The view from 2035

Global steel production today stands at just over 1.9 billion tonnes, a figure that has remained relatively stable over the past decade. But beneath the surface, the industry has begun a structural transformation. The stock of high-emission steel is shrinking, with targeted subsidies, public procurement, clean steel tariff exemptions, and investor expectations accelerating the shift toward certified green steel. Over 40% of global steel output is now low-carbon, recycled steel. A further 10% is near-zero emission primary steel.

Green steel is no longer a niche product. It is the new benchmark of industrial competitiveness.

China was not the first country to deploy near-zero emission primary steel, but was one of several places where initial technological breakthroughs were made, with others coming from a mixture of start-ups and established industry leaders across Europe, Japan and the United States. And China did what it has done so many times before: mobilised industrial transformation at an unprecedented scale and a pace that was simply unstoppable.

The result? China is now the world’s largest producer of green steel.

At a crossroads

The global steel sector stood at a crossroads ten years ago. Overcapacity was chronic, emissions were high and low-carbon production mainly remained stuck in the pilot stage.

It was not a good situation, either for the industry or for those governments who professed themselves determined to drive the transition to net-zero. It was clear by the mid 2020s that the technologies existed and that it was a lack of policy alignment and incentives holding industry back from taking them up.

It was also clear that governments needed to drive the change. They did so, not because of climate idealism, but because the transition offered some producers the promise of increased industrial competitiveness, and when they acted, others felt that standing still was increasingly risky. The switch from seeing decarbonisation as a cost to seeing it as an investment in long term strategic advantage was key.

Early movers

The accelerated expansion of carbon contracts for difference in Europe, enabling competitive near-zero emission primary steel production, was an early win. When this policy support was opened to steel plants using imported green iron from Brazil, costs fell, showing the advantage of producing green iron in locations with the best renewable energy and iron ore resources. China followed suit, with the government supporting state-owned steel companies to import green iron from Australia. Public procurement policies — especially in Europe, Brazil and some US States - were updated to mandate low-carbon materials in infrastructure, housing, transport and defence. Global demand for green steel began to rise, led by sectors such as electric vehicles, offshore wind and commercial construction.

These early developments caused some turbulence in the market and there were moments when it felt as if the transition might falter. Governments of countries that had moved early, such as Sweden, Germany and South Korea, were concerned that the strong policy support given to steel companies to scale up the first wave of hydrogen DRI pilots to commercial production would be difficult to replicate for the whole sector, unless conditions in the global market changed. This would depend disproportionately on the actions of the world's largest steel producer countries, China, India, Japan and the USA.

Building momentum

By 2029, the economic logic of green steel had become harder to ignore. With Europe and China having shown that a subsidy-led approach to deploying near-zero emission primary steel was viable, and with green iron production in Australia and Brazil threatening to reshape the sector's global supply chains, industry and government perceptions shifted. Whereas before, first-mover risk had dominated their concerns, now the risks of being a late mover in the transition appeared more significant. Following the lead of Europe and China, first Japan, then India, and then the USA began directly subsidising steel decarbonisation projects. Green hydrogen production scaled up across Europe, India and the Gulf.

With confidence in clean steel technologies increasing, carbon tariffs hardening, and lifecycle emissions standards in end-use sectors tightening, high-emission steel found itself locked out of premium markets. In response, trade diplomacy turned its focus towards the transition.

New bilateral agreements — such as green iron offtake deals between Australia and China, and clean steel access pacts between Europe, the US and India — established preferential terms for certified near-zero emission steel. These agreements began to knit together what would later become an informal green steel trade zone. Negotiations between Europe and China centred on reducing excess capacity in China in return for Chinese near-zero emission steel having tariff-free access to the European market.

The demand side also matured. Global automakers pledged that all new electric vehicles would use 100% green steel by 2040, recognising that this would add less than one percent to the cost of a car, and that it was likely soon to become a regulatory requirement in any case. Today, in 2035, over 90% already do. Green building codes took root in the global megacities. Solar and wind developers required green steel for project finance eligibility.

National governments

Circular design principles and scrap-sorting technologies advanced significantly, improving the availability of high-quality steel scrap. The shift enabled more efficient dismantling, easier separation of steel components and reduced contamination in scrap flows. At the same time, innovations in automated sorting — such as sensor-based material recognition, AI-assisted classification, and robotic disassembly —dramatically improved the quality and consistency of recycled steel inputs.

Deploying at scale

Once the conditions aligned — cost parity between electrolytic hydrogen and natural gas, a critical mass of demand for clean steel globally, and adequate renewable electricity infrastructure — China redoubled its commitment to the transition. Blast furnace steel production had no growth prospects, and its harmful effect on local air quality had long been a problem. Drawing on the learning from its first wave of hydrogen DRI projects, as well as those of other early movers, China was able to deploy the new technologies on an unrivalled scale.

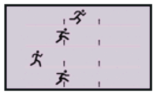
What had been an assortment of pilot projects – scattered across the country in the late 2020s – were built up, replicated, connected to the national electricity network, and transformed into a growing fleet of large-scale hydrogen DRI plants in the early 2030s. This was supported by integrated policies across ministries and state-owned enterprises, ensuring alignment on land, power, finance and logistics. EAF capacity was rapidly scaled up in parallel, supported by improvements in scrap collection, circular design and digital traceability. The government in Beijing deployed capital, coordination and political will.

Green steel – including both primary and secondary – now accounts for a third of Chinese production. It has built its bilateral partnerships to co-develop green iron and steel production hubs with Australia and South Africa. Its exports are certified, traceable, and compliant with global standards - which means China once again has access to high-value markets that were previously closed to it due to high-emissions.

Radical. Different.

Today, the global steel market looks radically different. Countries accounting for over two thirds of global production now operate under harmonised low-carbon steel standards. While high-emission steel still accounts for the majority of global production, it is no longer viable in high-margin markets. Investment is now easier to access for companies planning to build new near-zero emission steel plants, and far harder to secure for any new blast furnaces.

The global transition is not over. Competition remains fierce, particularly in emerging markets. Trade disputes remain, particularly around the fairness of countries' clean steel subsidies, echoing the disputes over electric vehicles in the mid-2020s. But the direction of travel is clear: green steel is not only the future — it is the present.



Falling Behind

Falling Behind describes a future where demand for low carbon steel is high and green steel production in China is low.

Demand for green steel has been slow to take off but is accelerating as western nations push hard to decarbonise, and other countries take advantage of rapid technological progress.

China has strong capabilities in clean steel technology but has been caught out by the pace of the transition. The scale of change it must now make domestically to regain its global position is significant, allowing other, more nimble producers to capture significant market share.

The view from 2035

The global steel industry has undergone a dramatic transformation in the last decade, shaped by strong policies, market forces, and surprisingly fast technological progress, sparking a decade-long race to capture the green iron and steel value chain.

The sector, once defined by overcapacity, carbon intensity and relentless price competition, has become a proving ground for the decarbonisation of heavy industry. Policy instruments including green public procurement and subsidies for near-zero emission technologies have restructured global trade flows, redirected investment and reshaped corporate strategy. Breakthroughs in electrolyser technology, and in its application to molten oxide electrolysis, have made clean steel production viable in a wide range of countries. In many economies, green steel is no longer a policy aspiration but an industrial strategy. Market access, financing terms, and competitive positioning are now inextricably linked to emissions credentials. Meanwhile, countries are using trade defences vigorously to protect jobs in the high emitting steel plants which still account for the majority of global production.

China, the undisputed heavyweight of global steel a decade ago, has been caught out by the pace of change. While others acted quickly, China continued its initial policy mix of low-level carbon pricing and clean steel demonstration projects a little too long, holding back from stronger policies out of concern to protect jobs and government budgets. As a result, it was too slow to invest in new primary clean steel plants, and too slow to make those plants operational on a large scale. It wasn't by much – but it was enough to fall behind.

Reset

China's initial stance was completely understandable a decade ago. The high level of global overcapacity and the fragmented approach to climate policy across major economies made the prevailing view - that steel would remain one of the hardest sectors to decarbonise – hard to challenge.

Yet within a few years, that's exactly what a disruptive group of producers began to do, building momentum for the transition on the back of rising concern about climate change and a strategic rethink of industrial policy.

The EU, UK, Canada and Japan moved first, introducing and expanding carbon border adjustment mechanisms (CBAMs) that taxed high-emission imports and shielded those domestic producers who had invested early in clean steel technologies. Public procurement policies simultaneously moved to require certified green steel for public infrastructure, transport systems and defence contracts, creating guaranteed demand for compliant producers. Competitive advantage began to shift toward low-carbon production.

As clean industrial capacity scaled up, trade incentives (and barriers) were layered in. Green trade blocs emerged, not through international treaties but through gradual policy alignment. Compliant producers were welcomed; emissions-heavy exporters found themselves shut out or priced out. This was motivated as much by the desire to protect national industries (including conventional steel producers) from global overcapacity as it was by the need to protect clean steel producers from being undercut by high emitters in other countries.

What had seemed at first like a gradual market evolution reached a tipping point in the late 2020s as technological change accelerated. The effect was a dramatic reshaping of the producer landscape.

The world turned upside down

Europe — often written off in the 2020s for its bureaucratic inertia — took a lead in the emerging production landscape. Stringent carbon pricing, generous support for hydrogen-based production and an aggressive CBAM turned its industry into a high-cost, high-value export engine. German and Scandinavian mills, long dependent on coal, became pioneers of hydrogen DRI routes powered by clean hydrogen and renewable electricity.

India, once seen as a potential loser in the green steel race due to its fast-growing domestic demand, reliance on coal-based production, and low-quality iron ore, recognised the danger of being locked out of the newly emerging green trade blocs. It moved decisively to align industry practice with the direction of growth in global demand, expanding its national hydrogen strategy - coupled with state-backed incentives for solar-powered hydrogen DRI, and investment in the development of new technologies for low-cost beneficiation.

Both India and Brazil mandated the use of green ammonia in fertiliser production, motivated by food security interests. Europe followed. This caught investors' imagination and money flooded into the electrolyser industry, with the result that by 2029, electrolytic hydrogen could be produced at cost-parity with fossil fuel based 'grey' hydrogen.

Japan and South Korea focussed on achieving competitive advantage in high-quality speciality steels, and in developing disruptive new clean steel technologies. Their strengths in innovation have paid off and they now hold a premium market niche, as well as remaining competitive in the high-volume market.

The US's Inflation Reduction Act (IRA), passed in 2022, provided powerful incentives for decarbonisation for a short time – but after these were cancelled in 2025, the domestic steel sector was slower to pivot than its counterparts in Europe or Asia. The US government nevertheless used carbon-based tariffs to protect its domestic production which was already dominated by EAF capacity. At the same time, molten ore electrolysis (MOE) technology developed by a US company outperformed early expectations, and attracted large-scale private investment. The US exported the MOE technology to be used in steel production in other countries. Its small, modular nature allowed it to be deployed at first in smaller capacities, making it easier to secure finance and grid connections. By the early 2030s, MOE was being used to produce steel in Southeast Asia, Africa, the Middle East, and Central and South America.

Caught out

China - focussed through the mid 2020s on preserving jobs, minimising disruption and maintaining provincial economic stability - was caught out by the speed and direction of global change.

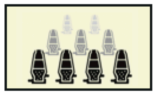
Policy directed at marginal gains - efficiency upgrades, emissions monitoring and modestly increasing scrap utilisation – proved enough to meet the policy target of peaking the sector's emissions before 2030, since domestic demand for steel had plateaued by the late 2020s, and trade protectionism in the global market left no room for export-led growth. The emissions trading system contributed to the push towards recycling, but created only weak incentives. The capability for hydrogen DRI production was there, but without strong deployment policies, it

remained far too long at the demonstration stage. Structural inertia and fragmented governance meant that producers lost sight of the wider picture. Producers simply underestimated how quickly green trade standards would limit access to key export markets. And nobody had expected the rapid breakthrough of MOE.

When Beijing finally pivoted toward strong deployment policies for near-zero emission primary steel production in the early 2030s, the rest of the world was already racing ahead. Now, in 2035, the consequences are clear. China's share of global steel production has fallen below 40%. Its high-emission producers are blocked from many markets by carbon border adjustments, tariffs and quotas. It needs more time to build near-zero emission plants that qualify to supply the new green steel trade blocs, which means market share is certain to fall further before it recovers. And as small-scale MOE steel production spreads, a growing number of countries have developed interest in building and protecting their own domestic steel industries.

New order

The global map of steel production looks markedly different than it did a decade ago. More steel is produced in the ‘sunbelt’ countries where renewable energy is abundant and cheap. Less is produced in the ‘rustbelt’ of older centres of production in Europe, North America, and North Asia, but through a mixture of specialisation and protectionism, these industries continue. Green steel is no longer a niche product; it is becoming the standard in most advanced economies. Production is more distributed, thanks in large part to the rise of MOE. No single country dominates as China once did. No single country may ever do so again.



Maximum Blast Furnaces

Maximum Blast Furnaces describes a future where demand for low carbon steel is limited and green steel production in China is low.

Economic uncertainty hampers growth and limits collaboration on technologies and trade frameworks that support the decarbonisation of energy intensive industries. Policies relating to steel production focus primarily on keeping energy costs low.

China, like most major producers, avoids the economic risks of producing higher-cost green steel. Its strategy is to maximise profits from blast furnace production and exports, while building readiness through small scale clean steel pilot projects, to hedge against the long-term risk of the transition.

The view from 2035

It takes a lot of time and effort to turn an industry around when the market conditions are favourable and when demand and supply are moving into alignment. Transition is a different ball game entirely when conditions are unfavourable or when demand and supply are mismatched.

That is the situation the global steel industry has found itself in for the last decade. The industry is effectively trapped in a holding pattern characterised by clean primary steel pilot projects that never quite develop into commercial-scale production, incremental efficiency gains and gradually increasing use of scrap steel, cautious hedging and sustained traditional production in blast furnaces. The overall ambition to achieve the transition to clean steel is broadly shared (or to be more accurate, perhaps, widely stated) but no government or company seems willing to move

first.

The story of the last ten years, then, is not one of denial but of drift. Steel remains one of the world's most carbon-intensive industries. Confidence in near-zero emission primary steel production technologies has increased but their adoption has been partial, small-scale, and limited to a few regions. The global steel industry is optimised for cost and efficiency, just not for the climate.

Caution: bumpy road ahead

Following the inflationary shocks of the early 2020s, the global economy entered a cautious recovery in 2026. Steel demand began to pick up, driven by sustained infrastructure development in the ASEAN nations, India, Africa and Latin America. But while economic activity returned, transformative investment in green steel did not.

Policy mechanisms like the EU's emissions trading system turned out to have less leverage than expected, incentivising increasing use of scrap steel but not the deployment of clean primary steel technologies. The EU extended the steel sector's free allowances under the scheme, recognising that the carbon border adjustment mechanism (CBAM) provided an incomplete defence against high emitting foreign competition. Several of the emerging economies adopted emissions trading systems but kept carbon prices low by avoiding any tight caps on emissions. Most international trade agreements remained focussed on generating growth by any means; most production focussed on keeping costs as low as possible. Maintaining legacy infrastructure, streamlining operations and improving efficiency without substantive investment were the order of the day.

With hindsight, some Chinese analysts say that China's reaction to market conditions – deemed prudent at the time - was too cautious. With the market for green steel remining sluggish at best, Beijing's policymakers prioritised energy security and economic stability over systemic decarbonisation. Early progress on pilot hydrogen DRI plants, expansion of EAF capacity, and anti-pollution measures in industrial regions all slowed. Meanwhile, new blast furnaces were approved for construction as the industry pursued growth opportunities in the emerging markets. It was hardly a surprise when, despite official optimism, China failed to reach its steel emissions peak by 2030.

The global reaction was subdued but significant. Investors took the missed target as confirmation that the business case for green steel remained unproven beyond its use as a niche product in prestige demonstration projects. Opponents of the transition in other countries used it to strengthen their arguments for continued inaction.

Course correction

China's failure to achieve peak steel emissions led to debate in Beijing about what should be done next. Some argued that a course correction was needed to minimise negative narratives about China's commitment to its long term carbon goals.

Other officials and analysts highlighted the global conditions that caused the delay, pointed out that China's steel industry had remained strong and profitable over the past decade and argued that there was no point investing in higher-cost clean primary steel technologies unless it was clear that other major markets were committed to that path.

The debate was won by those who argued for a strengthening of the hedging strategy to prepare

more seriously for a transition that appeared likely to take place sooner or later. They pointed to steel producers in the UAE and Saudi Arabia in particular who were also trying to build green steel capacity, despite having strong interests in continuing to export fossil fuels.

With a modest renewal of policy support, the industry picked up where it had left off a few years earlier, renewing its investment in green steel industrial clusters with access to renewables, hydrogen and export infrastructure. Established hydrogen DRI pilot facilities received new investment with a mandate to develop a scalable model for large-scale deployment, enabled by central government finance, low-cost capital and preferential electricity pricing. Output would be utilised in public procurement and in partnerships with automotive, shipping and infrastructure companies.

An uncertain future

The approach strengthens China's preparedness for a future low-carbon steel sector through disciplined, strategic experimentation. But it falls short of a commitment to taking a leading role in making that transition happen.

While other major producers also prevaricate and hedge their bets, the question of exactly when that transition will begin remains uncertain.

The green steel pilot programme has certainly piqued the interest of investors and other producers but they remain cautious. The world has not rejected green steel but China's renewed efforts have not done enough to move the world on.

That is why, pilot projects and future aspirations notwithstanding, China's steel industry today remains firmly anchored in BF-BOF production. Green steel remains confined to niche applications and regulated export markets, while conventional output flows at scale to price-sensitive economies across Asia and Africa.

While overcapacity remains and carbon pricing remains limited in scope, the *status quo* seems likely to hold for now. For many in the steel sector, that is just fine.

For policymakers focused on limiting the risks of climate change, the outlook is more troubling. Progress in developing zero emission solutions is slow across the set of energy intensive industry, agriculture and land use sectors that together make up nearly half of global emissions. The world has already started experiencing individual years with global average temperatures more than 2°C above the pre-industrial baseline. As national net zero targets look increasingly optimistic, and carbon cycle feedbacks in the Earth system prove stronger than expected, analysts now predict a temperature increase of 3-4°C before the end of the century – a level that has traditionally been described as 'catastrophic'.

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