

In collaboration with
Oliver Wyman



China's Climate Challenge: Financing the Transition to Net Zero

INSIGHT REPORT

JULY 2022



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Foreword

China holds immense opportunities to realize net-zero ambitions and global environmental change.



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An April 2022 Intergovernmental Panel on Climate Change report found that the global community is on a pathway to global warming of more than double the 1.5°C (or 2.7° Fahrenheit) limit agreed upon in Paris in 2015. The report underscores the urgency with which private and public sector leaders must act, and China – currently the world's largest carbon emitter – has made an ambitious pledge to achieve carbon peak by 2030 and carbon neutrality by 2050.

Fulfilling this commitment will require an enormous amount of financing – about CNY 140 trillion (Chinese yuan renminbi) (\$22 trillion) in total for the 2020-2060 period across the electricity, steel, mobility, and construction and real estate industries alone. These are also heavily polluting industries that are particularly hard to transition and require the application of innovative, new technologies that are early-stage, capital-intensive and risky. Public and private stakeholders, both from carbon-intensive industries and the financial services community, need to create new financing models to develop, test and scale these technologies.

To facilitate this process, the World Economic Forum, in collaboration with Oliver Wyman, is engaging global industry leaders in the Financing the Transition to a Net-Zero Future initiative. In October 2021 – and in time for the 26th United Nations (UN) Climate Change Conference of the Parties (COP26) – initiative members published an [insight report](#) presenting initial findings from these global discussions. Building on this work and

recognizing China's significance in accelerating capital mobilization towards these early-stage decarbonization technologies, the Forum and Oliver Wyman convened a group of Chinese industry leaders and experts in early 2022 to explore how challenges and opportunities in China align with or differ from global dynamics. Through numerous workshops and expert interviews, more than 50 industry and public sector leaders contributed insights and observations and posed yet-to-be-solved questions that are presented in this insight report.

China holds a critical and outsized role in helping the global community achieve the targets of the Paris Agreement and preserving the planet's biosphere. At the same time, China's available financing mechanisms and its financial system remain somewhat distinct. A nuanced understanding of prioritized net-zero technologies and potential pathways to financing these technologies in Greater China is therefore critical to ensure the country can achieve its net-zero ambitions. This publication seeks to help in turning these ambitions into realities, show the enormous opportunities China holds for contributing to the global carbon-neutrality agenda and also highlight remaining challenges.

We welcome your feedback on the ideas presented in this insight report and encourage you to become part of this important work facilitated by the World Economic Forum through the Shaping the Future of Financial and Monetary Systems Platform and the Mission Possible Platform.

Executive summary

China has the most ambitious net-zero target of any country worldwide and so must ensure it can finance a carbon-neutral transition.

China has declared itself fully committed to having a decarbonized economy by 2060, a massive ambition. For more than 15 years, due to its heavily industrialized economy, it has been the world's biggest emitter of greenhouse gases. One unique challenge the world's second biggest economy will face in transitioning to carbon neutrality is balancing its decarbonization ambitions with the need to maintain a compelling economic growth rate.

At the 26th UN Climate Change Conference of the Parties (COP26) held in Glasgow, Scotland, from 31 October to 13 November 2021, China and the US agreed to boost climate cooperation over the next decade. In a joint declaration, the two countries called for increased efforts to close the significant gap, which will be necessary if the world is to keep its target of restricting the average global temperature rise to 1.5°C, as set out in the Paris Agreement of 2015. They renewed this commitment to cooperate at the Forum's Annual Meeting 2022 in Davos.

Despite these bold words, China's journey to a carbon-free future has only just started. As this report shows, the coming decades will see China having to invest heavily in economic transformation, above all in three sectors that, along with energy, dominate the country's carbon emissions: steel, mobility, and construction and real estate.

Covering the R&D expenditure needed to identify and develop the necessary new technologies and

paying for the new machinery and equipment that must be bought and installed will require an immense amount of funding.

This report identifies three areas where change will be needed to make these shifts possible:

- Finance innovation, particularly in finding ways in which lending packages can be structured to meet the needs of long-term borrowers facing higher costs and/or lower margins.
- Collaboration, particularly between different players within an industry that can create incentives for companies to produce or use sustainable products and inputs.
- Policy support, particularly in the areas of standards and the use of tax incentives to discourage unwanted behaviour, such as through the imposition of carbon taxes, and encourage desirable practices, such as tax breaks on green products and services.

Although realizing some of these changes will be challenging, none looks insurmountable. Rather, as this report concludes, given the resources China has available, the commitment of its government and the time scale over which China's transition to carbon neutrality will occur, there is good reason to believe the Chinese economy will indeed be carbon neutral by 2060.

1

China's commitment to tackling climate change

Through the adoption of green technologies, China can radically transform their economy to achieve net zero.



China is active in the world's major global initiatives to tackle climate change. Like most other countries, it recognizes that a global problem needs global solutions. It is moving ahead with the ongoing adoption of the Paris Accords, including those commitments agreed at COP26 in Glasgow in November 2021.

In addition, despite broader geopolitical tensions, China and the US issued a joint statement

addressing the climate crisis, followed by a joint declaration on tackling climate change at COP26, which demonstrate a commitment to boosting climate cooperation over the next decade (Figure 1). Domestic policies in China are also heavily focused on climate change. The latest five-year plan, covering 2021-25, puts decarbonization at the centre of policy-making, and the country has also made progress in the carbon trading market.

FIGURE 1 China's recent commitment to tackling climate change



UN General Assembly
September 2020

Xi Jinping commits China's CO₂ emissions to peak by 2030 and for the country to be carbon neutral by 2060.



14th Five-Year Plan
March 2021

China's top economic planning document includes a midpoint non-fossil energy share target for its nationally determined contribution, and energy and carbon intensity reduction targets for 2025.



China Carbon Emission Trade Exchange (CCETE)
July 2021

China's national carbon trading market was launched with 2,162 key emission units from the country's power generation industry. Covering 4.5 billion tonnes of CO₂ emissions, CCETE is the world's largest carbon market.



China-US joint declaration
November 2021

The China-US pledge has increased collaboration to tackle climate change, including commitments to cooperate on sharing information and technology, reducing methane emissions and using more renewable energy.

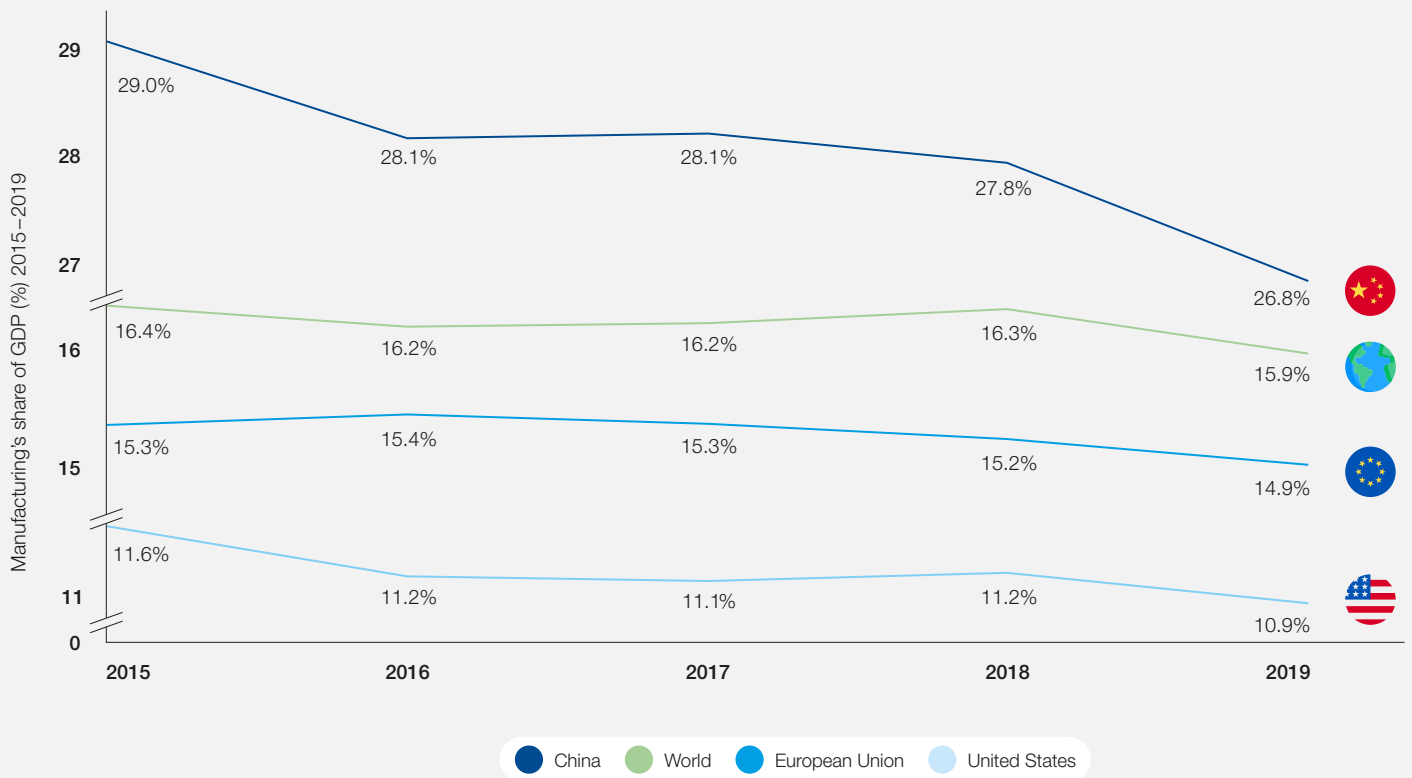
Source: World Economic Forum and Oliver Wyman, 2022, based on official disclosures

Nonetheless, it is also clear that China's transition to a carbon-free future has only just started. Its commitment to reaching peak CO₂ emissions by 2030 and having net-zero CO₂ emissions by 2060 represents a gigantic project that is unique in two ways. First, industrial output constitutes a much higher proportion of the Chinese economy than any other major economy. And second, its economic governance model means that the West's free-market mechanisms might be less applicable to driving change.

China is considered to be "the world's factory", with its manufacturing's share of GDP – 27% in

2019 – far higher than in any of the developed economies such as Germany and Japan (Figure 2).¹ Furthermore, this manufacturing is heavily concentrated in sectors with high CO₂ emissions (Figure 3), including steel, cement, petrochemicals and automotive.² China's manufacturing CO₂ emissions alone are equal to 2.2 times the total emissions in Europe and almost 13 times the carbon sunk from photosynthesis in the Amazon jungle.³ This carbon-heavy core of the Chinese economy will require substantial technological advances and investment to reach net zero.

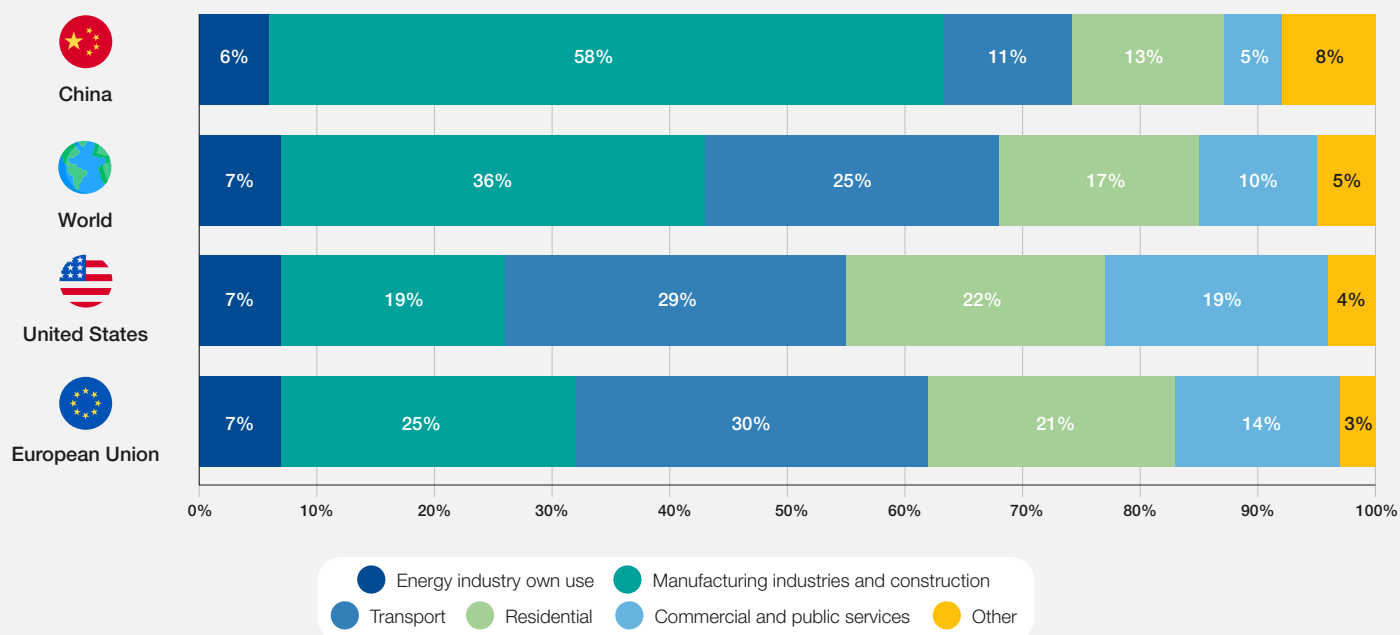
FIGURE 2 | The proportion of manufacturing in GDP in China, the EU, the US and globally (2015-2019)



Source: World Economic Forum and Oliver Wyman, adapted from World Bank, *Data – Manufacturing, value added (% of GDP)*, 2021



FIGURE 3 | CO₂ emissions by final sector (2018)



Source: World Economic Forum and Oliver Wyman, adapted from International Energy Agency, *Data and statistics*, 2020

Consequently, China's net-zero commitment will depend on a revolutionary transformation of its economy driven by the widespread adoption of

green technologies, which will require enormous investment (Table 1).

TABLE 1 | **Prioritized technology to be financed, with expected contribution to China becoming net zero by 2060**

Industry	Technology breakthroughs		Expected contribution to 2060 net zero in China
Energy	Photovoltaic (PV)	Generating electricity from solar power with PV modules	15-20%
	Wind power	Generating power with wind turbines	10-15%
	Nuclear power, etc.	Generating electricity from nuclear power, geothermal, tidal and other low-carbon energy	5-8%
Construction and real estate	Green cement	Using waste or green materials and more efficient technologies in cement production	3-5%
	Building energy management	Efficient in-building energy management and use of building in renewable energy production (e.g. rooftop PV)	2-3%
Iron and steel	Long process to mini-mill	Using electric furnaces which have shorter processes and lower emissions, using scrap steel as raw material	8-10%
	Hydrogen metallurgy	Using hydrogen as a reducing agent instead of coal for metallurgy	1-2%
Mobility	Electrification of automobiles	Using electric vehicles to replace fuel vehicles	3-5%
	Green auto factories	Using recycled materials and components, efficient processes and energy management tools	1-2%
Heating	Green heating	Using geothermal, industrial waste heat and other energy sources to replace coal for heating	3-5%
General	Carbon capture, utilization and storage	Captures carbon dioxide emissions from sources for either storage or reuse	15-20%

Source: Oliver Wyman estimation



China's unique economic model will shape this transition with both the government and provincial administrations playing key roles due to their involvement in detailed economic planning. State-owned enterprises will also be important due to their substantial market share in many industries, including the carbon-heavy industries needing to transition and the financial services that will have to finance that transition.

Compared with Western market-driven models, especially those where corporate's quarterly results are a focus, this top-down approach to economic planning may prove advantageous in investing for the long term. However, China will also need to ensure market vitality remains strong so that it encourages the innovation and development of the new technologies needed to ensure successful decarbonization (Figure 4).

FIGURE 4 Four key forces in Chinese society and their participation in net zero



While central and regional governments and state-owned enterprises often have good access to resources, they typically struggle to identify the best projects to focus on.



Financial institutions have ample funding resources, but often lack the professional knowledge needed to identify the most productive investment targets.



Many key technologies need to be imported and tailored to China's specific demands, which requires both intensive investment and industry expertise.

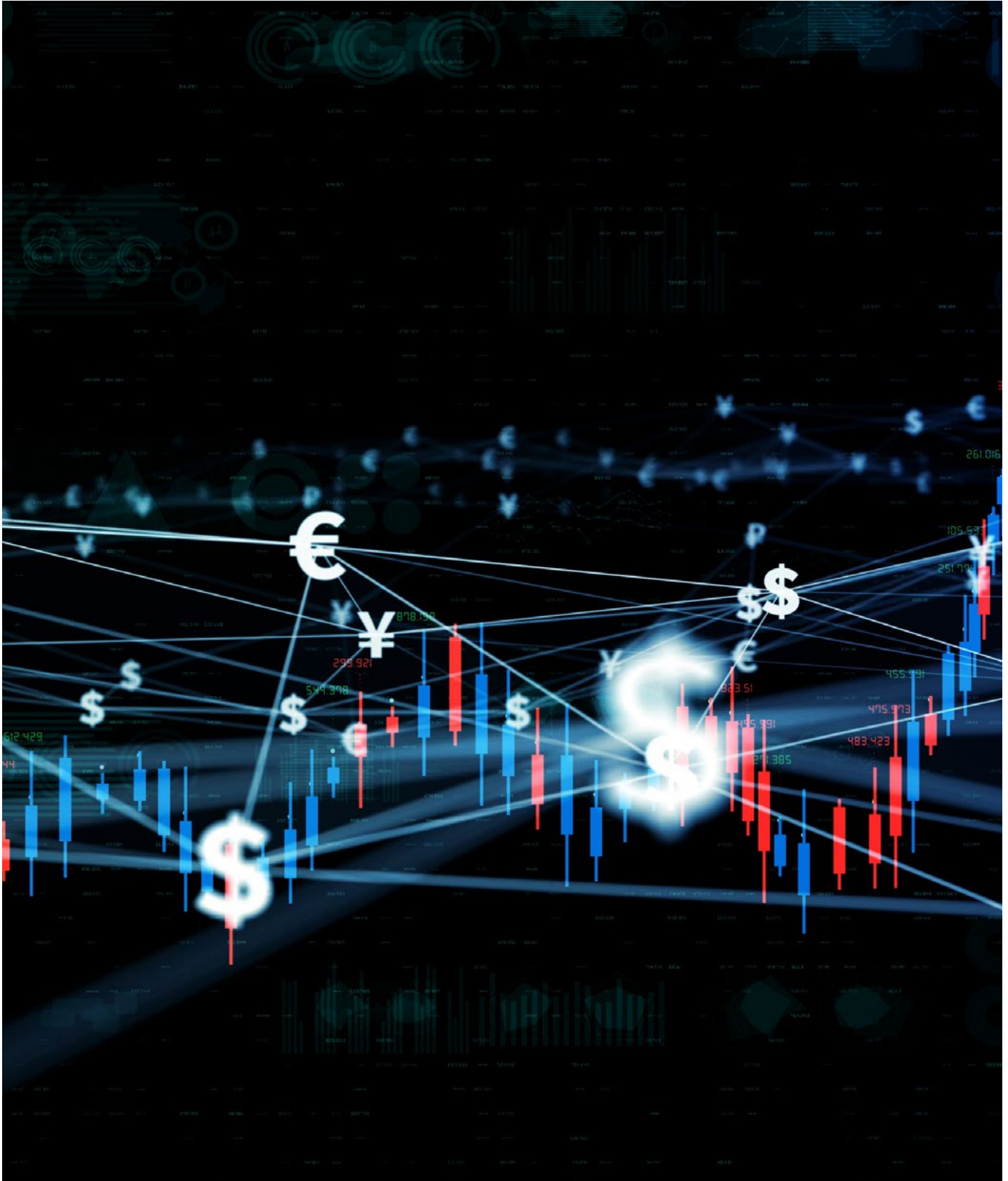


Private sector companies, the most effective group at driving environmental, social and governance (ESG) development, usually require major incentives before action.

2

The financing gap

China must promote an enabling environment that can create functioning markets for green financing.



“ For the key technologies required to support China’s 2060 net-zero ambitions, financing challenges range from insufficient investor awareness to high levels of perceived risk.

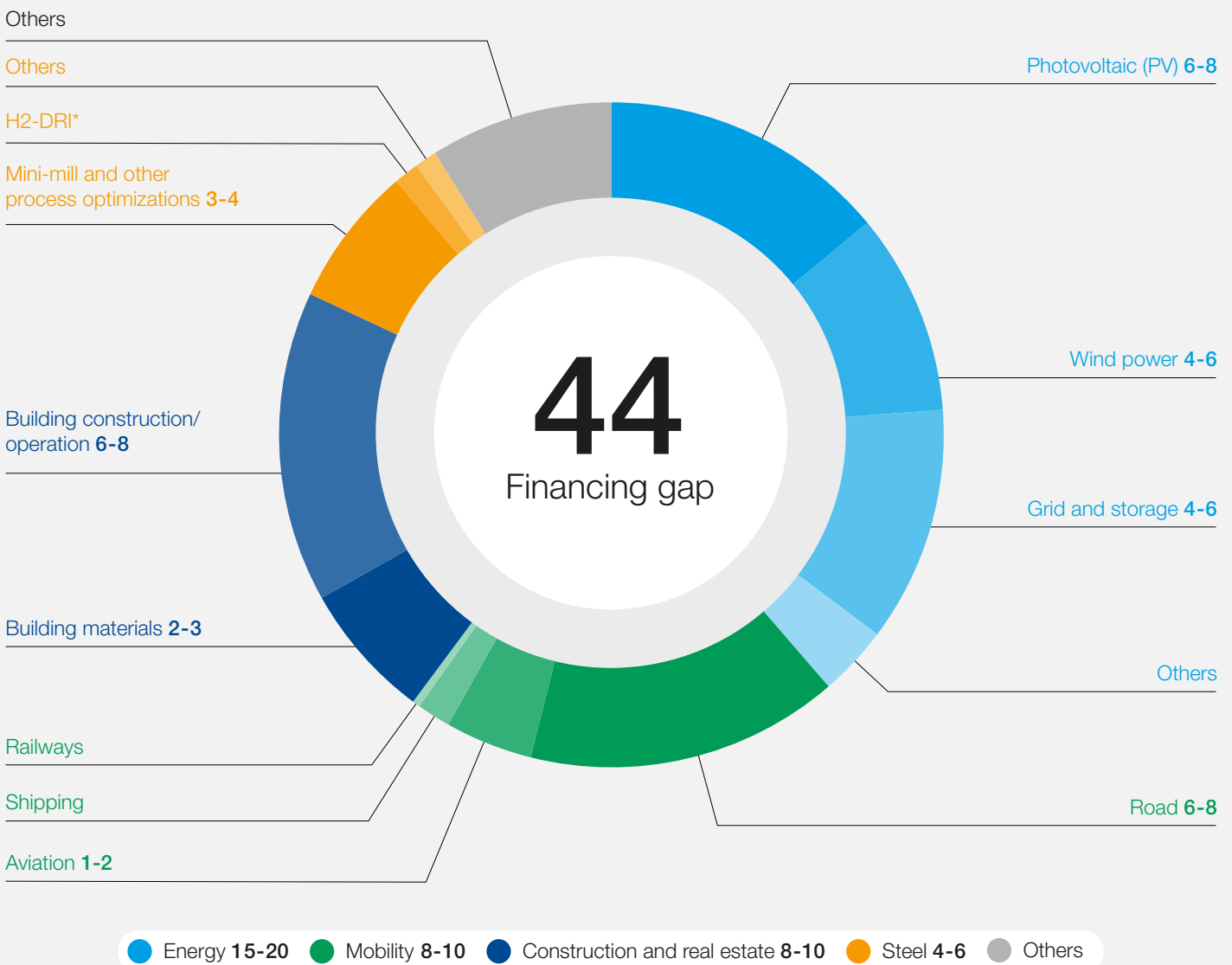
China’s transition to net zero will require an enormous amount of green financing – about CNY 140 trillion (\$22 trillion) for the 2020-60 period across electricity, steel, mobility, and construction and real estate. Currently, however, a funding gap of around CNY 1.1 trillion (\$170 billion) a year, or CNY 44 trillion (\$6.7 trillion) for the entire period, exists between this total and the likely supply of funds.

At the core of this gap is the need to finance innovative technology. Given the unproven nature of many of the technologies, funding such an investment represents a material risk to financing providers. In China, the gap is exacerbated by a structural imbalance between the supply of and demand for financial services, especially for various asset classes and loan tenors.

For the key technologies required to support China’s 2060 net-zero ambitions, financing challenges

range from insufficient investor awareness to high levels of perceived risk (Figure 5). For example, the steel industry faces a gap in the unfunded process optimization of mini-mill electric arc furnaces and depreciation of integrated blast furnaces and depreciation of integrated blast furnace projects of around CNY 3-4 trillion from 2020 to 2060 – approximately half the entire steel industry’s gap. Mobility, and construction and real estate also face major green financing gaps (both CNY 8-10 trillion from 2020 to 2060). Energy, although facing the largest funding gap – approximately CNY 15-20 trillion – has a far clearer path to carbon neutrality. An understanding of the technologies required already exists, leaving the issue of scaling financial support as the only major outstanding issue. Accordingly, the relatively more difficult transition pathways for the mobility, steel and the real estate and construction sectors are the main focus of this report.

FIGURE 5 Green financing gap in key industries and technology areas (in CNY trillion, 2020-60)



* Hydrogen-fuelled direct reduced iron

Source: Oliver Wyman estimation

One of the key reasons for a funding gap is the structural mismatch, including instruments and tenors, between the available and required financing. According to surveys conducted within the Forum communities in China, the manufacturing sector expects significantly lower interest rates for green financing projects compared to its general financing cost for non-green projects.

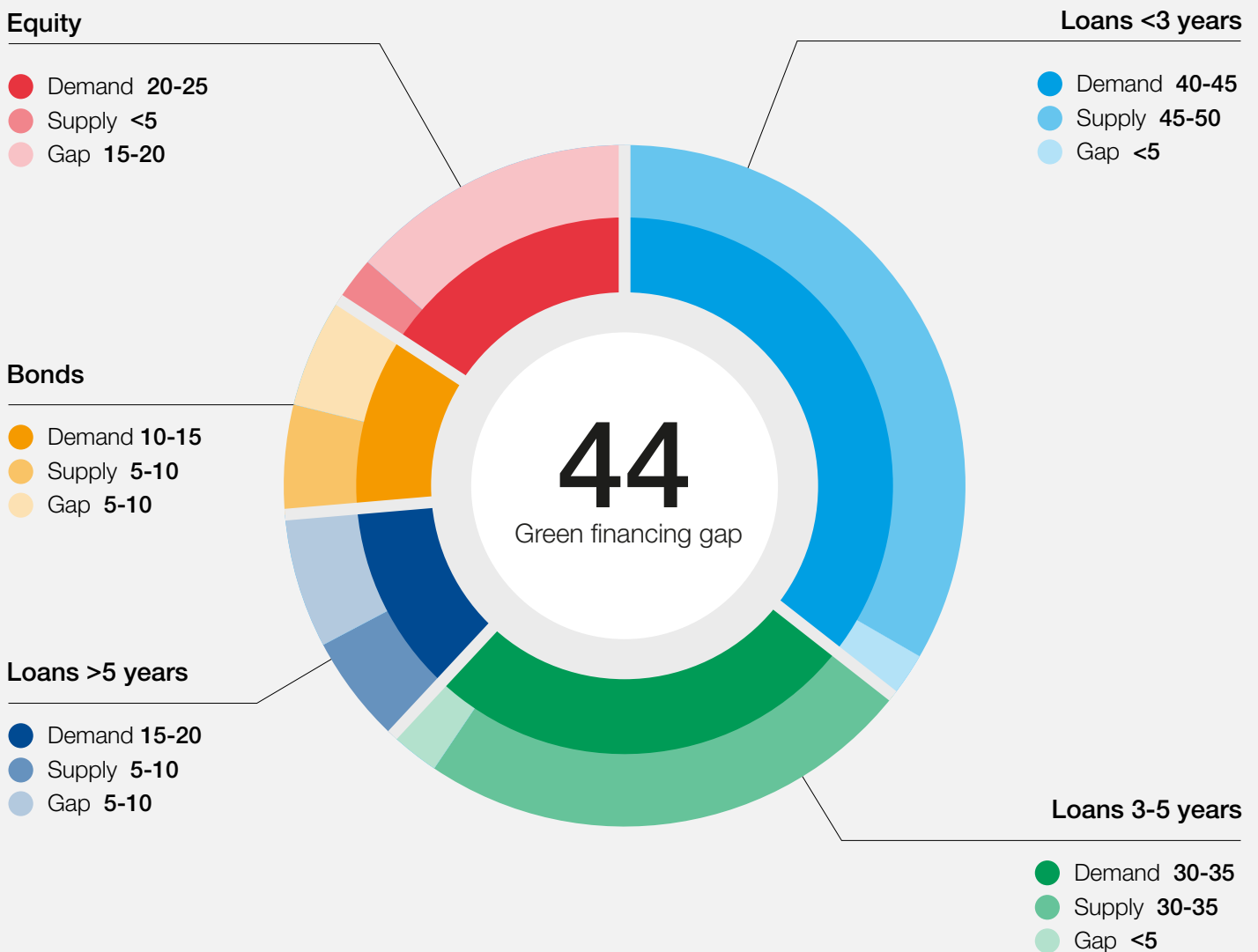
Other factors which would help companies raise funds needed for green capital expenditure and operational expenditure include:

- More flexible collateral requirements, especially for small and medium-sized enterprises (SMEs)

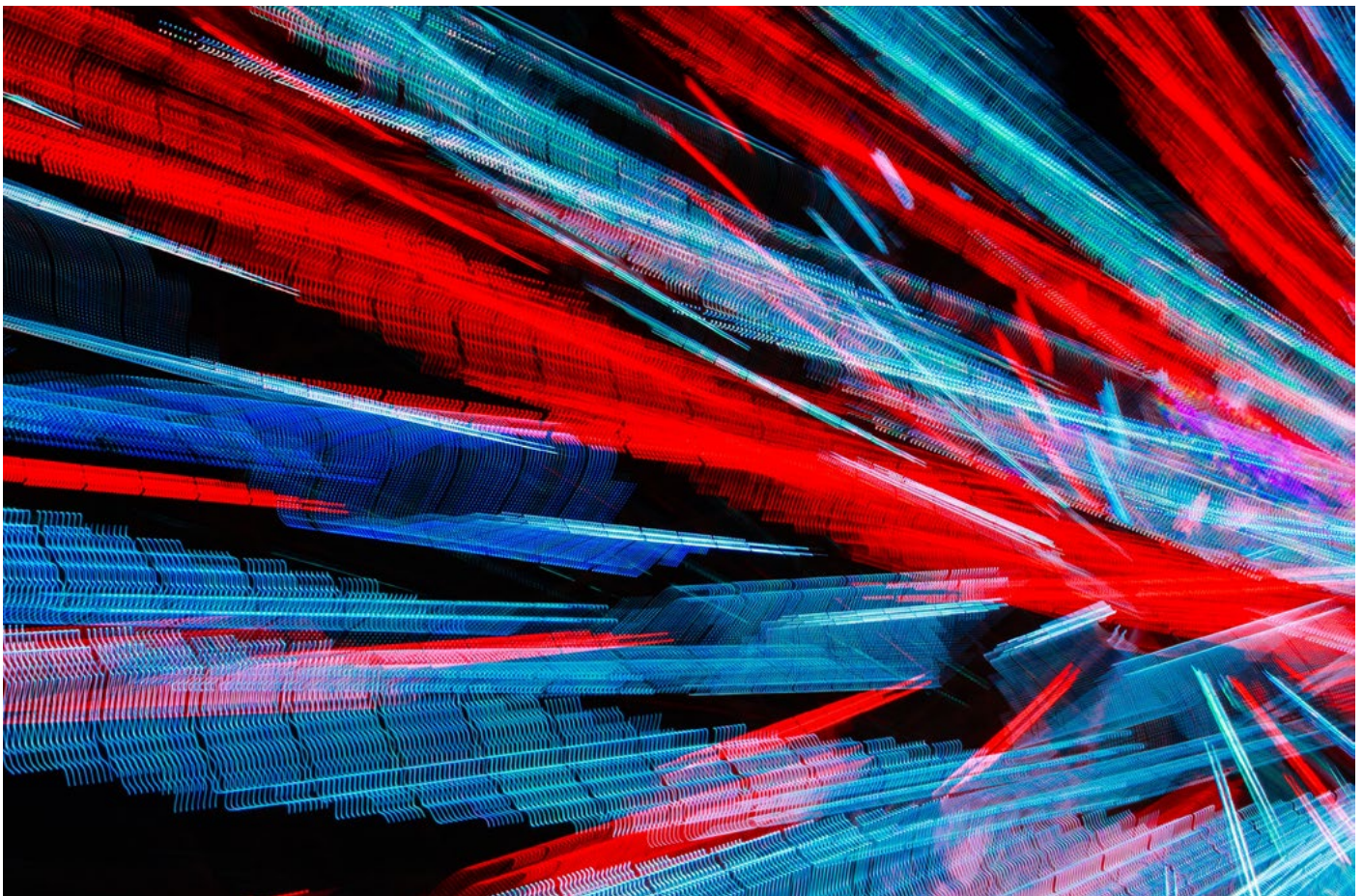
- More depth and availability in the green bond market
- Longer tenor financing
- New products, including blended equity capital structures

Such challenges are not insurmountable. Mismatches in finance offerings and demands, including financial instruments, tenors and other terms, present the opportunity for mitigating the yawning gap more efficiently by developing a more optimized green finance supply (Figure 6).

FIGURE 6 Green financing gap for key industries and technology areas (in CNY billion, 2020-60)



This poses the question of how China can create the enabling environment that will encourage such shifts towards realizing the kind of smooth-functioning financial markets needed for its net-zero transition.



2.1 Building a stronger information infrastructure

In recent years, financial resources have flowed into funds targeting China's ESG ventures. However, such investments need to be validated by credible data and aligned with unified standards for what is green, both of which require clarifications of

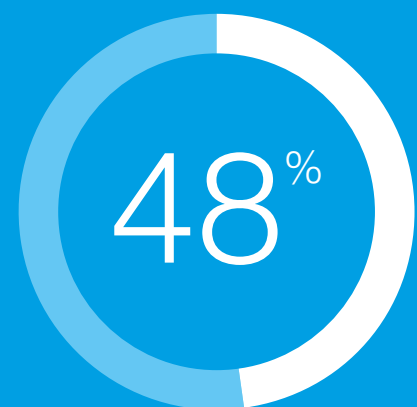
the expected scope and metrics of corporate disclosures. Many financial institutions lament the absence of such disclosures and lack the infrastructure to capture related data.

“ China has no robust tools and data to evaluate whether a target is really green. On many occasions, it's just claimed to be green. Demand exists for green financing data providers and standardized green evaluation tools.

“ In China, we lack the data to gain the relevant facts, including how to assess a target and how to monitor if it's using money properly.

“ Emission factors used in China are based on 2012 data. That's very outdated and can only calculate unreasonably low emission numbers.

Source: Quotes collected from poll engine under Chatham House Rule, 2022



of financial institutes interviewed flagged data as the biggest challenge

“ Carbon-evaluation methodologies must be refined and aligned across the country.

To create the robust, dependable data infrastructure needed to support climate-mitigation financing in China, the following steps need to be taken:

- **Designing data standards and frameworks relevant to China.** While international standards and frameworks do exist, China's market idiosyncrasies, including the scale of its economy, its many domestically developed manufacturing practices and the use of heat values and emissions factors that are only applicable in China, make it difficult for these frameworks to adapt to China's needs or they are likely to result in significant divergences in evaluation results.
- **Putting in place evaluation methodologies and tools for carbon quantification.** China's evaluation methodologies and tools for carbon quantification are underdeveloped compared to those used in developed markets. Prevalent leading evaluation systems, such as those of the Partnership for Carbon Accounting Financials (PCAF) or the Paris Agreement Capital Transition Assessment (PACTA), are not designed to handle manufacturing on the scale found in China. Interviews suggest manufacturers are also unwilling to disclose data deemed sensitive by the Chinese government. Currently available solutions in China are regarded, especially by overseas financial institutions, as insufficiently developed and prone to underestimating CO₂ emissions.
- **Improving data collection.** China lacks mechanisms for collecting industry data regularly and consolidating data gathered from different sources. As a result, its emissions data is fragmented and outdated. Various data points, including some serving as crucial parameters for carbon calculations, have not been updated for more than ten years.

- **Standardizing disclosures needed for carbon-neutrality compliance.** Regulatory standards for green projects, especially those which align with the Task Force on Climate-Related Financial Disclosures and its specific localization for China, are limited in their required contents, formats and timings of disclosures. The resulting deficiencies and inconsistencies hinder financial institutions from adequately monitoring fund flows and usage.

Addressing the above challenges will require efforts from multiple parties:

- The central government can help provide the impetus to establish universal green-financing standards and disclosure frameworks and ensure their consistent implementation across the country. These should be supported by appropriate incentives and penalties such as tax benefits, access to government support, fines and withdrawal of official backing.
- Carbon-evaluation methodologies must be refined and aligned across the country. This can be achieved either through localizing global methods (such as those of PCAF, PACTA and the Intergovernmental Panel on Climate Change), adjusting them to China's specific conditions, or by refining the evaluation system that China now has in place.
- It is essential to build the appropriate databases for providing better green portfolio evaluation. Such databases will have to include information such as production capacity, emissions, pricing and geospatial updates that can be readily updated and accessed. Emerging technologies, such as sensors based on the internet of things (IoT), can play an invaluable role in this respect.

2.2 Balancing lending supply and demand

The risk-averse nature of financial institutions has long led them to favour providing funds for projects in industries, innovations, companies and asset classes with tested profitability track records. With many net-zero schemes unproven, institutions will perceive a higher degree of lending risk than they are accustomed to. We have identified several areas

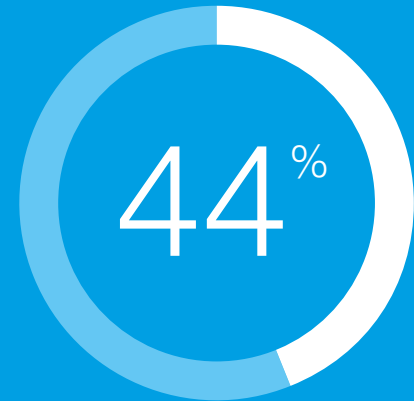
that must be addressed during China's net-zero transition, but which financial institutions have paid insufficient attention to due to a lack of information. This is particularly true for certain industries, companies and innovation areas. The unbalanced distribution of financial supply significantly exacerbates key parts of the funding gap.

“ Some sectors are already overcapitalized thanks to floods of hot money. Meanwhile, some other innovations, such as mini-mills, are still little understood by financial institutions.

“ For many leading players, debt financing may not be attractive. Capital market plays and cash management solutions, such as industry funds, IPOs or injections from downstream suppliers, are required.

“ Many green projects are too small and so too costly to do due diligence on.

Source: Quotes collected from poll engine under Chatham House Rule, 2022



of interviewed industry players flagged lending supply-demand imbalances as a major challenge

Underlying the lack of financing solutions for these innovations are two key reasons:

- **Knowledge gap.** Projects require deep industry expertise to understand emission dynamics and investors in China have yet to acquire the necessary technical expertise to assess them. Industry research suggests that most players in the market don't have sufficient expertise to engage in, let alone evaluate, such projects (Table 2).

- **Endogenous risks.** The structure of certain industries makes investing in them less attractive. For example, the steel industry's limited profitability and the real estate sector's high leverage point towards them having a higher credit risk. In addition, these industries sometimes resort to disguising projects as green to raise funds to resolve immediate financial difficulties. This creates an even more challenging market and an uncertain outlook for genuinely green projects.

TABLE 2 The challenges of assessing a steel project

A fair investment decision requires...	Financial institutions are challenged by the fact that...
Technical expertise to project key evaluation indicators accurately, such as manufacturing capacity, final passed yield, costs, etc.	Time is required to set up an investment team with cutting-edge metallurgical domain knowledge
Insights about the prospects of different pathways	Their access to prospects on policies, technical advancement trends, etc. is limited
The willingness and resources to conduct continuous on-site due diligence	It is hard to recruit analysts who are willing to perform continuous on-site due diligence; outsourced teams with the right knowledge are scarce



“ Ensuring there are clear anchor commitments to driving the greening of supply chains will, in turn, increase the demand for more innovative greening solutions.

Small and medium-sized manufacturing innovators face an especially hard time securing financing. This is despite them being the most proactive businesses when it comes to resolving net-zero technical difficulties and their general importance to the economy, accounting for 65% of total CO₂ emissions in China⁴ and around 60% of GDP and 80% of all employment. As SMEs are more responsible for Scope 3 emissions than larger companies, greening their operations will have a major impact on lowering the upstream emissions of those larger companies.

Underlying their problems in securing funding are:

- **A lack of appropriately tailored financial products.** Financial institutions tend to avoid lending to SMEs due to less public data being available about such companies' performance. If data is available, financial institutions often still struggle to develop financing offerings that meet the needs of SMEs.
- **A lack of long-term financing support.** Green projects, especially those requiring investment in research and innovation, typically require a longer payback time than conventional projects. For example, a green cement manufacturing plant typically takes 8-10 years to repay its loans, longer than a traditional cement plant. It is also likely to have higher costs and so will be less profitable. Most financial institutions prefer short tenors (1-3 years) for such projects.
- **Top-down push from anchors.** Driving innovation and greening the supply chain, for which SMEs are key, requires a greater push from their anchors, i.e. core buyers. However, if the anchors themselves lack carbon emission ambitions and know-how, the entire supply chain remains disincentivized. As such, ensuring there are clear anchor commitments to driving the greening of supply chains will, in turn, increase the demand for more innovative greening solutions.

The following approaches could help financial institutions de-risk lending to SMEs:

Establish touch points where investors and entrepreneurs can gain exposure to each other.

Such points could include focus groups, industry forums and associations, and one-off events, all aimed at mitigating the information gap between SMEs and financial decision-makers.

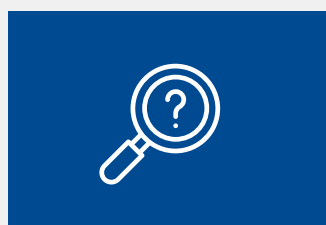
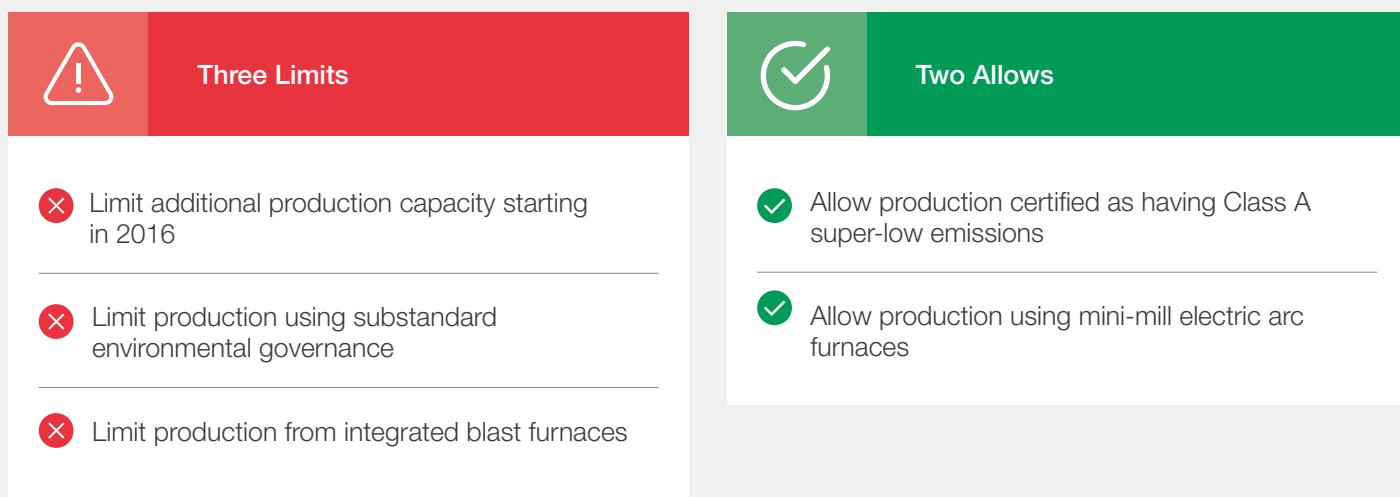
- **Develop new knowledge services.** Knowledge services, such as consulting, expert networks, data provision, and AI-driven data capture and knowledge tools, have enormous potential to provide tools useful for understanding new green technologies.
- **Create appropriate financing products.** Investors with “smart green money” – funds that can be committed to long-term green projects – and grassroots financing efforts, such as green deposits, are the best funding sources for innovators with long financing cycles. For example, HSBC, the first international bank to offer green deposits in China, puts the funds raised into long-term green investment projects. Such schemes also have the benefit of contributing to the bank's corporate sustainability agendas and reputation.
- **Offer one-stop financing solutions that integrate funding sources with different tenors.** For example, private equity firms, asset managers and banks can work together to provide funding for different tenors, with private equity/venture capital firms offering the longest terms, asset managers offering mid-term facilities and banks covering short-term loans.
- **Clear commitments from anchors.** Anchors need to work collaboratively with their financiers to design propositions that create the right incentives for green supply chains and access to investments that support the transition. This will require broader collaboration beyond banks and anchors, including third parties, to assess, measure and verify incentives for SMEs.

2.3 Enhancing the policy framework

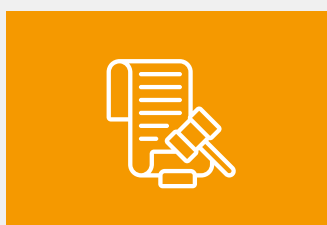
Government policies are crucial for supporting green initiatives and related financing activities, many of which have powerful externality welfare benefits but cannot be self-financed or expected to have positive cash flows. An intensive effort is required to develop such policies and the structure and organizations needed to oversee their implementation.

China has made good progress with its policy framework, but room for improvement remains in various areas. For example, its Limit Three, Allow Two policy covering emissions by the steel industry has been implemented with differing levels of stringency across the country (Figure 7).

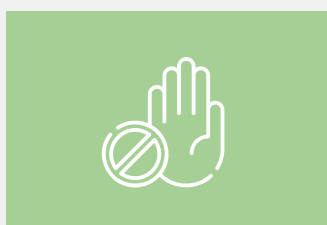
FIGURE 7 The Limit Three, Allow Two policy



Standards are unclear for environmental governance, leaving room for discretion by local governments.



Policies are inconsistently implemented. Industry participants acknowledge large companies are more likely to escape the limitations. SMEs face more stringent regulations.



Policies are neglected and stand in the way of innovation. New procedures and techniques, such as enhanced experimental H₂-DRI and blast furnaces with new carbon capture, utilization and storage technology, are less likely to be deployed as the new technologies lack empirical proof of emission reduction.



Policy can be unpredictable, especially for small and medium-sized players. As a result, they struggle to plan accordingly.



Other policy challenges remain. Among those which stand out are:

- **Reducing the need for government support.** Government support is crucial during the early stages of many ESG-related innovations. However, companies should also be encouraged to find ways of monetizing their new products instead of relying on government subsidies as their primary source of income. In the long run, evidence of market viability will also be needed to obtain financing from the market.
- **Regional policy variation.** Policies and policy implementation often vary between provinces in China and sometimes even between cities and prefectures within the same province. Among the elements which can vary are metrics, subsidies and technical specifications.

Such differences can make it hard for companies to create products that can be used at any location and for financial institutions to conduct due diligence studies (Figure 8: Different green building standards in selected Chinese cities).^{5,6,7,8} In April 2022, the State Council announced it was launching an initiative to establish a “unified national market”, which appears to have the potential to end or mitigate local protectionism, policy variance and market fragmentation.⁹

- **Tax incentives.** Despite being a potentially powerful tool to accelerate transitions, tax incentives remain an underutilized tool in China. Carbon taxes on exports, the opposite of the EU approach, could have a sizeable impact given the scale of the country’s exports. Tax exemptions could be put in place for green products and services.

FIGURE 8 Different green building standards in selected Chinese cities



Source: World Economic Forum and Oliver Wyman, based on local government disclosures



Policies are different across regions and often keep changing, forcing financial institutions to keep reviewing their strategies.



Top-down political pressure is still needed to force the industry to finish its green transition.

Source: Quotes collected from poll engine under Chatham House Rule, 2022

“ Carbon inclusion could prove to be an important instrument for raising customer awareness of the importance of switching to carbon-neutral products.

Several approaches could be used to help financial institutions face less risk in their development of products for financing China's transition to carbon neutrality:

- **Build consumer awareness of the benefits of buying green products to reduce reliance on policies.** Promotions and media campaigns explaining the long-term benefits of paying a premium for green products can play a role in changing public attitudes to sustainability. According to the 2021 Oliver Wyman Forum Global Consumer Sentiment Survey, clearer sustainability labels alone would encourage 45% of people in China to adopt more sustainable buying habits.¹⁰

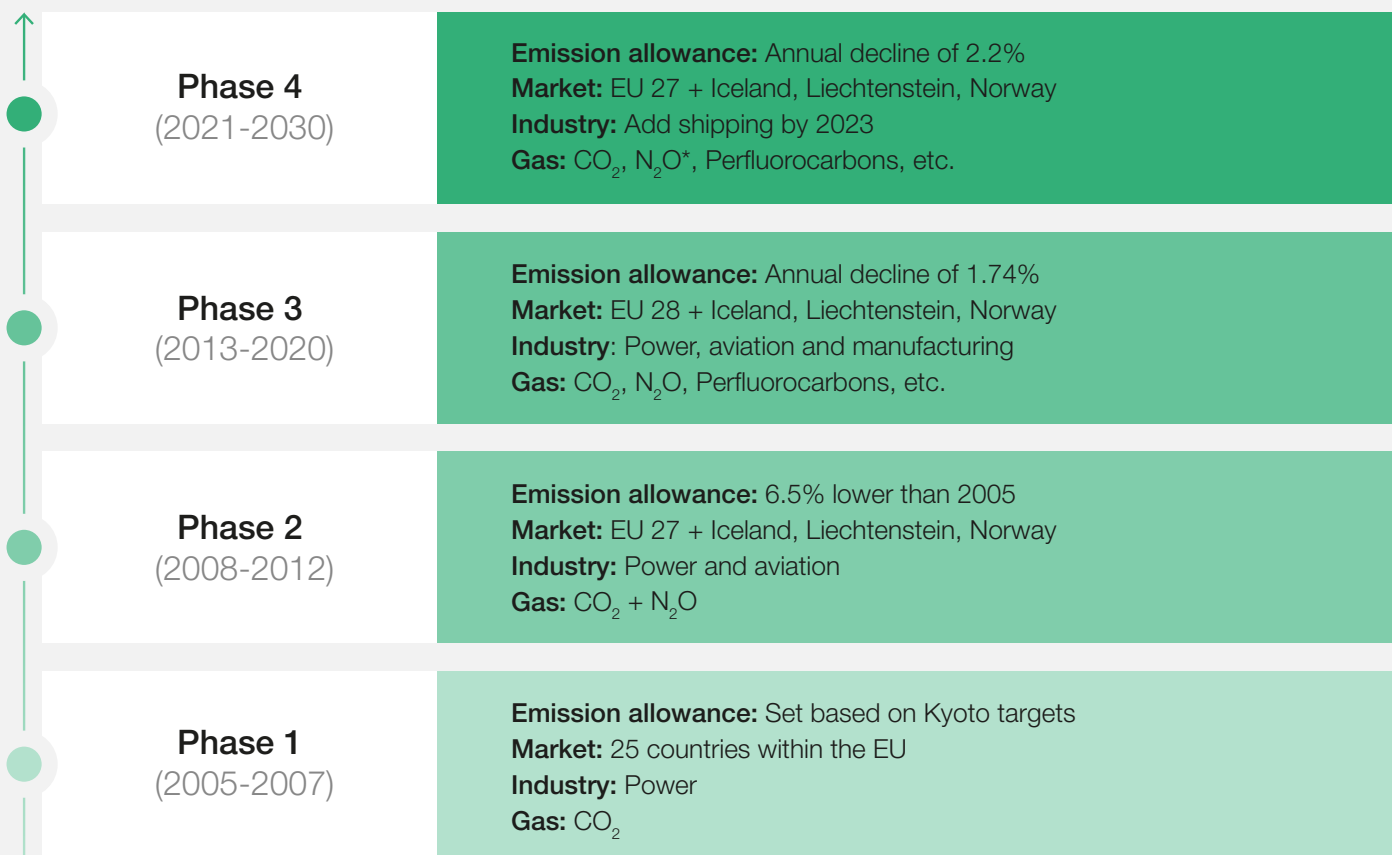
Dedicated products could also support sales of green products from financial institutions, such as green mortgage products for green residences and green insurance for electric passenger vehicles. As a result, the primary source of revenue could shift from direct government support mechanisms such as subsidies, tax benefits and extra-low-rate loans to market mechanisms.

- Carbon inclusion could prove to be an important instrument for raising customer awareness of the importance of switching

to carbon-neutral products. Giving people CO₂ emission credits, such as those of the China Certified Emission Reduction (CCER) scheme, could stimulate an awareness of the need for emissions control. One possible way of doing this would be to grant people credits for using public transport or EVs. While such schemes present technical difficulties, overcoming them could also lead to innovative ways of educating the public about the importance of cutting CO₂ emissions.

- **Put in place a unified and consistent nationwide policy framework governing regulations, standards, subsidies and other relevant mechanisms.** A useful model for emulation in this respect is the one used in the European Union to build its emissions trading system (Figure 9: The evolution of the EU Emissions Trading System (ETS) policies).¹¹
- **Develop mechanisms for mobilizing public-private financing.** For example, state guarantees are one way of providing additional reassurance to lenders, while new market mechanisms, such as the CCER, have great potential to attract more support from private capital.

FIGURE 9 The evolution of EU ETS policies



* Nitrous oxide

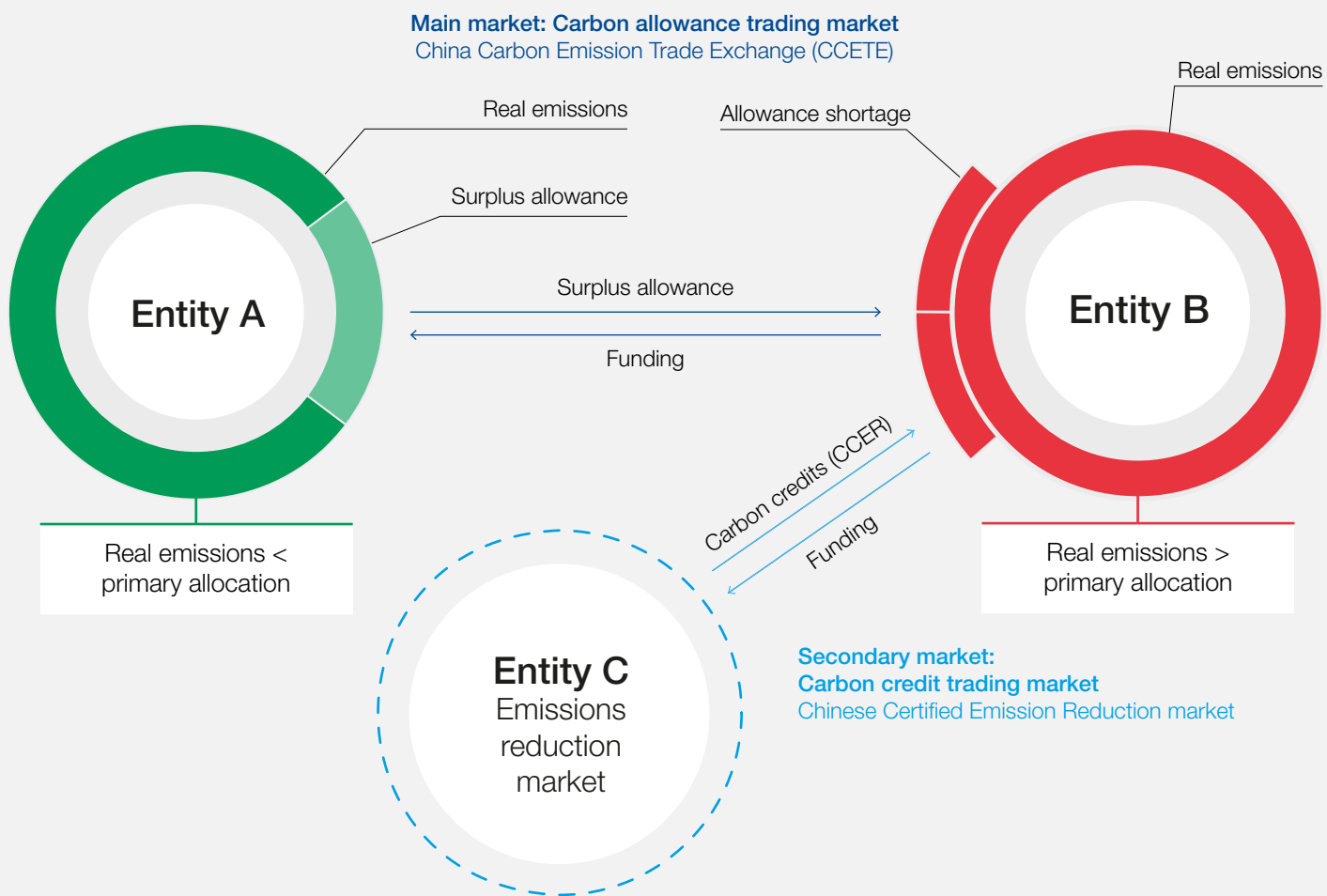
Source: World Economic Forum and Oliver Wyman, adapted from the European Commission, *EU Emissions Trading System*, 2022



China's emissions trading market, CCETE and the CCER scheme had been intended to play a similar role to the EU ETS (Figure 10: Emissions trading systems in China and international markets compared). While CCETE was launched successfully in July 2021, the CCER scheme was

suspended in 2017 due to a lack of demand for carbon credits from industry, underdeveloped carbon-reduction evaluation mechanisms and substandard projects. An improved mechanism for CCER, including evaluation mechanisms and project admittance, will be needed at some point.

FIGURE 10 Emissions trading systems in China and international markets



Source: World Economic Forum and Oliver Wyman

3

Industry analysis

Transitioning China's critical sectors will be instrumental in reducing current emissions and closing funding gaps.



In its transition to carbon neutrality, China will have to transform its entire economy. At the same time, it is clear that transitioning a handful of industries will be particularly critical because of their current emissions contribution, their role in the economy, and the size of their respective financing gaps. One such critical industry is mobility, because of its role in everyday life. Similarly, construction and real

estate poses another unique challenge because of the scale of building that China will need in the coming decades as part of its ongoing urbanization. And then there is steel – arguably the greatest marker of China’s industrial development due to the country’s 57% share of world output. This section explores the innovation and financing needs of each of these industries in detail.

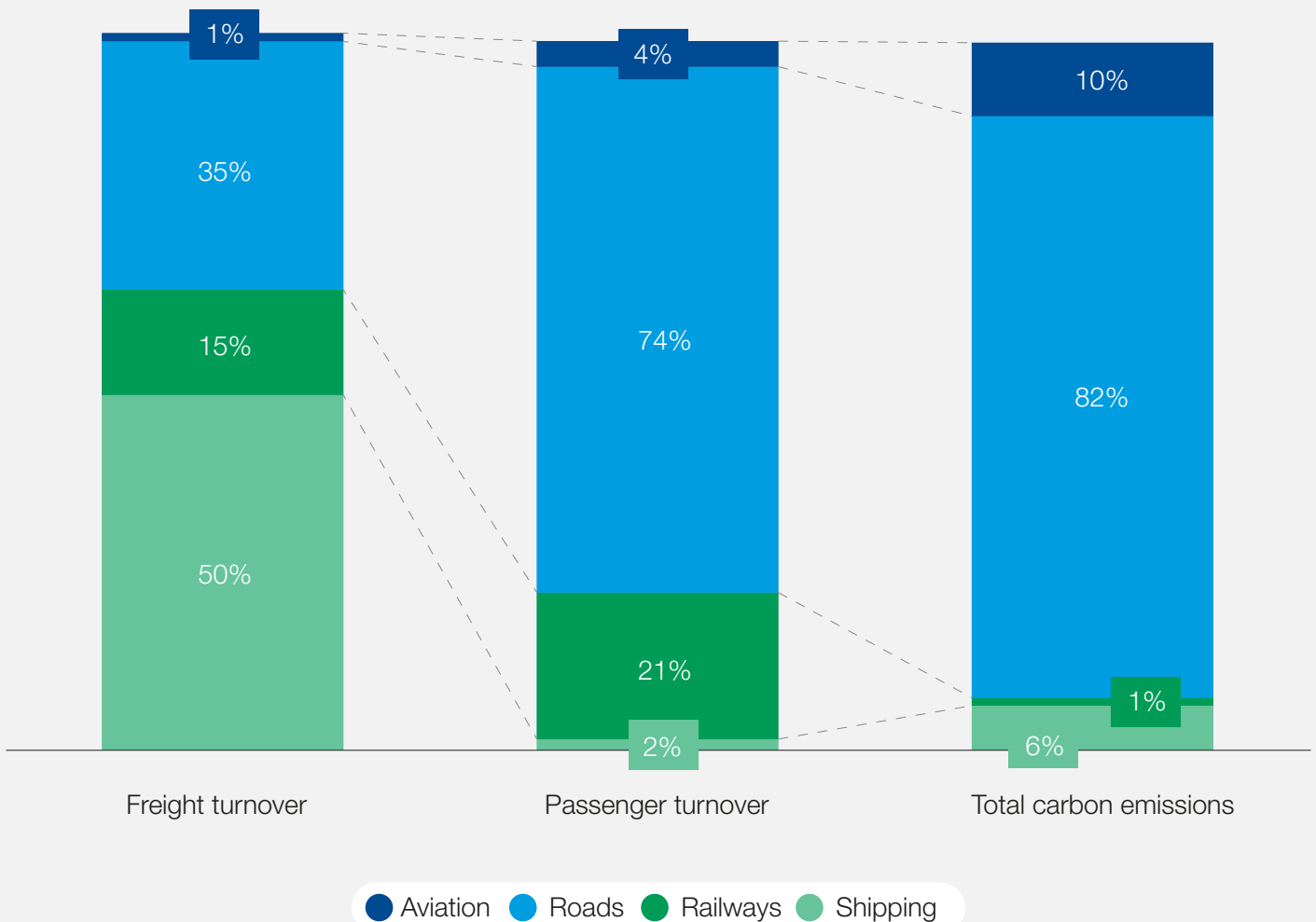
3.1 Mobility

Overview

China’s mobility sector emitted 1.1 billion tonnes of carbon in 2020, accounting for 11% of all emissions.¹² Although this relative figure is far lower than in the world’s developed economies, where the industry typically accounts for at least 30% of emissions, it is likely to grow as China’s industrialization and construction slow.

Within mobility, China’s automotive sector, including vehicle manufacturing and use, and covering both freight and passenger transport, is by far the biggest source of CO₂ emissions, accounting for more than 80% of all such emissions from the four major types of transport (Figure 11),¹³ and 9% of China’s total CO₂ emissions.

FIGURE 11 Proportion of CO₂ emissions of the four major types of mobility in China (2019)



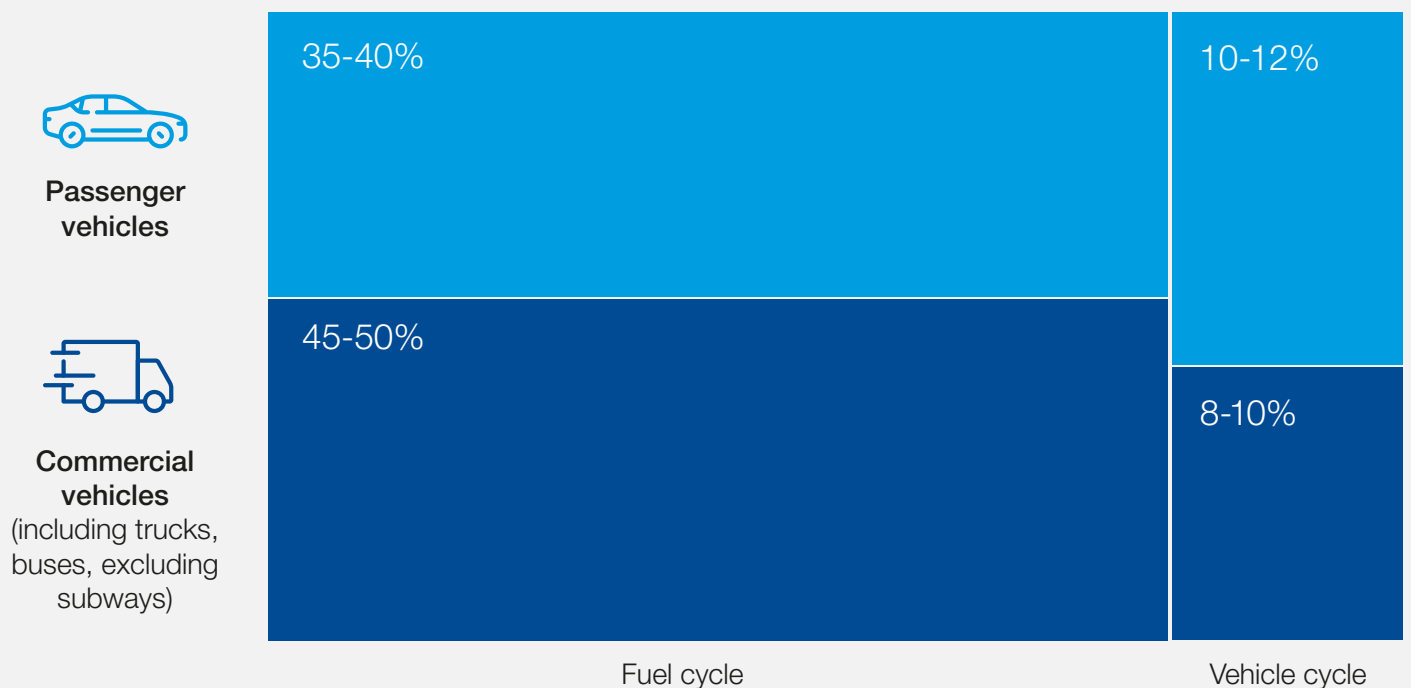
Source: World Economic Forum and Oliver Wyman, adapted from MOT, *Statistical Bulletin on Transport Industry Development*, 2020



With vehicle usage still on the rise in China, automotive emissions are growing at more than 5% a year, higher than any other major sector (globally, the share of total emissions is far greater at 18%, but the total amount is shrinking by 0.5% a year).

Passenger vehicles account for approximately 40-45% of the sector's emissions (35-40% during the fuel cycle, 10-12% during production and for maintenance), while commercial vehicles account for around 55-65% (between 45-50% in the fuel cycle and 8-10% during production and maintenance) (Figure 12).^{14, 15}

FIGURE 12 Distribution of CO₂ emissions in China's auto industry



Source: World Economic Forum and Oliver Wyman, adapted from World Resources Institute, *Evaluation and Management for Vehicle Life Cycle Carbon Emission*, 2020, and CATARC, *China Energy Saving and NEV Development Report 2021*, 2021

Because of the automotive industry's dominant share of mobility's emissions, this section largely focuses on this sector. This does not mean, however, that the emissions from other mobility sectors are insignificant.

Aviation, which accounts for 10% of all mobility emissions, clearly presents severe challenges to China's net-zero goal, especially given that this will likely be the fastest growing of the four sectors. Due to the huge volume of Chinese exports transported by sea, shipping accounts for around 6% of China's mobility CO₂ emissions. With international shipping accounting for approximately 2% of global CO₂ emissions, and China responsible for around 26% of that total, Chinese shippers can play an important role in helping the world realize its maritime net-zero ambitions. With most of its greenhouse gas emissions arising from fuel combustion, addressing this issue will be the most effective and important way of reducing its impact.

Rail transport, although accounting for just 1% of China's mobility CO₂ emissions, has a different kind

of significance. Given that it is already a relatively green means of transport, the question is how best to reduce its emissions while at the same time expanding usage, both by people and for freight.

Oliver Wyman estimates the total investment needed to transition the mobility sector to carbon neutrality between 2020 and 2060 to be CNY 30-35 trillion (around \$5 trillion), or around CNY 800 billion a year. It estimates the funding gap for the sector to be CNY 8-10 trillion.

In line with the greater public support given to the road sector – around 76% of all official funding to the mobility sector during the 2016-21 period – funding is expected to be more easily available for transitioning the auto sector to net zero than for the other sectors.

Overall, Oliver Wyman estimates the total funding gap for auto mobility to be CNY 6-8 trillion, for aviation, CNY 1-2 trillion, and for shipping and rail, CNY 1 trillion.

Key net-zero technology pathways

“ With international shipping accounting for approximately 2% of global CO₂ emissions, and China responsible for around 26% of that total, Chinese shippers can play an important role in helping the world realize its maritime net-zero ambitions.

The principal step towards greening automotive mobility will be having new energy vehicles (NEVs) dominate the market, which, combined with the development and introduction of renewable energy sources, will end the sector's reliance on fossil fuels.

Key technology innovations are still underdeveloped. It is widely forecast that NEVs will need at least another ten to fifteen years to be as cost efficient across their life cycle as traditional internal-combustion engine vehicles. Currently, NEVs typically cost more to produce than traditional vehicles and depreciate faster. Production will require large-scale investment and innovation ranging from long-life batteries to efficient electric engines, and not just for their manufacture and use. For example, battery laddering technology continues to hold great promise both to improve battery utilization and lower battery production costs. However, problems with safety, including the threat of explosions, are holding back its adoption. For example, large-scale energy storage projects using ladder batteries have been banned.

In addition, moving to an automotive sector dominated by NEVs will require concerted efforts to green the rest of the industry chain, from automotive component production, through

vehicle manufacturing and sales, to the aftermarket supply of parts and accessories and provision of eco-services such as intelligent route-planning and car-sharing, to the eventual dismantling and reuse or disposal of vehicles and their materials. A key challenge here that needs substantial R&D is identifying the status of recycled batteries.

Given the size of China's auto industry – production was around 21 million passenger cars in 2019, more than for any other country – reworking the industry will be an enormous and complex task, especially when it comes to establishing net-zero supply chains across the extended production networks that characterize the industry (Case study 1: GAC Motor green factory). Currently, CO₂ emissions attributable to indirect sources in the automotive value chain – Scope 3 emissions, as they are known – account for around 35% of automotive emissions.

Measurement, reporting and verification (MRV) standards and classifications will also have to be put in place for used and scrap materials to support the recycling of parts. Immature energy-conversion technologies also remain problematic. With many safety issues still unresolved, large-scale energy-storage projects remain banned in China.



GAC Motor, a Guangzhou-based Chinese automobile maker owned by the Guangzhou Automobile Industry Group, which works with Fiat, Jeep, Honda, Mitsubishi and Toyota, is exploring new, greener processes with its AION Smart Ecological Factory. Among the factory's features are:

- **An energy-saving design** that uses unequal room heights cuts construction costs by 8% and reduces energy consumption by 15% through space saving.
- **Lightweight component materials** such as aluminum alloys which, by reducing a vehicle's weight, can cut its energy consumption.
- **Environmentally-friendly production** techniques that replace volatile organic compounds such as benzene with water-based solutions and use new coating pre-treatment processes that reduce the emission of harmful substances.
- **Intelligent energy management systems** which use new energy-storage technologies to store surplus electricity and integrate its dispatch.
- **Renewable energy production** through the installation of 52,000 PV panels with an annual generating capacity of more than 16.7 million kWh – 15% of the factory's full-load electricity consumption.
- **IoT energy management** using sensors deployed across the stamping workshop that reduce processes such as motor braking and starting by 98%.

Source: World Economic Forum and Oliver Wyman, 2022



Smart driving services using the internet of vehicles (IoV), big data and other technologies can optimize routes to reduce idling and unnecessary detours for traffic scheduling and predictive maintenance. For example, Dida Chuxing, one of China's leading car-hailing platforms, reports cutting CO₂ emissions by 1.1 million tonnes through carpooling. According to the company, each kilometre of carpool driving saves an average of 173g of CO₂ emissions.¹⁶

Beijing Sinoiov Information Technology is an IoV solution provider that offers sensors and monitors

to provide drivers and traffic managers with route algorithms and intelligent vehicle schedules. Among the services it is developing for drivers are smart reminders for vehicle maintenance, refuelling route plans and advice for drivers on energy-saving driving habits. For cities, it offers supervised machine learning of traffic data that can help improve the planning of traffic restriction mechanisms and infrastructure, such as charging stations.



BOX 1 | Transitioning shipping, aviation and rail

Mobility's green transition challenges for the shipping, aviation and especially the railway sectors appear manageable.

Short-term initiatives aimed at addressing shipping emissions included in the 14th Five-Year Plan covering the 2021-25 period include setting up a national ship energy consumption centre, an emission-reduction monitoring system and actively participating in the global governance of industry emission reductions.

A transition to using liquid natural gas as shipping's principal fuel would bring sizeable benefits, among them the elimination of nitrogen oxide and sulfide emissions released by fuels currently used. However, technical difficulties and the risk inherent in the scale of the required investment are impeding the development and application of the relevant technologies.

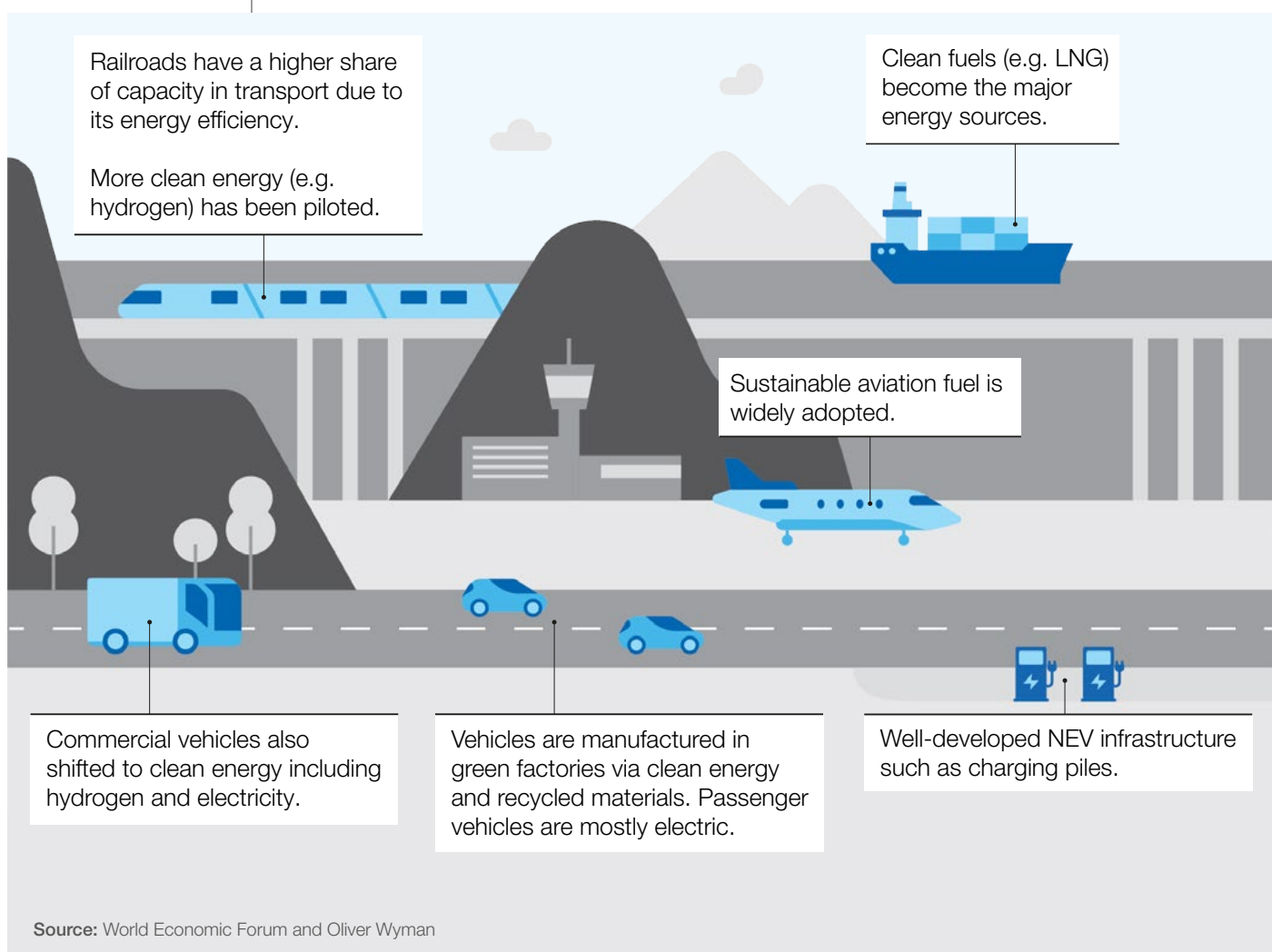
In the longer term, reductions will come from leveraging synergy with ports and other infrastructure, and the development and application of new fuels and propulsive technologies.

Because of rail's low share of China's mobility emissions, its main contribution to moving the country towards its net-zero target will be by increasing its share of passengers and freight transport, thereby reducing road and air transport. In cities, this will call for a further acceleration in the construction of subway networks and elsewhere for a greater use of rail in multimodal cargo networks such as rail-water, rail-sea and rail-air.

Efficient scheduling and command systems, network optimization and the use of green construction and operation practices can also play a role, along with adapting decarbonization solutions in the construction of infrastructure and rail vehicles.

Aviation, like shipping, primarily emits carbon and other greenhouse gases through fuel combustion. Sustainable aviation fuels, produced from sustainable feedstocks, will likely be the solution. Currently, such feedstocks include food waste such as cooking oil and solid waste from homes and industry. Potential sources include algae and various plants.

FIGURE 13 | Green transition end stage of mobility



“ Achieving a green transition across the sector’s various value chains will require innovative mechanisms to motivate upstream players.

What needs to happen

Due to the scale of change needed, the auto sector’s green transition will need to be addressed both from within the sector, by automakers and their suppliers, but also from the outside by looking at the needs of consumers, what policy steps the central and regional governments should be taking and how finance can best play a role. Innovation will be critical in all these areas.

1. Finance innovation

Given the funding gap faced by various emerging NEV technologies and the slow pace of infrastructure development, financial support will be required across several key innovation areas. Capital has been rushing into NEVs but there are also other carbon-reducing technologies that require funding, as well as potentially profitable innovation areas with larger financing gaps.

Financing the infrastructure for charging is one area that stands out, along with support for battery recycling and possibly establishing a national rare-earth pricing mechanism.

Also, new financial solutions require data infrastructure, stronger and extended research capabilities, and channels to reach related targets, as described in section 2 of this paper. Interviews with experts from different Forum communities showed that loans with tenors of five or more years are still lacking in these areas. The industry, and especially emerging NEV makers, would also benefit from more equity investments and capital market tools that more closely meet their specific requirements. Developing these new tools will require close collaboration between banks, private equity and venture capital firms to manage the risk-reward trade-offs.

Financial institutions must also examine whether and how they can be incentivized to offer discounted lending rates to green vehicle makers and their suppliers. Such an approach would help the industry and financial institutions achieve their net-zero ambitions. Banks need to get ahead of their own ambitions to affect change.

2. Collaboration

As Scope 3 emissions account for around 35% of all mobility emissions, producing and operating green vehicles, trains, aircraft and ships call for coordinated efforts involving many companies. Finding ways to incentivize all players to move together poses difficult organizational problems, but there is no alternative to closer collaboration.

Building out vehicle charging networks is one crucial area that could benefit from public-private partnerships, with the private sector supplying the technology and financing, and the public sector helping with the provision of sites.

More broadly, manufacturing supply chains across the mobility sector are long and complex. Achieving a green transition across the sector’s various value chains will require innovative mechanisms to motivate upstream players. One approach is for manufacturers to set mandatory green standards for their suppliers, working with financing institutions to design green financing propositions to verify progress in line with incentives and goals. Another is for buyers to pay higher rates for green products to incentivize their suppliers to make their operations sustainable.

Alternatively, companies can explore softer approaches. Ford’s Partnership for a Cleaner Environment (PACE), for example, does not set mandatory requirements for suppliers but rather sets out to gain their support through a three-stage process:

- Empowerment: providing suppliers with the means they need to overcome their carbon neutrality “pain points”, such as not having the right data evaluation tools.
- Guidance: helping suppliers standardize their carbon neutrality practices by designing norms and standards, including data collection and result reporting.
- Sharing: encouraging suppliers to share their successful carbon neutrality practices with other companies.

Already more than 50 companies have joined PACE. They are expected to reduce Ford’s supply-chain CO₂ emissions by 680,000 tonnes over the next five years. Further down the road, financial institutions, or possibly Ford itself, could offer supply chain financing products tied to the green performance of supply chain players; the greener their operations, the better the financing terms they are offered.

Finally, as many consumers remain either unaware or unconvinced of the need to shift to green mobility, better consumer education measures could lead to increased adoption of green mobility products and their related financial products, such as loans and insurance for EVs.

3. Policy support

Beyond finance, the central and local governments will also have to provide broad policy support.

Tax policies giving preferential treatment regarding the construction, purchase and use of EVs over internal-combustion-powered vehicles, currently covering the period up to the end of 2022, will need to be extended and possibly broadened. Hong Kong offers a model that the rest of China might want to emulate, waiving up to HKD 97,500 (\$12,500) of the first registration tax (FRT) for electric passenger cars and waiving all FRT and allowing a 100% capital expenditure profit-tax deduction for commercial EVs.

Standards are another important area for policy, for example, for charging methods to prevent sites from only offering Tesla-specific superchargers. An example worth considering is the United Kingdom and its rollout of a charging network with standardized connectors (plugs) and quality standards developed by the British Standards Institute, data transparency rules and payment methods, all aimed at improving the user experience.¹⁷

Other policy options that need to be considered include the construction of industrial parks, special land-leasing schemes, support for upstream suppliers and staff training and education schemes.

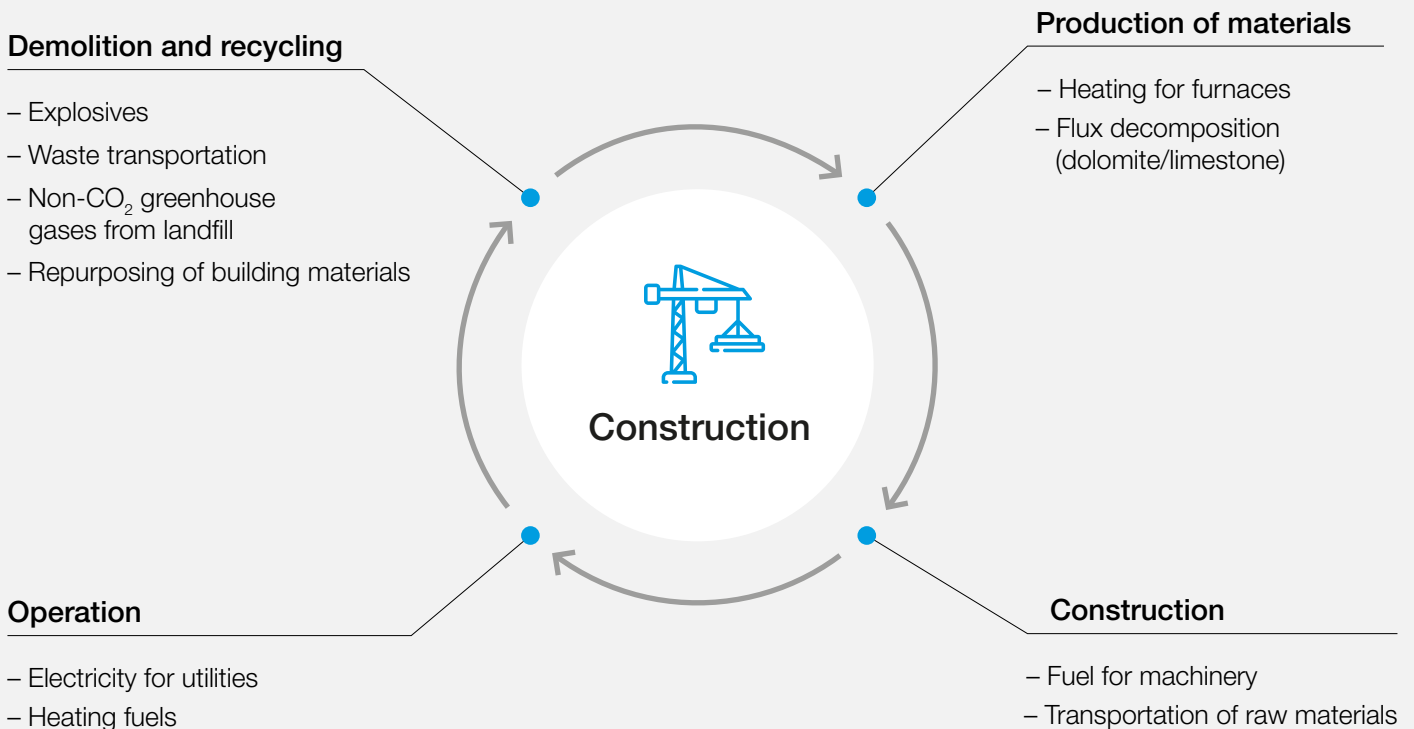
3.2 Construction and real estate

Overview

The construction and real estate sector contributes around 15%¹⁸ of China's CO₂ emissions, slightly higher than its 14% contribution to GDP. These emissions come from two principal sources: the materials used in construction and construction itself, and from the operation of a building over its life cycle. Overall emissions across the building life

cycle can account for 51% of total Chinese CO₂ emissions¹⁹ if taking all Scope 1,2 and 3 emissions from indoor activities into account (Figure 14: CO₂ emissions along the construction life cycle). Scope 3 emissions, among them materials (including steel), construction technologies and building operations, are the main targets for reduction.

FIGURE 14 Forms of emission across the construction and real estate life cycle



Source: World Economic Forum and Oliver Wyman

Developed countries are leading China in the application of technologies for low-carbon materials, construction, operation and recycling, and also in having stringent environmental standards, all of which point the way forward in many areas. Financial institutions are also starting to explore initiatives aimed at helping the construction industry reduce its CO₂ emissions.

As a significant portion of real estate-related CO₂ emissions occur during the production of materials, especially cement, and the construction stages of a building project, investment in innovation should be focused on these areas. Upgrading construction technologies also has a role to play, as does finding ways of reducing energy usage and maintenance services throughout a building's life.

Key net-zero technology pathways

CO₂ emissions are produced during the four stages of a building's lifetime, which are construction and transport of materials, the building's operation and demolition.

The building materials component, referred to as embodied carbon, contributes a significant

amount of emissions – cement production alone is responsible for 15% of China's greenhouse gas emissions. Worldwide, cement production is responsible for around 5-6% of emissions. The widespread uptake of low-carbon alternatives to cement offers a possible way forward for the industry (Case study 2: Anhui Conch Cement).

CASE STUDY 2 Anhui Conch Cement



Anhui Conch Cement is China's largest cement manufacturer. Headquartered in the Anhui province of Wuhu, its whole-process smart cement production plant works to reduce carbon emissions across the entire production process through the use of innovative technologies and alternative energy sources.

Anhui Conch has received substantial official support for its green transition. In 2020, government subsidies, including tax rebates for the comprehensive use of resources, totalled more than CNY 800 million (\$125 million). It has also obtained loans at favourable rates from the China Clean Development Mechanism Fund and other institutions.

Production process	Raw material crushing	Raw meal and clinker production	Cement grinding
Innovation or technology applied	Using industrial solid waste as raw material; installing carbon capture, usage and storage equipment.	Improved energy-efficiency systems introduced for grinding, pre-heating, electric motors, etc. Scrubbing technologies introduced to treat kiln smoke and flue gases.	Introduction of solar, wind, biomass and other new energy sources for the single biggest power-consuming process in cement manufacturing.
Outcome	50,000 tonnes of high-purity industrial- and food-grade CO ₂ produced annually.	Nitrogen oxide (NO _x) emissions cut by around 1.3 tonnes annually. Company-wide, energy savings will reduce CO ₂ emissions by 8.5 tonnes annually.	Company-wide, standard coal usage will be cut by 10.8 tonnes annually, and CO ₂ emissions by 28 tonnes annually.

Source: World Economic Forum and Oliver Wyman, 2022





“ One of the principal ways of lowering emissions during the design and construction phase is by introducing certified green practices

One of the principal ways of reducing emissions is by addressing energy efficiency and the use of lower carbon materials upfront in the design stage. Certain certifications, such as Leadership in Energy and Environment Design (LEED), can provide helpful guidelines.

Reducing emissions over the lifetime of a building’s operation requires using energy from renewable sources and increasing energy usage efficiency. Applicable energy technologies include geothermal heat pumps to draw energy from the ground as well as windmills and solar panels. Insulated bricks made of polymer materials with low thermal conductivity can help retain warmth in the winter and keep a building cool in the summer.

Traditionally, a building’s life ended with it being demolished by bulldozers or explosives and much of the subsequent waste material being transferred to landfills, resulting in both resource depletion and environmental damage. Alternatives now under development involve reusing as much of a building’s materials as possible. Various countries are experimenting with the design for disassembly/adaptation processes that allow future buildings to be built from previous ones. This requires buildings to be built with easily separable structural and architectural components that are purposefully designed so that whole buildings can be reused.

FIGURE 15 Green transition end stage of construction and real estate



Recycling
Buildings are designed for recycling, with the majority of components being recycled.

Building materials
Cement is produced with recycled/waste materials and green energy.

Reduced usage of toxic materials.

Construction
Energy-efficient machineries and vehicles are used.

Green standards are widely adopted (e.g. LEED).

Operation
Building management systems for energy, water, etc. to reduce resource usage.

Buildings become an energy generator itself by applying distributed PV modules.

Demolition
Buildings are designed for disassembly/adaptation.

Source: World Economic Forum and Oliver Wyman

“ With most green real estate projects taking even longer to earn a return than conventional schemes and typically exhibiting both higher costs and lower margins, long-term financial support is crucial.

What needs to happen

Tackling the construction and real estate sector's transition to net-zero emissions will require less technology innovation than in the mobility and steel industries, and more reliance on regulatory and incentive schemes that encourage optimal industry behaviours.

1. Finance innovation

With many green real estate projects requiring higher upfront costs and a longer payback period, long-term financial support is critical. While there is growing research that indicates green buildings can generate increased cash flow relative to less sustainable peers, the higher initial cost can dissuade developers that do not plan to hold the asset long-term. Loan periods need to extend for at least ten years; the average period from land acquisition to the first sale of units.

To facilitate such loans, industry players need to address the gap between the information and data it currently provides lending institutions and what those institutions will require for their lending decisions. Also needed will be taxonomies and standards for assessing energy savings, emission reductions and other measures for judging environmental sustainability.

Financial institutions should play a role in ensuring that lending practices align with official regulations and, where necessary, stipulate how standards should be established and the criteria which need to be met for loans to be extended.

Real estate companies' demands for green financing include longer-term solutions and more SME funding. For the most part, SMEs are still neglected by lending institutions, which prefer to provide green financing support to large companies. These large institutions need to work with banks to put in place the right incentives to support the greening of their supply chains. There is a shared interest in large companies, financiers and SMEs working together to make this happen, which requires banks to innovate their solutions while working closely with the industry.

2. Collaboration

Raising green funding requires the supply of better information than the industry currently provides. Developing and installing environmental monitoring systems along with appropriate data management and analysis technologies are necessary steps.

Cross-value-chain cooperation will be required to set, assess and regulate emission control efforts, all necessary to reduce Scope 3 emissions. All relevant parties must contribute to green certification standards, methodologies for greenhouse gas MRV

and how information and data can be accessed and shared. This collaborative process needs to be supported by the right incentives, both financial and non-financial.

The industry's long-term development will also be helped by educating end-users on the role of mortgages and other real estate financial products and the impact green building practices can have on the cost of such instruments. In Shanghai, for example, the daily rent for a green grade-A office building is RMB 10.5 per square metre, while for a non-green grade-A building, it is RMB 8.5. What benefits will accrue to a renter of the former? As many buyers and users remain unwilling to pay a green premium for buildings, education on the importance of moving the real estate sector towards carbon neutrality is needed. Shared-space models, such as WeWork or Airbnb, can also contribute to reducing a building's carbon footprint by increasing its space utilization rate in the way similar models in the mobility sector, such as car-hailing, have proven effective in lowering overall carbon usage for travel.

3. Policy support

Governments at all levels will have to offer policy support, particularly for setting and monitoring green and other standards. Various surveys have found that people across the country tend to see officials as the key force driving change. For example, when asked "Who do you think should be most responsible for addressing climate change?", some 68% of Chinese polled by the Forum and Oliver Wyman named the government, higher than the global average of 60%.²⁰

Currently, standards vary widely in different parts of China, sometimes even between neighbouring regions such as Shanghai and Zhejiang. Standards can also vary across a building's life cycle. Cement products certified as green by building materials departments may not be regarded as such by construction standards. Methodologies for calculating the amount of carbon reduction resulting from the application of new processes have also yet to be standardized.

City and provincial governments can contribute by establishing clear guidelines aligned with local needs and resources. Beijing's Chaoyang district, for example, offers grants of RMB 20 per square metre for all new LEED platinum-certified buildings and RMB 800,000 for buildings included in pilot energy-efficiency projects.²¹

Lastly, tax incentives also have a role to play in the real estate and construction sector. These could range from tax credits for installing renewable energy systems such as solar panels, geothermal heat pumps or wind turbines to reductions, exemptions and rebates for completed green buildings.

3.3 Steel

Overview

Steel production contributes around 13%²² of China's CO₂ emissions, largely due to the use of coal in making iron. Although the industry has great potential for decarbonization, holding the process back is the high cost of replacing many relatively new blast furnaces and the high levels of leverage that already exist in the sector. Oliver Wyman calculates the funding gap for China's steel sector to be around CNY 4-6 trillion for the 2020-60 period, or CNY 100-120 billion a year. The gap comes from the funding shortage for key technology advancements, including mini-mills and H2-DRI.

Policies impacting the industry include the 14th Five-Year Plan and the National Development and Reform Commission's Industrial Resources Comprehensive Use Plan, which focus on reducing raw materials consumption by steel producers.

The 14th Five-Year Plan, covering 2021 to 2025, includes a commitment for China's raw materials sector to adopt a development strategy built around achieving higher quality, better profitability and low carbon. A statement on the plan's goals, issued by the Ministry of Industry and Information Technology and other government agencies in December 2021, called for efforts across the industry to realize a "digital and green shift". It also called on steel producers to not increase production capacity. A notice issued by the National Development and Reform Commission, together with other central departments, calls for a substantial reduction in industrial solid waste in key industries, including iron and steel, to achieve a utilization rate for the bulk industrial solid waste of 57% by 2025.



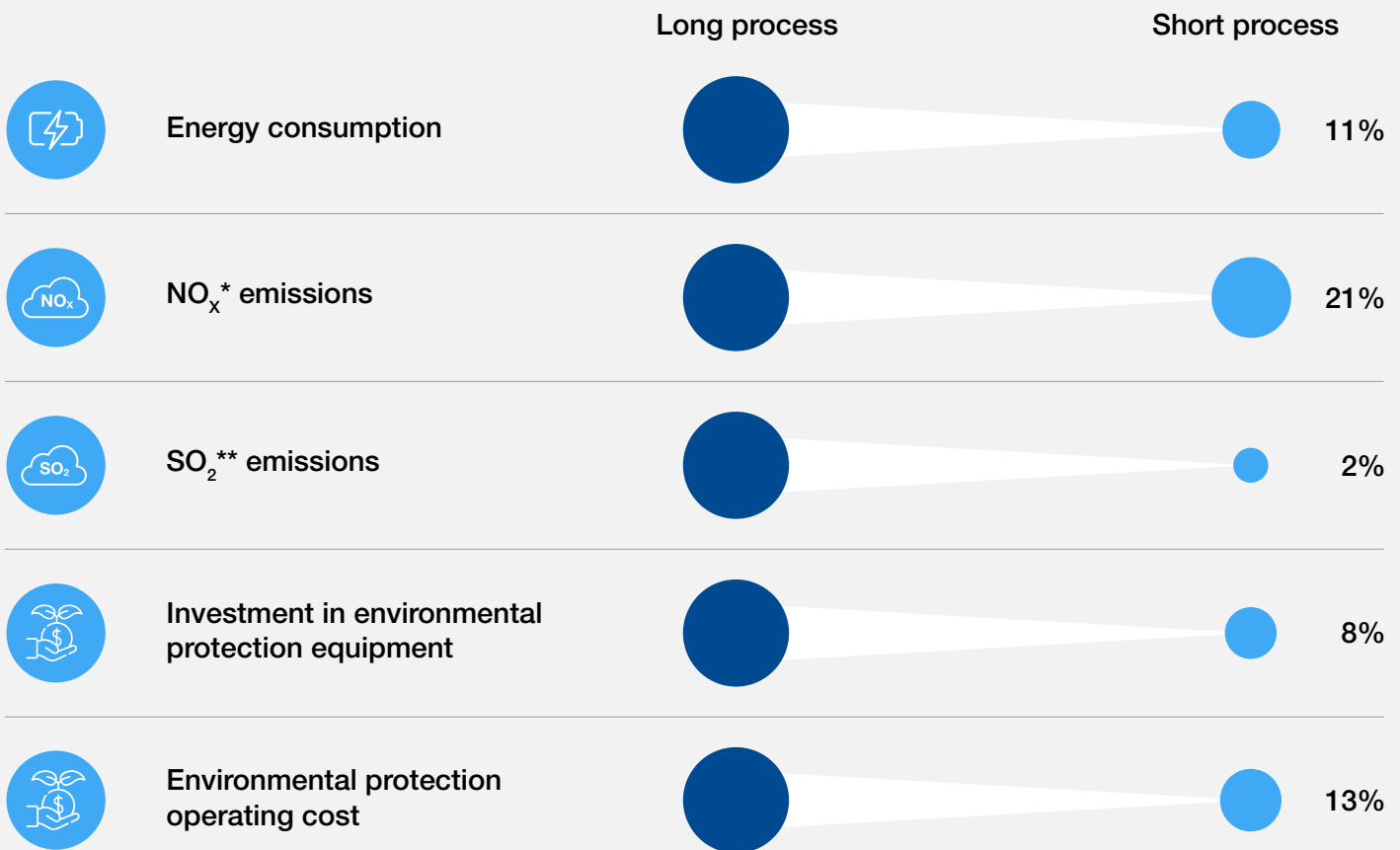
Key net-zero technology pathways

Short-process mini-mills, which use scrap steel to produce new steel, generate significantly lower CO₂ emissions than traditional long-process steel-making, which uses iron ore as its principal input. However, such mills require significant capital expenditure – around CNY 4 billion for a typical 1 million tonne per year production line – and a reliable source of scrap. Steel produced from such mills costs around 10-15% more than long-process steel.

The government is trying to boost this share, curbing the usage of traditional integrated steel plants while raising the capacity for mini-mills. With steel companies' profitability being low – gross margins averaged just 10.6% in 2020 and net margins just 3.9% – encouraging the large-scale take-up of new technologies requires substantial support from the government, state-owned enterprises, the private sector, banks and foreign technology providers (Figure 16).²³

FIGURE 16 Environmental impacts of long process and mini-mills

- **Effective use** of scrap steel alloying elements
- **Flexible process: precise temperature control** in the furnace



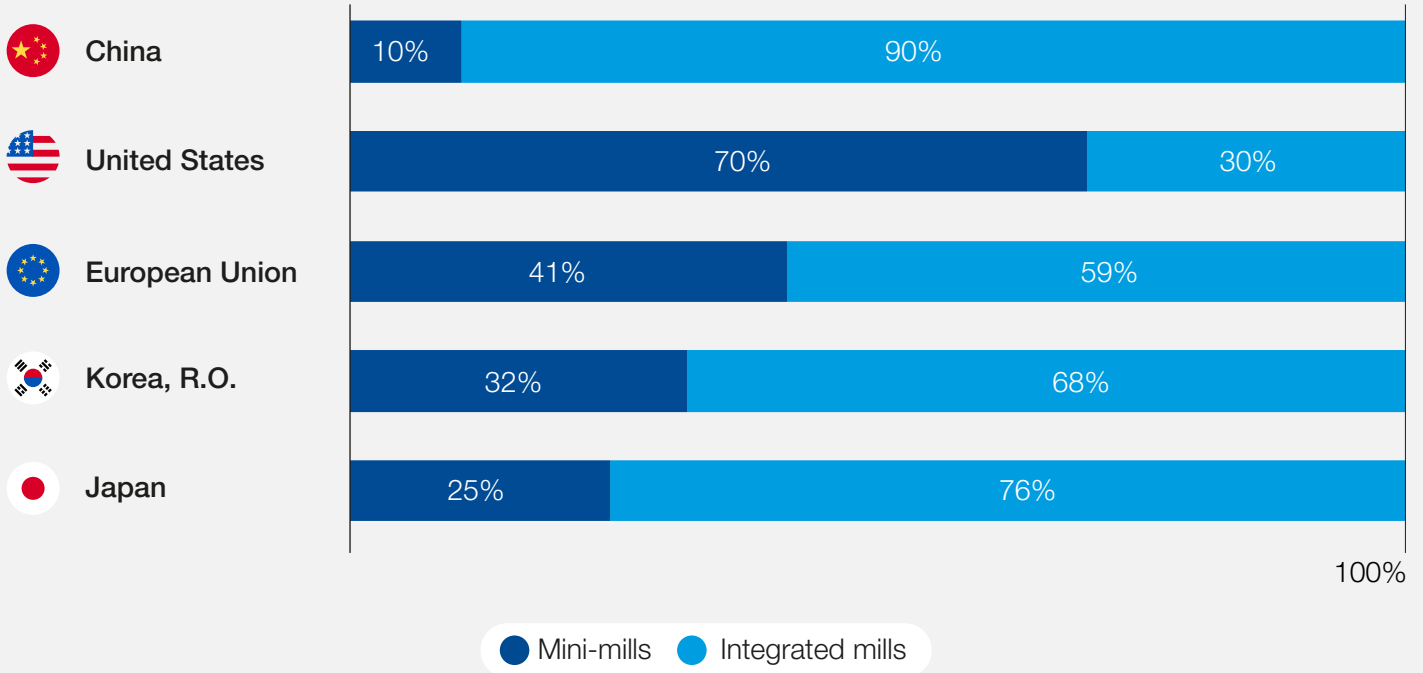
* Nitrogen oxide; ** Sulfur dioxide

Source: World Economic Forum and Oliver Wyman, adapted from the China Metallurgical Group, *Comparison of environmental protection and energy consumption between short and long processes, 2020*

Industry experts forecast that mini-mills, which use scrap steel as their raw material and electricity to power their furnaces, could contribute to reducing the industry's emissions by around 8-10%. In the

US, mini-mills account for around 70% of all steel-making capacity; in China, their share currently is only around 15%, though it is forecast to rise to approximately 80% by 2050 (Figure 17).^{24, 25}

FIGURE 17 | Percentage of mini-mills across countries



Source: World Economic Forum and Oliver Wyman, adapted from China Metallurgical Information and Standardization Institute, *Overview of steel production and steel consumption in the 15 RCEP countries, 2020*; Hwabao Securities, *Analysis of Carbon Neutrality Status and Carbon Reduction Path in the Steel Industry, 2021*

The challenges to switching to mini-mills include the cost of electricity needed to power them (traditional furnaces rely on coal), insufficient supplies of scrap steel (total supplies in 2020 were only 260 million tonnes while demand stood at more than 1 billion

tonnes), and access to funds to install sufficient capacity. Yet, with adequate support from policy-makers, banks and local administrations, the benefits of switching to mini-mills could be realized relatively quickly (Case study 3: Hebei Iron and Steel).

Hebei Iron and Steel (HBIS) has embarked on the process of introducing short-process mini-mills to its Shigang New Area facility in Shijiazhuang city, Hebei province.

Initially, it faced two major challenges – securing an adequate and stable supply of scrap steel of the right quality and being able to afford the higher price of the mills.

HBIS solved the supply issue by developing two sources of scrap steel: setting up an auto steel recycling project near its plant and using imports processed to meet national standards.

And it compensated for the cost of mini-mills with a three-pronged strategy:

- Reducing logistics costs by using compact plant layouts to reduce inter-process logistics and transport needs
- Lowering processing costs by optimizing the structure of scrap used as it was able to secure access to high-quality scrap supplies
- Raising the quality of output to produce more premium steels

Crucial to the plant's success had been government policy encouraging steel manufacturers to rethink their long-term strategies. National standards for recycled steel materials received approval in December 2020 and recently the go-ahead was given to allow high-quality steel scrap imports.

While curbs had been in place on expanding traditional steel-making plants, companies were able to add unlimited electric furnace short-process steel-manufacturing capacity. The government had also put in place a number of favourable financial and tax policies specifically targeting the development of the scrap steel industry.

HBIS's Shigang plant now uses mini-mills to produce around 7,000 tonnes of steel daily. Compared with traditional steel-making, the mills use 62% less energy and 46% less water, and produce 75% fewer major pollutants (particulate matter, SO₂ and nitrogen oxides).

HBIS expects short-process electric furnaces to account for 25% of its output by 2030, with its scrap steel utilization ratio rising to 20%.

Source: World Economic Forum and Oliver Wyman, 2022



Using H₂-DRI processes could contribute a further 1-2% reduction in carbon usage. DRI-based reduction emits less CO₂ than traditional steel production largely due to using flammable gases, such as natural gas, and in a more advanced form, natural hydrogen gas, as its fuel. For China, the challenge is securing adequate gas supplies at a reasonable price.

Helping the industry move to net zero is the fact that the growth of steel production has peaked for many companies due to the introduction of government production curbs. China Baosteel, one of China's biggest listed steel manufacturers, increased its output yearly from 2016 to 2021. Last year, however, the government introduced a volume control policy forecast to reduce output over

the next few years. Despite the capacity cuts, the company's profitability has been increasing due to increased sales of silicon steel, one of its flagship high-end products, and cost reductions, which have improved efficiency.

An unforeseen drawback of the government's production limits has been that it has discouraged companies from adding production capacity using new emissions-control technology, resulting in them continuing to operate their existing plants.

Change, perhaps driven by the emergence of a scrap steel industry complementing China's traditional steel sector, is leading to new companies exploring digital opportunities for the sector (Case study 4: Ouyeel).



Ouyeel, an online steel transaction platform established by Shanghai-based state-owned China Baosteel, which handles more than 20 million tonnes of steel scrap annually, completed two rounds of financing in 2021 through the Shanghai United Assets and Equity Exchange as a result of its adoption of digital platform technology, bringing its total funding to date to \$432 million. The company is now planning to raise further funds through a market listing in 2023.

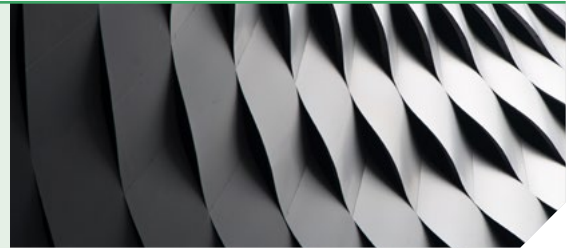
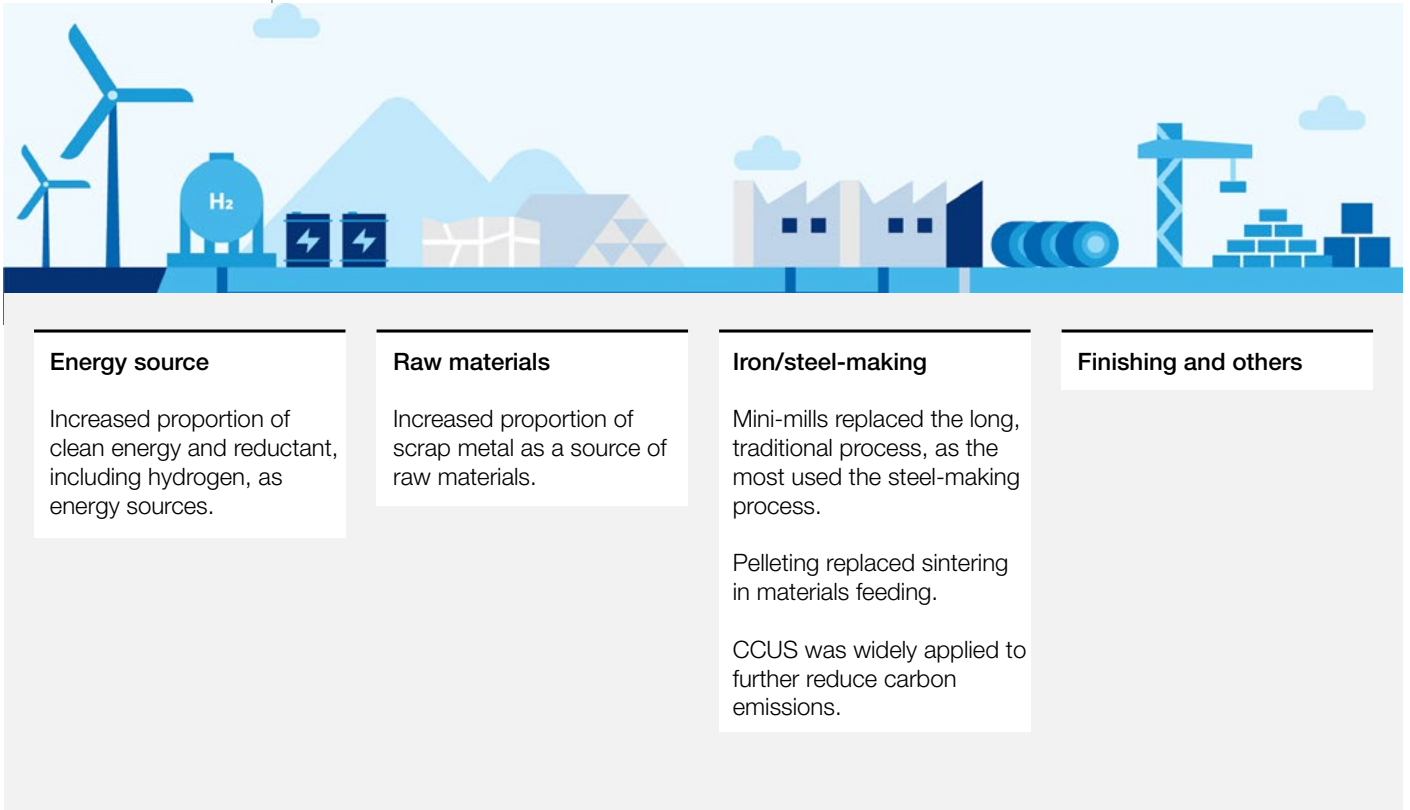


FIGURE 18 The green transition end stage of steel



What needs to happen

The steel sector’s transition to net zero hinges on access to financing, particularly on overcoming the challenges presented by the industry’s low levels of profitability. Because of these dynamics, collaboration and policy support will both play important roles in helping steel producers find transition pathways and develop and deploy several key technologies.

1. Finance innovation

One of the biggest challenges for decarbonizing China’s steel industry will be securing the funding necessary in an industry with a long history of high leverage, poor cash flows and low margins. The CNY 100-150 billion needed annually to finance its transition to net zero is far too great to be paid for from operating capital.

Although the government has mandated that the industry move to ultra-low emissions, official support is still somewhat lacking. In addition, steel producers will likely find themselves having to participate in China’s carbon market on a major scale. Online trading on China’s national carbon market, CCETE, started on July 16, 2021. Included in the scheme are 2,162 key emission units in China’s power generation industry, responsible for some 4.5 billion tonnes of CO₂ emissions, making it the largest carbon market in the world. Although CCETE only covers the trading of carbon credits for thermal power plants, more sophisticated carbon trading markets are under development.

The CCER scheme has the potential to play a significant role by allowing ultra-low emission steel producers, such as those using H₂-DRI technologies, to monetize their investments. As Europe has demonstrated with its EU-ETS, steel-makers can readily be motivated to accelerate

“ Tackling the challenges facing the steel industry’s move to net zero will call for the involvement of officials at the highest levels, with coordination necessary between the industry, funding sources in both the private and public sector and policy-makers.

carbon reduction programmes where there is a clear pathway to a financial benefit.

More generally, as companies may find it hard to secure loans or other forms of debt financing at attractive rates, alternative forms of tapping capital markets and managing cash will be required. Among the possibilities the industry is exploring are the establishment of industry funds, the flotation of innovative new businesses, capital injections from downstream suppliers and ownership reform that brings in new partners.

2. Collaboration

Another alternative for steel producers is to transfer the higher costs they will inevitably face for producing green steel for end-users. If that steel is of higher quality or shows unique characteristics, such as being fire-resistant, it may be possible to find customers willing to pay a premium, in turn opening a pathway for producers to afford high-end manufacturing capabilities in a virtuous circle.

Companies can then explore the possibility of turning themselves into an “ecosystem play”, meaning that they tie up with green partners along their value chains, such as the auto and construction sectors, by reducing their Scope 3 emissions. China Metallurgical Group (MCC), one of the largest manufacturers of steel and other equipment in China, has developed ties with suppliers with green qualifications. Linking with MCC is one way in which steel producers can plug into other businesses that can help them transition to net zero.

Another form of collaboration is for banks to divide a project into separate elements rather than view it as a whole. For example, separating technology development from business operations can reduce complexity and allow different types of risk to be assessed differently. Lending institutions can then fund the parts of a steel manufacturing operation they are comfortable with and charge accordingly.

Finally, central or local governments can support the price of green steel for early movers and draw up guidelines covering the risk posed by stranded assets if all or part of a project were to run into difficulties.²⁶

3. Policy support

Tackling the challenges facing the steel industry’s move to net zero will call for the involvement of officials at the highest levels, with coordination necessary between the industry, funding sources in both the private and public sector and policy-makers.

The government will be helped because state-owned companies, many of them of enormous size, dominate China’s steel sector. As their ultimate owner, the government can exert influence more easily than over a sector dominated by private players. While profitability is important to the sector, through its ownership of steel manufacturers or their parent companies, the government can exercise a major influence over key decisions.

Tax incentives are another powerful tool accelerating China’s transition to net zero. Work is already underway on a carbon tax, with a scheme likely to be drawn up in the next one or two years. More targeted would be a carbon tax on exports, which could be significant given the large scale of China’s overseas steel sales (67 million tonnes in 2021). This is a contrast to the EU’s planned tax on all non-green imports. Tax exemptions in various forms could be granted to green products and services. Hindering the development of such measures are concerns over the government’s ability to put in place accurate MRV emission schemes and avoiding putting too great additional burdens on emission-heavy but important industries such as steel.

Direct government support will likely also play an important role, be it in tax breaks for investment, spending on R&D or via direct subsidies. Incentives for steel users could also prove important. Businesses such as automakers will need to manage the carbon footprint of their inputs to reduce their Scope 3 emissions and, in the process, may demand more low-emission materials.



Conclusion

China faces major but not insurmountable challenges in transitioning its economy to net-zero carbon emissions. The country's unique features, notably its reliance on manufacturing, result in that transition having greater costs than in the more service-driven economies of Europe and North America.

At the same time, China's unique features are also an advantage. Its form of governance, for example, offers a good reason for believing it will stand by its long-term commitment to carbon neutrality. Because of its already powerful position in renewable energy, particularly wind and solar power, China is on a promising path to building a sustainable power sector. Its significant and rising spending on R&D positions it to discover and

deploy the technologies needed to green other critical industries as well.

Nevertheless, major funding gaps remain. This report has outlined how a combination of financial innovation by lenders, a collaboration between government and industry, the necessary policy environment and above all, putting in place carbon and other tax incentives, can lead to China realizing its carbon neutrality goal by 2060.

While the road to get there is steep, if China gets this journey right, it could position itself to drive a green revolution globally as the country's scale and its position in the global economy and supply chains will inevitably trigger and drive transformation in other parts of the world as well.

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